der Stahl abgerollt, geglättet und die für das fertige Bauteil 5 notwendige Größe der Platine 1 ausgestanzt bzw. abgeschnitten. Von dort aus werden die Platinen 1 einer Pufferzone 6 zugeführt. Dieses Zwischenlagern ist allerdings nicht unbedingt erforderlich, vielmehr können die Platinen 1 auch unmittelbar nach Verlassen des Werkzeuges 4 einem ersten Ofen 7 zugeführt werden, in dem sie eine Wärmebehandlung gemäß dem Temperatur- Zeit- Diagramm nach Fig. 2 erfahren. Unmittelbar dem ersten Ofen 7 nachgelagert ist eine Abkühlzone 8, in der die Platinen 1 abgeschreckt werden und die abschließenden Phasen der Wärmebehandlung durchlaufen. Die Abkühlzone 8 verlassend werden die wärmebehandelten Platinen 1 einem Zwischenlager 9 zugeführt.

Der erste Ofen 7 kann vom konstruktiven Aufbau her ein bereits erwähnter Durchlaufofen, ein Karussell- Ofen oder dergleichen sein.

Die einzelnen Phasen der Wärmebehandlung wurden bereits eingangs mit Hinweis auf Fig. 2 erläutert. Das relativ langsam vonstatten gehende Aufheizen auf Solltemperatur sowie die übrige Verweildauer im ersten Ofen 7 zum Herbeiführen der Austenitisierung und zum Verändern der Topographie (Beschichtungsaufbau, Schichtdicke) summiert sich auf eine Gesamt- Verweildauer von etwa 9 Minuten, wobei erfahrungsgemäß eine maximale Verweildauer von 30 Minuten nicht überschritten werden darf, damit die Platine nicht unbrauchbar wird. Der Transport in die Abkühlzone 8 und die dortige Abschreckung der Platine 1 vollzieht sich innerhalb relativ kurzer Zeiträume, während ein restliches Abkühlen auf Raumtemperatur RT im Zwischenlager 9 erfolgen kann. Am Ende der Wärmebehandlung weist die Platine 1 ein Martensitgefüge auf.

Mittels einer geeigneten Transportvorrichtung 10, beispielsweise einem Gelenkarmroboter, werden die Platinen 1 einem Induktionsofen 11 zugeführt, von wo aus sie über eine weitere Transportvorrichtung 12, z. B. wiederum ein Gelenkarmroboter, in ein für Serienprozesse geeignetes, gekühltes Umform-/Vergütungswerkzeug 13 eingelegt werden. Diesem ist eine Presseneinrichtung 14 sowie eine Kühlvorrichtung 15 zugeordnet, und beim Schließen der Presseneinrichtung 14 wird die heiße Platine 1 zu einem Bauteil 5 auf Entform umgeformt und im geschlossenen Umform-/Vergütungswerkzeug 13 bei aufgebrachter Schließkraft schnell abgekühlt und dadurch gehärtet. In einem letzten Verfahrenschritt wird jedes Bauteil 5 über eine Transportvorrichtung 16 einer Beschnittvorrichtung 17 zugeführt, wo ein Fertigkontur- und Lochbeschnitt des fertig geformten und gehärteten Bauteiles 5 vorzugsweise mittels Laserschneiden durchgeführt wird. Selbstverständlich kann dies auch über geeignete Beschnittmesser auf mechanischem Wege erfolgen.

Die im Induktionsofen 11 und im nachgeschalteten Umform-/Vergütungswerkzeug 13 vonstatten gehende Wärmebehandlung der Platine 1 ist im Temperatur- Zeit- Diagramm gemäß Fig. 3 anhand der Warmumformkurve 20 und der Wärmebehandlungsunter- / obergrenze 18, 19 dargestellt. Sie ist gekennzeichnet durch eine ausgesprochen kurze Verweildauer der Platine im Induktionsofen 11. Während das Aufheizen auf Solltemperatur (Austenitisierungstemperatur) innerhalb weniger Sekunden (ca. zehn sec.) erfolgt dient eine nachgeschaltete kurze Verweilzeit von etwa zehn Sekunden bis maximal zwei Minuten dazu, eine Gefügeumwandlung vonstatten gehen zu lassen. Eine Änderung von Dicke und Aufbau der Beschichtung ist nicht mehr erforderlich, da dies bereits im ersten Ofen 7 erfolgt ist. Nach demzufolge äußerst kurzer Verweildauer im Induktionsofen 11 kann die Platine bereits dem Umfom-/Vergütungswerkzeug 13 zugeführt werden, in dem neben der Umformung das Abschrecken in gleicher Weise (gleicher Verlauf der Warmumformkurve 20) vonstatten geht wie in der Abkühlzone 8. Beim Verlassen des Umform-/Vergütungswerkzeuges 13 weist das Bauteil 5 bereits Martensitgefüge auf, die Abkühlung auf Raumtemperatur RT kann beim Weitertransport zur bzw. innerhalb der Beschnittvorrichtung 17 erfolgen.

Auf diese Weise wurde eine eine ursprüngliche Zugfestigkeit von etwa 500 bis 600 N/mm^2 aufweisende Platine 1 in ein eine Zugfestigkeit von etwa 1300 bis 1500 N/mm^2 aufweisendes Bauteil 5 umgeformt.

In vorteilhafter Weiterbildung der Erfindung wäre denkbar, im Induktionsofen 11 die Platine 1 partiell unterschiedlich stark zu erwärmen, mit der Folge, dass, falls dies gewünscht ist, das umgeformte und abgeschreckte Bauteil 5 partiell unterschiedliche Festigkeiten aufweist.

Weiter wäre vorteilhaft möglich, die Platine 1 vor der zweiten Wärmebehandlung (Induktionsofen 11) zum Beispiel durch Aufschweißen von Verstärkungsblechen (Patches) lokal zu verstärken. Ein solchermaßen gepatchtes Verbundblech könnte dann dem zweiten Ofen und danach dem Umform-/Vergütungswerkzeug 13 zugeführt werden. Dies hätte insgesamt positive Auswirkungen auf die Werkstoffeigenschaften und die Formgenauigkeit.

Das erfindungsgemäße Verfahren ist auch bei Verwendung von Tailored blanks Platinen vorteilhaft anwendbar.

Ein wesentlicher Vorteil der Erfindung ist die Möglichkeit der Entkopplung der einzelnen Verfahrensschritte. So kann die erste Wärmebehandlung im Ofen 7 bereits beim Stahl- bzw. Blechhersteller erfolgen und die so vorbehandelten Platinen 1 können dann

dem weiterverarbeitenden Unternehmen (z. B. Fahrzeughersteller) bereitgestellt werden (Zwischenlager 9).

In einer weiteren vorteilhaften Weiterbildung der Erfindung ist denkbar, der Transportvorrichtung 10 einen Induktor zuzuordnen bzw. diesen in die Transportvorrichtung 10 baulich zu integrieren, so dass die Wärmebehandlung der Platine 1 während ihres Transportes zum Umform-/Vergütungswerkzeug 13 vonstatten gehen kann. Ein separater Induktionsofen 11 sowie eine diesem nachgeschaltete weitere Transportvorrichtung 12 könnten dadurch entfallen.

IP 5081
Ge/Sc

ANSPRÜCHE

1. Verfahren zur Herstellung eines Bauteils durch Umformen einer beschichteten, vorzugsweise aluminiumbeschichteten Platine aus einem Vergütungsstahl, wobei vor dem Umformen in einem ersten Verfahrensschritt die Platine einem ersten Ofen zugeführt und dort austenitisiert wird und wobei die Verweildauer der Platine im ersten Ofen so gewählt wird, dass neben der Gefügeumwandlung ein Schichtdickenwachstum vonstatten geht, gekennzeichnet durch folgende weitere Verfahrensschritte:

   - schnelles Abkühlen und anschließendes Zwischenlagern der wärmebehandelten Platine (1)
   - erneutes, kurzzeitiges Erwärmen der Platine (1) in einem zweiten Ofen (11) auf Austenitisierungstemperatur unmittelbar vor dem Umformen zum Bauteil (5) und
   - nach erfolgter Gefügeumwandlung Umformen und Härten der Platine (1).

2. Verfahren nach Patentanspruch 1, gekennzeichnet durch eine Verweildauer im ersten Ofen (7) zwischen neun Minuten und dreißig Minuten.

3. Verfahren nach Patentanspruch 1, dadurch gekennzeichnet, dass bei der wiederholten Erwärmung der Platine (1) auf Austenitisierungstemperatur im zweiten Ofen (11) die Verweildauer so gewählt wird, dass lediglich eine Gefügeumwandlung, aber kein Schichtdickenwachstum mehr statt findet.

4. Verfahren nach Patentanspruch 3, gekennzeichnet durch eine Verweildauer der Platine (1) im zweiten Ofen (11) von zehn Sekunden bis zweieinhalb Minuten.

5. Verfahren nach Patentanspruch 1, dadurch gekennzeichnet, dass die Erwärmung der Platine (1) im ersten Ofen (7) auf Elektro- oder Gas-Basis erfolgt, während die Erwärmung im zweiten Ofen (11) durch Induktion vonstatten geht.

6. Verfahren nach Patentanspruch 1, dadurch gekennzeichnet, dass die erste Erwärmung beim Stahl- bzw. Blechhersteller erfolgt, während die zweite Wärmebehand-

lung beim weiterverarbeitenden Unternehmen, z. B. Fahrzeughersteller, vonstatten geht.

7. Verfahren nach Patentanspruch 1, dadurch gekennzeichnet, dass während der zweiten Wärmebehandlung die Platine (1) über ihre Oberfläche unterschiedlich stark erwärmt wird.

8. Verfahren nach Patentanspruch 1, dadurch gekennzeichnet, dass die Platine (1) vor dem erneuten Erwärmen im zweiten Ofen (11) durch Aufbringen von mindestens einem Verstärkungsblech lokal verstärkt wird.

9. Verfahren nach Patentanspruch 1, gekennzeichnet durch die Verwendung eines Tailored blanks als Platine (1).

10. Vorrichtung zur Durchführung des Verfahrens nach einem der Patentansprüche 1-9, gekennzeichnet durch

- ein Werkzeug (4) zum Herstellen von Platinen (1) aus einem Coil (3),
- einen ersten Ofen (7) zur ersten Wärmebehandlung einschließlich Herbeiführen eines Schichtdickenwachstums der Platinen (1),
- eine Abkühlzone (8) für die Platinen (1),
- ein Zwischenlager (9) für die Platinen (1),
- einen zweiten Ofen (11) zur erneuten Wärmebehandlung der Platinen (1),
- ein Umform-/Vergütungswerkzeug (13) mit einer Presseneinrichtung (14) und einer Kühlvorrichtung (15) und
- eine Beschnittvorrichtung (17) zur Herstellung eines Fertigkontur- und Lochbeschnittes.

11. Vorrichtung nach Patentanspruch 10, gekennzeichnet durch einen ersten Ofen (7) auf Elektro-und/oder Gas-Basis und einen Induktionsofen (11) zur zweiten Wärmebehandlung.

12. Vorrichtung nach Patentanspruch 11, dadurch gekennzeichnet, dass ein Induktor in eine Transportvorrichtung (10) integriert ist, die zwischen Zwischenlager (9) und Umform-Vergütungswerkzeug (13) angeordnet ist.

13. Vorrichtung nach Patentanspruch 10, dadurch gekennzeichnet, dass zwischen der Abkühlzone (8) und dem zweiten Ofen (11) eine Station zum Aufbringen, insbesondere Aufschweißen, von mindestens einem Verstärkungsblech auf die Platine (1) angeordnet ist.

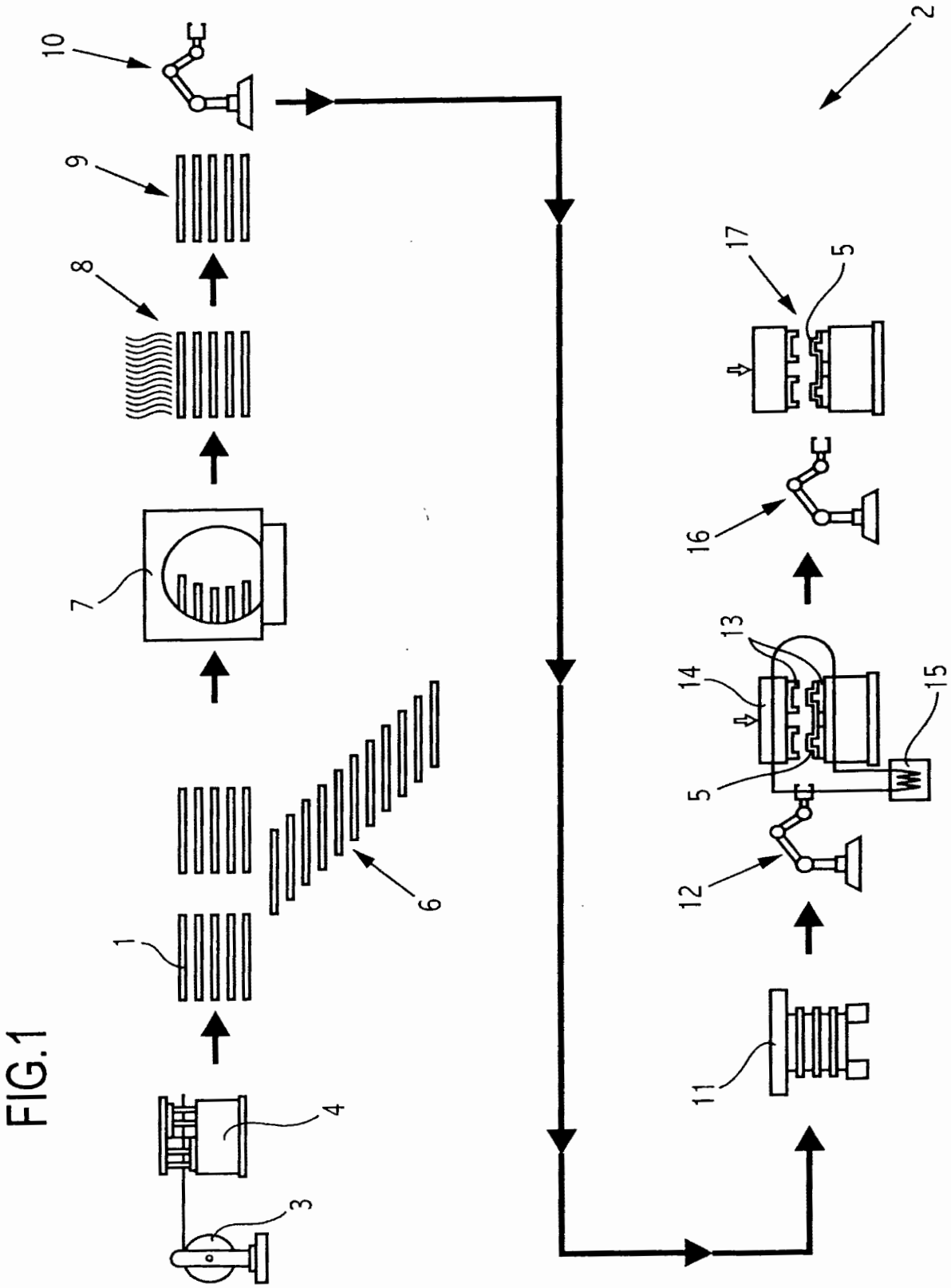


FIG.1

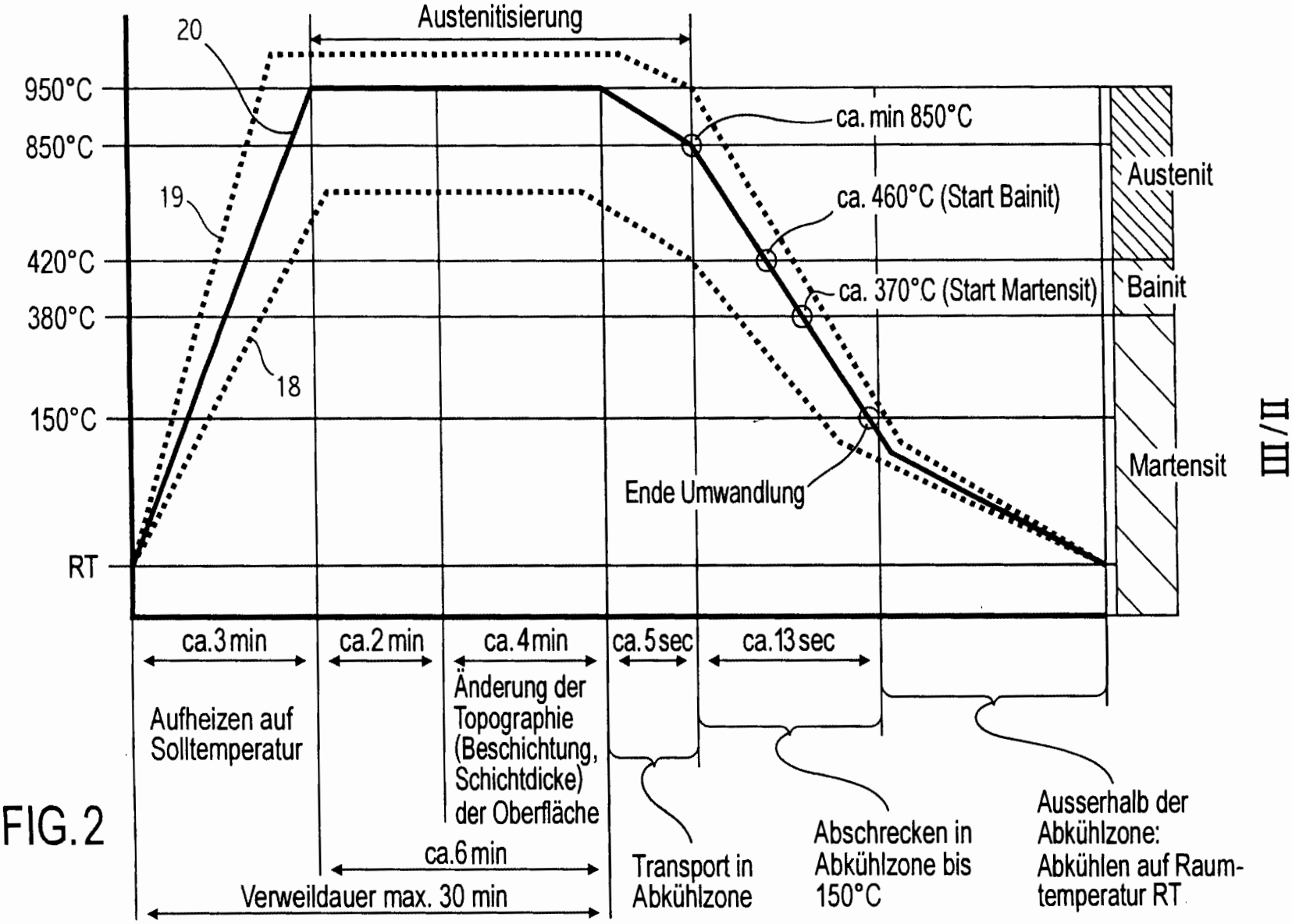
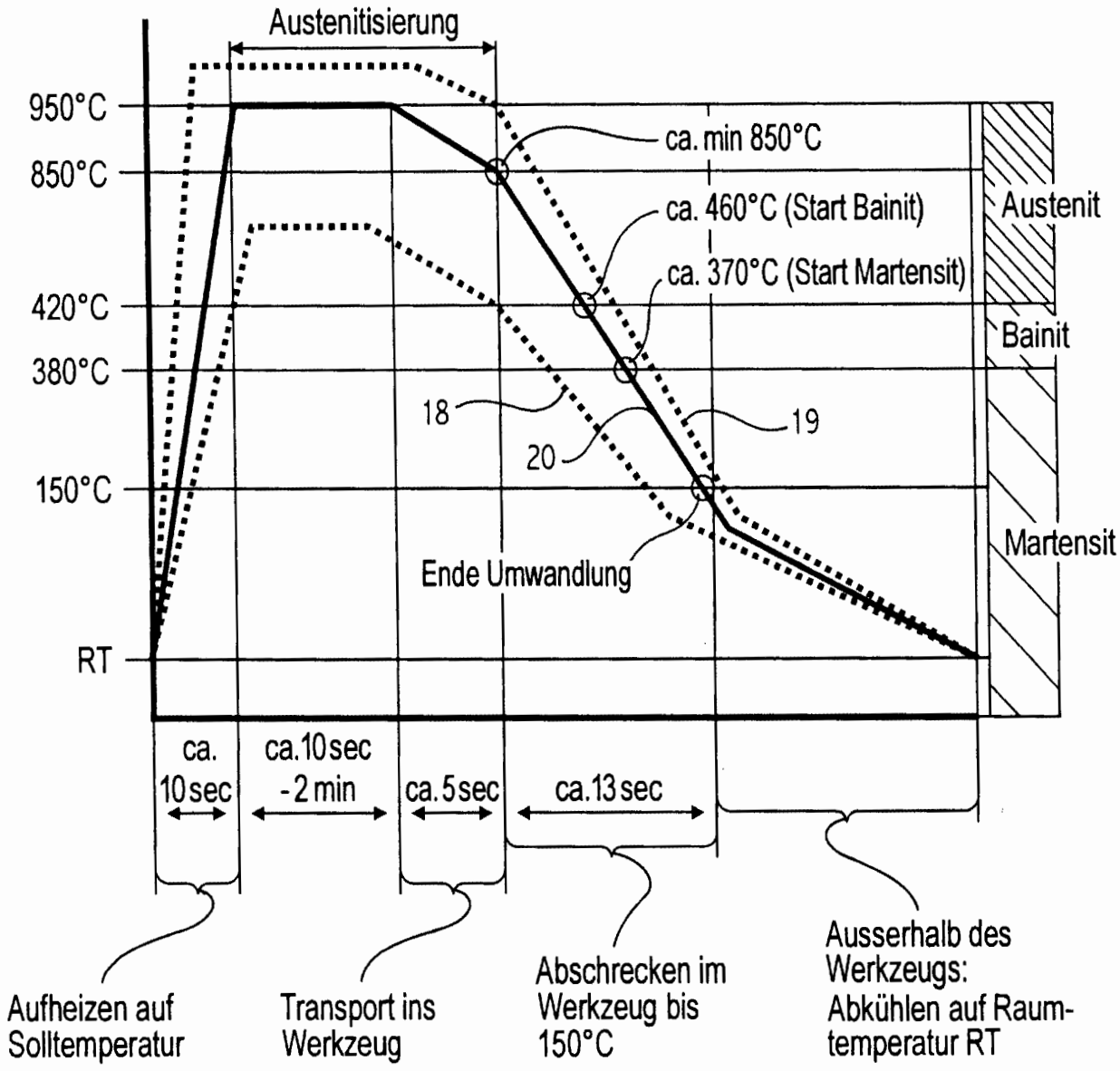

Austenitisierung
20
19
18
950°C
850°C
420°C
380°C
150°C
RT
ca. min 850°C
ca. 460°C (Start Bainit)
ca. 370°C (Start Martensit)
Ende Umwandlung
Austenit
Bainit
Martensit
ca.3 min
ca.2 min
ca.4 min
ca.5 sec
ca.13 sec
Aufheizen auf Solltemperatur
Änderung der Topographie (Beschichtung, Schichtdicke) der Oberfläche
ca.6 min
Verweildauer max. 30 min
Transport in Abkühlzone
Abschrecken in Abkühlzone bis 150°C
Ausserhalb der Abkühlzone: Abkühlen auf Raumtemperatur RT

FIG.2

II/III

FIG. 3


Austenitisierung
950°C
850°C
420°C
380°C
150°C
RT
ca. min 850°C
ca. 460°C (Start Bainit)
ca. 370°C (Start Martensit)
Austenit
Bainit
Martensit
18
19
20
Ende Umwandlung
ca. 10 sec
ca. 10 sec - 2 min
ca. 5 sec
ca. 13 sec
Aufheizen auf Solltemperatur
Transport ins Werkzeug
Abschrecken im Werkzeug bis 150°C
Ausserhalb des Werkzeugs: Abkühlen auf Raumtemperatur RT

INTERNATIONAL SEARCH REPORT

International Application No
PCT/EP2005/000853

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 C21D9/46

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 C21D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal, PAJ, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP 1 380 666 A (NISSAN MOTOR CO., LTD) 14 January 2004 (2004-01-14) the whole document	1-13
A	PATENT ABSTRACTS OF JAPAN vol. 2003, no. 11, 5 November 2003 (2003-11-05) -& JP 2003 181549 A (NIPPON STEEL CORP), 2 July 2003 (2003-07-02) the whole document	1-13
A	US 4 517 229 A (NICKOLA ET AL) 14 May 1985 (1985-05-14) the whole document	1-13

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
25 April 2005	06/05/2005

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Swiatek, R

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INTERNATIONAL SEARCH REPORT

Internal Application No
PCT/EP2005/000853

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 6 185 977 B1 (SCHIESSL GERHARD ET AL) 13 February 2001 (2001-02-13) cited in the application the whole document -----	1-13
A	DE 102 12 400 C1 (BENTELER AUTOMOBILTECHNIK GMBH) 3 April 2003 (2003-04-03) cited in the application the whole document -----	1-13

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/EP2005/000853

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 1380666 A	14-01-2004	JP 2004043887 A	12-02-2004
		CN 1472068 A	04-02-2004
		EP 1380666 A1	14-01-2004
		US 2004009366 A1	15-01-2004
JP 2003181549 A	02-07-2003	CN 1531604 A	22-09-2004
		WO 02103073 A2	27-12-2002
US 4517229 A	14-05-1985	AT 36874 T	15-09-1988
		CA 1223158 A1	23-06-1987
		DE 3473775 D1	06-10-1988
		EP 0149655 A1	31-07-1985
		JP 5055594 B	17-08-1993
		JP 60501765 T	17-10-1985
		WO 8500386 A1	31-01-1985
		US 4837091 A	06-06-1989
		US 4666794 A	19-05-1987
US 6185977 B1	13-02-2001	DE 19653543 A1	25-06-1998
		DE 59702545 D1	30-11-2000
		WO 9828097 A1	02-07-1998
		EP 0946311 A1	06-10-1999
		ES 2151299 T3	16-12-2000
		JP 2001506543 T	22-05-2001
DE 10212400 C1	03-04-2003	FR 2837216 A1	19-09-2003

INTERNATIONALER RECHERCHENBERICHT

Internationales Aktenzeichen
PCT/EP2005/000853

A. KLASSIFIZIERUNG DES ANMELDUNGSGEGENSTANDES
IPK 7 C21D9/46

Nach der Internationalen Patentklassifikation (IPK) oder nach der nationalen Klassifikation und der IPK

B. RECHERCHIERTE GEBIETE

Recherchierter Mindestprüfstoff (Klassifikationssystem und Klassifikationssymbole)
IPK 7 C21D

Recherchierte aber nicht zum Mindestprüfstoff gehörende Veröffentlichungen, soweit diese unter die recherchierten Gebiete fallen

Während der internationalen Recherche konsultierte elektronische Datenbank (Name der Datenbank und evtl. verwendete Suchbegriffe)
EPO-Internal, PAJ, WPI Data

C. ALS WESENTLICH ANGESEHENE UNTERLAGEN

Kategorie°	Bezeichnung der Veröffentlichung, soweit erforderlich unter Angabe der in Betracht kommenden Teile	Betr. Anspruch Nr.
A	EP 1 380 666 A (NISSAN MOTOR CO., LTD) 14. Januar 2004 (2004-01-14) das ganze Dokument -----	1-13
A	PATENT ABSTRACTS OF JAPAN Bd. 2003, Nr. 11, 5. November 2003 (2003-11-05) -& JP 2003 181549 A (NIPPON STEEL CORP), 2. Juli 2003 (2003-07-02) das ganze Dokument -----	1-13
A	US 4 517 229 A (NICKOLA ET AL) 14. Mai 1985 (1985-05-14) das ganze Dokument -----	1-13
	-/--	

[X] Weitere Veröffentlichungen sind der Fortsetzung von Feld C zu entnehmen

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Datum des Abschlusses der internationalen Recherche	Absendedatum des internationalen Recherchenberichts
25. April 2005	06/05/2005

Name und Postanschrift der Internationalen Recherchenbehörde	Bevollmächtigter Bediensteter
Europäisches Patentamt, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Swiatek, R

Formblatt PCT/ISA/210 (Blatt 2) (Januar 2004)

INTERNATIONALER RECHERCHENBERICHT

Internales Aktenzeichen
PCT/EP2005/000853

C.(Fortsetzung) ALS WESENTLICH ANGESEHENE UNTERLAGEN

Kategorie°	Bezeichnung der Veröffentlichung, soweit erforderlich unter Angabe der in Betracht kommenden Teile	Betr. Anspruch Nr.
A	US 6 185 977 B1 (SCHIESSL GERHARD ET AL) 13. Februar 2001 (2001-02-13) in der Anmeldung erwähnt das ganze Dokument -----	1-13
A	DE 102 12 400 C1 (BENTELER AUTOMOBILTECHNIK GMBH) 3. April 2003 (2003-04-03) in der Anmeldung erwähnt das ganze Dokument -----	1-13

INTERNATIONALER RECHERCHENBERICHT

Angaben zu Veröffentlichungen, die zur selben Patentfamilie gehören

Internationales Aktenzeichen
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Im Recherchenbericht angeführtes Patentdokument		Datum der Veröffentlichung	Mitglied(er) der Patentfamilie		Datum der Veröffentlichung
EP 1380666	A	14-01-2004	JP	2004043887 A	12-02-2004
			CN	1472068 A	04-02-2004
			EP	1380666 A1	14-01-2004
			US	2004009366 A1	15-01-2004
JP 2003181549	A	02-07-2003	CN	1531604 A	22-09-2004
			WO	02103073 A2	27-12-2002
US 4517229	A	14-05-1985	AT	36874 T	15-09-1988
			CA	1223158 A1	23-06-1987
			DE	3473775 D1	06-10-1988
			EP	0149655 A1	31-07-1985
			JP	5055594 B	17-08-1993
			JP	60501765 T	17-10-1985
			WO	8500386 A1	31-01-1985
			US	4837091 A	06-06-1989
			US	4666794 A	19-05-1987
US 6185977	B1	13-02-2001	DE	19653543 A1	25-06-1998
			DE	59702545 D1	30-11-2000
			WO	9828097 A1	02-07-1998
			EP	0946311 A1	06-10-1999
			ES	2151299 T3	16-12-2000
			JP	2001506543 T	22-05-2001
DE 10212400	C1	03-04-2003	FR	2837216 A1	19-09-2003

Espacenet

Bibliographic data: FR2833504 (A1) — 2003-06-20

Hot forming of motor vehicle wheel components involves hot stamping of pre-coated hot- or cold-rolled steel sheet

Inventor(s): LAURENT JEAN PIERRE; DERUY SYLVAIN; DEVROC JACQUES ± (LAURENT JEAN PIERRE, ; DERUY SYLVAIN, ; DEVROC JACQUES)

Applicant(s): USINOR [FR] ± (USINOR)

Classification: **- international:** ***B21D53/26; B21D53/30;*** (IPC1-7): B21D53/26; C21D8/02; C22C38/32; C22C38/38
- cooperative: **B21D53/26**; **B21D53/30**; **C21D1/673**

Application number: FR20010016185 20011214

Priority number(s): FR20010016185 20011214

Abstract of FR2833504 (A1)

A method for hot forming, notably to obtain all or part of a motor vehicle wheel, such as, for example, a hub cap, utilizes, in a hot stamping operation, a pre-coated, heat treated, hot- or cold-rolled steel sheet. The composition of the steel sheet is (by weight): 0.15 - 0.5% carbon; 0.5 - 3% manganese; 0.1 - 0.5% silicon; 0 - 1% chromium; less than 0.2% titanium; less than 0.1% aluminum; less than 0.1% phosphorus; less than 0.05% sulfur; and 0.0005 - 0.08% boron. The coating is aluminum-based with some silicon, iron, and possibly zinc.

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DESCRIPTION FR2833504

<Desc / Clms Page number 1>

Hot forming method and in particular obtaining all or part of a motor vehicle wheel.

The present invention relates to obtaining a workpiece by a hot forming process and in particular obtaining all or part of a motor vehicle wheel.

Currently, the webs of wheels are obtained either by cold stamping of a sheet blank or flow spinning.

In the case of obtaining a web by stamping a sheet blank, it is necessary to perform several shaping operations, which requires the realization of several stamping tools. The number of stamping tools is of the order of 7, 8 or 9.

The main disadvantages of the present technique cited are the following: - Any change in shape requires the machining or manufacture of 7 to 9 pairs of different tools.

- Any change of manufacture causes the disassembly then the assembly and the setting of 7 to 9 tools as well as the setting of the associated presses.

- These many tools must be stored.

- The cost of manufacturing tools does not allow the production of small series in an economical way.

- It is not possible to make thick parts.

In the case of obtaining, for example, a spinning wheel veil, the productivity is reduced compared to the stamping, which limits the production in large series.

In both techniques mentioned: - The use of drawing oil or lubricant is imperative and requires degreasing before painting.

- It is necessary to store and treat these oils as well as the effluents.

From the point of view of the desired characteristics: The increase of the mechanical characteristics leads to a decrease of the formability, which limits the shape of the sails, and generates an increased elastic return, penalizing the dimensional guarantees.

- The increase in mechanical characteristics requires the use of increasingly powerful presses.

<Desc / Clms Page number 2>

- The temporary protection against corrosion, before painting for example a stamped film, requires oiling the part then degrease it. It is also necessary to remove the stamping oil before painting, which involves a cost and an ecological risk.

The object of the invention is the production of a part by hot stamping, in a single pass, respecting the dimensional guarantees, while having the possibility of obtaining complex shapes.

The object of the invention is to obtain a part by a hot forming process and in particular to obtain all or part of a motor vehicle wheel, for example a wheel cover, characterized in that In a hot stamping operation, a hot-rolled steel sheet for heat treatment, pre-coated, is used.

The other characteristics of the invention are: the steel sheet is a pre-coated hot or cold rolled steel sheet of the following general weight composition: 0, 15% <carbon <0.5% 0.5% <manganese <3% 0, 1% <silicon <0, 5% 0% <chromium <1% titanium <0.2% aluminum <0, 1% phosphorus <0, 1% sulfur <0.05% 0, 0005 % <boron <0.08% the other characteristics of the invention are: - the coating is based on aluminum, - preferably, the steel sheet is a pre-coated hot rolled or cold rolled steel sheet of the following composition by weight: 0.15% <carbon <0.5% 0.8% <manganese <1.5% 0.1% <silicon <0.35% 0% <chromium <1% titanium <0, 1% aluminum <0.1%

<Desc / Clms Page number 3>

phosphorus <0.05% sulfur <0.03% 0.0005% <boron <0.01% in the weight composition of the sheet, the titanium content with respect to the nitrogen content is greater than 3.42, - the metal bath of the coating comprises, in its basic weight composition, from 9% to 10% of silicon, from 2% to 3.5% of iron, the rest of the bath being composed of aluminum and impurities, - the metal bath the coating comprises in its basic composition by weight of 2% to 4% of iron, the metal bath of the coating may contain in its basic composition by weight, from 0 to 50% of zinc.

The following description will make the invention clear.

The problem is to achieve a part by a hot forming process and in particular obtaining all or part of a motor vehicle wheel such as, for example, a VL wheel or PL wheel (light car or weight heavy) or a wheel cover and a part of the wheel rim, in one pass, respecting the dimensional guarantees, while achieving complex shapes.

It is known from the patent application FR No. 98 08793 a hot and cold steel sheet coated and having a very high resistance after heat treatment. It is also known from the patent application FR No. 98 16477 a method of producing a part from a strip of rolled steel sheet and in particular hot rolled.

According to the invention, a particularly important use of a sheet and the method presented has

been demonstrated, in obtaining a part by a hot forming process and, in particular, obtaining all or part of a wheel of a motor vehicle, in a single hot stamping pass, while the techniques used to date, requires numerous tools, complex, and many operations formatting.

Against known industrial habits, the inventors have obtained, in a single pass, by hot stamping a pre-coated hot rolled steel sheet, a wheel cover, which previously was made in 7 or 8 stamping operations, the pre-cut sheet metal plane having the following general weight composition:

<Desc / Clms Page number 4>

0, 15% <carbon <0, 5% 0, 5% <manganese <3%

0, 1% <silicon <0, 5% 0, 01% <chromium <1% titanium <0.2% aluminum <0, 1% phosphorus <0, 1% sulfur <0.05% 0.0005% <boron <0.08 The use of a pre-coated heat treatment steel makes it possible to obtain a notable gain in fatigue resistance without posing a welding problem and exhibiting an increased resistance to corrosion after painting.

In addition, the process and the steel used allow a noticeable lightening and an increase in fatigue life. Finally, the veil obtained can be welded and painted without modification of existing lines.

Preferably, the steel of the sheet has the following weight composition: 0.15% <carbon <0.5% 0.8% <manganese <1.5% 0.1% <silicon <0.35% 0.01 % <chromium <1% titanium <0, 1% aluminum <0.1% phosphorus <0.05% sulfur <0.03% 0.0005% <boron <0.01% the sheet ensuring a very high mechanical strength after heat treatment and aluminum-based coating ensuring high resistance to corrosion and fatigue.

To obtain the part, in a single pass, by hot stamping of the hot rolled coated sheet, it is preferable that the titanium content with respect to the nitrogen content is greater than 3.42.

The coating of the aluminum-based, hot-rolled coated sheet comprises in its basic weight composition from 9% to 10% silicon, from 2% to 3.5% iron.

The coating of the coated hot-rolled sheet may also comprise in its basic weight composition from 2% to 4% iron. The metal bath may contain in its basic composition by weight of 0 to 50% zinc.

In an exemplary embodiment, the steel according to the invention containing 0.231% of carbon; 1.145% manganese; 0.020% phosphorus; 0.0038% sulfur; 0.239% silicon; 0.043% aluminum; 0.009% copper; 0.020% nickel; 0.179% chromium; 0.0042% nitrogen; 0.032% titanium; 0.0028% boron; 0.0051% of calcium in the form of a sheet is coated with an aluminum-based layer having about 25 µm in thickness prior to heat treatment.

The sheet blank is heated in an oven at a temperature between 7500C and 1000 C and more generally at a temperature between 850 C and 9500C for a time varying according to the thickness. For a thickness of 2 mm, the sheet blank stays for 6 minutes in the oven. The rate of rise in temperature is greater than 3 C / s. Due to the coating, it is not necessary to use an inert atmosphere furnace.

During the reheating of the sheet blank, the coating is alloyed with the substrate to form an intermetallic alloy. The alloying causes, by inter-diffusion, an increase in the thickness of the layer which, for the treatment above specified, generally corresponds to an increase of 50%.

The blank of hot sheet is then transferred into the tool cooled or not, depending on the rate, the thickness of the sheet and the target cooling rate, to be shaped. There should be no blank greenhouse pressure to prevent tearing of the sheet due to its low resistance to high temperature. The rate of deformation must be sufficient to avoid deforming the steel at a temperature below 400 C.

The wheel veil thus obtained is held in the tool until a temperature of less than 2000C and preferably less than 100 C is reached in order to respect the dimensional guarantees. The average cooling rate must be greater than 27 C / s, between the outlet temperature of the oven and 400 C, if the target structure for the substrate is a martensitic structure. If the average cooling rate is less than this value, bainite, ferrite or even perlite may appear. It is thus possible to obtain different structures and therefore different properties depending on the target cooling rate.

Nevertheless, the best

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Fatigue results are obtained with a steel structure, totally martensitic.

Because of the hot forming, there is no damage to the metallurgical structure. This has a beneficial effect on the fatigue resistance due to the elimination of internal defects that can be used to initiate fatigue cracks. It is not necessary to add stamping lubricant because the pre-coating acts as a lubricant.

The piece thus obtained can undergo the painting cycle directly. If this is not the case, it is not necessary to apply temporary protection against corrosion because the alloy layer slows down the appearance of corrosion. During the thermal cycle, the coating, whether or not alloyed, protects the steel from oxidation and decarburization.

The alloy layer produced on the part has a hardness gradient. Starting with

from the extreme layer and moving towards the sheet, the hardness varies from 750HVO, 1 to 300 HVO, 1 to the interface layer-coating sheet, then increases up to about 500HVO, 1 in the sheet, when the structure Steel is totally martensitic. It is the 300HVO layer, 1 which, by stopping cracks, gives the piece an increased fatigue resistance.

If using the steel of the proposed solution but not pre-coated, there is a significant degradation of average endurance limit, as shown in Table 1 below mainly related to the decarburization of steel. The proposed solution, because of the presence of pre-protection, avoids this phenomenon. The fatigue tests in alternating plane flexion show a noticeable gain.

Table 1.

Steel RpO. 2 Rm Number of cycles of Limit of endurance (MPa) (MPa) validation of the Average (MPa) Travers Travers limitation of the limit of endurance <SEP > (millions of cycles) USIDUR 355 example of 432 514 1. 106 279 comparison USIFORM 800 example 766 872 2.106 388 from comparison <tb > Obtaining according to 980 1490 2.106 249 the invention, no pre coated Obtaining according to < SEP> 980 1480 2. 106 439 the invention

<Desc / Clms Page number 7>

Compared to the USIDUR 355 sheet, commonly used industrially for the production of wheel sails, the gain is 40% in life or lightening.

Compared to the mentioned grade used for the wheel sails, the endurance limit has a gain of more than 12%.

The advantages of obtaining a part by a hot forming process and in particular obtaining all or part of a wheel of a motor vehicle are the following: a realization of a wheel sail in a single pass of forming, - because of the important formability to hot, only one tool is necessary. it is therefore possible to make parts of complex shapes in series economically such as the wheels of style, - a very good dimensional guarantee because there is no springback as in the case of cold stamping or flow spinning, - the high mechanical characteristics after quenching in the stamping tool allow significant lightening, - the pre-coating ensures an increased guarantee against corrosion and wear, - an increased formability during the heating of the blank of sheet metal makes it possible to heat-form thicknesses that can usually be shaped only by spinning, - deformation can take place in the austenitic phase when hot, without damage, which guarantees a better resistance to fatigue by eliminating internal defects generally created during a cold deformation, - because of the pre-coating, it is useless to lubricate the sheet during hot forming, thus eliminating i the degreasing step before painting, - thanks to the coating, it is useless to apply a temporary protection against corrosion on the parts waiting to paint, - the pre-coating not heat treated, unlike coatings based on zinc, does not degrade the fatigue strength and even increases it, - the impact behavior is reinforced by the use of the selected type of steel, - the heat treated pre-coating does not require special welding equipment and precaution.

Other parts can benefit from this method of obtaining. Mention may in particular be made of the ground connection parts dimensioned in fatigue such as: the suspension arms, wheel arms, etc.

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CLAIMS FR2833504

CLAIMS.

1.
Hot forming method and in particular, obtaining all or part of a motor vehicle wheel such as a wheel cover, characterized in that, in a hot stamping operation, a sheet metal is used. hot rolled or cold rolled steel for pre-coated heat treatment.

2.

Process according to Claim 1, characterized in that the steel sheet is a hot-rolled steel sheet pre-coated with the following general weight composition: 0.15% <carbon <0.5% 0.5% <manganese <3% 0, 1% <silicon <0, 5% 0% <chromium <1% titanium <0.2% aluminum <0.1% phosphorus <0.1% sulfur <0.05% 0.0005% < boron <0.08% 3.

Process according to Claim 1, characterized in that the coating is based on aluminum.

4.
Process according to Claim 1, characterized in that the steel sheet is preferably a hot rolled or cold rolled steel sheet pre-coated with the following composition by weight: 0.15% <carbon <0.5% 0 , 8% <manganese <1.5% 0, 1% <silicon <0, 35% 0.01% <chromium <1% titanium <0.1% aluminum <0.1% phosphorus <0.05% sulfur < 0.03% 0.0005% <boron <0.01%

5.
Process according to Claim 1, characterized in that, in the weight composition of the sheet, the titanium content with respect to the nitrogen content is greater than 3.42.

6.
Process according to Claim 1, characterized in that the metal bath of the coating comprises, in its basic weight composition, from 9% to 10% of silicon, from 2% to 3.5% of iron, the rest of the bath being composed of aluminum and impurities.

7.
Process according to Claim 1, characterized in that the metal bath of the coating comprises in its basic weight composition from 2% to 4% of iron.

8.
Process according to Claim 1, characterized in that the metal bath of the coating may contain, in its basic weight composition, from 0 to 50% of zinc.

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(54) PROCEDE DE MISE EN FORME A CHAUD ET NOTAMMENT L'OBTENTION DE TOUT OU PARTIE D'UNE ROUE DE VEHICULE AUTOMOBILE.

(57) Procédé de mise en forme à chaud et notamment, obtention de tout ou partie d'une roue de véhicule automobile comme par exemple un voile de roue, caractérisé en ce qu'on utilise, dans une opération d'emboutissage à chaud, une tôle d'acier laminée à chaud pour traitement thermique pré revêtu.

FR 2 833 504 - A1

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Procédé de mise en forme à chaud et notamment l'obtention de tout ou partie d'une roue de véhicule automobile.

La présente invention concerne l'obtention d'une pièce par un procédé de mise en forme à chaud et notamment l'obtention de tout ou partie d'une roue de véhicule automobile.

Actuellement, les voiles de roues sont obtenus soit par emboutissage à froid d'un flan de tôle soit par fluotournage.

Dans le cas de l'obtention d'un voile par emboutissage d'un flan de tôle, il est nécessaire de réaliser plusieurs opérations de mise en forme, ce qui impose la réalisation de plusieurs outils d'emboutissage. Le nombre d'outils d'emboutissage est de l'ordre de 7, 8 ou 9.

Les principaux inconvénients de la présente technique citée sont les suivants :

- Tout changement de forme nécessite l'usinage ou la fabrication de 7 à 9 paires d'outils différents.
- Tout changement de fabrication occasionne le démontage puis le montage et le réglage de 7 à 9 outils ainsi que le réglage des presses associées.
- Ces nombreux outils doivent être stockés.
- Le coût de fabrication des outils ne permet pas la réalisation de petites séries de manière économique.
- Il n'est pas possible de réaliser des pièces de forte épaisseur.

Dans le cas de l'obtention, par exemple, d'un voile de roue par fluotournage, la productivité est réduite comparativement à l'emboutissage, ce qui limite la fabrication en grandes séries.

Dans les deux techniques citées :

- L'utilisation d'huile d'emboutissage ou de lubrifiant est impératif et nécessite un dégraissage avant mise en peinture.
- Il faut stocker et traiter ces huiles ainsi que les effluents.

Du point de vue des caractéristiques recherchées :

- L'augmentation des caractéristiques mécaniques entraîne une diminution de la formabilité, ce qui limite la forme des voiles, et génère un retour élastique accru, pénalisant les garanties dimensionnelles.
- L'augmentation des caractéristiques mécaniques impose d'utiliser des presses de plus en plus puissantes.

- La protection temporaire contre la corrosion, avant peinture par exemple d'un voile embouti, nécessite d'huiler la pièce puis de la dégraisser. Il est également nécessaire de retirer l'huile d'emboutissage avant peinture, ce qui comporte un coût et un risque écologique.

Le but de l'invention est la réalisation d'une pièce par emboutissage à chaud, en une seule passe, en respectant les garanties dimensionnelles, tout en ayant la possibilité d'obtenir des formes complexes.

L'invention a pour objet l'obtention d'une pièce par un procédé de mise en forme à chaud et notamment l'obtention de tout ou partie d'une roue de véhicule automobile comme par exemple un voile de roue, caractérisée en ce qu'on utilise, dans une opération d'emboutissage à chaud, une tôle d'acier laminée à chaud pour traitement thermique, pré revêtue.

Les autres caractéristiques de l'invention sont :

- la tôle d'acier est une tôle d'acier laminée à chaud ou à froid pré revêtue de composition générale pondérale suivante :

0,15% < carbone < 0,5%
0,5% < manganèse < 3%
0,1% < silicium < 0,5%
0% < chrome < 1%
titane < 0,2%
aluminium < 0,1%
phosphore < 0,1%
soufre < 0,05%
0,0005% < bore < 0,08%

les autres caractéristiques de l'invention sont :

- le revêtement est à base d'aluminium,
- de préférence, la tôle d'acier est une tôle d'acier laminée à chaud ou à froid pré revêtue de la composition pondérale suivante :

0,15% < carbone < 0,5%
0,8% < manganèse < 1,5%
0,1% < silicium < 0,35%
0% < chrome < 1%
titane < 0,1%
aluminium < 0,1%

phosphore < 0,05%

soufre < 0,03%

0,0005% < bore < 0,01%

- dans la composition pondérale de la tôle, la teneur en titane par rapport à la teneur en azote est supérieure à 3,42,
- le bain métallique du revêtement comprend dans sa composition pondérale de base, de 9% à 10% de silicium, de 2% à 3,5% de fer, le reste du bain étant composé d'aluminium et des impuretés,
- le bain métallique du revêtement comprend dans sa composition pondérale de base de 2% à 4% de fer,
- le bain métallique du revêtement peut contenir dans sa composition pondérale de base, de 0 à 50% de zinc.

La description qui suit fera bien comprendre l'invention.

Le problème posé est de réaliser une pièce par un procédé de mise en forme à chaud et notamment l'obtention de tout ou partie d'une roue de véhicule automobile comme par exemple, un voile de roue de VL ou PL (voiture légère ou poids lourd) ou un voile de roue et une partie de la jante de roue, en une seule passe, en respectant les garanties dimensionnelles, tout en réalisant des formes complexes.

Il est connu de la demande de brevet FR N° 98 08793 une tôle d'acier à chaud et à froid revêtue et comportant une très haute résistance après traitement thermique. Il est également connu de la demande de brevet FR N° 98 16477 un procédé de réalisation d'une pièce à partir d'une bande de tôle d'acier laminée et notamment laminée à chaud.

Selon l'invention, une utilisation particulièrement importante d'une tôle et du procédé présentés a été démontrée, dans l'obtention d'une pièce par un procédé de mise en forme à chaud et, notamment, l'obtention de tout ou partie d'une roue de véhicule automobile, en une seule passe d'emboutissage à chaud, alors que les techniques utilisées à ce jour, demande des outillages nombreux, complexes, ainsi que des opérations nombreuses de mise en forme.

A l'encontre des habitudes industrielles connues, les inventeurs ont obtenu, en une seule passe, par emboutissage à chaud d'une tôle d'acier laminée à chaud pré revêtu, un voile de roue, qui antérieurement, était réalisé en 7 ou 8 opérations d'emboutissage, le plan de tôle prédécoupé ayant la composition pondérale générale suivante :

0,15% < carbone < 0,5%

0,5% < manganèses < 3%

0,1% < silicium < 0,5%

0,01% < chrome < 1%

titane < 0,2%

aluminium < 0,1%

phosphore < 0,1%

soufre < 0,05%

0,0005% < bore < 0,08%

L'utilisation d'un acier pour traitement thermique pré revêtu permet d'obtenir un gain notable en résistance à la fatigue sans poser de problème de soudage et en présentant une résistance accrue à la corrosion après peinture.

De plus, le procédé et l'acier utilisé permettent un allègement notable et une augmentation de la durée de vie en fatigue. Enfin, le voile obtenu peut être soudé puis peint sans modification des lignes existantes.

De préférence l'acier de la tôle a la composition pondérale suivante :

0,15% < carbone < 0,5%

0,8% < manganèses < 1,5%

0,1% < silicium < 0,35%

0,01% < chrome < 1%

titane < 0,1%

aluminium < 0,1%

phosphore < 0,05%

soufre < 0,03%

0,0005% < bore < 0,01%

la tôle assurant une très haute résistance mécanique après traitement thermique et le revêtement à base d'aluminium assurant une haute tenue à la corrosion et à la fatigue.

Pour l'obtention de la pièce, en une seule passe, par emboutissage à chaud de la tôle laminée à chaud revêtue, il est préférable que la teneur en titane par rapport à la teneur en azote soit supérieure à 3,42.

Le revêtement de la tôle laminée à chaud revêtue, à base d'aluminium, comprend dans sa composition pondérale de base, de 9% à 10% de silicium, de 2% à 3,5% de fer.

Le revêtement de la tôle laminée à chaud revêtue peut également comprendre dans sa composition pondérale de base, de 2% à 4% de fer. Le bain métallique peut contenir dans sa composition pondérale de base de 0 à 50% de zinc.

Dans un exemple de réalisation, l'acier selon l'invention contenant 0,231% de carbone ; 1,145% de manganèse ; 0,020% de phosphore ; 0,0038% de soufre ; 0,239% de silicium ; 0,043% d'aluminium ; 0,009% de cuivre ; 0,020% de nickel ; 0,179% de chrome ; 0.0042% d'azote ; 0.032% de titane ; 0,0028% de bore ; 0,0051% de calcium, sous la forme d'une tôle est revêtue d'une couche à base d'aluminium ayant environ 25 µm d'épaisseur avant traitement thermique.

Le flan de tôle est chauffé dans un four, à une température comprise entre 750°C et 1000°C et plus généralement à une température comprise entre 850°C et 950°C pendant un temps variant en fonction de l'épaisseur. Pour une épaisseur de 2 mm, le flan de tôle séjourne pendant 6 minutes dans le four. La vitesse de montée en température est supérieure à 3°C/s. Du fait du revêtement, il n'est pas nécessaire d'utiliser un four à atmosphère inerte.

Lors du réchauffage du flan de tôle, le revêtement s'allie avec le substrat pour former un alliage intermétallique. L'alliation entraîne, par inter diffusion, une augmentation de l'épaisseur de la couche qui, pour le traitement ci-dessus spécifié, correspond généralement à une augmentation de 50%.

Le flan de tôle chaud est ensuite transféré dans l'outil refroidi ou non, en fonction de la cadence, de l'épaisseur de la tôle et de la vitesse de refroidissement visée, pour être mis en forme. Il ne doit pas y avoir de pression de serre flan afin d'éviter le déchirement de la tôle dû à sa faible résistance à haute température. La vitesse de déformation doit être suffisante pour éviter de déformer l'acier à une température inférieure à 400°C.

Le voile de roue ainsi obtenu est maintenu dans l'outil jusqu'à atteindre une température inférieure à 200°C et de préférence inférieure à 100°C afin de respecter les garanties de dimension. La vitesse de refroidissement moyenne doit être supérieure a 27°C/s, entre la température de sortie du four et 400°C, si la structure visée pour le substrat est une structure martensitique. Si la vitesse moyenne de refroidissement est inférieure à cette valeur, de la bainite, de la ferrite, voire de la perlite peuvent apparaître. Il est ainsi possible d'obtenir différentes structures et donc différentes propriétés en fonction de la vitesse de refroidissement visée. Néanmoins, les meilleurs

résultats en fatigue sont obtenus avec une structure de l'acier, totalement martensitique.

Du fait du formage à chaud, il n'y a pas d'endommagement de la structure métallurgique. Ceci a un effet bénéfique sur la tenue en fatigue du fait de la suppression des défauts internes pouvant servir d'initiation des fissures en fatigue. Il n'est pas nécessaire d'ajouter de lubrifiant d'emboutissage car le pré revêtement fait office de lubrifiant.

La pièce ainsi obtenue peut subir directement le cycle de peinture. Si ce n'est pas le cas, il n'est pas nécessaire d'appliquer une protection temporaire contre la corrosion car la couche alliée ralentit l'apparition de la corrosion. Lors du cycle thermique, le revêtement, alliée ou non, protège l'acier de l'oxydation et de la décarburation.

La couche alliée réalisée sur la pièce présente un gradient de dureté. En partant de la couche extrême et en se déplaçant vers la tôle, la dureté varie de 750HV0,1 à 300 HV0,1 à l'interface couche de revêtement - tôle, puis augmente jusqu'à environ 500HV0,1 dans la tôle, lorsque la structure de l'acier est totalement martensitique. C'est la couche à 300HV0,1 qui, en arrêtant les fissures, confère à la pièce une tenue en fatigue accrue.

Si on utilise l'acier de la solution proposée mais non pré revêtu, on note une dégradation importante de limite d'endurance moyenne, comme matérialisé sur le tableau 1 ci-dessous liée principalement à la décarburation de l'acier. La solution proposée, de part la présence de la pré protection, évite ce phénomène. Les essais de fatigue en flexion plane alternée montre un gain notable.

Tableau 1.

Acier	Rp0.2 (MPa) Travers	Rm (MPa) Travers	Nombre de cycles de validation de la limitation de la limite d'endurance (millions de cycles)	Limite d'endurance Moyenne (MPa)
USIDUR 355 exemple de comparaison	432	514	1. 106	279
USIFORM 800 exemple de comparaison	766	872	2. 106	388
Obtention selon l'invention, non pré revêtue	980	1490	2. 106	249
Obtention selon l'invention	980	1480	2. 106	439

Par rapport à la tôle USIDUR 355, couramment utilisé industriellement pour la réalisation des voiles de roues, le gain est de 40% en durée de vie ou en allègement. Par rapport à la nuance citée, utilisée pour les voiles de roues, la limite d'endurance présente un gain supérieur à 12%.

Les avantages de l'obtention d'une pièce par un procédé de mise en forme à chaud et notamment l'obtention de tout ou partie d'une roue de véhicule automobile sont les suivants :

- une réalisation de voile de roue en une seule passe de formage,
- du fait de la formabilité importante à chaud, un seul outil est nécessaire. il est donc possible de faire des pièces de formes complexes en série de manière économique telles que les roues de style,
- une très bonne garantie dimensionnelle car il n'y a pas de retour élastique comme dans le cas de l'emboutissage à froid ou du fluotournage,
- les caractéristiques mécaniques élevées après trempe dans l'outil d'emboutissage permettent un allègement significatif,
- le pré revêtement assure une garantie accrue à la corrosion et à l'usure,
- une formabilité accrue lors de la chauffe du flan de tôle permet de former à chaud des épaisseurs ne pouvant habituellement être mise en forme que par fluotournage,
- une déformation peut avoir lieu dans la phase austénitique à chaud, sans endommagement, ce qui garantie une meilleure tenue à la fatigue par élimination des défauts internes généralement créés lors d'une déformation à froid,
- du fait du pré revêtement, il est inutile de lubrifier la tôle lors du formage à chaud, supprimant ainsi l'étape de dégraissage avant peinture,
- grâce au revêtement, il est inutile d'appliquer une protection temporaire contre la corrosion sur les pièces en attente de peinture,
- le pré revêtement non traité thermiquement, contrairement aux revêtements à base de zinc, ne dégrade pas la tenue à la fatigue et même l'augmente,
- le comportement aux chocs est renforcé par l'utilisation du type d'acier choisi,
- le pré revêtement traité thermiquement ne nécessite pas de matériel de soudage et de précaution particuliers.

D'autres pièces peuvent bénéficier de cette méthode d'obtention. On peut citer en particulier les pièces de liaison au sol dimensionnées en fatigue telles que : les bras de suspension, bras de roue...

REVENDICATIONS.

1. Procédé de mise en forme à chaud et notamment, obtention de tout ou partie d'une roue de véhicule automobile comme par exemple un voile de roue, caractérisé en ce qu'on utilise, dans une opération d'emboutissage à chaud, une tôle d'acier laminée à chaud ou à froid pour traitement thermique pré revêtu.

2. Procédé selon la revendication 1, caractérisé en ce que la tôle d'acier est une tôle d'acier laminée à chaud pré revêtu de la composition générale pondérale suivante :

0,15% < carbone < 0,5%
0,5% < manganèse < 3%
0,1% < silicium < 0,5%
0% < chrome < 1%
titane < 0,2%
aluminium < 0,1%
phosphore < 0,1%
soufre < 0,05%
0,0005% < bore < 0,08%

3. Procédé selon la revendication 1, caractérisé en ce que le revêtement est à base d'aluminium.

4. Procédé selon la revendication 1, caractérisé en ce que de préférence, la tôle d'acier est une tôle d'acier laminée à chaud ou à froid pré revêtue de la composition pondérale suivante :

0,15% < carbone < 0,5%
0,8% < manganèse < 1,5%
0,1% < silicium < 0,35%
0,01% < chrome < 1%
titane < 0,1%
aluminium < 0,1%
phosphore < 0,05%
soufre < 0,03%
0,0005% < bore < 0,01%

5. Procédé selon la revendication 1, caractérisé en ce que dans la composition pondérale de la tôle, la teneur en titane par rapport à la teneur en azote est supérieure à 3,42.

6. Procédé selon la revendication 1, caractérisé en ce que le bain métallique du revêtement comprend dans sa composition pondérale de base, de 9% à 10% de silicium, de 2% à 3,5% de fer, le reste du bain étant composé d'aluminium et des impuretés.

7. Procédé selon la revendication 1, caractérisé en ce que le bain métallique du revêtement comprend dans sa composition pondérale de base, de 2% à 4% de fer.

8. Procédé selon la revendication 1, caractérisé en ce que le bain métallique du revêtement peut contenir dans sa composition pondérale de base, de 0 à 50% de zinc.

RÉPUBLIQUE FRANÇAISE

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FA 611824
FR 0116185

RAPPORT DE RECHERCHE PRÉLIMINAIRE

établi sur la base des dernières revendications déposées avant le commencement de la recherche

DOCUMENTS CONSIDÉRÉS COMME PERTINENTS		Revendication(s) concernée(s)	Classement attribué à l'invention par l'INPI
Catégorie	Citation du document avec indication, en cas de besoin, des parties pertinentes		
D,X	FR 2 780 984 A (LORRAINE LAMINAGE) 14 janvier 2000 (2000-01-14) * le document en entier *	1-8	B21D53/26 C21D8/02 C22C38/32 C22C38/38
D,X	FR 2 787 735 A (LORRAINE LAMINAGE) 30 juin 2000 (2000-06-30) * le document en entier *	1	
A	US 4 397 345 A (RAMARATNAM KRISHNASWAMY ET AL) 9 août 1983 (1983-08-09)		
			DOMAINES TECHNIQUES RECHERCHÉS (Int.CL.7)
			B21D

1

Date d'achèvement de la recherche	Examinateur
14 août 2002	Peeters, L

CATÉGORIE DES DOCUMENTS CITÉS

X : particulièrement pertinent à lui seul
Y : particulièrement pertinent en combinaison avec un autre document de la même catégorie
A : arrière-plan technologique
O : divulgation non-écrite
P : document intercalaire

T : théorie ou principe à la base de l'invention
E : document de brevet bénéficiant d'une date antérieure à la date de dépôt et qui n'a été publié qu'à cette date de dépôt ou qu'à une date postérieure.
D : cité dans la demande
L : cité pour d'autres raisons

& : membre de la même famille, document correspondant

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2833504

ANNEXE AU RAPPORT DE RECHERCHE PRÉLIMINAIRE RELATIF A LA DEMANDE DE BREVET FRANÇAIS NO. FR 0116185 FA 611824

La présente annexe indique les membres de la famille de brevets relatifs aux documents brevets cités dans le rapport de recherche préliminaire visé ci-dessus.
Les dits membres sont contenus au fichier informatique de l'Office européen des brevets à la date du 14-08-2002
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Document brevet cité au rapport de recherche	Date de publication	Membre(s) de la famille de brevet(s)	Date de publication
FR 2780984 A	14-01-2000	FR 2780984 A1	14-01-2000
		BR 9902712 A	08-03-2000
		EP 0971044 A1	12-01-2000
		JP 2000038640 A	08-02-2000
		US 6296805 B1	02-10-2001
FR 2787735 A	30-06-2000	FR 2787735 A1	30-06-2000
		EP 1013785 A1	28-06-2000
US 4397345 A	09-08-1983	AUCUN	

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Pour tout renseignement concernant cette annexe : voir Journal Officiel de l'Office européen des brevets, No.12/82

Espacenet

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Process for manufacturing of a part from a hot-rolled sheet

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- cooperative: **C21D1/673**; **C21D9/48**; **C23C2/12**; **C23C2/26**; **C23C2/28**

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Abstract of EP1013785 (A1)

A component is produced from a strip of rolled (especially hot-rolled) sheet steel, by coating with aluminum or its alloy and pressing operations. The process involves: (a) coating the rolled sheet with a metal or an alloy assuring protection of the surface and the steel; (b) raising the temperature of the coated sheet for forming; (c) producing, at the surface, an intermetallic alloy composite assuring protection against corrosion and decarburation of the steel, with the intermetallic composite able to assure a lubrication function; (d) forming the coated sheet, notably by pressing; (e) cooling the formed component in order to confer increased hardness of the steel and increased surface hardness in the coating. The metal used for coating the steel sheet is aluminum or an aluminum alloy, so that the intermetallic alloy composite is made up of aluminum, iron and silicon.

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DESCRIPTION EP1013785

[0001]
The invention relates to a method of producing a part from a strip of rolled steel sheet and in particular hot rolled.

[0002]

Steel sheets to be subjected to high temperature forming and / or heat treatment are not delivered coated for coating considerations during heat treatment. The coating is therefore performed on finished part which requires a careful cleaning of surfaces and hollow parts. This cleaning requires the use of acids and / or bases whose recycling and storage are a significant financial burden and present risks for operators and the environment. In addition, the heat treatment must be carried out under a controlled atmosphere in order to avoid decarburization and oxidation of the steel. Then, in the case of hot forming, calamine, by virtue of its abrasive power, damages the forming tools, which reduces the quality of the parts obtained from the dimensional and aesthetic point of view, or forces frequent and expensive tool repairs. Finally, to increase their resistance to corrosion, the parts thus obtained must receive an expensive post-processing whose application is difficult or impossible, especially in the case of parts with depressions.

[0003]
The object of the invention is to propose sheet steel rolled from 0.2 mm to about 20 mm thick, coated in particular after hot rolling, and to be shaped, either hot or cold followed by a heat treatment, the temperature rise to be ensured without decarburization of the steel of the sheet,

without oxidation of the surface of said sheet, before, during and after hot forming and or heat treatment .

[0004]
The subject of the invention is a process for producing a part from a strip of rolled steel sheet, in particular hot rolled, which is characterized in that: the sheet metal coated with a metal or a metal alloy providing a protection of the surface and steel, the coated sheet is subjected to a temperature rise for its shaping, thereby producing an intermetallic alloy compound, on the surface, providing protection against the corrosion, against the decarburization of the steel, the intermetallic compound being able to provide a lubricating function, the shaping is carried out in particular by stamping, the formed part is cooled to impart high mechanical hardness characteristics of the steel and a high surface hardness of the coating.

[0005]
The other characteristics of the invention are: the hot rolled sheet is coated after hot rolling and pickling, the metal or the metal coating alloy is aluminum or an aluminum alloy. the intermetallic alloy is a compound based mainly on aluminum, iron and silicon, the coating of metal or metal alloy and carried out by hot dipping. the coated sheet is subjected to a temperature rise above 700 ° C before shaping and or heat treatment, the coated sheet is hot stamped. the piece obtained in particular by stamping is cooled to undergo quenching at a speed greater than the critical quenching speed.

[0006]
The invention also relates to a hot-rolled sheet including a surface-deposited metal or metal alloy coating, for hot-forming an intermetallic compound, the intermetallic compound providing, a protection against corrosion, a barrier against the decarburization of the steel of the sheet, a lubrication during the hot shaping of the sheet, and on the finished part, after shaping and cooling, the mechanical properties of hardness of the high steel as well as a high surface hardness of the surface of said finished part.

[0007]
Another feature of the invention is: the sheet has a surface deposit of aluminum or an aluminum alloy.

[0008]

The invention also relates to the use of the sheet in the hot forming, in particular by stamping parts with high mechanical properties in hardness and high surface hardness characteristics ensuring very good resistance to abrasion.

The following description will make the invention clear.

[0009]

The process according to the invention consists in coating a steel, especially a hot-rolled steel, for heat treatment and hot forming, with a metal or a metal alloy such as aluminum or an aluminum alloy composed, for example, of aluminum and silicon.

The metal or metal alloy coating is selected to have corrosion protection and to withstand a high temperature.

During a heat treatment, or a temperature rise for forming, the coating forms an alloy layer having a high resistance to corrosion, abrasion, wear and fatigue.

The coating does not alter the formability properties of the steel and thus allows a wide variety of cold and hot forming.

[0010]

After hot rolling the strip can be pickled and cold rolled before being coated.

In the case where the sheet is cold rolled, it can be annealed before being coated.

[0011]

The laminated sheet can be coated with, for example, the following two types of metal alloy: Alloy No. 1: Si: 9% to 10%; Fe: 2% to 3.5%; Balance: Al and impurities. Alloy No. 2: Fe: 2% to 4%; Balance: Al and impurities. For alloy No. 1 the coating thickness is between 5 microns and 100 microns, and preferably between 10 microns and 25 microns. For alloy No. 2 the coating thickness is between 15 microns and 100 microns, and preferably between 30 microns and 50 microns.

[0012]

For shaping or heat treatment, the sheet is subjected to a temperature rise preferably between 750 ° C and 1200 ° C in an oven with an atmosphere no longer requiring control because of the barrier to oxidation formed by the coating. When raising the temperature, the aluminum-based coating is transformed into an alloyed surface layer having different phases depending on the temperature treatment and having a high hardness of more than 600 HV 100g.

[0013]
According to the process of the invention, it is possible to produce sheets having a thickness of between 0.2 mm and 20 mm, having good shaping properties as well as good resistance to corrosion.

[0014]
The sheets delivered coated, have a significant resistance to corrosion during temperature rises, shaping, heat treatments, and during the use of finished formed parts.

[0015]

The presence of the coating during heat treatments or hot forming avoids in addition to corrosion, the decarburization of the base steel.

This has an undeniable advantage in the case of hot forming, for example in a stamping press.

Indeed, the formed intermetallic alloy avoids the formation of calamine, the wear of the tools by calamine, and thereby allows an extension of the average life of said tools. It has been noticed that the hot formed intermetallic alloy has a high temperature lubricant function. In addition, the

effect of protection against decarburization of the intermetallic alloy allows the use of high temperature furnace exceeding 900 ° C having an uncontrolled atmosphere, and this, even for heating times of several hours.

[0016]
Out of the oven, it is no longer necessary to strip the piece obtained, resulting in a saving due to the removal of the pickling bath of finished parts.

[0017]

Due to the characteristics of the coating after temperature rise, the resulting pieces have increased resistance to fatigue, wear, abrasion and corrosion.

In addition, the coating is weldable before and after temperature rise.

[0018]
The steel of the sheet ensures, by cooling quenching effect, high mechanical characteristics of the part obtained after forming, the coating converted into a hot intermetallic alloy, for its part, because of its lubricant qualities and resistance to friction, improved shaping, especially in the field of hot stamping.

[0019]

In one exemplary embodiment, a strip of hot-rolled steel sheet with the following weight composition is used: carbon: 0.15% to 0.25%, manganese: 0.8% to 1.5%, silicon: 0, 1% to 0.35%, chromium: 0.01% to 0.2%, titanium: less than 0.1%, aluminum: less than 0.1%, phosphorus: less than 0.05%, sulfur: less of 0.03%, boron: 0.0005% to 0.01%, the sheet metal strip is coated with a coating of alloy type No. 1 or 2, the sheet is austenitized at 950 ° C. before forming and quenched in the tool, the coating providing a role of lubricant during shaping, in addition to its protection functions against cold corrosion, hot and against decarburization.

During quenching, the alloy coating does not interfere with the extraction of heat by the tool and can promote it. After forming and quenching, it is no longer necessary to strip the part or to protect

it, the base coating providing protection throughout the process.

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CLAIMS EP1013785

1.
Process for producing a workpiece from a strip of rolled steel sheet, in particular hot-rolled steel sheet, characterized in that: - the rolled metal sheet is coated with a metal or a metal alloy providing protection against the surface and steel, - the coated sheet is subjected to an elevation in temperature for its shaping, - is thus realized an intermetallic alloy compound, surface, providing protection against corrosion, against decarburization of steel, the intermetallic compound being able to provide a lubricating function, the forming is carried out in particular by stamping, the part formed is cooled to give high mechanical hardness characteristics of the steel and a high surface hardness of coating.

2.
Process according to Claim 1, characterized in that the hot-rolled sheet is coated immediately after hot rolling,

3.
Process according to claim 1 characterized in that the metal or metal coating alloy is aluminum or an aluminum alloy.

4.
Process according to Claim 1, characterized in that the intermetallic alloy is a compound based on aluminum, iron and silicon.

5.
Process according to Claim 1, characterized in that the coating of metal or metal alloy is carried out under hot dipping.

6.
A method according to claim 1 characterized in that the coated sheet is subjected to a temperature rise above 700 ° C before shaping and / or heat treatment.

7.
Process according to Claim 1, characterized in that the coated sheet is hot-drawn.

8.
Process according to Claim 1, characterized in that the part obtained, in particular by stamping, is cooled to undergo quenching at a speed greater than the critical quenching speed.

9.
Rolled sheet, especially when hot, comprising a surface-deposited metal or metal alloy coating for hot-forming an intermetallic compound, the intermetallic compound providing, a protection against corrosion, a barrier against the decarburization of steel of sheet metal, lubrication during the hot shaping of the sheet, and on the finished part, after shaping and cooling, the high mechanical hardness characteristics of the steel and a high surface hardness of the surface of said finished part.

10.
Hot-rolled sheet according to claim 9, characterized in that it comprises a surface deposit of aluminum or an aluminum alloy.

11.
Use of the sheet according to claims 9 or 10 in the hot forming, in particular by stamping parts with high mechanical properties in hardness and high surface hardness characteristics ensuring a very good resistance to abrasion.

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(54) Procédé de réalisation d'une pièce à partir d'une bande de tôle d'acier laminée et notamment laminée à chaud

(57) Procédé de réalisation d'une pièce à partir d'une bande de tôle d'acier laminée et notamment laminée à chaud, caractérisée en ce que:

- on revêt la tôle laminée d'un métal ou d'un alliage métallique assurant une protection de la surface et de l'acier,
- on soumet la tôle revêtue à une élévation en température pour sa mise en forme,
- on réalise, de ce fait un composé allié intermétallique, en surface, assurant une protection contre la corrosion, contre la décarburation de l'acier, le composé intermétallique pouvant assurer une fonction de lubrification,
- on effectue la mise en forme notamment par emboutissage,
- on refroidit la pièce formée pour conférer des caractéristiques mécaniques de dureté élevées de l'acier et une dureté superficielle élevée du revêtement.

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Description

[0001] L'invention concerne un procédé de réalisation d'une pièce à partir d'une bande de tôle d'acier laminée et notamment laminée à chaud.

[0002] Les tôles en acier devant subir un formage à haute température et ou un traitement thermique ne sont pas livrées revêtues pour des considérations de tenue du revêtement lors du traitement thermique. Le revêtement est donc effectué sur pièce finie ce qui nécessite un nettoyage soigné des surfaces et des parties creuses. Ce nettoyage requiert l'utilisation d'acides et ou de bases dont le recyclage et le stockage sont une charge financière importante et présentent des risques pour les opérateurs et pour l'environnement. De plus, le traitement thermique doit être effectué sous atmosphère contrôlée afin d'éviter toute décarburation et oxydation de l'acier. Ensuite, dans le cas du formage à chaud, la calamine, de par son pouvoir abrasif, endommage les outils de mise en forme, ce qui diminue la qualité des pièces obtenues du point de vue dimensionnel et esthétique, ou oblige à de fréquentes et coûteuses réparations d'outils. Enfin, pour augmenter leur résistance à la corrosion, les pièces ainsi obtenues doivent recevoir un post traitement coûteux dont l'application est difficile, voire impossible, en particulier dans le cas de pièces comportant des creux.

[0003] Le but de l'invention est de proposer des tôles d'acier laminées de 0,2 mm à environ 20 mm d'épaisseur, revêtues notamment après laminage à chaud, et devant subir une mise en forme, soit à chaud, soit à froid suivie d'un traitement thermique, l'élévation de température devant être assurée sans décarburation de l'acier de la tôle, sans oxydation de la surface de ladite tôle, avant, pendant et après la mise en forme à chaud et ou le traitement thermique.

[0004] L'invention a pour objet un procédé de réalisation d'une pièce à partir d'une bande de tôle d'acier laminée et notamment laminée à chaud et qui se caractérise en ce que:

- on revêt la tôle laminée d'un métal ou d'un alliage métallique assurant une protection de la surface et de l'acier,
- on soumet la tôle revêtue à une élévation en température pour sa mise en forme,
- on réalise, de ce fait un composé allié intermétallique, en surface, assurant une protection contre la corrosion, contre la décarburation de l'acier, le composé intermétallique pouvant assurer une fonction de lubrification,
- on effectue la mise en forme notamment par emboutissage,
- on refroidit la pièce formée pour conférer des caractéristiques mécaniques de dureté élevées de l'acier et une dureté superficielle élevée du revêtement.

[0005] Les autres caractéristiques de l'invention sont:

- on revêt la tôle laminée à chaud après laminage à chaud et décapage,
- le métal ou l'alliage métallique de revêtement est de l'aluminium ou un alliage d'aluminium.
- l'alliage intermétallique est un composé à base principalement d'aluminium, de fer et de silicium,
- le revêtement de métal ou d'alliage métallique et effectué au trempé à chaud.
- la tôle revêtue est soumise à une élévation de température supérieure à 700°C avant la mise en forme et ou le traitement thermique,
- la tôle revêtue est emboutie à chaud.
- la pièce obtenue notamment par emboutissage est refroidie pour subir une trempe, à une vitesse supérieure à la vitesse critique de trempe.

[0006] L'invention concerne également une tôle laminée notamment à chaud comportant un revêtement de métal ou d'alliage métallique déposé en surface, pour la réalisation à chaud d'un composé intermétallique, le composé intermétallique assurant, une protection contre la corrosion, une barrière contre la décarburation de l'acier de la tôle, une lubrification lors de la mise en forme à chaud de la tôle, et sur la pièce finie, après mise en forme et refroidissement, des caractéristiques mécaniques de dureté de l'acier élevées ainsi qu'une dureté superficielle élevée de la surface de ladite pièce finie.

[0007] Une autre caractéristique de l'invention est:

- la tôle comporte un dépôt en surface d'aluminium ou d'un alliage d'aluminium.

[0008] L'invention concerne encore l'utilisation de la tôle dans la mise en forme à chaud notamment par emboutissage de pièces de hautes caractéristiques mécaniques en dureté et de hautes caractéristiques de dureté en surface assurant une très bonne tenue à l'abrasion. La description qui suit fera bien comprendre l'invention.

[0009] Le procédé selon l'invention consiste à revêtir un acier notamment laminé à chaud, pour traitement thermique et ou formage à chaud, avec un métal ou un alliage métallique tels que de l'aluminium ou un alliage d'aluminium composé par exemple d'aluminium et de silicium. Le revêtement de métal ou d'alliage métallique est choisi de manière à avoir une protection contre la corrosion et de manière à résister à une haute température. Lors d'un traitement thermique, ou d'une élévation de température pour la mise en forme, le revêtement forme une couche alliée présentant une grande résistance à la corrosion, à l'abrasion, à l'usure et à la fatigue. Le revêtement ne modifie pas les propriétés de formabilité de l'acier et autorise ainsi une grande variété de mise en forme à froid et à chaud.

[0010] Après laminage à chaud la bande peut être décapée et laminée à froid avant d'être revêtue. Dans le

cas ou la tôle est laminée à froid, celle ci peut être recuite avant d'être revêtue.

[0011] On peut revêtir la tôle laminée avec, par exemple, les deux types d'alliage métallique suivants:

Alliage N°1: Si: 9% à 10%; Fe: 2% à 3,5%; Solde: Al et des impuretés.
Alliage N°2: Fe: 2% à 4%; Solde: Al et des impuretés.

Pour l'alliage N°1 l'épaisseur du revêtement est compris entre 5 µm et 100 µm, et de préférence entre 10 µm et 25 µm. Pour l'alliage N°2 l'épaisseur du revêtement est compris entre 15 µm et 100 µm, et de préférence entre 30 µm et 50 µm.

[0012] Pour la mise en forme ou le traitement thermique, la tôle est soumise à une élévation de température comprise de préférence entre 750°C et 1200°C dans un four comportant une atmosphère ne nécessitant plus de contrôle du fait de la barrière à l'oxydation formée par le revêtement. Lors de l'élévation de la température, le revêtement à base d'aluminium se transforme en une couche alliée en surface comportant différentes phases dépendant du traitement en température et présentant une grande dureté pouvant dépasser 600 HV 100g.

[0013] Selon le procédé de l'invention, on peut produire des tôles dont l'épaisseur est comprise entre 0,2 mm et 20 mm, ayant de bonnes propriétés de mise en forme ainsi qu'une bonne résistance à la corrosion.

[0014] Les tôles livrées revêtues, présentent une résistance importante à la corrosion pendant les élévations de température, la mise en forme, les traitements thermiques, et lors de l'utilisation des pièces formées finies.

[0015] La présence du revêtement lors de traitements thermiques ou de formages à chaud permet d'éviter en plus de la corrosion, la décarburation de l'acier de base. Cela à un avantage indéniable dans le cas d'une mise en forme à chaud par exemple dans une presse d'emboutissage. En effet, l'alliage intermétallique formé évite, la formation de la calamine, l'usure des outils par la calamine, et permet de ce fait, un allongement de la vie moyenne desdits outils. Il a été remarqué que l'alliage intermétallique formé à chaud, a une fonction de lubrifiant à haute température. De plus, l'effet de protection contre la décarburation de l'alliage intermétallique permet l'usage de four haute température dépassant 900°C ayant une atmosphère non contrôlée, et cela, même pour des temps de chauffe de plusieurs heures.

[0016] En sortie de four, il n'est plus nécessaire de décaper la pièce obtenue, d'où une économie du fait de la suppression du bain de décapage des pièces finies.

[0017] De par les caractéristiques du revêtement après élévation de température, les pièces obtenues ont une résistance accrue à la fatigue, à l'usure, à l'abrasion et à la corrosion. De plus, le revêtement est soudable avant et après élévation de température.

[0018] L'acier de la tôle assure, par effet de trempe au refroidissement, des caractéristiques mécaniques élevées de la pièce obtenue après mise en forme, le revêtement transformé en un alliage intermétallique à chaud assurant pour sa part, du fait de ses qualités de lubrifiant et de résistance aux frottement, une amélioration de la mise en forme, notamment, dans le domaine de l'emboutissage à chaud.

[0019] Dans un exemple de réalisation, on utilise une bande de tôle laminée à chaud en acier de composition pondérale suivante:

carbone: 0,15% à 0,25%,
manganèse: 0,8% à 1,5%,
silicium: 0,1% à 0,35%,
chrome: 0,01 % à 0,2%,
titane: moins de 0,1%,
aluminium: moins de 0,1 %,
phosphore: moins de 0,05%,
soufre: moins de 0,03%,
bore : 0,0005% à 0,01%,

on revêt la bande de tôle d'un revêtement de type alliage N°1 ou 2, on austénitise la tôle à 950°C avant formage et trempe dans l'outil, le revêtement assurant un rôle de lubrifiant lors de la mise en forme, en plus de ses fonctions de protection contre la corrosion à froid, à chaud et contre la décarburation. Lors de la trempe, le revêtement allié ne gène pas l'extraction de la chaleur par l'outil et peut la favoriser. Après formage et trempe, il n'est plus nécessaire de décaper la pièce ou de la protéger, le revêtement de base assurant la protection tout au long du procédé.

Revendications

1. Procédé de réalisation d'une pièce à partir d'une bande de tôle d'acier laminée et notamment laminée à chaud, caractérisée en ce que:

   - on revêt la tôle laminée d'un métal ou d'un alliage métallique assurant une protection de la surface et de l'acier,
   - on soumet la tôle revêtue à une élévation en température pour sa mise en forme,
   - on réalise, de ce fait un composé allié intermétallique, en surface, assurant une protection contre la corrosion, contre la décarburation de l'acier, le composé intermétallique pouvant assurer une fonction de lubrification,
   - on effectue la mise en forme notamment par emboutissage,
   - on refroidit la pièce formée pour conférer des caractéristiques mécaniques de dureté élevées de l'acier et une dureté superficielle élevée du revêtement.

2. Procédé selon la revendication 1 caractérisé en ce

que on revêt le tôle laminée à chaud immédiatement après laminage à chaud,

3. Procédé selon la revendication 1 caractérisé en ce que le métal ou l'alliage métallique de revêtement est de l'aluminium ou un alliage d'aluminium.

4. Procédé selon la revendication 1 caractérisé en ce que l'alliage intermétallique est un composé à base d'aluminium, de fer et de silicium.

5. Procédé selon la revendication 1 caractérisé en ce que le revêtement de métal ou d'alliage métallique et effectué au trempé à chaud.

6. Procédé selon la revendication 1 caractérisé en ce que la tôle revêtue est soumise à une élévation de température supérieure à 700°C avant la mise en forme et ou le traitement thermique.

7. Procédé selon la revendication 1 caractérisé en ce que la tôle revêtue est emboutie à chaud.

8. Procédé selon la revendication 1 caractérisé en ce que la pièce obtenue notamment par emboutissage est refroidie pour subir une trempe, à une vitesse supérieure à la vitesse critique de trempe.

9. Tôle laminée notamment à chaud comportant un revêtement de métal ou d'alliage métallique déposé en surface, pour la réalisation à chaud d'un composé intermétallique, le composé intermétallique assurant, une protection contre la corrosion, une barrière contre la décarburation de l'acier de la tôle, une lubrification lors de la mise en forme à chaud de la tôle, et sur la pièce finie, après mise en forme et refroidissement, des caractéristiques mécaniques de dureté de l'acier élevées ainsi qu'une dureté superficielle élevée de la surface de ladite pièce finie.

10. Tôle laminée à chaud selon la revendication 9 caractérisée en ce qu'elle comporte un dépôt en surface d'aluminium ou d'un alliage d'aluminium.

11. Utilisation de la tôle selon les revendications 9 ou 10 dans la mise en forme à chaud notamment par emboutissage de pièces de hautes caractéristiques mécaniques en dureté et de hautes caractéristiques de dureté en surface assurant une très bonne tenue à l'abrasion.

Office européen des brevets

RAPPORT DE RECHERCHE EUROPEENNE

Numéro de la demande
EP 99 40 3227

DOCUMENTS CONSIDERES COMME PERTINENTS

Catégorie	Citation du document avec indication, en cas de besoin, des parties pertinentes	Revendication concernée	CLASSEMENT DE LA DEMANDE (Int.Cl.7)
X A	FR 1 297 906 A (BEAUJEU-DUMONTEL G.) 23 novembre 1962 (1962-11-23) * page 1, colonne 1, alinéa 1 - colonne 2, alinéa 1 * * page 1, colonne 2, alinéa 7 - page 2, colonne 1, alinéa 10 * * page 2, colonne 2, alinéa 9 - page 3, colonne 2, alinéa 4 * * page 3, colonne 2, alinéa 10 * * revendications A.1-A.4,B; figure * ---	9-11 1,3-7	C23C2/12 C23C2/40 C23C2/26
A	DE 12 52 034 B (SOCIÉTÉ DES ACIÉRIES DE POMPEY) 12 novembre 1967 (1967-11-12) * le document en entier * ---	1,3-11	
A	GIEREK A. E.A.: "Tauchalitieren - Eigenschaften und Einsatzgebiete" V.D.I. ZEITSCHRIFT, vol. 118, no. 8, avril 1976 (1976-04), pages 19-22, XP002114744 * page 19 * * page 21, colonne 2, alinéa 2 * ---	1-11	DOMAINES TECHNIQUES RECHERCHES (Int.Cl.7) C23C B21D
A	DATABASE WPI Week 9046 Derwent Publications Ltd., London, GB; AN 347101 XP002114745 "Aluminised steel strip production process - involves cooling and hot rolling under compression to improve adhesion of covering to base" & SU 331 284 A (FRUNZE POLY), 9 janvier 1991 (1991-01-09) * abrégé * --- -/--	1-11	

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CATEGORIE DES DOCUMENTS CITES

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A	US 4 655 852 A (RALLIS ANTHONY T) 7 avril 1987 (1987-04-07) * le document en entier *	1-11	
A	CH 382 512 A (FELTEN & GUILLEAUME CARLSWREK EISEN UND STAHL A.G.) 30 novembre 1964 (1964-11-30) * le document en entier *	1-11	
			DOMAINES TECHNIQUES RECHERCHES (Int.Cl.7)

Le présent rapport a été établi pour toutes les revendications

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ANNEXE AU RAPPORT DE RECHERCHE EUROPEENNE RELATIF A LA DEMANDE DE BREVET EUROPEEN NO. EP 99 40 3227

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Document brevet cité au rapport de recherche		Date de publication	Membre(s) de la famille de brevet(s)	Date de publication
FR 1297906	A	23-11-1962	AUCUN	
DE 1252034	B		AUCUN	
SU 331284	A		AUCUN	
US 4655852	A	07-04-1987	AUCUN	
CH 382512	A		AUCUN	

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(54) **Title**: METHOD OF HOT FORMING A STEEL BLANK AND THE HOT FORMED PART

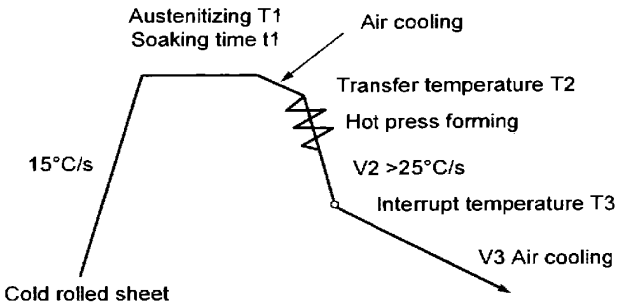

Fig. 1

(57) **Abstract**: According to a first aspect the present invention provides a method of hot forming a steel blank into an article the method comprising the following steps: d) cooling a heated steel blank to form an article during hot forming, starting at a starting temperature T2 above Ar3; to an interrupt temperature T3 in the range of 400 - 550 °C at a cooling rate V2 of at least 25 °C/s; e) immediately further cooling the article from the interrupt temperature T3 to ambient temperature at a cooling rate V3 of 0.2 - 10 °C/s, wherein the interrupt temperature T3 and cooling rate V3 are selected such that the article thus obtained has multiphase microstructure comprising by volume fraction: 55 - 90% of bainitic ferrite 5 - 15% of retained austenite 5 - 30% martensite.

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METHOD OF HOT FORMING A STEEL BLANK AND THE HOT FORMED PART

The invention relates to a method of hot forming a steel blank into a hot formed article having very high mechanical properties, such as an automotive part, to an article thus hot formed and to a steel strip, sheet or blank for use in a thermomechanical treatment process, in particular for use in a hot forming method according to the invention.

Recent progress in developing advanced high strength steels (AHSS) enables automotive manufacturers to increase vehicle's safety and crashworthiness of automotive parts and to reduce the weight of car bodies. Despite AHSS's high strength and light weight, inferior formability, poor ductility and toughness, compared to conventional steels, have become major hurdles for the application of AHSS to complex automotive parts such as A- or B-pillars reinforcements.

In attempts to solve the formability problem, hot (press) forming (hot stamping or press hardening) has been developed. By hot (press) forming, the strength of the steel article is improved through fast cooling after heating it to a temperature range where an austenitic phase exists and through the phase transformations of the austenite to harder phases such as bainite and martensite.

The basics of the hot forming technique and steel compositions adapted to be used were for the first time described in GB1490535. Afterwards a lot of Carbon - Manganese - Boron based steels have been developed for use in hot press forming.

A typical steel used for the hot press forming is based on a composition system of 22MnB5, i.e. 0.22% of C, 1.2% of Mn, maximum 50 ppm of B, specified in EN10083. Hot press forming of 22MnB5 steel can produce complex parts such as bumpers and pillars with ultrahigh strength, minimum springback, and

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reduced sheet thickness. The tensile strength of boron steels is up to 1600 MPa, which is far above that of the highest-strength conventional cold stamping steels. However the ductility of total elongation A5 is less than 6%.

To improve the crash-resistance of the steel, the ductility and toughness should be further increased. Advanced high strength steels with TRIP (transformation induced plasticity) added multiphase microstructure are a solution. These steels are characterized by a ferritic-bainitic microstructure with retained austenite, which undergoes martensitic transformation during forming of products, additionally contributing to the strengthening of a ready part.

US2008/0286603 A1 has disclosed a steel sheet that exhibits an ultra-high strength after hot press forming followed by rapid cooling, and an enhanced yield strength after painting. The steel sheet has a composition (expressed in % by weight) comprising 0.1 to 0.5 C, 0.01 to 1.0 Si, 0.5 to 4.0 Mn, 0.1 or less P, 0.03 or less S, 0.1 soluble Al, 0.01 to 0.1 N, 0.3 or less W, and the balance being Fe and other inevitable impurities. Further a hot-pressed part made of the steel sheet and a method for manufacturing the hot-pressed part are disclosed. The hot-pressed part achieves a high increment in yield strength after heat treatment for painting while ensuring an ultra-high tensile strength. The steel provided according to this US patent application has an ultimate tensile strength (UTS) of 1500 MPa with the total elongation being less than 8%.

From US2008/0251160 A1 a high-strength cold-rolled steel sheet having an uniform elongation is known, including (in wt.%): 0.10 - 0.28 C; 1.0 - 2.0 Si; and 1.0 - 3.0 Mn. The structure has the space factors: 30 - 65% of bainitic ferrite; 30 - 50% of polygonal ferrite; and 5 - 20% of residual austenite. The desired microstructures were obtained according to the following process. After hot rolling and cold rolling, the steel sheet was heated for soaking up to a temperature which is equal to or higher than the A3 transformation point (A3), then cooled down temporarily to a temperature Tq expressed by the formula $A3-250\ (°C) \leq Tq \leq A3-20\ (°C)$ at an average cooling rate of 1 - 10 °C/s, and then quenched from this temperature down into a bainitic transformation

temperature range at an average cooling rate of 11 °C/s or faster. The tensile properties of the steel after such a heat treatment are typically, UTS = 1000 MPa and total elongation less than 15%.

US2008/0308194 A1 has disclosed a process for manufacturing a part made of steel having a multiphase microstructure. The composition of steel comprises, in % by weight: C 0.01 - 0.50, Mn 0.5 - 3.0, Si 0.001 - 3.0, Al 0.005 - 3.0, Mo ≤ 1.0, Cr ≤ 1.5, P ≤ 0.10, Ti ≤ 0.20, V ≤ 1.0 and optionally, one or more elements such as: Ni ≤ 2.0, Cu ≤ 2.0, S ≤0.05 and Nb ≤0.15, the balance of the composition being iron and inevitable impurities. In the process the steel sheet is heated to reach a soaking temperature Ts above Ac1 but below Ac3 and is held at this soaking temperature Ts for a soaking time ts so that the steel has an austenite content equal to or greater than 25 % by area; the steel blank is transferred into a forming tool for hot forming; and the part obtained is cooled within the tool at a cooling rate V to obtain a multiphase microstructure comprising ferrite, martensite or bainite and retained austenite, and ferrite is homogeneous in each of the regions.

Ryu H.-B et al., in a paper "Effect of thermomechanical processing on the retained austenite content in a Si-Mn transformation-induced-plasticity steel" (published in METALLURGICAL & MATERIALS TRANSACTIONS A, Vol. 33A, No. 9, 2002, p. 2811-2816), has reported a process of hot forming a steel specimen into a deformed article. This known process comprises - after austenizing for 5 minutes at 1000 °C - compression deformation at 920 °C. After this hot forming step is completed at this temperature, the deformed specimens are cooled at rates ranging from 10 - 35 °C/s to a simulated coiling temperature in the range of 420 - 480 °C. At this temperature the specimens are slowly cooled to 420 °C over a 2-minute period to complete bainitic transformation. Finally the specimens are air cooled to ambient temperature.

From EP1686195 A1 a heat treatment procedure - without deformation - for an already drawn wire is known. This heat treatment procedure comprises an intermediate isothermal transformation period of 60 - 3600 seconds at a

temperature between Ms - 50 °C and Bs.

JP2003193193 teaches steel sheet having a two phase microstructure comprising bainite/bainitic ferrite as a main phase and austenite as a second phase. The manufacturing process comprises an isothermal heat treatment at 200 - 450 °C for 1 - 3000 seconds.

In order to meet the requirements of the automotive industry there is an ongoing demand for steel articles having improved mechanical properties.

It is an object of the present invention to provide a manufacturing method of such steel articles, as well as steel compositions, in particular suitable for use in this method, more particularly advanced high strength TBF (TRIP-aided bainitic ferrite) steel products suitable for hot press forming as a Boron steel alternative for automotive applications.

Another object of the present invention is to provide a multiphase microstructured steel resulting in simultaneously improved strength and ductility.

Yet a further object is to provide a steel having an ultimate tensile strength higher than 1400 MPa, such as about 1500 Mpa. Still another object is to provide a steel having a total elongation higher than 8%, such as about 12%.

According to a first aspect the invention provides a method of hot forming a steel blank into an article, such as an automotive part, as defined in claim 1, wherein the method comprises the following steps:

d) cooling a heated steel blank to form an article during hot forming, starting at a starting temperature T2 above Ar3 to an interrupt temperature T3 in the range of 400 - 550 °C at a cooling rate V2 of at least 25 °C/s;

e) immediately further cooling the article from the interrupt temperature T3 to ambient temperature at a cooling rate V3 of 0.2 - 10 °C/s

wherein the interrupt temperature T3 and cooling rate V3 are selected such that the article thus obtained has a multiphase microstructure comprising by volume fraction:

55 - 90% of bainitic ferrite

5 - 15% of retained austenite

5 - 30% martensite.

The steel blank as a starting material for executing the method according to the invention can be obtained by standard casting processes, or indirectly from steel strip or sheet material. In hot rolling the cast ingot, the preheating temperature may be about 1100 - 1250 °C. Traditional hot rolling passes and rolling conditions may be implemented to roll the steel ingot to a sheet product of about 3 to 5 mm in thickness. The finish rolling temperature is about 850 - 880 °C. After hot rolling, the steel sheet is cooled at an average cooling rate of 5 - 50 °C/s to a coiling temperature between 550 and 700 °C. An excess of martensite or bainite is formed at a coiling temperature lower than 550 °C, resulting in an excessive increase in the strength of the hot-rolled steel sheet. The excessively increased strength acts as a load during subsequent cold rolling for the production of a cold-rolled steel sheet causing problems, such as a poor appearance. During cold rolling the coiled hot-rolled sheet is pickled and cold-rolled. Cold rolling can also be carried out under standard conditions at a reduction of about 30 - 75%. However, in view of prevention of uneven recrystallization, the cold rolling reduction is preferably controlled to range from 40 to 70%. After cold rolling, the sheet has a thickness of about 1 to 2 mm according to product requirements. After cold rolling the sheet may be decoiled and blanked to proper size suitable for hot forming according to the invention. A cold rolled sheet is a preferred starting product in the method according to the invention.

In the present method of cooling during hot forming, the two-step cooling pattern and the interrupt cooling temperature are properly controlled.

Advantageously the heated steel blank used in step d) has an austenite structure. In a preferred embodiment for obtaining such austenite structure the method according to the invention also comprises the steps of

a) heating the steel blank to an austenitizing temperature T1 above Ac3, preferably in the range of Ac3 + 20 °C to Ac3 + 60 °C, more preferably at a heating rate of 10 - 25 °C/s;

b) soaking the steel blank in said range, preferably during a soaking time t1 of 1 - 5 minutes;

c) optionally transferring the heated and soaked blank to a hot forming facility.

These austenitizing steps of the method for obtaining an austenite structure are performed by heating steel sheets, strips of blanks e.g. in a furnace or in a hot forming facility itself, to a temperature T1 above Ac3, more preferably in the range of Ac3 + 20 °C to Ac3 + 60 °C. Preferably the heating rate is in the range of 10 - 25 °C/s. This heating step is followed by soaking at a temperature above Ac3, preferably in the range of Ac3 + 20 °C to Ac3 + 60 °C, for a short period of time, preferably 1 - 5 min (Ac3 being the temperature at which transformation of ferrite into austenite is completed in hypoeutectoid steel, upon heating). The austenitizing temperature (T1) and soaking time are selected to ensure complete dissolution of carbides. If applicable, then the steel blank thus soaked is transferred to the hot forming device such as a hot forming press. If applicable, the transferring time is controlled, usually to a short transfer time such as less than 10 seconds to prevent cooling of the blank below the starting temperature T2 of the next hot forming step. The starting temperature T2 for hot forming and simultaneous cooling should be above the Ar3 point (typically in the range of 780~830 °C) to prevent any ferrite phase transformation, e.g. during transferring. (Ar3 being the temperature at which austenite begins to convert to ferrite upon cooling a steel.) During hot forming the blank is deformed and at the same time cooled down to an interrupt quenching temperature T3 in the range of 400 to 550 °C at a cooling rate V2 higher than 25 °C/s to avoid formation of proeutectoid ferrite and pearlite. If the cooling rate V2 is less than 25 °C/s, pearlite may be generated during quenching. Immediately, i.e. without holding

the blank for a predetermined time at a temperature of about T3, such as isothermal austempering at T3, the steel blank is allowed to cool down further to room temperature at a further cooling rate V3 of 0.2 - 10 °C/s. The higher cooling rates above 5 °C/s within said range are advantageous for achieving a high total elongation (At). The range of 0.5 - 5 °C/s is preferred in view of high Ultimate Tensile Strength (UTS). The combined adjustment of the interrupt temperature T3 and the further cooling rate V3 in the final step effectively controls the volume fraction of the various phases in the final microstructure of the article thus manufactured. The interrupt quenching temperature T3 is in the bainitic transformation range. If T3 is too high, generally above 550 °C, some pearlite structure may form during the following slow cooling step at cooling rate V3. If T3 is too low, below Ms point, bainitic structure may be obtained in an insufficient amount in the final microstructure. If V3 is too fast, too much martensite is obtained in the final microstructure, and it is impossible to ensure sufficient elongation. If V3 is too small, too less martensite is obtained in order to guarantee the high strength. Moreover, the combination of T3 and V3 is selected such that the article obtained comprises a multiphase microstructure comprising by volume fraction 55 - 90% of bainitic ferrite, 5 - 15% retained austenite and 5 - 30% martensite. A low martensite content within this range, typically below 10 %, offers a relatively high total elongation. A relatively high UTS is achieved if the multiphase microstructure comprises 55 - 85% bainitic ferrite, 5 - 15% retained austenite and 10 - 30% martensite. Generally the higher the interrupt temperature T3, the lower V3 has to be in order to get this multiphase microstructure.

Preferably the steel, in particular TBF steel, in the article as manufactured, is characterized by a multiphase structure comprising, more preferably consisting of, carbide free bainitic ferrite, carbon enriched retained austenite and a relatively small amount of martensite. In the multiphase structure, the mother-phase structure (matrix) comprises fine plates of essentially carbide free bainitic ferrite. The formation of such a microstructure is due to the fact that the precipitation of cementite during bainitic transformation is suppressed by alloying the steel with a sufficient amount of Si and/or Al, which have very low

solubility in cementite and greatly retards growth of cementite from austenite. Carbon that is rejected from the bainitic ferrite enriches the residual austenite, thereby transforming to martensite during cooling after bainitic transformation or stabilizing it down to room temperature.

The advantages of this type of microstructure are manifold. The bainitic ferrite in TBF steel is present in the form of plates with an ultra fine grain size, usually the length ranging up to about 15 micrometer at most and the thickness ranging up to 0.3 micrometer at most (typically ~10 µm long and ~0.2 µm thick). Furthermore the strength and ductility are improved simultaneously. The high flow stresses are due to the small thickness of the bainitic laths and to the absence of proeutectoid polygonal ferrite contrary to existing TRIP (transformation induced plasticity) steels. It is assumed that the retained austenite offers an additional TRIP effect, and that it is useful for improving total elongation. The presence of martensite islands leads to a high strength and to high instantaneous hardening rates. If the synergy effect is secured between transformation induced plasticity attained by residual austenite and use of fine plate bainitic ferrite in TBF steel, a dramatic improvement of elongation of TBF steel is attained. Toughness and crash performance are improved as well.

Moreover, to reach a high strength and a high ductility of the steel, the constituents of the various phases in the final microstructure preferably comprise, by volume fraction, bainitic ferrite: 55 - 90%, retained austenite: 5 - 15% and martensite: 5 - 30%.

The multiphase microstructure according to the invention can be obtained by designing steel with a specific composition and by applying careful control of the thermomechanical treatment process as discussed above.

Thus, in other words in a first aspect a preferred embodiment of the present invention relates to a method of hot forming a steel blank into an article, wherein the method comprises heating the steel blank to an austenitizing temperature T1, advantageously in the range of Ac3 + 20 °C and Ac3 + 60 °C,

and soaking the steel blank in the austenitizing temperature range, such that carbides are completely dissolved; introducing the heated and soaked blank in a hot forming device, such as a hot press, while preventing ferrite phase transformation; hot forming the steel blank to form a shaped article starting at a starting temperature T2 above Ar3 and cooling the article thus being hot formed to an interrupt temperature T3 in the bainitic transformation range at a cooling rate such that formation of proeutectoid ferrite and pearlite is avoided; and further cooling the article from the interrupt temperature T3 to ambient temperature at a cooling rate such that the volume fraction of bainitic ferrite is 55 - 90%, of retained austenite 5 - 15%, and of martensite 5 - 30% in the article thus manufactured.

Advantageously, the steel comprises the following elements (in wt. %):C 0.15 - 0.45, Si 0.6 - 2.5, Mn 1.0 - 3.0, Mo 0 - 0.5, Cr 0 - 1.0, P 0.001 - 0.05, S < 0.03, Ca < 0.003, Ti 0.1 or less and V 0.1 or less and the balance Fe and other inevitable impurities. Optionally, the steel may also contain Al less than 1.5%, partially replacing the same amount of Si, provided that the sum of Si and Al is in the range of 1.2 - 2.5%. Preferably, the amounts of Mn and Cr satisfy Mn + Cr ≤ 3%, while also preferably, the amounts of C and Mo satisfy C + 1/3Mo ≤ 0.45% for better control of the multiphase microstructure.

Hereinbelow the functions of each element in the steel composition is described. Content is represented as % by weight of the total composition.

C is an element for securing high strength, and for securing retained austenite. C is added in an amount of 0.15% or more to form the desired multiphase microstructure to achieve ultra-high strength and ductility. Meanwhile, when the C content exceeds 0.45%, it is difficult to obtain the multiphase microstructure through the method according to the invention comprising a contiguous cooling subprocess. Moreover, there is a great possibility that the toughness and weldability of the steel sheet will be deteriorated. C is preferably present in an amount of 0.2 - 0.4%, more preferably 0.2 - 0.35%.

Mn is one of the main elements in the steel composition according to the invention. The functions of Mn include stabilizing the austenite and obtaining the desired multiphase microstructure. If Mn is less than 1.0%, the effects are not sufficiently marked. Whereas if the content exceeds 3%, a fully martensite structure is easily created. As a result, the steel is hardened and embrittled during press forming. Besides, Mn is an element that is useful in lowering the Ac3 temperature. A higher Mn content is advantageous in lowering the temperature necessary for hot press forming. The Mn content is limited to the range of 1.0 - 3.0%, preferably 1.5 - 2.5% and more preferably 1.6 - 2.5%, even more preferably 1.7 - 2.4%.

Si is an element effective for reinforcing a solid solution, and is useful for suppressing production of carbide due to decomposition of retained austenite. To obtain high ductility, toughness and formability, the formation of carbides (either transition carbide or cementite) should be avoided as much as possible. Si suppresses the precipitation of brittle cementite during bainite formation, and hence results in an improvement in formability and toughness. A minimum of 1.0% Si is needed to form carbide free bainite. However, Si is also known to deteriorate galvanizability due to the formation of oxides adherent to the steel substrate. Therefore, the upper limit of Si is controlled below 2.5%. The Si content is advantageously limited to the range of 1.2 - 2.5% and more preferably to the range of 1.4 - 2.0%.

Al is also an element useful for suppressing production of carbide due to decomposition of, particularly, retained austenite. Partial replacement of Si by a same amount of Al has been shown to effectively retard cementite formation without a detrimental effect on hot-dip coatability in TBF steels. However, a high concentration of Al leads to higher possibility of polygonal ferrite to be generated, which is less effective than fine plate ferrite in view of strength. A full substitution of Si by an equivalent amount of Al leads to a marked deterioration of the strength-ductility balance. If added, the amount of Al is limited to 1.5% or smaller.

P is an element useful for maintaining desired retained austenite, and its effect is exerted by an amount of P of 0.001% or larger, more preferably 0.005% or larger, but P may deteriorate the workability of the steel when it is added in an excess amount. Accordingly, the P content is preferably limited to 0.05% or less.

S is a harmful element which forms sulfide based inclusions such as MnS, which initiates crack formation, and deteriorates processibility. Therefore, it is desirable to reduce the amount of S as much as possible. Accordingly, S is controlled to 0.03% or smaller.

Mo and Cr serve to improve the hardenability of the steel and facilitate the formation of bainite ferrite. At the same time, they are elements having similar effectiveness useful for stabilizing retained austenite. Therefore, Mo and Cr are very effective for process control. It is advantageous that each of them is contained at 0.05% or larger. However, when each of them is added excessively, the effect is saturated and a higher addition is not economical. Therefore, the amount of Mo is 0.5% or smaller, and the amount of Cr is 1% or smaller.

Ti and V have the effect of forming strengthening precipitates and refining microstructure. The amount of each of them is 0.1% or smaller, preferably 0.05% or smaller.

Ca is an element effective for controlling a form of sulfide in the steel, and improving processibility. It is recommended that Ca is contained at 0.0003% or more. However, when it is added excessively, the effect is saturated. Therefore, the preferred amount is 0.0003 - 0.003%.

Regarding a practical manufacturing process, the heat treatment described above may be carried out by heating and cooling in a continuous annealing facility (CAL), hot press forming facility, salt bath or the like.

Advantageously the first combined deformation/cooling step d) is performed in a hot forming facility. In a preferred embodiment the second cooling step e) is performed in air or in stock outside the hot forming facility.

Preferably the steel of the formed article has an ultimate tensile strength (UTS) of at least 1400 MPa, advantageously at least 1500 MPa, more preferably at least 1600 MPa, and most preferably at least 1700 MPa.

Advantageously the steel of the formed article has a total elongation of at least 8%, preferably at least 10%, more preferably at least 12%, and most preferably at least 14%.

The heat treatment processes can be simply performed by applying the hot (press) forming in a standard hot forming facility with only modification of the simultaneous cooling process, including cooling interrupt temperature and velocities. After austenitizing, the heat blank is inserted into the die sets of a hot press, in which the blank is shaped and cooled. The transfer time (e.g. 5 to 10 s) between furnace and the press forming tools is controlled to secure that the starting deformation temperature is higher than Ar3. The cooling rate V2 of the steel part in the forming tool depends on the deformation and on the quality of the contact between the tool and the steel blank. The forming tools may be cooled for example by using circulation of a liquid to ensure that the cooling rate is high enough (>25 °C/s) during quenching in the press mould. The interrupt cooling temperature can be controlled by the time for separation of the pressing tools. The formed article is then removed from the mould and cooled to room temperature in air. The formed articles, e.g. sheets, may also be stacked and then cooled to ambient temperature in air.

After cooling down to room temperature, the parts will be built in the car body structure. Then the paintbake process is performed. The paintbake cycle does not affect the properties.

In a second aspect the present invention provides a steel article, preferably formed according to the method of the present invention, wherein the steel has a microstructure comprising by volume fraction:

55 - 90% of bainitic ferrite

5 - 15% of retained austenite

5 - 30% martensite.

The details of the composition and microstructure as discussed above in view of the method according to the invention, in particular the advantageous and/or preferred embodiments are similarly applicable to the second aspect of the invention. Preferably the steel has an Ultimate Tensile Strength of at least 1400 MPa, advantageously at least 1500 MPa, preferably at least 1600 MPa, more preferably at least 1700 MPa and/or a total elongation of at least 8%, preferably at least 10%, more preferably at least 12%, most preferably at least 14%.

According to a third aspect the present invention provides a steel strip, sheet or strip for use in a thermomechanical treatment, in particular a hot forming method according to the invention described above, having a composition, in weight %:

C:	0.15 - 0.45
Si:	0.6 - 2.5
Mn:	1.0 - 3.0
Al:	0 - 1.5
Mo:	0 - 0.5
Cr:	0 - 1.0
P:	0.001 - 0.05
S:	< 0.03
Ca:	< 0.003
Ti:	< 0.1
V:	< 0.1

the balance being Fe and inevitable impurities,

wherein Si + Al = 1.2 - 2.5%.

Preferably the relationships Mn + Cr ≤ 3% and C + 1/3Mo ≤ 0.45% are applied.

In preferred compositions of the steel strip, sheet or blank according to the third aspect of the invention comprises, the alloying elements are present in, expressed in weight %,:

C:	0.2 - 0.4, preferably 0.2 - 0.35 and/or
Si:	0.8 - 2.0, preferably 1.2 - 1.8 and/or
Mn:	1.5 - 2.5, preferably 1.7 -2.4 and/or
Mo:	0.05 - 0.5 and/or
Cr:	0.05 - 1.0 and/or
P:	0.005 - 0.05 and/or
Ca:	0.0003 - 0.003.

The articles obtained from the strip, sheet or blank exhibit a high tensile strength by rapid cooling after heat treatment and achieve a high increment in yield strength after heat treatment, especially for painting. Based on these advantages, excellent impact properties of the steel article according to the present invention are attained. In addition, the steel article according to the present invention advantageously exhibits good adhesion to a coating layer. Furthermore, other advantages of the steel article according to the present invention are good surface appearance and superior corrosion resistance after painting.

A schematic representation of a practical embodiment of the method according to the invention is shown in Fig. 1, showing a temperature vs. time plot. A steel blank is heated at a heating rate of 15 °C to the austenitizing temperature T1 in the range of Ac3 + 20 °C to Ac3 + 60 °C and soaked at that temperature during a soaking time t1. The thus heated and soaked blank is transferred from the furnace to the hot forming facility, during which cooling by air occurs to some extent. Care is taken that the temperature T2 is not decreased below Ar3 before hot press forming of the blank. After hot press forming the blank thus formed is cooled down to the interrupt temperature T3 at a rate of more than 25 °C. Then air cooling is carried out.

The invention is further illustrated by the following examples.

Steels having compositions A-F as specified in Table 1 were cast to ingots of about 25 kg (100x110x330 mm). The ingots were reheated and then roughly hot rolled to slabs having a thickness of 40 mm. Then finish hot rolling was applied with the following process parameters: preheating at 1200°C for 30 min; multi-pass rolling to thickness 4 mm (40-27-18-12-8-6-4 mm); and finishing rolling temperature 860 ± 20 °C. Controlled cooling at a rate 30 °C/s to 600 °C in a run-out-table was carried out in order to simulate the commercially used coiling process. After the coiling process the steel plates contain a microstructure consisting of ferrite and pearlite and have a tensile strength less than 700 MPa. The plate was then cold rolled from 4 to 1 mm sheet.

Table 1. Chemical compositions (in wt. %) of TBF steel

Alloy	C	Si	Mn	Mo	Cr	Ti	P	S	Ac3 (°C)	Ms (°C)
A	0.31	1.47	1.66	-	-	0.01	0.03	0.01	863	334
B	0.40	1.48	1.67	-	-	0.01	0.03	0.01	848	306
C	0.29	1.76	2.39	-	-	0.01	0.03	0.01	879	313
D	0.22	1.57	2.35	0.25	-	0.01	0.03	0.01	890	340
E	0.30	1.50	2.40	0.25	-	0.01	0.03	0.01	876	318
F	0.30	1.50	2.00	0.25	0.5	0.01	0.03	0.01	874	315

V and Al were below detection level.

The critical temperatures such as Ac3 and Ms were determined by applying standard dilatometric analysis to facilitate the determination of the temperatures in the process according to the invention.

The resulting cold rolled sheets were subjected to a heat treatment by using a CASIM simulator. Specifically, the steel sheets were heated to 870 to 920°C at a rate of 15 °C/s, holding the sheets at this temperature for 2 min, then cooling at a rate of 50 °C/s to an interrupt temperature between 400 and 550 °C, thereafter, cooling at a rate of 0.2 to 10 °C/s to simulate different air cooling conditions.

Tensile tests were conducted by applying JIS 5 tensile test specimen to measure tensile strength and elongation of the specimens with the required microstructures. The volume fraction of bainite and/or martensite in the microstructures was estimated by using metallographic characterisation in combination with dilatametric analysis. The volume fraction of the retained austenite was determined by using TEM. Other measurements are standard. The tensile test results and the invented alloys with the required the microstructure constituents are given in Table 2.

The experimental results indicate that the microstructures and the properties are essentially independent from the austenitizing temperature T1 as long as the T1 is above Ac3, advantageously between Ac3 + 20 °C and Ac3 + 60 °C. It is also proven that the transferring temperature T2 and the cooling rate V2 do not significantly affect the microstructures and properties as well provided that T2 is higher than Ar3 and V2 is equal to or more than 25 °C/s and preferably less than 100 °C/s. However, the microstructures and the properties are strongly dependent on the interrupt temperature T3 and the cooling rate V3. The C content and alloying element contents have a large effect on the selection of T3 and V3. From these results, the conditions for the required multiphase microstructures of the alloys according to the invention can be obtained by careful adjustment of T3 and V3. For alloys with higher C or higher Mo contents, the cooling rate V3 can be controlled in a lower range 0.25 to 2 °C/s; for alloys containing lower C or lower Mo, the cooling rate V3 can be controlled in a higher range 2 to 10° C/s. For a given alloy composition at a fixed T3 temperature, higher cooling rate will result in less bainitic ferrite, but relatively more martensite. Therefore higher strength will be obtained. Lower cooling rate will result in more bainitic ferrite, but relatively less martensite, then higher elongation will be achieved. The higher T3 temperature is, the relatively more bainitic ferrite will be in the final microstructure for a given cooling rate, resulting in high strength but lower elongation.

Table 2. Hardness and tensile properties of the alloys and their microstructures

Alloy	T3	V3	Final microstructure			HV5	YS	UTS	At
	(°C)	(°C/s)	BF(%)	M(%)	Ar(%)		(MPa)	(MPa)	(%)
A	450	4	65	23	12	435	1024	1503	10.5
A	500	8	76	16	10	410	943	1435	14
B	400	1	74	20	6	476	1035	1660	12
B	450	1	87	8	5	435	965	1420	14.2
C	450	1	77	14	9	460	1023	1572	12.5
C	500	1	85	8	7	455	987	1475	13.6
D	450	2	85	5	10	485	914	1451	12.5
E	450	0.5	65	25	10	491	1025	1796	9
E	550	0.5	68	23	9	480	1016	1693	8.9
F	500	0.5	80	12	8	475	997	1599	11
F	550	0.5	72	20	8	519	1011	1695	9.5

In the above table the following abbreviations are used:

BF = Bainitic Ferrite

M = Martensite

Ar = Retained Austenite

HV5 = Vickers hardness measured at load of 5 kgf

YS = Yield Strength

UTS = Ultimate Tensile Strength

At = Total Elongation

CLAIMS

1. Method of hot forming a steel blank into an article, the method comprising the following steps:

d) cooling a heated steel blank to form an article during hot forming, starting at a starting temperature T2 above Ar3 to an interrupt temperature T3 in the range of 400 - 550 °C at a cooling rate V2 of at least 25 °C/s;

e) immediately further cooling the article from the interrupt temperature T3 to ambient temperature at a cooling rate V3 of 0.2 - 10 °C/s,

wherein the interrupt temperature T3 and cooling rate V3 are selected such that the article thus obtained has a multiphase microstructure comprising by volume fraction:

55 - 90% of bainitic ferrite

5 - 15% of retained austenite

5 - 30% martensite.

2. Method according to claim 1, wherein the blank, optionally produced from a steel strip, sheet, has the following composition in weight %:

C:	0.15 - 0.45
Si:	0.6 - 2.5
Mn:	1.0 - 3.0
Al:	0 - 1.5
Mo:	0 - 0.5
Cr:	0 - 1.0
P:	0.001 - 0.05
S:	< 0.03
Ca:	< 0.003
Ti:	< 0.1
V:	< 0.1

the balance being Fe and inevitable impurities,

wherein Si + Al = 1.2 - 2.5%.

3. Method according to claim 2, wherein Mn + Cr ≤ 3% and C + 1/3 Mo ≤ 0.45%.

4. Method according to claim 2 or 3, wherein the composition comprises, in weight%:

C:	0.2 - 0.4 and/or
Si:	0.8 - 2.0 and/or
Mn:	1.5 - 2.5 and/or
Mo:	0.05 - 0.5 and/or
Cr:	0.05 - 1.0 and/or
P:	0.005 - 0.05 and/or
Ca:	0.0003 - 0.003.

5. Method according to any one of claims 2-4, wherein the composition comprises, in weight %:

C:	0.2 - 0.35 and/or
Si:	1.2 - 1.8 and/or
Mn:	1.7 - 2.4.

6. Method according to any one of the preceding claims, wherein the bainitic ferrite is essentially carbide free and the retained austenite is carbon enriched.

7. Method according to any one of the preceding claims, wherein the grains of bainitic ferrite have a length of at most 15 µm and a thickness of at most 0.3 µm.

8. Method according to any one of the preceding claims, further comprising - prior to the hot forming step d) - the steps of

a) heating the steel blank to an austenitizing temperature T1 above Ac3, preferably in the range of Ac3 + 20 °C - Ac3 + 60 °C, preferably at a heating rate of 10 - 25 °C/s;

b) soaking the steel blank in said range, preferably during a soaking time of 1-5 minutes;

c) optionally transferring the heated and soaked blank to a hot forming facility;

9. Method according to claim 5, wherein step a) is performed in a continuous annealing facility, or a hot forming facility, or a salt bath or equivalent.

10. Method according to any one of the preceding claims, wherein step d) is performed in a hot forming facility.

11. Method according to any one of the preceding claims, wherein step e) is performed outside a hot forming facility in air.

12. Steel article preferably formed according to the method of any one of the preceding claims, wherein the steel has a microstructure comprising by volume fraction:

55 - 90% of bainitic ferrite

5 - 15% of retained austenite

5 - 30% martensite.

13. Steel article according to claim 13, wherein the steel has an Ultimate Tensile Strength of at least 1400 MPa, advantageously at least 1500 MPa, preferably at least 1600 MPa, more preferably at least 1700 MPa and/or a total elongation of at least 8%, preferably at least 10%, more preferably at least 12%, most preferably at least 14%.

14. Steel strip, sheet or blank for use in a thermomechanical treatment process, preferably the method according to any one of the preceding claims 1-12, having a composition, in weight %:

C:	0.15 - 0.45
Si:	0.6 - 2.5
Mn:	1.0 - 3.0
Al:	0 - 0.6
Mo:	0 - 0.5
Cr:	0 - 1.0
P:	0.001 - 0.05
S:	< 0.03
Ca:	< 0.003
Ti:	< 0.1
V:	< 0.1

the balance being Fe and inevitable impurities,
wherein Si + Al = 1.2 - 2.5%.

15. Steel strip, sheet or blank according to claim 14, wherein Mn + Cr ≤ 3% and C + 1/3 Mo ≤ 0.45%.

16. Steel strip, sheet or blank according to claim 14 or 15, wherein, expressed in weight %,:

C:	0.2 - 0.4, preferably 0.2 - 0.35 and/or
Si:	0.8 - 2.0, preferably 1.2 - 1.8 and/or
Mn:	1.5 - 2.5, preferably 1.7 -2.4 and/or
Mo:	0.05 - 0.5 and/or
Cr:	0.05 - 1.0 and/or
P:	0.005 - 0.05 and/or
Ca:	0.0003 - 0.003.

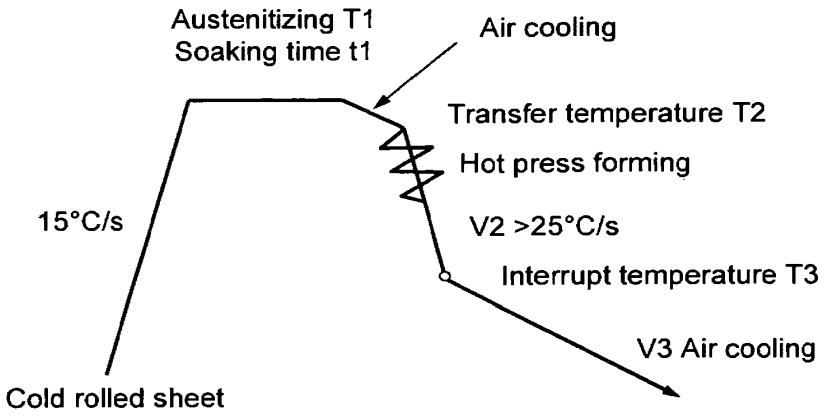
Austenitizing T1
Soaking time t1
Air cooling
Transfer temperature T2
Hot press forming
15°C/s
V2 >25°C/s
Interrupt temperature T3
V3 Air cooling
Cold rolled sheet

Fig. 1

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2011/005053

A. CLASSIFICATION OF SUBJECT MATTER
INV. C21D9/46 C22C38/02 C22C38/04 C22C38/12 C22C38/14
C21D1/673 C21D9/48
ADD.
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED
Minimum documentation searched (classification system followed by classification symbols)
C21D C22C

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal, CHEM ABS Data, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	RYU H-B ET AL: "Effect of thermomechanical processing on the retained austenite content in a Si-Mn transformation-induced-plasticity steel", METALLURGICAL AND MATERIALS TRANSACTIONS A: PHYSICAL METALLURGY & MATERIALS SCIENCE, ASM INTERNATIONAL, MATERIALS PARK, OH, US, vol. 33A, no. 9, 1 September 2002 (2002-09-01), pages 2811-2816, XP002584719, ISSN: 1073-5623, DOI: DOI:10.1007/S11661-002-0266-3 [retrieved on 2007-04-07] page 1 - page 2; figures 3, 6, 7; table 1 ----- -/--	1-16

[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

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"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
18 January 2012	27/01/2012

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Huber, Gerrit

1

Form PCT/ISA/210 (second sheet) (April 2005)

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2011/005053

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 1 686 195 A1 (KOBE STEEL LTD [JP]; SHINSHU TLO CO LTD [JP]) 2 August 2006 (2006-08-02) paragraph [0018] - paragraph [0028] page 7, line 5 - line 45 example E; table 1 -----	1-16
X	JP 2003 193193 A (NIPPON STEEL CORP) 9 July 2003 (2003-07-09) paragraph [0022] - paragraph [0026]; example c1; tables 1-3 -----	1-16

1

Form PCT/ISA/210 (continuation of second sheet) (April 2005)

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2011/005053

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 1686195 A1	02-08-2006	AT 535624 T	15-12-2011
		EP 1686195 A1	02-08-2006
		KR 20060087438 A	02-08-2006
		US 2006169367 A1	03-08-2006
JP 2003193193 A	09-07-2003	JP 3854506 B2	06-12-2006
		JP 2003193193 A	09-07-2003

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(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PE, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

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[Continued on next page]

(54) Title: METHOD FOR HOT FORMING A COATED METAL PART AND FORMED PART

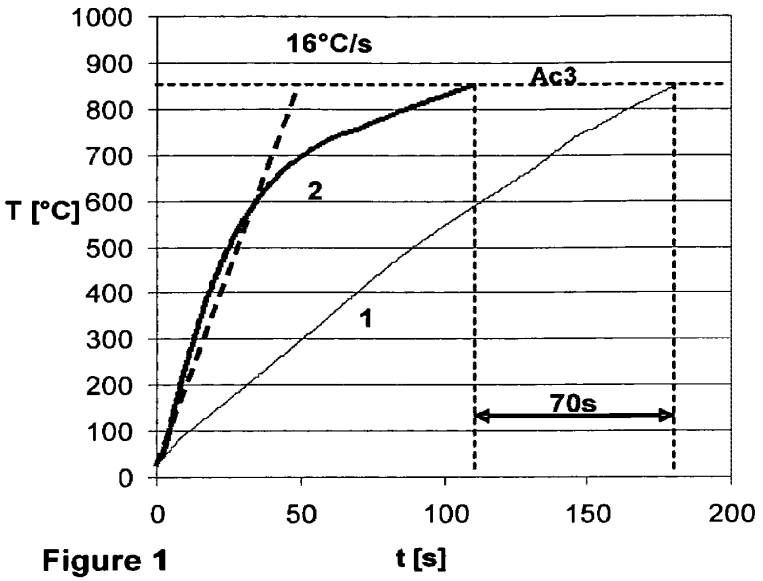

Figure 1

(57) Abstract: The invention relates to a method for manufacturing a coated part having very high mechanical properties using hot forming techniques. According to the invention, the method comprises the following steps: - providing an annealed steel strip or blank or pre-shaped part that has been coated with a metal or metal alloy before the annealing - if a strip is provided, cutting a blank from the strip before or after the annealing - optionally forming a pre-shaped part from the blank - heating the blank or pre-shaped part to a temperature of 500° C at an average heating rate of 16° C/s or more - further heating the blank or pre-shaped part to a temperature between 700 and 1000° C - hot forming the blank or pre-shaped part into a hot formed part - hardening the hot formed part. The invention also relates to a method for manufacturing a coated steel strip, blank or pre-shaped part, and to a coated steel strip, blank or part and a hot formed part.

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METHOD FOR HOT FORMING A COATED METAL PART AND FORMED PART

The invention relates to a method for manufacturing a coated part using hot forming techniques. The invention also relates to a method for manufacturing a coated steel strip, blank or pre-formed part for the hot forming method, and to a coated steel strip, blank, part or pre-formed part and a hot formed part.

The use of hot forming techniques for the forming of a part is well known, especially for automotive purposes. Starting from a sheet that can be easily formed, the hot forming techniques provide a formed part having very high mechanical properties, such as a tensile strength above 1200 MPa.

Usually the hot forming is performed by providing a blank, heating the blank to a temperature between 700° and 1000° C and keeping the blank at that temperature for a few minutes, placing the heated blank in a hot forming apparatus, forming the blank into a part in the hot forming apparatus, and hardening the hot formed part.

When using uncoated steel, the heating of the blank before the hot forming in a hot forming apparatus can be performed under a protective atmosphere to prevent oxidation and decarburization of the steel. However, the hot forming itself and the hardening take place in air, and thus oxidation occurs; therefore, after the hot forming the hot formed parts must be descaled. To overcome this drawback, in the last ten years it has been proposed to use coated steel sheets, which sheets are heated to a temperature above the Ac1 temperature. During the heating a diffusion layer is formed between the coating and the steel sheet, providing protection against oxidation and a good adherence of the coating to the steel sheet, also at the elevated temperatures which are used for hot forming.

Though a protective atmosphere is not necessary anymore when using coated steel sheets, the known method has some drawbacks. One of the main problems is that the heating velocity of the coated steel sheets has been found to be critical. This makes the whole process more difficult to control. It also results in the heating of a steel sheet taking a considerable time, for instance 5 minutes, whereas the hot forming in the hot forming apparatus and the subsequent hardening can be performed in less than 1 minute. Manufacturing at a high production rate, as made possible by the hot forming

apparatus, can be performed by heating a number of coated steel sheets in an oven. However, when there is a delay at the hot forming apparatus the coated steel sheets remain too long in the oven, which means that they have to be scrapped. This has a considerable influence on the cost of the hot forming process. Moreover, the oven has to be very long.

It is an object of the invention to provide a method for manufacturing a coated part using hot forming techniques, which makes it possible to control the process in a more flexible and robust manner.

It is also an object of the invention to provide a method for manufacturing a coated part using hot forming techniques, which makes it possible to easily and effectively produce hot formed parts.

It is a further object of the invention to provide a method for manufacturing a coated part using hot forming techniques, which is more cost-effective than the known method.

Furthermore, it is an object of the invention to provide a coated steel strip, a coated steel blank and a coated pre-shaped part, and a method to produce these, which can be used in the method according to the invention.

According to the invention one or more of these objects is reached by providing a method for manufacturing a coated part having very high mechanical properties using hot forming techniques, comprising the following steps:

1. providing an annealed steel strip or blank or pre-shaped part that has been coated with a metal or metal alloy before the annealing
2. if a strip is provided, cutting a blank from the strip before or after the annealing
3. optionally forming a pre-shaped part from the blank
4. heating the blank or pre-shaped part to a temperature of 500° C at an average heating rate of 16° C/s or more
5. further heating the blank or pre-shaped part to a temperature between 700 and 1000° C
6. hot forming the blank or pre-shaped part into a hot formed part
7. hardening the hot formed part.

The inventors have found that due to the use of annealed coated steel, the heating of the annealed steel strip or blank or pre-shaped part can be performed at an average heating rate of 16° C/s or more up to a temperature of 500° C. In this way, the

heating of the blank or pre-shaped part before the hot forming thereof can be performed much faster than usual. The heating of the blank or pre-shaped part can now be performed within 3 minutes before the blank or pre-shaped part is taken out of the oven and put in the hot forming apparatus. This fast heating according to the invention is possible using a blank, which is used in the direct hot forming process, or using a pre-shaped part, which is used in the indirect hot forming process.

According to a preferred embodiment, the blank or pre-shaped part in step 4 is heated to a temperature of 625° C at an average heating rate of 16° C/s or more, and further heated in step 5 to a temperature between 700 and 1000° C before the blank or pre-shaped part is hot formed. By heating the blank or pre-shaped part to a temperature of 700° C at the high heating rate of 16° C/s or more, the heating of the blank or pre-shaped part can be performed in an even shorter time period.

According to a further preferred embodiment, the blank or pre-shaped part in step 4 is heated to a temperature of 700° C at an average heating rate of 16° C/s or more, and optionally further heated in step 5 to a temperature between 700 and 1000° C before the blank or pre-shaped part is hot formed. By heating the blank or pre-shaped part to a temperature of 700° C at the high heating rate of 16° C/s or more, the heating of the blank or pre-shaped part can be performed in an even shorter time period of less then 2 minutes.

According to a further preferred embodiment, the blank or pre-shaped part in step 4 is heated to a temperature between 700 and 900° C at an average heating rate of 16° C/s or more, and optionally further heated in step 5 to a temperature of at most 1000° C before the blank or pre-shaped part is hot formed. By heating the blank or pre-shaped part to a temperature between 700 and 900° C at the high heating rate of 16° C/s or more, the heating of the blank or pre-shaped part can be performed in a very short time period of less then 90 seconds when the average heating rate of 16° C/s or more is used to temperatures above the Ac1 temperature.

Preferably the metal or metal alloy is zinc or a zinc alloy. The inventors have found that the use of an annealed zinc or zinc alloy coating makes it possible to use very high heating rates.

According to a preferred embodiment the coating on the blank or pre-shaped part remains solid during step 4 and step 5. This has of course the advantage that the coating remains on the blank or pre-shaped part, and especially for pre-shaped parts

remains evenly spread on non-horizontal portions of the pre-shaped part and does not flow. Because the coating remains solid it does not stick to handling equipment. Moreover, no energy is needed to transform the coating from the solid into the liquid state.

Preferably, the heating rate is 20° C/s or more, and more preferably 25° C/s or more. These high heating rates make it possible to heat the coated blank or pre-shaped part before the hot forming of the part in a time period shorter than one minute.

Preferably, in step 4 the blank or pre-shaped part is heated at an average heating rate of at most 50° C/s. Higher heating rates make it difficult to control the highest temperature to which the blank or pre-shaped part are heated.

According to a preferred embodiment, the steel has the following composition in weight percent:

$0,1 < C < 0,5$

$0,5 < Mn < 3,0$

$0,1 < Si < 0,5$

$Cr < 1,0$

$Ti < 0,2$

$Al < 0,1$

$P < 0,1$

$S < 0,05$

$0,0005 < B < 0,08$

optionally:

$Nb < 0,1$

$V < 0,1$

unavoidable impurities

the remainder being iron.

Though other metal composition are also possible, it has been found that the steel composition as given above will give very good results in most cases.

According to a preferred embodiment the metal alloy is a zinc alloy having the following composition in weight percent:

$1.0 < Al < 5.0$, preferably $1.5 < Al < 2.0$

$1.0 < Mg < 5.0$, preferably $1.5 < Mg < 2.0$

at most 0.2 in total of one or more standard alloying elements

remainder zinc and inevitable impurities.

The inventors have found that using a zinc alloy having this composition, the blank or pre-shaped part can be heated at very high heating rates above 16° C/s. The standard alloying elements are Pb, Sb, Ti, Ca, Mn, La, Ce, Cr, Ni, Zr, and Bi.

According to a second aspect of the invention there is provided a method for manufacturing the annealed steel strip or blank or pre-shaped part that has been coated with a metal or metal alloy before the annealing as provided in the first aspect of the invention, comprising the following steps:

1 - providing a steel strip or blank or pre-shaped part

2 - coating the steel with a layer of metal or metal alloy, preferably zinc or zinc alloy

3 - heating the coated steel to a temperature between 700° C and 1000 ° C and keeping the strip or blank or pre-shaped part at that temperature during a time period of at most 30 minutes

4 - cooling the coated steel.

This method for manufacturing a coated and annealed steel strip or blank or pre-shaped part is thus performed independently from the hot forming process as such. The choice for a high diffusion temperature between 700° C and 1000° C means that a relatively short production time for the forming of the diffusion layer can be obtained.

Preferably in the method according to the second aspect of the invention, if a strip is provided the steel strip is cut to form a blank from the strip, and a pre-shaped part is formed from the blank after step 1, 2, 3 or 4. Since blanks or pre-shaped parts are used in the hot forming process, it is preferred to store and transport blanks or pre-shaped parts which can be directly used in the hot forming process.

According to a third aspect of the invention the coated steel strip, blank, part or pre-shaped part as produced according to the method of the second aspect of the invention is provided with a coating of zinc or zinc alloy, wherein the outer layer of the coating on average contains more than 5 weight % Fe over a depth of 3 μm. A coated steel having more than 5 weight % Fe over a depth of 3 μm can be used in the hot forming of the blank or pre-shaped part.

Preferably the outer layer of the coating on average contains more than 10 weight % Fe over a depth of 3 μm, more preferably more than 20 weight % Fe, still more preferably more than 30 weight % Fe, and most preferably more than 40 weight

% Fe. A higher amount of Fe in the outer layer of the coating means that the coating and the Fe from the steel have better diffused.

According to a fourth aspect of the invention a hot formed coated part is provided that is manufactured using the method according to the first aspect of the invention.

The invention will be elucidated referring to the experiments hereinafter.

Figure 1 shows the heating curves for a substrate covered with two different coatings.

The substrate is a 1.5 mm thick 22MnB5 boron steel.

Example 1 is a blank which is covered by a zinc alloy containing 1.6 weight% Al and 1.6 weight% Mg, the remainder being zinc. The coating has a coating weight of 140 g/m^2(70 g/m^2 per side).

Example 2 is a blank which is covered by the same coating as in example 1, but the blank has been annealed at 750° C. Due to the annealing, the average Fe content of the coating is more than 20%.

The two blanks have been put in an oven together. The oven temperature had been set on 920° C. The blanks have been heated to a temperature of approximately 850° C; the temperature of the blanks has been measured using a thermocouple.

Figure 1 shows the heating curves of the blanks. The horizontal axis shows the dwell time t of the blanks in the oven in seconds; the vertical axis shows the temperature T of the blanks in ° C.

Inspection of the blanks showed that the coating of example 1 became liquid.

The coating of example 2remained solid through the full heating up to 850° C.

Figure 1 shows that the blank of example 2 is heated with a heating rate of more than 16° C/s up to a temperature of 500° C, and that the average heating rate is 16° C up to a temperature of approximately 650° C. Contrary to this the heating rate of the blank of example 1 is far below 16° C/s.

The time to reach the Ac3 temperature, at which the steel will fully transform into austenite and which is approximately 850° C/s for the present substrate, is approximately 110 seconds for example 2 and approximately 180 seconds for example 1.

After the blanks have reached the Ac3 temperature they can be given some additional time to homogenise into austenite before they can be put in a hot forming apparatus.

CLAIMS

1. Method for manufacturing a coated part having very high mechanical properties using hot forming techniques, comprising the following steps:
    1. providing an annealed steel strip or blank or pre-shaped part that has been coated with a metal or metal alloy before the annealing
    2. if a strip is provided, cutting a blank from the strip before or after the annealing
    3. optionally forming a pre-shaped part from the blank
    4. heating the blank or pre-shaped part to a temperature of 500° C at an average heating rate of 16° C/s or more
    5. further heating the blank or pre-shaped part to a temperature between 700 and 1000° C
    6. hot forming the blank or pre-shaped part into a hot formed part
    7. hardening the hot formed part.

2. Method for manufacturing a coated part according to claim 1, wherein the blank or pre-shaped part in step 4 is heated to a temperature of 625° C at an average heating rate of 16° C/s or more, and further heated in step 5 to a temperature between 700 and 1000° C before the blank or pre-shaped part is hot formed.

3. Method for manufacturing a coated part according to claim 1, wherein the blank or pre-shaped part in step 4 is heated to a temperature of 700° C at an average heating rate of 16° C/s or more, and optionally further heated in step 5 to a temperature between 700 and 1000° C before the blank or pre-shaped part is hot formed.

4. Method for manufacturing a coated part according to claim 1, wherein the blank or pre-shaped part in step 4 is heated to a temperature between 700 and 900° C at an average heating rate of 16° C/s or more, and optionally further heated in step 5 to a temperature of at most 1000° C before the blank or pre-shaped part is hot formed.

5. Method for manufacturing a coated part according to any one of the preceding claims, wherein the metal or metal alloy is zinc or a zinc alloy.

6. Method according to any one of the preceding claims, wherein the coating on the blank or pre-shaped part remains solid during step 4 and step 5.

7. Method according to any one of the preceding claims, wherein in step 4 the blank or pre-shaped part is heated at an average heating rate of at most 50 ° C/s.

8. Method according to any one of the preceding claims, wherein the steel has the following composition in weight percent:

$0,1 < C < 0,5$
$0,5 < Mn < 3,0$
$0,1 < Si < 0,5$
$Cr < 1,0$
$Ti < 0,2$
$Al < 0,1$
$P < 0,1$
$S < 0,05$
$0,0005 < B < 0,08$
optionally:
$Nb < 0,1$
$V < 0,1$
unavoidable impurities
the remainder being iron.

9. Method according to any one of the preceding claims, wherein the metal alloy is a zinc alloy having the following composition in weight percent:

$1.0 < Al < 5.0$, preferably $1.5 < Al < 2.0$
$1.0 < Mg < 5.0$, preferably $1.5 < Mg < 2.0$
at most 0.2 in total of one or more standard alloying elements
remainder zinc and inevitable impurities.

10. Method for manufacturing the annealed steel strip or blank or pre-shaped part that has been coated with a metal or metal alloy before the annealing, as provided in any one of the preceding claims, comprising the following steps:

1 - providing a steel strip or blank or pre-shaped part

2 - coating the steel with a layer of metal or metal alloy, preferably zinc or zinc alloy

3 - heating the coated steel to a temperature between 700° C and 1000 ° C and keeping the strip or blank or pre-shaped part at that temperature during a time period of at most 30 minutes

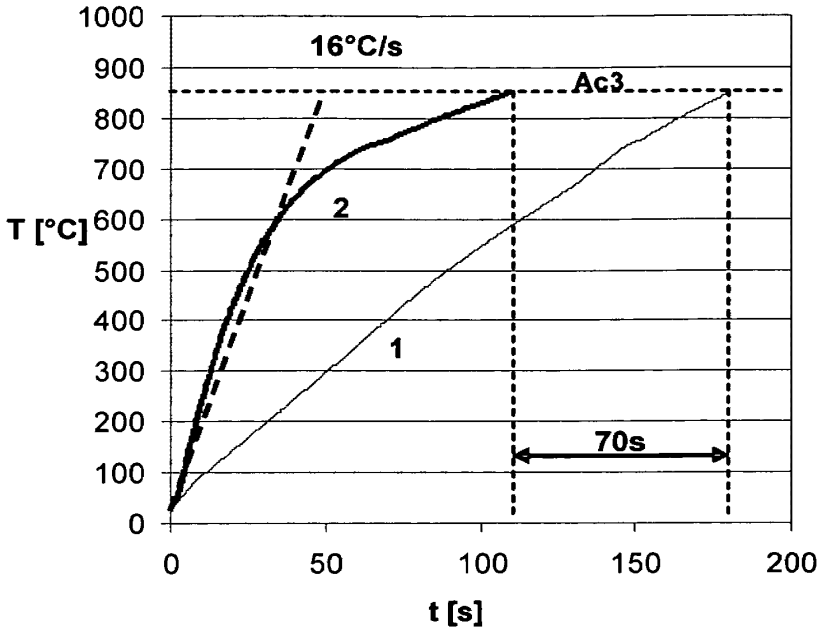
4 - cooling the coated steel.

11. Method according to claim 10, wherein if a strip is provided the steel strip is cut to form a blank from the strip and a pre-shaped part is formed from the blank after step 1, 2, 3 or 4.

12. Coated steel strip, blank, part or pre-shaped part provided with a coating of zinc or zinc alloy as produced according to the method of claim 10 or 11, wherein the outer layer of the coating on average contains more than 5 weight % Fe over a depth of 3 μm.

13. Coated steel strip, blank, part or pre-shaped part according to claim 12, wherein the outer layer of the coating on average contains more than 10 weight % Fe over a depth of 3 μm, preferably more than 20 weight % Fe, more preferably more than 30 weight % Fe, still more preferably more than 40 weight % Fe.

14. Part provided by performing the method according to any one of the claims 1 – 9.


1000
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T [°C]
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Ac3
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Figure 1

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2011/003601

A. CLASSIFICATION OF SUBJECT MATTER
INV. C21D8/04 C21D9/46 C22C38/02 C22C38/04 C21D1/673
C21D9/48
ADD.
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
C21D C22C

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal, CHEM ABS Data, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2010/005121 A1 (NIPPON STEEL CORP [JP]; MAKI JUN [JP]; ABE MASAYUKI [JP]; KUSUMI KAZUH) 14 January 2010 (2010-01-14) the whole document	1-4,7,8, 10,11,14
X	WO 2010/069588 A1 (CORUS STAAL BV [NL]; HENSEN GUIDO CORNELIS [NL]; VERLOOP WICO CORNELIS) 24 June 2010 (2010-06-24)	1-6, 10-14
Y	page 1 - page 3 page 5, line 1 - line 10 page 7, line 15 - line 20; table 1 claims 1-20	9
Y	EP 2 177 641 A1 (VOESTALPINE STAHL GMBH [AT]) 21 April 2010 (2010-04-21) paragraph [0027] - paragraph [0052]	9

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[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

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"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
29 September 2011	12/10/2011

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Huber, Gerrit

2

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INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2011/003601

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2010/085983 A1 (ARCELORMITTAL INVESTIGACION Y [ES]; AUDI NSU AUTO UNION AG [DE]; VOLKS) 5 August 2010 (2010-08-05) the whole document -----	1
X	DE 10 2008 022400 A1 (THYSSENKRUPP STEEL AG [DE]) 19 November 2009 (2009-11-19) paragraph [0019] - paragraph [0023] table 1 -----	1

2

Form PCT/ISA/210 (continuation of second sheet) (April 2005)

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2011/003601

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 2010005121 A1	14-01-2010	CA 2729942 A1	14-01-2010
		CN 102089451 A	08-06-2011
		EP 2312005 A1	20-04-2011
		JP 4724780 B2	13-07-2011
		KR 20110018420 A	23-02-2011
		US 2011174418 A1	21-07-2011
WO 2010069588 A1	24-06-2010	CA 2746212 A1	24-06-2010
EP 2177641 A1	21-04-2010	AT 478971 T	15-09-2010
		BR PI0412599 A	19-09-2006
		BR PI0412601 A	19-09-2006
		CA 2533327 A1	10-03-2005
		CA 2533633 A1	10-03-2005
		EP 1660693 A1	31-05-2006
		EP 1658390 A1	24-05-2006
		EP 1651789 A1	03-05-2006
		WO 2005021820 A1	10-03-2005
		WO 2005021822 A1	10-03-2005
		WO 2005021821 A1	10-03-2005
		JP 2007500285 A	11-01-2007
		JP 2007505211 A	08-03-2007
		KR 20060036111 A	27-04-2006
		KR 20060033921 A	20-04-2006
		MX PA06000825 A	23-08-2006
		MX PA06000826 A	23-08-2006
		PT 1651789 E	05-11-2010
		US 2007256808 A1	08-11-2007
		US 2007271978 A1	29-11-2007
		US 2007000117 A1	04-01-2007
		US 2011045316 A1	24-02-2011
WO 2010085983 A1	05-08-2010	CA 2751062 A1	05-08-2010
		WO 2010086186 A1	05-08-2010
DE 102008022400 A1	19-11-2009	NONE	

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European Patent Office
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(30) Priority: **11.07.2002 JP 2002202770**

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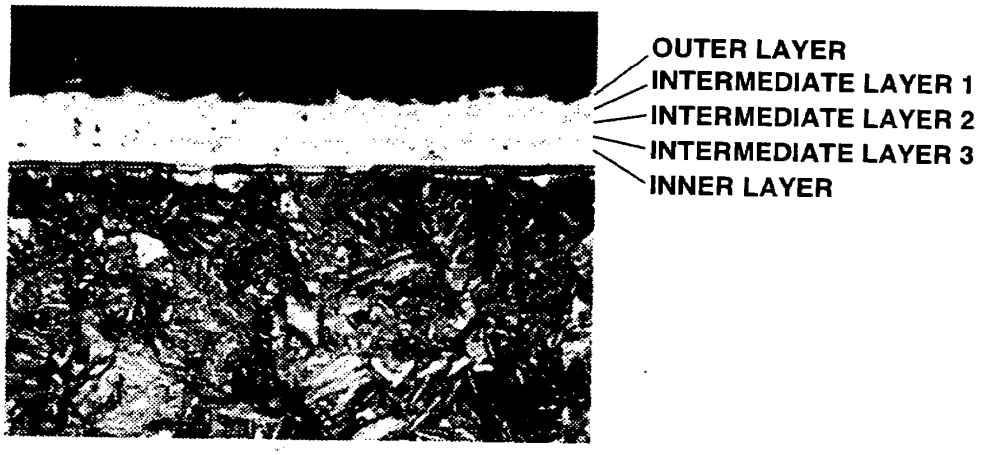
(54) Aluminium-coated structural member and production method

(57) An aluminum-coated structural member includes an Al-Si-Fe alloy layer formed on a steel substrate layer. The alloy layer includes a softer region having a hardness smaller than or equal to a hardness of the steel substrate layer, extends from the surface of the steel substrate layer toward a surface of the alloy layer, over a depth range greater than or equal to 50% of a thickness of the alloy layer. The Al-Si-Fe alloy layer has an oxide weight smaller than or equal to 500 mg/dm^2.

FIG.2A



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Description

BACKGROUND OF THE INVENTION

[0001] The present invention relates to an aluminum-coated structural member and a production method thereof. More specifically, the present invention relates to an aluminum-coated structure member, such as a structural member used for motor vehicles, produced by applying heat treatment and forming operation to aluminum-coated steel sheet, and coated with an alloy layer of an Al-Si-Fe alloy for improvement in formability, weldability and corrosion resistance.

[0002] A Published Japanese Patent Application Publication No. 2000-204463 shows a hot-dip aluminum-coated steel sheet which can be used for motor vehicles as fuel tank, muffler, heat shield plate, etc., from the viewpoint of excellent corrosion resistance due to oxide film, and less burden on the environment due to non-inclusion of heavy metal such as lead.

SUMMARY OF THE INVENTION

[0003] A hard Al-Fe alloy layer contained in a hot-dip aluminum-coated steel sheet at an interface with a steel substrate is more or less problematical in the formability. Moreover, the alloy layer tends to suffer cracks in a forming operation, and hence sometimes entails another treatment to ensure sufficient corrosion resistance. Weldability is another problem because an aluminum coating layer is low in melting point, and an aluminum single surface layer is insufficient in thermal conductivity. Accordingly, the hot-dip aluminum-coated steel sheet is limited in application.

[0004] It is an object of the present invention to provide aluminum-coated structural member and production method to the advantage of corrosion resistance, formability and weldability and wider application in motor vehicles.

[0005] According to one aspect of the present invention, an aluminum-coated structural member comprises: a steel substrate layer; and an Al-Si-Fe alloy layer formed on a surface of the steel substrate layer, the alloy layer including a softer region having a hardness smaller than or equal to a hardness of the steel substrate layer, extending from the surface of the steel substrate layer toward a surface of the alloy layer, and having a thickness greater than or equal to 50% of a thickness of the alloy layer, the Al-Si-Fe alloy layer having an oxide weight smaller than or equal to 500 mg/dm^2.

[0006] According to another aspect of the invention, a production method of an aluminum-coated structural member comprises: a first method element of heating a hot-dip aluminum-coated steel sheet at a heating rate in a range of 1~10°C/sec; a second method element of holding the hot-dip aluminum steel sheet at a raised temperature in a temperature range of 900~950°C for a duration in a range of 2~8 minutes; a third method element of cooling the hot-dip aluminum-coated steel sheet to a temperature in a temperature range of 700~800°C at a cooling rate in a range of 5~15°C/sec; a fourth method element of forming the hot-dip aluminum-coated steel sheet into a predetermined shape in the temperature range of 700~800°C; and a fifth method element of cooling the hot-dip aluminum-coated steel sheet in the predetermined shape rapidly from the temperature range of 700~800°C to a lower temperature lower than or equal to 300°C at a cooling rate in a range of 20~100°C/sec.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] FIG. 1 is a perspective view showing the shape and dimensions of specimens used in a test 1 according to an embodiment of the present invention, for evaluation of the formability.

[0008] FIG. 2A is a view of a photograph showing a microstructure of a coating layer in a structural member in a practical example No. 1 in the test 1.

[0009] FIG. 2B is a view of a photograph showing a microstructure of a coating layer in a structural member in a practical example No. 2 in the test 1.

[0010] FIG. 3 is a graph showing performance of consecutive spot welds in spot welding, of a structural member in the embodiment of the present invention in comparison with an ordinary hot-dip aluminum-coated steel sheet.

[0011] FIG. 4 is a view of a table 1 showing the result of test 1 in the embodiment.

[0012] FIG. 5 is a view of a table 2 showing the result of test 3 in the embodiment.

DETAILED DESCRIPTION OF THE INVENTION

[0013] In general, a hot-dip aluminum-coated steel sheet is formed by immersing a strip continuously in a bath of molten aluminum. According to the coating metal component, hot-dip aluminum-coated steel sheets are classified broadly into two categories. One employs, as coating metal, pure aluminum (for weather resistance), and the other employs Al-Si alloy (for heat resistance) containing Si in addition to Al. An embodiment according to the present invention employs heat resisting coated steel sheet containing an additive of Si (approximately 3~11 % Si).

[0014] The addition of Si to the coating layer is for restraining the growth of a hard Al-Fe alloy layer in a boundary

between the steel and coating during the process of aluminizing, and thereby for improving the adhesion and corrosion resistance of the Al coating layer. In such a hot-dip aluminum-coated steel sheet, there is formed an Al-Si-Fe alloy layer in the boundary between the Al coating and the steel substrate layer.

[0015] When a hot-dip aluminum-coated steel sheet of such a type is subjected to heat treatment under certain conditions, the Al-Si-Fe layer can grow and spread entirely until the surface is reached. FIG. 2A shows a sectional structure in one example of an aluminum-coated steel sheet including such an Al-Si-Fe layer grown to the surface by the heat treatment.

[0016] During the growth of the Al-Si-Fe alloy layer by the heat treatment, mutual diffusion between Al coating and steel substrate layer produces various Al-Si-Fe ternary intermetallic compounds such as αFeAlSi phase (alpha FeAlSi), βFeAlSi phase (beta FeAlSi) and γFeAlSi phase (gamma FeAlSi). The Al-Si-Fe alloy layer formed by the heat treatment has a layered structure made up of these intermetallic compounds, and offers advantages of formability, corrosion resistance and weldability.

[0017] When the hardness of Al-Si-Fe alloy layer exceeds the hardness of steel substrate, the Al-Si-Fe alloy layer exerts adverse influence on the formability in the forming process of the steel sheet, and on the corrosion resistance by deteriorating the compliance of the coating and increasing the possibility of cracks in the coating. Therefore, in this embodiment, there is formed a less hard or soft layer having a hardness smaller than the hardness of the steel substrate at or near the boundary between the steel and coating. This soft layer prevents crack, even if produced by any chance, from extending deeper from the surface toward the steel substrate. In this embodiment, the thickness of this soft layer is made equal to or greater than 50% of the total thickness of the alloy coating layer. The thick soft layer extending from a level at or near the boundary with the steel substrate, to or beyond the middle in the depth of the coating layer is effective for preventing progress of crack and securing sufficient corrosion resistance.

[0018] Oxygen contained in the form of oxides in the coating alloy layer causes pinholes in the process of electro deposition and thereby deteriorates the adhesion between the coating and deposited film if the amount of oxygen is increased. Therefore, the oxide quantity or oxide weight is made equal to or less than 500 mg/dm^2. In this specification, "oxide weight" is defined, as mentioned later, as a difference in mass between the mass of a specimen after a heat treatment at 950°C and the mass of the specimen before the heat treatment.

[0019] The mechanism of formation of the layered structure is not fully evident. Currently, the presumption by the inventors of the present invention is as follows: (1) The retention of a specimen at an elevated temperature causes the diffusion of Fe, and produce a concentration gradient in Fe and Si in the coating layer. (2) In this case, the coating alloy phase is urged to transform into a stable compound phase determined by the composition at each depth, so that there are formed different compound layers in different regions of depth. (3) Therefore, by controlling the raised temperature of the heating and the holding time at the raised temperature, the diffusion quantity of Fe is varied and the degree of transformation into a stable compound is varied.

[0020] The Al-Si-Fe alloy layer contiguous with the steel substrate layer is softened by the diffusion of Fe from the steel substrate layer, and made more adhesive with steel, and hence more formable. Specifically, a preferable range of the Fe content is 85~95%. When the Fe content is in this range, the hardness of the soft layer contacting with the steel substrate is equal to or lower than 80% (300~400 Hv) of an average hardness of the coating layer. When the Fe content is less than 85%, the above-mentioned advantageous effect by the diffusion of Fe tends to be insufficient. When the Fe content is more than 95%, the diffusion of Fe tends to become excessive and to make the Al content too low to obtain the corrosion resistance in the outermost layer in the multi-layer structure. In this specification, the percent % is used to mean "mass %" (percent by mass) unless otherwise specified.

[0021] The Al-Si-Fe alloy layer is made softer by the heat treatment and diffusion of Fe from the steel substrate. However, excessive diffusion of Fe could decrease the Al content below a level needed for the corrosion resistance. In order to maintain the minimum Al content from the viewpoint of corrosion resistance, and to form a layer softer than the steel base material, it is preferable to set the Al content within the range of 25~40% at least in one of three or more layers of the multi-layer structure. The corrosion resistance tends to be insufficient when the Al content is less than 25%. The formation of a softer layer becomes difficult, and the adhesion with the steel base could become poor when the Al content is more than 40%.

[0022] In the case of a multi-layer structure including three or more subordinate layers differing in composition or compound, there is one or more intermediate layers between an innermost layer contiguous with the steel substrate layer and an outermost layer forming the surface of the coating layer. Preferably, the intermediate layer or at least one of the intermediate layers contains 25~40% Al.

[0023] The weldability is improved by alloying of the aluminum coating layer with Fe diffused from the steel base material. The alloyed Al-Si-Fe coating layer is higher in melting point than an Al coating layer formed by hot dipping, so that welding is feasible from low current condition.

Moreover, adhesion of coating metal to a welding electrode is prevented in spot welding, to the advantage of improvement in consecutive spot welding.

[0024] Thermal stability is improved by alloying an Al-Si-Fe coating layer entirely into a multi-layer structure such as

a five-layer structure having five layers of different alloy compositions. A multi-layer structure including a hard outermost layer is advantageous for maintaining good contact with a welding gun in spot welding even under great pressure for high tension material.

[0025] As the Fe content increases with the progress of alloying between the aluminum coating layer and Fe diffused from the steel base, the thermal conductivity of the coating layer decreases and the welding with lower current becomes feasible. It is possible to combine weldability and corrosion resistance by making the Fe concentration in the surface or outermost layer of the coating in the rang of 35~50%. The coating layer having a surface Fe concentration in this range can be formed by forming an Al-Si-Fe layer having a multi-layer structure, or by forming an Al-Si-Fe layer having a concentration gradient of Fe content. The improvement in weldability is insufficient when the Fe concentration in the outermost layer is less than 35%. The Al content is decreased relatively and the corrosion resistance degrades when the Fe concentration in the outermost layer is more than 50%.

[0026] An aluminum-coated structural member having an Al-Si-Fe alloy layer on the surface as mentioned above can be obtained by the following process. First, a heat resisting hot-dip aluminum-coated steel sheet containing Si in a coating layer is heated at a rate of 1~10°C/sec to a temperature in the temperature range of 900~950°C, and held at that raised temperature for a holding time (or duration) of 2~8 minutes. In this case, the aluminum coating could melt locally when the hot-dip aluminum-coated steel sheet is heated at a heating rate faster than 10°C/sec to a temperature higher than 900°C. The coating layer could oxidize when the heating rate is slower than 1°C/sec. The progress of austenitizing in the steel base material is too slow to obtain a sufficient strength as a structural member when the raised temperature at which the specimen is held is lower than 900°C. When the raised temperature is higher than 950°C, the undesired oxidation of the coating layer proceeds, and the diffusion of Fe proceeds too much up to the surface of the coating layer. When the time for holding at the raised temperature is shorter than 2 minutes, then the formation of Al-Si-Fe alloy layer becomes insufficient. When the time for holding at the raised temperature is longer than 8 minutes, the oxidation of coating layer proceeds, and undesired influence is exerted on the adhesiveness of the coating film by electro deposition.

[0027] After the heat treatment for holding in the above-mentioned temperature range, the steel sheet is carried from a heating furnace to a forming press. During the transportation, cooling starts. In this case, the rate of cooling after the heat treatment is required to be 5~15°C/sec in order to perform the forming operation at a predetermined temperature and the rapid cooling from a predetermined temperature. When the cooling rate is slower than 5°C/sec, the oxidation of the coating layer becomes conspicuous. For cooling at a rate higher than 15°C/sec, the need arises for forced cooling.

[0028] The forming operation into a desired shape is started in the temperature range of 700~800°C. After the forming operation, the shaped sheet is cooled rapidly from the temperature range of 700~800°C, to a temperature lower than or equal to 300°C at a rate in the range of 20~100°C/sec. By this rapid cooling, the steel base material is cooled while preserving the Al-Si-Fe alloy layer formed by the heat treatment, and an aluminum-coated structural member of a desired shape is obtained. The above-mentioned conditions of the heat treatment are adequate also for quench hardening of the steel base material, and hence effective for enhance the strength of the material. To start the forming operation at a temperature higher than 800°C is not desirable because reheating is required and oxidation of coating is promoted. When the forming operation is started at a temperature lower than 700°C, the quenching temperature is too low for martensitic transformation. When the cooling rate after the forming operation is slower than 20°C/sec, the transformation to martensite is insufficient, and the diffusion of Fe proceeds too much. When the cooling rate after the forming operation is faster than 100°C/sec, the cost for facility is increased significantly for the need for improving a cooling system in production equipment. The rapid cooling to a temperature lower than or equal to 300°C is effective for preventing ferrite phase from being left over, and promoting martensitic transformation sufficiently.

[0029] The following is explanation on practical examples of the embodiment.

[0030] (Test 1) Aluminum-coated or aluminized structural members were produced under the following conditions and investigation was conducted on the formability, corrosion resistance and weldability.

[0031] [Hot-dip aluminum-coated steel sheet to be tested]

Composition of original sheet for coating: 0.22%C, 0.22%Si, 1.0%Mn, 0.015%P, 0.007%S.

Sheet thickness: 1.4mm.

Si concentration in Aluminum coating: 5%.

Thickness of aluminum coating layer: 10~20 μm.

[0032] [Test Procedure] From the above-mentioned hot-dip aluminum-coated steel sheet, a flat plate having a width of 160 mm, and a length of 160mm was cut out, heat-treated under the following conditions and formed into a shape shown in FIG. 1. Then, investigation was conducted on the composition of the alloy coating layer, hardness, formability, corrosion resistance and weldability.

<Conditions of Heat treatment>	
Heating rate	8°C/sec

(continued)

<Conditions of Heat treatment>	
Heating temperature	900~950°C
Holding time	2~10min
Rate of Primary cooling	7°C/sec
Temperature at a start of forming	720°C
Temperature at a start of rapid cooling	720°C
Rate of Secondary cooling (quenching)	30°C/sec
Temperature at an end of cooling	100°

[0033] [Results of Testing] Table 1 shows the results of the test. In all the cases in Table 1, a softest layer in a coating is a layer contiguous with a steel substrate layer of steel base material. Table 1 includes a column of production conditions, divided into a column of raised temperature and a column of hold time; a column of coating layer structure and composition (%), divided into a column of component and hardness, a column of inner layer (INNER), a column of first intermediate layer (INTER1), a column of a second intermediate layer (INTER2), a column of a third intermediate layer (INTER3), and a column of outer layer (OUTER); a column of hardness of steel base material (Hv); a column of hardness of coating layer (Hv), divided into a column of softest layer, a column of average, and a column of a range (%) softer than the base material; a column of oxide weight (mg/dm^2); a column of formability; a column of corrosion resistance; and a column of weldability.

[0034] <Formability> Cracking was checked in the Al-Si-Fe alloy layer after the forming operation. Test samples having no cracks reaching the steel substrate layer were evaluated as proper and indicated by a sign of a circle. Samples having one or more cracks reaching the steel substrate layer were evaluated as improper and indicated by a sign of a cross. The samples showed good formability except the structural member of No. 2 coated with a coating layer so hardened that an average hardness of the coating layer is greater than the hardness of the steel base material, and the hardness of the coating layer is harder in a region spreading over a depth range greater than 50% of the thickness of the alloy layer. As a typical example, FIG. 2A shows a micro structure of the coating layer in the structural member of No. 1 having no cracks, and FIG. 2B show a micro structure of the coating layer in the structural member of No. 2 suffering a crack.

[0035] <Corrosion Resistance> Produced structural members were subjected to a salt spray test (SST) as defined by JIS Z2371, to evaluate the corrosion resistance of each structural member. As a result, a poorer corrosion resistance was shown by the structural member of No. 3 in which the diffusion of Fe was excessive because of too long a holding time at the raised temperature, and hence the aluminum content was too low in the outermost layer.

[0036] <Weldability> Produced structural members were subjected to spot welding in succession under the conditions mentioned below. As the number of consecutive spots increases, in general, a nugget diameter tends to decrease and the weld strength tends to decrease. Accordingly, spot welding was carried out under the following welding conditions until the number of spots reaches a number smaller than a class A judgment reference in JIS Z3140. The weldability was determined in accordance with the number of consecutive spots. The No. 3 structural member was judged as improper and indicated by X since the number of consecutive spots was about 500 below the level of the judgment reference. As to the structural members other than the No. 3 structural member, numbers of spot welds up to 3000, to a level satisfying the judgment reference were obtained and the spot welding was ended at that point. Thus, the structural members other than the No. 3 specimen are indicated as proper by circle. Thus, the results of the test show that the weldability is degraded when the holding time for the heat treatment is too long and the diffusion of Fe softens the coating layer, as in the No. 3 sample. The No. 3 sample is poorer in corrosion resistance and weldability. However, the No. 3 sample is good in formability. Therefore, the No. 3 sample is still adequate for some applications.

[Welding Conditions]	
Base material	Aluminum-coated steel sheet (thickness of 1.2mm) and GA material (2.0 mm thick) of a type having a tensile strength of 440Mpa
Pressing Force	5.98 kN
Squeeze	50 Hz
Up slope	3 Hz
Energization	9kA×18Hz
Hold	21 Hz

[0037] (Test 2) By using a hot-dip aluminum-coated steel sheet heat-treated in the same manner as the No. 1 sample of Test 1, and a hot-dip aluminum-coated steel sheet not subjected to heat treatment, as a comparative sample, comparison was made about the characteristic of consecutive spot welds under the following conditions. Fig. 3 shows the results of the test 2 for samples of the embodiment and comparative samples. The sample using the hot-dip aluminum-coated steel sheet without heat treatment shows about 500 points whereas the sample of this example according to the present invention shows 3000 points or more.

(Test Conditions)	
Base material	Aluminum-coated steel sheet (1.2t) and GA material (2.0t) of a type having a tensile strength of 440Mpa
Pressing Force	610 kgf
Squeeze	50 cyc
Up slope	3 cyc
Energization	9kA×18 cyc
Hold	21 cyc

[0038] (Test 3) Hot-dip aluminum-coated steel sheets were held at 950°C for various lengths of time, to form an Al-Si-Fe alloy layer, and subjected to electro deposition coating onto the alloy layer. Then, the samples were checked to examine a relation between the oxide weight in the alloy layer and the paintability. The results are shown in Table 2. The oxide weight herein is defined as a difference in mass between the result of mass measurement by a chemical balance before the heating and the result of mass measurement after the heating.

[0039] As evident from Table 2, when the oxide weight becomes greater than 500mg/dm^2, the occurrence of pinhole becomes noticeable in the deposited coating film. In the samples impaired with pinholes, the adhesion of the coating film is insufficient, and the corrosion resistance is not improved sufficiently by the electro deposition coating.

[0040] In the aluminum-coated structural member according to the embodiment of the present invention, the Al-Si-Fe alloy layer on the steel substrate or base layer prevents a hard layer from being formed between the steel substrate and the coating, and instead forms a softer region ranging wide in the depth direction. Moreover, the alloy layer is low in the oxide weight. Therefore, the embodiment can improve the formability and the paintability, and attain both corrosion resistance and weldability by balancing the Al content and Fe content.

[0041] In the production method according to the embodiment of the present invention, a steel sheet coated with a hot-dip aluminum coating layer containing Si is heat-treated, formed into a desired shape, and cooled rapidly. Therefore, this production method can improve the corrosion resistance, paintability, weldability and formability.

[0042] This application is based on a prior Japanese Patent Application No. 2002-202770 filed on July 11, 2002. The entire contents of this Japanese Patent Applications No. 2002-202770 are hereby incorporated by reference.

[0043] Although the invention has been described above by reference to certain embodiments of the invention, the invention is not limited to the embodiments described above. Modifications and variations of the embodiments described above will occur to those skilled in the art in light of the above teachings. The scope of the invention is defined with reference to the following claims.

Claims

1. An aluminum-coated structural member comprising:

   a steel substrate layer; and
   an Al-Si-Fe alloy layer formed on a surface of the steel substrate layer, the alloy layer including a softer region having a hardness smaller than or equal to a hardness of the steel substrate layer, extending from the surface of the steel substrate layer toward a surface of the alloy layer, and having a thickness greater than or equal to 50% of a thickness of the alloy layer, the Al-Si-Fe alloy layer having an oxide weight smaller than or equal to 500 mg/dm^2.

2. The aluminum-coated structural member as claimed in Claim 1, wherein the Al-Si-Fe alloy layer has a multi-layer structure including an inner layer contiguous with the steel substrate layer, and an outer layer forming the surface of the alloy layer.

3. The aluminum-coated structural member as claimed in Claim 2, wherein the inner layer is a softest layer in the

multi-layer structure.

4. The aluminum-coated structural member as claimed in Claim 2 or 3, wherein the inner layer contains 85~95% Fe, and the inner layer is softer in Hv hardness than an average hardness of the alloy layer by a percentage more than or equal to 20%.

5. The aluminum-coated structural member as claimed in Claim 2, 3 or 4, wherein the multi-layer structure of the Al-Si-Fe alloy layer further comprises an intermediate layer containing 25~40% Al, and the intermediate layer is lower in hardness than the steel substrate layer.

6. The aluminum-coated structural member as claimed in Claim 2, 3 or 4, wherein the multi-layer structure of the Al-Si-Fe alloy layer further comprises a plurality of intermediate layers, at least one of the intermediate layers containing 25~40% Al, and being lower in hardness than the steel substrate layer.

7. The aluminum-coated structural member as claimed in Claim 2, 3, 4, 5 or 6, wherein the outer layer of the Al-Si-Fe alloy layer is harder than the steel substrate layer.

8. The aluminum-coated structural member as claimed in Claim 2, 3, 4, 5, 6 or 7, wherein the outer layer contains 35~50% Fe.

9. An aluminum-coated structural member comprising:

a steel substrate layer; and
an Al-Si-Fe alloy layer formed on a surface of the steel substrate layer, the Al-Si-Fe alloy layer having a multi-layer structure including an inner layer contiguous with the steel substrate layer, an outer layer forming a surface of the alloy layer and an intermediate layer formed between the inner and outer layers, the inner layer containing 85~95% Fe, the intermediate layer containing 25~40% Al, and the outer layer being harder than the steel substrate layer.

10. A production method of an aluminum-coated structural member comprising:

heating a hot-dip aluminum-coated steel sheet at a heating rate in a range of 1~10°C/sec;
holding the hot-dip aluminum steel sheet at a raised temperature in a temperature range of 900~950°C for a duration in a range of 2~8 minutes;
cooling the hot-dip aluminum-coated steel sheet to a temperature in a temperature range of 700~800°C at a cooling rate in a range of 5~15°C/sec;
forming the hot-dip aluminum-coated steel sheet into a predetermined shape in the temperature range of 700~800°C; and
cooling the hot-dip aluminum-coated steel sheet in the predetermined shape rapidly from the temperature range of 700~800°C to a lower temperature lower than or equal to 300°C at a cooling rate in a range of 20~100°C/sec.

FIG.1

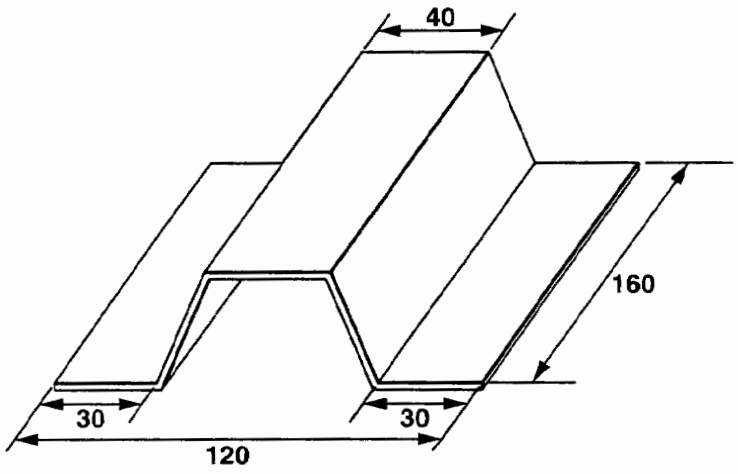

FIG.2A

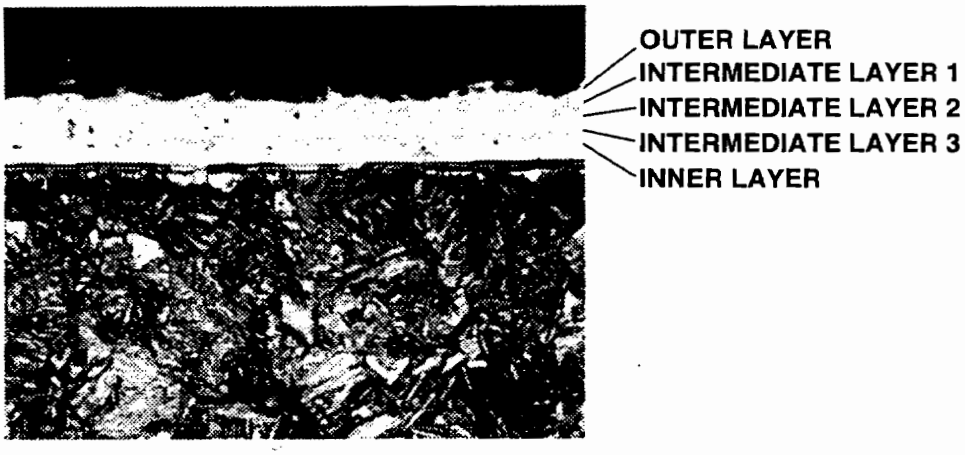
OUTER LAYER
INTERMEDIATE LAYER 1
INTERMEDIATE LAYER 2
INTERMEDIATE LAYER 3
INNER LAYER

FIG.2B

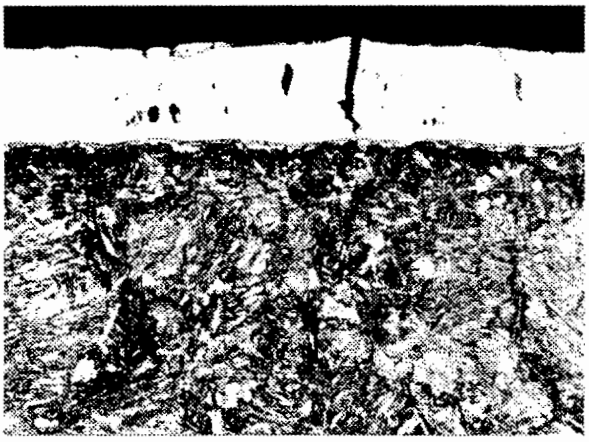

FIG.3

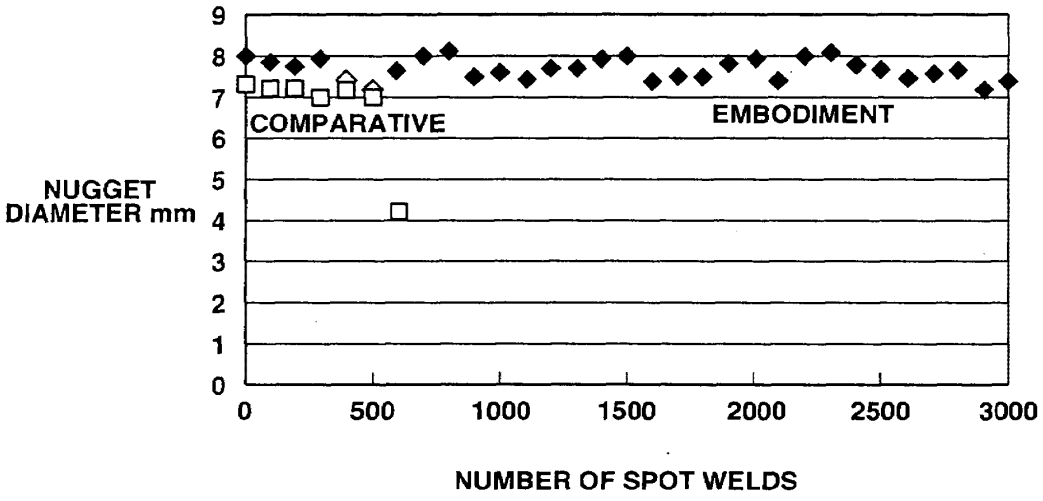
NUGGET DIAMETER mm
9
8
7
6
5
4
3
2
1
0
COMPARATIVE
EMBODIMENT
0
500
1000
1500
2000
2500
3000
NUMBER OF SPOT WELDS

FIG.4

TABLE 1

No.	PRODUCTION		COATING LAYER STRUCTURE & COMPOSITION (%)						STEEL BASE HARDNESS (Hv)	COATING LAYER HARDNESS (Hv)			OXIDE WEIGHT (mg/dm²)	FORMABILITY	CORROSION RESISTANCE	WELDABILITY
	RAISED TEMPERATURE (°C)	HOLD TIME (min.)	COMPONENT & HARDNESS	INNER	INTER 1	INTER 2	INTER 3	OUTER		SOFTEST	AVERAGE	SOFTER RANGE (%)				
1	920	3	Al	7.7	31.0	48.4	31.6	54.8	450	310	415	51	300	○	○	○
			Si	2.0	3.9	1.2	5.7	0.8								
			Fe	89.6	65.9	50.1	62.0	44.5								
			Hv	310	360	750	700	800								
2	900	2	Al	27.2	48.4	31.6		54.9	415	380	455	22	275	×	○	○
			Si	4.1	1.2	5.7	—	0.8								
			Fe	67.2	50.1	61.9		44.1								
			Hv	380	760	720	—	810								
3	930	10	Al	9.4				11.6	400	305	385	78	550	○	×	×
			Si	1.3	—	—	—	1.8								
			Fe	88.4				85.7								
			Hv	305	—	—	—	410								
4	950	5	Al	6.0	27.8	51.9	30.4	47.4	440	280	400	59	385	○	○	○
			Si	1.5	4.3	0.6	5.3	2.2								
			Fe	90.7	66.7	46.8	63.1	49.8								
			Hv	280	340	720	690	800								
5	900	4	Al	3.2	54.5	33.4		54.5	440	300	410	56	335	○	○	○
			Si	0.4	2.5	15.3	—	6.8								
			Fe	94.3	42.7	51.4		38.4								
			Hv	300	740	700	—	810								

FIG.5

TABLE 2

HEATING TEMPERATURE (°C)	HOLDING TIME (min.)	OXIDE WEIGHT (mg/dm^2)	ADHESION	
			PIN HOLE	CROSS CUT TEST
950	3	290	NONE	○
	5	385	NONE	○
	10	540	PRODUCED	×
	15	690	PRODUCED	×
	20	760	PRODUCED	×
	25	790	PRODUCED	×
	30	805	PRODUCED	×

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 03 01 3731

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
X	US 4 517 229 A (NICKOLA RICHARD A ET AL) 14 May 1985 (1985-05-14) * column 2, line 54 - column 10, line 49 * ---	1-9	C23C2/12 C23C2/28 B32B15/01
X	PATENT ABSTRACTS OF JAPAN vol. 004, no. 135 (C-025), 20 September 1980 (1980-09-20) & JP 55 085623 A (NISSHIN STEEL CO LTD), 27 June 1980 (1980-06-27) * abstract * ---	1-9	
X	US 4 546 051 A (KATAYAMA KIICHIRO ET AL) 8 October 1985 (1985-10-08) * column 2, line 40 - column 6, line 55 * ---	1-9	
A	FR 1 391 659 A (COMMISSARIAT ENERGIE ATOMIQUE;POMPEY ACIERIES) 12 March 1965 (1965-03-12) * the whole document * -----	1-10	

TECHNICAL FIELDS SEARCHED (Int.Cl.7)

C23C
B32B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
MUNICH	11 November 2003	Brisson, O

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
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L : document cited for other reasons

& : member of the same patent family, corresponding document

EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 03 01 3731

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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11-11-2003

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 4517229 A	14-05-1985	AT 36874 T	15-09-1988
		CA 1223158 A1	23-06-1987
		DE 3473775 D1	06-10-1988
		EP 0149655 A1	31-07-1985
		JP 5055594 B	17-08-1993
		JP 60501765 T	17-10-1985
		WO 8500386 A1	31-01-1985
		US 4837091 A	06-06-1989
		US 4666794 A	19-05-1987
JP 55085623 A	27-06-1980	JP 1323056 C	27-06-1986
		JP 60048570 B	28-10-1985
US 4546051 A	08-10-1985	NONE	
FR 1391659 A	12-03-1965	NONE	

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

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(54) COATED STEEL STRIPS, METHODS OF MAKING THE SAME, METHODS OF USING THE SAME, STAMPING BLANKS PREPARED FROM THE SAME, STAMPED PRODUCTS PREPARED FROM THE SAME, AND ARTICLES OF MANUFACTURE WHICH CONTAIN SUCH A STAMPED PRODUCT

(57) Coated steel having a well defined and uniform thickness is useful and advantageous for preparing products by hot stamping. Products prepared by hot stamping such a steel are particularly advantageous when subjected to a subsequent spot welding step.

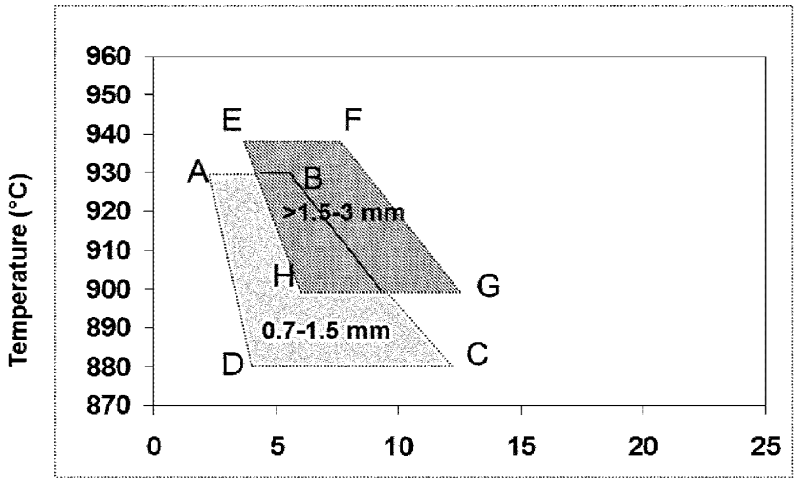

FIG.7

EP 3 290 200 A1

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Description

FIELD OF THE INVENTION

[0001] The present invention relates to, among other things, coated steels, methods of making such coated steels, including hot dipping, methods of using such coated steels, stamping blanks prepared from coated steels, stamped products prepared from coated steels, and to various uses of the invention products such as in spot welding, etc.

[0002] Additional advantages and other features of the present invention will be set forth in part in the description that follows and in part will become apparent to those having ordinary skill in the art upon examination of the following or may be learned from the practice of the present invention. The advantages of the present invention may be realized and obtained as particularly pointed out in the appended claims. As will be realized, the present invention is capable of other and different embodiments, and its several details are capable of modifications in various obvious respects, all without departing from the present invention. The description is to be regarded as illustrative in nature, and not as restrictive.

BACKGROUND OF THE INVENTION

[0003] In recent years the use of pre-coated steels in hot-stamping processes for the shaping of parts has become important, especially in the automotive industry. Fabrication of such parts may include the following main steps:

- Pre-coating of a steel sheets, by hot dipping
- Trimming or cutting for obtaining blanks
- Heating the blanks in order to obtain alloying of the steel substrate with the pre-coating, as well as the austenitizing of the steel
- Hot forming followed by rapid cooling of the part in order to obtain predominantly martensitic structures

See for Example U.S. 6,296,805, incorporated herein by reference.

[0004] Thanks to an alloying of the pre-coating with the steel substrate, which has the effect of creating intermetallic alloys with high melting temperature, the blanks having such coating may be heated in a temperature range where austenitizing of the metallic substrate takes place, allowing further hardening by quenching.

[0005] Heat treatments of the blanks in view of the intermetallic alloying of the coating and austenitizing of the substrate are most frequently performed in furnaces, where blanks are traveling on rollers. The thermal cycles experienced by the blanks include first a heating phase whose rate is a function of parameters such as blank thickness, furnace temperature, traveling speed, and coating reflectivity. After this heating phase, thermal cycles generally include a holding phase, whose temperature is the regulation temperature of the furnace. Problems however are experienced with the furnace operation: the rollers may become fouled by metallic deposits which come from the pre-coating of the blanks. If these deposits are excessive, maintenance of the rollers has to be performed and productivity is decreased.

[0006] Parts obtained after heating and rapid cooling display very high mechanical resistance and may be used for structural applications, for example for automotive industry applications. These parts must be frequently welded with others and high weldability is required. This means that:

- The welding operation should be performable in a sufficiently wide operating range in order to guarantee that an eventual drift of the nominal welding parameters has no incidence on weld quality. For resistance welding, which is very common in the automotive industry, an operating welding range is defined by the combination of parameters: welding current intensity I and force F applied of the parts during welding being among the most important. A proper combination of these parameters helps to ensure that insufficient nugget diameter is not obtained (caused by too low intensity or too low force) and that no weld expulsion occurs.
- The welding operation should also be performed in such a way that high mechanical resistance is obtained on the weld. This mechanical resistance may be evaluated by tests such as by shear-tensile tests or cross-tensile tests.

[0007] There remains a need for coated steels which may be conveniently used to prepare shaped parts by a stamping process. There also remains a need for coated steels which may be used to prepare shaped parts by a stamping process which are suitable for welding. There also remains a need for processes for preparing such coated steels and stamped parts.

SUMMARY OF THE INVENTION

[0008] The inventors have discovered that certain coated steels in which a base steel strip is at least partially coated (sometimes termed "pre-coated," this prefix indicating that a transformation of the nature of the pre-coating will take place during heat treatment before stamping) on at least one side with a coating of either aluminum or an aluminum alloy and in which the coating has a defined thickness and is preferably substantially uniform, are conveniently formed into shaped parts after heating by stamping and are conveniently welded. In addition, the inventors have discovered that the roller fouling problem described above generally arises from an insufficient degree of intermetallic alloying between the substrate and the metallic pre-coating. Furthermore, it was discovered that the location of the fouling of the rollers corresponds to zones of the blanks in contact with the rollers where

the metallic pre-coating thickness locally exceeds the average thickness. While not bound by a particular theory, it is believed that if a pre-coating is locally too thick, intermetallic alloying is insufficient and the pre-coating melts, fouling the rollers. Thus, the inventors have discovered that the control of the homogeneity of the pre-coating thickness over the entire sheet within given tolerances is an important factor for obtaining the desired degree of intermetallic alloying, allowing one to improve the resistance to the subsequent melting of the coating during travel on rollers.

[0009] The inventors have also discovered that particularly good weldability of aluminized and hot stamped parts is associated with a special succession of coating layers on the parts, proceeding from steel substrate outwards.

[0010] The inventors have also discovered that a specific combination of transfer time between the heating furnace and the stamping die, the amount of deformation during stamping, the temperature of stamping, the cooling rate of the product during stamping, leads to the fabrication of a part with a fully homogeneous martensitic structure and that an increase in ductility or energy absorption of the parts after stamping is obtained by a reduction of sulfur below a critical value, these two benefits being obtained with or without the invention aluminum/aluminum alloy coating, and with other coatings.

OBJECTS OF THE INVENTION

[0011] Accordingly, and in view of the above, it is one object of the present invention to provide novel pre-coated steels strips which may be conveniently processed into stamping blanks.

[0012] It is another object of the present invention to provide novel pre-coated steels strips or sheets which may be conveniently formed into parts by stamping.

[0013] It is another object of the present invention to provide novel coated steels which may be conveniently formed into parts by hot stamping.

[0014] It is another object of the present invention to provide novel methods for making such a coated steel.

[0015] It is another object of the present invention to provide novel stamping blanks which are prepared from such a coated steel.

[0016] It is another object of the present invention to provide novel methods of making such stamping blanks.

[0017] It is another object of the present invention to provide novel stamped parts which are prepared from such a coated steel.

[0018] It is another object of the present invention to provide novel methods of making such stamped parts.

[0019] It is another object of the present invention to provide novel articles of manufacture, such as a motor vehicle, which contain such stamped parts.

[0020] It is another object of the present invention to provide novel stamped parts.

[0021] It is another object of the present invention to provide novel methods of making welded stamped parts.

[0022] It is another object of the present invention to provide novel articles of manufacture, such as a motor vehicle, which contain such welded stamped parts.

[0023] It is another object of the present invention to provide novel welded coated steels and welded stamping blanks.

[0024] It is another object of the present invention to provide novel methods of making such welded coated steels and welded stamping blanks.

[0025] These and other objects, which will become apparent during the following detailed description.

BRIEF DESCRIPTION OF THE DRAWINGS

[0026]

Figure 1 illustrates a preferred embodiment of an invention coated part, after heat treatment and stamping. The succession of layers of the coating on the steel substrate is: (a) interdiffusion layer; (b) intermediate layer; (c) Intermetallic layer; and (d) superficial layer. This arrangement is particularly favorable for the further welding of the part.

Figure 2 illustrates a coating of a steel substrate after heat treatment and stamping which does not correspond to the invention. This succession of layers (interdiffusion layer and intermetallic layer) yields inferior results in resistance spot welding.

Figure 3 illustrates a microstructure of a steel part, hot stamped and cooled under conditions not according to the invention.

Figure 4 illustrates the microstructure of a steel part, hot stamped and cooled according to a preferred set of conditions according to the invention.

Figure 5 illustrates the influence of sulfur on the bending angle of parts after hot stamping.

Figure 6 illustrates the influence of sulfur on the initiation energy of fracture of parts after hot stamping.

Figure 7 shows conditions of furnace temperature as a function of the total dwell time in the furnace for sheets of total thicknesses of from 0.7-1.5 and 1.5-3 mm that provide particularly favorable coatings for welding.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0027] As noted above, the inventors' discovery that certain coated steels, in which a base steel is at least partially pre-coated on at least one side with a coating of either aluminum or an aluminum alloy and in which the pre-coating has a defined thickness and is substantially uniform, are conveniently formed into shaped parts by stamping, forms one basis for the invention.

[0028] In the context of the present invention, the terms first side (or side 1) and second side (or side 2) of the strip or sheet, etc., of base steel refer to the two large,

opposite-facing, surfaces which have a surface area defined by the length and width of the strip of base steel. In contrast, the side edges of the strip of base steel are the two small, opposite-facing, surfaces which have a surface area defined by the length and thickness of the strip. The top and bottom edges of the strip of base steel are the two small, opposite-facing, surfaces which have a surface area defined by the width and thickness of the strip. In the following, t_p designates the thickness of the pre-coating, at any considered location on the sides 1 and 2 of a sheet or a blank. In particular, in the case of sheets coated on two sides 1 and 2, t_{p1} stands for the thickness on side 1, and t_{p2} for the thickness on side 2. According to a highly preferred embodiment t_p is controlled in a precise range, expressed by (t_{pmin}, t_{pmax}), in order to improve the resistance to the fouling of the rollers. The thickness is preferably controlled, both in the longitudinal (or rolling) direction of the strip or sheet, as well in the transverse direction.

[0029] In relation to the problem of the fouling of rollers, the control of the pre-coating thickness on the side of the sheet or blank which is directly in contact with the rollers is especially important. Because different operations can follow the step of coating the steel sheet (for example hot-dip-coating which provides coated sides 1 and 2), it is preferable to carefully control the pre-coating on both sides of the sheet. For example, after any of coiling, handling, cutting, punching, etc., sides 1 and 2 may be not readily identifiable. But when control of t_p is effected on the two sides of the sheet that has been coated (first side and second side) it is not necessary to track sides 1 and 2 as neither side will foul the roller. In addition, it is not necessary to trim the sheet in order to obtain a preferred smaller sheet having a more uniform homogeneity of pre-coating thickness, thus providing a sheet that is pre-coated by, e.g., hot-dipping. In other words, important benefits are obtained when one controls the pre-coating minimum and maximum thickness of the first side (t_{pmin1} , t_{pmax1}) and the pre-coating minimum and maximum thickness of the second side (t_{pmin2} , t_{pmax2}) of the subject steel sheet or blank.

Hot-dip coated steels are the preferred steels herein. However, regardless of the coating method, the pre-coating thickness on one or both sides of the sheet can be measured and monitored continuously on a coating line directly after the coating operation. This may be realized by devices known per se, such as thickness gages relying on X-Ray absorption. At every moment, the measurement of thickness at a given location may be performed for example on an area of a few hundreds of mm^2, this representing the dimension of the zone irradiated by X-Ray.

[0030] In a preferred embodiment, a plurality of such devices are positioned at different distances in the transverse direction of the strip in order to obtain a profile of the thickness of the pre-coating along the strip width.

[0031] The inventors have discovered that the resistance to the pollution or fouling of the rollers in the furnaces is improved when the minimum and maximum thickness respectively of at least one of the first side (t_{pmin1}, t_{pmax1}) and the second side (t_{pmin2}, t_{pmax2}) are respectively equal to 20 and 33 micrometers (a micrometer is the same as a micron and is a metric unit of length equal to one millionth of a meter). In other words, in a preferred embodiment, at every location on at least one face of the sheet or the blank, the thickness t_p of the pre-coating is preferably from 20 - 33 micrometers in thickness, including 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31 and 32 micrometers and all ranges and subranges therebetween, and including all numbers between each listed value as if written out in its entirety (e.g., 22.34 micrometers). For hot-dip coating, precise control of this range of pre-coating thickness can be realized on an operating line for example using a system of nozzles blowing gas after coating, for example after exit of the strip or sheet from a bath, and by the flatness of the strip. Number, geometry and location of the nozzles, and flow rates are among the main parameters for a precise control of the thickness t_p. Given the present disclosure, one of ordinary skill in this art can control the pre-coating thickness as described herein without undue labor.

The invention refers to strips produced in industrial conditions, i.e. where control of pre-coating thickness is effective over a wide surface strip, i.e. with a length greater than 100m, and with a width greater than 600mm. In such a way, blanks cut or trimmed out these strips display very high homogeneity of pre-coating thickness, and the settings of the heating treatments in the furnace do not have to be changed for being adapted to eventual variations of this thickness.

[0032] While not bound by a particular theory of operation, the inventors believe that several of the benefits of the invention are related to this pre-coating thickness range, such as the following :

- For a pre-coating thickness less than 20 micrometers, the alloyed layer which is formed during the heating of the blank has an insufficient roughness. Thus, the adhesion of subsequent painting is low on this surface, and the corrosion resistance is decreased.
- If the pre-coating thickness is more than 33 micrometers at a given location on a sheet, the risk is that the difference of thickness between this location and some other locations where the pre-coating is thinner, becomes too important : The settings of the heating treatment in the furnace may be adapted to the thinner value of the pre-coating, but not to the thicker one. Thus, the alloying reaction forming the intermetallic alloy may take place to an insufficient degree since the mean diffusion distance of the elements in the pre-coating becomes significantly less than the local value of the pre-coating thickness. As a matter of results, alloying will become much more difficult in the external (or superficial) part, particularly in the case of high heating rate.

[0033] Thus, in a first embodiment, the present invention provides certain coated steel strips, which comprise a strip of base steel and a pre-coating of aluminum or an aluminum alloy on at least a part of one side of the strip of the base steel. For many applications, the strip of base steel may comprise any type of steel which may be coated with either aluminum or an aluminum alloy. However, for certain applications, such as a structural part of an automobile, it is preferred that the strip of base steel comprise an ultra high strength steel (UHSS). In such cases, it is particularly preferred that the strip of base steel comprises a boron steel.

[0034] The inventors have also discovered that good welding results are achieved if the coating obtained on parts made out of blanks having undergone intermetallic alloying, austenitizing and hot stamping, displays distinctive features. It must be pointed out that this coating is different from the initial pre-coating, since the thermal treatment causes an alloying reaction with the steel substrate which modifies both the physico-chemical nature and the geometry of the pre-coating : in this regard, the inventors have discovered that particularly good weldability of aluminized and hot stamped parts is associated with the following succession of coating layers on the parts, proceeding from steel substrate outwards :

- (a) Interdiffusion layer,
- (b) Intermediate layer,
- (c) Intermetallic layer,
- (d) Superficial layer

See, e.g., Figure 1. In a preferred embodiment these layers are as follows:

- (a) Interdiffusion layer, preferably with medium hardness (e.g., HV50g between 290 and 410, HV50g designating the hardness measured under a load of 50 grams) In a preferred embodiment this layer has the following composition, by weight: 86-95%Fe, 4-10%Al, 0-5%Si
- (b) Intermediate layer (HV50g around 900 - 1000 e.g., +/- 10%)) In a preferred embodiment this layer has the following composition, by weight : 39-47% Fe, 53-61%Al, 0-2%Si
- (c) Intermetallic layer, with hardness HV50g around 580-650, e.g., +/- 10%) In a preferred embodiment this layer has the following composition, by weight : 62-67%Fe, 30-34 %Al, 2-6%Si
- (d) Superficial layer (HV50g around 900 - 1000 e.g., +/- 10%))

[0035] In a preferred embodiment this layer has the following composition, by weight : 39-47% Fe, 53-61%Al, 0-2%

In a preferred embodiment the total thickness of layers (a) to (d) is greater than 30 micrometers.

In another preferred embodiment, the thickness of layer (a) is less than 15 micrometers, for example 14, 12, 10, 8, 6, 4, 2, or 1 micrometers, and all whole numbers, ranges and subranges therebetween, and including all numbers between each listed value as if written out in its entirety (e.g., 13.84 micrometers).

[0036] The inventors have discovered that high weldability is especially obtained when layers (c) and (d) are essentially continuous (i.e.: occupying at least 90% of the level corresponding to the considered layer) and when less than 10% of layer (c) is present at the extreme surface of the part. Without being bound by a theory, it is thought that this particular layer disposal, in particular layer (a) and layers (c) and (d) influence the resistivity of the coating both by their intrinsic characteristics and by the effect of roughness. Thus, current flow, heat generation at the surfaces, and nugget formation in the initial stage of spot welding are affected by this particular arrangement.

This favorable layer disposition is obtained for example when aluminum- or aluminum alloy pre-coated steel sheets, whose thickness range from, e.g., 0.7 to 3mm, are heated for 3 to 13 minutes (this dwell time includes the heating phase and the holding time) in a furnace heated to a temperature of 880 to 940°C. Other conditions leading to such favorable layer dispositions are found in Figure 7:

For sheets of total thicknesses greater or equal to 0.7mm, and less than or equal to 1.5mm, the preferred treatment conditions : (furnace temperature, total dwell time in the furnace) are illustrated in figure 7 by conditions lying within the limits of diagram "ABCD"

For sheets of total thicknesses greater than 1.5mm, and less than or equal to 3mm, the preferred treatment conditions : (furnace temperature, total dwell time in the furnace) are illustrated in figure 7 by diagram "EFGH" .

The heating rate V_c is comprised between 4 and 12°C/s for producing a favorable alloyed layer disposition. In this regard, this "heating rate" reflects the temperature rise which is experienced by the pre-coated steel upon being located in the preheated furnace. V_c is defined as the mean heating rate between 20 and 700°C. The inventors have discovered that the control of V_c in this precise range is a key factor, because it controls directly the nature and the morphology of the alloyed layers which are formed. It is here underlined that the heating rate V_c is different from the mean heating rate, which is the heating rate between room temperature and furnace temperature. The rates of 6, 7, 8, 9, 10, and 11 °C/s are included as are all numbers, ranges and subranges therebetween, and including all numbers between each listed value as if written out in its entirety (e.g., 7.7 °C/s). In this regard, all of the conditions specified within Figure 7 are incorporated herein by reference thereto. Particularly preferred conditions are:

(for thicknesses of 0.7-1.5mm)

- 930°C, from 3 minutes up to 6 minutes;
- 880°C, from 4 minutes 30 seconds up to 13 minutes

(for thicknesses of 1.5 to 3 mm)

- 940°C, from 4 minutes up to 8 minutes;
- 900°C, from 6 minutes 30 seconds up to 13 minutes

A special advantage arises from pre-coatings whose thickness is comprised between 20 and 33 micrometers, since this thickness range yields favorable layer disposal, and since the homogeneity of the pre-coating thickness is associated to an homogeneity of the coating formed after alliation treatment.

[0037] Heated blanks are thereafter transferred to a die, hot stamped to obtain a part or product, and cooled at a rate of more than 30°C/s. The cooling rate is defined here as the mean rate between the exit of the heated blank from the furnace, down to 400°C.

[0038] The strip of base steel is coated with either aluminum or an aluminum alloy. Commercially pure aluminum is known in the art as Type 2 aluminum, while alloys of aluminum with 5 to 11 % by weight of silicon are known in the art as Type 1 aluminum. Silicon is present in order to prevent the formation of a thick iron-metallic intermetallic layer which reduces adherence and formability. Other alloying elements useful with aluminum herein include iron, between 2.5 and 3% by weight, and calcium, between 15 and 30ppm by weight, including combinations of two or more thereof with aluminum.

[0039] A typical metal bath for an Al-Si coating generally contains in its basic composition by weight, from 8% to 11% silicon, from 2% to 4% iron, the remainder being aluminum or aluminum alloy, and impurities inherent in processing. Typical composition of Al-Si coating is: Al-9,3%Si-2,8%Fe. Invention coatings are not limited to these compositions, however.

[0040] The strip of base steel used herein may be any which can be coated by a conventional coating technique. For example, the strip of base steel may be any hot rolled strip, such as those prepared by hot rolling a steel slab (either with or without subsequent cold rolling). Typically, the strip of base steel will be stored and transported in the form of a coil both before and after the formation of the coating.

[0041] An example of a preferred steel for the strip of base steel is one having the following composition by weight:

0.10% < carbon < 0.5%
0.5% < manganese < 3%
0.1% < silicon < 1%
0.01% < chromium < 1%
titanium < 0.2%
aluminum < 0.1%
phosphorus < 0.1%
sulfur < 0.05%
0.0005% < boron < 0.010%,

the remainder comprising, consisting essentially of, or consisting of iron and impurities inherent in processing. Use of such a steel provides a very high mechanical resistance after thermal treatment and the aluminum-based coating provides a high resistance to corrosion.

[0042] Particularly preferably, the composition by weight of the steel in the strip of base steel is the following:

0.15% < carbon < 0.25%
0.8% < manganese < 1.8%
0.1% < silicon < 0.35%
0.01% < chromium < 0.5%
titanium < 0.1%
aluminum < 0.1%
phosphorus < 0.1%
sulfur < 0.05%
0.002% < boron < 0.005%,

the remainder comprising, consisting essentially of, or consisting of iron and impurities inherent in processing.

[0043] A preferred strip herein is 100 m long and 600mm wide. Preferred thicknesses are 0.7 to 3 mm.

[0044] Even more preferably, in the composition by weight of the sheet, the weight ratio of titanium content with respect to the nitrogen content is in excess of 3.42, believed to be a level at which the boron is no longer able to combine with the nitrogen.

[0045] An example of preferred commercially available steel for use in the strip of base steel is 22MnB5.

[0046] Chromium, manganese, boron and carbon may be added, in the composition of the steel according to the invention, for their effect on hardenability. In addition, carbon makes it possible to achieve high mechanical characteristics thanks to its effect on the hardness of the martensite.

[0047] Aluminum is introduced into the composition, to perform deoxidation in the liquid state and to protect the effectiveness of the boron.

[0048] Titanium, the ratio of the content of which with respect to the nitrogen content should be in excess of 3.42, is introduced for example in order to prevent combining of the boron with the nitrogen, the nitrogen being combined with titanium.

[0049] The alloying elements, Mn, Cr, B, make possible a hardenability allowing hardening in the stamping tools or the use of mild hardening fluids limiting deformation of the parts at the time of thermal treatment. In addition, the composition according to the invention is optimized from the point of view of weldability.

[0050] The steel in the sheet may undergo a treatment for globularization of sulfides performed with calcium, which has the effect of improving the fatigue resistance of the sheet.

[0051] As mentioned above, ultra-high-strength can be provided with the steel sheet coated and hot stamped according to the invention. This high level of strength is sometimes associated with a limited ductility. In applications requiring a higher ductility, in particular when an ability for bending is required from a part or a product, the inventors have discovered that increased ductility can

be obtained if sulfur is particularly controlled: when the sulfur level of base steel is lower than or equal to 0.002% (20 ppm), the bending angle can be greater than 60° and enhanced ductility and tearing resistance are obtained on the parts having experienced heat treatment and stamping. Preferred levels include 20, 18, 15, 13, 10, 8, 5, 2, etc ppm sulfur. In fact, this benefit applies to steels in general, and is not limited to coated steels or to steels coated with Al or Al alloy coatings. While not bound by a particular theory, when analyzing causes of premature failure of some parts in bending operations, the inventors observed that failure initiated on sulfide inclusions. It is thus believed that decohesions between inclusions and the martensitic or bainito-martensitic matrix act as stress-concentration factors and trigger further crack propagation in the ductile mode.

[0052] The invention also concerns a process for producing a part starting from an invention coated sheet, then cut into a blank which, after shaping, the coating of the blank is subjected to an increase in temperature at a speed in excess of 4°C/second, but lower than 12°C/second. The heating rate V_c is defined as the mean rate between 20 and 700°C.

[0053] The invention also concerns the use of a hot-rolled steel sheet which then can be cold-rolled and coated, for structural and/or anti-intrusion or substructure parts for a land motor vehicle, such as, for example, a bumper bar, a door reinforcement, a wheel spoke, etc.

[0054] The sheet according to the invention described above can derive, by reason of its processing, from a hot-rolling mill, and possibly may be cold-rerolled again depending on the final thickness desired. It then is coated with an aluminum-based coating, for example by dipping in a bath containing, in addition to the aluminum source/alloy, e.g., from 8% to 11% silicon and from 2% to 4% iron, the sheet having a high mechanical resistance after thermal treatment and a high resistance to corrosion, as well as a good capacity for painting and gluing.

[0055] The coating is preferably controlled as above, and has in particular the function of protecting the basic sheet against corrosion in various conditions. The thermal treatment applied at the time of a hot-forming process or after forming makes it possible to obtain high mechanical characteristics which can exceed 1500 MPa for mechanical resistance and 1200 MPa for yield stress. The final mechanical characteristics are adjustable and depend in particular on the martensite fraction of the structure, on the carbon content of the steel and on the thermal treatment. At the time of thermal treatment performed on a finished part or at the time of a hot-shaping process, the coating forms a layer having a substantial resistance to abrasion, wear, fatigue, shock, as well as a good resistance to corrosion and a good capacity for painting and gluing. The coating makes it possible to avoid different surface-preparation operations such as for steel sheets for thermal treatment not having any coating.

[0056] The steel sheet can be pre-coated by dipping, after pickling, in an aluminum bath containing for example only aluminum or either aluminum and from 8% to 11% silicon and 2% to 4% iron, or only from 2% to 4% iron, or even in an aluminum bath preferably containing from 9% to 10% silicon and 2% to 3.5% iron. The aluminum may be aluminum per se or an aluminum alloy.

[0057] In an example of implementation of a coating of the sheet by dipping in a metal bath containing an aluminum alloy comprising a proportion of approximately 90% aluminum, the coating layer comprises a first alloy layer in contact with the surface of the steel. This layer, directly in contact with the surface of the sheet, is highly alloyed with iron.

[0058] A second coating layer, on top of the first, contains approximately 90% aluminum and may contain silicon and a small amount of iron, depending on the composition of the bath.

[0059] The first alloy layer may crack when the sheet is submitted to high strains during cold forming operations of the manufacture of parts.

[0060] According to the invention, after the forming of the part, the coating is subjected to an increase in temperature at a speed in excess of 4°C /second. This rise in temperature makes possible a rapid remelting of the aluminum which fills in the cracks generated by the operation of shaping of the part.

[0061] At the time of thermal treatment, the base coating, of aluminum for example, is transformed into a layer alloyed with iron and comprising different phases depending on the thermal treatment and having a considerable hardness which may exceed 600 HV50 g.

[0062] Another advantage of the invention lies in the fact that the diffusion of the iron in the coating is initiated at high temperature. One thus will have a better cohesion between coating and steel in the sheet. In another form of the invention, the thermal treatment may be performed locally, in heavily deformed zones.

According to the invention, the sheet, in the delivery state in a coil or in a sheet, the thickness of which may range between 0.25 mm and 15 mm, has good forming properties and a good resistance to corrosion as well as a good capacity for painting or gluing. Preferably, the steel sheet or blank has a thickness less than 3 mm, since the cooling rates that may be achieved after quenching are high and help to obtain martensitic structures.

[0063] The steel sheet, a coated product, has a substantial resistance to corrosion in the delivery state, during forming and thermal treatments as well as during usage of the finished part.

The presence of the coating at the time of thermal treatment of the parts makes it possible to prevent any decarburization of the base metal as well as any oxidation. That is an undeniable advantage, in particular in the case of hot forming. Furthermore, heating of the treated part does not require a furnace having a controlled atmosphere to prevent a decarburization.

[0064] Thermal treatment of the metal in the sheet comprising heating at a temperature ranging between Ac1, starting temperature of austenitic transformation

when heating, for example 750°C and 1200°C, in a furnace, for a period which depends on the temperature to be reached and the thickness of the blank. The composition is optimized so as to limit the grain growth at the time of thermal treatment. If the structure sought is completely martensitic, the holding temperature should be in excess of Ac3, for example 840°C, temperature of complete austenitic transformation. The temperature holding should be followed by a cooling adjusted to the final structure sought.

[0065] Blanks are thereafter transferred from the furnace to a stamping press. When the elapsed time between the exit of the blanks from the furnace and the introduction in the stamping press is more 10 seconds, a partial transformation from austenite is susceptible to appear: if obtaining a full martensitic structure is desired, the transfer time between the exit of the furnace and stamping should be less than 10s.

[0066] The inventors have also discovered that the obtaining of a fully martensitic structure is linked to the amount of deformation in the hot forming operation: the amount of local deformation caused by hot forming is closely linked to the shape of the part or product and may exceed locally 40 or 50% in some particular regions. The inventors found that, when the local strain exceeds a critical value of 10%, the cooling rate must be sufficiently high in order to get a total martensitic transformation. Otherwise, bainitic transformation can take place at a significant amount instead of martensitic transformation. Thus, the risk is that heterogeneous structure appears on parts with complex shape where some locations are much more deformed than others. In this respect, the inventors put into evidence that, on the locations of the parts where the forming strain is higher than 10%, the cooling rate must be increased beyond 50°C/s in order to guarantee full martensitic transformation. The cooling rate is defined as the mean rate between the exit of the heated blank from the furnace, down to 400°C.

[0067] But one may also seek to obtain ferrito-bainitic or ferrito-martensitic structures, by a heating at a temperature ranging between Ac1, for example 750°C and Ac3, for example 840°C, followed by an appropriate cooling. According to the level of resistance to be achieved and the thermal treatment applied, one or several of these constituents is/are present in variable proportions.

[0068] The modulation of thermal treatment parameters makes it possible to achieve, with a given composition, different levels of hot and cold sheet resistance according to the thickness sought. For the highest resistance levels, the structure is composed predominantly of martensite.

[0069] The steel is particularly suited to the production of structural and anti-intrusion parts.

[0070] The invention thus enables one to produce a hot- or cold-rolled steel sheet of a desired thickness, coated, and affording extensive forming possibilities and which, after thermal treatment performed on the finished part, makes it possible to obtain a mechanical resistance in excess of 1000 MPa, a substantial resistance to shocks, fatigue, abrasion and wear, while retaining a good resistance to corrosion as well as a good capacity for welding, painting and gluing.

[0071] The present invention will now be further described by way a certain exemplary embodiments which are not intended to be limiting.

EXAMPLES

Example 1 :

[0072] In a first example of implementation, a cold rolled steel sheet, 1.9 mm thick, containing by weight: 0.23 % carbon, 1.25% manganese, 0.017% phosphorus, 0.002% sulfur, 0.27% silicon, 0.062% aluminum, 0.021% copper, 0.019% nickel, 0.208% chromium, 0.005% nitrogen, 0.038% titanium, 0.004% boron, 0.003% calcium- has been pre-coated with an aluminum-based alloy with composition 9.3% silicon, 2.8% iron, the remainder being aluminum and unavoidable impurities. According to the conditions of fabrication, namely the settings of the blowing devices on the operating line, sheets of 120m long and 650mm wide with various thickness ranges were produced.

- Sheet A (according to the invention): The thickness t_{p1} and t_{p2} on each side of the sheet was controlled to be within the range (20-33) micrometers, at every location of the two faces of the sheet, both in the longitudinal (or rolling) direction and in the transversal direction. Measurement was performed continuously with thickness gages devices relying on X-Ray emission. At every moment, the spot of measurement of each gage was a circular zone of about 20mm radius. The sheets were afterwards cut into blanks of 1.2 x 0.5m^2 of overall dimensions.
- Sheet B (reference): On these sheets, the pre-coating thickness had a wider variability since the thickness t_{p1} and t_{p2} on the two sides of the sheet was comprised in the range (30-45) micrometers. Blanks cut out of these sheets exhibit the same pre-coating thickness.

[0073] The blanks were then submitted to heating in a furnace at T=920°C. Heating time was 3 min, with 4 mn holding time. The microstructure is then fully austenitic. Blanks were thereafter transferred from the furnace to a stamping press. When the elapsed time between the exit of the blanks from the furnace and the transfer in the stamping press is more 10 seconds, a partial transformation from austenite was susceptible to appear, thus reducing the mechanical resistance of the stamped part. The blanks were directly cooled afterwards without hot stamping in order to appreciate the eventual remelting of the coating

On series A, no melting of the pre-coating was found. Intermetallic alloying between the pre-coating and the

steel substrate occurred completely.
On series B, the pre-coating underwent mainly alloying, but some traces of remelting were found, particularly on the former thicker locations of the pre-coating. This partial remelting of the aluminium pre-coating contributes to the progressive fouling of the rollers in the furnace. The sheets according to the invention do not contribute to this progressive buildup on the rollers.

Example 2 :

[0074]

i) Conditions according to the invention: In a second example of implementation, a cold rolled steel sheet, 1,2mm thick, 120m long and 650mm wide, with same composition and same pre-coating as in example 1, has been fabricated. The sheets were afterwards cut into blanks which were heated at 920°C for 6mn, this time including the heating phase and the holding time. Heating rate V_c between 20 and 700°C was 10°C/s. The blanks were finally hot stamped and quenched in order to obtain full martensitic structures.
The parts obtained after hot-stamping are covered by a coating, 40 micrometers thick, illustrated at figure 1, which has a four layer structure. Starting from the steel substrate, the layers are the following:

- (a) Interdiffusion layer or intermetallic layer, 17 micrometers thick. This layer is itself composed of two sub-layers. Hardness HV50g ranges from 295 to 407, and the mean composition is: 90%Fe, 7%Al, 3%Si.
- (b) Intermediate layer, appearing darker, 8 micrometers thick. This layer has a hardness of 940HV50g and a mean composition, by weight : 43%Fe, 57%Al, 1%Si.
- (c) Intermetallic layer appearing as a pale phase, 8 micrometers thick, displaying a hardness of 610HV50g, a mean composition of 65%Fe, 31%Al, 4%Si
- (d) Darker superficial layer, 7 micrometers thick, 950 HV50g, with a mean composition of 45%Fe, 54%Al, 1%Si

Layers (c) and (d) are quasi-continuous, i.e. occupying at least 90% of the level corresponding to the considered layer. In particular, layer (c) does not reach the extreme surface except very exceptionally. Anyway, this layer (c) occupies less than 10% of the extreme surface.
ii) Conditions of reference: On the other hand, blanks with the same base material and pre-coating parts were furnace-heated in different conditions: The blanks were heated to 950°C for 7 minutes, this time including the heating phase. Heating rate V_c was 11°C/s. These conditions correspond to a degree of alloying which is more important than in conditions (i)

- In this coating, the pale intermetallic layer (c), is not continuous and appears as to be scattered within the coating. About 50% of this layer is present at the extreme surface of the part. Moreover, the interdiffusion layer, 10 micrometers thick in contact with the steel substrate is thinner than in the previous case of figure 1.

Resistance spot welding was performed in the two situations i) and ii):

- (i): Coating with quasi-continuous layers (c) and (d), layer (c) occupying less than 10% of the extreme surface
- (ii) : Coating with mixed and discontinuous layers, layer (c) occupying more than 10% of the extreme surface

[0075] Resistance spot welding was performed by superposing two parts and joining them in the following conditions:

- Squeeze force and welding force : 4000 N
- Squeeze time: 50 periods
- Welding and holding time: 18 periods respectively

[0076] In each condition, the suitable intensity range was determined for obtaining:

- No sputter during welding
- Acceptable nugget size.

[0077] For the condition i), the weldability range, expressed in terms of current intensity, is 1,4kA. For the condition ii) the weldability range is extremely small.
[0078] Thus, it may be seen that the coating according to the invention, yields much more satisfactory results.

Example 3 :

[0079] In a third example of implementation, a cold rolled steel sheet of the example 1 was cut into blanks of 500x500mm^2 which were heated at 920°C, during 6mn, then hot stamped and cooled in tools, in such conditions that two different cooling rates were obtained :

- (A): Cooling rate: V_A= 30°C/s
- (B) : Cooling rate: V_B = 60°C/s

[0080] Due to the shape of he parts, different deformation levels ε were created during hot stamping. In particular, some zones largely strained display deformation levels higher than 30%.

- As illustrated on figure 3, metallographic observations reveal that when ε >10%, partial bainitic or fer-

ritic transformation occurs on parts cooled with V_A= 30°C/s, mainly on former austenitic grain boundaries. On the other hand, the parts cooled with V_B= 60°C/s display fully martensitic microstructure as illustrated on figure 4. The latter structures display superior mechanic resistance and a great homogeneity in the case of mechanical solicitation.

[0081] Thus, even in products or parts where straining is larger than 10%, the application of cooling according to the invention guarantees a microstructural and mechanical homogeneity.

Example 4:

[0082] In a fourth example of implementation, steel castings containing different values of sulfur, were elaborated. These steels were further hot rolled, then cold rolled steel into sheets, 2,2mm thick. Sulfur content varies from 11ppm (0,0011%) to 59ppm (0,006%) in weight. Apart sulfur, the compositions of these different steel castings comprise in weight:

0,24% carbon, 1,17% manganese, 0,01% phosphorus, 0,25% silicon, 0,045% aluminum, 0,01% copper, 0,02% nickel, 0,2% chromium, 0,04% titanium, 0,003% boron, 0,002% calcium, the remainder being iron and unavoidable impurities.

[0083] These sheets were pre-coated with an aluminum-based alloy of composition comprising 9,3% silicon, 2.8% iron, the remainder being aluminum and unavoidable impurities.

[0084] The sheets were afterwards cut into blanks which were heated at 950°C for 5mn, then hot stamped and cooled in tools in order to obtain a full martensitic structure. Mechanical resistance exceeded 1450 MPa.

[0085] Specimens were extracted according to the transverse sense of rolling direction and submitted to a bending test with alternate bending modes.

[0086] The inventors put into evidence that the critical bending angle (angle at fracture) is closely related to the sulfur content of the steel: when sulfur content is lower than 0,002%, the bending angle exceeds 60°, which indicates higher ductility and energy absorption.

[0087] Compact Tensile-Test type specimens were also extracted according to the transverse rolling direction in order to measure the resistance to tearing, i.e. the energy which is necessary for the initiation or propagation of an existing crack. The results, illustrated on figure 6, indicate that a initiation energy higher than 18 Joules is achieved when sulfur content is lower than 0,002% in weight.

[0088] As these qualities of high resistance, high energy absorption and weldability are required in automobile industry, the parts or products fabricated according to the invention will be used with profit for such applications.

[0089] While the above description is clear with regard to the understanding of the invention, the following terms as used in the following list of preferred embodiments and claims have the following noted meanings in order to avoid any confusion:

pre-coating - the material (Al or Al alloy) coated on or located on at least a portion of the strip or sheet, etc., of base steel to form a pre-coating/base composite, the composite not having been subjected to an alliation reaction between the coated Al or Al alloy material and base steel

alliation - a reaction between the pre-coating and base steel, to produce at least one intermediate layer different in composition from both the base steel and the pre-coating. The alliation reaction happens during the heat treatment immediately preceding hot stamping . The alliation reaction affects the total thickness of the pre-coating. In a highly preferred embodiment the alliation reaction forms the following layers: (a) interdiffusion, (b) intermediate, (c) intermetallic, and (d) superficial as described above;

pre-coated steel - the pre-coating/base composite, not having been subjected to an alliation reaction between the coated material and base steel;

coating - the pre-coating after having been subjected to an alliation reaction between the pre-coating and base steel. In a highly preferred embodiment the coating comprises layers (a) interdiffusion, (b) intermediate, (c) intermetallic, and (d) superficial described above;

coated steel or product - the pre-coated steel or product that has been subjected to an alliation reaction between the pre-coating and base steel. In a highly preferred embodiment the coated steel is a strip or sheet, etc., of base steel having thereon an invention coating comprising layers (a) interdiffusion, (b) intermediate, (c) intermetallic, and (d) superficial described above;

blank - a shape cut from a strip.

product - a stamped blank

Thus, the present invention provides, among other things, the following preferred embodiments:

1. A pre-coated steel strip, comprising:

(a) a strip of base steel having a length, a width, a first side, and a second side;

(b) said length of said strip of base steel being at least 100m and said width being at least 600mm, and

(c) an aluminum or an aluminum alloy pre-coating on at least part of one of said first and second sides of said strip of base steel, wherein (i) the thickness t_p of the said pre-coating is from 20 - 33 micrometers at every location on at least one of said first and second sides.

2. A method for making a pre-coated steel strip according to embodiment 1 wherein the pre-coated steel strip has a thickness of not greater than 3 mm.

3. A process for making a hot stamped coated steel sheet product, comprising:

(A) heating an aluminum- or aluminum alloy pre-coated steel sheet in a furnace preheated to a temperature and during a time defined by diagram ABCD of figure 7 if thickness of said sheet is greater than or equal to 0.7mm and less than or equal to 1.5mm, and by diagram EFGH of figure 7 if thickness of said sheet is greater than 1.5mm and less than or equal to 3mm, at a heating rate V_c between 20 and 700°C comprised between 4 and 12°C/s, to obtain a heated blank;
(B) transferring said heated blank to a die; and
(C) stamping said heated blank in said die, to thereby obtain a hot stamped steel sheet product, and

wherein the said heated product is cooled at a rate of at least 30°C/s.

4. A process for making a hot stamped coated steel sheet product, comprising:

(A) providing a heated blank according to embodiment 3; and
(B) transferring said heated blank to a die; and
(C) stamping said heated blank in said die, to thereby obtain a hot stamped steel sheet product,

wherein the elapsed time between said heated blank exits said furnace and said stamping commences is not more than 10 seconds, and wherein said heated blank is deformed by a quantity higher than 10% during said stamping and the said heated product is cooled at a rate of at least 50°C/s.

5. A process for making a hot stamped coated steel sheet product, comprising :

hot dip pre-coating a steel strip having a first side and a second side with aluminum or aluminum alloy to obtain a pre-coated steel strip, the pre-coating thickness on at least one of said first side and said second side of said strip having a thickness of from 20 to 33 μm at every location on at least one of said first and second sides of said strip;
cutting said pre-coated steel strip to obtain a sheet;
heating the sheet in a pre-heated furnace to obtain a heated blank in which the steel is austenitic;
transferring said heated blank to a die while maintaining said steel in the austenitic phase; and
stamping said heated blank in a die to obtain a hot stamped steel sheet product in which the steel microstructure is martensitic.

6. A hot stamped coated steel sheet product, which is prepared by a process comprising :

(A) providing a pre-coated strip according to embodiment 1, said strip being pre-coated with aluminum or aluminum alloy
(B) Cutting said pre-coated steel strip to a predetermined size and shape to obtain a sheet
(C) heating said steel sheet in a furnace preheated to a temperature and during a time defined by diagram ABCD of figure 7 if thickness of said product is greater than or equal to 0.7mm and less than or equal to 1.5mm, and by diagram EFGH of figure 7 if thickness of said product is greater than 1.5mm and less than or equal to 3mm, to obtain a heated blank;
(D) transferring said heated blank to a die; and
(E) stamping said heated blank in said die, to thereby obtain a hot stamped steel sheet product,

wherein the elapsed time between said heated blank exits said furnace and said stamping commences is not more than 10 seconds, and wherein said heated product cools at a rate higher than 30°C/s during said stamping.

7. A process for making a hot stamped coated steel sheet product, comprising:

(A) providing a heated blank according to embodiment 6
(B) transferring said heated blank to a die; and
(C) stamping said heated blank in said die, to thereby obtain a hot stamped steel sheet product,

wherein the elapsed time between said heated blank exits said furnace and said stamping commences is not more than 10 seconds, and
wherein said heated product cools at such a rate during said stamping that the steel microstructure is martensitic.

8. The pre-coated steel strip according to embodiment 1, wherein the base steel comprises the following components by weight based on total weight:

0.15%<carbon<0.5%
0.5%<manganese<3%

0.1%<silicon<0.5%

0.01%<chromium<1%

titanium<0.2%
aluminum<0.1%
phosphorus<0.1%
sulfur<0.05%

0.0005%<boron<0.08%,

and further comprises iron and impurities inherent in processing.

9. The pre-coated steel strip according to embodiment 8, wherein the base steel comprises the following components by weight based on total weight:

0.20%<carbon<0.5%
0.8%<manganese<1.5%
0.1%<silicon<0.35%
0.01%<chromium<1%

titanium<0.1%
aluminum<0.1%

phosphorus<0.05%

sulfur<0.03%

0.0005%<boron<0.01 %,

and further comprises iron and impurities inherent in processing.

10. The pre-coated steel strip according to embodiment 8 or 9, wherein the base steel comprises 20 ppm or less of sulfur.

11. The pre-coated steel strip according to any of embodiments 8 to 10, wherein the ratio of titanium to nitrogen in the steel sheet in weight % is in excess of 3.42.

12. The pre-coated steel strip according to any of the embodiments 1 or 8 to 11, wherein the aluminum or aluminum alloy pre-coating comprises from 8% to 11% silicon by weight, from 2% to 4% iron by weight, the remainder being aluminum and impurities inherent in processing.

13. A coated steel stamped product, which comprises:

(a) a strip of base steel having a first side and a second side; and
(b) a coating on at least one of said first side of said strip of base steel and said second side of said strip of base steel,

wherein:,

(i) said coating results from the interdiffusion between said base steel, and aluminium or aluminium alloy pre-coating,
(ii) said coating comprises, proceeding from base steel outwards,

- (a) Interdiffusion layer
- (b) Intermediate layer
- (c) Intermetallic layer
- (d) Superficial layer

14. A coated steel stamped product according to embodiment 13,
wherein said coating has a thickness greater than 30 micrometers

15. A coated steel stamped product according to embodiments 13 or 14,
wherein said layer (a) has a thickness less than 15 micrometers

16. A coated steel stamped product according to any of the embodiments 13 to 15,
wherein the said layers (c) and (d) are occupying at least 90% of the level corresponding to the considered said layers and wherein less than 10% of layer (c) is present at the extreme surface of the product

17. A coated steel stamped product according to any of the embodiments 13 to 16, wherein the steel in the strip has a composition according to embodiment 8

18. A coated steel stamped product according to any of the embodiments 13 to 16, wherein the steel in the strip has a composition according to embodiment 9

19. A coated steel stamped product according to any of the embodiments 13 to 18, wherein the steel has a composition according to embodiment 10

20. A coated steel stamped product according to any of the embodiments 13 to 19, wherein the steel has a composition according to embodiment 11

21. A coated steel stamped product according to any of the embodiments 13 to 20, the aluminum or aluminum alloy pre-coating comprises from 8% to 11% silicon by weight, from 2% to 4% iron by weight, the remainder being aluminum and impurities inherent in processing.

22. A land motor vehicle comprising the heat treated

coated steel product according to any of the embodiments 6, 13 to 21

23. A land motor vehicle comprising the heat treated coated steel product produced according to any of the embodiments 3, 4, 5, 7

[0090] The above written description of the invention provides a manner and process of making and using it such that any person skilled in this art is enabled to make and use the same, this enablement being provided in particular for the subject matter of the appended claims, which make up a part of the original description. As used above, the phrases "selected from the group consisting of," "chosen from," and the like include mixtures of the specified materials. Terms such as "contain(s)" and the like as used herein are open terms meaning 'including at least' unless otherwise specifically noted. All references, patents, applications, tests, standards, documents, publications, brochures, texts, articles, etc. mentioned herein are incorporated herein by reference. Where a numerical limit or range is stated, the endpoints are included. Also, all values and subranges within a numerical limit or range are specifically included as if explicitly written out. The above description is presented to enable a person skilled in the art to make and use the invention, and is provided in the context of a particular application and its requirements. Various modifications to the preferred embodiments will be readily apparent to those skilled in the art, and the generic principles defined herein may be applied to other embodiments and applications without departing from the spirit and scope of the invention. Thus, this invention is not intended to be limited to the embodiments shown, but is to be accorded the widest scope consistent with the principles and features disclosed herein.

Claims

1. A process for making a hot stamped coated steel sheet product, comprising:

   hot dip pre-coating a steel strip having a first side and a second side with aluminum or aluminum alloy to obtain a pre-coated steel strip, the pre-coating thickness on at least one of said first side and said second side of said strip having a thickness of from 20 to 33 μm at every location on at least one of said first and second sides of said strip;
   cutting said pre-coated steel strip to obtain a sheet;
   heating the sheet in a pre-heated furnace to obtain a heated blank in which the steel is austenitic;
   transferring said heated blank to a die while maintaining said steel in the austenitic phase; and
   stamping said heated blank in a die to obtain a hot stamped steel sheet product in which the steel microstructure is martensitic.

2. The process according to claim 1, wherein the sheet is heated to a temperature and during a time defined by diagram ABCD of figure 7 if thickness of said sheet is greater than or equal to 0.7mm and less than or equal to 1.5mm, and by diagram EFGH of figure 7 if thickness of said sheet is greater than 1.5mm and less than or equal to 3mm, at a heating rate Vc between 20 and 700°C comprised between 4 and 12°C/s, the heating rate Vc being different from the mean heating rate between room temperature and the furnace temperature.

3. The process according to any one of claims 1 or 2, wherein the elapsed time between said heated blank exits said furnace and said stamping commences is not more than 10 seconds.

4. The process according to any one of claims 1 to 3, wherein said heated blank is deformed by a quantity higher than 10% during said stamping.

5. The process according to any one of claims 1 to 4, wherein the heated blank is cooled at a mean rate between the exit of the heated blank from the furnace, down to 400°C of at least 30°C/s.

6. The process according to any one of claims 1 to 5, wherein the heated blank is cooled at a mean rate between the exit of the heated blank from the furnace, down to 400°C of at least 50°C/s.

7. The process according to any one of claims 1 to 6, wherein the steel strip is made of a base steel comprising the following components by weight based on total weight:

   0.15%<carbon<0.5%
   0.5%<manganese<3%
   0.1%<silicon<0.5%
   0.01%<chromium<1%
   titanium<0.2%
   aluminum<0.1%
   phosphorus<0.1%
   sulfur<0.05%
   0.0005%<boron<0.08%,

   and further comprises iron and impurities inherent in processing.

8. The process according to claim 7, wherein the base steel comprises the following components by weight based on total weight:

0.20%<carbon<0.5%
0.8%<manganese<1.5%
0.1%<silicon<0.35%
0.01%<chromium<1%
titanium<0.1%
aluminum<0.1%
phosphorus<0.05%
sulfur<0.03%
0.0005%<boron<0.01 %,

and further comprises iron and impurities inherent in processing.

9. The process according to claim 7 or 8, wherein the base steel comprises 20 ppm or less of sulfur.

10. The process according to any of claims 7 to 9, wherein the ratio of titanium to nitrogen in the base steel in weight % is in excess of 3.42.

11. The process according to any of the claims 1 to 10, wherein the aluminum or aluminum alloy pre-coating comprises from 8% to 11% silicon by weight, from 2% to 4% iron by weight, the remainder being aluminum and impurities inherent in processing.

12. A land motor vehicle comprising the heat treated coated steel product produced according to any of the claims 1 to 11.

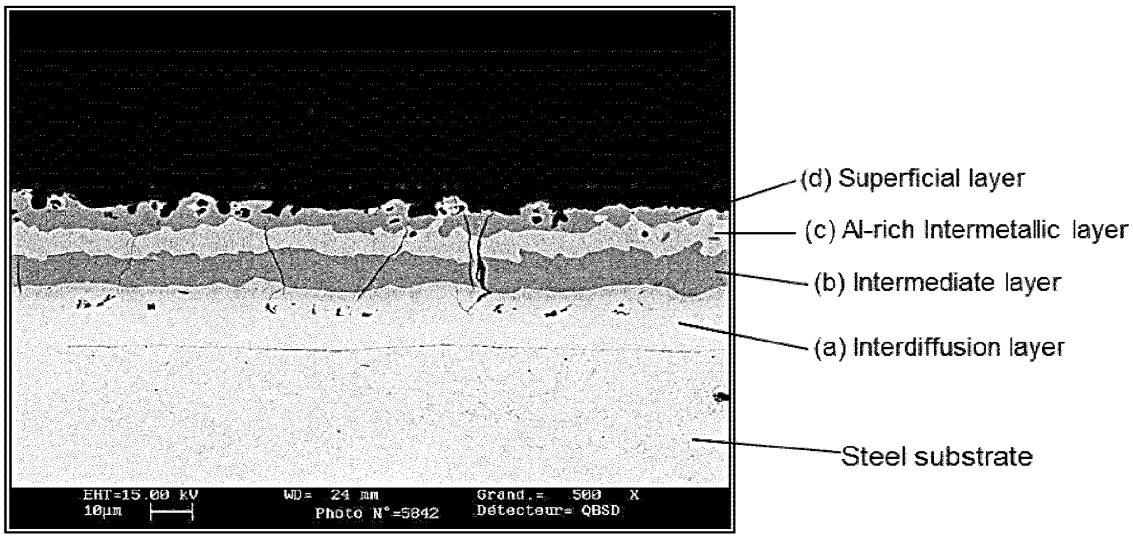
(d) Superficial layer
(c) Al-rich Intermetallic layer
(b) Intermediate layer
(a) Interdiffusion layer
Steel substrate
EHT=15.00 kV
10µm
WD= 24 mm
Photo N°=5842
Grand.= 500 X
Détecteur= QBSD
10µm

FIG.1

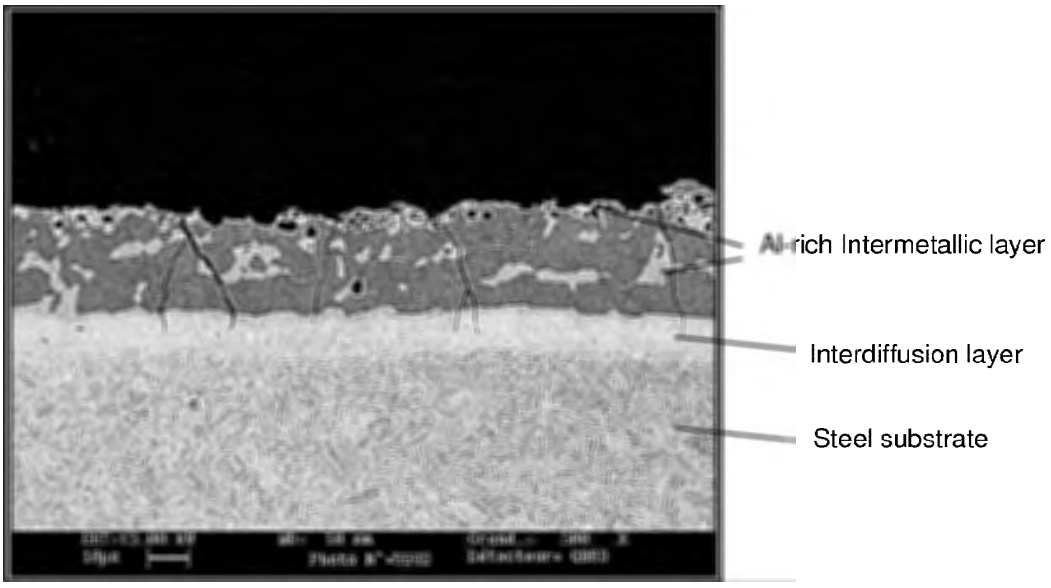
Al-rich Intermetallic layer
Interdiffusion layer
Steel substrate
10µm

FIG.2

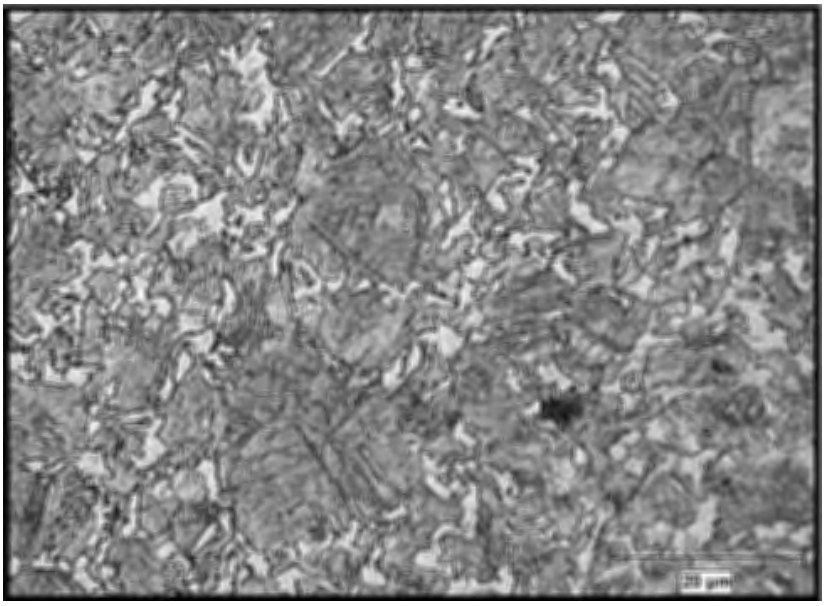

FIG.3

10µm

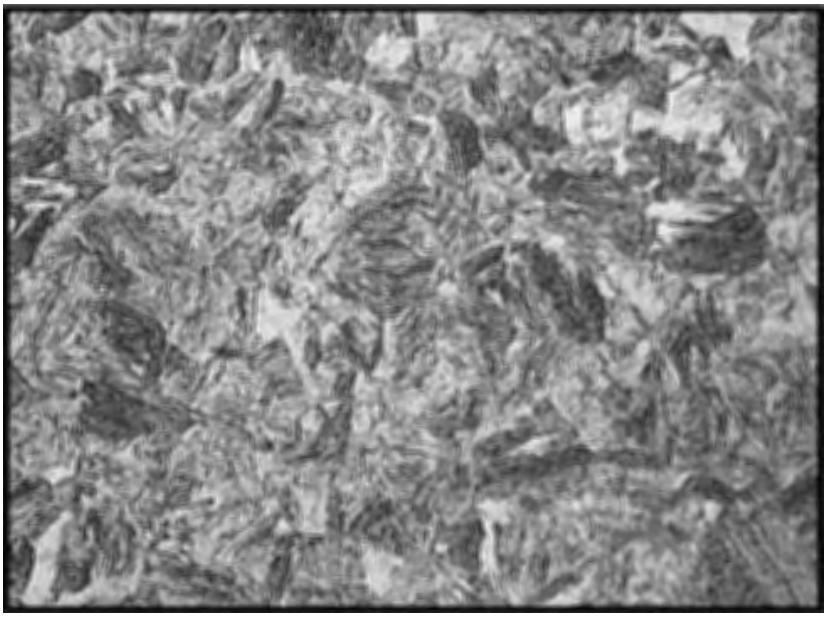

FIG.4

10 µm

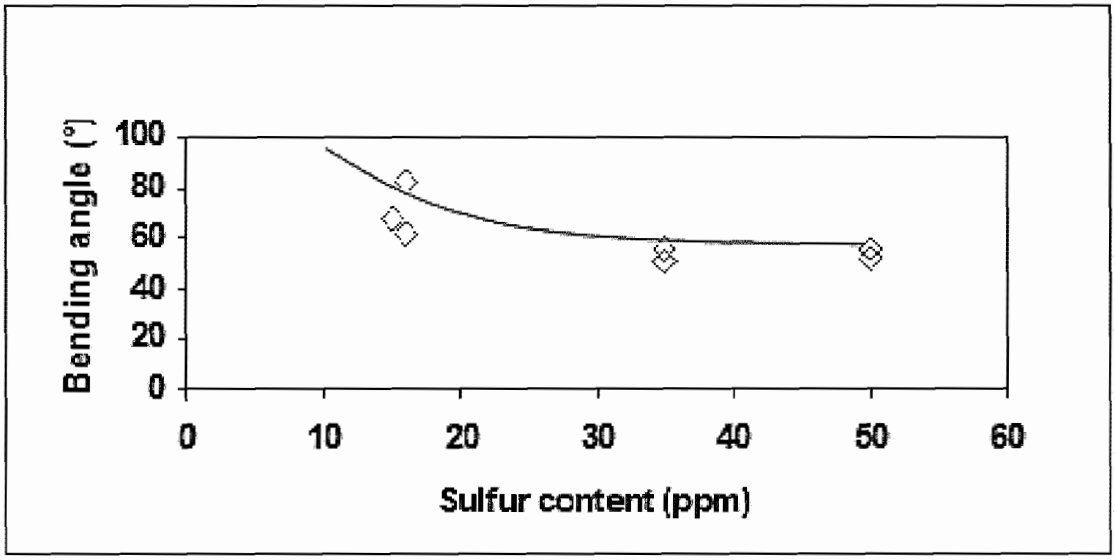
Bending angle (°)
100
80
60
40
20
0
0
10
20
30
40
50
60
Sulfur content (ppm)

FIG.5

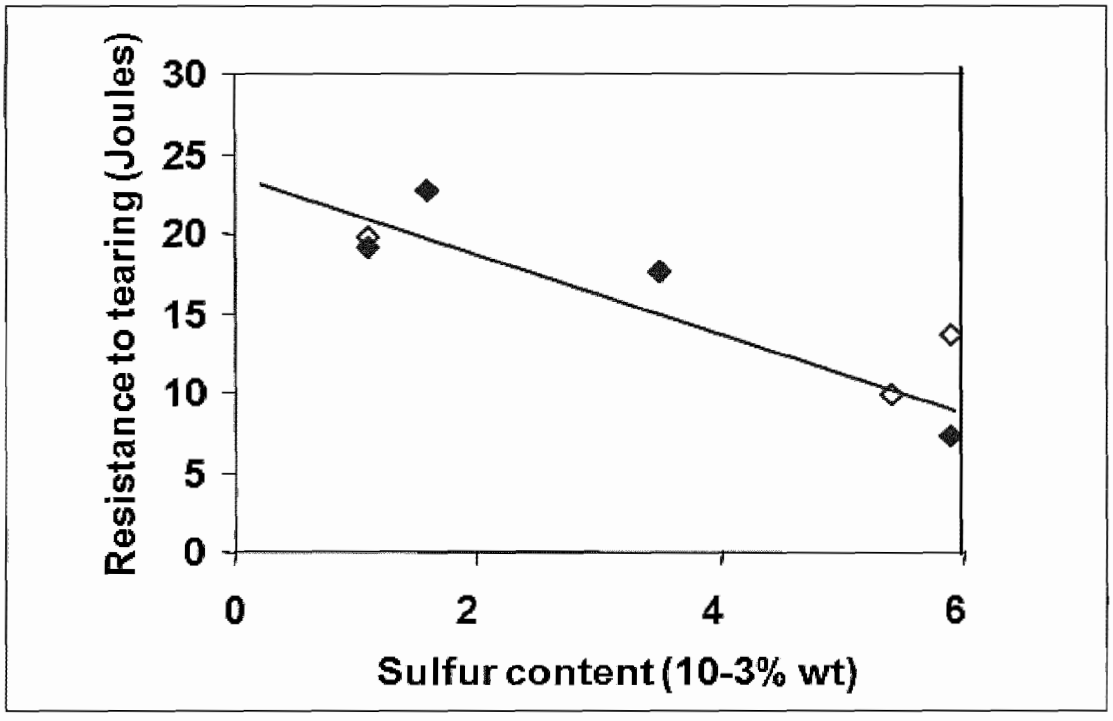
Resistance to tearing (Joules)
30
25
20
15
10
5
0
0
2
4
6
Sulfur content (10-3% wt)

FIG.6

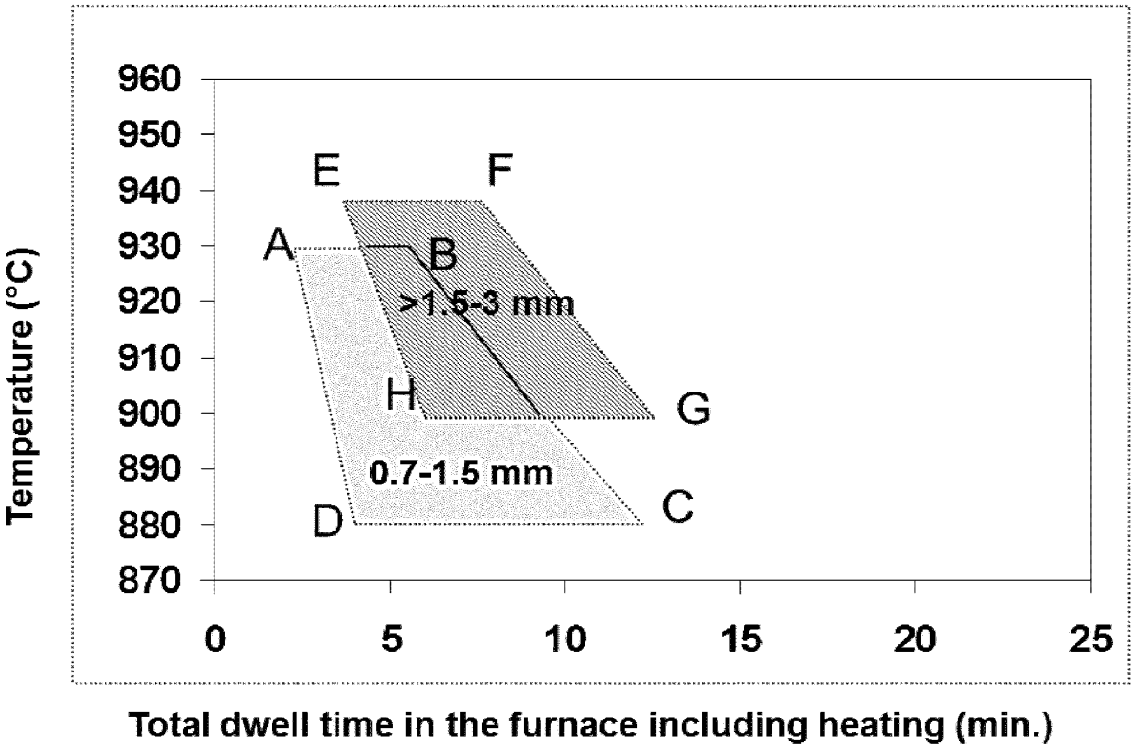
960
950
940
930
920
910
900
890
880
870
Temperature (°C)
E
F
A
B
>1.5-3 mm
H
G
0.7-1.5 mm
D
C
0
5
10
15
20
25
Total dwell time in the furnace including heating (min.)

FIG.7

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EUROPEAN SEARCH REPORT

Application Number
EP 17 19 2418

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	US 6 296 805 B1 (LAURENT JEAN-PIERRE [FR] ET AL) 2 October 2001 (2001-10-02) * column 2, line 25 - column 4, line 18 * * claims 1-14 *	1-12	INV. B32B15/00 C21D9/46
X	EP 1 013 785 A1 (LORRAINE LAMINAGE [FR] ARCELOR FRANCE [FR]) 28 June 2000 (2000-06-28) * paragraphs [0001], [0003] - [0005], [0011] - [0013], [0019]; claims 1-11 *	1,8,9, 11,12	
X	EP 1 336 666 A (BHP STEEL JLA PTY LTD [AU]) 20 August 2003 (2003-08-20) * paragraphs [0007], [0041] - [0043], [0060], [0079] * * claims 1,6 *	12	
A	EP 0 356 783 A2 (ARMCO INC [US] ARMCO STEEL CO LP [US]) 7 March 1990 (1990-03-07) * the whole document *	1-12	
A	FR 2 720 079 A1 (LORRAINE LAMINAGE [FR]) 24 November 1995 (1995-11-24) * the whole document *	1-12	TECHNICAL FIELDS SEARCHED (IPC) C22C B32B C23C C23F
A	FR 2 758 571 A1 (LORRAINE LAMINAGE [FR]) 24 July 1998 (1998-07-24) * the whole document *	1-12	C21D
A	WO 2006/097593 A (ARCELOR FRANCE [FR]; LAURENT JEAN-PIERRE [FR]; DEVROC JACQUES [FR]) 21 September 2006 (2006-09-21) * the whole document *	1-12	

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	25 January 2018	Gavriliu, Alexandru

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 17 19 2418

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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 6296805 B1	02-10-2001	AT 240419 T	15-05-2003
		BR 9902712 A	08-03-2000
		CA 2276911 A1	09-01-2000
		DE 69907816 D1	18-06-2003
		DE 69907816 T2	11-03-2004
		DK 0971044 T3	11-08-2003
		EP 0971044 A1	12-01-2000
		ES 2196740 T3	16-12-2003
		FR 2780984 A1	14-01-2000
		JP 3931251 B2	13-06-2007
		JP 2000038640 A	08-02-2000
		PT 971044 E	29-08-2003
		US 6296805 B1	02-10-2001
EP 1013785 A1	28-06-2000	AT 343658 T	15-11-2006
		DE 69933751 T2	04-10-2007
		DK 1013785 T3	15-01-2007
		EP 1013785 A1	28-06-2000
		ES 2274609 T3	16-05-2007
		FR 2787735 A1	30-06-2000
		PT 1013785 E	31-01-2007
EP 1336666 A	20-08-2003	CN 1353212 A	12-06-2002
		EP 1336666 A1	20-08-2003
		NZ 514712 A	01-03-2002
		US 2003152796 A1	14-08-2003
EP 0356783 A2	07-03-1990	AR 245228 A1	30-12-1993
		BR 8904258 A	10-04-1990
		CA 1330506 C	05-07-1994
		CN 1040828 A	28-03-1990
		DE 68912243 D1	24-02-1994
		DE 68912243 T2	30-06-1994
		EP 0356783 A2	07-03-1990
		ES 2048795 T3	01-04-1994
		FI 894015 A	01-03-1990
		IN 171867 B	30-01-1993
		JP 2516259 B2	24-07-1996
		JP H02104650 A	17-04-1990
		NO 893424 A	01-03-1990
		US 5023113 A	11-06-1991
		YU 161889 A	28-02-1991
		ZA 8906221 B	30-05-1990
FR 2720079 A1	24-11-1995	AT 158823 T	15-10-1997
		DE 69500797 D1	06-11-1997

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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
		DE 69500797 T2	05-03-1998
		EP 0698671 A1	28-02-1996
		ES 2107283 T3	16-11-1997
		FR 2720079 A1	24-11-1995
FR 2758571 A1	24-07-1998	NONE	
WO 2006097593 A	21-09-2006	----------	

EPO FORM P0459

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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- US 6296805 B **[0003]**

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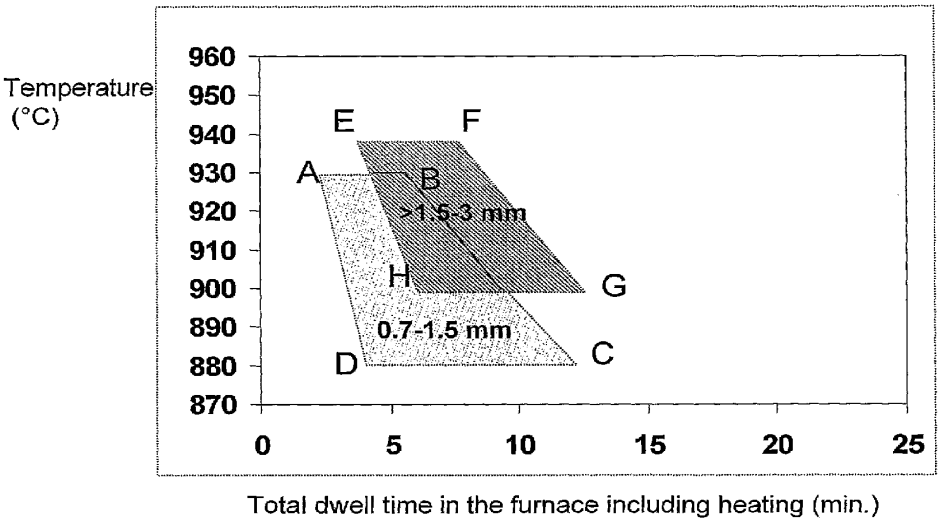
(54) Title: COATED STEEL STRIPS, METHODS OF MAKING THE SAME, METHODS OF USING THE SAME, STAMPING BLANKS PREPARED FROM THE SAME, STAMPED PRODUCTS PREPARED FROM THE SAME, AND ARTICLES OF MANUFACTURE WHICH CONTAIN SUCH A STAMPED PRODUCT



(57) Abstract: Coated steel having a well defined and uniform thickness is useful and advantageous for preparing products by hot stamping. Products prepared by hot stamping such a steel are particularly advantageous when subjected to a subsequent spot welding step.

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COATED STEEL STRIPS, METHODS OF MAKING THE SAME, METHODS OF USING THE SAME, STAMPING BLANKS PREPARED FROM THE SAME, STAMPED PRODUCTS PREPARED FROM THE SAME, AND ARTICLES OF MANUFACTURE WHICH CONTAIN SUCH A STAMPED PRODUCT

FIELD OF THE INVENTION

The present invention relates to, among other things, coated steels, methods of making such coated steels, including hot dipping, methods of using such coated steels, stamping blanks prepared from coated steels, stamped products prepared from coated steels, and to various uses of the invention products such as in spot welding, etc.

Additional advantages and other features of the present invention will be set forth in part in the description that follows and in part will become apparent to those having ordinary skill in the art upon examination of the following or may be learned from the practice of the present invention. The advantages of the present invention may be realized and obtained as particularly pointed out in the appended claims. As will be realized, the present invention is capable of other and different embodiments, and its several details are capable of modifications in various obvious respects, all without departing from the present invention. The description is to be regarded as illustrative in nature, and not as restrictive.

BACKGROUND OF THE INVENTION

In recent years the use of pre-coated steels in hot-stamping processes for the shaping of parts has become important, especially in the automotive industry. Fabrication of such parts may include the following main steps:

- Pre-coating of a steel sheets, by hot dipping
- Trimming or cutting for obtaining blanks

- Heating the blanks in order to obtain alloying of the steel substrate with the pre-coating, as well as the austenitizing of the steel
- Hot forming followed by rapid cooling of the part in order to obtain predominantly martensitic structures

See for Example U.S. 6,296,805, incorporated herein by reference.

Thanks to an alloying of the pre-coating with the steel substrate, which has the effect of creating intermetallic alloys with high melting temperature, the blanks having such coating may be heated in a temperature range where austenitizing of the metallic substrate takes place, allowing further hardening by quenching.

Heat treatments of the blanks in view of the intermetallic alloying of the coating and austenitizing of the substrate are most frequently performed in furnaces, where blanks are traveling on rollers. The thermal cycles experienced by the blanks include first a heating phase whose rate is a function of parameters such as blank thickness, furnace temperature, traveling speed, and coating reflectivity. After this heating phase, thermal cycles generally include a holding phase, whose temperature is the regulation temperature of the furnace. Problems however are experienced with the furnace operation: the rollers may become fouled by metallic deposits which come from the pre-coating of the blanks. If these deposits are excessive, maintenance of the rollers has to be performed and productivity is decreased.

Parts obtained after heating and rapid cooling display very high mechanical resistance and may be used for structural applications, for example for automotive industry applications. These parts must be frequently welded with others and high weldability is required. This means that:

- The welding operation should be performable in a sufficiently wide operating range in order to guarantee that an eventual drift of the nominal welding parameters has no incidence on weld quality. For resistance welding, which is very common in the automotive industry, an operating welding range is defined by the combination of parameters: welding current intensity I and force F applied of the parts during welding being among the most important. A proper combination of these parameters helps to ensure that insufficient nugget diameter is

not obtained (caused by too low intensity or too low force) and that no weld expulsion occurs.

- The welding operation should also be performed in such a way that high mechanical resistance is obtained on the weld. This mechanical resistance may be evaluated by tests such as by shear-tensile tests or cross-tensile tests.

There remains a need for coated steels which may be conveniently used to prepare shaped parts by a stamping process. There also remains a need for coated steels which may be used to prepare shaped parts by a stamping process which are suitable for welding. There also remains a need for processes for preparing such coated steels and stamped parts.

SUMMARY OF THE INVENTION

The inventors have discovered that certain coated steels in which a base steel strip is at least partially coated (sometimes termed "pre-coated," this prefix indicating that a transformation of the nature of the pre-coating will take place during heat treatment before stamping) on at least one side with a coating of either aluminum or an aluminum alloy and in which the coating has a defined thickness and is preferably substantially uniform, are conveniently formed into shaped parts after heating by stamping and are conveniently welded. In addition, the inventors have discovered that the roller fouling problem described above generally arises from an insufficient degree of intermetallic alloying between the substrate and the metallic pre-coating. Furthermore, it was discovered that the location of the fouling of the rollers corresponds to zones of the blanks in contact with the rollers where the metallic pre-coating thickness locally exceeds the average thickness. While not bound by a particular theory, it is believed that if a pre-coating is locally too thick, intermetallic alloying is insufficient and the pre-coating melts, fouling the rollers. Thus, the inventors have discovered that the control of the homogeneity of the pre-coating thickness over the entire sheet within given tolerances is an important factor for obtaining the desired degree of intermetallic alloying, allowing one to improve the resistance to the subsequent melting of the coating during travel on rollers.

The inventors have also discovered that particularly good weldability of aluminized and hot stamped parts is associated with a special succession of coating layers on the parts, proceeding from steel substrate outwards.

The inventors have also discovered that a specific combination of transfer time between the heating furnace and the stamping die, the amount of deformation during stamping, the temperature of stamping, the cooling rate of the product during stamping, leads to the fabrication of a part with a fully homogeneous martensitic structure and that an increase in ductility or energy absorption of the parts after stamping is obtained by a reduction of sulfur below a critical value, these two benefits being obtained with or without the invention aluminum/aluminum alloy coating, and with other coatings.

OBJECTS OF THE INVENTION

Accordingly, and in view of the above, it is one object of the present invention to provide novel pre-coated steels strips which may be conveniently processed into stamping blanks.

It is another object of the present invention to provide novel pre-coated steels strips or sheets which may be conveniently formed into parts by stamping.

It is another object of the present invention to provide novel coated steels which may be conveniently formed into parts by hot stamping.

It is another object of the present invention to provide novel methods for making such a coated steel.

It is another object of the present invention to provide novel stamping blanks which are prepared from such a coated steel.

It is another object of the present invention to provide novel methods of making such stamping blanks.

It is another object of the present invention to provide novel stamped parts which are prepared from such a coated steel.

It is another object of the present invention to provide novel methods of making such stamped parts.

It is another object of the present invention to provide novel articles of manufacture, such as a motor vehicle, which contain such stamped parts.

It is another object of the present invention to provide novel stamped parts.

It is another object of the present invention to provide novel methods of making welded stamped parts.

It is another object of the present invention to provide novel articles of manufacture, such as a motor vehicle, which contain such welded stamped parts.

It is another object of the present invention to provide novel welded coated steels and welded stamping blanks.

It is another object of the present invention to provide novel methods of making such welded coated steels and welded stamping blanks.

These and other objects, which will become apparent during the following detailed description.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 illustrates a preferred embodiment of an invention coated part, after heat treatment and stamping. The succession of layers of the coating on the steel substrate is: (a) interdiffusion layer; (b) intermediate layer; (c) Intermetallic layer; and (d) superficial layer. This arrangement is particularly favorable for the further welding of the part.

Figure 2 illustrates a coating of a steel substrate after heat treatment and stamping which does not correspond to the invention. This succession of layers (interdiffusion layer and intermetallic layer) yields inferior results in resistance spot welding.

Figure 3 illustrates a microstructure of a steel part, hot stamped and cooled under conditions not according to the invention.

Figure 4 illustrates the microstructure of a steel part, hot stamped and cooled according to a preferred set of conditions according to the invention.

Figure 5 illustrates the influence of sulfur on the bending angle of parts after hot stamping.

Figure 6 illustrates the influence of sulfur on the initiation energy of fracture of parts after hot stamping.

Figure 7 shows conditions of furnace temperature as a function of the total dwell time in the furnace for sheets of total thicknesses of from 0.7-1.5 and 1.5-3 mm that provide particularly favorable coatings for welding.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

As noted above, the inventors' discovery that certain coated steels, in which a base steel is at least partially pre-coated on at least one side with a coating of either aluminum or an aluminum alloy and in which the pre-coating has a defined thickness and is substantially uniform, are conveniently formed into shaped parts by stamping, forms one basis for the invention.

In the context of the present invention, the terms first side (or side 1) and second side (or side 2) of the strip or sheet, etc., of base steel refer to the two large, opposite-facing, surfaces which have a surface area defined by the length and width of the strip of base steel. In contrast, the side edges of the strip of base steel are the two small, opposite-facing, surfaces which have a surface area defined by the length and thickness of the strip. The top and bottom edges of the strip of base steel are the two small, opposite-facing, surfaces which have a surface area defined by the width and thickness of the strip. In the following, t_p designates the thickness of the pre-coating, at any considered location on the sides 1 and 2 of a sheet or a blank. In particular, in the case of sheets coated on two sides 1 and 2, t_{p1} stands for the thickness on side 1, and t_{p2} for the thickness on side 2.

According to a highly preferred embodiment t_p is controlled in a precise range, expressed by (t_{pmin}, t_{pmax}), in order to improve the resistance to the fouling of the rollers. The thickness is preferably controlled, both in the longitudinal (or rolling) direction of the strip or sheet, as well in the transverse direction.

In relation to the problem of the fouling of rollers, the control of the pre-coating thickness on the side of the sheet or blank which is directly in contact with the rollers is especially important. Because different operations can follow the step of coating the steel sheet (for example hot-dip-coating which provides coated sides 1 and 2), it is preferable to carefully control the pre-coating on both sides of the sheet. For example, after any of coiling,

handling, cutting, punching, etc., sides 1 and 2 may be not readily identifiable. But when control of t_p is effected on the two sides of the sheet that has been coated (first side and second side) it is not necessary to track sides 1 and 2 as neither side will foul the roller. In addition, it is not necessary to trim the sheet in order to obtain a preferred smaller sheet having a more uniform homogeneity of pre-coating thickness, thus providing a sheet that is pre-coated by, e.g., hot-dipping. In other words, important benefits are obtained when one controls the pre-coating minimum and maximum thickness of the first side (t_{pmin1} , t_{pmax1}) and the pre-coating minimum and maximum thickness of the second side (t_{pmin2} , t_{pmax2}) of the subject steel sheet or blank.

Hot-dip coated steels are the preferred steels herein. However, regardless of the coating method, the pre-coating thickness on one or both sides of the sheet can be measured and monitored continuously on a coating line directly after the coating operation. This may be realized by devices known per se, such as thickness gages relying on X-Ray absorption. At every moment, the measurement of thickness at a given location may be performed for example on an area of a few hundreds of mm^2, this representing the dimension of the zone irradiated by X-Ray.

In a preferred embodiment, a plurality of such devices are positioned at different distances in the transverse direction of the strip in order to obtain a profile of the thickness of the pre-coating along the strip width.

The inventors have discovered that the resistance to the pollution or fouling of the rollers in the furnaces is improved when the minimum and maximum thickness respectively of at least one of the first side (t_{pmin1}, t_{pmax1}) and the second side (t_{pmin2}, t_{pmax2}) are respectively equal to 20 and 33 micrometers (a micrometer is the same as a micron and is a metric unit of length equal to one millionth of a meter). In other words, in a preferred embodiment, at every location on at least one face of the sheet or the blank, the thickness t_p of the pre-coating is preferably from 20 - 33 micrometers in thickness, including 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31 and 32 micrometers and all ranges and subranges therebetween, and including all numbers between each listed value as if written out in its entirety (e.g., 22.34 micrometers). For hot-dip coating, precise control of this range of pre-coating

thickness can be realized on an operating line for example using a system of nozzles blowing gas after coating, for example after exit of the strip or sheet from a bath, and by the flatness of the strip. Number, geometry and location of the nozzles, and flow rates are among the main parameters for a precise control of the thickness t_p. Given the present disclosure, one of ordinary skill in this art can control the pre-coating thickness as described herein without undue labor.

The invention refers to strips produced in industrial conditions, i.e. where control of pre-coating thickness is effective over a wide surface strip, i.e. with a length greater than 100m, and with a width greater than 600mm. In such a way, blanks cut or trimmed out these strips display very high homogeneity of pre-coating thickness, and the settings of the heating treatments in the furnace do not have to be changed for being adapted to eventual variations of this thickness.

While not bound by a particular theory of operation, the inventors believe that several of the benefits of the invention are related to this pre-coating thickness range, such as the following :

- For a pre-coating thickness less than 20 micrometers, the alloyed layer which is formed during the heating of the blank has an insufficient roughness. Thus, the adhesion of subsequent painting is low on this surface, and the corrosion resistance is decreased.

- If the pre-coating thickness is more than 33 micrometers at a given location on a sheet, the risk is that the difference of thickness between this location and some other locations where the pre-coating is thinner, becomes too important : The settings of the heating treatment in the furnace may be adapted to the thinner value of the pre-coating, but not to the thicker one. Thus, the alloying reaction forming the intermetallic alloy may take place to an insufficient degree since the mean diffusion distance of the elements in the pre-coating becomes significantly less than the local value of the pre-coating thickness. As a matter of results, alloying will become much more difficult in the external (or superficial) part, particularly in the case of high heating rate.

Thus, in a first embodiment, the present invention provides certain coated steel strips, which comprise a strip of base steel and a pre-coating of

aluminum or an aluminum alloy on at least a part of one side of the strip of the base steel. For many applications, the strip of base steel may comprise any type of steel which may be coated with either aluminum or an aluminum alloy. However, for certain applications, such as a structural part of an automobile, it is preferred that the strip of base steel comprise an ultra high strength steel (UHSS). In such cases, it is particularly preferred that the strip of base steel comprises a boron steel.

The inventors have also discovered that good welding results are achieved if the coating obtained on parts made out of blanks having undergone intermetallic alloying, austenitizing and hot stamping, displays distinctive features. It must be pointed out that this coating is different from the initial pre-coating, since the thermal treatment causes an alloying reaction with the steel substrate which modifies both the physico-chemical nature and the geometry of the pre-coating : in this regard, the inventors have discovered that particularly good weldability of aluminized and hot stamped parts is associated with the following succession of coating layers on the parts, proceeding from steel substrate outwards :

- (a) Interdiffusion layer,
- (b) Intermediate layer,
- (c) Intermetallic layer,
- (d) Superficial layer

See, e.g., Figure 1. In a preferred embodiment these layers are as follows:

- (a) Interdiffusion layer, preferably with medium hardness (e.g., HV50g between 290 and 410, HV50g designating the hardness measured under a load of 50 grams) In a preferred embodiment this layer has the following composition, by weight : 86-95%Fe, 4-10%Al, 0-5%Si
- (b) Intermediate layer (HV50g around 900 - 1000 e.g., +/- 10%))
  In a preferred embodiment this layer has the following composition, by weight : 39-47% Fe, 53-61%Al, 0-2%Si
- (c) Intermetallic layer, with hardness HV50g around 580-650, e.g., +/- 10%)
  In a preferred embodiment this layer has the following composition, by weight : 62-67%Fe, 30-34 %Al, 2-6%Si
- (d) Superficial layer (HV50g around 900 - 1000 e.g., +/- 10%))

In a preferred embodiment this layer has the following composition, by weight : 39-47% Fe, 53-61%Al, 0-2%

In a preferred embodiment the total thickness of layers (a) to (d) is greater than 30 micrometers.

In another preferred embodiment, the thickness of layer (a) is less than 15 micrometers, for example 14, 12, 10, 8, 6, 4, 2, or 1 micrometers, and all whole numbers, ranges and subranges therebetween, and including all numbers between each listed value as if written out in its entirety (e.g., 13.84 micrometers).

The inventors have discovered that high weldability is especially obtained when layers (c) and (d) are essentially continuous (i.e.: occupying at least 90% of the level corresponding to the considered layer) and when less than 10% of layer (c) is present at the extreme surface of the part. Without being bound by a theory, it is thought that this particular layer disposal, in particular layer (a) and layers (c) and (d) influence the resistivity of the coating both by their intrinsic characteristics and by the effect of roughness. Thus, current flow, heat generation at the surfaces, and nugget formation in the initial stage of spot welding are affected by this particular arrangement.

This favorable layer disposition is obtained for example when aluminum- or aluminum alloy pre-coated steel sheets, whose thickness range from, e.g., 0.7 to 3mm, are heated for 3 to 13 minutes (this dwell time includes the heating phase and the holding time) in a furnace heated to a temperature of 880 to 940°C. Other conditions leading to such favorable layer dispositions are found in Figure 7:

For sheets of total thicknesses greater or equal to 0.7mm, and less than or equal to 1.5mm, the preferred treatment conditions : (furnace temperature, total dwell time in the furnace) are illustrated in figure 7 by conditions lying within the limits of diagram "ABCD"

For sheets of total thicknesses greater than 1.5mm, and less than or equal to 3mm, the preferred treatment conditions : (furnace temperature, total dwell time in the furnace) are illustrated in figure 7 by diagram "EFGH" .

The heating rate V_c is comprised between 4 and 12°C/s for producing a favorable alloyed layer disposition. In this regard, this "heating rate" reflects

the temperature rise which is experienced by the pre-coated steel upon being located in the preheated furnace. V_c is defined as the mean heating rate between 20 and 700°C. The inventors have discovered that the control of V_c in this precise range is a key factor, because it controls directly the nature and the morphology of the alloyed layers which are formed. It is here underlined that the heating rate V_c is different from the mean heating rate, which is the heating rate between room temperature and furnace temperature. The rates of 6, 7, 8, 9, 10, and 11 °C/s are included as are all numbers, ranges and subranges therebetween, and including all numbers between each listed value as if written out in its entirety (e.g., 7.7 °C/s). In this regard, all of the conditions specified within Figure 7 are incorporated herein by reference thereto. Particularly preferred conditions are:

(for thicknesses of 0.7-1.5mm)

- 930°C, from 3 minutes up to 6 minutes;
- 880°C, from 4 minutes 30 seconds up to 13 minutes

(for thicknesses of 1.5 to 3 mm)

- 940°C, from 4 minutes up to 8 minutes;
- 900°C, from 6 minutes 30 seconds up to 13 minutes

A special advantage arises from pre-coatings whose thickness is comprised between 20 and 33 micrometers, since this thickness range yields favorable layer disposal, and since the homogeneity of the pre-coating thickness is associated to an homogeneity of the coating formed after alliation treatment.

Heated blanks are thereafter transferred to a die, hot stamped to obtain a part or product, and cooled at a rate of more than 30°C/s. The cooling rate is defined here as the mean rate between the exit of the heated blank from the furnace, down to 400°C.

The strip of base steel is coated with either aluminum or an aluminum alloy. Commercially pure aluminum is known in the art as Type 2 aluminum, while alloys of aluminum with 5 to 11 % by weight of silicon are known in the art as Type 1 aluminum. Silicon is present in order to prevent the formation of a thick iron-metallic intermetallic layer which reduces adherence and formability. Other alloying elements useful with aluminum herein include iron,

between 2.5 and 3% by weight, and calcium, between 15 and 30ppm by weight, including combinations of two or more thereof with aluminum.

A typical metal bath for an Al-Si coating generally contains in its basic composition by weight, from 8% to 11% silicon, from 2% to 4% iron, the remainder being aluminum or aluminum alloy, and impurities inherent in processing. Typical composition of Al-Si coating is: Al-9,3%Si-2,8%Fe. Invention coatings are not limited to these compositions, however.

The strip of base steel used herein may be any which can be coated by a conventional coating technique. For example, the strip of base steel may be any hot rolled strip, such as those prepared by hot rolling a steel slab (either with or without subsequent cold rolling). Typically, the strip of base steel will be stored and transported in the form of a coil both before and after the formation of the coating.

An example of a preferred steel for the strip of base steel is one having the following composition by weight:

0.10% < carbon < 0.5%
0.5% < manganese < 3%
0.1% < silicon < 1%
0.01% < chromium < 1%
titanium < 0.2%
aluminum < 0.1%
phosphorus < 0.1%
sulfur < 0.05%
0.0005% < boron < 0.010%,

the remainder comprising, consisting essentially of, or consisting of iron and impurities inherent in processing. Use of such a steel provides a very high mechanical resistance after thermal treatment and the aluminum-based coating provides a high resistance to corrosion.

Particularly preferably, the composition by weight of the steel in the strip of base steel is the following:

0.15% < carbon < 0.25%
0.8% < manganese < 1.8%
0.1% < silicon < 0.35%

0.01% < chromium < 0.5%
titanium < 0.1%
aluminum < 0.1%
phosphorus < 0.1%
sulfur < 0.05%
0.002% < boron < 0.005%,

the remainder comprising, consisting essentially of, or consisting of iron and impurities inherent in processing.

A preferred strip herein is 100 m long and 600mm wide. Preferred thicknesses are 0.7 to 3 mm.

Even more preferably, in the composition by weight of the sheet, the weight ratio of titanium content with respect to the nitrogen content is in excess of 3.42, believed to be a level at which the boron is no longer able to combine with the nitrogen.

An example of preferred commercially available steel for use in the strip of base steel is 22MnB5.

Chromium, manganese, boron and carbon may be added, in the composition of the steel according to the invention, for their effect on hardenability. In addition, carbon makes it possible to achieve high mechanical characteristics thanks to its effect on the hardness of the martensite.

Aluminum is introduced into the composition, to perform deoxidation in the liquid state and to protect the effectiveness of the boron.

Titanium, the ratio of the content of which with respect to the nitrogen content should be in excess of 3.42, is introduced for example in order to prevent combining of the boron with the nitrogen, the nitrogen being combined with titanium.

The alloying elements, Mn, Cr, B, make possible a hardenability allowing hardening in the stamping tools or the use of mild hardening fluids limiting deformation of the parts at the time of thermal treatment. In addition, the composition according to the invention is optimized from the point of view of weldability.

The steel in the sheet may undergo a treatment for globularization of sulfides performed with calcium, which has the effect of improving the fatigue resistance of the sheet.

As mentioned above, ultra-high-strength can be provided with the steel sheet coated and hot stamped according to the invention. This high level of strength is sometimes associated with a limited ductility. In applications requiring a higher ductility, in particular when an ability for bending is required from a part or a product, the inventors have discovered that increased ductility can be obtained if sulfur is particularly controlled: when the sulfur level of base steel is lower than or equal to 0.002% (20 ppm), the bending angle can be greater than 60° and enhanced ductility and tearing resistance are obtained on the parts having experienced heat treatment and stamping. Preferred levels include 20, 18, 15, 13, 10, 8, 5, 2, etc ppm sulfur. In fact, this benefit applies to steels in general, and is not limited to coated steels or to steels coated with Al or Al alloy coatings. While not bound by a particular theory, when analyzing causes of premature failure of some parts in bending operations, the inventors observed that failure initiated on sulfide inclusions. It is thus believed that decohesions between inclusions and the martensitic or bainito-martensitic matrix act as stress-concentration factors and trigger further crack propagation in the ductile mode.

The invention also concerns a process for producing a part starting from an invention coated sheet, then cut into a blank which, after shaping, the coating of the blank is subjected to an increase in temperature at a speed in excess of 4°C/second, but lower than 12°C/second. The heating rate V_c is defined as the mean rate between 20 and 700°C.

The invention also concerns the use of a hot-rolled steel sheet which then can be cold-rolled and coated, for structural and/or anti-intrusion or substructure parts for a land motor vehicle, such as, for example, a bumper bar, a door reinforcement, a wheel spoke, etc.

The sheet according to the invention described above can derive, by reason of its processing, from a hot-rolling mill, and possibly may be cold-rerolled again depending on the final thickness desired. It then is coated with an aluminum-based coating, for example by dipping in a bath containing, in

addition to the aluminum source/alloy, e.g., from 8% to 11% silicon and from 2% to 4% iron, the sheet having a high mechanical resistance after thermal treatment and a high resistance to corrosion, as well as a good capacity for painting and gluing.

The coating is preferably controlled as above, and has in particular the function of protecting the basic sheet against corrosion in various conditions. The thermal treatment applied at the time of a hot-forming process or after forming makes it possible to obtain high mechanical characteristics which can exceed 1500 MPa for mechanical resistance and 1200 MPa for yield stress. The final mechanical characteristics are adjustable and depend in particular on the martensite fraction of the structure, on the carbon content of the steel and on the thermal treatment. At the time of thermal treatment performed on a finished part or at the time of a hot-shaping process, the coating forms a layer having a substantial resistance to abrasion, wear, fatigue, shock, as well as a good resistance to corrosion and a good capacity for painting and gluing. The coating makes it possible to avoid different surface-preparation operations such as for steel sheets for thermal treatment not having any coating.

The steel sheet can be pre-coated by dipping, after pickling, in an aluminum bath containing for example only aluminum or either aluminum and from 8% to 11% silicon and 2% to 4% iron, or only from 2% to 4% iron, or even in an aluminum bath preferably containing from 9% to 10% silicon and 2% to 3.5% iron. The aluminum may be aluminum per se or an aluminum alloy.

In an example of implementation of a coating of the sheet by dipping in a metal bath containing an aluminum alloy comprising a proportion of approximately 90% aluminum, the coating layer comprises a first alloy layer in contact with the surface of the steel. This layer, directly in contact with the surface of the sheet, is highly alloyed with iron.

A second coating layer, on top of the first, contains approximately 90% aluminum and may contain silicon and a small amount of iron, depending on the composition of the bath.

The first alloy layer may crack when the sheet is submitted to high strains during cold forming operations of the manufacture of parts.

According to the invention, after the forming of the part, the coating is subjected to an increase in temperature at a speed in excess of 4°C /second. This rise in temperature makes possible a rapid remelting of the aluminum which fills in the cracks generated by the operation of shaping of the part.

At the time of thermal treatment, the base coating, of aluminum for example, is transformed into a layer alloyed with iron and comprising different phases depending on the thermal treatment and having a considerable hardness which may exceed 600 HV50 g.

Another advantage of the invention lies in the fact that the diffusion of the iron in the coating is initiated at high temperature. One thus will have a better cohesion between coating and steel in the sheet. In another form of the invention, the thermal treatment may be performed locally, in heavily deformed zones.

According to the invention, the sheet, in the delivery state in a coil or in a sheet, the thickness of which may range between 0.25 mm and 15 mm, has good forming properties and a good resistance to corrosion as well as a good capacity for painting or gluing. Preferably, the steel sheet or blank has a thickness less than 3 mm, since the cooling rates that may be achieved after quenching are high and help to obtain martensitic structures.

The steel sheet, a coated product, has a substantial resistance to corrosion in the delivery state, during forming and thermal treatments as well as during usage of the finished part.

The presence of the coating at the time of thermal treatment of the parts makes it possible to prevent any decarburization of the base metal as well as any oxidation. That is an undeniable advantage, in particular in the case of hot forming. Furthermore, heating of the treated part does not require a furnace having a controlled atmosphere to prevent a decarburization.

Thermal treatment of the metal in the sheet comprising heating at a temperature ranging between Ac1, starting temperature of austenitic transformation when heating, for example 750°C and 1200°C, in a furnace, for a period which depends on the temperature to be reached and the thickness of the blank. The composition is optimized so as to limit the grain growth at the time of thermal treatment. If the structure sought is completely

martensitic, the holding temperature should be in excess of Ac3, for example 840°C, temperature of complete austenitic transformation. The temperature holding should be followed by a cooling adjusted to the final structure sought.

Blanks are thereafter transferred from the furnace to a stamping press. When the elapsed time between the exit of the blanks from the furnace and the introduction in the stamping press is more 10 seconds, a partial transformation from austenite is susceptible to appear: if obtaining a full martensitic structure is desired, the transfer time between the exit of the furnace and stamping should be less than 10s.

The inventors have also discovered that the obtaining of a fully martensitic structure is linked to the amount of deformation in the hot forming operation: the amount of local deformation caused by hot forming is closely linked to the shape of the part or product and may exceed locally 40 or 50% in some particular regions. The inventors found that, when the local strain exceeds a critical value of 10%, the cooling rate must be sufficiently high in order to get a total martensitic transformation. Otherwise, bainitic transformation can take place at a significant amount instead of martensitic transformation. Thus, the risk is that heterogeneous structure appears on parts with complex shape where some locations are much more deformed than others. In this respect, the inventors put into evidence that, on the locations of the parts where the forming strain is higher than 10%, the cooling rate must be increased beyond 50°C/s in order to guarantee full martensitic transformation. The cooling rate is defined as the mean rate between the exit of the heated blank from the furnace, down to 400°C.

But one may also seek to obtain ferrito-bainitic or ferrito-martensitic structures, by a heating at a temperature ranging between Ac1, for example 750°C and Ac3, for example 840°C, followed by an appropriate cooling. According to the level of resistance to be achieved and the thermal treatment applied, one or several of these constituents is/are present in variable proportions.

The modulation of thermal treatment parameters makes it possible to achieve, with a given composition, different levels of hot and cold sheet

resistance according to the thickness sought. For the highest resistance levels, the structure is composed predominantly of martensite.

The steel is particularly suited to the production of structural and anti-intrusion parts.

The invention thus enables one to produce a hot- or cold-rolled steel sheet of a desired thickness, coated, and affording extensive forming possibilities and which, after thermal treatment performed on the finished part, makes it possible to obtain a mechanical resistance in excess of 1000 MPa, a substantial resistance to shocks, fatigue, abrasion and wear, while retaining a good resistance to corrosion as well as a good capacity for welding, painting and gluing.

The present invention will now be further described by way a certain exemplary embodiments which are not intended to be limiting.

EXAMPLES

Example 1 :

In a first example of implementation, a cold rolled steel sheet, 1.9 mm thick, containing by weight: 0.23 % carbon, 1.25% manganese, 0.017% phosphorus, 0.002% sulfur, 0.27% silicon, 0.062% aluminum, 0.021% copper, 0.019% nickel, 0.208% chromium, 0.005% nitrogen, 0.038% titanium, 0.004% boron, 0.003% calcium–has been pre-coated with an aluminum-based alloy with composition 9.3% silicon, 2.8% iron, the remainder being aluminum and unavoidable impurities. According to the conditions of fabrication, namely the settings of the blowing devices on the operating line, sheets of 120m long and 650mm wide with various thickness ranges were produced.

- Sheet A (according to the invention): The thickness t_{p1} and t_{p2} on each side of the sheet was controlled to be within the range (20-33) micrometers, at every location of the two faces of the sheet, both in the longitudinal (or rolling) direction and in the transversal direction. Measurement was performed continuously with thickness gages devices relying on X-Ray emission. At every moment, the spot of measurement of each gage was a circular zone of about 20mm radius. The sheets were afterwards cut into blanks of 1.2 x 0.5m^2 of overall dimensions.

- Sheet B (reference): On these sheets, the pre-coating thickness had a wider variability since the thickness t_{p1} and t_{p2} on the two sides of the sheet was comprised in the range (30-45) micrometers. Blanks cut out of these sheets exhibit the same pre-coating thickness.

The blanks were then submitted to heating in a furnace at T=920°C. Heating time was 3 min, with 4 mn holding time. The microstructure is then fully austenitic. Blanks were thereafter transferred from the furnace to a stamping press. When the elapsed time between the exit of the blanks from the furnace and the transfer in the stamping press is more 10 seconds, a partial transformation from austenite was susceptible to appear, thus reducing the mechanical resistance of the stamped part.

The blanks were directly cooled afterwards without hot stamping in order to appreciate the eventual remelting of the coating

On series A, no melting of the pre-coating was found. Intermetallic alloying between the pre-coating and the steel substrate occurred completely.

On series B, the pre-coating underwent mainly alloying, but some traces of remelting were found, particularly on the former thicker locations of the pre-coating. This partial remelting of the aluminium pre-coating contributes to the progressive fouling of the rollers in the furnace. The sheets according to the invention do not contribute to this progressive buildup on the rollers.

Example 2 :

i) Conditions according to the invention: In a second example of implementation, a cold rolled steel sheet, 1,2mm thick, 120m long and 650mm wide, with same composition and same pre-coating as in example 1, has been fabricated. The sheets were afterwards cut into blanks which were heated at 920°C for 6mn, this time including the heating phase and the holding time. Heating rate V_c between 20 and 700°C was 10°C/s. The blanks were finally hot stamped and quenched in order to obtain full martensitic structures.

The parts obtained after hot-stamping are covered by a coating, 40 micrometers thick, illustrated at figure 1, which has a four layer structure. Starting from the steel substrate, the layers are the following:

- (a) Interdiffusion layer or intermetallic layer, 17 micrometers thick. This layer is itself composed of two sub-layers. Hardness HV50g ranges from 295 to 407, and the mean composition is: 90%Fe, 7%Al, 3%Si.
- (b) Intermediate layer, appearing darker, 8 micrometers thick. This layer has a hardness of 940HV50g and a mean composition, by weight : 43%Fe, 57%Al, 1%Si.
- (c) Intermetallic layer appearing as a pale phase, 8 micrometers thick, displaying a hardness of 610HV50g, a mean composition of 65%Fe, 31%Al, 4%Si
- (d) Darker superficial layer, 7 micrometers thick, 950 HV50g, with a mean composition of 45%Fe, 54%Al, 1%Si

Layers (c) and (d) are quasi-continuous, i.e. occupying at least 90% of the level corresponding to the considered layer. In particular, layer (c) does not reach the extreme surface except very exceptionally. Anyway, this layer (c) occupies less than 10% of the extreme surface.

ii) Conditions of reference: On the other hand, blanks with the same base material and pre-coating parts were furnace-heated in different conditions: The blanks were heated to 950°C for 7 minutes, this time including the heating phase. Heating rate V_c was 11°C/s. These conditions correspond to a degree of alloying which is more important than in conditions (i)

- In this coating, the pale intermetallic layer (c), is not continuous and appears as to be scattered within the coating. About 50% of this layer is present at the extreme surface of the part. Moreover, the interdiffusion layer, 10 micrometers thick in contact with the steel substrate is thinner than in the previous case of figure 1.

Resistance spot welding was performed in the two situations i) and ii):

- (i): Coating with quasi-continuous layers (c) and (d), layer (c) occupying less than 10% of the extreme surface
- (ii) : Coating with mixed and discontinuous layers, layer (c) occupying more than 10% of the extreme surface

Resistance spot welding was performed by superposing two parts and joining them in the following conditions:

- Squeeze force and welding force : 4000 N
- Squeeze time: 50 periods
- Welding and holding time: 18 periods respectively

In each condition, the suitable intensity range was determined for obtaining:

- No sputter during welding
- Acceptable nugget size.

For the condition i), the weldability range, expressed in terms of current intensity, is 1,4kA. For the condition ii) the weldability range is extremely small.

Thus, it may be seen that the coating according to the invention, yields much more satisfactory results.

Example 3 :

In a third example of implementation, a cold rolled steel sheet of the example 1 was cut into blanks of 500x500mm² which were heated at 920°C, during 6mn, then hot stamped and cooled in tools, in such conditions that two different cooling rates were obtained :

- (A): Cooling rate: V_A= 30°C/s
- (B) : Cooling rate: V_B = 60°C/s

Due to the shape of he parts, different deformation levels ε were created during hot stamping. In particular, some zones largely strained display deformation levels higher than 30%.

- As illustrated on figure 3, metallographic observations reveal that when ε >10%, partial bainitic or ferritic transformation occurs on parts cooled with V_A= 30°C/s, mainly on former austenitic grain boundaries. On the other hand, the parts cooled with V_B= 60°C/s display fully martensitic microstructure as illustrated on figure 4. The latter structures display superior mechanic resistance and a great homogeneity in the case of mechanical solicitation.

Thus, even in products or parts where straining is larger than 10%, the application of cooling according to the invention guarantees a microstructural and mechanical homogeneity.

Example 4:

In a fourth example of implementation, steel castings containing different values of sulfur, were elaborated. These steels were further hot rolled, then cold rolled steel into sheets, 2,2mm thick. Sulfur content varies from 11ppm (0,0011%) to 59ppm (0,006%) in weight. Apart sulfur, the compositions of these different steel castings comprise in weight:

0,24% carbon, 1,17% manganese, 0,01% phosphorus, 0,25% silicon, 0,045% aluminum, 0,01% copper, 0,02% nickel, 0,2% chromium, 0,04% titanium, 0,003% boron, 0,002% calcium, the remainder being iron and unavoidable impurities.

These sheets were pre-coated with an aluminum-based alloy of composition comprising 9,3% silicon, 2.8% iron, the remainder being aluminum and unavoidable impurities.

The sheets were afterwards cut into blanks which were heated at 950°C for 5mn, then hot stamped and cooled in tools in order to obtain a full martensitic structure. Mechanical resistance exceeded 1450 MPa.

Specimens were extracted according to the transverse sense of rolling direction and submitted to a bending test with alternate bending modes. The inventors put into evidence that the critical bending angle (angle at fracture) is closely related to the sulfur content of the steel: when sulfur content is lower than 0,002%, the bending angle exceeds 60°, which indicates higher ductility and energy absorption.

Compact Tensile-Test type specimens were also extracted according to the transverse rolling direction in order to measure the resistance to tearing, i.e. the energy which is necessary for the initiation or propagation of an existing crack. The results, illustrated on figure 6, indicate that a initiation energy higher than 18 Joules is achieved when sulfur content is lower than 0,002% in weight.

As these qualities of high resistance, high energy absorption and weldability are required in automobile industry, the parts or products fabricated according to the invention will be used with profit for such applications.

While the above description is clear with regard to the understanding of the invention, the following terms as used in the following list of preferred embodiments and claims have the following noted meanings in order to avoid any confusion:

pre-coating – the material (Al or Al alloy) coated on or located on at least a portion of the strip or sheet, etc., of base steel to form a pre-coating/base composite, the composite not having been subjected to an alliation reaction between the coated Al or Al alloy material and base steel

alliation – a reaction between the pre-coating and base steel, to produce at least one intermediate layer different in composition from both the base steel and the pre-coating. The alliation reaction happens during the heat treatment immediately preceding hot stamping . The alliation reaction affects the total thickness of the pre-coating. In a highly preferred embodiment the alliation reaction forms the following layers: (a) interdiffusion, (b) intermediate, (c) intermetallic, and (d) superficial as described above;

pre-coated steel - the pre-coating/base composite, not having been subjected to an alliation reaction between the coated material and base steel;

coating – the pre-coating after having been subjected to an alliation reaction between the pre-coating and base steel. In a highly preferred embodiment the coating comprises layers (a) interdiffusion, (b) intermediate, (c) intermetallic, and (d) superficial described above;

coated steel or product - the pre-coated steel or product that has been subjected to an alliation reaction between the pre-coating and base steel. In a highly preferred embodiment the coated steel is a strip or sheet, etc., of base steel having thereon an invention coating comprising layers (a) interdiffusion, (b) intermediate, (c) intermetallic, and (d) superficial described above;

blank – a shape cut from a strip.

product – a stamped blank

Thus, the present invention provides, among other things, the following preferred embodiments:

1. A pre-coated steel strip, comprising:

(a) a strip of base steel having a length, a width, a first side, and a second side;

(b) said length of said strip of base steel being at least 100m and said width being at least 600mm, and

(c) an aluminum or an aluminum alloy pre-coating on at least part of one of said first and second sides of said strip of base steel, wherein

(i) the thickness t_p of the said pre-coating is from 20 - 33 micrometers at every location on at least one of said first and second sides.

2. A method for making a pre-coated steel strip according to embodiment 1 wherein the pre-coated steel strip has a thickness of not greater than 3 mm.

3. A process for making a hot stamped coated steel sheet product, comprising:

(A) heating an aluminum- or aluminum alloy pre-coated steel sheet in a furnace preheated to a temperature and during a time defined by diagram ABCD of figure 7 if thickness of said sheet is greater than or equal to 0.7mm and less than or equal to 1.5mm, and by diagram EFGH of figure 7 if thickness of said sheet is greater than 1.5mm and less than or equal to 3mm, at a heating rate V_c between 20 and 700°C comprised between 4 and 12°C/s, to obtain a heated blank;

(B) transferring said heated blank to a die; and

(C) stamping said heated blank in said die, to thereby obtain a hot stamped steel sheet product, and

wherein the said heated product is cooled at a rate of at least 30°C/s.

4. A process for making a hot stamped coated steel sheet product, comprising:

(A) providing a heated blank according to embodiment 3; and

(B) transferring said heated blank to a die; and

(C) stamping said heated blank in said die, to thereby obtain a hot stamped steel sheet product,
wherein the elapsed time between said heated blank exits said furnace and said stamping commences is not more than 10 seconds, and
wherein said heated blank is deformed by a quantity higher than 10% during said stamping and the said heated product is cooled at a rate of at least 50°C/s.

5. A process for making a hot stamped coated steel sheet product, comprising :
hot dip pre-coating a steel strip having a first side and a second side with aluminum or aluminum alloy to obtain a pre-coated steel strip, the pre-coating thickness on at least one of said first side and said second side of said strip having a thickness of from 20 to 33 µm at every location on at least one of said first and second sides of said strip;
cutting said pre-coated steel strip to obtain a sheet;
heating the sheet in a pre-heated furnace to obtain a heated blank in which the steel is austenitic;
transferring said heated blank to a die while maintaining said steel in the austenitic phase; and
stamping said heated blank in a die to obtain a hot stamped steel sheet product in which the steel microstructure is martensitic.

6. A hot stamped coated steel sheet product, which is prepared by a process comprising :
(A) providing a pre-coated strip according to embodiment 1, said strip being pre-coated with aluminum or aluminum alloy
(B) Cutting said pre-coated steel strip to a predetermined size and shape to obtain a sheet
(C) heating said steel sheet in a furnace preheated to a temperature and during a time defined by diagram ABCD of figure 7 if thickness of said product is greater than or equal to 0.7mm and less than or equal to 1.5mm, and by diagram EFGH of figure 7 if thickness of said product is

greater than 1.5mm and less than or equal to 3mm, to obtain a heated blank;

(D) transferring said heated blank to a die; and

(E) stamping said heated blank in said die, to thereby obtain a hot stamped steel sheet product,

wherein the elapsed time between said heated blank exits said furnace and said stamping commences is not more than 10 seconds, and

wherein said heated product cools at a rate higher than 30°C/s during said stamping.

7 A process for making a hot stamped coated steel sheet product, comprising:

(A) providing a heated blank according to embodiment 6

(B) transferring said heated blank to a die; and

(C) stamping said heated blank in said die, to thereby obtain a hot stamped steel sheet product,

wherein the elapsed time between said heated blank exits said furnace and said stamping commences is not more than 10 seconds, and

wherein said heated product cools at such a rate during said stamping that the steel microstructure is martensitic.

8. The pre-coated steel strip according to embodiment 1, wherein the base steel comprises the following components by weight based on total weight:

0.15%<carbon<0.5%

0.5%<manganese<3%

0.1%<silicon<0.5%

0.01%<chromium<1%

titanium<0.2%

aluminum<0.1%

phosphorus<0.1%

sulfur<0.05%

0.0005%<boron<0.08%,

and further comprises iron and impurities inherent in processing.

9 The pre-coated steel strip according to embodiment 8, wherein the base steel comprises the following components by weight based on total weight:

0.20%<carbon<0.5%
0.8%<manganese<1.5%
0.1%<silicon<0.35%
0.01%<chromium<1%
titanium<0.1%
aluminum<0.1%
phosphorus<0.05%
sulfur<0.03%
0.0005%<boron<0.01%,

and further comprises iron and impurities inherent in processing.

10 The pre-coated steel strip according to embodiment 8 or 9, wherein the base steel comprises 20 ppm or less of sulfur.

11. The pre-coated steel strip according to any of embodiments 8 to 10, wherein the ratio of titanium to nitrogen in the steel sheet in weight % is in excess of 3.42.

12. The pre-coated steel strip according to any of the embodiments 1 or 8 to 11, wherein the aluminum or aluminum alloy pre-coating comprises from 8% to 11% silicon by weight, from 2% to 4% iron by weight, the remainder being aluminum and impurities inherent in processing.

13. A coated steel stamped product, which comprises:
(a) a strip of base steel having a first side and a second side; and
(b) a coating on at least one of said first side of said strip of base steel and said second side of said strip of base steel,
wherein:,

(i) said coating results from the interdiffusion between said base steel, and aluminium or aluminium alloy pre-coating,
(ii) said coating comprises, proceeding from base steel outwards,
- (a) Interdiffusion layer
- (b) Intermediate layer
- (c) Intermetallic layer
- (d) Superficial layer

14. A coated steel stamped product according to embodiment 13, wherein said coating has a thickness greater than 30 micrometers

15. A coated steel stamped product according to embodiments 13 or 14, wherein said layer (a) has a thickness less than 15 micrometers

16. A coated steel stamped product according to any of the embodiments 13 to 15,
wherein the said layers (c) and (d) are occupying at least 90% of the level corresponding to the considered said layers and wherein less than 10% of layer (c) is present at the extreme surface of the product

17. A coated steel stamped product according to any of the embodiments 13 to 16, wherein the steel in the strip has a composition according to embodiment 8

18. A coated steel stamped product according to any of the embodiments 13 to 16, wherein the steel in the strip has a composition according to embodiment 9

19. A coated steel stamped product according to any of the embodiments 13 to 18, wherein the steel has a composition according to embodiment 10

20. A coated steel stamped product according to any of the embodiments 13 to 19, wherein the steel has a composition according to embodiment 11

21. A coated steel stamped product according to any of the embodiments 13 to 20, the aluminum or aluminum alloy pre-coating comprises from 8% to 11% silicon by weight, from 2% to 4% iron by weight, the remainder being aluminum and impurities inherent in processing.

22. A land motor vehicle comprising the heat treated coated steel product according to any of the embodiments 6, 13 to 21

23. A land motor vehicle comprising the heat treated coated steel product produced according to any of the embodiments 3, 4, 5, 7

The above written description of the invention provides a manner and process of making and using it such that any person skilled in this art is enabled to make and use the same, this enablement being provided in particular for the subject matter of the appended claims, which make up a part of the original description. As used above, the phrases "selected from the group consisting of," "chosen from," and the like include mixtures of the specified materials. Terms such as "contain(s)" and the like as used herein are open terms meaning 'including at least' unless otherwise specifically noted. All references, patents, applications, tests, standards, documents, publications, brochures, texts, articles, etc. mentioned herein are incorporated herein by reference. Where a numerical limit or range is stated, the endpoints are included. Also, all values and subranges within a numerical limit or range are specifically included as if explicitly written out. The above description is presented to enable a person skilled in the art to make and use the invention, and is provided in the context of a particular application and its requirements. Various modifications to the preferred embodiments will be readily apparent to those skilled in the art, and the generic principles defined herein may be applied to other embodiments and applications without departing from the spirit and scope of the invention. Thus, this invention is not intended to be limited to the embodiments shown, but is to be accorded the widest scope consistent with the principles and features disclosed herein.

CLAIMS

1. A pre-coated steel strip, comprising:

(a) a strip of base steel having a length, a width, a first side, and a second side;

(b) said length of said strip of base steel being at least 100m and said width being at least 600mm, and

(c) an aluminum or an aluminum alloy pre-coating on at least part of one of said first and second sides of said strip of base steel, wherein

(i) the thickness t_p of the said pre-coating is from 20 - 33 micrometers at every location on at least one of said first and second sides.

2. A method for making a pre-coated steel strip according to claim 1 wherein the pre-coated steel strip has a thickness of not greater than 3 mm.

3. A process for making a hot stamped coated steel sheet product, comprising:

(A) heating an aluminum- or aluminum alloy pre-coated steel sheet in a furnace preheated to a temperature and during a time defined by diagram ABCD of figure 7 if thickness of said sheet is greater than or equal to 0.7mm and less than or equal to 1.5mm, and by diagram EFGH of figure 7 if thickness of said sheet is greater than 1.5mm and less than or equal to 3mm, at a heating rate V_c between 20 and 700°C comprised between 4 and 12°C/s, to obtain a heated blank;

(B) transferring said heated blank to a die; and

(C) stamping said heated blank in said die, to thereby obtain a hot stamped steel sheet product, and

wherein the said heated product is cooled at a rate of at least 30°C/s.

4. A process for making a hot stamped coated steel sheet product, comprising:

(A) providing a heated blank according to claim 3; and

(B) transferring said heated blank to a die; and

(C) stamping said heated blank in said die, to thereby obtain a hot stamped steel sheet product,

wherein the elapsed time between said heated blank exits said furnace and said stamping commences is not more than 10 seconds, and

wherein said heated blank is deformed by a quantity higher than 10% during said stamping and the said heated product is cooled at a rate of at least 50°C/s.

5. A process for making a hot stamped coated steel sheet product, comprising :

hot dip pre-coating a steel strip having a first side and a second side with aluminum or aluminum alloy to obtain a pre-coated steel strip, the pre-coating thickness on at least one of said first side and said second side of said strip having a thickness of from 20 to 33 µm at every location on at least one of said first and second sides of said strip;

cutting said pre-coated steel strip to obtain a sheet;

heating the sheet in a pre-heated furnace to obtain a heated blank in which the steel is austenitic;

transferring said heated blank to a die while maintaining said steel in the austenitic phase; and

stamping said heated blank in a die to obtain a hot stamped steel sheet product in which the steel microstructure is martensitic.

6. A hot stamped coated steel sheet product, which is prepared by a process comprising :

(A) providing a pre-coated strip according to claim 1, said strip being pre-coated with aluminum or aluminum alloy

(B) Cutting said pre-coated steel strip to a predetermined size and shape to obtain a sheet

(C) heating said steel sheet in a furnace preheated to a temperature and during a time defined by diagram ABCD of figure 7 if thickness of said product is greater than or equal to 0.7mm and less than or equal to

1.5mm, and by diagram EFGH of figure 7 if thickness of said product is greater than 1.5mm and less than or equal to 3mm, to obtain a heated blank;

(D) transferring said heated blank to a die; and

(E) stamping said heated blank in said die, to thereby obtain a hot stamped steel sheet product,

wherein the elapsed time between said heated blank exits said furnace and said stamping commences is not more than 10 seconds, and wherein said heated product cools at a rate higher than 30°C/s during said stamping.

7 A process for making a hot stamped coated steel sheet product, comprising:

(A) providing a heated blank according to claim 6

(B) transferring said heated blank to a die; and

(C) stamping said heated blank in said die, to thereby obtain a hot stamped steel sheet product,

wherein the elapsed time between said heated blank exits said furnace and said stamping commences is not more than 10 seconds, and wherein said heated product cools at such a rate during said stamping that the steel microstructure is martensitic.

8. The pre-coated steel strip according to claim 1, wherein the base steel comprises the following components by weight based on total weight:

0.15%<carbon<0.5%

0.5%<manganese<3%

0.1%<silicon<0.5%

0.01%<chromium<1%

titanium<0.2%

aluminum<0.1%

phosphorus<0.1%

sulfur<0.05%

0.0005%<boron<0.08%,

and further comprises iron and impurities inherent in processing.

9 The pre-coated steel strip according to claim 8, wherein the base steel comprises the following components by weight based on total weight:

0.20%<carbon<0.5%
0.8%<manganese<1.5%
0.1%<silicon<0.35%
0.01%<chromium<1%
titanium<0.1%
aluminum<0.1%
phosphorus<0.05%
sulfur<0.03%
0.0005%<boron<0.01%,

and further comprises iron and impurities inherent in processing.

10 The pre-coated steel strip according to claim 8 or 9, wherein the base steel comprises 20 ppm or less of sulfur.

11. The pre-coated steel strip according to any of claims 8 to 10, wherein the ratio of titanium to nitrogen in the steel sheet in weight % is in excess of 3.42.

12. The pre-coated steel strip according to any of the claims 1 or 8 to 11, wherein the aluminum or aluminum alloy pre-coating comprises from 8% to 11% silicon by weight, from 2% to 4% iron by weight, the remainder being aluminum and impurities inherent in processing.

13. A coated steel stamped product, which comprises:
(a) a strip of base steel having a first side and a second side; and
(b) a coating on at least one of said first side of said strip of base steel and said second side of said strip of base steel,
wherein:,

(i) said coating results from the interdiffusion between said base steel, and aluminium or aluminium alloy pre-coating,

(ii) said coating comprises, proceeding from base steel outwards,

- (a) Interdiffusion layer
- (b) Intermediate layer
- (c) Intermetallic layer
- (d) Superficial layer

14. A coated steel stamped product according to claim 13, wherein said coating has a thickness greater than 30 micrometers

15. A coated steel stamped product according to claims 13 or 14, wherein said layer (a) has a thickness less than 15 micrometers

16. A coated steel stamped product according to any of the claims 13 to 15, wherein the said layers (c) and (d) are occupying at least 90% of the level corresponding to the considered said layers and wherein less than 10% of layer (c) is present at the extreme surface of the product

17. A coated steel stamped product according to any of the claims 13 to 16, wherein the steel in the strip has a composition according to claim 8

18. A coated steel stamped product according to any of the claims 13 to 16, wherein the steel in the strip has a composition according to claim 9

19. A coated steel stamped product according to any of the claims 13 to 18, wherein the steel has a composition according to claim 10

20. A coated steel stamped product according to any of the claims 13 to 19, wherein the steel has a composition according to claim 11

21. A coated steel stamped product according to any of the claims 13 to 20, the aluminum or aluminum alloy pre-coating comprises from 8% to 11%

silicon by weight, from 2% to 4% iron by weight, the remainder being aluminum and impurities inherent in processing.

22. A land motor vehicle comprising the heat treated coated steel product according to any of the claims 6, 13 to 21

23. A land motor vehicle comprising the heat treated coated steel product produced according to any of the claims 3, 4, 5, 7

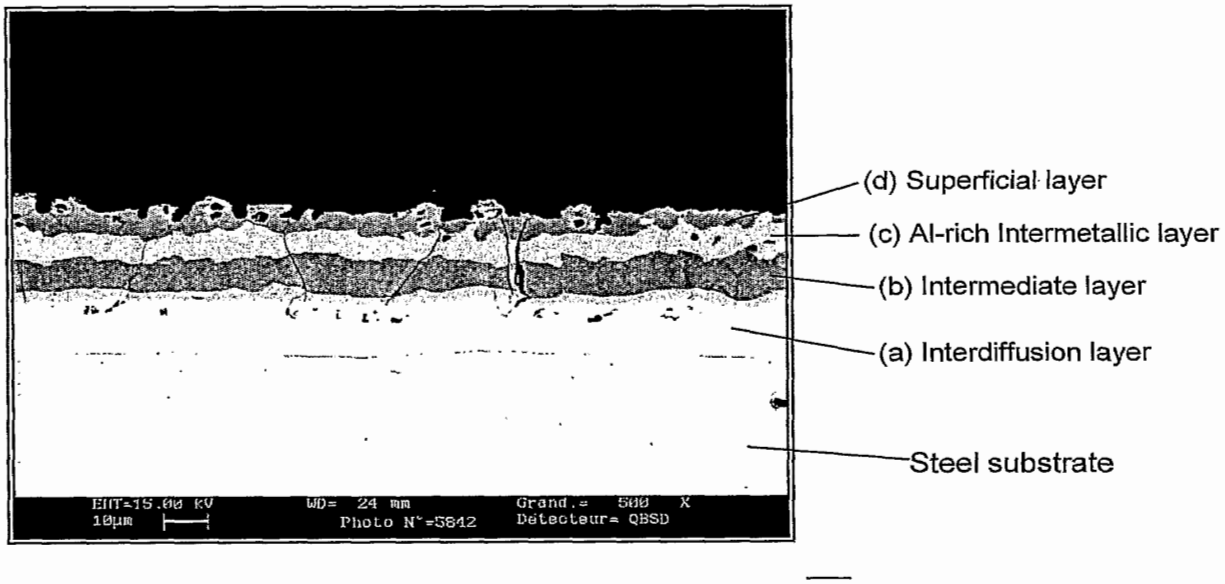
(d) Superficial layer
(c) Al-rich Intermetallic layer
(b) Intermediate layer
(a) Interdiffusion layer
Steel substrate
EHT=15.00 kV
WD= 24 mm
Grand.= 500 X
10µm
Photo N°=5842
Détecteur= QBSD
10µm

Fig. 1

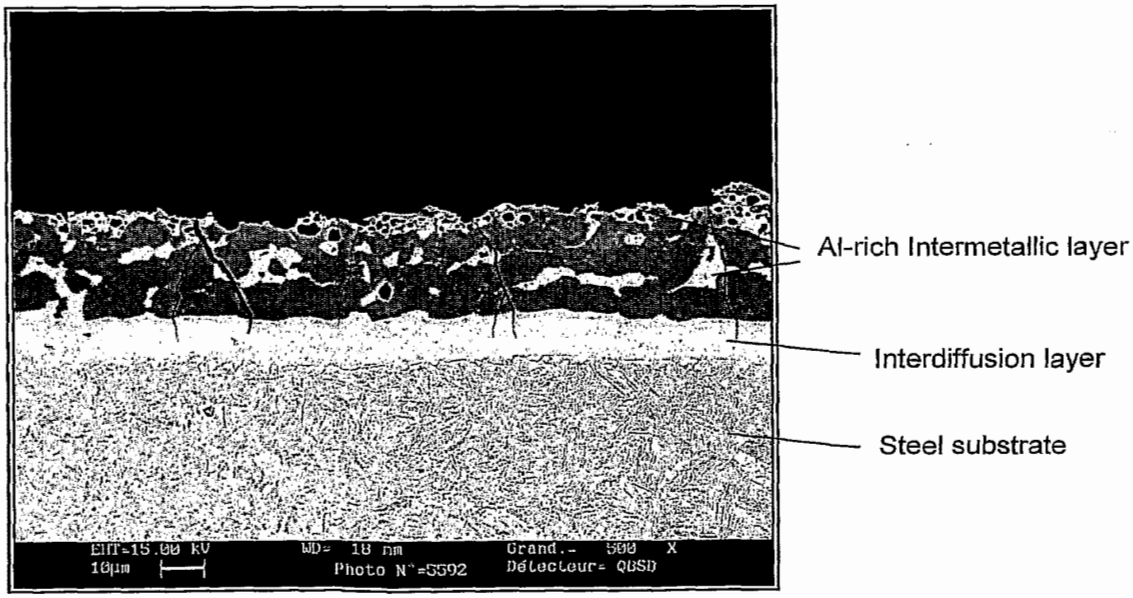
Al-rich Intermetallic layer
Interdiffusion layer
Steel substrate
EHT=15.00 kV
WD= 18 mm
Grand.= 500 X
10µm
Photo N°=5592
Détecteur= QBSD
10µm

Fig.2

Fig. 3

10µm

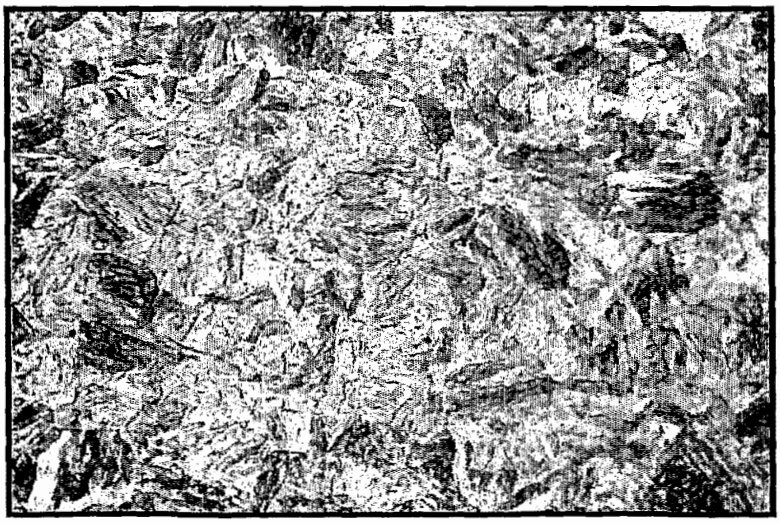

Fig. 4

10 µm

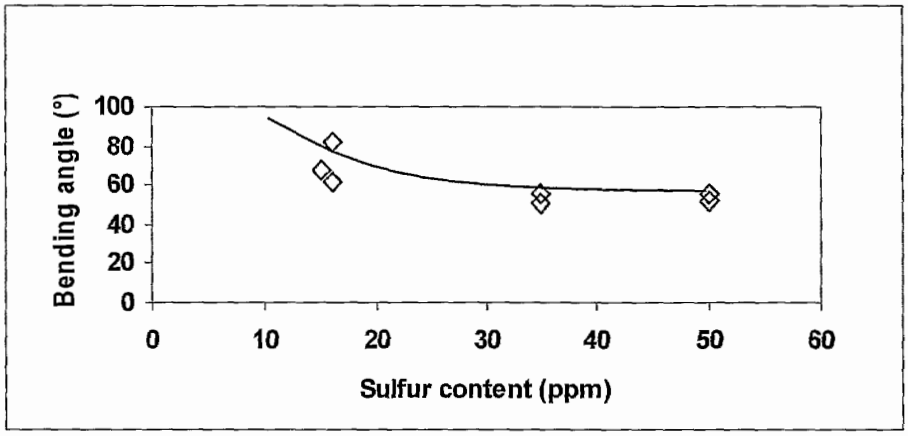
Bending angle (°)
100
80
60
40
20
0
0
10
20
30
40
50
60
Sulfur content (ppm)

Fig. 5

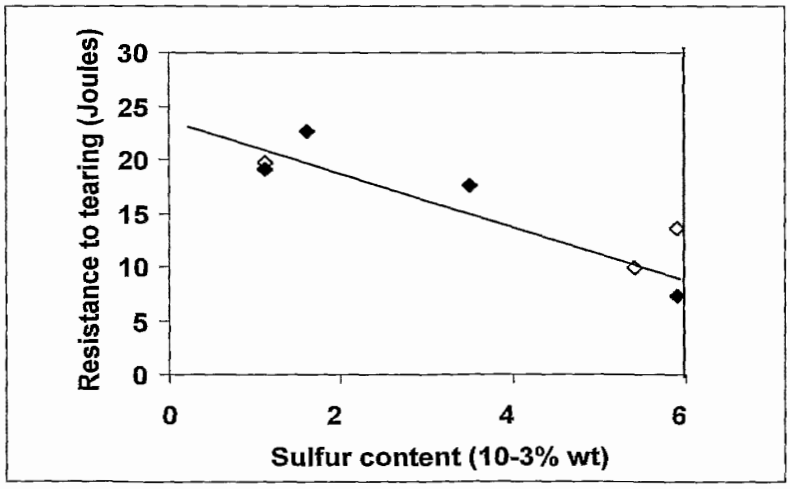
Resistance to tearing (Joules)
30
25
20
15
10
5
0
0
2
4
6
Sulfur content (10-3% wt)

Fig. 6

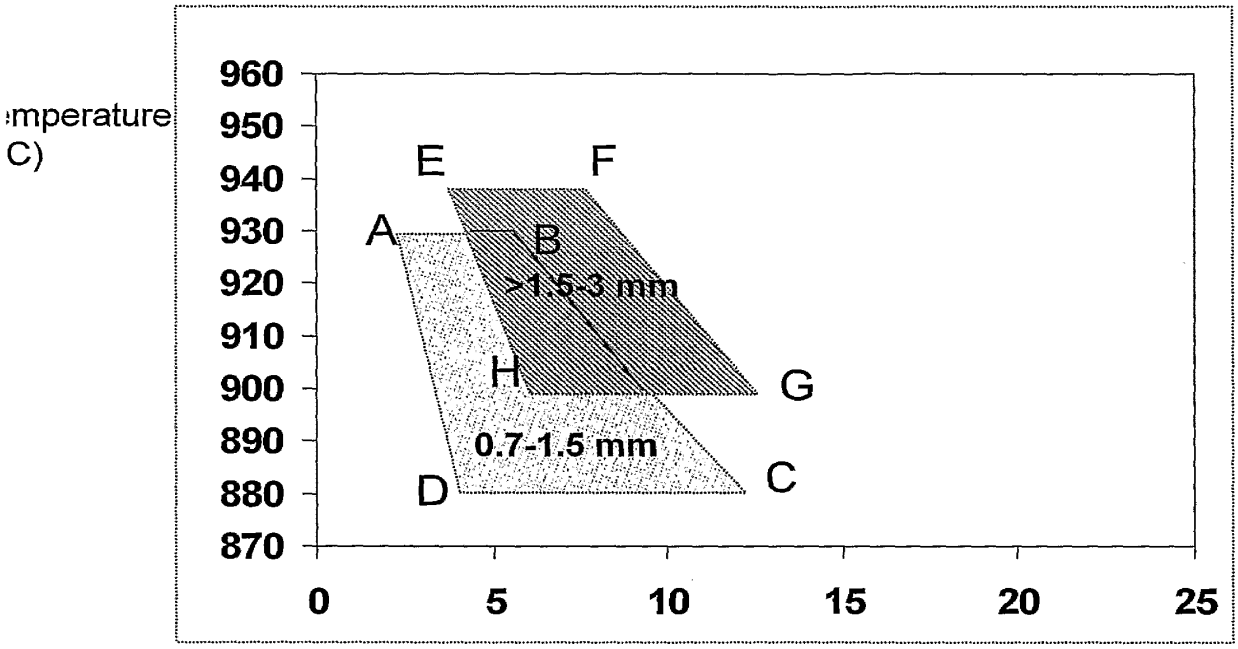
mperature
C)
960
950
940
930
920
910
900
890
880
870
E
F
A
B
>1.5-3 mm
H
G
0.7-1.5 mm
D
C
0
5
10
15
20
25
Total dwell time in the furnace including heating (min.)

Fig. 7

INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2006/004019

A. CLASSIFICATION OF SUBJECT MATTER
INV. B32B15/00 C21D9/46

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
C22C B32B C23C C23F C21D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal, CHEM ABS Data, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 6 296 805 B1 (LAURENT JEAN-PIERRE [FR] ET AL) 2 October 2001 (2001-10-02) column 2, line 25 - column 4, line 18 claims 1-14	1-23
X	EP 1 013 785 A1 (LORRAINE LAMINAGE [FR] ARCELOR FRANCE [FR]) 28 June 2000 (2000-06-28) paragraphs [0001], [0003] - [0005], [0011] - [0013], [0019]; claims 1-11	1,2,5,7
X	EP 1 336 666 A (BHP STEEL JLA PTY LTD [AU]) 20 August 2003 (2003-08-20) paragraphs [0007], [0041] - [0043], [0060], [0079] claims 1,6	1,2

-/--

[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
15 June 2007	22/06/2007

Name and mailing address of the ISA/	Authorized officer
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Form PCT/ISA/210 (second sheet) (April 2005)

INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2006/004019

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP 0 356 783 A2 (ARMCO INC [US] ARMCO STEEL CO LP [US]) 7 March 1990 (1990-03-07) the whole document	1-23
A	FR 2 720 079 A1 (LORRAINE LAMINAGE [FR]) 24 November 1995 (1995-11-24) the whole document	1-23
A	FR 2 758 571 A1 (LORRAINE LAMINAGE [FR]) 24 July 1998 (1998-07-24) the whole document	1-23
A	WO 2006/097593 A (ARCELOR FRANCE [FR]; LAURENT JEAN-PIERRE [FR]; DEVROC JACQUES [FR]) 21 September 2006 (2006-09-21) the whole document	1-23

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/IB2006/004019

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 6296805 B1	02-10-2001	AT 240419 T	15-05-2003
		BR 9902712 A	08-03-2000
		CA 2276911 A1	09-01-2000
		DE 69907816 D1	18-06-2003
		DE 69907816 T2	11-03-2004
		DK 971044 T3	11-08-2003
		EP 0971044 A1	12-01-2000
		ES 2196740 T3	16-12-2003
		FR 2780984 A1	14-01-2000
		JP 2000038640 A	08-02-2000
		PT 971044 T	29-08-2003
EP 1013785 A1	28-06-2000	AT 343658 T	15-11-2006
		DK 1013785 T3	15-01-2007
		FR 2787735 A1	30-06-2000
EP 1336666 A	20-08-2003	CN 1353212 A	12-06-2002
		NZ 514712 A	01-03-2002
		US 2003152796 A1	14-08-2003
EP 0356783 A2	07-03-1990	AR 245228 A1	30-12-1993
		AU 3942589 A	08-02-1990
		BR 8904258 A	10-04-1990
		CA 1330506 C	05-07-1994
		CN 1040828 A	28-03-1990
		DE 68912243 D1	24-02-1994
		DE 68912243 T2	30-06-1994
		ES 2048795 T3	01-04-1994
		FI 894015 A	01-03-1990
		IN 171867 A1	30-01-1993
		JP 2104650 A	17-04-1990
		JP 2516259 B2	24-07-1996
		NO 893424 A	01-03-1990
		US 5023113 A	11-06-1991
		YU 161889 A1	28-02-1991
		ZA 8906221 A	30-05-1990
FR 2720079 A1	24-11-1995	AT 158823 T	15-10-1997
		DE 69500797 D1	06-11-1997
		DE 69500797 T2	05-03-1998
		EP 0698671 A1	28-02-1996
		ES 2107283 T3	16-11-1997
FR 2758571 A1	24-07-1998	NONE	
WO 2006097593 A	21-09-2006	FR 2883007 A1	15-09-2006

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CLAIMS RU2040556

METHOD FOR MANUFACTURING OF STRIPS of low carbon hot rolled steel, comprising a heating step at a predetermined rate to the annealing temperature of 700 740oS cooling to alyumotsinkovaniya temperature alyumotsinkovanie and tempering at 300 400 ° C, characterized in that the heating is carried out first at a speed of 7 9 19oS / s to 500 600 ° C, and then at a speed of 0.8–3.3 ° C / s to the annealing temperature, holding for 47–94 s, cooling from the annealing temperature is carried out at a speed of 2.7–12 ° C / s to 500–600 ° C.

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DESCRIPTION RU2040556

METHOD OF MANUFACTURE OF THE STRUCTURE FROM LOW-CARBON HOT-ROLLED STEEL

The invention relates to metallurgy, in particular the production of strips with alyumotsinkovy coating, and can be used in the production of hot-rolled low-carbon steel sheets with alyumotsinkovkoy coating on the units of continuous hot alumunikovaniya.

Sheet steel with an alumina-zinc coating used in mechanical engineering must have a high corrosion resistance, stampability, prevent the coating from peeling off from the base during processing by stamping and be characterized by the following quality indicators (Table 1).

The depth of the hole according to Eriksen in the table. 1 is indicated for a 2.0 mm sheet. Violations of the integrity of the coating during this test are not allowed.

The corrosion resistance K is determined according to the method TU-14-11-247-88 by the weight loss of the sample for 3 hours in a solution of 50 g / l NaCl 0.1% H2O2.

The production technology of the strips with the complex of properties indicated in Table 1 usually includes hot rolling, pickling, cold rolling, cleaning, heat treatment, aluminum zincing, tempering and tempering [1] At the same time, the additional operation of cold rolling lengthens the production cycle, increases energy costs, the cost of rental and the price finished products, worsens the environmental situation.

A known method for the production of strips of mild steel, including hot rolling of the steel with a rolling end temperature of 780-820 ° C, cooling and winding at a roll at 620-680 ° C, cold rolling, continuous annealing according to the mode: heating at a speed of 12-18 ° C / s to 620-660 ° C , holding at this temperature for 45--66 s and then cooling first at a speed of 6--12 ° C / s to 560--600 ° C and then at a speed of 1--4 ° C / s [2] The disadvantages of this method are that the strip after the hot Zincing has insufficient quality coating (due to delaminations and low corrosion resistance), as well as poor formability.

There is also known a method of producing strips of mild steel for tinning, including cold rolling of hot rolled strips, continuous heat treatment with two-stage heating: first up to 480-520 ° C and then at a speed of 1.5-3.5 ° C / s to an annealing temperature of 640-680 ° C, after then the strip is cooled slowly with a speed of 0.9-1.7 ° C / s to 480-520 ° C [3] This method turned out to be unsuitable for the production of hot-rolled strips with an alumino-zinc coating due to insufficient formability of the substrate, delamination of the coating during stamping.

Closest to the present invention is a method for the production of strips of low-carbon hot-rolled steel with alyumotsinkovym coating. The method includes continuous heat treatment by multi-stage heating: first at a rate of 25 ° C / s to 480-490 ° C, holding, then at a speed of 8-9 ° C / s to an annealing temperature of 710-730 ° C, after which the strip is cooled at a rate of 4.5-5.5 ° C / with hot-dip galvanizing temperature of 460-480 ° C, coated by the method of immersion in the molten metal of the coating and released at 300-400 ° C [4] The disadvantages of the prototype method are that when using a cold-rolled strip of low carbon steel as the steel basis with zinc-coated: temporary tensile strength and yield strength are higher than the allowable values, the relative elongation and depth of the Eriksen well are insufficient. When stamping parts, there are gaps in the steel base, the appearance of coating delamination, which is unacceptable.

The purpose of the invention to improve the quality of coating and stampability bands.

The goal is achieved by the fact that in the known method of producing strips from low-carbon hot rolled steel with an alumina zinc coating including continuous heat treatment by multistage heating at regulated speeds up to an annealing temperature of 700-740 ° C, cooling at a rate of 2.7-12 ° C / s 300-400 ° C, heating is carried out at a rate of 7.9-19 ° C / s to 500-600 ° C, and then at a rate of 0.7-3.3 ° C / s to the annealing temperature at which the strip is kept 47-94c, and cooling before hot zinc heating lead to 500-60 0 ° C

Known and proposed technical solutions have the following common features. Both of them are methods for the production of strips of mild hot-rolled steel with alyumotsinkovym coating. Both include continuous heat treatment by multistage heating at regulated rates to an annealing temperature of 700-740 ° C. In both cases, the strip is provided with a cooling rate of 2.7-12 ° C / s, subsequent hot-dip galvanizing and tempering of the coated strip at 300-400 ° C.

The differences of the proposed method consist in the fact that heating is first carried out at a rate of 7.9-19 ° C / s to 500-600 ° C, whereas in the known one at a rate of 25 ° C / s to 480-490 ° C. In the proposed method, after the temperature of the first stage is reached, the heating rate is reduced to 0.7-3.3 ° C / s, while in the well-known method they are held at a constant temperature, after which heating is continued at a rate of 8-9 ° C / s to the annealing temperature.

In the proposed method, the strip is maintained at the annealing temperature for 47-94 s, which is not in the known method. And finally, in the proposed method, the cooling is carried out to 500-600 ° C, and in the known way to 460-480 ° C.

The essence of the proposed technical solution is as follows.

Hot-rolled low-carbon steel is a ferrite-pearlite two phase mixture was structurally free cementite and has anisotropy of mechanical properties caused by hot deformation textured. Heating at 7,9-19oS / s to 500-600oS rapidly cooled hot rolled steel provides equiaxed ferrite grains, coagulation carbides. Subsequent heating at a rate of 0.7-3.3 ° C / s ensures uniform growth of ferrite grains, decomposition of lamellar perlite and a change in its morphology. Extract 700-740oS at the annealing temperature and the subsequent cooling at a rate regulated 0,7-3,3oS / s can form an optimal (in terms of formability) steel microstructure, enabling increase teksturylil} crystallographic orientation as well as the adhesion of molten aluminum with zinc to the strip. At a temperature 500-600oS strip during hot 300-400 coatings during tempering it provides the best coating quality and finish hot-aging steel, which leads to the conservation of its mechanical properties during the further transport, storage and processing.

It was established experimentally that the heating in the first stage at a rate 7,9-19oS / s to the beginning of the percolation 500-600oS provides zakristallizatsii processes in areas of maximum structural defects of hot metal rapidly cooled. By increasing the heating rate of 19 ° or more decrease in temperature less than 500 ° C the mechanical properties after alyumotsinkovaniya bands do not match, resulting in degradation of formability. A decrease in the heating rate of less than 7.9 ° C / s or an increase in temperature of more than 600 ° C contributes to the formation of different grain sizes, deterioration of stampability and quality of the coating.

reheat rate, annealing temperature and holding time at this temperature is determined combination of mechanical properties of the strip after alyumotsinkovaniya, the nature of the microstructure and strength of the coating adhesion to the steel substrate. The process of hot galvanizing and subsequent tempering increases the strength of hot-rolled steel, reduces its ductility and stampability. Therefore, the mechanical properties of the steel base before coating should be higher than the requirements in Table 1.

When a reheat rate 3,3oS / with an annealing temperature below 700 ° C and residence time of less than 47c, as experiments have shown, the mechanical properties of the finished strip are unsatisfactory: strength values exceed permissible, and the ductility and hole depth less Erichsen setpoints. It turns out fine-grained microstructure with 9 points of ferrite grain, which contains clusters of carbides in the matrix. Carbon does not have time to diffuse over long distances, to coagulate, the matrix is not cleared. In addition to hardening, such steel fails to combine satisfactorily with the aluminous-zinc coating.

Reduced reheat rate less 0,7oS / s, increasing the annealing temperature or more residence time 740oS more 94c, as experiments have shown, increases the inequigranular, weakening the intergranular bonds, reduction of formability and coating ruptures during forming due to uneven deformation.

The temperature of the metal before hot zinc oxidation besides the mechanical properties determines the quality of the hot coating. At temperatures below 500C strip alyumotsinkovym coating quality is poor, but at a temperature of more iron strip 600C is intensive interaction of aluminum and zinc, the corrosion resistance deteriorates coating bath contaminated alyumotsinkovaniya unit.

PRI me R. Slab of mild steel with a section of 200x1400 mm of the following chemical composition, wt. C 0.07 Si 0.03 Mn 0.94 Cr 0.04 Ni 0.04 Al 0.04 N2 0.007 heated in reheating furnace to 1280oS and rolled on a continuous mill wideband 1700

band section 2 x x1350 mm. The temperature of the rolling end is maintained at 840 ° C. Then the strip is rapidly cooled with water to 630 ° C and wound into a roll. After cooling roll it is mounted on the unwinder unit and subjected to an etching sulfuric-acid pickling for descaling with simultaneous trimming the side edges to obtain the bandwidth of 1300 mm, which after washing is wound into a roll.

Then the roll is mounted on the decoiler of a continuous hot galvanizing unit (ANGA).

In Ang performed trimming to 1250 mm strip width and surface chemical treatment is carried out in strips of brush-washing machines in a water solution of caustic soda with trisodium phosphate. After cleaning, the strip is washed with water and dried with air at 95 ° C.

The cleaned strip is fed to a continuous furnace, where the strip is heated in steps in a protective and reducing atmosphere, first with a speed of Vн.1 13.5 ° C / s to Tn.1 550 ° C. Then the strip is reheated at a rate of V.2.2 ° C / s to an annealing temperature of To 720 ° C, at which it is held for about 70 ° C. After completion of the exposure, the strip is cooled at a rate of Vo. 7.4 ° C / with jets of protective gas to a temperature of TC of 550 ° C and coated with an alumo-zinc alloy by immersion into the melt of the following composition, wt.

Zn Fe Si Al 43.1 0.65 1.48 Base The strip after the hot coating is cooled to a temperature Tot. tempering at 350 ° C, at which it is kept for 100 s. Released ready-made strip is wound into a roll and transported to the consumer.

In tab. 2 shows the options for the implementation of the proposed method and the prototype method, and in table 3 the quality indicators of hot-rolled strips with a Zinc-coated coating.

From tab. 3 it follows that in the case of the implementation of the proposed method (options 2-4), the quality of the coating and the stampability of the strips are improved, as evidenced by the best combination of mechanical properties and maximum corrosion resistance. For exorbitant values of the stated parameters (options 1.5-11), there is a decrease in the quality of the coating and the stampability of the strips. When implementing the prototype method (option 12), the coating quality and the stampability of the strips are unsatisfactory.

Technical and economic advantages of the proposed method consist in the fact that heating first with a speed of 7.9-19 ° C / s to 500-600 ° C, reheating with a speed of 0.7-3.3 ° C / s to 700-740 ° C, holding at this temperature 47 -94c, cooling at a rate of 2.7-12 ° C / s to 500-600 ° C and tempering of the metal with a coating at 300-400 ° C ensure the production of high-quality alumino-zinc coating and high formability of hot-rolled strip of mild steel. This allows to exclude the operation of cold rolling from the technological cycle.

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(54) METHOD OF MAKING STRIPS OF LOW-CARBON HOT ROLLED STEEL

(57) Abstract:

FIELD: metallurgy. SUBSTANCE: method comprises steps of heating a slab of low-carbon steel with a cross section (200 x 1400) mm in a furnace up to 1280 C and rolling it to a strip with a cross section (2 x 1350) mm; keeping a temperature of rolling process termination, equal to 840 C; performing a rapid cooling of the strip by water up to 630 C and coiling it to a coil; removing scale after the coil had been cooled; placing the to an uncoiler of a plant for hot coating it by aluminium0zinc alloy, guiding the cleaned strip in a protection-reduction atmosphere at first with a rate 13.5 C/s up to 550 C, then with a rate 2 C/s up to 720 C and curing it at 7 C; performing a cooling procedure with rate 7.4 C/s by jets of the protective gas up to 550 C and coating it by the aluminium-zinc alloy; cooling the strip after hot coating had been applied onto it, up to a temperature of tempering, being 350 C, and curing it at 100 C; coiling the temperedstrip to a coil. EFFECT: enhanced quality of strip. 1 cl, 3 tbl

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(54) СПОСОБ ПРОИЗВОДСТВА ПОЛОС ИЗ МАЛОУГЛЕРОДИСТОЙ ГОРЯЧЕКАТАНОЙ СТАЛИ

(57) Реферат:

Изобретение относится к металлургии, в частности к получению полос с алюмоцинковым покрытием, и может быть использовано при получении горячекатаной малоуглеродистой листовой стали с алюмоцинковым покрытием на агрегатах непрерывного горячего алюмоцинкования. Сляб из малоуглеродистой стали сечением 200 х 1400 мм разогревают в печи до 1280°С и прокатывают в полосу сечением 2 х 1350 мм. Температуру конца прокатки поддерживают равной 840°С. Затем полосу ускоренно охлаждают водой до 630°С и сматывают в рулон. После охлаждения рулона удаляют окалину. Затем рулон устанавливают на разматыватель агрегата непрерывного горячего алюмоцинкования. Очищенную полосу направляют ступенчато в защитно-восстановительной атмосфере, вначале со скоростью 13,5°С/с до 550°С, затем со скоростью 2°С/с до 720°С и выдерживают 7°С. Охлаждение ведут со скоростью 7,4°С/с струями защитного газа до 550°С и покрывают алюмоцинковым сплавом. После горячего покрытия полосу охлаждают до температуры отпуска 350°С и выдерживают 100°С. Отпущенную полосу сматывают в рулон. 3 табл.

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Изобретение относится к металлургии, в частности к получению полос с алюмоцинковым покрытием, и может быть использовано при производстве горячекатанной малоуглеродистой листовой стали с алюмоцинковым покрытием на агрегатах непрерывного горячего алюмоцинкования.

Листовая сталь с алюмоцинковым покрытием, используемая в машиностроении, должна обладать высокой коррозионной стойкостью, штампуемостью, не допускать отслоений покрытия от основы при переработке штамповкой и характеризоваться следующими показателями качества (табл.1).

Глубина лунки по Эриксену в табл. 1 указана для листа толщиной 2,0 мм. Нарушения сплошности покрытия при этом испытании не допускаются.

Коррозионную стойкость К определяют согласно методике ТУ-14-11-247-88 по потере веса образца за 3 ч в растворе 50 г/л NaCl 0,1% H_2O_2.

Технология производства полос с указанным в табл.1 комплексом свойств обычно включает горячую прокатку, травление, холодную прокатку, очистку, термообработку, алюмоцинкование, отпуск и дрессировку [1] При этом дополнительная операция холодной прокатки удлиняет производственный цикл, увеличивает энергозатраты, себестоимость проката и цену готовой продукции, ухудшает экологическую ситуацию.

Известен способ производства полос из малоуглеродистой стали, включающий горячую прокатку подката с температурой конца прокатки 780-820°С, охлаждение и смотку в рулон при 620-680°С, холодную прокатку, непрерывный отжиг по режиму: нагрев со скоростью 12-18°С/с до 620-680°С, выдержка при этой температуре в течение 45-66 с и последующее охлаждение вначале со скоростью 6-12°С/с до 560-600°С, а затем со скоростью 1-4°С/с [2]

Недостатки известного способа состоят в том, что полоса после горячего алюмоцинкования имеет недостаточно высокое качество покрытия (вследствие отслоений и низкой коррозионной стойкости), а также плохую штампуемость.

Известен также способ производства полос из малоуглеродистой стали для лужения, включающий холодную прокатку горячекатаных полос, непрерывную термообработку с двухступенчатым нагревом: вначале до 480-520°С, а затем со скоростью 1,5-3,5°С/с до температуры отжига 640-680 °С, после чего полосу замедленно охлаждают со скоростью 0,9-1,7°С/с до 480-520°С [3]

Данный способ оказался непригоден для производства горячекатаных полос с алюмоцинковым покрытием из-за недостаточной штампуемости основы, отслоений покрытия при штамповке.

Наиболее близким к предлагаемому является способ производства полос из малоуглеродистой горячекатаной стали с алюмоцинковым покрытием. Способ включает непрерывную термообработку путем многоступенчатого нагрева: вначале со скоростью 25°С/с до 480-490°С, выдержку, затем со скоростью 8-9°С/с до температуры отжига 710-730°С, после чего полосу охлаждают со скоростью 4,5-5,5°С/с до температуры горячего цинкования 460-480 °С, покрывают методом погружения в расплав металла покрытия и отпускают при 300-400°С [4]

Недостатки способа-прототипа заключаются в том, что при использовании в качестве стальной основы холоднокатаной полосы из малоуглеродистой стали не обеспечивается требуемого качества полос с алюмоцинковым покрытием: временное сопротивление разрыву и предел текучести выше допустимых значений, относительное удлинение и глубина лунки Эриксена недостаточны. При штамповке деталей имеют место разрывы стальной основы, появления отслоений покрытия, что недопустимо.

Цель изобретения повышение качества покрытия и штампуемости полос.

Цель достигается тем, что в известном способе производства полос из малоуглеродистой горячекатаной стали с алюмоцинковым покрытием, включающем непрерывную термообработку путем многоступенчатого нагрева с регламентированными скоростями до температуры отжига 700-740°С, охлаждение со скоростью 2,7-12°С/с, горячее алюмоцинкование и отпуск при 300-400°С, нагрев осуществляют со скоростью 7,9-19 °С/с до 500-600°С, а затем со скоростью 0,7-3,3°С/с до температуры отжига, при которой полосу выдерживают 47-94с, а охлаждение перед горячим алюмоцинкованием ведут до 500-600°С.

Известное и предложенное технические решения имеют следующие общие признаки. Оба они являются способами производства полос из малоуглеродистой горячекатаной стали с алюмоцинковым покрытием. Оба включают непрерывную термообработку путем многоступенчатого нагрева с регламентированными скоростями до температуры отжига 700-740°С. В обоих случаях предусмотрено охлаждение полосы со скоростью 2,7-12°С/с, последующее горячее алюмоцинкование и отпуск полосы с покрытием при 300-400°С.

Отличия предложенного способа состоят в том, что нагрев вначале осуществляют со скоростью 7,9-19°С/с до 500-600°С, тогда как в известном со скоростью 25°С/с до 480-490°С. В предложенном способе после достижения температуры первой ступени скорость нагрева снижают до 0,7-3,3°С/с, тогда как в известном делают выдержку при постоянной температуре, после чего продолжают нагрев со скоростью 8-9°С/с до температуры отжига.

В предложенном способе полосу выдерживают при температуре отжига в течение 47-94 с, что в известном способе нет. И, наконец, в предложенном способе охлаждение ведут до 500-600°С, а в известном до 460-480°С.

Сущность предложенного технического решения состоит в следующем.

Горячекатаная малоуглеродистая сталь представляет из себя двухфазную ферритно-перлитную смесь со структурно

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свободным цементитом и обладает анизотропией механических свойств, обусловленной текстурой горячей деформации. Нагрев со скоростью 7,9-19°С/с до 500-600°С быстроохлажденной горячекатаной стали обеспечивает получение равноосных ферритных зерен, коагуляцию карбидов. Последующий нагрев со скоростью 0,7-3,3°С/с обеспечивает равномерный рост зерен феррита, распад пластинчатого перлита и изменение его морфологии. Выдержка при температуре отжига 700-740°С и последующее регламентированное охлаждение со скоростью 0,7-3,3°С/с позволяют сформировать оптимальную (с точки зрения штампуемости) микроструктуру стали, увеличить благоприятную кристаллографическую ориентировку текстуры{{{} а также адгезию расплава алюминия с цинком к полосе. При температуре полосы 500-600°С в процессе горячего покрытия 300-400 °С при отпуске обеспечивается наилучшее качество горячего покрытия и завершаются процессы старения стали, что приводит к сохранению ее механических свойств при дальнейшем транспортировании, хранении и переработке.

Экспериментально установлено, что нагрев на первой ступени со скоростью 7,9-19 °С/с до 500-600°С обеспечивает начало протекания процессов закристаллизации в местах наибольших дефектов структуры быстроохлажденного горячекатаного металла. При увеличении скорости нагрева более 19°С или снижении температуры менее 500°С механические свойства полос после алюмоцинкования не соответствуют заданным, что приводит к ухудшению штампуемости. Снижение скорости нагрева менее 7,9°С/с или повышение температуры более 600°С способствует образованию разнозернистости, ухудшению штампуемости и качества покрытия.

Скорость повторного нагрева, температура отжига и время выдержки при этой температуре определяют комплекс механических свойств полосы после алюмоцинкования, характер микроструктуры и прочность сцепления покрытия со стальной основой. Процесс горячего алюмоцинкования и последующий отпуск повышают прочность горячекатаной стали, снижают ее пластичность и штампуемость. Поэтому механические свойства стальной основы перед покрытием должны быть выше требований, обусловленных в табл.1.

При скорости повторного нагрева более 3,3°С/с температуре отжига ниже 700°С и времени выдержки менее 47с, как показали эксперименты, механические свойства готовой полосы неудовлетворительны: показатели прочности превышают допустимые, а пластичность и глубина лунки Эриксена менее заданных значений. Получается мелкозернистая микроструктура с 9 баллом зерна феррита, которая содержит скопления карбидов в матрице. Углерод не успевает диффундировать на большие расстояния, коагулировать, матрица не очищена. Помимо упрочнения такая сталь неудовлетворительно соединяется с алюмоцинковым покрытием.

Снижение скорости повторного нагрева менее 0,7°С/с, увеличение температуры отжига более 740°С или времени выдержки более 94с, как показали эксперименты, приводит к увеличению разнозернистости, ослаблению межзеренных связей, снижению штампуемости и разрывам покрытия при штамповке вследствие неравномерной деформации.

Температура металла перед горячим алюмоцинкованием помимо механических свойств определяет качество горячего покрытия. При температуре полосы ниже 500 °С качество алюмоцинкового покрытия неудовлетворительное, а при температуре полосы более 600°С идет интенсивное взаимодействие алюминия и цинка с железом, ухудшается коррозионная стойкость покрытия, загрязняется ванна агрегата алюмоцинкования.

П р и м е р. Сляб из малоуглеродистой стали сечением 200х1400 мм следующего химического состава, мас. С 0,07 Si 0,03 Mn 0,94 Cr 0,04 Ni 0,04 Al 0,04 N_2 0,007

разогревают в методической печи до 1280 °С и прокатывают на непрерывном широкополосном стане 1700 в полосу сечением 2 х х1350 мм. Температуру конца прокатки поддерживают равной 840°С. Затем полосу ускоренно охлаждают водой до 630°С и сматывают в рулон. После охлаждения рулона его устанавливают на разматыватель травильного агрегата и подвергают сернокислотному травлению для удаления окалины с одновременной обрезкой боковых кромок для получения ширины полосы 1300 мм, которую после промывки сматывают в рулон.

Затем рулон устанавливают на разматыватель агрегата непрерывного горячего алюмоцинкования (АНГА).

На АНГА осуществляют обрезку кромок до ширины полосы 1250 мм и осуществляют химическую очистку поверхности полос в щеточно-моечных машинах в водяном растворе каустической содой с тринатрийфосфатом. После очистки полосу промывают водой и сушат воздухом при 95°С.

Очищенную полосу подают в проходную печь, где полосу нагревают ступенчато в защитно-восстановительной атмосфере, вначале со скоростью $V_{н.1}$ 13,5°С/с до $T_{н.1}$ 550 °С. Затем полосу повторно нагревают со скоростью $V_{н.2}$ 2°С/с до температуры отжига $T_о$ 720°С, при которой выдерживают в течение $\tau_о$ 70с. После завершения выдержки полосу охлаждают со скоростью $V_{охл.}$ 7,4°С/с струями защитного газа до температуры $T_ц$ 550°С и покрывают алюмоцинковым сплавом методом погружения в расплав следующего состава, мас.

Zn Fe Si Al

43,1 0,65 1,48 Основа

Полосу после горячего покрытия охлаждают до температуры $T_{отп.}$ отпуска 350 °С, при которой выдерживают 100 с. Отпущенную готовую полосу сматывают в рулон и транспортируют потребителю.

В табл. 2 приведены варианты реализации предложенного способа и способа-прототипа, а в табл.3 показатели качества горячекатаных полос с алюмоцинковым покрытием.

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Из табл. 3 следует, что в случае реализации предложенного способа (варианты 2-4) обеспечивается повышение качества покрытия и штампуемости полос, о чем свидетельствует наилучший комплекс механических свойств и максимальная коррозионная стойкость. При запредельных значениях заявленных параметров (варианты 1,5-11) имеет место снижение качества покрытия и штампуемости полос. При реализации способа-прототипа (вариант 12) качество покрытия и штампуемость полос получаются неудовлетворительной.

Технико-экономические преимущества предложенного способа состоят в том, что нагрев вначале со скоростью 7,9-19°С/с до 500-600°С, повторный нагрев со скоростью 0,7-3,3°С/с до 700-740°С, выдержка при этой температуре 47-94с, охлаждение со скоростью 2,7-12°С/с до 500-600°С и отпуск металла с покрытием при 300-400°С обеспечивают получение качественного алюмоцинкового покрытия и высокую штампуемость горячекатаных полос из малоуглеродистой стали. Это позволяет исключить из технологического цикла операцию холодной прокатки.

Формула изобретения:

СПОСОБ ПРОИЗВОДСТВА ПОЛОС ИЗ МАЛОУГЛЕРОДИСТОЙ ГОРЯЧЕКАТАНОЙ СТАЛИ, включающий ступенчатый нагрев с заданными скоростями до температуры отжига 700 740°С, охлаждение до температуры алюмоцинкования, алюмоцинкование и отпуск при 300 400°С, отличающийся тем, что нагрев осуществляют сначала со скоростью 7,9 19°С/с до 500 600 °С, а затем со скоростью 0,8 3,3°С/с до температуры отжига, выдержку в течение 47 - 94с, охлаждение с температуры отжига ведут со скоростью 2,7 12°С/с до 500 600°С.

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Таблица 1

Показатели качества листов с алюмоцинковым покрытием

$\sigma_в$, кг/мм^2	$\sigma_т$, кг/мм^2	δ_4, %	Глубина лунки по Эриксену Е, мм	Коррозионная стойкость, К, г/м^2
36–43	28–37	Не менее 30	Не менее 11	Не более 3

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Таблица 2

Режимы производства горячекатаных полос с алюмоцинковым покрытием

№ п/п	V_{H1}, °С	T_{H1}, °С	V_{H2}, °С/с	T_o, °С	τ_o, С	$V_{охл.}$, °С/с	$T_ц$, °С	$T_{отп}$, °С
1	20	450	4,0	690	95	13	490	410
2	19	500	3,3	700	94	12	500	400
3	13,5	550	2,0	720	70	7,4	550	350
4	7,9	600	0,7	740	47	2,7	600	300
5	7,7	620	0,5	750	45	2,5	620	290
6	20	620	2,1	710	55	11	510	340
7	7,5	480	3,1	735	85	2,9	560	360
8	18	590	3,5	690	48	10	520	390
9	8,0	501	0,6	750	92	3,2	510	350
10	18	600	3,2	700	45	11	490	380
11	8,2	520	0,8	740	96	2,8	610	320
12 (прототип)	25	480	9	720	–	5,0	470	350

Примечание. Вариант 12 предусматривает выдержку продолжительностью 8 с после первой ступени нагрева.

Таблица 3

Показатели качества горячекатанных полос с алюмоцинковым покрытием

№ п/п	$\sigma_в$, кг/мм^2	$\sigma_т$, кг/мм^2	δ_4, %	E, мм	K, г/м^2
1	47	41	22	7	1,59
2	43	37	31	11	1,27
3	39	36	35	13	0,98
4	36	28	36	12	1,23
5	42	27	28	10	1,51
6	44	38	29	10	1,62
7	35	27	30	11	1,75
8	45	39	26	9	1,60
9	34	26	30	10	1,80
10	35	27	29	9	1,48
11	45	38	28	10	1,71
12	48	29	19	6	1,79

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[32] 2001. 6.25 [33] JP [31] 190709/2001
[32] 2001. 6.29 [33] JP [31] 198431/2001
[32] 2001. 7.23 [33] JP [31] 220807/2001
[32] 2001. 7.27 [33] JP [31] 228431/2001
[32] 2001. 8. 9 [33] JP [31] 241633/2001
[32] 2001. 8.31 [33] JP [31] 264727/2001
[32] 2001.12.18 [33] JP [31] 383852/2001
[32] 2001.12.25 [33] JP [31] 390842/2001

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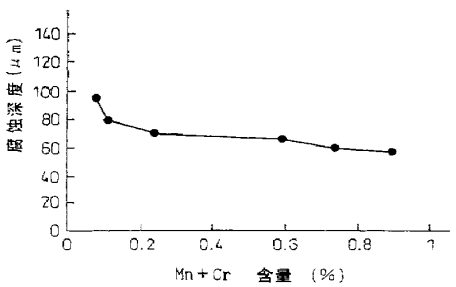
权利要求书 3 页 说明书 44 页 附图 7 页

[54] 发明名称 镀有铝合金体系的高强度钢板以及具有优异的耐热性和喷漆后耐腐蚀性的高强度汽车零件

[57] 摘要

本发明提供了一种用于制备高强度汽车部件(具体地说，一种需要高强度的零件，例如汽车的底盘组件)的热压方法。更具体地说，本发明提供了一种适用于高温成型(热成型)的镀铝钢板或镀铝－锌钢板，其中在高温成型之后获得高强度，本发明还提供了这种钢板的制备方法。另外，本发明提供了一种热浸镀铝钢板，它抑制了在压制成型期间电镀层的合金化反应并具有漂亮的外观，本发明还提供了一种具有优异的喷漆后耐腐蚀性的热压用的镀有铝－体系的钢板。具体地说，本发明是一种具有优异的耐热性和优异的喷漆后耐腐蚀性的高强度的镀有铝体系的钢板，其特征在于在该钢板的表面上具有 Fe－Al－体系镀层，以质量计，该镀层中含有总量大于 0.1%的 Mn 和 Cr，以质量计，该钢板含有 C：0.05－0.7%、Si：0.05－1%、Mn：0.5－3%、P：不大于 0.1%、S：不大于 0.1%和 Al：不大于 0.2%，此外还含有一种或多种选自以下的元素：Ti：0.01－0.8%、Cr：不大于 3%和 Mo：不大于 1%，以便满足以下表达式 1：$Ti + 0.5 \times Mn + Cr + 0.5 \times Mo > 0.4 \cdots 1$。



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1、一种具有优异的耐热性和喷漆后耐腐蚀性的高强度的镀有铝合金体系的钢板，其特征在于在该钢板的表面上具有 Fe-Al-体系镀层，该镀层中含有总量大于 0.1%的 Mn 和 Cr。

2、一种具有优异的耐热性和喷漆后耐腐蚀性的高强度的镀有铝合金体系的钢板，其特征在于在该钢板的表面上具有 Fe-A1-体系镀层，以质量计，该镀层中含有总量大于 0.1%的 Mn 和 Cr，以质量计，该钢板含有 C：0.05-0.7%、Si：0.05-1%、Mn：0.5-3%、P：不高于 0.1%、S：不高于 0.1%和 Al：不高于 0.2%，此外还含有一种或多种选自以下的元素：Ti：0.01-0.8%、Cr：不高于 3% 和 Mo：不高于 1%，以便满足以下表达式 1：

$$Ti + 0.5\times Mn + Cr + 0.5\times Mo > 0.4 \quad \ldots 1$$

3、如权利要求 2 的具有优异的耐热性和喷漆后耐腐蚀性的高强度的镀有铝合金体系的钢板，其特征在于，以质量计，该钢还含有一种或多种选自以下的元素：N：不高于 0.1%、Nb：不高于 0.1%、V：不高于 0.1%、Ni：不高于 1%、Cu：不高于 1%、B：0.0003-0.03%、Sn：不高于 0.1%和 Sb：不高于 0.1%。

4、如权利要求 1 的具有优异的耐热性和喷漆后耐腐蚀性的高强度的镀有铝合金体系的钢板，其特征在于，以质量计，该钢含有：C：0.15-0.55%、Si：不高于 0.5%、Mn：0.2-3%、P：不高于 0.1%、S：不高于 0.04%、Al：0.01-0.1%和 N：不高于 0.01%，并且还含有一种或多种选自以下的元素：B：0.0002-0.0050%、Ti：0.01-0.8%、Cr：不高于 2%、Mo：不高于 1%、Ni：不高于 1%、Cu：不高于 0.5%和 Sn：不高于 0.2%。

5、如权利要求 1-4 任一项的具有优异的耐热性和喷漆后耐腐蚀性的高强度的镀有铝合金体系的钢板，其特征在于所述 Fe-Al-体系镀

层还含有 1-20%的 Si。

6、如权利要求 1-5 任一项的用于高强度汽车部件的镀有铝合金体系的钢板，其特征在于 Fe-Al-体系镀层中的 Al 浓度不高于 35 重量%。

7、如权利要求 1-6 任一项的具有优异的耐热性和喷漆后耐腐蚀性的高强度的镀有铝合金体系的钢板，其特征在于所述 Fe-Al-体系镀层还含有 Zn：1-50%和 Mg：0.1-10%中的一种或两种。

8、如权利要求 1-7 任一项的具有优异的耐热性和喷漆后耐腐蚀性的高强度的镀有铝合金体系的钢板，其特征在于所述 Fe-Al-体系镀层的厚度是 3-35 μm。

9、一种用于高强度汽车部件的镀有铝合金体系的钢板，其特征在于其具有：钢板表面上的主要由 Fe-Al 组成的镀层；在该镀层下面的厚度从不小于 2 μm 至不高于钢板厚度的十分之一的铁氧体层；和在该铁氧体层下面的主要由马氏体组成的基底钢。

10、如权利要求 9 的用于高强度汽车部件的镀有铝合金体系的钢板，其特征在于钢板表面上的铝合金体系镀层和金属间化合物层下面的铁氧体层中含有 Si。

11、如权利要求 9 或 10 的用于高强度汽车部件的镀有铝合金体系的钢板，其特征在于所述铁氧体相的硬度不高于 200。

12、一种压制成型的高强度汽车零件，其至少一部分是由如权利要求 1-11 任一项的钢制成的。

13、如权利要求 12 的高强度汽车零件，其特征在于在其表面的至少一部分上具有厚度为 1-200 μm 的镀膜。

14、一种高强度汽车部件的热轧方法，其中，在采用热压方法制备该汽车部件时，所用钢板是用主要由 Al 组成的金属电镀含有不小于 0.05 重量%的 C 作为钢组分的钢而制得的，该部件是在比以下 A、B、C 和 D 条件的时间更长的加热条件下加热之后通过压制成型形成

的，并且该部件的至少一部分在不低于 10℃/秒的冷却速率下冷却：

A (800℃, 13 分钟)、B (900℃, 6 分钟)、C (1,050℃, 1.5 分钟)、D (1,200℃, 0.3 分钟)。

镀有铝合金体系的高强度钢板以及具有优异的耐热性和喷漆后耐腐蚀性的高强度汽车零件

技术领域

本发明涉及一种镀有铝合金体系的钢板，其适用于通过高温压制生产的需要强度的部件（例如汽车零件的结构部件）以及所述钢板的制备方法，具体地说，本发明涉及一种需要高强度的部件（如汽车等的底盘组件）以及用于制备这种部件的钢材。

背景技术

为了减轻汽车重量(源自全球环境问题)，要求用于汽车的钢板具有尽可能高的强度。然而，一般说来，提高钢板强度的同时，伸长率和 r-值降低，因此成型性受损。因此需要一种同时具有高强度、高成型性和形状固定性的钢板。

解决该问题的一种方法是一种通过将残留奥氏体转变成马氏体而制备的 TRIP (相变感生塑性)钢，并且最近 TRIP 钢的使用越来越多。然而，尽管可以使用 TRIP 钢制备成型性优异的 1,000 MPa 级高强度钢板，但是难以保证更高强度的钢板的良好的成型性，例如，强度不低于 1,500 MPa 的超高强度钢板。而且，通过该工艺难以解决形状固定性的问题。

为了解决这些问题，有一种温压工艺，它是一种最近才引起注意的工艺，是另一种协调高强度和高成型性的方式。日本未审专利公开号 2000-234153 公开了一种在加热的同时形成钢板并利用成型期间产生的热量来增加强度的工艺。该工艺的目的在于通过适当控制钢中的组分，在铁氧体的温度范围内加热该钢板，并在该温度范围内利用沉

淀强化来增加强度。

在日本未审专利公开号 2000-87183 中提出了一种高强度钢板，其中在成型温度下的屈服强度降至远远低于室温下的屈服强度，旨在提高压制成型的精确度。然而，通过该工艺获得的强度可能有一定的限制。

作为一种克服该缺陷的工艺，在文献(SAE, 2001-01-0078)中公开了一种工艺，它是将钢板加热至形成奥氏体单相的温度范围，然后在压制成型期间将其冷却。

该工艺通过将钢板在不低于800℃的高温下成形来获得所需物料性能，这样做解决了高强度钢板的成型问题，并且在成型之后冷却时将其淬火。然而，由于该工艺涉及在大气中加热，因此在钢板表面上产生氧化物并且需要在下面的过程中除去这些氧化物。在上述文献(SAE, 2001-01-0078)中还公开了一种抑制加热期间的这种氧化的镀铝工艺。

另外，可以采用如下方式来获得高强度：在室温下形成钢板之后，通过将部分钢板快速加热和快速冷却来进行淬火。在这种情况下，通过局部加热钢板，可以仅提高需要高强度的这部分的强度。日本未审专利公开号 2000-83640 公开了这样一种工艺并为此使用碳含量在0.15-0.5%的钢板。

在上述现有技术中公开了一种热成型工艺和一种将镀铝钢板用于热成型的工艺。然而，在这些现有技术中，当将钢板加热至不低于800℃的高温时，在短时间内 Fe 扩散至表面并且铝镀层变成金属间化合物，本文后面称之为“铝合金体系镀层”。由于这种铝合金体系镀层非常硬且脆，有时它产生裂缝并以粉状剥离，因此喷漆后耐腐蚀性受损受到关注。即使不产生裂缝，在喷漆后耐腐蚀性方面存在镀铝钢板比其它表面处理过的钢板(例如，热浸镀锌钢板或热浸电退火(galvannealed)钢板)差的情形。更具体地说，在高温成型之后评价喷

漆后耐腐蚀性，并且当有划痕（例如以交叉形状切割的划痕）时，基底钢的腐蚀易于从这部分沿深度方向蔓延，并且其延伸速度比牺牲防腐蚀型的热浸镀锌或热浸电退火钢板要快。

而且，也存在剥落的镀层堆积在模具上，并在压制期间产生疤痕的可能性。这是由于，尽管所述电镀层可以经受热成型的加工，但是实际上难以对整个零件进行热加工，并且存在所述电镀层易于在加工延迟并且温度降低的部分剥离的问题。这里的另一个问题是，当温度降低时，淬火使得基底钢形成主要由马氏体组成的硬结构，因此应力趋于逐渐升高。

发明概述

本发明人为了解决上述问题进行了彻底的研究，并发现可以通过在高温成型后的钢板表面上施加含有 Mn 和 Cr 总量大于 0.1%的 Fe-Al-体系来制备具有优异的喷漆后耐腐蚀性的涂镀钢板(plated steel sheet)。经过热成型和局部快速加热之后的铝-体系镀层全部转化成铝合金体系镀层，并且该化合物非常脆，因此在加工期间易于产生裂缝。本发明定义的镀有铝体系的钢板是指镀层中 Al 和 Fe 含量至少为 70%的涂镀钢板。而且，由于该镀层具有比基底钢板高的电势，因此基底钢的腐蚀从裂缝开始，并且喷漆后耐腐蚀性趋于降低。为了避免喷漆后耐腐蚀性的降低，将 Mn 加入到所述铝合金体系镀层中是非常有效的。尽管 Mn 的功能还不清楚，但是据说 Mn 起通过控制合金层的电势使 Fe-Al-体系镀层的电势接近基底钢板的电势的作用，并且除了该功能之外，Mn 还可以控制在磷酸盐处理(喷漆前的预处理)中磷酸盐结晶的形状。

通过将 C、Si、Mn、P、S 和 Al 指定为基底钢组分，并加入 Ti、Cr 和 Mo(其加入是有效的)，以便满足以下等式 1：

$$Ti + 0.5\times Mn + Cr + 0.5\times Mo > 0.4 \quad \ldots 1$$

从而可以获得极其优异的耐热性，尤其是加工之后的耐热性。

估计是这些元素加速了 Al 和 Fe 之间的扩散，并且这样以来即使在镀层中产生裂缝时，Fe 和 Al 之间的反应在裂缝的周围进行，因此几乎不曝露基底钢。

而且，本发明人还获悉通过加入 N、Nb、V、Ni、Cu、B、Sn 和 Sb 作为钢组分，可以获得更优异的喷漆后耐腐蚀性。

与此同时，合金化处理之后的电镀层含有 Si 也是有益的，并且加入 Zn、Mg 等可以获得更好的耐腐蚀性。为了抑制合金层中的裂缝，合金层中的 Al 含量不大于 35%是重要的。而且，从喷漆后耐腐蚀性的角度来看，Fe-Al-体系合金层的理想厚度是 3-35 μm。

而且，为了克服上述问题，本发明人详细研究了合金化处理之后影响镀有铝体系的钢板的可加工性的因素，并获得以下知识。即，由于铝合金体系镀层和基底钢都硬，因此内部应力增加，但是，由于在铝合金体系镀层和基底钢之间存在软层，因此使应力减弱，故剥落耐性显著提高。所述软层由铁氧体相组成，并且估计所述软层不小于 1 μm 的事实防止了合金层中的裂缝蔓延至基底钢。

此外，为了克服上述问题，本发明人详细研究了合金化处理之后影响镀有铝体系的钢板的可加工性的因素，并获得以下知识。即，通过使加热条件最佳化可以防止电镀层剥落。其原因还不清楚，但是估计是在加热条件镀层被合金化，相结构发生复杂变化，并且出现保证可加工性的合适的相结构。本发明的要点如下：

(1) 一种具有优异的喷漆后耐腐蚀性的高强度的镀有铝合金体系的钢板，其特征在于在该钢板的表面上具有 Fe-Al-体系镀层，该镀层中含有总量大于 0.1%的 Mn 和 Cr。

(2) 一种具有优异的耐热性和喷漆后耐腐蚀性的高强度的镀有铝合金体系的钢板，其特征在于在该钢板的表面上具有 Fe-A1-体系镀层，以质量计，该镀层中含有总量大于 0.1%的 Mn 和 Cr，以质量计，

该钢板含有 C：0.05-0.7%、Si：0.05-1%、Mn：0.5-3%、P：不高于 0.1%、S：不高于 0.1%和 Al：不高于 0.2%，此外还含有一种或多种选自以下的元素：Ti：0.01-0.8%、Cr：不高于 3% 和 Mo：不高于 1%，以便满足以下等式 1：

$$Ti + 0.5\times Mn + Cr + 0.5\times Mo > 0.4 \quad \ldots 1$$

(3) 如第(2)项的具有优异的耐热性和喷漆后耐腐蚀性的高强度的镀有铝合金体系的钢板，其特征在于该钢还含有(以质量计)一种或多种选自以下的元素：N：不高于 0.1%、Nb：不高于 0.1%、V：不高于 0.1%、Ni：不高于 1%、Cu：不高于 1%、B：0.0003-0.03%、Sn：不高于 0.1%和 Sb：不高于 0.1%。

(4) 如第(1)项的具有优异的耐热性和喷漆后耐腐蚀性的高强度的镀有铝合金体系的钢板，其特征在于该钢含有(以质量计)：C：0.15-0.55%、Si：不高于 0.5%、Mn：0.2-3%、P：不高于 0.1%、S：不高于 0.04%、Al：0.01-0.1%和 N：不高于 0.01%，并且还含有一种或多种选自以下的元素：B：0.0002-0.0050%、Ti：0.01-0.8%、Cr：不高于 2%、Mo：不高于 1%、Ni：不高于 1%、Cu：不高于 0.5%和 Sn：不高于 0.2%。

(5) 如第(1)-(4)项任一的具有优异的耐热性和喷漆后耐腐蚀性的高强度的镀有铝合金体系的钢板，其特征在于所述 Fe-Al-体系镀层还含有 1-20%的 Si。

(6) 如第(1)-(5)项任一的用于高强度汽车部件的镀有铝合金体系的钢板，其特征在于所述 Fe-Al-体系镀层中的 Al 浓度不高于 35 重量%。

(7) 如第(1)-(6)项任一的具有优异的耐热性和喷漆后耐腐蚀性的高强度的镀有铝合金体系的钢板，其特征在于所述 Fe-Al-体系镀层还含有 Zn：1-50%和 Mg：0.1-10%中的一种或两种。

(8) 如第(1)-(7)项任一的具有优异的耐热性和喷漆后耐腐蚀性的

高强度的镀有铝合金体系的钢板，其特征在于所述 Fe-Al-体系镀层的厚度是 3-35 μm。

(9) 一种用于高强度汽车部件的镀有铝合金体系的钢板，其特征在于具有：在钢板的表面上主要由 Fe-Al 组成的镀层；在该镀层下面的厚度从不小于 2 μm 至不大于钢板厚度的十分之一的铁氧体层；和在该铁氧体层下面主要由马氏体组成的基底钢。

(10) 如第(9)项的用于高强度汽车部件的镀有铝合金体系的钢板，其特征在于钢板表面上的铝合金体系镀层和金属间化合物层下面的铁氧体层含有 Si。

(11) 如第(9)或(10)项的用于高强度汽车部件的镀有铝合金体系的钢板，其特征在于铁氧体相的硬度不高于 200。

(12) 一种高强度汽车零件，其是通过将由如第(1)-(11)项任一的钢组成的至少一部分压制成型而形成的。

(13) 如第(12)项的高强度汽车零件，其特征在于在其表面的至少一部分上具有厚度为 1-200 μm 的镀膜。

(14) 一种高强度汽车部件的热成型方法，其中，在采用热成型方法制备该汽车部件时，所用钢板是通过在含有不小于 0.05 重量%的 C 的钢上电镀以 Al 为主要组成的金属而制得的，该部件是在比以下条件 A、B、C 和 D 的时间更长的加热条件下加热之后通过压制成型而形成的，并且所述部件的至少一部分在不低于 10℃/秒的冷却速率下冷却：

A (800℃, 13 分钟)、B (900℃, 6 分钟)、C (1,050℃, 1.5 分钟)、D (1,200℃, 0.3 分钟)。

附图简述

图 1 是显示铝合金体系镀层中 Mn 和 Cr 的总量对喷漆后耐腐蚀性的影响的图。

图 2 是显示 Ni、Cu 和 Sn 的加入量与裸露耐腐蚀性之间的关系的图。

图 3 是显示 Ni、Cu 和 Sn 的加入量与喷漆后耐腐蚀性之间的关系的图。

图 4 是显示 Cr 和 Mo 的加入量与裸露耐腐蚀性之间的关系的图。

图 5 是显示 Cr 和 Mo 的加入量与喷漆后耐腐蚀性之间的关系的图。

图 6 是 950℃的温度下 Fe-Al-Si-体系的三相图。

图 7 是显示通过光学显微镜拍摄的本发明结构的一个实例的照片(反向散射电子图象)。

图 8 是显示外层厚度与电镀层的可加工性之间的关系的图。

图 9 是显示通过光学显微镜拍摄的本发明金属结构的一个实例的照片(反向散射电子图象)。

图 10 是显示通过将本发明的钢板成形而获得的形状的图。

图 11 是显示了本发明的加热时间与加热温度之间的关系的图。

实施本发明的最佳方式

实施方式 1

下面解释用于本发明的钢板的化学组成。

C：本发明的钢板在成型之后具有不低于 1,000 MPa 的高强度，其是通过在高温压制之后快速冷却并由此将其结构转化成主要由马氏体组成的结构而获得的。在这种意义下，C 含量不小于 0.05%是理想的，并且为了稳定地获得高强度，该含量不小于 0.1%更理想。另一方面，即使 C 含量增加至不小于 0.7%，其强度饱和并且也趋于产生焊接裂缝，因此其上限定在 0.7%。

Si：由于 Si 含量太低使得疲劳特性受损，因此其加入量不小于

0.05%是理想的。然而，在再结晶退火期间 Si 在钢板表面上形成稳定氧化物薄膜并阻碍镀铝性能。为此，Si 的上限定在 1%。

Mn：Mn 是公知的强化钢板可硬化性的元素。同样，Mn 也是防止由 S(是一种不可避免的杂质)引起的热脆化所需的元素。为此，其加入量不小于 0.5%是优选的。而且，Mn 还强化镀铝之后的耐热性。然而，由于 Mn 加入量超过 3%使得淬火之后的抗冲性能受损，因此该值确定为其上限。

Ti：Ti 对铝镀层的耐热性影响最大。在超过 900℃的温度范围内使用钢板的情况下，正如本发明的情形，从耐热性的角度优选加入 Ti，并且其加入量不小于 0.01%对获得该效果是理想的。然而，由于 Ti 与 C 形成 TiC，降低了赋予强度的 C 的量，因此必需相应于 Ti 的加入量增加 C 的量。而且，Ti 的影响在约 0.8%的量时达到饱和，因此该值确定为其上限。

Cr：与 Mn 和 Ti 类似，Cr 有利于提高镀铝之后的耐热性。然而，Mn 通过在钢板的表面上形成稳定的氧化物而使镀铝性能受损，其方式与 Si 相同。而且，Cr 是一种相对昂贵的元素，因此在加入它时其上限定在 3%。

Mo：与 Mn、Ti 和 Cr 相似，Mo 也有利于提高镀铝之后的耐热性，并且其加入是理想的。然而，由于 Mo 是一种相对昂贵的元素，并且其效果会饱和，因此其上限定在 1%。

在本发明中，优选加入提高镀铝之后的耐热性的元素，诸如 Ti、Mn、Cr 和 Mo，其方式满足以下表达式：

$Ti+0.5\times Mn+Cr+0.5\times Mo > 0.4$，

具体地说，Ti 和 Cr 具有在加热期间防止镀层剥落的效果。而且，Mn 可以相对大量地加入并且对耐热性非常有利。

本发明还将 P、S 和 Al 加入到钢中。然而，由于 P 和 Al 损害钢的延展性和疲劳强度，并且 S 使其韧性受损，因此对它们每一个确定

了一个上限。此外，偶尔需要时可以在钢中含有 Ni、Nb、V、N、Cu、B、Sn 和 Sb 中的一种或多种。Ni 和 Cu 对钢的耐腐蚀性有利，并且 B 提高可硬化性。

在许多情况下，钢板是在将铝镀层合金化之后，然后喷漆才使用的。在这些情况下，喷漆后耐腐蚀性受铝合金体系镀层中 Mn 和 Cr 的量的影响。当这些元素的量不小于 0.1%时，获得良好的喷漆后耐腐蚀性。作为加入 Mn 和 Cr 的方法，有钢组分扩散法和将它们加入到镀浴中的方法，并且只要其加入量不小于 0.1%，这两种方法任意一种都可以获得该效果。已知 1-5 个相可以共存于一个铝合金体系镀层中，这取决于电镀的沉积量、钢组成、加热条件等。由于在表面附近的相的影响特别大，因此在分析它们时，优选通过在距离表面 5 μm 深度内的区域的横截面上的约 5 个部分使用诸如 EPMA 定量分析等的手段来测定它们，并计算其平均值，从而进行判断。正如后面所述，在热浸镀铝的情形下，通常加入 Si，此时，Si 也含在铝合金体系镀层内。其量是约 1-20%，并且 1-5 相的铝合金体系镀层中的 Si 的量可以有很大的变化。尽管 1-5 相的 Fe-Al-体系镀层可以具有不同的组成，诸如 Fe-Al-Si-体系铝合金体系镀层、Fe_2Al_5、$FeAl_3$、Fe_3Al、FeAl、溶解 Al 的铁氧体，等等，在任意这些组成中，只要 Mn 和 Cr 的总量不小于 0.1%，便可以获得稳定的喷漆后耐腐蚀性。至于存在许多相时应分析哪一相，由于已知 Mn 和 Cr 有利于提高喷漆后耐腐蚀性，并且腐蚀现象是一种宏观现象，因此本发明人认为：即使存在多个相，通过在随机的约 5 个部分分析它们，并计算其平均值，可以获得常规信息，并且这样做，可以进行判断。而且，为了观察加热之后的结构的横截面，规定横截面用 2-3%的 nitral 蚀刻。这是由于不蚀刻的话，不能观察到基底金属和溶解 Al 的铁氧体之间的界面。

镀铝的沉积量影响耐腐蚀性、可焊性、可加工性等等。如果沉积量太小，喷漆后耐腐蚀性不足，而如果太大，可焊性和可加工性受损。

至于可加工性，它是由于在加热之后的压制期间脆的铝合金体系镀层趋于剥离。

镀铝方法没有特别的限制，并且可以使用热浸镀法、电镀法、真空沉积法、在金属外覆以另一金属的方法等等。目前工业上最广泛使用的方法是热浸镀法，并且经常将 Al-10%Si 用于镀浴中，其中含有 Fe 作为不可避免的杂质。除了这些之外，已经报道了加入 Cr 和 Mn 提高喷漆后耐腐蚀性。作为其它添加元素，推荐有 Mg、Ti、Zn、Sb、Sn、Cu、Ni、Co、In、Bi、混合稀土等，并且只要电镀层主要由 Al 组成，那么可以使用这些元素。

本发明没有特别定义镀铝的预处理和后处理。作为电镀预处理，推荐预电镀 Ni、Cu、Cr 或 Fe 等，并且这些中任意的都可以采用。作为电镀后处理，推荐有铬酸盐处理、树脂镀层处理等等，旨在主要防止生锈和光滑，但是由于有机树脂受热时消失，因此它不是优选的。至于铬酸盐处理，考虑目前对六价铬的管制，优选含有三价铬的处理薄膜，例如电解铬酸盐等等。可以使用无机体系铬酸盐处理以外的其它后处理。也可以预先使用氧化铝、二氧化硅、MoS_2 等的处理，旨在光滑。

实施方式 2

下面将描述本发明的实施方式 2 中调节钢组份的理由。

N 是一种不可避免包含的元素并且在不加入 B 时要特别添加的，但是，当加入 B 并且其量过大时，必需增加 Ti 的加入量。结果，存在的问题是最终产生的 TiN 量增加并且发生热裂缝，并且成本也增加。因此，其上限定在 0.1%。

加入 B 是为了提高压制成型期间或之后冷却时的可硬化性，并且为了获得该效果，其加入必需不小于 0.0002%。然而，当其加入量过大时，存在热裂缝的问题并且该效果饱和。因此，其上限定在

0.03%。

Ni、Cu 和 Sn 具有在高温加热之后的压制成型期间通过改变高温加热期间合金化铝镀层的状态来改变表面裂缝状态的效果，并且由于它们导致成型产品的喷漆后耐腐蚀性提高因此是重要的。至于这些元素，由通过测定 Ni、Cu 和 Sn 的加入量获得的图 2 和 3 所示的结果，和实验室试验中高温成型之后样品的裸露耐腐蚀性和喷漆后耐腐蚀性，本发明人发现，为了获得上述效果，不得不加入 Ni、Cu 和 Sn，以便它们可以满足等式 3。这里，采用在实施例中所示的条件下测定的方法，使用取自在高温成型之后进行加工的部分的样品来评价其裸露耐腐蚀性和喷漆后耐腐蚀性。

$$(Ni+0.5\times Cu+3\times Sn)\geq 0.012 \quad \ldots 3$$

至于 Ni、Cu 和 Sn 中的每一种，加入过量的 Ni 使得这些效果饱和并且使成本增加，Cu 和 Sn 具有产生表面裂缝的问题，因此每一元素的上限分别定在 1.0%、1% 和 0.2%。

本发明的钢板的制备条件没有特别的规定，但是下面将解释优选的制备条件。

将具有上述组份的钢铸造，并将所得热平板，直接或者在加热之后，或者将冷却并再加热的平板，热轧。这里，几乎不能识别直接轧制热平板和再加热之后轧制之间钢的性能的差异。而且，再加热温度不特定，但是考虑到生产率，优选将其调节在 1,000-1,300℃的范围内。

至于热轧，可以采用常规热轧法或者将平板彼此相连并在精轧时轧制的连续热轧法。考虑到生产率和钢板厚度的精确度，优选控制热轧时的抛光温度不低于 Ar3 转化温度。

采用常规方法进行热轧之后的冷却。在这种情况下，从生产率的角度，优选将该冷却温度控制在不低于 550℃。另一方面，如果冷却温度太高，酸渍能力受损，因此优选将该冷却温度控制在不高于 750℃。

就酸渍处理或冷轧处理而言，可以使用常规方法，并且就接下来的镀铝处理或接下来的镀铝-锌处理而言，也可以使用常规方法。即，在镀铝处理的情况下，镀浴中 Si 浓度为 5-12%是合适的，而在镀铝-锌处理中，镀浴中 Zn 浓度为 40-50%是合适的。

这里，至于电镀处理中的气氛，可以使用具有非氧化炉的连续电镀设备或者没有非氧化炉的连续电镀设备进行电镀，只要保持常规条件。因此，在生产本发明的产品时不需要特别的控制，并且因此生产率不受到干扰。

在上面的生产条件下，在电镀之前没有对钢板表面进行金属预电镀，但是即使使用 Ni 预电镀、Fe 预电镀或其它金属预电镀以提高电镀性能时，也不会产生特定的问题。

而且，即使当 Mg 和 Zn 包括在铝镀层或者 Mg 包括在铝-锌电镀层时，不会产生特定的问题并且可以制得具有类似性能的钢板。

实施方式 3

下面首先解释在实施方式 3 中按照本发明调节钢组份的理由。

C 元素的加入使冷却之后的结构由马氏体构成，并且确保材料质量，并且要求其加入量不小于 0.15%以保证强度不低于 1,200 MPa。另一方面，如果加入量过大，几乎不能保证抗冲击变形的强度，因此其上限定在 0.55%。

Si 是一种溶质强化元素，并且可以相对低的成本增加钢板的强度。然而，如果其加入过量，那么电镀性能将受损，因此其上限定在 0.5%。

Mn 加入是为了保证在广泛的冷却速率范围下的冷却后强度。

当 C 量大但是 Mn 的加入量小时，在常规冷却速率的范围(该范围可以在压制成型期间获得)内不能获得马氏体结构，因此其强度几乎不能得到保证。在钢板厚度为 1.4 mm 的情况下，本文引证的冷却

速率的范围不高于 500℃/秒。为了展示这种功能，要求其加入量不小于 0.2%。另一方面，如果 Mn 量太大，不仅成本增加，而且该效果饱和。因此，其上限定在 3%。

S 是一种不可避免地包含并且引起可加工性受损的元素。因此，需要尽可能地降低其量。通过使其量降低至不高于 0.04%，消除了可加工性的问题，并且因此确定其含量不高于 0.04%。

P 是一种溶质强化元素，并且可以相对低的成本增加钢板的强度。然而，如果其加入量增加太大，那么在热轧或冷轧期间因脆化产生裂缝，并且因此其上限定在 0.1%。

Al 用作脱氧剂，并为了展示这种效果，要求钢中 Al 含量不小于 0.005%。另一方面，其加入量超过 0.1%使得氧化物-体系包含物增加，并引起表面质量降低的问题，因此其上限定在 0.10%。

Cr 和 Mo 具有在高温加热之后的压制成型期间通过改变高温加热期间合金化铝镀层的状态来改变表面裂缝的状态的作用，并且由于它们导致成型产品的喷漆后耐腐蚀性提高因此是重要的。对于这些元素，由通过测定 Cr 和 Mo 的加入量获得的图 2 和 3 所示的结果，和实验室试验中高温成型之后样品的裸露耐腐蚀性和喷漆后耐腐蚀性，本发明人发现不得不加入 Cr 和 Mo。这里，采用在实施例中所示的条件下测定的方法，使用取自高温成型后经过加工的部分的样品来评价其裸露耐腐蚀性和喷漆后耐腐蚀性。

对于 Cr 和 Mo 中的每一种，加入过量的 Cr 导致性能问题和成本增加，并且过量的 Mo 使得这些效果饱和并且使成本增加。因此每一元素的上限分别定在 2.0%和 1.0%。

对其它组份没有特别的规定。不可避免地包括 Ni，并且如果其量在常规范围内，不会产生问题。

本发明的钢板的制备条件没有特别的规定，但是下面将解释优选的制备条件。

将具有上述组份的钢铸造，并将所得热平板，直接或者在加热之后，或者将冷却并再加热的平板，热轧。这里，几乎不能识别直接轧制热平板和再加热之后轧制之间钢的性能的差异。而且，再加热温度不特定，但是考虑生产率，优选将其调节在 1,000-1,300℃的范围内。

至于热轧，可以采用常规热轧法或者将平板彼此相连并在精轧时轧制的连续热轧法。考虑生产率和钢板厚度的精确度，优选控制热轧时的抛光温度不低于 Ar3 转化温度。

采用常规方法进行热轧之后的冷却。在这种情况下，从生产率的角度考虑，优选将该冷却温度控制在不低于 550℃。另一方面，如果冷却温度太高，酸渍能力受损，因此优选将该冷却温度控制在不高于 750℃。

就酸渍处理或冷轧处理而言，可以使用常规方法，并且就接下来的镀铝处理或接下来的镀铝-锌处理而言，也可以使用常规方法。即，在镀铝处理的情况下，镀浴中 Si 浓度为 5-12%是合适的，并且在镀铝-锌处理中，镀浴中 Zn 浓度为 40-50%是合适的。

这里，对电镀处理中的气氛，可以使用具有非氧化炉的连续电镀设备或者没有非氧化炉的连续电镀设备进行电镀，只要保持常规条件。因此，在生产本发明的产品时不需要特别的控制，并且因此生产率不受到干扰。

在上面的生产条件下，在电镀之前没有对钢板表面进行金属预电镀，但是即使使用 Ni 预电镀、Fe 预电镀或其它金属预电镀以提高电镀性能时，也不会产生特定的问题。

而且，即使当 Mg 和 Zn 包括在铝镀层或者 Mg 包括在铝-锌电镀层时，不会产生特定的问题并且可以制得具有类似性能的钢板。

实施方式 4

通过加热铝镀层并由此将其转变成合金层，即 Fe-Al-体系镀层，

并且还通过将 Al 量控制在不大于 35%，并由此将 Fe-Al-体系镀层转变成 Fe+Fe_3Al(其中溶解有 Al 和 Si)，这样与那些含有 Fe+Fe_3Al 之外的其它相的电镀层相比，在经受加工的部分获得更优异的可加工性和耐腐蚀性。

C：本发明的钢板在成型之后具有不低于 1,000 MPa 的高强度，其是通过热轧之后快速冷却并由此将其结构转化成主要由马氏体组成的结构而获得的。为了这样做，C 含量必需不小于 0.05%。另一方面，即使 C 含量增加至不小于 0.7%，该强度饱和并且也趋于产生焊接裂缝，因此其上限定在 0.7%。

除 C 之外的钢组份没有特别限制，但是推荐诸如 Si、Mn、P、Al、N、Cr、Mo、Ti、Nb、B、Ni、Cu、V、Sn、Sb 等的元素作为加入元素或者不可避免的杂质元素。这些元素可以在偶尔需要时加入。实例是：Mn 和 B 在可硬化性方面有效；Cr、Ti 和 Mo 在铝镀层的耐热性方面有效；并且 Ni 和 Cu 提高耐腐蚀性。其加入的理想范围是：Mn：0.5-3%、Si：不高于 1%、P：不高于 0.1%、S：不高于 0.1%、Al：不高于 0.1%、N：不高于 0.01%、Cr：不高于 2%、Mo：不高于 0.5%、Ti：不高于 0.5%、Nb：不高于 0.1%、B：不高于 0.05%、Ni：不高于 1%、Cu：不高于 1%、V：不高于 0.1%、Sn：不高于 0.1%和 Sb：不高于 0.1%。

如上所述，镀铝的沉积量越小，越容易形成 Fe+Fe_3Al 区域。在这种意义下，两面的沉积量不大于 120 g/m^2 是理想的。

镀铝方法没有特别的限制，并且可以使用热浸镀法、电镀法、真空沉积法、在金属外覆以另一金属的方法等等。目前工业上最广泛使用的方法是热浸镀法，并且经常将 Al-10%Si 用于镀浴中，其中含有 Fe 作为不可避免的杂质。在这种情况下，在加热之后 Si 进入合金层并且 Si 量可以随相结构而变化。然而，Fe+Fe_3Al 区域中的 Si 量不大于 15% ，并因此将该值确定为 Si 的上限。作为其它添加元素，推荐

有 Mn、Cr、Mg、Ti、Zn、Sb、Sn、Cu、Ni、Co、In、Bi、混合稀土等，并且只要电镀层主要由 Al 组成，那么可以使用这些元素。加入 Zn 和 Mg 能够有效地防止红锈产生。然而，加入过量的这些元素(其蒸汽压力高)使得产生含有 Zn 和 Mg 的烟雾和在表面上产生粉状物质，等等。因此，Zn 的加入量不小于 60%并且 Mg 的加入量不小于 10%是不理想的。

本发明没有特别定义镀铝的预处理和后处理。作为电镀预处理，推荐预电镀 Ni、Cu、Cr 或 Fe 等，并且这些中任意的都可以采用。作为电镀后处理，推荐有铬酸盐处理、树脂镀层处理等等，旨在主要防止生锈和光滑，但是由于有机树脂受热时消失，因此它不是优选的。至于铬酸盐处理，考虑目前对六价铬的管制，优选含有三价铬的处理薄膜，例如电解铬酸盐等等。也可以使用无机体系铬酸盐处理以外的其它后处理。还可以预先使用氧化铝、二氧化硅、MoS_2 等的处理，旨在光滑。

实施方式 5

在实施方式 5 中，将解释对铝-体系镀层的组成的限制。本文所述的铝-体系镀层是指一种还未加热并因此还未合金化的镀层。

Si：Si 能够有效地降低镀铝-体系的合金层(一种由在镀层和钢板之间的界面上形成的金属间化合物构成的层)的厚度。而且，通过加入 Mg，与 Si 复合形成 Mg_2Si，有效地提高了耐腐蚀性。为了享有这些效果，其加入量不小于 1%是有效的。过量加入 Si 使得熔点升高，并且当 Si 单相在镀层上结晶时，它使得耐腐蚀性受损。因此，其上限定在 15%。

Mg：已知 Mg 能够有效地提高耐腐蚀性，特别是在盐破坏环境下。特别是通过形成 Mg_2Si，释放到环境中的效率增加并且耐腐蚀性提高。为了保证耐腐蚀性，Mg 的加入量不小于 0.5%。由于过量加入

使得镀浴的表面产生剧烈氧化并使镀浴的熔点升高，因此将其加入量定在不大于 10%。为了抑制镀浴表面的氧化，加入少量 Ca (不大于 0.5%)是有效的，并且可以加入大致这一量的 Ca。

Zn：Zn 具有比 Al 或钢更低的电势，并且具有抑制基底钢腐蚀的功能。当 Zn 加入量不小于 1%时这些效果开始出现，并且当 Zn 量是 20-60%时获得最佳性能。然而，加入量超过 60%时，耐腐蚀性大大受损。因此，Zn 量的下限和其上限分别定在 1% 和 60%。

当实际使用本发明的镀有铝-体系的钢板制备一零件时，在压制之后用模具快速冷却零件来进行淬火，因此该结构主要由马氏体构成。为了保证部件足够的强度，测定马氏体的百分比不小于 60%体积。本文中，马氏体的百分比是通过抛光和蚀刻样品，之后用光学显微镜观察并使用图象分析计算得出的。

实施方式 6

下面描述在实施方式 6 中调节钢板的组份等的原因。

本发明的钢板在通过铝镀层合金化形成的金属间化合物层和主要由马氏体组成的基底钢之间具有一厚度从不小于 2 μm 至不大于钢板厚度的十分之一的软铁氧体层。通常，约 1-10%的 Al 存在于铁氧体层中。除了 Al 之外，该铁氧体相也可以含有 Si。其厚度限制在不小于 1 μm。其原因在于，如果该软铁氧体层的厚度不大于上面的厚度，那么不能充分获得该镀层的剥落耐性。另一方面，由于该层软，如果太厚的话，整个钢板的强度受损。为此，确定其上限不大于钢板厚度的十分之一。通常，经常通过热浸镀法制得一镀铝钢板，并且在这种情况下，在钢板和镀层之间的界面上的铝合金体系镀层(称作“合金层”)趋于生长。如果该层生长过度，那么钢板的可加工性受损，并且，因此在加入约 10%的 Si 的镀浴中制得该镀铝钢板。在本发明中，由于是在整个镀层受热合金化之后趁热加工镀铝钢板，不需要在

镀浴中加入 Si，但是即使加入 Si 也没有特别的问题。

在本发明中，根据维氏硬度，优选铁氧体层的硬度不高于 200。如上所述，该层起着防止硬合金层在加工期间剥离的作用。为此，优选该层是软的。然而，当该层含有溶质强化元素如 Al、Si 等时，它比常规铁氧体层硬。

接下来，描述与本发明有关的其它组份。首先，关于钢组份，由于本发明旨在获得常规 TRIP 钢不能获得的高强度区域，并通过淬火增强强度，理想的 C 量不小于 0.05%，优选不小于 0.1%。至于钢中的其它元素，通常使用 Si、Mn、Ti、B、Cr、Mo、Al、P、S、N 等元素。Si 在疲劳特性方面有效，Mn 和 B 有利于提高可硬化性。Ti、Si、Cr、Mo 和 Al 是在镀铝之后提高耐热性的元素。

至于铝镀层的构造，如上所述，铝镀层主要由 Al 组成并且可以含有 Si。作为其它加入元素，推荐有 Cr、Mg、Ti、Sb、Sn、Zn 等，并且只要该镀层主要由 Al 组成，那么它们都可使用。然而，Zn 的沸点低，并且当过量使用时，在加热期间 Zn 在其表面上产生锌粉，这样在压制期间引起磨损。因此，其加入量不小于 60%是不理想的。

在铝合金体系镀层中产生的组分有 $FeAl_3$、Fe_2Al_5、Fe_3Al、Fe_2Al_5Si 等。这些相趋于以层状方式形成多层结构，但是这些相的结构并不特别规则。当其组成主要由 Al 和 Fe 构成，并且将 Si 加入到铝镀浴中时，其含有约 5-10%的 Si。这些元素在所有组成中占不小于 90%。而且，可以保留有少量未合金化的 Al，但是只要其量小，它不影响镀铝钢板的性能。

用光学显微镜测定铁氧体层的厚度。通过将横截面抛光，并且之后用约 2%的 nital 蚀刻它，清楚地观察到铁氧体层的厚度。然而，存在一种几乎不能观察到金属间化合物层的边界的情况，在这种情况下，另外采用 EPMA 分析。这样，由 Fe 和 Al 之间的放射强度的差异可以容易地鉴定铁氧体层。它是通过测定约 5 个随机部分的厚度并

计算其平均值进行铁氧体层的厚度的测定来确定的。而且，基底钢由主要由马氏体组成的结构组成，并且例如可以通过用苦味酸酒精溶液蚀刻并用光学显微镜观察到该结构。

图 7 显示了本发明的结构的实例。在其界面处识别到两层，并且根据 EPMA 定量分析的结果，下层是厚度为约 5 μm 的铁氧体层。在本文的图 7 中，标号 1 显示该层由 Al：26.85%、Si：9.83%、Fe：59.92%组成；标号 2 显示组成为 Al：49.54%、Si：3.11%、Fe：44.89%；标号 3 显示组成为 Al：30.75%、Si：8.88%、Fe：56.91%；标号 4 显示组成为 Al：9.59%、Si：2.92%、Fe：84.02%。

最后，对于涂镀钢板的加热和冷却条件，对加热和冷却方法没有特别的限制。为了获得硬化结构，事实上冷却速率大大影响它，并且冷却速率不低于约 30℃/秒是理想的。这取决于钢组份，并且对于具有良好的可硬化性的钢，主要由马氏体组成的理想结构甚至可以在约 10℃/秒的冷却速率下获得，或者在另一情况下，要求冷却速率不低于 100℃/秒，这取决于钢等级。为了获得所需厚度的铁氧体层，需要使加热条件最佳化。

实施方式 7

下面描述在实施方式 7 中调节钢板组成等的理由。

本发明是一种在成型之后具有不低于约 1,000 Mpa 的高强度的高强度钢板，并且其是在经受热轧或局部快速加热之后，通过快速冷却将其淬火而获得的钢板，这样做，将其转变成主要由马氏体组成的结构。因此，测定基底钢的硬度不低于 250。该硬度是根据维氏硬度测定的。为了获得该硬度，C 量为 0.05%是理想的。至于钢中的其它元素，没有特别的限制，但是经常使用元素 Si、Mn、Ti、B、Cr、Mo、Al、P、S、N 等。Si 在疲劳特性方面有效，Mn 和 B 有利于提高可硬化性。Ti、Si、Cr、Mo 和 Al 是在镀铝之后提高耐热性的元素。

而且，本发明钢板在基底钢的表面上有一主要由 Al 和 Fe 组成的铝合金体系镀层，并且该铝合金体系镀层的厚度限制在 3-35 μm，优选 3-18 μm。如上所述，这一限制是在考虑到可焊性、喷漆后耐腐蚀性和耐热性之间的平衡才确定的。即，当层厚小于 3 μm 时，不能获得足够的喷漆后耐腐蚀性和耐热性。特别是在铝镀层中不加 Si 的情况下，耐热性受损明显。通过可点焊性确定其厚度的上限。当电镀厚度不大于 35 μm 时，可以获得与镀锌钢板相同的可点焊性(电极寿命)；并且当电镀厚度不大于 18 μm 时，可以获得与热浸合金化镀锌钢板相同的可点焊性。可以将 $FeAl_3$、Fe_2Al_5、Fe_3Al、Fe_2Al_8Si 等形成为合金层。而且，在合金化层和基底钢之间的界面处可以经常地识别含有 Al 的铁氧体层的形成。

通常，在镀铝钢板中，Fe-Al-体系合金化层趋于生长并破坏可加工性。因此，经常发生加入 Si 以抑制合金层生长并提高可加工性。在热轧的情况下，由于钢板是在铝镀层受热并合金化至其表面之后趁热加工的，因此不是特别需要加入 Si。然而，事实上也可以加入 Si。在对部分钢板进行快速加热的情况下，由于在室温下进行加工，因此 Si 的加入必不可少。推荐 Cr、Mg、Ti、Sb、Sn、Zn 等作为铝镀层中的其它加入元素，并且只要该镀层主要由 Al 组成，那么这些元素都可以使用。然而，Zn 的沸点低，并且当过量使用时，在加热期间 Zn 在其表面上产生锌粉，这样在压制期间引起磨损。因此，其加入量不小于 60%是不理想的。

本发明没有特别定义电镀的预处理和后处理，以及压制期间钢板的加热方法及其冷却方法。作为电镀后处理，推荐有铬酸盐处理、树脂镀层处理等等，旨在主要防止生锈和光滑，然而，至于铬酸盐处理，考虑目前对六价铬的管制，优选含有三价铬的处理薄膜，例如电解铬酸盐等等。可以使用树脂镀层处理通常可以有效地提高成型性，并且在成型之后将一部分钢板快速加热时特别有效。当钢板受热然后成型

时，树脂薄膜分解，因此没有影响。

对镀铝钢板的制备方法也没有规定。可以使用常规制钢条件和热轧条件。经常通过热浸镀法进行镀铝，但是方法并不限于此，可以使用在无水溶剂中电镀、蒸汽沉积处理等。作为电镀之前的预处理推荐有 Ni 预电镀等，并且可以采用它。

加热或冷却钢板的方法也没有特别的规定。可以采用一种加热装置如电加热、在炉中加热、高频加热等。在这些装置中，高频加热适合快速对部分钢板进行加热。

实施方式 8

下面描述在实施方式 8 中调节钢板组份等的理由。

如上所述，本发明是一种通过加热之后趁热形成镀铝钢板，之后将其立即冷却，并由此将其淬火以保证所需强度的工艺，并要求钢板的组份赋予该钢板优异的可硬化性。为了满足该要求，要求 C 量不小于 0.05%，优选不小于 0.1%。至于钢中的其它元素，经常使用元素 Si、Mn、Ti、B、Cr、Mo、Al、P、S、N 等。Si 在疲劳特性方面有效，Mn 和 B 有利于提高可硬化性。Ti、Si、Cr、Mo 和 Al 是在镀铝之后提高耐热性的元素。

加热之后在表面上可以产生铝合金体系镀层组分有 $FeAl_3$、Fe_2Al_5、Fe_3Al、Fe_2Al_5Si 等。这些相趋于以层状方式形成多层结构，但是这些相的结构并不特别规则。当其组成主要由 Al 和 Fe 构成，并且将 Si 加入到铝镀浴中时，其中含有约 5-10%的 Si。这些元素在所有组成中占不小于 90%。而且，在镀层受热转变成铝合金体系镀层至其表面之后，才将镀铝钢板经受压制加工。这是由于，当 Al 大量留在表面上时，可焊性和喷漆后耐腐蚀性受损。

至于本发明的加热和冷却条件，对加热和冷却方法没有特别的限制。可以使用任意一种加热方式，例如在大气炉中加热、感应加热、

电加热等。此时的加热速率也没有限制。加热速率事实上大大取决于钢板的厚度和形状。新近获悉，在炉中停留时间越长，在接下来的成型期间的镀层附着性越好。加热温度大致在 800-1,200℃的范围内，优选 900-1,000℃，并且重要的是保持钢板在该温度范围内持续约几分钟。然而，停留时间取决于温度，并且确定该停留时间必需长于以下四个条件的时间：A (800℃、13 分钟)、B (900℃、6 分钟)、C (1,050℃、1.5 分钟)和 D (1,200℃、0.3 分钟)。

然而，较长的停留时间使得压制成型时的生产率受损。通过在950℃下加热 5-8 分钟可以获得实际上足够的镀层附着性，这一条件是作为折衷点而确定的。硬化结构实际上大大受到冷却速率的影响，并且为了获得所述硬化结构，要求冷却速率不低于 10℃/秒。这取决于钢组份，并且在为具有良好可硬化性的钢板的情况下，即使在约10℃/秒的冷却速率下也可以获得主要由马氏体组成的所需结构，或者在另一情况下，根据钢等级要求冷却速率为约 30℃/秒。

接下来，以实施例为基础详细解释本发明。

实施例 1

对作为物料的酸渍钢板(厚 1.8 mm)和冷轧钢板(厚 1.2 mm)(具有表 1 所示的钢组成并通过常规热轧和冷轧法制得)施加热浸镀铝。表 1 中的第 1、3、5、7 和 9 号是冷轧钢板，其它的是热轧钢板。在热浸镀铝时，使用非氧化炉还原炉型的管线，在浸镀之后采用气体擦去法(gas wiping method)将电镀的沉积量调整至每面 40 g/m^2，并且在此之后，将钢板冷却并经受零锌花(zero-spangle)处理。此时的镀浴组成是 Al-10%Si-2%Fe。镀浴中的 Fe 是电镀设备和镀浴中的钢板不可避免地提供的组份。镀层外观良好，没有未电镀缺陷等。评价由此制得的热浸镀铝钢板的可硬化性和耐热性。评价方法示于下。

作为实际的合金化的方法，将镀铝钢板在 950℃下加热 30 分钟，

之后冷却，同时在氮气环境下将其插入由钢制成的模具之间。冷却速率是 100℃/秒。肉眼评价钢板镀层的剥落。另外，施加 100 g 载荷下测定钢板横截面的维氏硬度。之后，将钢板经受常用于镀铝的化学处理，并镀锌，涂布厚度为 20 μm 的阳离子电沉积漆(Nippon Paint Co., Ltd.；powernix 110)，烘焙，并在切出十字形状之后经受 20 天的喷盐试验(JIS-Z2371)，并测定十字形切割部分的腐蚀深度。这里，十字形切割的深度是约 50 μm。因此，由记录值减去 50 μm 得到的值是真正的腐蚀深度。而且，为了获得 Fe-Al 金属间化合物中的 Mn 和 Cr 的浓度，淬火之后，在从表面到 5 μm 深的区域的横截面的 5 个经抛光的部分，使用 EPMA 通过定量分析一样品来测定 Mn 和 Cr 的量。评价结果示于表 2。

耐热性的评价标准

O：没有剥落

Δ：从边缘部分剥落

X：产生剥落

喷漆后耐腐蚀性的评价标准

O：腐蚀深度不大于 80 μm

X：腐蚀深度大于 80 μm

(每一值包括十字形切割的深度。)

表 1

编号	化学组成(质量%)											
	C	Si	Mn	P	S	Al	N	Ti	Cr	Mo	B	Ti*
1	0.23	0.12	1.21	0.02	0.009	0.03	0.004	0.02	0.13	-	0.002	0.76
2	0.21	0.20	0.81	0.02	0.007	0.05	0.004	0.22	0.20	-	-	0.83
3	0.17	0.15	1.24	0.01	0.008	0.03	0.003	0.01	1.10	-	0.0008	1.73
4	0.42	0.7	2.41	0.01	0.009	0.01	0.003	0.66	0.21	-	0.001	2.08
5	0.23	0.31	1.54	0.02	0.007	0.05	0.003	0.02	0.44	-	0.002	1.23
6	0.25	0.18	1.22	0.01	0.01	0.04	0.003	0.02	0.66	0.20	0.005	1.29
7	0.24	0.2	0.41	0.01	0.02	0.05	0.004	0.09	0.10	0.15	0.01	0.47
8	0.2	0.2	2.43	0.01	0.01	0.04	0.003	0.09	0.21	-	0.0008	1.52
9	0.03	0.1	1.4	0.02	0.01	0.03	0.004	0.25	0.15	-	0.0003	1.1
10	0.23	0.12	0.3	0.01	0.008	0.05	0.003	0.03	0.23	-	-	0.41
11	0.24	0.10	0.51	0.01	0.008	0.03	0.004	0.05	0.03	-	0.0022	0.34

注 1) Ti*： Ti + 0.5Mn + Cr + 0.5Mo

表 2

编号	Mn + Cr 量	耐热性	维氏硬度	喷漆后耐腐蚀性
1	0.4	O	515	O
2	0.22	O	480	O
3	0.96	O	405	O
4	0.85	O	766	O
5	0.30	O	511	O
6	0.30	O	548	O
7	0.15	O	539	O
8	0.78	O	466	O
9	0.44	O	200	O
10	0.19	O	311	O
11	0.21	Δ	522	O

当 C 量过低时，如第 9 个钢板，其强度降低。一般说来，通过将维氏硬度乘以 3 得到接近材料强度的值(MPa)，并且在这种情况下，获得最多仅仅 600 Mpa 级别的强度。当对淬火有效的元素（例如 Mn、B 等）的加入量小时，如第 10 号钢板，即使 C 量大也不能获得淬火效果，并且该强度在一定程度上趋于受损。而且，在 Ti*：Ti + 0.5×Mn

+ Cr + 0.5×Mo 的值小的情况下，如第 11 号钢板，加热之后镀层剥离并且耐热性在一定程度上趋于受损。在第 1-8 号钢板中，其中这些元素在钢中的加入量得到适当控制，强度、耐热性和喷漆后耐腐蚀性都显示出良好的结果。

接下来，表 1 中本实施例的第 7 号钢板在主要含有 Al-10%Si-2%Fe 并且其中加入 Mn 和 Cr 的镀浴中电镀。电镀的沉积量是每一面 60 g/m^2，并且获得良好的电镀外观。在加热之后将钢板用模具在 900℃下淬火 2 分钟。冷却速率是约 100℃/秒。此时镀浴中的 Mn 和 Cr 的量和评价结果示于表 3。当金属间化合物中的 Mn 和 Cr 的量小时，如第 1 号钢板，喷漆后耐腐蚀性差，但是随着镀浴中 Mn 和 Cr 的加入量增加，其耐腐蚀性提高。此时金属间化合物内 Mn 和 Cr 的量与喷漆后耐腐蚀性的关系示于图 3。应理解的是喷漆后耐腐蚀性随 Mn 和 Cr 的量增加而提高。

表 3

编号	镀浴中元素的量(%)		金属间化合物内元素的量(%)		喷漆后耐腐蚀性
	Mn	Cr	Mn	Cr	
1	0	0	0.08	0	X
2	0.1	0	0.11	0	O
3	0.2	0	0.24	0	O
4	0.4	0.05	0.51	0.08	O
5	0.6	0	0.73	0	O
6	0.8	0.1	0.75	0.14	O

实施例 2

将表 4 中所示具有不同化学组成的钢铸造，再次加热至 1,050-1,250℃的温度，之后热轧、酸渍、冷轧、退火、经受电镀处理(镀铝或者镀铝-锌：镀"Galvalium ®")，之后以 0.8%的收缩率(reduction rate)经受回火轧。而且，作为整个合金化过程，将这些钢板加热至

900-1,000℃的温度，在该温度下保持 5 分钟，之后用室温的模具进行压制成型，然后调查其性能。对物料性能的测定是通过从轧制时快速冷却的部分切取样品，并对其施加抗拉试验来进行的。该试验是按照 JIS-Z2201 将样品切割成 5 个试验片，并按照 JIS-Z2241 中所述的测定方法进行的。评价结果示于表 5。

表 4

钢号	C	Si	Mn	S	P	Al	Ti	N	Ni	Cu	B	Sn	Ti−3.42*N
1	0.22	0.20	1.05	0.020	0.020	0.025	0.020	0.0024	0.02	0.02	0.0030	—	0.012
2	0.21	0.15	0.94	0.018	0.023	0.024	0.022	0.0035	0.25	0.10	0.0027	—	0.010
3	0.22	0.15	0.94	0.018	0.023	0.024	0.022	0.0025	0.01	0.01	0.0027	0.01	0.013
4	0.16	0.48	1.70	0.009	0.015	0.021	0.017	0.0025	0.80	0.02	0.0002	—	0.008
5	0.35	0.05	1.00	0.015	0.012	0.030	0.020	0.0028	0.01	0.01	0.0020	—	0.010
6	0.53	0.10	1.10	0.010	0.020	0.026	0.200	0.0021	0.02	0.01	0.0010	0.05	0.193
7	0.53	0.10	0.30	0.010	0.020	0.030	0.020	0.0020	0.90	0.02	0.0047	—	0.013
8	0.22	0.20	1.00	0.002	0.015	0.035	0.005	0.0034	0.02	0.02	0.0005	—	-0.007
9	0.21	0.20	1.10	0.022	0.021	0.028	0.020	0.0026	0.00	0.02	0.0020	—	0.011
10	0.22	0.20	2.00	0.010	0.010	0.030	0.020	0.0033	0.01	0.01	—	—	0.009
11	0.35	0.15	2.10	0.012	0.013	0.023	0.018	0.0028	0.05	0.01	—	0.01	0.008
12	0.24	0.20	2.50	0.008	0.009	0.035	0.026	0.0035	0.02	0.01	—	—	0.014

表 5

钢号	冷却温度(℃)	退火温度(℃)	电镀类型	成型之前的TS(Mpa)	成型之前的加热温度(℃)	YP(MPa)	TS(MPa)	裸露耐腐蚀性	喷漆后耐腐蚀性
1	630	780	镀铝	560	950	1250	1580	O	O
	610	775	镀Galvalium	550	950	1255	1600	O	O
2	680	760	镀铝	550	950	1220	1610	O	O
	650	780	镀Galvalium	558	950	1210	1590	O	O
3	620	730	镀铝	570	950	1280	1550	O	O
	630	730	镀Galvalium	564	950	1270	1540	O	O
4	650	830	镀铝	500	980	1110	1310	O	O
	660	840	镀Galvalium	508	980	1100	1320	O	O
5	630	770	镀铝	603	950	1480	1830	O	O
	640	770	镀Galvalium	605	950	1490	1820	O	O
6	650	775	镀铝	654	940	1610	1990	O	O
	660	780	镀Galvalium	660	940	1620	1980	O	O
7	650	760	镀铝	780	910	1850	2100	O	O
	650	760	镀Galvalium	774	910	1820	2120	O	O
8	650	790	镀铝	553	950	750	980	O	O
9	630	800	镀铝	558	950	1210	1540	X	O
10	640	780	镀铝	554	950	1240	1580	O	O
	630	775	镀Galvalium	550	950	1230	1575	O	O
11	650	760	镀铝	572	950	1200	1510	O	O
	650	760	镀Galvalium	563	950	1205	1520	O	O
12	620	730	镀铝	595	950	1270	1560	O	O
	630	730	镀Galvalium	598	950	1275	1570	O	O

从压制成型期间经过加工的部分切取样品，并评价作为高温成型之后的表面性能的裸露耐腐蚀性和喷漆后耐腐蚀性。通过使样品经受湿罐试验(相对湿度：95%，温度：40℃)持续 3 天来评价裸露耐腐蚀性；在样品上切出十字形切痕，然后通过使样品经受持续 30 天的喷盐试验(JIS-Z2134)来评价喷漆后耐腐蚀性。采用阳离子电沉积漆作为这种情况下的喷漆，并且喷漆厚度是 15 μm。从其外观判断其裸露耐

腐蚀性，并使用标记 O 或 X 来标记，其评价标准是：X 代表发生红锈，O 代表没有红锈。同样，从其外观判断喷漆后耐腐蚀性，并使用标记 O、Δ或 X 来标记，其评价标准是：O 代表起凸不大于 2 mm，Δ代表起凸大于 2 mm 但不大于 4 mm，并且 X 代表起凸大于 4 mm。第 1-7 号钢是组份在本发明所述范围内的钢，并且在本发明所述范围内的条件下生产的所有钢板在高温成型之后可以保证高强度，而且，在裸露耐腐蚀性和喷漆后耐腐蚀性方面都没有问题。这里，在第 7 号钢的情况下，还显示了在这些条件(退火温度得自本发明所述的范围)下制得的钢板的结果，并且，在这种情况下，由于钢板强度太高，因此没有评价这些性能。在第 8 和 9 号钢的情况下，钢板组成偏离本发明所述的范围内。结果，在第 8 号钢的情况下，高温成型之后的强度(为本发明的一个目标)低，并且在为第 9 号钢的情况下，无法保证裸露耐腐蚀性和喷漆后耐腐蚀性。

实施例 3

将表 6 中所示具有不同化学组成的钢铸造，再次加热至 1,050-1,250℃的温度，之后热轧、酸渍、冷轧、退火、经受电镀处理(镀铝或者镀铝-锌)，之后以 0.8%的收缩率经受回火轧。而且，作为整个合金化过程，将这些钢板加热至 900-1,000℃的温度，在该温度下保持 5 分钟，之后用室温的模具进行压制成型，然后调查其性能。对物料性能的测定是通过从轧制时快速冷却的部分切取样品，并对其施加抗拉试验进行的。该试验是按照 JIS-Z2201 将样品切割成 5 个试验片并按照 JIS-Z2241 中所述的测定方法进行的。评价结果示于表 7。

表 6

钢号	C	Si	Mn	S	P	Al	N	Cr	Mo	Cr+7×Mo	注
1	0.16	0.20	0.72	0.006	0.020	0.035	0.0025	1.00	0.18	2.260	本发明实施例
2	0.21	0.21	0.68	0.008	0.018	0.032	0.0030	0.95	0.15	2.000	本发明实施例
3	0.50	0.25	0.75	0.006	0.020	0.026	0.0028	0.98	0.17	2.170	本发明实施例
4	0.23	0.20	1.50	0.010	0.015	0.030	0.0030	0.32	0.00	0.320	本发明实施例
5	0.22	0.45	2.20	0.009	0.010	0.038	0.0035	0.00	0.05	0.350	本发明实施例
6	0.23	0.15	0.30	0.008	0.012	0.032	0.0026	1.90	0.00	1.900	本发明实施例
7	0.21	0.20	0.50	0.008	0.010	0.033	0.0028	0.00	0.80	5.600	本发明实施例
8	0.22	0.21	0.65	0.006	0.015	0.032	0.0030	0.10	0.02	0.240	本发明实施例
9	0.22	0.20	0.70	0.008	0.014	0.025	0.0025	0.25	0.00	0.250	本发明实施例
10	0.21	0.18	0.45	0.010	0.012	0.028	0.0025	0.00	0.03	0.210	对比实施例

表 7

钢编号	冷却温度(℃)	退火温度(℃)	电镀类型	成型之前的TS (MPa)	成型之前的加热温度(℃)	YP (MPa)	TS (Mpa)	裸露耐腐蚀性	喷漆后耐腐蚀性	注
1	630	780	镀铝	565	980	1080	1280	O	O	本发明实施例
	620	780	镀铝-锌	560	980	1090	1270	O	O	本发明实施例
2	650	770	镀铝	605	950	1290	1560	O	O	本发明实施例
	650	765	镀铝-锌	600	950	1285	1580	O	O	本发明实施例
3	635	740	镀铝	725	930	1705	1890	O	O	本发明实施例
	630	750	镀铝-锌	750	930	1700	1900	O	O	本发明实施例
4	645	775	镀铝	500	950	1390	1610	O	O	本发明实施例
	650	780	镀铝-锌	508	950	1400	1600	O	O	本发明实施例
5	630	770	镀铝	603	950	1300	1550	O	O	本发明实施例
	630	770	镀铝-锌	605	950	1320	1555	O	O	本发明实施例
6	650	770	镀铝	654	950	1390	1620	O	O	本发明实施例
	640	760	镀铝-锌	660	950	1380	1620	O	O	本发明实施例
7	640	770	镀铝	780	950	1320	1510	O	O	本发明实施例
	650	760	镀铝-锌	774	950	1325	1520	O	O	本发明实施例
8	630	765	镀铝	553	950	1320	1580	O	O	本发明实施例
	635	760	镀铝-锌	555	950	1310	1570	O	O	本发明实施例
9	640	770	镀铝	558	950	1340	1575	O	O	本发明实施例
	645	770	镀铝-锌	562	950	1350	1585	O	O	本发明实施例
10	630	765	镀铝	554	950	1350	1595	X	X	对比实施例
	640	760	镀铝-锌	550	950	1330	1530	X	X	对比实施例

从压制成型期间经受加工的部分切取样品，并在高温成型之后评价作为表面性能的裸露耐腐蚀性和喷漆后耐腐蚀性。通过使样品经受持续 3 天的湿罐试验(相对湿度：95%，温度：40℃)来评价裸露耐腐蚀性；在样品上切出十字形切痕，然后通过使样品经受持续 30 天的喷盐试验(JIS-Z2134)来评价喷漆后耐腐蚀性。采用阳离子电沉积漆作为这种情况下的喷漆，并且喷漆厚度是 15 μm。从其外观判断其裸露耐腐蚀性，使用标记 O 或 X 标记，其评价标准是：X 代表发生红锈，O 代表没有红锈。同样，从其外观判断喷漆后耐腐蚀性，使用标记 O、Δ或 X 标记，其评价标准是：O 代表起凸不大于 2 mm，Δ代表起凸大于 2 mm 但不大于 4 mm，并且 X 代表起凸大于 4 mm。第 1-9 号钢是组份在本发明所述范围内的钢，并且在本发明所述范围内的条件下生产的所有钢板在高温成型之后可以保证高强度，而且，在裸露耐腐蚀性和喷漆后耐腐蚀性方面都没有问题。在第 10 号钢的情况下，钢板组成偏离本发明所述的范围，并因此无法保证裸露耐腐蚀性和喷漆后耐腐蚀性。

实施例 4

对作为物料的酸渍钢板(厚 1.8 mm)和冷轧钢板(厚 1.2 mm)(具有表 8 所示的钢组成并通过常规热轧和冷轧法制得)施加热浸镀铝。表 8 中的第 1、3、5 和 7 号是冷轧钢板，其它的是热轧钢板。在热浸镀铝时，使用非氧化炉还原炉型的管线，在电镀之后通过气体擦去法将电镀的沉积量调整至两个面都是 80 g/m^2，并且在此之后，将钢板冷却并经受零锌花处理。此时的镀浴组成是 Al-10%Si-2%Fe。镀浴中的 Fe 是电镀设备和镀浴中的钢板不可避免地提供的组份。电镀外观良好，没有未电镀缺陷等。性能示于表 9。

评价由此制得的热浸镀铝钢板的可硬化性和可加工性。可加工性是通过如下评价的：作为实际合金化的方法，将镀铝钢板在大气中

950℃下加热 10 分钟，之后冷却，同时将其插入由钢制成的模具之间(冷却速率：约 30℃/秒)，将其冷却至室温，之后使其经受冲击试验。而且，施加 100 g 载荷下测定钢板横截面的维氏硬度。

可加工性的评价标准

O：没有剥落

Δ：产生裂缝

X：产生粉状剥落

表 8

编号	化学组成 (重量%)										
	C	Si	Mn	P	S	Al	N	Ti	Cr	Mo	B
1	0.23	0.12	1.21	0.02	0.009	0.03	0.004	0.02	0.13	-	0.002
2	0.21	0.20	0.81	0.02	0.007	0.05	0.004	0.22	0.20	-	-
3	0.17	0.15	1.24	0.01	0.008	0.03	0.003	0.01	1.10	-	0.0008
4	0.23	0.31	1.54	0.02	0.007	0.05	0.003	0.02	0.44	-	0.002
5	0.25	0.18	1.22	0.01	0.01	0.04	0.003	0.02	0.66	0.20	0.005
6	0.24	0.2	0.95	0.01	0.02	0.05	0.004	0.09	0.5	0.15	0.01
7	0.2	0.2	2.43	0.01	0.01	0.04	0.003	0.09	0.21	-	0.0008
8	0.04	0.1	1.4	0.02	0.01	0.03	0.004	0.25	0.15	-	0.0003

表 9

编号	可加工性	Fe-Al 镀层中的 Al 量(%)	维氏硬度
1	O	15	515
2	O	15	480
3	O	15	405
4	O	15	511
5	O	15	548
6	O	15	539
7	O	15	466
8	O	15	209

当 C 量相对低时，如第 8 号钢中的，其强度也相对低。一般说

来，通过将维氏硬度乘以 3 得到接近材料拉伸强度的值(MPa)，并且在这种情况下，获得最多仅仅 600 Mpa 级别的强度。在为第 1-7 号钢的情况下，强度和可加工性都显示良好的结果。使用 EPMA 定量分析这种情况下 Fe-Al 镀层中 Al 的量，并且该值是约 15%。这里，该值是通过在从表面到 10 μm 深的范围内分析淬火后样品横截面的 5 个部分并将该分析数据平均获得的。

接下来，表 8 中本实施例的第 1 号钢板用主要由 Al-10%Si-2%Fe 组成的金属电镀，并且电镀的沉积量是每一面都在 60 g/m^2 到 200 g/m^2 之间。将由此获得的样品在大气中 950℃下加热，同时改变停留时间，用冲击试验评价其可加工性，并通过实施例 4 的第 1 项中所述的方法测定 Fe-Al 镀层中 Al 的量。如表 10 中所示，其可加工性取决于 Fe-Al 镀层中 Al 的量，并且当 Al 的量不大于 35%时，获得良好的可加工性。而且，Fe-Al 镀层中 Al 的量取决于沉积量和停留时间，并且可以理解为沉积量越小并且停留时间越长，扩散进行越充分，并且 Fe-Al 镀层中 Al 的量越少。

表 10

编号	沉积量(g/m^2)	停留时间	Fe-Al 镀层中 Al 的量(%)	可加工性
1	60	0	36	Δ
2	60	1	29	O
3	60	2	17	O
4	80	0	38	X
5	80	1	35	Δ
6	80	2	20	O
7	120	2	42	X
8	120	4	36	X
9	120	6	15	O
10	200	5	44	X
11	200	10	38	X
12	200	15	377	X

实施例 5

对作为物料的酸渍钢板(厚 1.8 mm)和冷轧钢板(厚 1.2 mm)(具有表 11 所示的钢组成并通过常规热轧和冷轧法制得)施加热浸镀 Al-Si-Mg。表 11 中的 A、C、E 和 G 号是冷轧钢板，其它的是热轧钢板。在热浸镀铝时，使用非氧化炉还原炉型的管线，在电镀之后通过气体擦去法将电镀的沉积量调整至每面 40 g/m^2，并且在此之后，将钢板冷却并经受零锌花处理。此时的镀浴组成是 Al-8%Si-6%Mg-1%Fe-0.1%Ca。镀浴中的 Fe 是电镀设备和镀浴中的钢板不可避免地提供的组份。电镀外观显示闪烁图案并且良好，没有未电镀缺陷等。这种情况下的制备条件示于表 12。

评价由此制得的热浸镀钢板的可硬化性和耐腐蚀性。下面描述评价方法。作为实际合金化方法，将该热浸镀钢板经受 5%拉伸应力，然后在 950℃下加热 5 分钟，之后冷却，同时将其插入钢板之间。冷却速率是约 30℃/秒。肉眼观察冷却之后的样品以评价其耐热性。然后，通过使样品经受持续 3 天的湿罐试验(相对湿度：95%，温度：40℃)来评价裸露耐腐蚀性；在样品上切出十字形切痕，然后通过使样品经受持续 30 天的喷盐试验(JIS-Z2134)来评价喷漆后耐腐蚀性。采用阳离子电沉积漆作为这种情况下的喷漆并且喷漆厚度是 15 μm。而且，通过施加 100 g 载荷测定钢板的维氏硬度。

耐热性的评价标准

O：良好

Δ：在表面上产生裂缝状图案

X：产生红垢(red scales)

裸露耐腐蚀性的评价标准

O：良好

Δ：产生红锈

喷漆后耐腐蚀性的评价标准

◎ ：油漆起凸不大于 1 mm

O：油漆起凸不大于 2 mm

Δ：油漆起凸 2-4 mm

X：油漆起凸大于 4 mm

表 11

钢号	C	Si	Mn	P	S	Al	N	Ti	Cr	Mo	Ni	B
A	0.21	0.20	0.81	0.02	0.007	0.05	0.004	0.05	0.20	-	-	0.0005
B	0.17	0.15	1.24	0.01	0.008	0.03	0.003	0.15	1.10	-	-	0.0008
C	0.42	0.7	2.41	0.01	0.009	0.01	0.003	0.46	0.21	-	-	0.001
D	0.23	0.31	1.54	0.02	0.007	0.4	0.003	0.24	0.44	-	-	0.002
E	0.25	0.18	1.22	0.01	0.01	0.04	0.003	0.003	0.66	0.20	-	0.005
F	0.24	0.2	0.95	0.01	0.02	0.05	0.004	0.001	-	0.15	0.33	0.01
G	0.08	0.1	1.4	0.02	0.01	0.03	0.004	0.25	0.15	-		0.0003
H	0.24	0.10	0.31	0.01	0.008	0.03	0.004	0.21	0.03	-		0.0001

表 12

编号	所用钢编号	裸露耐腐蚀性	喷漆后耐腐蚀性	维氏硬度
1	A	O	O	485 (O)
2	B	O	O	401 (O)
3	C	O	O	769 (O)
4	D	O	O	509 (O)
5	E	O	O	544 (O)
6	F	O	O	540 (O)
7	G	O	O	289 (X)
8	H	O	O	301 (X)

当 C 量太小时，如第 7 号钢板中的，不能获得足够的强度。一般说来，通过将维氏硬度乘以 3 得到接近材料强度的值(MPa)，并且在这种情况下，获得最多仅仅 800 Mpa 级别的强度。当对淬火有效的元素如 Mn、B 等的量小时，如第 8 号钢板，即使 C 量大也不能获得

淬火效果。在为第 1-6 号钢板的情况下，其中这些钢中加入的元素量适当控制，在为 Mn-B-体系或 Mo-Cr-Ni-体系的情况下，强度和耐腐蚀性都显示良好的结果。

然后，使用表 11 中的钢 E，随着热浸镀管线的镀浴组成的变化来研究镀层组成与涂镀钢板性能之间的关系。镀层组成与镀后的性能之间的关系汇总于表 13。这里，每一种情况下的维氏硬度在 470-510 的范围内。

在为第 8 号钢板(属于 Mg-Zn-体系)的情况下，耐腐蚀性差。另一方面，第 4-7 号钢板(属于 Si-Mg-体系)显示优异的耐腐蚀性。同样，第 1-3 号钢板(属于 Si-Mg-Zn-体系)显示优异的耐腐蚀性。

表 13

编号	镀层的组成(质量%)				裸露耐腐蚀性	喷漆后耐腐蚀性
	Si	Mg	Zn	Ca		
1	2	3	40	0.1	O	◎
2	5	7	20	0.1	O	◎
3	8	6	10	-	O	◎
4	12	8	-	0.1	O	◎
5	8	6	-	0.1	O	◎
6	6	3	-	-	O	◎
7	9	0.5	-	-	O	◎
8	-	1	3	-	X	X

实施例 6

对作为物料的冷轧钢板(厚 1.2 mm)(具有表 14 所示的钢组成并通过常规热轧和冷轧法制得)施加热浸镀铝。在热浸镀铝时，使用非氧化炉还原炉型的管线，在电镀之后通过气体擦去法将电镀的沉积量调整至每一面都是 60 g/m^2，并且在此之后，将钢板冷却并经受零闪烁处理。此时的镀浴组成是 Al-10%Si-2%Fe。镀浴中的 Fe 是电镀设备和镀浴中的钢板不可避免地提供的组份。电镀外观良好，没有未电镀

缺陷等。将由此制得的镀铝钢板加热至950℃，并以实际合金化方法评价空气冷却期间镀层的可加工性(剥落耐性)。

此时，通过改变加热时间和加热方式改变铁氧体层的厚度。通过冲击试验进行加工，随着冷却期间加工温度的变化肉眼判断剥落状态，并且在不发生镀层剥落的最低温度下评价镀层的可加工性。这里，在为该钢的情况下，即使在10℃/秒的冷却速率下可硬化性依然良好，并且即使在空气冷却的情况下仍获得主要由马氏体组成的结构。图8显示了中间铁氧体层的厚度与这种情况下可以获得良好加工的最低温度之间的关系。

如图8所示，应理解，当铁氧体层的厚度不小于2 μm，优选不小于4 μm时，镀层的剥落耐性提高。当铁氧体层的厚度是约0.5 μm时，即使在800℃下加工也观察到镀层的粉状剥落。而且，作为实际合金化方法，镀层的可加工性取决于电镀的沉积量。尽管铁氧体层的厚度是2 μm，当每一面的沉积量是30 g/m^2时，获得良好加工的最低温度是约500℃。而且，通过用光学显微镜观察和接下来的图象分析来分析此时基底钢的结构，并且在所有情况下不小于80%的结构由马氏体组成。

表14

C	Si	Mn	P	S	Al	N	Ti	Cr	Mo	B
0.36	0.21	0.65	0.02	0.006	0.027	0.003	0.002	1.01	0.16	0.0001

实施例7

对作为物料的酸渍钢板(厚1.8 mm)和冷轧钢板(厚1.2 mm)(具有表15所示的钢组成并通过常规热轧和冷轧法制得)施加热浸镀铝。表15中的第1、3和5号是冷轧钢板，其它的是热轧钢板。在热浸镀铝时，使用非氧化炉还原炉型的管线，在电镀之后通过气体擦去法将电

镀的沉积量调整至每个面都是 60 g/m^2，并且在此之后，将钢板冷却并经受零闪烁处理。此时的镀浴组成是 Al-10%Si-2%Fe。电镀外观良好，没有未电镀缺陷等。作为实际合金化方法，将由此制得的热浸镀铝钢板加热至 950℃，通过水冷模具冷却，在温度达到约 600℃时经受压制成型。肉眼判断在经过弯曲加工的部分的电镀层的剥落状态，所有钢板都没有观察到电镀层剥落。此时，铁氧体层的厚度是 10-20 μm，并且在所有基底钢中的马氏体百分比不小于 80%。这里，冷却速率是约 150℃/秒。

表 15

编号	C	Si	Mn	P	S	Al	N	Ti	Cr	Mo	B
1	0.22	0.20	0.94	0.02	0.007	0.025	0.003	0.22	0.05	0.002	0.0017
2	0.16	0.17	0.69	0.02	0.007	0.037	0.004	0.002	0.98	0.17	0.0001
3	0.20	0.20	0.67	0.02	0.006	0.033	0.003	0.002	0.96	0.17	0.0002
4	0.22	0.15	0.88	0.03	0.007	0.022	0.004	0.55	0.12	0.01	0.0005
5	0.25	0.55	0.72	0.02	0.009	0.025	0.003	0.31	0.58	0.12	0.0020

实施例 8

对作为物料的冷轧钢板(厚 1.2 mm)(具有表 16 所示的钢组成并通过常规热轧和冷轧法制得)施加热浸镀铝。在热浸镀铝时，使用非氧化炉还原炉型的管线，在电镀之后通过气体擦去法将电镀的沉积量调整至每一面都是 30-80 g/m^2，并且在此之后，将钢板冷却并经受零闪烁处理。此时的镀浴组成是 Al-10%Si-2%Fe。镀浴中的 Fe 是电镀设备和镀浴中的钢板不可避免地提供的组份。电镀外观良好，没有未电镀缺陷等。评价由此制得的镀铝钢板的淬火之后的硬度、金属间化合物的厚度、可焊性、耐热性和喷漆后耐腐蚀性。作为实际合金化方法，通过将钢板在大气中 950℃下加热 0.5-20 分钟进行淬火，之后在平板状态下用模具将该钢板压制并将其冷却。此时，冷却速度是约 300℃/

秒。这样做，通过改变沉积量和加热时间获得具有不同厚度的合金层以及合金化至表面的淬火钢板。这里，所有钢板的外观几乎均匀。并且这些性能的评价方法和评价标准显示如下。

表 16

编号	C	Si	Mn	P	S	Al	N	Ti	Cr	Mo	B
1	0.22	0.20	0.94	0.02	0.007	0.025	0.003	0.22	0.05	0.002	0.0017

[硬度]

在钢板的横截面的中心部分通过赋予 100 g 载荷测定维氏硬度。

[金属间化合物的厚度]

通过使用显微镜观察钢板的横截面，然后用 2% nitral 蚀刻它，之后用 EPMA 分析该结构来测定金属间化合物的厚度。一个分析实例示于图 9。标号 1 显示具有如下组成的层：Al：26.85%、Si：9.83%、Fe：59.92%；标号 2 显示具有如下组成的层：Al：49.54%、Si：3.11%、Fe：44.87%；标号 3 显示具有如下组成的层：Al：30.75%、Si：8.88%、Fe：56.91%；和标号 4 显示具有如下组成的层：Al：9.59%、Si：2.92%、Fe：84.02%。

[可焊性]

在以下条件下评价可点焊性：

电极：由分散有铜的氧化铝制成并具有 6ϕ-40R 电极头的 Dome 电极，

压力：600 kgf，

焊接电流：10 kA，

焊接时间：12 个周期(60 Hz)。

评价标准：

O：大于 2,000 个周期的连续点焊

Δ：1,200-2,000 个周期的连续点焊

X：小于 1,200 个周期的连续点焊

[喷漆后耐腐蚀性]

在化学处理液(常用于钢板的镀铝和镀锌)中将一钢板经受约 2 分钟的化学处理，然后涂布厚度为 20 μm 的阳离子电沉积漆，在 140℃下烘烤 20 分钟，在切出十字形切痕之后经受 20 天的喷盐试验，并根据十字形切痕部分的腐蚀深度判断喷漆后耐腐蚀性。此处用切割机切出的十字形切痕的深度是约 50 μm。因此，由测定值减去 50 μm 获得的值是真正的腐蚀深度。

评价结果汇总于表 17。

评价标准

O：腐蚀深度不大于 80 μm

X：腐蚀深度大于 80 μm

表 17

编号	合金层的厚度(μm)	基材的硬度(Hv)	可点焊性	喷漆后耐腐蚀性
1	2	397	O	X
2	5	395	O	O
3	10	399	O	O
4	17	401	O	O
5	25	398	Δ	O
6	32	399	Δ	O
7	38	397	X	O

如表 17 所示，当合金层的厚度小时，钢板趋于具有优异的可点焊性，但是喷漆后耐腐蚀性较差。当该厚度太薄时，如第 1 号钢板，该钢板具有较差的喷漆后耐腐蚀性，并且当该厚度太厚时，如第 7 号钢板，该钢板具有较差的可点焊性。同样，在为第 5 和 6 号钢板的情况下，钢板趋于具有较差的可点焊性。因此，当认为可点焊性重要时，

使合金层的厚度相对薄些是较理想的。

实施例 9

将表 18 中显示的钢所制得的钢板用主要由 Al-10%Si-2%Fe 组成的金属电镀，并且观察到良好的电镀外观。测定在与实施例 7 的第 1 项相同条件下淬火之后的合金层的厚度，这些值在 8-15 μm 的范围内。对于这些钢板，评价与实施例 7 的第 1 项相同的评价项。结果，所有钢板获得相当于实施例 1 的评价等级 O 的评价结果，并且显示良好的可焊性和良好的喷漆后耐腐蚀性。

表 18

编号	C	Si	Mn	P	S	Al	N	Ti	Cr	Mo	B
1	0.22	0.20	0.94	0.02	0.007	0.025	0.003	0.22	0.05	0.002	0.0017
2	0.16	0.17	0.69	0.02	0.007	0.037	0.004	0.002	0.98	0.17	0.0001
3	0.20	0.20	0.67	0.02	0.006	0.033	0.003	0.002	0.96	0.17	0.0002
4	0.36	0.21	0.65	0.02	0.006	0.027	0.003	0.002	1.01	0.16	0.0001
5	0.22	0.15	0.88	0.03	0.007	0.022	0.004	0.55	0.12	0.01	0.0005
6	0.25	0.55	0.72	0.02	0.009	0.052	0.003	0.31	0.58	0.12	0.0020
7	0.23	0.18	0.21	0.03	0.007	0.025	0.003	0.27	0.03	0.01	0.0022

实施例 10

对作为物料的冷轧钢板(厚 1.2 mm)(具有表 19 所示的钢组成并通过常规热轧和冷轧法制得)施加热浸镀铝。在热浸镀铝时，使用非氧化炉还原炉型的管线，在电镀之后通过气体擦去法将电镀的沉积量调整至每一面都是 60 g/m^2，并且在此之后，将钢板冷却并经受零闪烁处理。此时的镀浴组成是 Al-10%Si-2%Fe。镀浴中的 Fe 是电镀设备和镀浴中的钢板不可避免地提供的组份。电镀外观良好，没有未电镀缺陷等。将由此制得的热浸镀铝钢板在大气中加热，然后保持在不同温度下，并形成图 10 所示的形状。此时，用水冷模具将这些钢板冷

却。加热速率是约 5-10℃/秒，而冷却速率各部分不尽相同，在冷却速率高的部分其约为 100℃/秒，在冷却速率低的部分其约为 20℃/秒。评价此时电镀层的可加工性(剥落耐性)。在压制表面上以条状或点状形成电镀层剥落。在表 20 中显示了加热条件和电镀层的剥落状态之间的关系。另外，本发明的加热条件示于图 11。

表 19

C	Si	Mn	P	S	Al	N	Ti	Cr	Mo	B
0.24	0.21	0.95	0.02	0.006	0.027	0.003	0.002	1.01	0.16	0.0018

表 20

编号	加热温度(℃)	加热时间(分钟)	附着性
1	800	20	Δ
2	850	15	O
3	900	13	O
4	950	8	O
5	1000	6	O
6	1050	4	O
7	1100	2	O
8	900	5	X
9	1000	2	X

附着性的评价标准

O：电镀层没有剥落

Δ：在部分电镀层产生裂缝

X：电镀层发生剥落

如表 20 所示，对于实际的合金化过程，如果温度低至 800℃，即使加热 20 分钟，也难以达到理想的附着性。而当加热温度升高时，停留时间不大于 10 分钟便获得良好的附着性。对于实际的合金化过

程，当在 900℃下停留时间为 5 分钟，或者在 1,000℃下停留时间为 2 分钟时，附着性仍然不足。

工业实用性

如上所述，本发明提供了一种形成高强度汽车零件的热轧方法，并且大大有利于在未来减轻汽车的重量。

图1

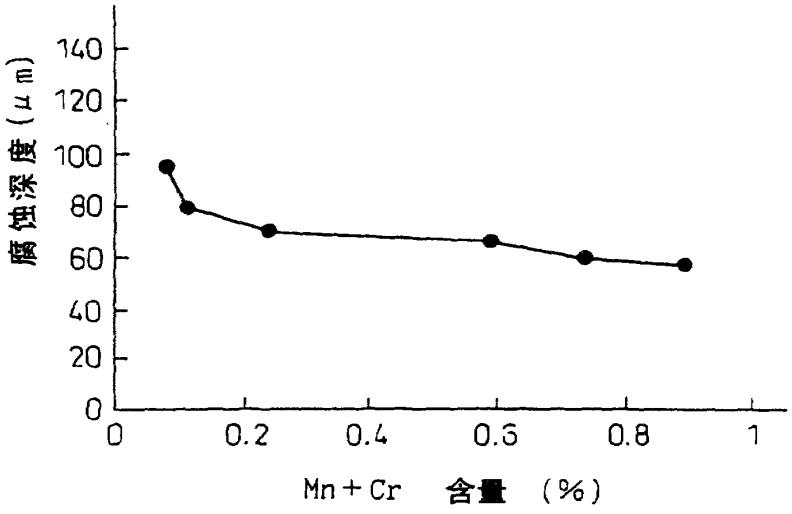


图2

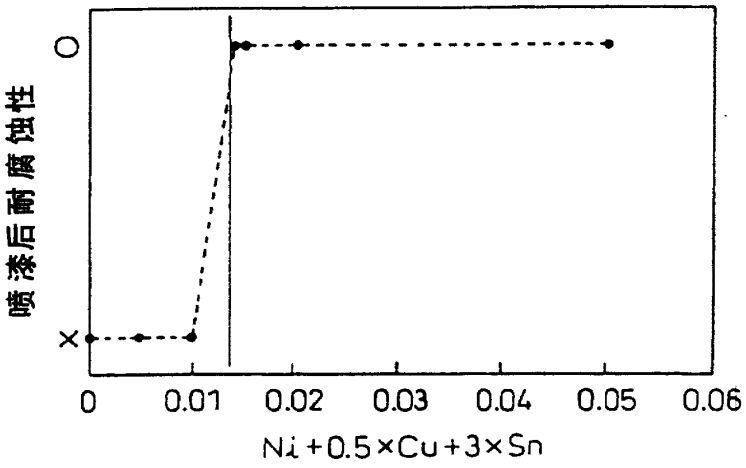

喷漆后耐腐蚀性
○
×
0
0.01
0.02
0.03
0.04
0.05
0.06
Ni+0.5×Cu+3×Sn

图3

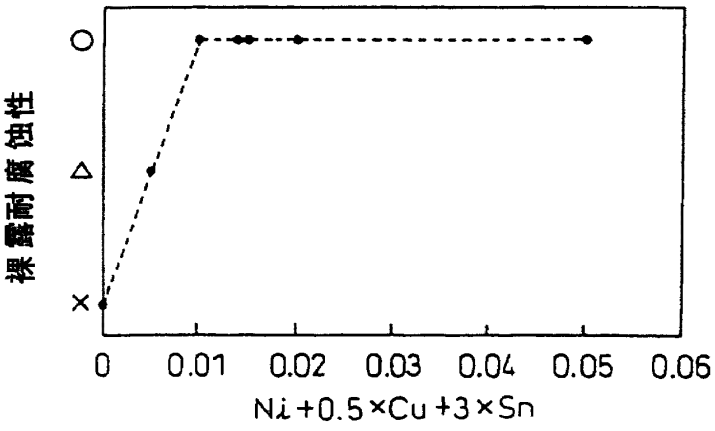

裸露耐腐蚀性
○
△
×
0
0.01
0.02
0.03
0.04
0.05
0.06
Ni+0.5×Cu+3×Sn

图4

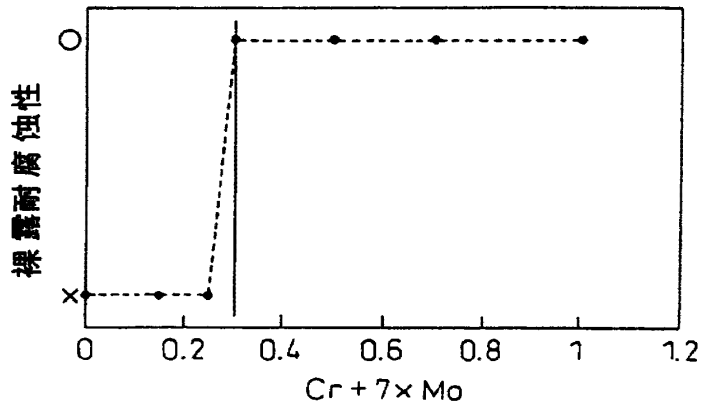


图5

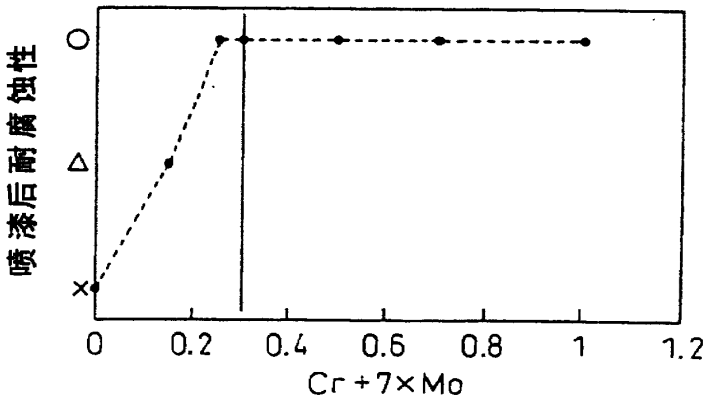


图6

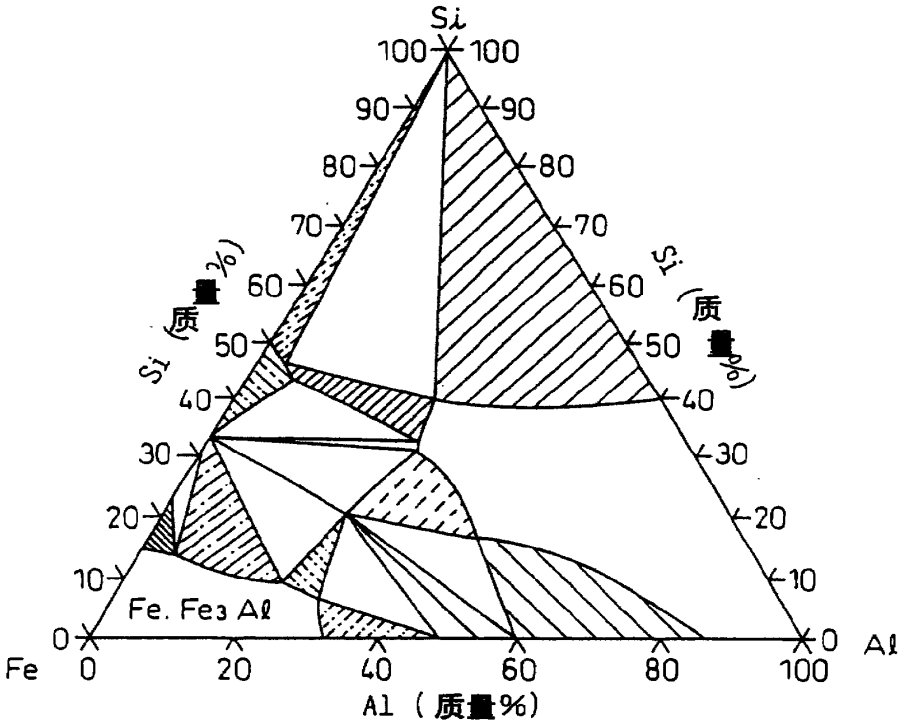

Si
100
90
80
70
60
50
40
30
20
10
0
Si（质量%）
Si（质量%）
Fe. Fe3 Al
Fe
0
20
40
60
80
100
Al
Al（质量%）

图7

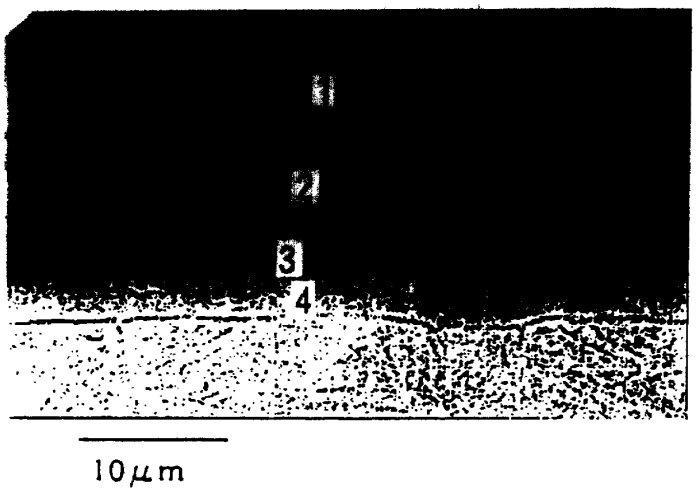

1
2
3
4
10μm

图8

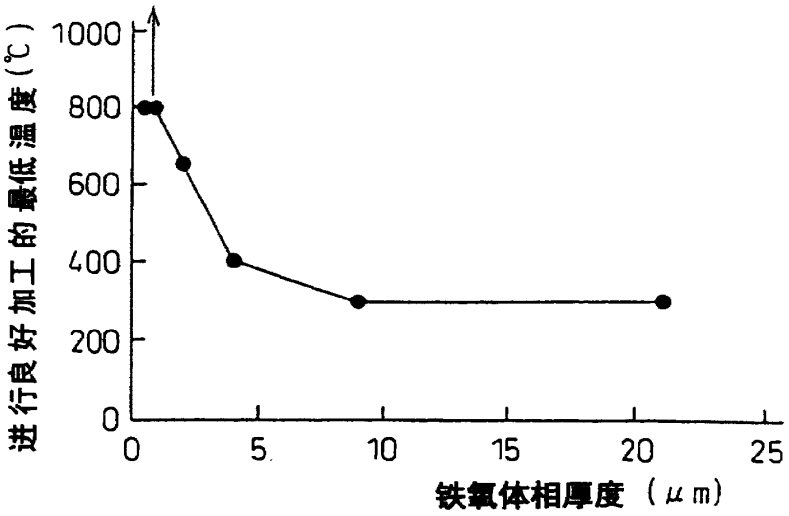

进行良好加工的最低温度(℃)
1000
800
600
400
200
0
0
5
10
15
20
25
铁氧体相厚度 (μm)

图9

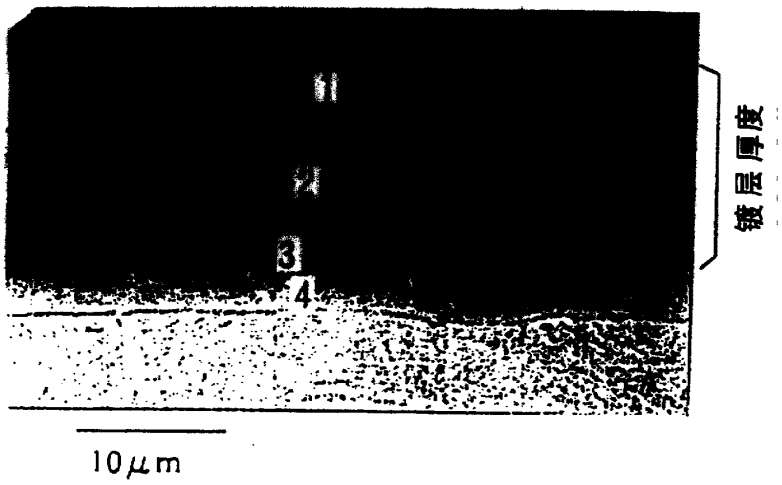


图10

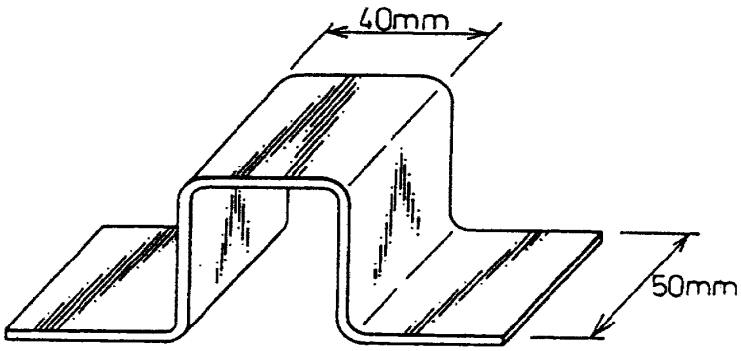
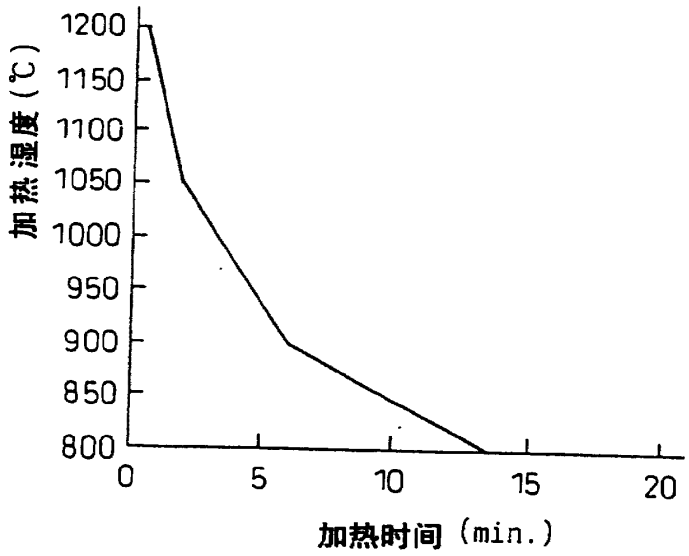

40mm
50mm

图11


加热温度(℃)
1200
1150
1100
1050
1000
950
900
850
800
0
5
10
15
20
加热时间(min.)

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2001-390842	25 December 2001 (25.12.2001)	JP

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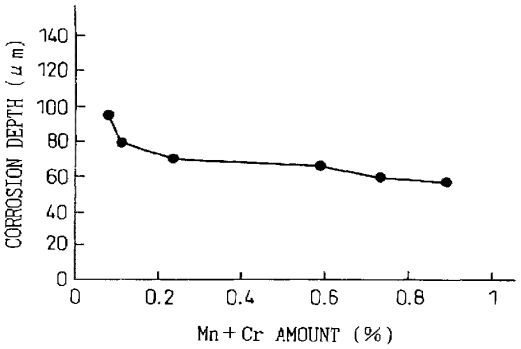
[Continued on next page]

(54) Title: HIGH-STRENGTH ALLOYED ALUMINUM-SYSTEM PLATED STEEL SHEET AND HIGH-STRENGTH AUTOMOTIVE PART EXCELLENT IN HEAT RESISTANCE AND AFTER-PAINTING CORROSION RESISTANCE



(57) Abstract: The present invention provides a hot press method used for producing a high-strength member for an automobile and, in particular, a part which requires high-strength, such as an undercarriage component of an automobile. More specifically, the present invention provides an aluminum plated steel sheet or an aluminum-zinc plated steel sheet suitable for high temperature forming (hot forming) wherein high strength is obtained after high temperature forming, and a method of producing the same. Also, the present invention provides a hot dip aluminum plated steel sheet which suppresses the alloying reaction of a plated layer during press forming and has beautiful appearance, and an aluminum-system plated steel sheet for hot press having excellent after-painting corrosion resistance. Concretely, the present invention is a high-strength aluminum-system plated steel sheet excellent in heat resistance and after-painting corrosion resistance, characterized by having an Fe-Al-system coating containing, in mass, Mn and Cr of more than 0.1% in total on the surface of the steel containing, in mass, C: 0.05 to 0.7%, Si: 0.05 to 1%, Mn: 0.5 to 3%, P: not more than 0.1%, S: not more than 0.1% and Al: not more than 0.2%, and, in addition, one or more element(s) selected from among Ti: 0.01 to 0.8%, Cr: not more than 3% and Mo: not more than 1%, so as to satisfy the following expression (1): Ti + 0.5xMn + Cr + 0.5xMo > 0.4 ... 1

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STEEL CORPORATION, YAWATA WORKS, 1-1, Tobihata-cho, Tobata-ku, Kitakyushu-shi, Fukuoka 804-8501 (JP). **KUSUMI, Kazuhisa** [JP/JP]; C/O NIPPON STEEL CORPORATION, YAWATA WORKS, 1-1, Tobihata-cho, Tobata-ku, Kitakyushu-shi, Fukuoka 804-8501 (JP).

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DESCRIPTION

HIGH-STRENGTH ALLOYED ALUMINUM-SYSTEM PLATED STEEL SHEET AND HIGH-STRENGTH AUTOMOTIVE PART EXCELLENT IN HEAT RESISTANCE AND AFTER-PAINTING CORROSION RESISTANCE

Technical Field

The present invention relates to an alloyed aluminum-system plated steel sheet suitable for a member, which is produced by a high-temperature press and requires strength, as represented by a structural member for an automotive part, and a method of producing the same and, in particular, to a member which requires high strength such as an undercarriage component of an automobile or the like, and a steel material used for producing the same.

Background Art

For pursuing the weight reduction of an automobile, originating from global environmental problems, a steel sheet used for an automobile is required to have the highest possible strength. However, in general, when the strengthening of a steel sheet is enhanced, elongation and an r-value are lowered and thus formability is deteriorated. Therefore, a steel sheet is desired to have high-strength, high formability and shape fixability simultaneously.

One solution to the problem is a TRIP (Transformation Induced Plasticity) steel produced by using the martensite transformation of retained austenite and the application of a TRIP steel is increasing recently. However, though it is possible to produce a 1,000 MPa class high-strength steel sheet excellent in formability using a TRIP steel, it is difficult to secure good formability in a higher-strength steel sheet, for example, an ultra-high-strength steel sheet having a

strength of not lower than 1,500 MPa. Moreover, it is difficult to solve the problem of the shape fixability by that technology.

To cope with the problems, there is a warm press technology which is a technology attracting attention recently as another means which reconciles high-strength and high formability. A technology of increasing strength by forming a steel sheet while warm and making use of the heat generated during the forming is disclosed in Japanese Unexamined Patent Publication No. 2000-234153. This technology aims at increasing strength by controlling components in a steel appropriately, heating the steel sheet in the temperature range of ferrite and making use of the precipitation strengthening in the temperature range.

In Japanese Unexamined Patent Publication No. 2000-87183, proposed is a high-strength steel sheet wherein the yield strength at a temperature during forming is decreased far lower than the yield strength at the room temperature, aiming at improving the accuracy of press forming. However, there may be a limitation in the strength obtained by this technology.

As a technology which overcomes this drawback, a technology of heating a steel sheet to the temperature range where austenite single phase is formed and then cooling it during press forming is disclosed in the literature (SAE, 2001-01-0078).

This is a technology of obtaining desired material properties by forming a steel sheet in the state of heating it to a high temperature of not lower than 800°C, by so doing, solving the forming problem of a high-strength steel sheet, and then quenching it in the cooling after forming. However, as the technology involves heating in the atmosphere, oxides are generated on the surface of a steel sheet and it is required to remove the oxides in a downstream process. A technology of applying aluminum plating for suppressing the

oxidation during heating is also disclosed in the aforementioned literature (SAE, 2001-01-0078).

As another means, a means of obtaining high strength by, after forming a steel sheet at the room temperature, heating rapidly and cooling rapidly a part of the steel sheet and thus quenching it can be adopted. In this case, by heating the steel sheet locally, it is possible to enhance the strength of only the portion where high strength is required. Japanese Unexamined Patent Publication No. 2000-83640 discloses such a technology and a steel sheet containing carbon at 0.15 to 0.5% is used therefor.

A hot forming technology and a technology of applying an aluminum plated steel sheet in the hot forming are disclosed in the aforementioned prior arts. However, in the prior arts, when a steel sheet is heated to a high temperature of not lower than 800°C, Fe diffuses up to the surface for a short period of time and an aluminum plated layer changes to an intermetallic compound, hereinafter called "alloyed aluminum-system plated layer". Since the alloyed aluminum-system plated layer is very hard and brittle, sometimes it generates cracks and peels off in the state of powder, and therefore the deterioration of corrosion resistance after painting has been a concern. Even when cracks are not generated, there have been cases where an aluminum plated steel sheet is inferior to another surface treated steel sheet, for example, a hot-dip galvanized steel sheet or a hot-dip galvannealed steel sheet, in after-painting corrosion resistance. More specifically, after-painting corrosion resistance is evaluated after a forming at a high temperature and, when scratches, such as cutting in a cross shape, are provided, the corrosion of the base steel has been apt to propagate from the portion in the direction of the depth and to advance more than the case of a hot-dip galvanized or hot-dip galvannealed steel sheet of a sacrificial corrosion prevention type.

Further, there also is the possibility that the exfoliated plated layer piles up on dies and causes flaws during pressing. This is because, though the plated layer can withstand the working of a hot forming, it is practically difficult to work the whole part while it is hot and there is the problem of the plated layer being apt to peel off at the portion where the working has been delayed and the temperature has dropped. Another problem here is that, when the temperature drops, the base steel constitutes a hard structure mainly composed of martensite as a result of quenching, and therefore the stress is apt to escalate.

Disclosure of the Invention

The present inventors conducted a basic study for solving the aforementioned problems, and found that a plated steel sheet excellent in after-painting corrosion resistance could be produced by applying an Fe-Al-system coating containing Mn and Cr of more than 0.1% in total on the surface of a steel sheet after a high temperature forming. An aluminum-system plated layer after being subjected to a hot forming and being rapidly heated locally is transformed into an alloyed aluminum-system plated layer up to its surface, and the compound is very brittle and thus tends to generate cracks during working. The aluminum-system plated steel sheet defined in the present invention means a plated steel sheet having a plated layer composed of Al and Fe content of at least 70%. Further, since the layer has a nobler electric potential than the base steel sheet, the corrosion of the base steel is initiated starting from the cracks and after-painting corrosion resistance is apt to deteriorate. For avoiding the deterioration of the after-painting corrosion resistance, Mn addition to the alloyed aluminum-system plated layer is very effective. Though the function of Mn is not clarified yet, it is said that Mn plays the roll of bringing the electric

potential of an Fe-Al-system plated layer close to that of the steel sheet by controlling the electric potential of the alloy layer, and, in addition to the function, there is also the possibility that Mn controls also the shape of phosphate crystals in a phosphating treatment which is a pre-painting treatment.

Extremely excellent heat resistance, in particular, heat resistance after working, can be obtained by specifying the amounts of C, Si, Mn, P, S and Al as base steel components and by adding Ti, Cr and Mo, which addition was effective, so as to satisfy the following equation 1:

$$Ti + 0.5\times Mn + Cr + 0.5\times Mo > 0.4 \quad \ldots 1$$

It is estimated that those elements accelerate the diffusion between Al and Fe, and, by so doing, even when cracks are generated in a plated layer, the reaction between Fe and Al proceeds from the circumference of the cracks and therefore the base steel is hardly exposed.

Further, the present inventors also obtained the knowledge that, by adding N, Nb, V, Ni, Cu, B, Sn and Sb as steel components, further excellent after-painting corrosion resistance could be obtained.

In the meantime, it is advantageous for a plated layer after alloying treatment to contain Si further, and furthermore, better corrosion resistance is obtained by adding Zn, Mg, etc. It is important that Al content in an alloy layer is not more than 35% in view of suppressing cracks in the alloy layer. Further, it is desirable that the thickness of an Fe-Al-system alloy layer is 3 to 35 μm from the viewpoint of after-painting corrosion resistance.

Further, for overcoming the above-mentioned problems, the present inventors studied in detail the factors influencing the workability of an aluminum-system plated steel sheet after alloying treatment, and obtained

the following knowledge. That is, since both an alloyed aluminum-system plated layer and a base steel are hard, the internal stress increases, but, since a soft layer exists between the alloyed aluminum-system plated layer and the base steel, the stress is mitigated and therefore exfoliation resistance is improved markedly. The soft layer is composed of a ferrite phase, and it is estimated that the fact that the thickness of the soft layer is not less than 1 μm prevents the cracks in the alloyed layer propagating up to the base steel.

In addition, for overcoming the above-mentioned problems, the present inventors studied in detail the factors influencing the workability of an aluminum-system plated steel sheet after alloying treatment, and obtained the following knowledge. That is, it is possible to prevent the exfoliation of a plated layer by optimizing the heating conditions. The reason is not clear but it is estimated that a plated layer is alloyed according to heating conditions, the phase structure changes complicatedly, and there is an appropriate phase structure for securing workability. The gist of the present invention is as follows:

(1) A high-strength alloyed aluminum-system plated steel sheet excellent in after-painting corrosion resistance, characterized by having an Fe-Al-system coating containing Mn and Cr of more than 0.1% in total on the surface of the steel sheet.

(2) A high-strength alloyed aluminum-system plated steel sheet excellent in heat resistance and after-painting corrosion resistance, characterized by having an Fe-Al-system coating containing, in mass, Mn and Cr of more than 0.1% in total on the surface of the steel containing, in mass, C: 0.05 to 0.7%, Si: 0.05 to 1%, Mn: 0.5 to 3%, P: not more than 0.1%, S: not more than 0.1% and Al: not more than 0.2%, and, in addition, one or more element(s) selected from among Ti: 0.01 to 0.8%, Cr: not

more than 3% and Mo: not more than 1%, so as to satisfy the following equation 1:

$$Ti + 0.5 \times Mn + Cr + 0.5 \times Mo > 0.4 \quad \ldots 1$$

(3) A high-strength alloyed aluminum-system plated steel sheet excellent in heat resistance and after-painting corrosion resistance according to the item (2), characterized in that the steel further contains, in mass, one or more element(s) selected from among N: not more than 0.1%, Nb: not more than 0.1%, V: not more than 0.1%, Ni: not more than 1%, Cu: not more than 1%, B: 0.0003 to 0.03%, Sn: not more than 0.1% and Sb: not more than 0.1%.

(4) A high-strength alloyed aluminum-system plated steel sheet excellent in heat resistance and after-painting corrosion resistance according to the item (1), characterized in that the steel contains, in mass, C: 0.15 to 0.55%, Si: not more than 0.5%, Mn: 0.2 to 3%, P: not more than 0.1%, S: not more than 0.04%, Al: 0.01 to 0.1% and N: not more than 0.01%, and also one or more element(s) selected from among B: 0.0002 to 0.0050%, Ti: 0.01 to 0.8%, Cr: not more than 2%, Mo: not more than 1%, Ni: not more than 1%, Cu: not more than 0.5% and Sn: not more than 0.2%.

(5) A high-strength alloyed aluminum-system plated steel sheet excellent in heat resistance and after-painting corrosion resistance according to any one of the items (1) to (4), characterized in that the Fe-Al-system coating further contains Si of 1 to 20%.

(6) An alloyed aluminum-system plated steel sheet for high-strength automotive members according to any one of the items (1) to (5), characterized in that Al concentration in the Fe-Al-system coating layer is not more than 35% in weight.

(7) A high-strength alloyed aluminum-system plated steel sheet excellent in heat resistance and after-painting corrosion resistance according to any one of the items (1) to (6), characterized in that the Fe-Al-system coating further contains either one or both of Zn: 1 to 50% and Mg: 0.1 to 10%.

(8) An alloyed high-strength aluminum-system plated steel sheet excellent in heat resistance and after-painting corrosion resistance according to any one of the items (1) to (7), characterized in that the thickness of the Fe-Al-system coating layer is 3 to 35 μm.

(9) An alloyed aluminum-system plated steel sheet for high-strength automotive members, characterized by having: a coating layer mainly composed of Fe-Al on the surface of the steel sheet; a ferrite layer having a thickness from not less than 2 μm to not more than one tenth of the steel sheet thickness at the underside of the coating layer; and the base steel mainly composed of martensite at the underside of the ferrite layer.

(10) An alloyed aluminum-system plated steel sheet for high-strength automotive members according to the item (9), characterized in that the alloyed aluminum-system plated layer on the surface of the steel sheet and the ferrite layer at the underside of the intermetallic compound layer contain Si.

(11) An alloyed aluminum-system plated steel sheet for high-strength automotive members according to the item (9) or (10), characterized in that the hardness of the ferrite phase is not higher than 200.

(12) A high-strength automotive part formed by press

forming, at least a portion of which is composed of a steel according to any one of the items (1) to (11).

(13) A high-strength automotive part according to the item (12), characterized by having a coated film 1 to 200 μm in thickness on at least a part of the surface.

(14) A hot forming method for a high-strength automotive member, wherein, when the automotive member is produced by a hot forming using a steel sheet produced by plating a steel containing C of not less than 0.05% in weight as a steel component with a metal mainly composed of Al, the member is formed by press forming after heated on the heating condition of the longer time period side than the following regions, A, B, C and D, and at least a part of the member is cooled at a cooling rate of not lower than 10°C/sec.:

A (800°C, 13 min.), B (900°C, 6 min.), C (1,050°C, 1.5 min.), D (1,200°C, 0.3 min.).

Brief Description of the Drawings

Fig. 1 is a graph showing the influence of the total amount of Mn and Cr in an alloyed aluminum-system plated layer on after-painting corrosion resistance.

Fig. 2 is a graph showing the relation between the addition amount of Ni, Cu and Sn and bare corrosion resistance.

Fig. 3 is a graph showing the relation between the addition amount of Ni, Cu and Sn and after-painting corrosion resistance.

Fig. 4 is a graph showing the relation between the addition amount of Cr and Mo and bare corrosion resistance.

Fig. 5 is a graph showing the relation between the addition amount of Cr and Mo and after-painting corrosion resistance.

Fig. 6 is the Fe-Al-Si-system ternary phase diagram

at the temperature of 950°C.

Fig. 7 is a photograph (back scattered election image) showing an example of structures according to the present invention, taken by an optical microscope.

Fig. 8 is a graph showing the relation between the thickness of an outer layer and the workability of a plated layer.

Fig. 9 is a photograph (back scattered electron image) showing an example of metallic structures according to the present invention, taken by a microscope.

Fig. 10 is a view showing a shape obtained by forming a steel sheet according to the present invention.

Fig. 11 is a graph showing the relation between a heating time and a heating temperature according to the present invention.

Best Mode for Carrying out the Invention

Embodiment 1

Chemical compositions of steel sheets used in the present invention will be explained hereunder.

C: A steel sheet according to the present invention has a high-strength of not lower than 1,000 MPa after forming and is obtained by rapidly cooling it after a high temperature press and thus transforming the structure thereof into a structure mainly composed of martensite. In that sense, a C content of not less than 0.05% is desirable, and, for obtaining a high-strength stably, the content of not less than 0.1% is more desirable. On the other hand, even though C content is increased to not less than 0.7%, the strength is saturated and also weld cracking tends to be generated, and therefore the upper limit is set at 0.7%.

Si: Since too low an Si content causes fatigue property to deteriorate, the addition amount of not less than 0.05% is desirable. However, Si is also an element which forms a stable oxide film on the surface of a steel

sheet during recrystallizing annealing and hinders aluminum plating properties. For that reason, the upper limit of Si is set at 1%.

Mn: Mn is well known as an element which enhances the hardenability of a steel sheet. Also, Mn is an element which is necessary for preventing hot embrittlement caused by S which is an unavoidable impurity. For that reason, the addition amount of not less than 0.5% is preferable. Further, Mn also enhances heat resistance after aluminum plating. However, since Mn addition amount exceeding 3% causes the impact property after quenching to deteriorate, the value is determined to be the upper limit.

Ti: Ti affects the heat resistance of an aluminum plated layer most. In the case where a steel sheet is used in such a temperature range as exceeding 900°C, as is the case of the present invention, Ti addition is preferable from the viewpoint of heat resistance, and an addition amount of not less than 0.01% is desirable for achieving the effect. However, since Ti forms TiC with C and decreases the amount of C which contributes to strength, it is necessary to increase C amount corresponding to the Ti addition amount. Further, the effect of Ti is saturated in the amount of about 0.8%, and therefore this value is determined to be the upper limit.

Cr: Cr, like Mn and Ti, contribute to the improvement of the heat resistance after aluminum plating. However, Mn deteriorates aluminum plating properties by forming a stable oxide film on the surface of a steel sheet, in the same way as Si. Further, Cr is a relatively expensive element, and therefore the upper limit is set at 3% when it is added.

Mo: Mo, like Mn, Ti and Cr, also contributes to the improvement of the heat resistance after aluminum plating and its addition is desirable. However, since Mo is a relatively expensive element and the effect is saturated,

the upper limit is set at 1%.

In the present invention, it is preferable to add the elements which improve the heat resistance after aluminum plating, such as Ti, Mn, Cr and Mo, in a manner of satisfying the following expression:

$$Ti+0.5\times Mn+Cr+0.5\times Mo > 0.4.$$

In particular, Ti and Cr have an effect against the exfoliation of a plated layer during heating. Further, Mn may be added relatively abundantly and greatly contributes to heat resistance.

The present invention prescribes that P, S and Al are further added in a steel. However, since P and Al deteriorate the ductility and fatigue strength of a steel and S deteriorates toughness thereof, an upper limit is determined for each of them. In addition, one or more of Ni, Nb, V, N, Cu, B, Sn and Sb can be contained in a steel as occasion demands. Ni and Cu contribute to the corrosion resistance of a steel and B improves hardenability.

On many occasions, a steel sheet is used after an aluminum plated layer is alloyed and then it is painted. On those occasions, after-painting corrosion resistance is affected by the amounts of Mn and Cr in an alloyed aluminum-system plated layer. When the amount of these elements is not less than 0.1%, good after-painting corrosion resistance is obtained. As the methods of adding Mn and Cr, there are a method of diffusing steel components and a method of adding them in a plating bath, and either of the methods can achieve the effect as long as the addition amount is not less than 0.1%. It is known that one to five phases can coexist in an alloyed aluminum-system plated layer depending on the deposit amount of plating, the steel composition, the heating conditions and the like. Since the influence of phases in the vicinity of a surface is particularly large, when analyzing them, it is preferable to judge by measuring them at about 5 portions on a cross-section in the region

within 5 μm in depth from the surface using a means such as the EPMA quantitative analysis or the like, and by calculating the average thereof. As is stated later, in case of hot dip aluminum plating, it is common to add Si and, at that time, Si is further contained in the alloyed aluminum-system plated layer. The amount is about 1 to 20% and the Si amount in the alloyed aluminum-system plated layer of one to five phases may vary considerably. Though an Fe-Al-system coating of one to five phases can have various compositions, such as an Fe-Al-Si-system alloyed aluminum-system plated layer, Fe_2Al_5, $FeAl_3$, Fe_3Al, FeAl, Al dissolved ferrite, or the like, in any of the compositions, stable after-painting corrosion resistance can be obtained as long as the total amount of Mn and Cr is not less than 0.1%. With regard to which phase should be analyzed when a plurality of phases exist, since the knowledge that Mn and Cr contribute to the improvement of after-painting corrosion resistance was obtained and the corrosion phenomenon is a macroscopic phenomenon, the present inventors think that; general information can be obtained by analyzing them at about 5 portions at random, even when a plurality of phases exist, and calculating the average thereof and, by so doing, the judgement can be made. Further, it is prescribed that a cross-section is etched with nitral of 2 to 3% for observing the cross-section of a structure after heating. This is because the interface between a base metal and Al dissolved ferrite, which is formed particularly when the heating time is longer, cannot be observed without etching.

The deposit amount of aluminum plating affects corrosion resistance, weldability, workability and the like. If the deposit amount is too small, after-painting corrosion resistance is insufficient, and if it is too large, weldability and workability deteriorate. With regard to workability, it is because a brittle alloyed aluminum-system plated layer tends to peel off during the

press after heating.

A method of aluminum plating is not specifically restricted, and the hot dip plating method, the electroplating method, the vacuum deposition method, the clad method or the like can be employed. The method most widely employed industrially at present is the hot dip plating method, and usually Al-10%Si is frequently used in a plating bath and Fe is contained therein as an unavoidable impurity. It was already described before that, in addition to those, the addition of Cr and Mn improves after-painting corrosion resistance. As other additional elements, Mg, Ti, Zn, Sb, Sn, Cu, Ni, Co, In, Bi, misch metal, etc. are nominated, and those elements may be applied as long as the plated layer is mainly composed of Al.

The present invention does not specifically define a pre-treatment and a post-treatment of aluminum plating. As a plating pre-treatment, a pre-plating of Ni, Cu, Cr, or Fe, or the like is nominated, and any of those can be adopted. As a plating post-treatment, a chromate treatment, a resin coating treatment or the like is nominated aiming at primary rust prevention and lubricity, but an organic resin is not preferable because it disappears when heated. With regard to a chromate treatment, considering the recent regulation against hexavalent chrome, a treatment film containing trivalent chrome, such as electrolytic chromate or the like, is preferable. Another post-treatment other than an inorganic-system chromate treatment can be applied. It is also possible to apply a treatment of alumina, silica, MoS_2 or the like, beforehand, aiming at lubricity.

Embodiment 2

The reason why the steel components are regulated in Embodiment 2 according to the present invention will be described hereunder.

N is an element unavoidably included and is not

specifically prescribed when B is not added, but, when B is added and the amount is excessively large, the addition amount of Ti must be increased. As a result, there is a problem that the amount of resultantly generated TiN increases and hot cracking occurs, and that costs increase also. Therefore, the upper limit is set at 0.1%.

B is added for enhancing hardenability at cooling during or after press forming, and, for achieving the effect, the addition of not less than 0.0002% is necessary. However, when the addition amount is excessive, there is a problem of hot cracking and the effect is saturated. Therefore, the upper limit is set at 0.03%.

Ni, Cu and Sn have the effect of changing the state of surface cracking during press forming after high temperature heating by changing the state of alloying an aluminum plated layer during the high temperature heating, and are important since they lead to an improvement of after-painting corrosion resistance of a formed product. With regard to those elements, from the results shown in Figs. 2 and 3 which were obtained by measuring the addition amounts of Ni, Cu and Sn, and bare corrosion resistance and after-painting corrosion resistance of the samples after high temperature forming in a laboratory test, the present inventors found that, for obtaining above-mentioned effects, Ni, Cu and Sn had to be added so that they might satisfy the equation 3. Here, the bare corrosion resistance and the after-painting corrosion resistance were evaluated by the method examined under the conditions shown in Example, using samples taken from the portions to which working was applied after high temperature forming.

$$(Ni+0.5\times Cu+3\times Sn) \geqq 0.012 \quad \ldots \quad 3$$

With regard to each of Ni, Cu and Sn, an excessive addition of Ni makes the effects saturated and causes a

cost increase, Cu and Sn have the problem of generating surface cracking and, therefore, the upper limit of each element is set at 1.0%, 1% and 0.2%, respectively.

The production conditions of a steel sheet according to the present invention is not specifically prescribed, but preferable production conditions will be explained hereunder.

A steel having components as described above was cast, and the obtained hot slab, directly or after heated, or the slab once cooled and reheated, was hot-rolled. Here, the difference in the properties of the steel between the direct rolling of the hot slab and the rolling after reheating is scarcely recognized. Further, the reheating temperature is not specified, but it is preferable to regulate it in the range from 1,000 to 1,300°C, taking productivity into consideration.

With regard to hot-rolling, either a regular hot-rolling process or a continuous hot-rolling process wherein slabs are connected with each other and rolled at the finish rolling can be adopted. It is preferable to control the finishing temperature at the hot-rolling to not lower than Ar3 transformation temperature taking the productivity and the accuracy of the sheet thickness into consideration.

The cooling after hot-rolling is carried out by a usual method. In that case, it is preferable to control the coiling temperature to not lower than 550°C from the viewpoint of productivity. On the other hand, if the coiling temperature is too high, pickling capability deteriorates, and therefore it is preferable to control the coiling temperature to not higher than 750°C.

For a pickling process or a cold-rolling process, a usual method may be employed, and, for a subsequent aluminum plating process or a subsequent aluminum-zinc plating process, a usual method may be employed too. That is, in case of an aluminum plating process, Si concentration of 5 to 12% in a plating bath is

appropriate, and, in case of an aluminum-zinc plating process, Zn concentration of 40 to 50% in a plating bath is appropriate.

Here, with regard to the atmosphere in a plating process, plating can be carried out using either a continuous plating equipment having a non-oxidizing furnace or a continuous plating equipment not having a non-oxidizing furnace as long as usual conditions are preserved. Therefore, no specific control is required in the production of a product according to the present invention and thus the productivity is not hindered.

In the above production conditions, metal pre-plating is not applied to the surface of a steel sheet before plating, but no specific problem arises even when Ni pre-plating, Fe pre-plating, or another metal pre-plating which improves plating properties is employed.

Further, even when Mg and Zn are included in an aluminum plated layer or Mg is included in an aluminum-zinc plated layer, no specific problem occurs and a steel sheet having similar properties can be produced.

Embodiment 3

Firstly, the reason why the steel components are regulated in Embodiment 3 according to the present invention will be described hereunder.

C is an element which is added for making a structure after cooling composed of martensite and securing material quality, and the addition amount of not less than 0.15% is required for securing a strength of not lower than 1,200 MPa. On the other hand, if the addition amount is excessive, the strength against impact deformation is hardly secured and, therefore, the upper limit is set at 0.55%.

Si is a solute strengthening element and can increase the strength of a steel sheet at a relatively low cost. However, if it is added excessively, plating properties are deteriorated, and therefore the upper

limit is set at 0.5%.

Mn is added for making it possible to secure the strength after cooling in a wide range of cooling rates.

When the C amount is large but the addition amount of Mn is small, a martensite structure cannot be obtained in a usual range of cooling rate, which range can be obtained during press forming, and therefore the strength is hardly secured. The range of cooling rates cited here is not higher than 500°C/sec. in the case of the sheet thickness of 1.4 mm. To demonstrate such function, the addition amount of not less than 0.2% is required. On the other hand, if the Mn amount is too large, not only the cost increases but also the effect is saturated. Therefore, the upper limit is set at 3%.

S is an element which is included unavoidably and causes the deterioration of workability. Therefore, it is necessary to decrease the amount as much as possible. By decreasing the amount to not more than 0.04%, the problem of the workability is eliminated and therefore the range is determined to be not more than 0.04%.

P is a solute strengthening element and can increase the strength of a steel sheet at a relatively low cost. However, if the addition amount increases too much, cracks are generated during hot-rolling or cold-rolling caused by the embrittlement, and therefore the upper limit is set at 0.1%.

Al is used as a deoxidizing agent and, for demonstrating the effect, an Al content of not less than 0.005% in a steel is required. On the other hand, the addition amount exceeding 0.1% causes the increase of oxide-system inclusions and a problem of the deterioration of surface quality, and therefore the upper limit is set at 0.10%.

Cr and Mo have the effect of changing the state of surface cracking during press forming after a high temperature heating by changing the state of alloying an aluminum plated layer during the high temperature

heating, and are important since they lead to the improvement of after-painting corrosion resistance of a formed product. With regard to those elements, from the results shown in Figs. 2 and 3, which were obtained by measuring the addition amounts of Cr and Mo, and bare corrosion resistance and after-painting corrosion resistance of the samples after high temperature forming in a laboratory test, the present inventors found that Cr and Mo had to be added. Here, the bare corrosion resistance and the after-painting corrosion resistance were evaluated by the method examined under the conditions shown in Example, using samples taken from the portions to which working was applied after high temperature forming.

With regard to each of Cr and Mo, an excessive addition of Cr causes problems in plating properties and cost increase and Mo makes the effects saturated and causes cost increase. Therefore, the upper limit of each element is set at 2.0% and 1.0%, respectively.

Other components are not specifically prescribed. Ni is included unavoidably, and, if the amount is within the usual range, no problem arises.

The production conditions of a steel sheet according to the present invention are not specifically prescribed, but preferable production conditions will be explained hereunder.

A steel having components as described above was cast, and the obtained hot slab, directly or after being heated, or the slab once cooled and reheated, was hot-rolled. Here, the difference in the properties of the steel between the direct rolling of the hot slab and the rolling after reheating is scarcely recognized. Further, the reheating temperature is not specified, but it is preferable to regulate it in the range from 1,000 to 1,300°C taking the productivity into consideration.

With regard to hot-rolling, either a regular hot-rolling process or a continuous hot-rolling process

wherein slabs are connected with each other and rolled at the finish rolling can be adopted. It is preferable to control the finishing temperature at the hot-rolling to not lower than Ar3 transformation temperature taking the productivity and the accuracy of the sheet thickness into consideration.

The cooling after hot-rolling is carried out by a usual method. In that case, it is preferable to control the coiling temperature to not lower than 550°C from the viewpoint of productivity. On the other hand, if the coiling temperature is too high, pickling capability deteriorates, and therefore it is preferable to control the coiling temperature to not higher than 750°C.

For a pickling process or a cold-rolling process, a usual method may be employed, and, for a subsequent aluminum plating process or a subsequent aluminum-zinc plating process, a usual method may be employed too. That is, in case of an aluminum plating process, Si concentration of 5 to 12% in a plating bath is appropriate and, in case of an aluminum-zinc plating process, Zn concentration of 40 to 50% in a plating bath is appropriate.

Here, with regard to the atmosphere in a plating process, plating can be carried out using either a continuous plating equipment having a non-oxidizing furnace or a continuous plating equipment not having a non-oxidizing furnace as long as usual conditions are preserved. Therefore, no specific control is required in the production of a product according to the present invention and thus the productivity is not hindered.

In the above production conditions, metal pre-plating is not applied to the surface of a steel sheet before plating, but no specific problem arises even when Ni pre-plating, Fe pre-plating, or another metal pre-plating which improves plating properties is employed. Further, even when Mg and Zn are included in an aluminum plated layer or Mg is included in an aluminum-zinc plated

layer, no specific problem occurs and a steel sheet having similar properties can be produced.

Embodiment 4

By heating an aluminum plated layer and thus converting it into an alloy layer, namely an Fe-Al-system coating layer, and also by controlling the Al amount to not more than 35% and thus converting the Fe-Al-system coating layer into $Fe+Fe_3Al$ wherein Al and Si are dissolved, obtained are far more excellent workability and corrosion resistance at a portion which is subjected to working than those of a plated layer which contains other phases than $Fe+Fe_3Al$.

C: A steel sheet according to the present invention has a high-strength of not lower than 1,000 MPa after forming and is obtained by rapidly cooling it after a hot press and thus transforming the structure thereof into a structure mainly composed of martensite. To do so, a C content of not less than 0.05% is necessary. On the other hand, even though the C content is increased to not less than 0.7%, the strength is saturated and also weld cracking tends to be generated, and therefore the upper limit is set at 0.7%.

Steel components except C are not specifically prescribed, but elements such as Si, Mn, P, Al, N, Cr, Mo, Ti, Nb, B, Ni, Cu, V, Sn, Sb, etc., are nominated as addition elements or unavoidable impurity elements. Those elements may be added as occasion demands. Examples are: Mn and B are effective in hardenability; Cr, Ti and Mo are effective in the heat resistance of an aluminum plated layer; and Ni and Cu improve corrosion resistance. The desirable ranges of their addition are Mn: 0.5 to 3%, Si: not more than 1%, P: not more than 0.1%, S: not more than 0.1%, Al: not more than 0.1%, N: not more than 0.01%, Cr: not more than 2%, Mo: not more than 0.5%, Ti: not more than 0.5%, Nb: not more than 0.1%, B: not more than 0.05%, Ni: not more than 1%, Cu:

not more than 1%, V: not more than 0.1%, Sn: not more than 0.1% and Sb: not more than 0.1%.

As stated above, the smaller the deposit amount of aluminum plating is, the more easily an $Fe+Fe_3Al$ region is formed. In that sense, it is desirable that the deposit amount is not more than 120 g/m^2 per both sides.

A method of aluminum plating is not specifically restricted, and the hot dip plating method, the electroplating method, the vacuum deposition method, the clad method or the like can be employed. The method most widely employed industrially at present is the hot dip plating method, and usually Al-10%Si is frequently used in a plating bath and Fe is contained therein as an unavoidable impurity. In this case, Si enters into an alloy layer after heating and the Si amount may vary depending on the phase structure. However, the Si amount in the $Fe+Fe_3Al$ region is not more than 15% and therefore the value is determined to be the upper limit of Si. As other additional elements, Mn, Cr, Mg, Ti, Zn, Sb, Sn, Cu, Ni, Co, In, Bi, misch metal, etc. are nominated, and those elements may be applied as long as the plated layer is mainly composed of Al. The addition of Zn and Mg is effective in making red rust hardly generated. However, the excessive addition of those elements, whose vapor pressures are high, causes the generation of fumes containing Zn and Mg, the generation of powdery substances on the surface caused by Zn and Mg, and the like. Therefore, a Zn addition of not less than 60% and a Mg addition of not less than 10% are not desirable.

The present invention does not specifically define a pre-treatment and a post-treatment of aluminum plating. As a plating pre-treatment, a pre-plating of Ni, Cu, Cr, or Fe, or the like is nominated, and any of these can be adopted. As a plating post-treatment, a chromate treatment, a resin coating treatment or the like is nominated aiming at primary rust prevention and lubricity, but an organic resin is not preferable because

it disappears when heated. With regard to a chromate treatment, considering the recent regulation against hexavalent chrome, a treatment film containing trivalent chrome, such as electrolytic chromate or the like, is preferable. Another post-treatment other than an inorganic-system chromate treatment can be applied. It is also possible to apply a treatment of alumina, silica, MoS_2 or the like beforehand aiming at lubricity.

Embodiment 5

In Embodiment 5, the restriction of the composition of an aluminum-system plated layer will be explained. The aluminum-system plated layer cited here means a plated layer which is not heated yet and thus not alloyed yet.

Si: Si is effective in decreasing the thickness of an alloy layer (a layer composed of an intermetallic compound formed at an interface between a plated layer and a steel sheet) of aluminum-system plating. Further, Si forms Mg_2Si by adding Mg complexly and is effective in improving corrosion resistance. To enjoy the effects, the addition of not less than 1% is effective. An excessive addition of Si causes the rise of a melting point and, when Si single phase crystallizes at the plated layer, it causes the deterioration of corrosion resistance. Therefore, the upper limit is set at 15%.

Mg: It is known that Mg is effective in improving corrosion resistance particularly under a salt damage environment. By forming Mg_2Si particularly, a emission efficiency into an environment is increased and corrosion resistance is improved. For securing corrosion resistance, a Mg amount of not less than 0.5% is added. Since an excessive addition causes fierce oxidation at the surface of a plating bath and a rise in the melting point of the plating bath, the addition amount is determined to be not more than 10%. For suppressing the oxidation of the surface of a plating bath, the addition

of a small amount of Ca (not more than 0.5%) is effective, and about this amount of Ca may be added.

Zn: Zn has an electric potential more basic than that of Al or steel and a function of suppressing the corrosion of a base steel. The effects begin to appear when Zn addition amount is not less than 1% and the best properties are obtained when Zn amount is 20 to 60%. However, with the addition amount exceeding 60%, corrosion resistance is rather deteriorated. Therefore, the lower limit and the upper limit of Zn amount are set at 1% and 60%, respectively.

When a part is practically produced using an aluminum-system plated steel sheet according to the present invention, quenching is carried out by rapidly cooling the part with the dies after press, and thus the structure is mainly composed of martensite. For securing a sufficient strength as a member, the percentage of martensite is determined to be not less than 60% in volume. Here, the percentage of martensite is calculated by polishing and etching a specimen and, after that, observing it with an optical microscope and using image analysis.

Embodiment 6

The reason why the components of a steel sheet and the like are regulated in Embodiment 6 will be described hereunder.

A steel sheet according to the present invention has a soft ferrite layer having a thickness from not less than 2 μm to not more than one tenth of a steel sheet thickness at the interface between an intermetallic compound layer formed by alloying an aluminum plated layer and a base steel mainly composed of martensite. Usually, Al of about 1 to 10% exists in the ferrite layer. The ferrite phase can also contain Si, in addition to Al. The thickness is limited to not less

than 1 μm. The reason is that, if the thickness of the soft ferrite layer is not more than the above thickness, the exfoliation resistance of the plated layer is not sufficiently obtained. On the other hand, this layer is soft and, if it is too thick, the strength of the whole steel sheet is deteriorated. For that reason, the upper limit is determined to be not more than one tenth of the steel sheet thickness. Usually, an aluminum plated steel sheet is often produced by the hot dip plating method, and, in this case, an alloyed aluminum-system plated layer (called "alloy layer") at the interface between the steel sheet and the plated layer tends to grow. If the layer grows excessively, the workability of the steel sheet is deteriorated and, therefore, the aluminum plated steel sheet is produced in a plating bath wherein Si of about 10% is added. In the present invention, as an aluminum plated steel sheet is worked in the hot after the whole plated layer is alloyed by heating, Si is not necessarily required to be added in the plating bath, but there is no specific problem even when Si is added.

In the present invention, it is desirable that the hardness of a ferrite layer is not higher than 200 in terms of Vickers hardness. As stated above, the layer plays a role of preventing a hard alloy layer from peeling off during working. For that reason, it is preferable that the layer is soft. However, as the layer contains solute strengthening elements such as Al, Si, etc., it is harder than a usual ferrite layer.

Next, other components related to the present invention will be described hereunder. Firstly, with regard to steel components, as the present invention aims at a high-strength region which cannot be obtained with a regular TRIP steel or the like and the enhancement of strength by quenching, it is desirable that C amount is not less than 0.05%, preferably not less than 0.1%. With regard to other elements in a steel, the elements of Si, Mn, Ti, B, Cr, Mo, Al, P, S, N, etc. are used usually.

Si is effective in fatigue property, and Mn and B contribute to the improvement of hardenability. Ti, Si, Cr, Mo and Al are elements which improve heat resistance after aluminum plating.

With regard to the construction of an aluminum plated layer, an aluminum plated layer is mainly composed of Al and may contain Si as stated above. As other addition elements, Cr, Mg, Ti, Sb, Sn, Zn, etc. are nominated, and those are applicable as long as the plated layer is mainly composed of Al. However, Zn has a low boiling point and, when added excessively, Zn generates zinc powder on the surface during heating and that causes galling during pressing. Therefore, the addition amount of not less than 60% is not desirable.

$FeAl_3$, Fe_2Al_5, Fe_3Al, Fe_2Al_8Si, etc. are generated as an element of the alloyed aluminum-system plated layer. Those phases tend to form a multi-layered structure in a laminar manner, but the structures of the phases are not specifically regulated. When the composition is mainly composed of Al and Fe, and Si is added in an aluminum plating bath, Si of about 5 to 10% is contained. Those elements account for not less than 90% of the composition in total. Further, a small amount of not-alloyed Al may remain, but it does not affect the properties of an aluminum plated steel sheet as long as the amount is small.

The thickness of a ferrite layer is measured with an optical microscope. The thickness of a ferrite layer is clearly observed by polishing a cross-section and, after that, etching it with nital at about 2%. However, there is a case where the boundary with an intermetallic compound layer is hardly observed, and, in that case, EPMA analysis is additionally adopted. By so doing, a ferrite layer can easily be identified from the difference between the radiation strength of Fe and that of Al. It is determined that the measurement of the thickness of a ferrite layer is carried out by measuring

the thickness at about 5 portions at random and calculating the average value. Further, a base steel consists of a structure mainly composed of martensite, and the structure can be observed, for example, by etching it with picral and using an optical microscope.

Fig. 7 shows an example of structures according to the present invention. Two layers are recognized at the interface, and, as a result of quantitative analysis with an EPMA, the lower layer is a ferrite layer about 5 μm in thickness. Here, in Fig. 7, the reference numeral 1 shows the layer composed of Al: 26.85%, Si: 9.83%, Fe: 59.92%; the reference numeral 2 the layer composed of Al: 49.54%, Si: 3.11%, Fe: 44.89%; the reference numeral 3 the layer composed of Al: 30.75%, Si: 8.88%, Fe: 56.91%; and the reference numeral 4 the layer composed of Al: 9.59%, Si: 2.92%, Fe: 84.02%.

Finally, with regard to the heating and cooling conditions of a plated steel sheet, a method of heating and cooling is not specifically defined. For obtaining a hardened structure, a cooling rate affects it largely as a matter of course, and a cooling rate of not lower than about 30°C/sec. is desirable. This depends on steel components, and, in case of a steel having good hardenability, a desired structure mainly composed of martensite can be obtained even at a cooling rate of about 10°C/sec., or, in another case, a cooling rate of not lower than 100°C/sec. is required depending on a steel grade. For obtaining a desired thickness of a ferrite layer, the optimization of heating conditions is required.

Embodiment 7

The reason why the components of a steel sheet and the like are regulated in Embodiment 7 will be described hereunder.

The present invention is a high-strength steel sheet having a high-strength of not lower than about 1,000 MPa

after forming, and is the steel sheet obtained by rapidly cooling it after it is subjected to hot press or partial rapid heating, thus quenching it and, by so doing, transforming it into a structure mainly composed of martensite. Therefore, the hardness of a base steel is determined to be not lower than 250. The hardness is measured in terms of Vickers hardness. For obtaining the hardness, a C amount of 0.05% is desirable. With regard to other elements in a steel, no specific restriction is determined, but the elements of Si, Mn, Ti, B, Cr, Mo, Al, P, S, N, etc. are used usually. Si is effective in fatigue property, and Mn and B contribute to the improvement of hardenability. Ti, Si, Cr, Mo and Al are elements which improve heat resistance after aluminum plating.

Further, in the present invention, a steel sheet has an alloyed aluminum-system plated layer mainly composed of Al and Fe on the surface of the base steel and the thickness of the alloyed aluminum-system plated layer is limited to 3 to 35 μm, preferably 3 to 18 μm. The restriction is determined considering the balance among weldability, after-painting corrosion resistance and heat resistance, as described above. That is, when the thickness of a layer is less than 3 μm, sufficient after-painting corrosion resistance and heat resistance cannot be obtained. In case of not adding Si to an aluminum plated layer in particular, the deterioration of heat resistance is remarkable. The upper limit of the thickness is determined by spot weldability. A spot weldability (electrode life) identical with a galvanized steel sheet can be obtained when the plating thickness is not more than 35 μm, and a spot weldability identical with a hot dip alloyed zinc-coated steel sheet can be obtained when the plating thickness is not more than 18 μm. $FeAl_3$, Fe_2Al_5, Fe_3Al, Fe_2Al_8Si, etc. can be formed as alloyed layers. Further, the formation of a ferrite

layer containing Al is recognized very often at the interface between the alloyed layer and the base steel.

Usually, in an aluminum plated steel sheet, an Fe-Al-system ally layer tends to grow and deteriorate workability. Therefore, it often happens that Si is added for suppressing the growth of the alloy layer and improving workability. In case of hot press, since a steel sheet is worked in the hot after the aluminum plated layer is heated and alloyed up to the surface, Si is not particularly required to be added. However, Si may be added as a matter of course. In case of rapidly heating a part of a steel sheet, since working is applied at the room temperature, Si addition is indispensable. Cr, Mg, Ti, Sb, Sn, Zn, etc. are nominated as other addition elements in an aluminum plated layer, and those elements are applicable as long as the plated layer is mainly composed of Al. However, Zn has a low boiling point and, when added excessively, Zn generates zinc powder on the surface during heating and that causes galling during press. Therefore, the addition amount of not less than 60% is not desirable.

The present invention does not specifically define a pre-treatment and a post-treatment of plating, a heating method of a steel sheet during pressing and a cooling method thereof. As a plating post-treatment, a chromate treatment, a resin coating treatment or the like is nominated aiming at primary rust prevention and lubricity. However, with regard to a chromate treatment, considering the recent regulation against hexavalent chrome, a treatment film containing trivalent chrome, such as electrolytic chromate or the like, is preferable. A resin coating treatment is effective in improving formability in general and it is particularly effective when a part of a steel sheet is rapidly heated after forming. When a steel sheet is heated and then formed, a resin film is decomposed and therefore has no effect.

A method of producing an aluminum plated steel sheet

is not prescribed either. Regular steelmaking conditions and hot-rolling conditions may be applied. An aluminum plating is carried out by the hot dip plating method usually, but a method is not limited to it and an electroplating in nonaqueous solvent, a vapor deposition treatment or the like can be used. As a pre-treatment before plating, Ni pre-plating or the like is nominated, and it can be adopted.

A method of heating or cooling a steel sheet is not particularly prescribed either. A heating means such as electric heating, heating in a furnace, high-frequency heating or the like may be adopted. Among those means, high-frequency heating is appropriate for rapidly heating a part of a steel sheet.

Embodiment 8

The reason why the components of a steel sheet and the like are regulated in Embodiment 8 will be described hereunder.

As stated above, the present invention is a technology which secures a desired strength by forming an aluminum plated steel sheet while hot after heating it, cooling it immediately after that, and thus quenching it, and the components of the steel sheet are required to grant excellent hardenability to the steel sheet. To meet the requirement, a C amount of not less than 0.05%, preferably not less than 0.1%, is required. With regard to other elements in a steel, the elements of Si, Mn, Ti, B, Cr, Mo, Al, P, S, N, etc. are used as usual. Si is effective in fatigue property, and Mn and B contribute to the improvement of hardenability. Ti, Si, Cr, Mo and Al are elements which improve heat resistance after aluminum plating.

An element of an alloyed aluminum-system plated layer, such as $FeAl_3$, Fe_2Al_5, Fe_3Al, Fe_2Al_8Si, etc. can be generated on a surface after heating. Those phases tend to form a multi-layered structure in a laminar manner,

but the structures of the phases are not specifically regulated. When the composition is mainly composed of Al and Fe and, Si is added in an aluminum plating bath, Si of about 5 to 10% is contained. Those elements account for not less than 90% of the composition in total. Further, it is determined that an aluminum plated steel sheet is subjected to press working after the plated layer is transformed into an alloyed aluminum-system plated layer up to the surface by heating. This is because, when Al remains abundantly on the surface, weldability and after-painting corrosion resistance are deteriorated.

With regard to the heating and cooling conditions in the present invention, a method of heating and that of cooling are not particularly restricted. Any one of heating in an atmospheric furnace, induction heating, electric heating or the like may be used. A heating rate at this time is not restricted either. The heating rate largely depends on the thickness and shape of a steel sheet as a matter of course. New knowledge was obtained that, the longer the retention time in a furnace was, the better the plating adhesiveness during subsequent forming was. The heating temperature is in the range roughly from 800 to 1,200°C, preferably 900 to 1,000°C, and it is important to retain a steel sheet within this temperature range for about several minutes. However, the retention time depends on temperature, and it is determined that the retention time must be longer than the four points of A (800°C, 13 min.), B (900°C, 6 min.), C (1,050°C, 1.5 min.) and D (1,200°C, 0.3 min.).

However, a longer retention time causes the deterioration of the productivity in press forming. A practically sufficient plating adhesiveness can be obtained by a heating at 950°C for 5 to 8 min., which condition is determined as a point of compromise. A hardened structure is largely affected by a cooling rate as a matter of course, and, to obtain the hardened

structure, a cooling rate of not lower than 10°C/sec. is required. This depends on steel components, and, in case of a steel sheet having good hardenability, a desired structure mainly composed of martensite can be obtained even at a cooling rate of about 10°C/sec., or, in another case, a cooling rate of about 30°C/sec. is required depending on the steel grade.

Next, the present invention will hereunder be explained in detail based on Examples.

Example 1

Hot dip aluminum plating was applied to pickled steel sheets (1.8 mm in thickness) and cold-rolled steel sheets (1.2 mm in thickness) as the materials, having steel compositions shown in Table 1 and being produced through regular hot-rolling and cold-rolling processes. Nos. 1, 3, 5, 7 and 9 in Table 1 are cold-rolled steel sheets, and the rests are hot-rolled steel sheets. In the hot dip aluminum plating, a line of non-oxidizing furnace-reducing furnace type was used, a deposit amount of plating was adjusted to 40 g/m^2 per one side by the gas wiping method after plating, and, after that, the steel sheets were cooled and subjected to a zero-spangle treatment. The plating bath composition at the time was Al-10%Si-2%Fe. Fe in the bath is a component unavoidably supplied by the plating apparatus and the steel sheets in the bath. The plating appearance was good without having non-plating defects or the like. The hardenability and heat resistance of the hot dip aluminum plated steel sheets thus produced were evaluated. The evaluation methods are shown below.

As substantial alloying process, an aluminum plated steel sheet was heated at 950°C for 30 minutes and thereafter cooled while inserted between dies made of steel under a nitrogen atmosphere. The cooling rate was 100°C/sec. The exfoliation of a plated later of a steel sheet was evaluated visually. Further, Vickers hardness

at the cross-section of a steel sheet was measured imposing a load of 100 g. Thereafter, a steel sheet was subjected to a chemical treatment which was commonly used for aluminum plating, a steel sheet and zinc plating, coated with a cationic electrodeposition paint (Nippon Paint Co., Ltd.; powernix 110) in the thickness of 20 μm, baked, and subjected to a salt spray test (JIS-Z2371) for 20 days after being cut in a cross shape, and the corrosion depth from the portion cut in a cross shape was measured. Here, the depth of the cut in a cross shape was about 50 μm. Therefore, a value obtained by subtracting 50 μm from a recorded value is a true corrosion depth. Further, for obtaining the concentrations of Mn and Cr in an Fe-Al intermetallic compound, the amounts of Mn and Cr were measured by quantitatively analyzing a specimen after quenched at 5 portions in a cross-section after polished in the region from the surface to the depth of 5 μm, using an EPMA. The evaluation results are shown in Table 2.

Evaluation criteria of heat resistance

○: No exfoliation

△: Partial exfoliation from edges

×: Exfoliation generated

Evaluation criteria of after-painting corrosion resistance

○: Corrosion depth not more than 80 μm

×: Corrosion depth more than 80 μm

(Each value includes the depth of a cut in a cross shape.)

[Tables 1 and 2]

Table 1

No.	Chemical composition (mass%)											
	C	Si	Mn	P	S	Al	N	Ti	Cr	Mo	B	Ti*
1	0.23	0.12	1.21	0.02	0.009	0.03	0.004	0.02	0.13	-	0.002	0.76
2	0.21	0.20	0.81	0.02	0.007	0.05	0.004	0.22	0.20	-	-	0.83
3	0.17	0.15	1.24	0.01	0.008	0.03	0.003	0.01	1.10	-	0.0008	1.73
4	0.42	0.7	2.41	0.01	0.009	0.01	0.003	0.66	0.21	-	0.001	2.08
5	0.23	0.31	1.54	0.02	0.007	0.05	0.003	0.02	0.44	-	0.002	1.23
6	0.25	0.18	1.22	0.01	0.01	0.04	0.003	0.02	0.66	0.20	0.005	1.29
7	0.24	0.2	0.41	0.01	0.02	0.05	0.004	0.09	0.10	0.15	0.01	0.47
8	0.2	0.2	2.43	0.01	0.01	0.04	0.003	0.09	0.21	-	0.0008	1.52
9	0.03	0.1	1.4	0.02	0.01	0.03	0.004	0.25	0.15	-	0.0003	1.1
10	0.23	0.12	0.3	0.01	0.008	0.05	0.003	0.03	0.23	-	-	0.41
11	0.24	0.10	0.51	0.01	0.008	0.03	0.004	0.05	0.03	-	0.0022	0.34

Note 1) Ti*: Ti + 0.5Mn + Cr + 0.5Mo

Table 2

No.	Mn + Cr amount	Heat resistance	Vickers hardness	After-painting corrosion resistance
1	0.4	○	515	○
2	0.22	○	480	○
3	0.96	○	405	○
4	0.85	○	766	○
5	0.30	○	511	○
6	0.30	○	548	○
7	0.15	○	539	○
8	0.78	○	466	○
9	0.44	○	200	○
10	0.19	○	311	○
11	0.21	△	522	○

When the C amount is excessively low as in the No. 9 steel sheet, the strength lowers. In general, a value close to material strength (MPa) is obtained by multiply a Vickers hardness by 3, and, in this case, a strength of only 600 MPa class at the most is obtained. When the addition amounts of the elements effective in quenching, such as Mn, B, etc., are small like No. 10 steel sheet, quenching effect is not obtained even though the C amount is large and the strength tends to decrease to some

extent. Further, in the case where the value of Ti*: Ti + 0.5xMn + Cr + 0.5xMo is low like No. 11 steel sheet, the plated layer peels off after heating and the heat resistance tends to deteriorate to some extent. In case of Nos. 1 to 8 steel sheets wherein the addition amounts of the elements in the steels are properly controlled, all of strength, heat resistance and after-painting corrosion resistance show good results.

Next, No. 7 steel sheet of this Example in Table 1 was plated in a plating bath which mainly contained Al-10%Si-2%Fe and in which Mn and Cr were added. The deposit amount of the plating was 60 g/m^2 per one side, and good plating appearance was obtained. The steel sheet was quenched with dies after heated at 900°C for 2 minutes. The cooling rate was about 100°C/sec. The amounts of Mn and Cr in the bath at this time and the evaluation results are shown in Table 3. When the amounts of Mn and Cr in the intermetallic compound are small like No 1 steel sheet, after-painting corrosion resistance is inferior, but the corrosion resistance improves with the increase of the addition amounts of Mn and Cr in the plating bath. The relation between the amounts of Mn and Cr in the intermetallic compound and the after-painting corrosion resistance at this time are shown in Fig. 3. It is understood that the after-painting corrosion resistance improves with the increase of the amounts of Mn and Cr.

[Table 3]

Table 3

No.	Amount of element in bath (%)		Amount of element in intermetallic compound (%)		After-painting corrosion resistance
	Mn	Cr	Mn	Cr	
1	0	0	0.08	0	×
2	0.1	0	0.11	0	○
3	0.2	0	0.24	0	○
4	0.4	0.05	0.51	0.08	○
5	0.6	0	0.73	0	○
6	0.8	0.1	0.75	0.14	○

Example 2

The steels having various chemical compositions as shown in Table 4 were cast, heated again to a temperature of 1,050 to 1,250°C, thereafter hot-rolled, pickled, cold-rolled, annealed, subjected to a plating treatment (aluminum plating or aluminum-zinc plating: "Galvalium®" plating), and thereafter subjected to temper rolling at the reduction rate of 0.8%. Further, as alloying process, these steel sheets were heated to a temperature of 900 to 1,000°C, retained for 5 minutes at the temperature, thereafter subjected to press forming with dies of the room temperature, and then subjected to the investigation on the properties. The investigation on material properties was carried out by cutting out the specimens from the portions which were rapidly cooled at the press and applying a tensile test thereto. The test was carried out by cutting the specimens into No. 5 test pieces according to JIS-Z2201 and following the test method described in JIS-Z2241. The evaluation results are shown in Table 5.

[Tables 4 and 5]

Table 4

Steel No.	C	Si	Mn	S	P	Al	Ti	N	Ni	Cu	B	Sn	Ti-3.42*N
1	0.22	0.20	1.05	0.020	0.020	0.025	0.020	0.0024	0.02	0.02	0.0030	-	0.012
2	0.21	0.15	0.94	0.018	0.023	0.024	0.022	0.0035	0.25	0.10	0.0027	-	0.010
3	0.22	0.15	0.94	0.018	0.023	0.024	0.022	0.0025	0.01	0.01	0.0027	0.01	0.013
4	0.16	0.48	1.70	0.009	0.015	0.021	0.017	0.0025	0.80	0.02	0.0002	-	0.008
5	0.35	0.05	1.00	0.015	0.012	0.030	0.020	0.0028	0.01	0.01	0.0020	-	0.010
6	0.53	0.10	1.10	0.010	0.020	0.026	0.200	0.0021	0.02	0.01	0.0010	0.05	0.193
7	0.53	0.10	0.30	0.010	0.020	0.030	0.020	0.0020	0.90	0.02	0.0047	-	0.013
8	0.22	0.20	1.00	0.002	0.015	0.035	0.005	0.0034	0.02	0.02	0.0005	-	-0.007
9	0.21	0.20	1.10	0.022	0.021	0.028	0.020	0.0026	0.00	0.02	0.0020	-	0.011
10	0.22	0.20	2.00	0.010	0.010	0.030	0.020	0.0033	0.01	0.01	-	-	0.009
11	0.35	0.15	2.10	0.012	0.013	0.023	0.018	0.0028	0.05	0.01	-	0.01	0.008
12	0.24	0.20	2.50	0.008	0.009	0.035	0.026	0.0035	0.02	0.01	-	-	0.014

Table 5

Steel No.	Coiling temperature (°C)	Annealing temperature (°C)	Kind of plating	TS before forming (Mpa)	Heating temperature before forming (°C)	YP (MPa)	TS (MPa)	Bare corrosion resistance	After-painting corrosion resistance
1	630	780	Aluminum plating	560	950	1250	1580	○	○
	610	775	Galvalium plating	550	950	1255	1600	○	○
2	680	760	Aluminum plating	550	950	1220	1610	○	○
	650	780	Galvalium plating	558	950	1210	1590	○	○
3	620	730	Aluminum plating	570	950	1280	1550	○	○
	630	730	Galvalium plating	564	950	1270	1540	○	○
4	650	830	Aluminum plating	500	980	1110	1310	○	○
	660	840	Galvalium plating	508	980	1100	1320	○	○
5	630	770	Aluminum plating	603	950	1480	1830	○	○
	640	770	Galvalium plating	605	950	1490	1820	○	○
6	650	775	Aluminum plating	654	940	1610	1990	○	○
	660	780	Galvalium plating	660	940	1620	1980	○	○
7	650	760	Aluminum plating	780	910	1850	2100	○	○
	650	760	Galvalium plating	774	910	1820	2120	○	○
8	650	790	Aluminum plating	553	950	750	980	○	○
9	630	800	Aluminum plating	558	950	1210	1540	×	○
10	640	780	Aluminum plating	554	950	1240	1580	○	○
	630	775	Galvalium plating	550	950	1230	1575	○	○
11	650	760	Aluminum plating	572	950	1200	1510	○	○
	650	760	Galvalium plating	563	950	1205	1520	○	○
12	620	730	Aluminum plating	595	950	1270	1560	○	○
	630	730	Galvalium plating	598	950	1275	1570	○	○

Specimens were cut out from the portions which underwent working during press forming and bare corrosion resistance and after-painting corrosion resistance were evaluated as the surface properties after high temperature forming. The bare corrosion resistance was evaluated by subjecting the specimens to a moisture tank test (relative humidity: 95%, temperature: 40°C) for 3 days, and the after-painting corrosion resistance was evaluated by subjecting the specimens to a salt spray test (JIS-Z2134) for 30 days after the specimens were cut in a cross shape. A cationic electrodeposition paint was adopted as the painting in this case and the painting thickness was 15 μm. The bare corrosion resistance was judged from the appearance using a mark ○ or ×, and the evaluation criteria were: × for the occurrence of red rust and ○ for no red rust. Likewise, the after-painting corrosion resistance was judged from the appearance using a mark ○, △ or ×, and the evaluation criteria were: ○ for blistering of not more than 2 mm, △ for blistering from more than 2 mm to not more than 4 mm, and × for blistering of more than 4 mm. Nos. 1 to 7 steels are the steels having the components within the range specified in the present invention, and all steel sheets produced on the conditions within the range specified in the present invention can secure high strength after high temperature forming and, moreover, have no problem with respect to both the bare corrosion resistance and the after-painting corrosion resistance. Here, in case of No. 7 steel, the results of the steel sheet produced on the conditions where the annealing temperature deviates from the range specified in the present invention is also shown, and, in this case, as the strength of the steel sheet is too high, the evaluation of the properties is not carried out thereafter. In case of Nos. 8 and 9 steels, the steel

compositions deviate from the range specified in the present invention. As a result, in case of No. 8 steel, the strength after high temperature forming, which is one of the targets of the present invention, is low, and, in the case of No. 9 steel, the bare corrosion resistance and the after-painting corrosion resistance are not secured.

Example 3

The steels having various chemical compositions as shown in Table 6 were cast, heated again to a temperature of 1,050 to 1,250°C, thereafter hot-rolled, pickled, cold-rolled, annealed, subjected to a plating treatment (aluminum plating or aluminum-zinc plating), and thereafter subjected to temper rolling at the reduction rate of 0.8%. Further, as substantial alloying process, these steel sheets were heated to a temperature of 900 to 1,000°C, retained for 5 minutes at this temperature, thereafter subjected to press forming with dies of the room temperature, and then subjected to the investigation on the properties. The investigation on material properties was carried out by cutting out specimens from the portions which were rapidly cooled at the press and applying a tensile test thereto. The test was carried out by cutting the specimens into No. 5 test pieces according to JIS-Z2201 and following the test method described in JIS-Z2241. The evaluation results are shown in Table 7.

[Tables 6 and 7]

Table 6

Steel No.	C	Si	Mn	S	P	Al	N	Cr	Mo	Cr+7xMo	Remarks
1	0.16	0.20	0.72	0.006	0.020	0.035	0.0025	1.00	0.18	2.260	Invented example
2	0.21	0.21	0.68	0.008	0.018	0.032	0.0030	0.95	0.15	2.000	Invented example
3	0.50	0.25	0.75	0.006	0.020	0.026	0.0028	0.98	0.17	2.170	Invented example
4	0.23	0.20	1.50	0.010	0.015	0.030	0.0030	0.32	0.00	0.320	Invented example
5	0.22	0.45	2.20	0.009	0.010	0.038	0.0035	0.00	0.05	0.350	Invented example
6	0.23	0.15	0.30	0.008	0.012	0.032	0.0026	1.90	0.00	1.900	Invented example
7	0.21	0.20	0.50	0.008	0.010	0.033	0.0028	0.00	0.80	5.600	Invented example
8	0.22	0.21	0.65	0.006	0.015	0.032	0.0030	0.10	0.02	0.240	Invented example
9	0.22	0.20	0.70	0.008	0.014	0.025	0.0025	0.25	0.00	0.250	Invented example
10	0.21	0.18	0.45	0.010	0.012	0.028	0.0025	0.00	0.03	0.210	Comparative example

Table 7

Steel No.	Coiling temperature (°C)	Annealing temperature (°C)	Kind of plating	TS before forming (Mpa)	Heating temperature before forming (°C)	YP (MPa)	TS (MPa)	Bare corrosion resistance	After-painting corrosion resistance	Remarks
1	630	780	Aluminum plating	565	980	1080	1280	○	○	Invented example
	620	780	Aluminum-zinc plating	560	980	1090	1270	○	○	Invented example
2	650	770	Aluminum plating	605	950	1290	1560	○	○	Invented example
	650	765	Aluminum-zinc plating	600	950	1285	1580	○	○	Invented example
3	635	740	Aluminum plating	725	930	1705	1890	○	○	Invented example
	630	750	Aluminum-zinc plating	750	930	1700	1900	○	○	Invented example
4	645	775	Aluminum plating	500	950	1390	1610	○	○	Invented example
	650	780	Aluminum-zinc plating	508	950	1400	1600	○	○	Invented example
5	630	770	Aluminum plating	603	950	1300	1550	○	○	Invented example
	630	770	Aluminum-zinc plating	605	950	1320	1555	○	○	Invented example
6	650	770	Aluminum plating	654	950	1390	1620	○	○	Invented example
	640	760	Aluminum-zinc plating	660	950	1380	1620	○	○	Invented example
7	640	770	Aluminum plating	780	950	1320	1510	○	○	Invented example
	650	760	Aluminum-zinc plating	774	950	1325	1520	○	○	Invented example
8	630	765	Aluminum plating	553	950	1320	1580	○	○	Invented example
	635	760	Aluminum-zinc plating	555	950	1310	1570	○	○	Invented example
9	640	770	Aluminum plating	558	950	1340	1575	○	○	Invented example
	645	770	Aluminum-zinc plating	562	950	1350	1585	○	○	Invented example
10	630	765	Aluminum plating	554	950	1350	1595	×	×	Comparative example
	640	760	Aluminum-zinc plating	550	950	1330	1530	×	×	Comparative example

Specimens were cut out from the portions which underwent working during press forming and bare corrosion resistance and after-painting corrosion resistance were evaluated as the surface properties after high temperature forming. The bare corrosion resistance was evaluated by subjecting the specimens to a moisture tank test (relative humidity: 95%, temperature: 40°C) for 3 days, and the after-painting corrosion resistance was evaluated by subjecting the specimens to a salt spray test (JIS-Z2134) for 30 days after the specimens were cut in a cross shape. A cationic electrodeposition paint was adopted as the painting in this case and the painting thickness was 15 μm. The bare corrosion resistance was judged from the appearance using a mark ○ or ×, and the evaluation criteria were: × for the occurrence of red rust and ○ for no red rust. Likewise, the after-painting corrosion resistance was judged from the appearance using a mark ○, △ or ×, and the evaluation criteria were: ○ for blistering of not more than 2 mm, △ for blistering from more than 2 mm to not more than 4 mm, and × for blistering of more than 4 mm. Nos. 1 to 9 steels are the steels having the components within the range specified in the present invention, and all steel sheets produced on the conditions within the range specified in the present invention can secure high strength after high temperature forming, and moreover have no problem with respect to both the bare corrosion resistance and the after-painting corrosion resistance. In case of the No. 10 steel, the steel composition deviates from the range specified in the present invention and therefore the bare corrosion resistance and the after-painting corrosion resistance are not secured.

Example 4

Hot dip aluminum plating was applied to pickled steel sheets (1.8 mm in thickness) and cold-rolled steel

sheets (1.2 mm in thickness) as the materials having steel compositions shown in Table 8 and being produced through regular hot-rolling and cold-rolling processes. Nos. 1, 3, 5 and 7 in Table 8 are cold-rolled steel sheets, and the rest are hot-rolled steel sheets. In the hot dip aluminum plating, a line of non-oxidizing furnace-reducing furnace type was used, a deposit amount of plating was adjusted to 80 g/m^2 per both sides by the gas wiping method after plating, and, after that, the steel sheets were cooled and subjected to a zero-spangle treatment. The plating bath composition at the time was Al-10%Si-2%Fe. Fe in the bath is a component unavoidably supplied from the plating apparatus and the steel sheets in the bath. Plating appearance was good without having non-plating defects or the like. The properties are shown in Table 9.

The hardenability and workability of the hot dip aluminum plated steel sheets thus produced were evaluated. The workability was evaluated by heating an aluminum plated steel sheet at 950°C for 10 minutes under the atmosphere, as substantial alloying process, thereafter cooling it while inserting it between dies made of steel (cooling rate: about 30°C/sec.), cooling it to the room temperature, and thereafter subjecting it to an impact test. Further, Vickers hardness at the cross-section of a steel sheet was measured by imposing a load of 100 g.

Evaluation criteria of workability

○: No exfoliation

△: Cracks generated

×: Powdery exfoliation generated

[Tables 8 and 9]

Table 8

No.	Chemical composition (wt%)										
	C	Si	Mn	P	S	Al	N	Ti	Cr	Mo	B
1	0.23	0.12	1.21	0.02	0.009	0.03	0.004	0.02	0.13	-	0.002
2	0.21	0.20	0.81	0.02	0.007	0.05	0.004	0.22	0.20	-	-
3	0.17	0.15	1.24	0.01	0.008	0.03	0.003	0.01	1.10	-	0.0008
4	0.23	0.31	1.54	0.02	0.007	0.05	0.003	0.02	0.44	-	0.002
5	0.25	0.18	1.22	0.01	0.01	0.04	0.003	0.02	0.66	0.20	0.005
6	0.24	0.2	0.95	0.01	0.02	0.05	0.004	0.09	0.5	0.15	0.01
7	0.2	0.2	2.43	0.01	0.01	0.04	0.003	0.09	0.21	-	0.0008
8	0.04	0.1	1.4	0.02	0.01	0.03	0.004	0.25	0.15	-	0.0003

Table 9

No.	Workability	Al amount in Fe-Al coating (%)	Vickers hardness
1	O	15	515
2	O	15	480
3	O	15	405
4	O	15	511
5	O	15	548
6	O	15	539
7	O	15	466
8	O	15	209

When the C amount is rather low as in the No. 8 steel, the strength is rather low. In general, a value close to the tensile strength (MPa) of a material is obtained by multiplying a Vickers hardness by 3, and, in this case, a strength of only 600 MPa class at the most is obtained. In case of Nos. 1 to 7 steels, both strength and workability show good results. The Al amount in the Fe-Al coating layer in this case is quantitatively analyzed using an EPMA, and the value is around 15%. Here, the value is obtained by analyzing 5 portions in a cross-section of a specimen after quenching in the range from the surface to the depth of 10 μm and averaging the analysis data.

Next, No. 1 steel sheet of this Example in Table 8 was plated with a metal mainly composed of Al-10%Si-2%Fe and the deposit amount of the plating was varied from 60

to 200 g/m^2 per both sides. The samples thus obtained were heated at 950°C under the atmosphere with the retention time being changed, the workability was evaluated with an impact test, and the Al amount in the Fe-Al coating layer was measured by the method described in the item 1 of Example 4. As shown in Table 10, the workability depends on the Al amount in the Fe-Al coating layer, and, when the Al amount is not more than 35%, good workability is obtained. Further, the Al amount in the Fe-Al coating layer depends on the deposit amount and the retention time, and it can be understood that, the smaller the deposit amount is and the longer the retention time is, the more the diffusion proceeds and the smaller the Al amount in the Fe-Al coating layer is.

[Table 10]

Table 10

No.	Deposit amount (g/m^2)	Retention time	Al amount in Fe-Al coating (%)	Workability
1	60	0	36	△
2	60	1	29	○
3	60	2	17	○
4	80	0	38	×
5	80	1	35	△
6	80	2	20	○
7	120	2	42	×
8	120	4	36	×
9	120	6	15	○
10	200	5	44	×
11	200	10	38	×
12	200	15	377	×

Example 5

Hot dip Al-Si-Mg plating was applied to pickled steel sheets (1.8 mm in thickness) and cold-rolled steel sheets (1.2 mm in thickness) as the materials, having steel compositions shown in Table 11 and being produced through regular hot-rolling and cold-rolling processes.

A, C, E and G in Table 11 are cold-rolled steel sheets, and the rest are hot-rolled steel sheets. In the hot dip plating, a line of non-oxidizing furnace-reducing furnace type was used, a deposit amount of plating was adjusted to 40 g/m^2 per one side by the gas wiping method after plating, and, after that, the steel sheets were cooled and subjected to a zero-spangle treatment. The plating bath composition at the time was Al-8%Si-6%Mg-1%Fe-0.1%Ca. Fe in the bath is a component unavoidably supplied from the plating apparatus and the steel sheets in the bath. Plating appearance showed a spangle pattern and was good without having non-plating defects or the like. The production conditions in this case are shown in Table 12.

The hardenability and corrosion resistance of the hot dip plated steel sheets thus produced were evaluated. The evaluation methods are described below. The hot dip plated steel sheets were subjected to 5% tensile stress, then heated at 950°C for 5 minutes, and, as substantial alloying process, thereafter cooled while inserted between steel sheets. The cooling rate was about 30°C/sec. The heat resistance was evaluated by visually observing the specimens after cooling. Then, the bare corrosion resistance was evaluated by subjecting the specimens to a moisture tank test (relative humidity: 95%, temperature: 40°C) for 3 days, and the after-painting corrosion resistance was evaluated by subjecting the specimens to a salt spray test (JIS-Z2134) for 30 days after the specimens were cut in a cross shape. A cationic electrodeposition paint was adopted as the painting in this case and the painting thickness was 15 μm. Further, the Vickers hardness of a steel sheet was measured by imposing a load of 100 g.

Evaluation criteria of heat resistance

○: Good

△: Crack-shaped patterns generated on the

surface

×: Red scales generated

Evaluation criteria of bare corrosion resistance

○: Good

△: Red rust generated

Evaluation criteria of after-painting corrosion resistance

◎: Paint blister not more than 1 mm

○: Paint blister not more than 2 mm

△: Paint blister 2 to 4 mm

×: Paint blister more than 4 mm

[Tables 11 and 12]

Table 11

Steel code	C	Si	Mn	P	S	Al	N	Ti	Cr	Mo	Ni	B
A	0.21	0.20	0.81	0.02	0.007	0.05	0.004	0.05	0.20	-	-	0.0005
B	0.17	0.15	1.24	0.01	0.008	0.03	0.003	0.15	1.10	-	-	0.0008
C	0.42	0.7	2.41	0.01	0.009	0.01	0.003	0.46	0.21	-	-	0.001
D	0.23	0.31	1.54	0.02	0.007	0.4	0.003	0.24	0.44	-	-	0.002
E	0.25	0.18	1.22	0.01	0.01	0.04	0.003	0.003	0.66	0.20	-	0.005
F	0.24	0.2	0.95	0.01	0.02	0.05	0.004	0.001	-	0.15	0.33	0.01
G	0.08	0.1	1.4	0.02	0.01	0.03	0.004	0.25	0.15	-		0.0003
H	0.24	0.10	0.31	0.01	0.008	0.03	0.004	0.21	0.03	-		0.0001

Table 12

No.	Code of applied steel	Bare corrosion resistance	After-painting corrosion resistance	Vickers hardness
1	A	○	○	485 (○)
2	B	○	○	401 (○)
3	C	○	○	769 (○)
4	D	○	○	509 (○)
5	E	○	○	544 (○)
6	F	○	○	540 (○)
7	G	○	○	289 (×)
8	H	○	○	301 (×)

When the C amount is too small as in the No. 7 steel sheet, sufficient strength is not obtained. In general,

a value close to material strength (MPa) is obtained by multiplying a Vickers hardness by 3, and, in this case, a strength of only 800 MPa class at the most is obtained. Further, when the amounts of the elements effective in quenching, such as Mn, B, etc., are small as in No. 8 steel sheet, the quenching effect is not obtained even though the C amount is large. In case of Nos. 1 to 6 steel sheets wherein the addition amounts of the elements in the steels are properly controlled, both strength and corrosion resistance show good results in either the case of the Mn-B-system or the Mo-Cr-Ni-system.

Then, using steel E in Table 11, the relation between the plating compositions and the properties of the plated steel sheets was investigated with the compositions in the plating bath of the hot dip plating line being varied. The relation between the compositions of the plated layers and the properties thereof after plating is summarized in Table 13. Here, the Vickers hardness was in the range from 470 to 510 in each case.

In case of a No. 8 steel sheet, which is of Mg-Zn-system, corrosion resistance is poor. On the other hand, Nos. 4 to 7 steel sheets, which are of Si-Mg-system, show excellent corrosion resistance. Likewise, Nos. 1 to 3 steel sheets, which are of Si-Mg-Zn-system, show excellent corrosion resistance.

[Table 13]

Table 13

No.	Composition of plated layer (mass %)				Bare corrosion resistance	After-painting corrosion resistance
	Si	Mg	Zn	Ca		
1	2	3	40	0.1	○	◎
2	5	7	20	0.1	○	◎
3	8	6	10	-	○	◎
4	12	8	-	0.1	○	◎
5	8	6	-	0.1	○	◎
6	6	3	-	-	○	◎
7	9	0.5	-	-	○	◎
8	-	1	3	-	×	×

Example 6

Hot dip aluminum plating was applied to cold-rolled steel sheets (1.2 mm in thickness) as the materials, having a steel composition shown in Table 14 and being produced through regular hot-rolling and cold-rolling processes. In the hot dip aluminum plating, a line of non-oxidizing furnace-reducing furnace type was used, a deposit amount of plating was adjusted to 60 g/m^2 per one side by the gas wiping method after plating, and, after that, the steel sheets were cooled and subjected to a zero-spangle treatment. The plating bath composition at the time was Al-10%Si-2%Fe. Fe in the bath is a component unavoidably supplied from the plating apparatus and the steel sheets in the bath. The plating appearance was good without having non-plating defects or the like. The aluminum plated steel sheets thus produced were heated to 950°C, and, as substantial alloying process, the workability (exfoliation resistance) of the plated layers during air-cooling was evaluated.

At this time, the thickness of the ferrite layers was varied by varying the heating times and heating patterns. Working was applied by an impact test, the exfoliation state was visually judged with the working temperature being varied during cooling, and the workability of the plated layers was evaluated at the

lowest temperature where the exfoliation of a plated layer did not occur. Here, in case of this steel, the hardenability was good even at the cooling rate of 10°C/sec. and a structure mainly composed of martensite was obtained even in case of air-cooling. The relation between the thickness of the intermediate ferrite layer and the lowest temperature where good working can be obtained in this case is shown in Fig. 8.

As shown in Fig. 8, it is understood that, when the thickness of a ferrite layer is not less than 2 μm, preferably not less than 4 μm, the exfoliation resistance of a plated layer improves. When the thickness of a ferrite layer is about 0.5 μm, powdery exfoliation of a plated layer is observed even in the case of the working at 800°C. Further, as substantial alloying process, the workability of a plated layer depends on the deposit amount of plating. Even though the thickness of a ferrite layer is 2 μm, when the deposit amount is 30 g/m^2 per one side, the lowest temperature where good working is obtained is about 500°C. Further, the structure of the base steel at the time was analyzed by the observation with an optical microscope and the subsequent image analysis, and not less than 80% of the structure was composed of martensite under all conditions.

[Table 14]

Table 14

C	Si	Mn	P	S	Al	N	Ti	Cr	Mo	B
0.36	0.21	0.65	0.02	0.006	0.027	0.003	0.002	1.01	0.16	0.0001

Example 7

Hot dip aluminum plating was applied to pickled steel sheets (1.8 mm in thickness) and cold-rolled steel sheets (1.2 mm in thickness) as the materials, having steel compositions shown in Table 15 and being produced through regular hot-rolling and cold-rolling processes.

Nos. 1, 3 and 5 in Table 15 are cold-rolled steel sheets, and the rests are hot-rolled steel sheets. In the hot dip aluminum plating, a line of non-oxidizing furnace-reducing furnace type was used, a deposit amount of plating was adjusted to 60 g/m^2 per one side by the gas wiping method after plating, and, after that, the steel sheets were cooled and subjected to a zero-spangle treatment. The plating bath composition at the time was Al-10%Si-2%Fe. Plating appearance was good without having non-plating defects or the like. The hot dip aluminum plated steel sheets thus produced were heated to 950°C, and, as substantial alloying process, thereafter subjected to press forming at the time when the temperature reached about 600°C while cooled by water-cooled dies. The exfoliation state of a plated layer at the portion to which bending working was applied was visually judged and the exfoliation of a plated layer was not observed for all steel sheets. At the time, the thickness of the ferrite layers was 10 to 20 μm, and the martensite percentage in all base steels was not less than 80%. Here, the cooling rate was about 150°C/sec.

[Table 15]

Table 15

No.	C	Si	Mn	P	S	Al	N	Ti	Cr	Mo	B
1	0.22	0.20	0.94	0.02	0.007	0.025	0.003	0.22	0.05	0.002	0.0017
2	0.16	0.17	0.69	0.02	0.007	0.037	0.004	0.002	0.98	0.17	0.0001
3	0.20	0.20	0.67	0.02	0.006	0.033	0.003	0.002	0.96	0.17	0.0002
4	0.22	0.15	0.88	0.03	0.007	0.022	0.004	0.55	0.12	0.01	0.0005
5	0.25	0.55	0.72	0.02	0.009	0.025	0.003	0.31	0.58	0.12	0.0020

Example 8

Hot dip aluminum plating was applied to cold-rolled steel sheets (1.2 mm in thickness) as the materials, having a steel composition shown in Table 16 and being produced through regular hot-rolling and cold-rolling processes. In the hot dip aluminum plating, a line of non-oxidizing furnace-reducing furnace type was used, the

deposit amounts of plating were adjusted to 30 to 80 g/m^2 per one side by the gas wiping method after plating, and, after that, the steel sheets were cooled and subjected to a zero-spangle treatment. The plating bath composition at the time was Al-10%Si-2%Fe. Fe in the bath is a component unavoidably supplied from the plating apparatus and the steel sheets in the bath. Plating appearance was good without having non-plating defects or the like. The hardness after quenching, the thickness of the intermetallic compounds, weldability, heat resistance and after-painting corrosion resistance of the aluminum plated steel sheets thus produced were evaluated. The quenching was applied by heating a steel sheet at 950°C for 0.5 to 20 minutes in the atmosphere, and, as substantial alloying process, thereafter pressing the steel sheet in the state of a plane sheet with dies and cooling it. At the time, the cooling rate was about 300°C/sec. By so doing, quenched steel sheets having alloy layers different in thickness and alloyed up to the surface were obtained by changing the deposit amounts and heating times. Here, the appearance of all steel sheets was almost homogenous. The evaluation methods and the evaluation criteria of the properties are shown below.

[Table 16]

Table 16

Number	C	Si	Mn	P	S	Al	N	Ti	Cr	Mo	B
1	0.22	0.20	0.94	0.02	0.007	0.025	0.003	0.22	0.05	0.002	0.0017

[Hardness]

Vickers hardness was measured at the center portion in the cross-section of a steel sheet by imposing a load of 100 g.

[Thickness of intermetallic compound]

The thickness of an intermetallic compound was measured by observing the cross-section of a steel sheet using a microscope, then etching it with 2% nitral, and

thereafter analyzing the structure using an EPMA. An example of the analysis is shown in Fig. 9. The reference numeral 1 shows the layer composed of Al: 26.85%, Si: 9.83%, Fe: 59.92%; the reference numeral 2 the layer composed of Al: 49.54%, Si: 3.11%, Fe: 44.87%; the reference numeral 3 the layer composed of Al: 30.75%, Si: 8.88%, Fe: 56.91%; and the reference numeral 4 the layer composed of Al: 9.59%, Si: 2.92%, Fe: 84.02%.

[Weldability]

Spot weldability was evaluated on the following conditions:

Electrode; Dome electrode made of alumina dispersed copper and having an electrode tip of 6ϕ-40R,

Pressure; 600 kgf,

Welding current; 10 kA,

Welding time; 12 cycles (60 Hz).

Evaluation criteria

○: Consecutive spot welding of more than 2,000 cycles

△: Consecutive spot welding of 1,200 to 2,000 cycles

×: Consecutive spot welding of less than 1,200 cycles

[After-painting corrosion resistance]

A steel sheet was subjected to a chemical treatment for about 2 minutes in a chemical treatment liquid, which was commonly used for aluminum plating a steel sheet and zinc plating, then coated with a cationic electrodeposition paint of 20 μm in thickness, baked at 140°C for 20 minutes, and thereafter subjected to a salt spray test for 20 days after cut in a cross shape, and the after-painting corrosion resistance was judged by the corrosion depth at the portion cut in a cross shape. Here, the depth of the cut in a cross shape with a cutter was about 50 μm. Therefore, a value obtained by subtracting 50 μm from a measured value is a true

corrosion depth.

The evaluation results are summarized in Table 17.

Evaluation criteria

○: Corrosion depth not more than 80 μm

×: Corrosion depth more than 80 μm

[Table 17]

Table 17

No.	Thickness of alloy layer (μm)	Hardness of base material (Hv)	Spot weldability	After-painting corrosion resistance
1	2	397	○	×
2	5	395	○	○
3	10	399	○	○
4	17	401	○	○
5	25	398	△	○
6	32	399	△	○
7	38	397	×	○

As shown in Table 17, when the thickness of an alloy layer is small, the steel sheet tends to be excellent in spot weldability but to be inferior in after-painting corrosion resistance. When the thickness is too thin like No. 1 steel sheet, the steel sheet is inferior in after-painting corrosion resistance, and when the thickness is too heavy like No. 7 steel sheet, the steel sheet is inferior in spot weldability. In case of Nos. 5 and 6 steel sheets too, the steel sheets tend to be inferior in spot weldability. Therefore, when spot weldability is regarded as important, it is desirable to make the thickness of an alloy layer rather thin.

Example 9

Steel sheets made of the steels shown in Table 18 were plated with a metal mainly composed of Al-10%Si-2%Fe, and good plating appearance was obtained. The thickness of the alloyed layers after quenched on the same conditions as the item 1 of Example 7 was measured

and the values were within the range from 8 to 15 μm. With respect to those steel sheets, the same evaluation items as the item 1 of Example 7 were evaluated. As a result, all of the steel sheets obtained the evaluation results which correspond to the evaluation rank ○ of Example 1, and showed good weldability and good after-painting corrosion resistance.

[Table 18]

Table 18

No.	C	Si	Mn	P	S	Al	N	Ti	Cr	Mo	B
1	0.22	0.20	0.94	0.02	0.007	0.025	0.003	0.22	0.05	0.002	0.0017
2	0.16	0.17	0.69	0.02	0.007	0.037	0.004	0.002	0.98	0.17	0.0001
3	0.20	0.20	0.67	0.02	0.006	0.033	0.003	0.002	0.96	0.17	0.0002
4	0.36	0.21	0.65	0.02	0.006	0.027	0.003	0.002	1.01	0.16	0.0001
5	0.22	0.15	0.88	0.03	0.007	0.022	0.004	0.55	0.12	0.01	0.0005
6	0.25	0.55	0.72	0.02	0.009	0.052	0.003	0.31	0.58	0.12	0.0020
7	0.23	0.18	0.21	0.03	0.007	0.025	0.003	0.27	0.03	0.01	0.0022

Example 10

Hot dip aluminum plating was applied to cold-rolled steel sheets (1.2 mm in thickness) as the materials having a steel composition shown in Table 19 and being produced through regular hot-rolling and cold-rolling processes. In the hot dip aluminum plating, a line of non-oxidizing furnace-reducing furnace type was used, a deposit amount of plating was adjusted to 60 g/m^2 per one side by the gas wiping method after plating, and, after that, the steel sheets were cooled and subjected to a zero-spangle treatment. The plating bath composition at the time was Al-10%Si-2%Fe. Fe in the bath is a component unavoidably supplied from the plating apparatus and the steel sheets in the bath. The plating appearance was good without having non-plating defects or the like. The hot dip aluminum plated steel sheets thus produced were heated in the atmosphere, then retained at various temperatures, and formed into the shape shown in Fig. 10. At the time, the steel sheets were cooled with water-

cooled dies. The heating rate was about 5 to 10°C/sec., and the cooling rate was, though it varied with the portions, about 100°C/sec. at a portion where cooling rate was high and about 20°C/sec. at a portion where cooling rate was low. The workability (exfoliation resistance) of a plated layer at the time was evaluated. The exfoliation of the plated layers was formed in a shape of streak or in a shape of spot on the compressed surface. The relation between the heating conditions and the state of the exfoliation of the plated layers is shown in Table 20. Further, the heating conditions according to the present invention are shown in Fig. 11.

[Tables 19 and 20]

Table 19

C	Si	Mn	P	S	Al	N	Ti	Cr	Mo	B
0.24	0.21	0.95	0.02	0.006	0.027	0.003	0.002	1.01	0.16	0.0018

Table 20

No.	Heating temperature (°C)	Heating time (min.)	Adhesiveness
1	800	20	△
2	850	15	○
3	900	13	○
4	950	8	○
5	1000	6	○
6	1050	4	○
7	1100	2	○
8	900	5	×
9	1000	2	×

Evaluation criteria of adhesiveness

○: No exfoliation of plated layer

△: Cracks generated partially in plated layer

×: Exfoliation of plated layer generated

As shown in Table 20, the adhesiveness is not regarded yet as perfect even after heating for 20 minutes when the temperature is as low as 800°C as substantial

alloying process. When a heating temperature rises, good adhesiveness is obtained with a retention time of not more than 10 minutes. Adhesiveness is still insufficient when the retention time is 5 minutes at 900°C, or 2 minutes at 1,000°C as substantial alloying process.

Industrial Applicability

As stated above, the present invention provides a hot press method for forming a high-strength automotive part, and will greatly contribute to the weight reduction of an automobile in the future.

CLAIMS

1. A high-strength alloyed aluminum-system plated steel sheet excellent in after-painting corrosion resistance, characterized by having an Fe-Al-system coating containing Mn and Cr of more than 0.1% in total on the surface of the steel sheet.

2. A high-strength alloyed aluminum-system plated steel sheet excellent in heat resistance and after-painting corrosion resistance, characterized by having an Fe-Al-system coating containing, in mass, Mn and Cr of more than 0.1% in total on the surface of the steel containing, in mass, C: 0.05 to 0.7%, Si: 0.05 to 1%, Mn: 0.5 to 3%, P: not more than 0.1%, S: not more than 0.1% and Al: not more than 0.2%, and, in addition, one or more element(s) selected from among Ti: 0.01 to 0.8%, Cr: not more than 3% and Mo: not more than 1%, so as to satisfy the following expression (1):

$$Ti + 0.5 \times Mn + Cr + 0.5 \times Mo > 0.4 \quad \ldots 1$$

3. A high-strength alloyed aluminum-system plated steel sheet excellent in heat resistance and after-painting corrosion resistance according to claim 2, characterized in that the steel further contains, in mass, one or more element(s) selected from among N: not more than 0.1%, Nb: not more than 0.1%, V: not more than 0.1%, Ni: not more than 1%, Cu: not more than 1%, B: 0.0003 to 0.03%, Sn: not more than 0.1% and Sb: not more than 0.1%.

4. A high-strength alloyed aluminum-system plated steel sheet excellent in heat resistance and after-painting corrosion resistance according to claim 1, characterized in that the steel contains, in mass, C: 0.15 to 0.55%, Si: not more than 0.5%, Mn: 0.2 to 3%, P: not more than 0.1%, S: not more than 0.04%, Al: 0.01 to 0.1% and N: not more than 0.01%, and also one or more element(s) selected from among B: 0.0002 to 0.0050%, Ti: 0.01 to 0.8%, Cr: not more than 2%, Mo: not more than 1%, Ni: not more than 1%, Cu: not more than 0.5% and Sn: not

more than 0.2%.

5. A high-strength alloyed aluminum-system plated steel sheet excellent in heat resistance and after-painting corrosion resistance according to any one of claims 1 to 4, characterized in that the Fe-Al-system coating further contains Si of 1 to 20%.

6. An alloyed aluminum-system plated steel sheet for high-strength automotive members according to any one of claims 1 to 5, characterized in that Al concentration in the Fe-Al-system coating layer is not more than 35% in weight.

7. A high-strength alloyed aluminum-system plated steel sheet excellent in heat resistance and after-painting corrosion resistance according to any one of claims 1 to 6, characterized in that the Fe-Al-system coating further contains either one or both of Zn: 1 to 50% and Mg: 0.1 to 10%.

8. A high-strength alloyed aluminum-system plated steel sheet excellent in heat resistance and after-painting corrosion resistance according to any one of claims 1 to 7, characterized in that the thickness of the Fe-Al-system coating layer is 3 to 35 μm.

9. An alloyed aluminum-system plated steel sheet for high-strength automotive members, characterized by having: a coating layer mainly composed of Fe-Al on the surface of the steel sheet; a ferrite layer having a thickness from not less than 2 μm to not more than one tenth of the steel sheet thickness at the underside of the coating layer; and the base steel mainly composed of martensite at the underside of the ferrite layer.

10. An alloyed aluminum-system plated steel sheet for high-strength automotive members according to claim 9, characterized in that the alloyed aluminum-system plated layer on the surface of the steel sheet and the ferrite layer at the underside of the intermetallic compound layer contain Si.

11. An alloyed aluminum-system plated steel sheet for high-strength automotive members according to claim 9 or 10, characterized in that the hardness of the ferrite phase is not higher than 200.

12. A high-strength automotive part formed by press forming, at least a portion of which is composed of a steel according to any one of claims 1 to 11.

13. A high-strength automotive part according to claim 12, characterized by having a coated film 1 to 200 μm in thickness on at least a part of the surface.

14. A hot press method for a high-strength automotive member, wherein, when the automotive member is produced by a hot press using a steel sheet produced by plating a steel containing C of not less than 0.05% in weight as a steel component with a metal mainly composed of Al, the member is formed by press forming after heated on the heating condition of the longer time period side than the following regions, A, B, C and D, and at least a part of the member is cooled at a cooling rate of not lower than 10°C/sec.:

A (800°C, 13 min.), B (900°C, 6 min.), C (1,050°C, 1.5 min.), D (1,200°C, 0.3 min.).

Fig.1

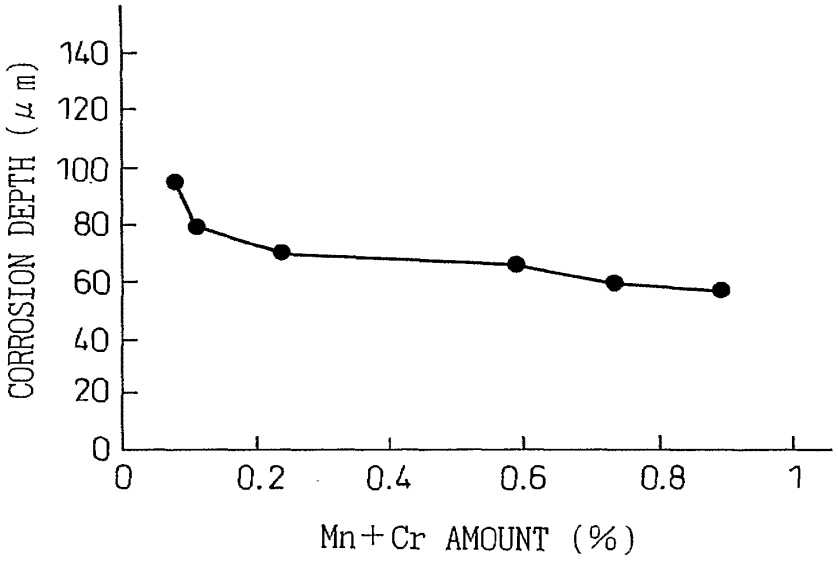

CORROSION DEPTH (μm)
140
120
100
80
60
40
20
0
0
0.2
0.4
0.6
0.8
1
Mn+Cr AMOUNT (%)

Fig.2

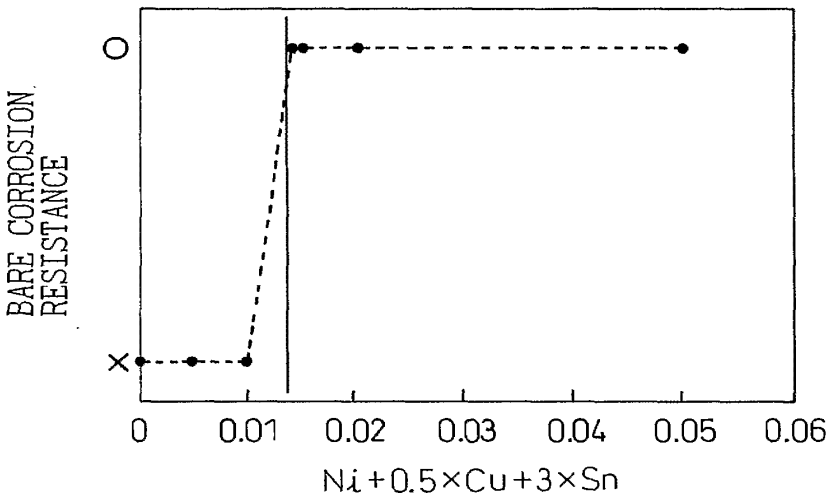

BARE CORROSION RESISTANCE
O
×
0
0.01
0.02
0.03
0.04
0.05
0.06
Ni+0.5×Cu+3×Sn

Fig.3

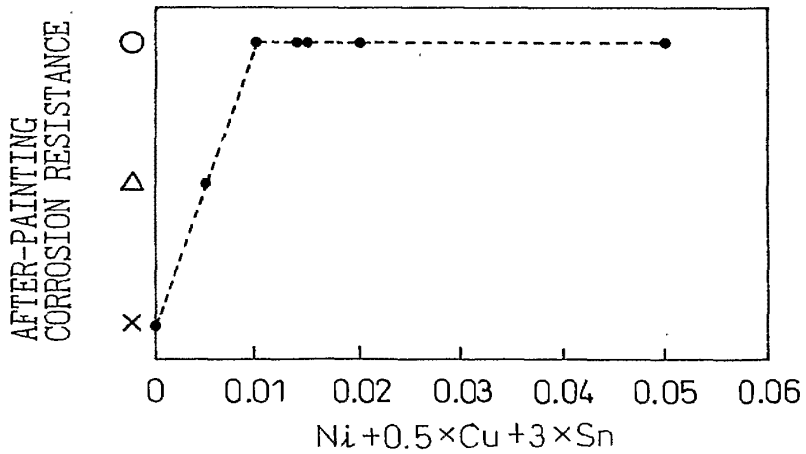

AFTER-PAINTING CORROSION RESISTANCE
O
△
×
0
0.01
0.02
0.03
0.04
0.05
0.06
Ni+0.5×Cu+3×Sn

Fig.4

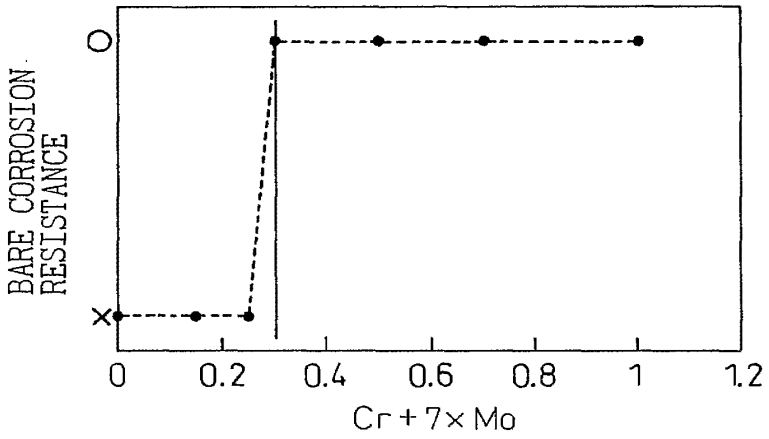

BARE CORROSION RESISTANCE
O
X
0
0.2
0.4
0.6
0.8
1
1.2
Cr + 7× Mo

Fig.5

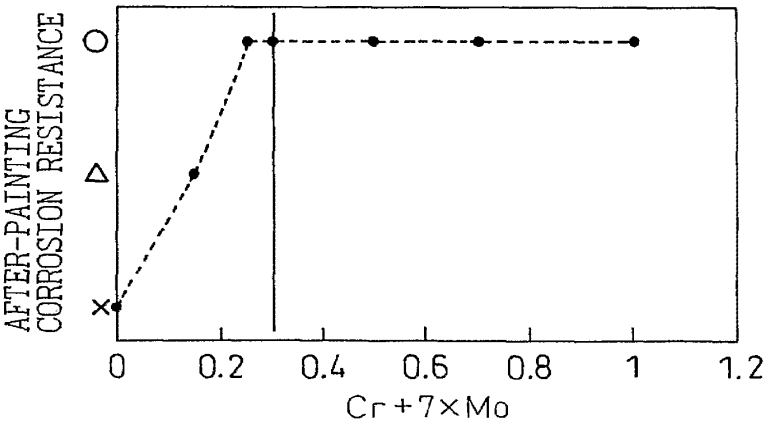

AFTER-PAINTING CORROSION RESISTANCE
O
Δ
X
0
0.2
0.4
0.6
0.8
1
1.2
Cr + 7× Mo

Fig.6

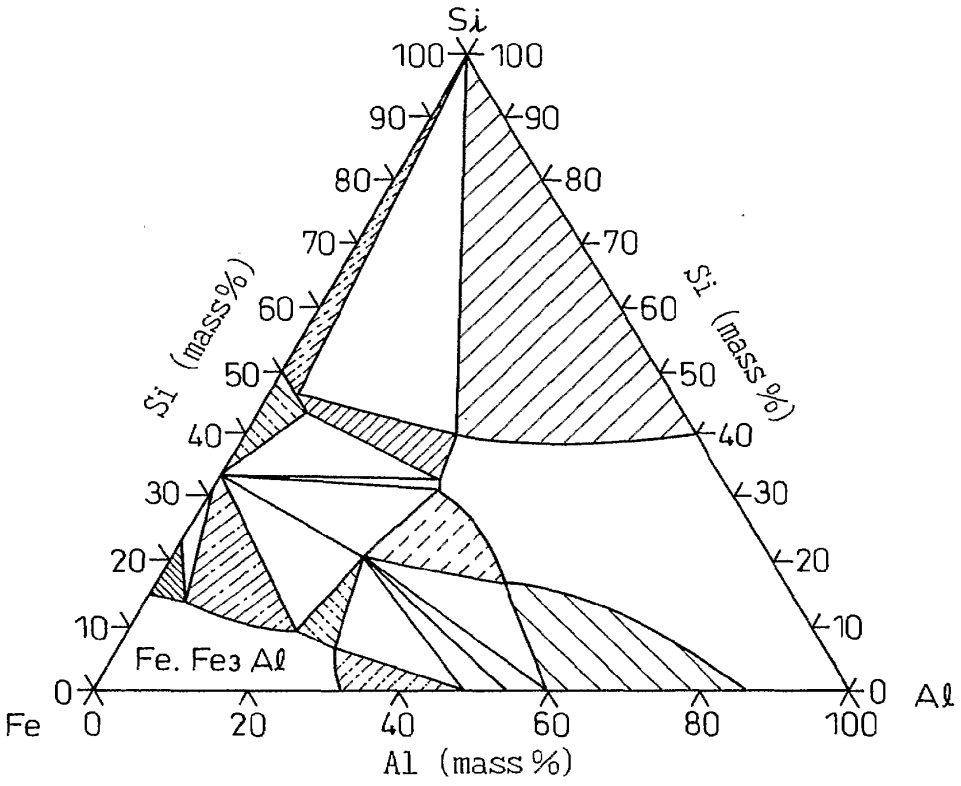

Si
100
90
80
70
60
50
40
30
20
10
0
Si (mass%)
Si (mass%)
Fe. Fe3 Al
Fe
Al
0
20
40
60
80
100
Al (mass%)

Fig.7

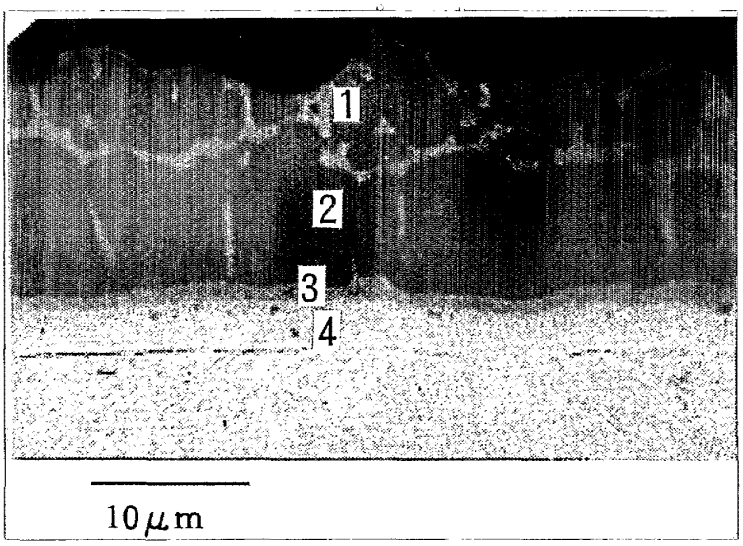

1
2
3
4
10μm

Fig.8

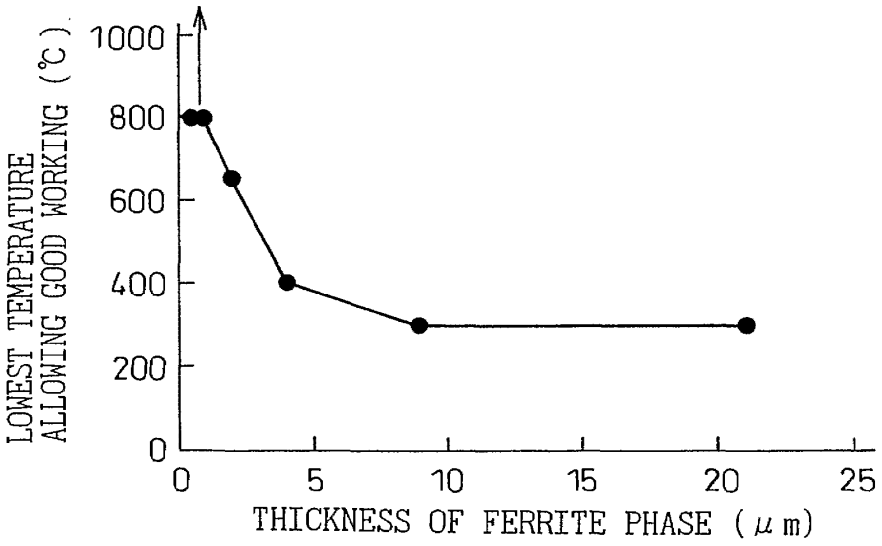

LOWEST TEMPERATURE ALLOWING GOOD WORKING (℃)
1000
800
600
400
200
0
0
5
10
15
20
25
THICKNESS OF FERRITE PHASE (μm)

Fig.9

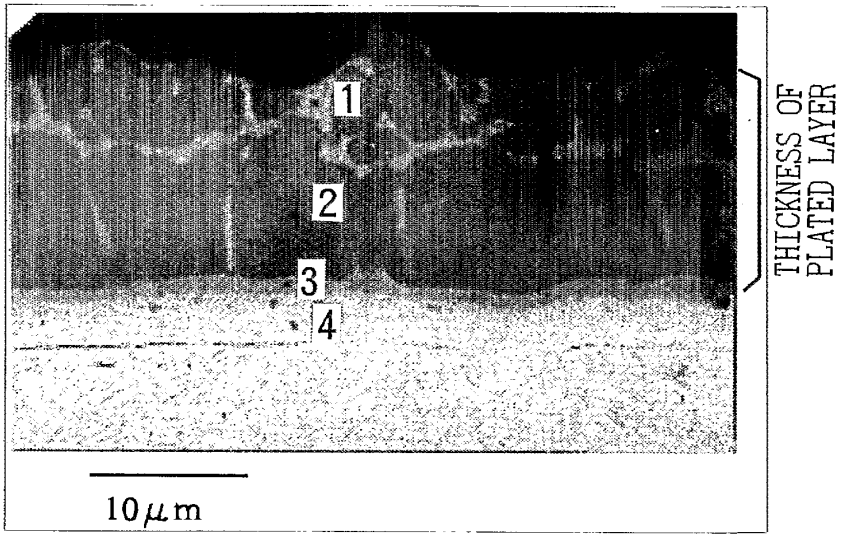


Fig.10

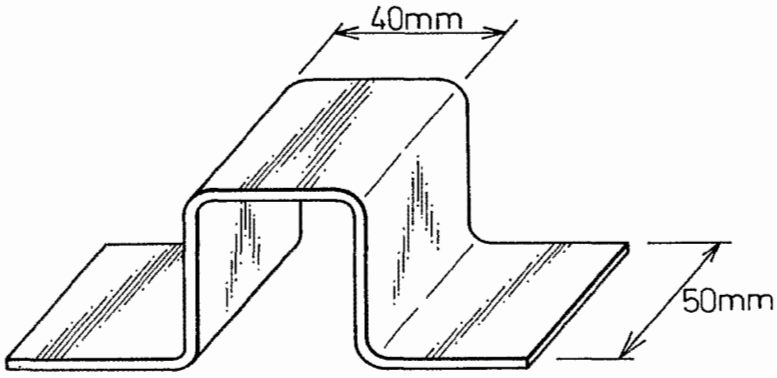
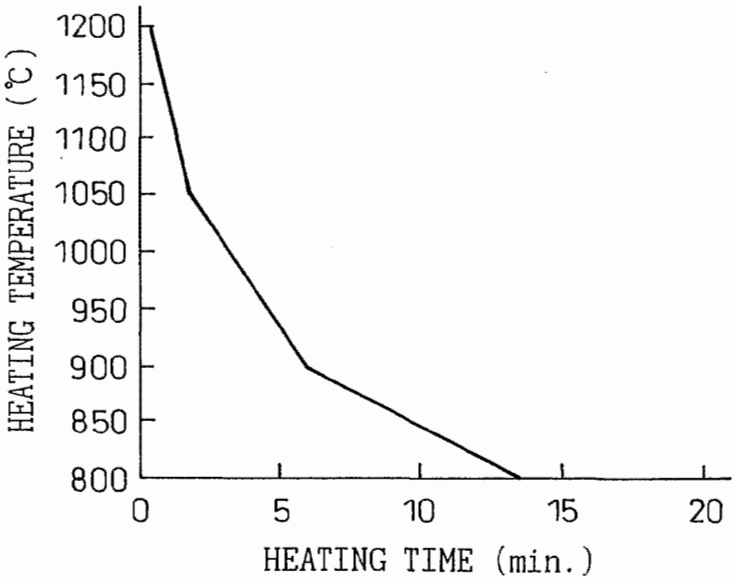

40mm
50mm

Fig.11


HEATING TEMPERATURE (℃)
1200
1150
1100
1050
1000
950
900
850
800
0
5
10
15
20
HEATING TIME (min.)

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最終頁に続く

(54)【発明の名称】熱処理後の耐久性に優れた熱間圧延および冷間圧延被覆鋼板

(57)【特許請求の範囲】

【請求項1】

熱間圧延鋼板にアルミニウムまたはアルミニウム合金を被覆した被覆鋼板において、

鋼板の鋼が下記重量組成：

0.15%＜炭素＜0.5%

0.5%＜マンガン＜3%

0.1%＜珪素＜0.5%

0.01%＜クロム＜1%

チタン＜0.2%

アルミニウム＜0.1%

リン＜0.1%

硫黄＜0.05%

0.0005%＜ホウ素＜0.08%

残部は鉄と製造に起因する不純物

を有し、上記被覆後に行う熱処理によって鋼板の機械強度が高くなることを特徴とする被覆鋼板。

【請求項2】

鋼板の鋼が下記重量組成を有する請求項１に記載の被覆鋼板：

0.20%＜炭素＜0.5%

0.8%＜マンガン＜1.5%

0.1%＜珪素＜0.35%
0.01%＜クロム＜1%
チタン＜0.1%
アルミニウム＜0.1%
リン＜0.05%
硫黄＜0.03%
0.0005%＜ホウ素＜0.01%
残部は鉄と製造に起因する不純物。

【請求項3】
鋼板の鋼の重量組成で、窒素含有率に対するチタン含有率が3.42以上である請求項１に記載の被覆鋼板。

【請求項4】
被覆用のアルミニウムまたはアルミニウム合金が重量組成で9～10%の珪素、2～3.5%の鉄を含み、残部がアルミニウムである請求項１に記載の被覆鋼板。

【請求項5】
被覆用のアルミニウムまたはアルミニウム合金が重量組成2～4%の鉄を含み、残部がアルミニウムである請求項１に記載の被覆鋼板。

【請求項6】
熱間圧延後で且つ被覆前に鋼板が冷間圧延される請求項１～５のいずれか一項に記載の被覆鋼板。

【請求項7】
請求項１～６のいずれか一項に記載の被覆鋼板から部品を製造する方法であって、
上記部品の成形後で且つ部品の熱処理前に、部品の被覆材の温度を５℃／秒以上の速度で昇温させることを特徴とする方法。

【請求項8】
上記被覆材を750℃以上の温度に加熱する請求項７に記載の方法。

【請求項9】
請求項１～５のいずれか一項に記載の熱間圧延被覆鋼板または請求項６に記載の熱間圧延後に冷間圧延した被覆鋼板の、陸上自動車用の構造部材および／または非貫入部材または基礎部品での使用。

【発明の詳細な説明】
【０００１】
【発明が属する技術分野】
本発明は熱処理後の耐久性が極めて高い熱間圧延および冷間圧延被覆鋼板に関するものである。

【０００２】
【従来の技術】
この技術分野では、機械特性を向上させる解決策は成形特性を損なうことになる。これを解決する一つの方法は成形特性と使用時に必要な特性とを分離することである。すなわち、使用時に必要な特性は後の熱処理で与えるか、成形時の熱処理で与える。この場合には、熱処理時に被覆材の安定性に問題があるため、鋼板には被覆をせず、被覆は完成品に施される。この皮膜形成には表面および凹部の入念な清浄を必要とする。また、鋼板の金属の脱炭および酸化を完全に防止するために、熱処理を制御雰囲気下で行わなければならないが、熱処理用鋼板は予備被覆されていないので、脱脂、酸洗および被覆の後処理が必要になる。

【０００３】
熱間圧延および冷間圧延鋼板の連続被覆では、鋼板を浴温に近い温度にするため、あるいは冷間圧延時に劣化した鋼板の機械特性を復元するために、予備焼成と亜鉛またはアルミニウム被覆前または後の冷却とが行われる。この熱サイクルは熱サイクル時に同素変態が起こらないように鋼の組成に応じて選択される。この熱サイクルの目的は被覆していない

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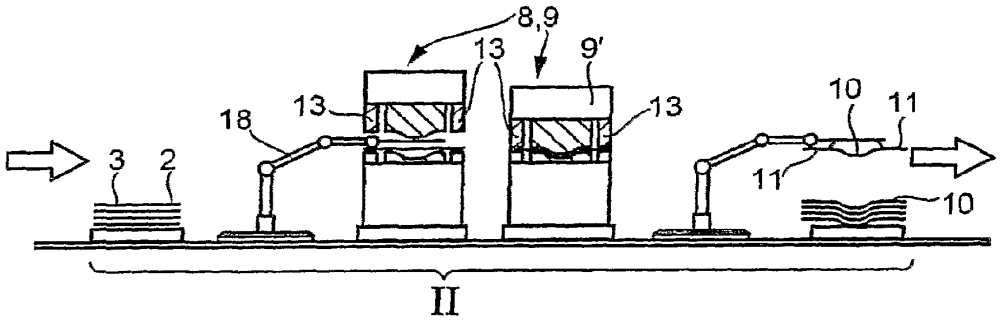
(81) Bestimmungsstaaten *(soweit nicht anders angegeben, für jede verfügbare nationale Schutzrechtsart)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NA, NI, NO, NZ, OM, PG,

[Fortsetzung auf der nächsten Seite]

(54) Title: PRESS-HARDENED COMPONENT AND METHOD FOR THE PRODUCTION OF A PRESS-HARDENED COMPONENT

(54) Bezeichnung: PRESSGEHÄRTETES BAUTEIL UND VERFAHREN ZUR HERSTELLUNG EINES PRESSGEHÄRTETEN BAUTEILS



(57) Abstract: The invention relates to a method for the production of press-hardened components, more particularly press-hardened components of the bodywork of an automobile, consisting of a semi-finished product (2) made of non-hardened, sheet steel which can be deformed when warm, in addition to a press-hardened component produced according to said method. The inventive method consists of several steps. The semi-finished product (2), which is pre-coated with a first coating (33), is used to form a component blank (10) in a cold-forming method, especially a drawing process. The edge-side of the component blank (10) is cut to form an edge contour (12') approximately corresponding to the component (1) which is to be produced. The cut component blank (17) is heated and is press-hardened in a warm forming tool (23), whereupon the press-hardened component blank (18) is provided with a second anti-corrosion coating (34) in a coating step.

(57) Zusammenfassung: Die Erfindung betrifft ein Verfahren zur Herstellung von pressgehärteten Bauteilen, insbesondere eines Karosseriebauteils, aus einem Halbzeug (2) aus ungehärtetem, warm umformbaren Stahlblech, sowie ein nach diesem Verfahren hergestelltes pressgehärtetes Bauteil. In dem Verfahren werden verschiedene Verfahrensschritte ausgeführt. Aus dem mit einer ersten Schicht (33) vorbeschichteten Halbzeug (2) wird durch ein Kaltumformverfahren, insbesondere ein Ziehverfahren, ein Bauteil-Rohling (10) geformt. Der Bauteil-Rohling (10) wird randseitig auf eine dem herzustellenden Bauteil (1) näherungsweise entsprechende Randkontur (12') beschnitten. Der beschnittene Bauteil-Rohling (17) wird erwärmt und in einem Warmumform-Werkzeug (23) pressgehärtet, anschließend wird der pressgehärtete Bauteil-Rohling (18) in einem Beschichtungsschritt mit einer zweiten vor Korrosion schützenden Schicht (34) überzogen.

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Pressgehärtetes Bauteil und Verfahren zur Herstellung eines pressgehärteten Bauteils

Die Erfindung betrifft ein pressgehärtetes Bauteil sowie ein Verfahren zur Herstellung eines pressgehärteten Bauteils gemäß den Oberbegriffen der unabhängigen Ansprüche.

An Steifigkeit und Festigkeit von Karosseriebauteilen werden im Fahrzeugbau zunehmend hohe Anforderungen gestellt. Gleichzeitig wird jedoch im Interesse einer Gewichtsminimierung eine Verringerung der Materialdicke angestrebt. Eine Lösung zur Erfüllung der widersprüchlichen Anforderungen bieten hochfeste und höchstfeste Stahlwerkstoffe, welche die Herstellung von Bauteilen mit sehr hohe Festigkeiten bei gleichzeitiger geringer Materialdicke ermöglichen. Durch eine geeignete Wahl von Prozessparametern während eines bei diesen Werkstoffen üblichen Warmumformens können Festigkeits- und Zähigkeitswerte eines Bauteils gezielt eingestellt werden.

Ein solcher Werkstoff ist z.B. der von der Firma Usinor unter dem Handelsnamen Usibor 1500 vertriebene vorbeschichtete Borstahl. Der Stahl ist mit einer AlSi-Beschichtung versehen, die unter anderem im Rahmen der spätere Wärmebehandlung vorteilhafte korrosionshemmende Eigenschaften zeigt.

Zur Herstellung eines solchen Bauteils mit Hilfe der Warmumformung wird zunächst aus einem Coil eine Platine ausgeschnitten, die anschließend oberhalb der Gefügeumwandlungstemperatur des Stahlwerkstoffs, oberhalb derer das Werkstoffgefüge im austenitischen Zustand vorliegt, erwärmt, im erwärmten Zustand in ein Umformwerkzeug eingelegt und in die gewünschte Bauteilform umgeformt und unter mechanischer Fixierung des gewünschten Umformzustands abgekühlt, wobei eine Vergütung bzw. Härtung des Bauteils erfolgt.

Oftmals wird das Bauteil vor der eigentlichen Warmumformung einem Vorformschritt oder einem Beschneidungsschritt unterzogen. Dies ist beispielsweise in der DE 101 49 221 C1 beschrieben. Ein solches Verfahren kann jedoch Probleme hinsichtlich der Korrosion zur Folge haben, da eine üblicherweise aufgebrachte Bandbeschichtung beim Vorformen beschädigt wird. Ein übliches Vorformen und Beschneiden der Bauteile besonders bei vorbeschichteten hochfesten Stählen wie Usibor 1500 PC, welcher eine AlSi-Beschichtung aufweist, wird daher unterlassen.

Aufgabe der Erfindung ist, ein pressgehärtetes Bauteil sowie ein Herstellverfahren für pressgehärtete Bauteile anzugeben, welches einen sicheren Korrosionsschutz für vorbeschichtete, warm umformbare Stähle ermöglicht.

Die Aufgabe wird erfindungsgemäß mit den Merkmalen der unabhängigen Ansprüche 1, 2 und 8 gelöst.

Eine erste Ausführungsform des erfindungsgemäßen Verfahrens zur Herstellung von pressgehärteten Bauteilen umfasst die folgenden Verfahrensschritte: aus dem vorbeschichteten Halbzeug wird durch ein Kaltumformverfahren, insbesondere ein Ziehverfahren, ein Bauteil-Rohling geformt; der Bauteil-

Rohling wird randseitig auf eine dem herzustellenden Bauteil näherungsweise entsprechende Berandungskontur beschnitten; der beschnittene Bauteil-Rohling wird erwärmt und in einem Warmumform-Werkzeug pressgehärtet; der pressgehärtete Bauteil-Rohling wird in einem Beschichtungsschritt mit einer vor Korrosion schützenden Schicht überzogen.

Diese Ausgestaltung der Erfindung ermöglicht einerseits, den Bauteil-Herstellungsprozess so zu gestalten, dass auf die verfahrenstechnisch aufwändige und kostenintensive abschließende Beschneiden des gehärteten Bauteils verzichtet werden kann. Die Randbereiche werden daher bereits im ungehärteten Zustand des Bauteils abgeschnitten und nicht erst - wie herkömmlicherweise beim Warmumformen üblich - nach dem Erwärmungs- und Härteprozess. Indem das Werkstück bereits im weichen Zustand beschnitten wird, sind wesentlich geringere Schneidkräfte als zum kalten Schneiden gehärteter Werkstoffe erforderlich, was zu einem verminderten Werkzeugverschleiß und zu einer Reduktion der Instandhaltungskosten der Schneidwerkzeuge führt. Weiterhin wird beim Beschneiden des hochfesten Werkstoffs im ungehärteten Zustand die Gefahr einer schnellen Rissbildung aufgrund der hohen Kerbempfindlichkeit dieser Werkstoffe erheblich reduziert.

Die auf dem Halbzeug vorgesehene Vorbeschichtung vermeidet ein Verzundern des beschnittenen Bauteil-Rohlings bei dem Härteprozess, und die Anforderungen an eine inerte Atmosphäre beim Härten können verringert werden. Außerdem verhindert die Vorbeschichtung eine Entkohlung des Werkstoffs beim Härten. Nach dem Härteprozess wird erfindungsgemäß eine weitere vor Korrosion schützende Schicht aufgebracht, so dass das Bauteil vollständig, also auch an den Kanten, beschichtet ist.

In einer weiteren Ausführungsform des erfindungsgemäßen Verfahrens zur Herstellung von pressgehärteten Bauteilen werden die folgenden Verfahrensschritte durchgeführt: das mit einer ersten Schicht vorbeschichtete Halbzeug wird erwärmt und in einem Warmumform-Werkzeug pressgehärtet; der auf diese Weise erzeugte Bauteil-Rohling wird randseitig auf eine dem herzustellenden Bauteil entsprechende Berandungskontur beschnitten; der pressgehärtete, beschnittene Bauteil-Rohling wird in einem Beschichtungsschritt mit einer zweiten vor Korrosion schützenden Schicht überzogen.

In dieser Ausführungsform erfolgt das Beschneiden des gehärteten Bauteils vorzugsweise mit Hilfe eines Laser- oder des Wasserstrahl-Schneideverfahrens, durch die ein hochwertiger Beschnitt der Bauteilkanten erreicht werden kann. Das nachfolgende Aufbringen der zweiten Korrosionsschutzschicht stellt sicher, dass das Bauteil auch im Bereich der beschnittenen Ränder gegen Korrosion geschützt ist.

Wird die Schicht mit einem Feuerverzinkungs-Verfahren auf den pressgehärteten Bauteil-Rohling aufgebracht, kann eine vor Korrosion schützende Schicht aus Zink in einem geeignet in einen Fertigungsprozess integrierbaren Beschichtungsverfahren aufgebracht werden.

Wird die Schicht mit einem thermischen Diffusions-Verfahren auf den pressgehärteten Bauteil-Rohling aufgebracht, kann ein gut steuerbares Verfahren eingesetzt werden, mit dem vorzugsweise eine Schicht aus Zink oder einer Zinklegierung aufgebracht werden kann, das auch für komplexe Bauteil-Geometrien und zur Kantenschichtung geeignet ist. Die Schichtdicke kann gezielt zwischen einigen µm und über 100 µm eingestellt werden. Eine thermische Belastung des Bauteils ist gering. Bauteile können unabhängig von ihrer Größe, den Abmessungen,

Konfiguration, Komplexität und Gewicht beschichtet werden. Eine Reinigung vor dem Beschichtungsschritt mit einer Trockenreinigung, insbesondere ein Strahlen des pressgehärteten Bauteil-Rohlings mit Glaspartikeln oder Zinkpartikeln, kann entfallen, da durch die Vorbeschichtung ein Verzundern des Bauteil-Rohlings bei der Warmumformung im wesentlichen unterbleibt. Dadurch wird ein Prozessschritt eingespart; zusätzlich wird vermieden, dass ein zwar geringer, aber möglicherweise störender Bauteilverzug durch ein Strahlen der Bauteile mit Partikeln entsteht.

Bei einer Vorbeschichtung mit einer aluminiumhaltigen Schicht, vorzugsweise aus AlSi, und einer zinkhaltigen Beschichtung ergibt sich eine gute Haftung zwischen den beiden Beschichtungen. Zusätzlich ergibt sich ein guter Schutz des Werkstoffs gegen Wasserstoffversprödung, gegen die insbesondere Zink den Werkstoff schützen kann. Die zweite Schicht, die auf die erste Schicht der Vorbeschichtung aufgebracht ist, sorgt für eine Kantenbeschichtung und für eine Beschichtung solcher Bereiche, bei denen die erste Schicht der Vorbeschichtung z.B. bei der Vor-Umformung abgeplatzt ist oder durch zu hohe Reibung rissig wurde.

Wird der Bauteil-Rohling nach dem Beschichtungsschritt von Rückständen gereinigt, beispielsweise mit Ultraschall, und passiviert, wird eine Oberfläche gebildet, die einen guten Haftgrund für Beschichtungen, insbesondere Grundierungen von Lacken oder Lacke selbst, ergibt.

Vorteilhaft wird der Bauteil-Rohling nach dem Beschichtungsschritt getempert. Besonders vorteilhaft ist, wenn der Bauteil-Rohling mit einer zinkhaltigen Schicht beschichtet ist, da an der Oberfläche ein Oxid gebildet wird, welches als Haftgrund geeignet ist.

Ein erfindungsgemäßes pressgehärtetes Bauteil, insbesondere ein Karosseriebauteil, aus einem Halbzeug aus ungehärtetem warm umformbaren Stahlblech, ist nach zumindest einer der Weiterbildungen des erfindungsgemäßen Verfahrens hergestellt. Ein solches Bauteil ist besonders geeignet mit einer entsprechenden Serienfertigung in großen Stückzahlen herstellbar und verbindet eine vorteilhafte Gewichtsminderung des Bauteils mit einem ausgezeichneten Korrosionsschutz.

Weitere Vorteile und Ausgestaltungen der Erfindung sind den weiteren Ansprüchen und der Beschreibung zu entnehmen.

Im folgenden ist die Erfindung anhand eines in einer Zeichnung dargestellten Ausführungsbeispiels näher erläutert.

Dabei zeigen:

Fig. 1 ein Verfahrensschema des erfindungsgemäßen Verfahrens eines pressgehärteten Bauteils mit 1a: Zuschneiden der Platine (Schritt I); 1b: Kaltumformung (Schritt II); 1c: Beschneiden der Ränder (Schritt III); 1d: Warmumformung (Schritt IV); 1e: Beschichtung (Schritt V); 1f: alternatives Verfahren zu Beschichtung (Schritt V');

Fig. 2 perspektivische Ansichten ausgewählter Zwischenstufen bei der Herstellung eines Bauteils mit 2a: ein vorbeschichtetes Halbzeug; 2b: ein daraus geformter Bauteil-Rohling; 2c: ein beschnittener Bauteil-Rohling; 2d: ein beschichteter Bauteil-Rohling;

Fig. 3 einen alternativen Verfahrensablauf zur Herstellung eines pressgehärteten Bauteils mit 1a: Zuschneiden der Platine (Schritt I); 1b: Warmumformung (Schritt II'); 1c: Beschneiden der Ränder (Schritt III'); 1d: Beschichtung (Schritt IV').

Die Figuren 1a bis 1e zeigen schematisch ein erfindungsgemäßes Verfahren zur Herstellung eines räumlich geformten, pressgehärteten Bauteils 1 aus einem Halbzeug 2. Im vorliegenden Ausführungsbeispiel wird als Halbzeug 2 eine Platine 3 verwendet, welche aus einem abgewickelten Coil 5 ausgeschnitten wird. Alternativ kann als Halbzeug 2 auch ein Verbundblech zum Einsatz kommen, wie es z.B. in der DE 100 49 660 A1 beschrieben ist und das aus einem Basisblech und mindestens einem Verstärkungsblech besteht. Weiterhin kann als Halbzeug 2 auch ein Taylored Blank verwendet werden, welches aus mehreren zusammen geschweißten Blechen unterschiedlicher Materialstärke und/oder unterschiedlicher Materialbeschaffenheit besteht. Alternativ kann das Halbzeug 2 ein durch ein beliebiges Umformverfahren hergestelltes dreidimensional geformtes Blechteil sein, welches mit Hilfe des erfindungsgemäßen Verfahrens eine weitere Umformung sowie eine Festigkeits- und/oder Steifigkeitserhöhung erfahren soll.

Das Halbzeug 2 besteht aus einem ungehärtetem, warm umformbaren Stahlblech. Ein besonders bevorzugter Werkstoff ist ein borhaltiger Vergütungsstahl, z.B. Usibor 1500, Usibor 1500 P oder Usibor 1500 PC, welche von der Firma Usinor unter diesen Handelsnamen vertrieben werden.

In einem ersten Prozessschritt I wird die Platine 3 (Fig. 1a) aus einem abgewickelten und gerade gerichteten Abschnitt eines Coils 5 aus einem vorbeschichteten, warm umformbaren Blech ausgeschnitten. Vorzugsweise ist die Beschichtung eine Beschichtung aus Aluminium oder einer Aluminiumlegierung, insbesondere einer siliziumhaltigen Aluminiumlegierung AlSi. Der warm umformbare Werkstoff befindet sich zu diesem Zeitpunkt in einem ungehärteten Zustand, so dass Platine 3 problemlos mit Hilfe konventioneller mechanischer Schneidmittel

4, z.B. einer Hubschere, ausgeschnitten werden kann. Im Großserieneinsatz erfolgt das Zuschneiden der Platine 3 vorteilhafterweise mit Hilfe einer Platinenpresse 6, welche eine automatisierte Zuführung des Coils 5 und ein automatisches Ausstanzen und Abführen der ausgeschnittenen Platine 3 gewährleistet. Die auf diese Weise ausgeschnittene Platine 3 ist in Fig.2a in einer schematischen perspektivischen Ansicht dargestellt.

Die ausgeschnittenen Platinen 3 werden auf einem Stapel 7 abgelegt und in gestapelter Form einer Kaltumformstation 8 zugeführt (Fig. 1b). Hier wird in einem zweiten Prozessschritt II aus der Platine 3 mit Hilfe des Kaltumform-Werkzeugs 8, beispielsweise einem zweistufigen Tiefziehwerkzeug 9, ein Bauteil-Rohling 10 geformt. Um eine qualitativ hochwertige Ausformung der Bauteilgeometrie gewährleisten zu können, weist die Platine 3 Randbereiche 11 auf, die über eine Außenkontur 12 des zu formenden Bauteils 1 hinausragen. Im Rahmen dieses Kaltumformprozesses (Prozessschritt II) wird der Bauteil-Rohling 10 endkonturnah ausgeformt. Unter „endkonturnah" soll dabei verstanden werden, dass diejenigen Teile der Geometrie des fertigen Bauteils 1, welche mit einem makroskopischen Materialfluss einhergehen, nach Abschluss des Kaltumformprozesses vollständig in den Bauteil-Rohling 10 eingeformt sind. Nach Abschluss des Kaltumformprozesses sind somit zur Herstellung der dreidimensionalen Form des Bauteils 1 nur noch geringe Formanpassungen notwendig, welche einen minimalen (lokalen) Materialfluss erfordern; der Bauteil-Rohling 10 ist in Fig. 2b dargestellt.

Je nach Komplexität des Bauteils 1 kann die endkonturnahe Formgebung in einem einzigen Tiefziehschritt erfolgen, oder sie kann mehrstufig erfolgen (Fig. 1b). Anschließend an den Kaltumformprozess wird der Bauteil-Rohling 10 in eine

Schneidvorrichtung 15 eingelegt und dort beschnitten (Prozessschritt III, Fig. 1c). Der Werkstoff befindet sich zu diesem Zeitpunkt immer noch im ungehärteten Zustand, daher kann das Beschneiden mit Hilfe konventioneller mechanischer Schneidmittel 14, wie etwa Schneidmesser, Abkant- und/oder Stanzwerkzeugen, erfolgen.

Für das Beschneiden kann, wie in Fig. 1c gezeigt, eine separate Schneidvorrichtung 15 vorgesehen sein. Alternativ können die Schneidmittel 14 in die letzte Stufe 9' des Tiefziehwerkzeugs 9 integriert sein, so dass in der letzten Tiefziehstufe 9' zusätzlich zu der Fertigformung des Blechteil-Rohlings 10 auch das randseitige Beschneiden erfolgt.

Durch den Kaltumformprozess und das Beschneiden (Prozessschritte II und III) wird aus der Platine 3 ein endkonturnah beschnittener Bauteil-Rohling 17 hergestellt der sowohl in Bezug auf seine dreidimensionale Form als auch in Bezug auf seine Randkontur 12' nur wenig von der gewünschten Form des Bauteils 1 abweicht. Die abgeschnittenen Randbereiche 11 werden in der Schneidvorrichtung 15 abgeführt; der Bauteil-Rohling 17 (Fig. 2c) wird mit Hilfe eines Manipulators 19 aus der Schneidvorrichtung 15 entnommen und dem nächsten Prozessschritt IV zugeführt.

In einer besonders vorteilhaften Alternative sind die Prozessschritte II und III in einer einzigen Bearbeitungsstation integriert, in der das Umformen und Schneiden vollautomatisch vorgenommen wird. Die Entnahme des Bauteil-Rohlings 17 aus der Bearbeitungsstation kann automatisiert erfolgen oder es kann eine manuelle Entnahme und Abstapelung der Bauteil-Rohlinge 17 erfolgen.

In dem folgenden Prozessschritt IV (Fig. 1d) wird der beschnittene Bauteil-Rohling 17 einer Warmumformung in einem Warmumformbereich 26 unterzogen, im Rahmen derer er auf eine endgültige Form des Bauteils 1 ausgeformt und gehärtet wird. Der beschnittene Bauteil-Rohling 17 wird von einem Manipulator 20 in einen Durchlaufofen 21 eingelegt, wo er auf eine Temperatur erhitzt wird, die oberhalb der Gefügeumwandlungstemperatur in den austenitischen Zustand liegt; je nach Stahlsorte entspricht dies einer Erhitzung auf eine Temperatur zwischen 700°C und 1100°C. Für einen bevorzugten Werkstoff eines borhaltigen Stahls, insbesondere Usibor 1500P, ist ein günstiger Bereich zwischen 900°C und 1000°C. Die Atmosphäre des Durchlaufofens kann durch Zugabe eines Schutzgases inertisiert werden, durch die Vorbeschichtung der Platinen 3 wird jedoch bereits zumindest ein ganzflächiges Verzundern der Rohlingsoberfläche verhindert.

Die unbeschichteten Schnittstellen der Randkontur 12' der beschnittenen Bauteil-Rohlinge 17 stellen nur einen sehr geringen Flächenanteil des Bauteil-Rohlings 17 dar, so dass eine Haftung einer später aufgebrachten Schicht praktisch nicht beeinflusst wird. Ein geeignetes Schutzgas zur Inertisierung ist z.B. Kohlendioxid oder Stickstoff.

Der erhitzte beschnittene Bauteil-Rohling 17 wird dann mit Hilfe eines Manipulators 22 in ein Warmumform-Werkzeug 23 eingelegt, in dem die dreidimensionale Gestalt und die Randkontur 12' des beschnittenen Bauteil-Rohlings 17 auf ihr gewünschtes Maß gebracht werden. Da der beschnittene Bauteil-Rohling 17 bereits endkonturnahe Maße aufweist, ist während der Warmumformung nur noch eine geringe Formanpassung notwendig. Im Warmumform-Werkzeug 23 wird der beschnittene Bauteil-Rohling 17 fertig geformt und schnell abgekühlt, wodurch ein feinkörniges martensitisches oder bainitisches Werkstoffgefü-

ge eingestellt wird. Dieser Schritt entspricht einer Härtung des Bauteil-Rohlings 18 und ermöglicht eine gezielte Einstellung der Werkstofffestigkeit. Einzelheiten eines solchen Härtungsprozesses sind z.B. in der DE 100 49 660 A1 beschrieben. Es kann sowohl der ganze Bauteil-Rohling 17 gehärtet werden, als auch lediglich lokal an ausgewählten Stellen des Bauteil-Rohlings 17 eine Härtung vorgenommen werden. Ist der gewünschte Härtungsgrad des Bauteil-Rohlings 18 erreicht, wird der gehärtete Bauteil-Rohling 18 mit einem Manipulator aus dem Warmumform-Werkzeug 23 genommen und gegebenenfalls bis zur weiteren Verarbeitung gestapelt. Wegen dem dem Warmumform-Prozess vorgelagerten endkonturnahen Beschneiden des Bauteil-Rohlings 10 sowie der Formanpassung der Randkontur 12' im Warmumform-Werkzeug 23 weist das Bauteil 18 nach Abschluss des Warmumform-Prozesses bereits die gewünschte Außenkontur 24 des fertigen Bauteils 1 auf, so dass nach der Warmumformung kein zeitaufwändiges Beschneiden des Bauteilrandes notwendig ist.

Um eine schnelle Abschreckung des Bauteil-Rohlings 18 im Zuge der Warmumformung zu erreichen, kann der Bauteil-Rohling 18 in einem gekühlten Warmumform-Werkzeug 23 abgeschreckt werden. Da die Oberfläche durch die Schicht 33 der Vorbeschichtung nicht verzundert, kann eine anschließende Reinigung entfallen.

Da kein Laserschneiden des gehärteten Bauteil-Rohlings 18 erfolgen muss, sind die Taktzeiten im Fertigungsverfahren vorteilhaft kurz. Im Verfahrensablauf ist nunmehr das Abkühlen des Bauteil-Rohlings 18 ein möglicher Engpass. Um diesen zu entschärfen, können lufthärtende oder wasserhärtende Werkstoffe für die Bauteile 1 eingesetzt werden. Der Bauteil-Rohling 18 braucht dann nur soweit abzukühlen, bis eine ausreichende Warmfestigkeit, Steifigkeit und damit verbundene

Maßhaltigkeit des Bauteil-Rohlings 18 erreicht ist. Dann kann der Bauteil-Rohling 18 aus dem Werkzeug 23 entnommen werden, so dass der weitere Wärmebehandlungsvorgang an der Luft oder in Wasser außerhalb des Werkzeugs 23 erfolgt, das dann nach einigen Sekunden sehr schnell wieder zur Aufnahme weiterer Bauteil-Rohlinge 17 zur Verfügung steht.

In einem weiteren Prozessschritt V (Fig. 1e) wird der pressgehärtete Bauteil-Rohling 18 in einem Beschichtungsverfahren mit einer eine Korrosion des Bauteils 1 verhindernden Schicht 34 überzogen. Dazu werden Trommeln 31 mit den pressgehärteten Bauteil-Rohlingen 18 sowie einem zinkhaltigen Pulver, vorzugsweise eine Zinklegierung oder eine zinkhaltige Mischung, beschickt, geschlossen und in eine Beschichtungsanlage 30 eingebracht. Dort werden die Bauteil-Rohlinge 18 langsam mit etwa 5-10 K/min unter langsamer Rotation der Trommeln 31 auf etwa 300°C erwärmt. In diesem thermischen Diffusionsverfahren verteilt sich das Zink bzw. die Zinklegierung im wesentlichen homogen über die gesamte Oberfläche der Bauteil-Rohlinge 18 und verbindet sich mit der Oberfläche. Bei einer aluminiumhaltigen Vorbeschichtung der Platinen 3 bildet sich eine ausgezeichnete Haftung zwischen der Vorbeschichtung, insbesondere AlSi und der zinkhaltigen Schicht 34 aus. Gleichzeitig werden auch die unbeschichteten Schnittkanten mit der zinkhaltigen Schicht 34 überzogen.

In Abhängigkeit der Zusammensetzung des Pulvers, der Zeit und der Temperatur stellt sich auf den Bauteil-Rohlingen 18 eine gleichmäßige Schichtdicke ein, die beliebig zwischen einigen μm und über 100 μm, bevorzugt zwischen 5 μm und 120 μm, eingestellt werden kann. Die Schicht 34 ist schweißbar und ergibt eine Zugfestigkeit, die für ein Bauteil 1 aus BTR 165 mehr als 1300 MPa betragen kann. Bei dem thermischen Diffusi-

onsverfahren fallen praktisch keine Rückstände oder Emissionen in die Umwelt an.

Das Beschichtungsverfahren wird mit einem Passivierungsvorgang in einer angrenzenden Passivierungsstation 35 abgeschlossen, bei dem die Trommeln 31 aus der Beschichtungsanlage 30 ausgeschleust, in einer Kühlstation 36 gekühlt, in einer Reinigungsstation 37 mit Ultraschall von Rückständen des Beschichtungspulvers befreit und in einer Temperstation 38 bei einer Temperatur von etwa 200°C für etwa 1 h getempert werden, wobei die Schicht 34 passiviert wird. Gegebenenfalls können auch geeignete Passivierungszusätze zugegeben werden. Dann können die fertigen korrosionsgeschützten Bauteile 1 aus der Trommel 31 entnommen werden.

In einer alternativen Ausgestaltung (Prozessschritt V', Fig. 1f) wird die zinkhaltige Schicht 34 mit einem Feuerverzinkungs-Verfahren in einem Beschichtungsbereich 40 auf den pressgehärteten Bauteil-Rohling 18 aufgebracht. Bauteil-Rohlinge 18 werden in ein Tauchgehäuse 41 eingehängt, welches die Bauteil-Rohlinge 18 durch mehrere Stationen des Beschichtungsbereichs 40 transportiert. In einer Flux-Station 42 werden die Bauteil-Rohlinge 18 in ein geeignet temperiertes Flussmittelbad gehängt, vorzugsweise mit Zinkchlorid bei etwa 360°C, dann in einer Trockenstation 43 getrocknet, vorzugsweise bei 80°C und anschließend in ein Verzinkungsbad 44 bei etwa 400-450°C eingetaucht und verzinkt. Dann können die fertigen Bauteile 1 aus dem Tauchgehäuse 31 entnommen werden.

Figuren 3a bis 3d zeigen schematisch einen alternativen Verfahrensablauf zur Herstellung eines räumlich geformten, pressgehärteten Bauteils 1 aus einem Halbzeug 2, insbesondere aus einer vorbeschichteten Platine 3. Ebenso wie im Ausführungsbeispiel der Figuren 1a bis 1e wird auch hier in einem

ersten Prozessschritt (Fig. 3a) die Platine 3 in der Platinenpresse 6 aus einem vorbeschichteten, warm umformbaren Blech ausgeschnitten. Anschließend wird die beschichtete Platine 3 einem Warmumformschritt unterzogen (Fig. 3b). Hierzu wird die Platine 3 von einem Manipulator 20' in einen Durchlaufofen 21' eingelegt, in dem die Platine 3 auf eine Temperatur erwärmt wird, die oberhalb der Übergangstemperatur in den austenitischen Gefügezustand liegt. Anschließend wird die erhitzte Platine 3 in ein Warmumformwerkzeug 23' eingelegt, in dem aus der Platine 3 ein Bauteil-Rohling 10' der gewünschten dreidimensionalen Form ausgeformt wird; dabei wird der Bauteil-Rohling 10' so schnell abgekühlt, dass er eine (bauteilweite oder lokale) Härtung erfährt. Der Durchlaufofen 21' und das Warmumformwerkzeug 23' können sich in einer Schutzgasatmosphäre 26' befinden, durch die Vorbeschichtung der Platinen 3 wird jedoch eine ganzflächige Verzunderung der Platinen 3 vermieden.

Dann wird der gehärtete Bauteil-Rohling 10' an eine Schneidvorrichtung 15' übergeben (Fig. 3c), in der der Bauteil-Rohling 10' randseitig beschnitten wird, um einen Rohling 18' mit Randkontur 12 zu erzeugen. Das Beschneiden erfolgt vorzugsweise mit einem Laser 14'. Die abgeschnittenen Randbereiche 11' werden entsorgt. In dem anschließenden Prozessschritt der Figur 3d wird der pressgehärtete und beschnittene Rohling 18' - analog zu der Prozessstufe V oder V' der Figuren 1e bzw. 1f - in einer Beschichtungsanlage 30 beschichtet.

Das pressgehärtete, beschichtete Bauteil 1 ist insbesondere als Karosseriebauteil im Fahrzeugbau geeignet, welche in großen Stückzahlen hergestellt werden. Das erfindungsgemäße Verfahren ermöglicht eine vorteilhafte Prozessführung mit kurzen Taktzeiten, alle Prozessschritte haben Industrialisierungspotential. Trotz Verwendung eines vorbeschichteten Werkstoffs

ist ein Einsatz einer konventionellen Vor-Umformung möglich. Durch das nachträgliche Aufbringen eines zusätzlichen Korrosionsschutzes wird ein konventionelles Umformen und Beschneiden auch bei hochfesten Werkstoffen möglich, so dass - bei Verwendung des Herstellungsverfahrens gemäß Figur 1 - das bei großen Stückzahlen aufwändige Laserschneiden kostengünstig ersetzt werden kann. Blechbauteile können durch diese Fertigungsmethode bereits in der Entwicklung durch konventionelle Umform-Simulation auf ihre Herstellung abgesichert werden. Hinzu kommt eine günstige Verbindung der Korrosionsschutzeigenschaften der Vorbeschichtung 33 einerseits mit denen der Schicht 34 mit dem Vorteil der Kantenbeschichtung, insbesondere bei AlSi-Schichten 33 in Verbindung mit Zinkschichten 34. In einem Fahrzeug wiederum, das aus solchen Bauteilen gefügt ist, wird der Kraftstoffverbrauch durch die Verminderung des Gewichts der Bauteile gesenkt, da diese wesentlich dünner sein können als konventionelle Blechteile, während gleichzeitig die passive Sicherheit erhöht wird, da die Bauteile eine sehr hohe Festigkeit aufweisen.

Patentansprüche

1. Verfahren zur Herstellung von pressgehärteten Bauteilen, insbesondere eines Karosseriebauteils, aus einem Halbzeug (2) aus ungehärtetem, warm umformbaren Stahlblech, dadurch gekennzeichnet, dass folgende Verfahrensschritte ausgeführt werden
   - aus dem mit einer ersten Schicht (33) vorbeschichteten Halbzeug (2) wird durch ein Kaltumformverfahren, insbesondere ein Ziehverfahren, ein Bauteil-Rohling (10) geformt;
   - der Bauteil-Rohling (10) wird randseitig auf eine dem herzustellenden Bauteil (1) näherungsweise entsprechende Randkontur (12') beschnitten;
   - der beschnittene Bauteil-Rohling (17) wird erwärmt und in einem Warmumform-Werkzeug (23) pressgehärtet;
   - der pressgehärtete Bauteil-Rohling (18) wird in einem Beschichtungsschritt mit einer zweiten, vor Korrosion schützenden Schicht (34) überzogen.

2. Verfahren zur Herstellung von pressgehärteten Bauteilen, insbesondere eines Karosseriebauteils, aus einem Halbzeug (2) aus ungehärtetem, warm umformbaren Stahlblech, dadurch gekennzeichnet, dass folgende Verfahrensschritte ausgeführt werden

- das mit einer ersten Schicht (33) vorbeschichtete Halbzeug (2) wird erwärmt und in einem Warmumform-Werkzeug (23) pressgehärtet;
- der auf diese Weise erzeugte pressgehärtete Bauteil-Rohling (10') wird randseitig auf eine dem herzustellenden Bauteil (1) entsprechende Randkontur (12) beschnitten;
- der pressgehärtete Bauteil-Rohling (18') wird in einem Beschichtungsschritt mit einer zweiten, vor Korrosion schützenden Schicht (34) überzogen.

3. Verfahren nach Anspruch 1 oder 2,
d a d u r c h g e k e n n z e i c h n e t ,
dass die Schicht (34) mit einem Feuerverzinkungs-Verfahren auf den pressgehärteten Bauteil-Rohling (18,18') aufgebracht wird.

4. Verfahren nach Anspruch 1 oder 2,
d a d u r c h g e k e n n z e i c h n e t ,
dass die Schicht (34) mit einem thermischen Diffusions-Verfahren auf den pressgehärteten Bauteil-Rohling (18,18') aufgebracht wird.

5. Verfahren nach zumindest einem der vorangegangenen Ansprüche,
d a d u r c h g e k e n n z e i c h n e t ,
dass die Schicht (34) sowohl auf der Vorbeschichtung (33) als auch auf unbeschichteten Bereichen des Bauteil-Rohlings (18,18') abgeschieden wird.

6. Verfahren nach zumindest einem der vorangegangenen Ansprüche,
d a d u r c h g e k e n n z e i c h n e t ,
dass der beschichtete Bauteil-Rohling (18,18') nach dem

Beschichtungsschritt von Rückständen des Beschichtungsschritts gereinigt wird.

7. Verfahren nach zumindest einem der vorangegangenen Ansprüche,
d a d u r c h g e k e n n z e i c h n e t ,
dass der beschichtete Bauteil-Rohling (18,18') nach dem Beschichtungsschritt getempert wird.

8. Pressgehärtetes Bauteil, insbesondere Karosseriebauteil, aus einem Halbzeug (2) aus ungehärtetem, warm umformbaren, mit einer Korrosionsschutzschicht (33) vorbeschichteten Stahlblech,
d a d u r c h g e k e n n z e i c h n e t ,
dass es nach dem Verfahren nach zumindest einem der vorangegangenen Ansprüche hergestellt ist.

9. Pressgehärtetes Bauteil nach Anspruch 8,
d a d u r c h g e k e n n z e i c h n e t ,
dass ein Überzug aus einer ersten, aluminiumhaltigen Schicht (33) und einer darüber angeordneten zweiten, zinkhaltigen Schicht (34) auf dem Bauteil abgeschieden ist.

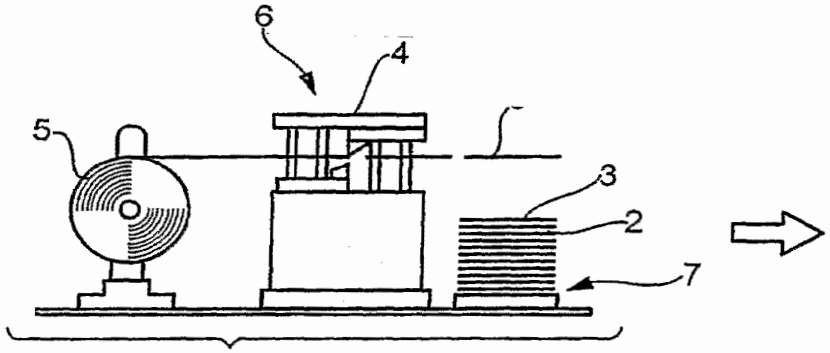

Fig. 1a

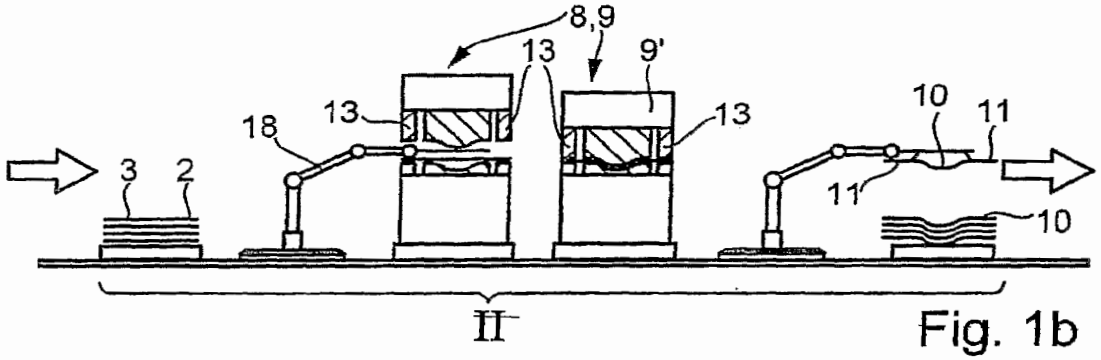

Fig. 1b

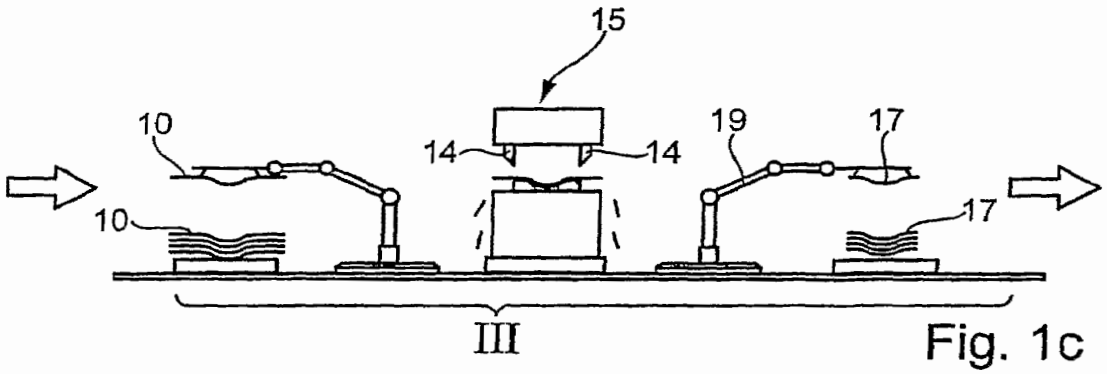

Fig. 1c

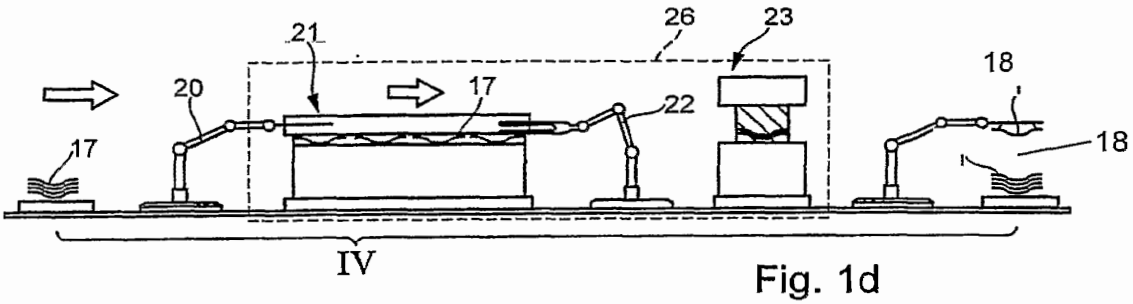

Fig. 1d

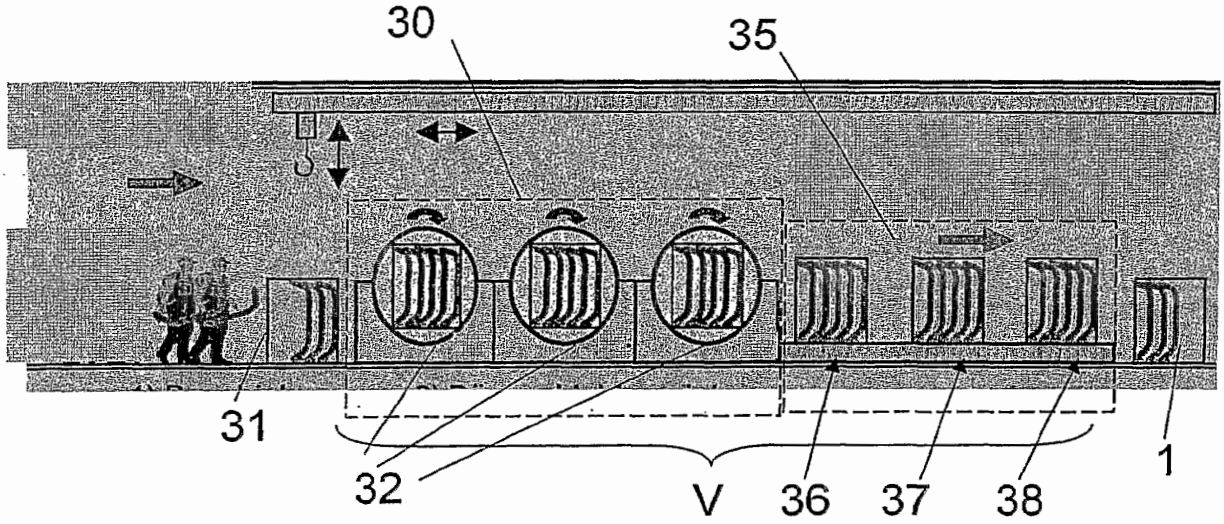

Fig. 1e

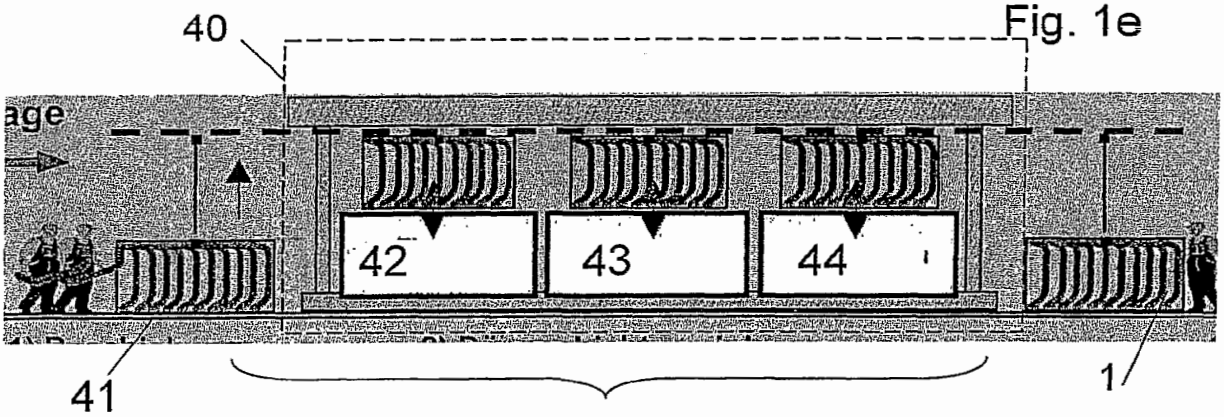

Fig. 1f

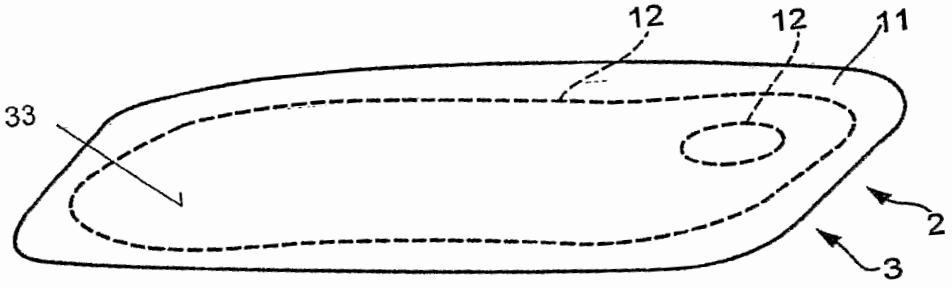

Fig. 2a

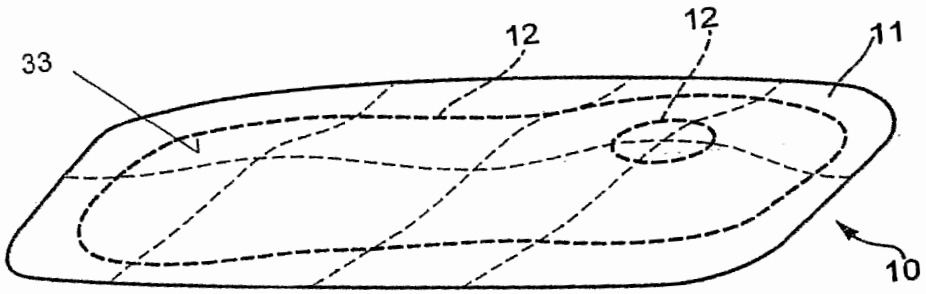

Fig. 2b

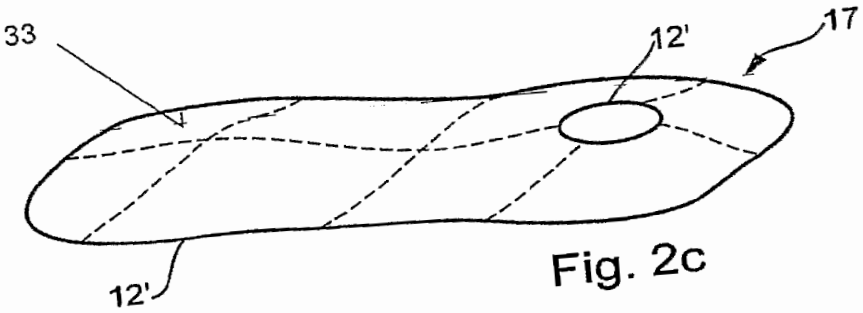

Fig. 2c

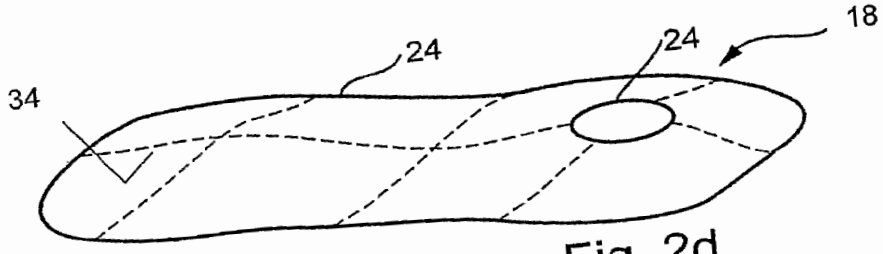

Fig. 2d

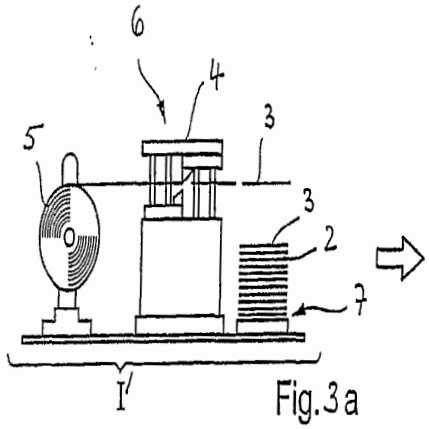

Fig. 3a

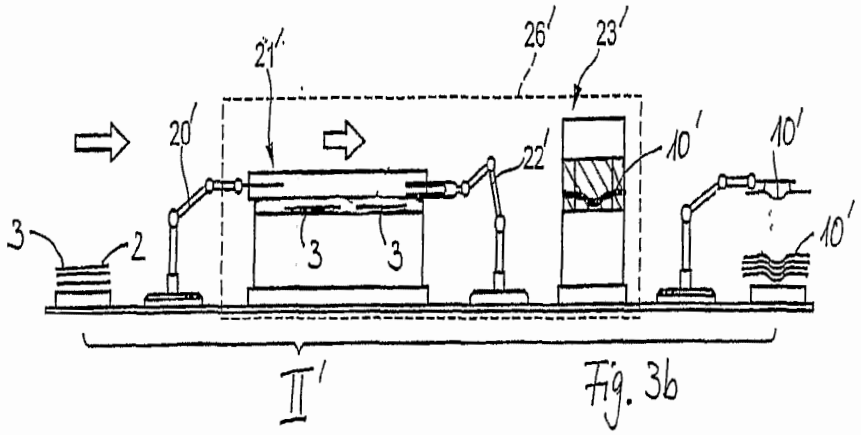

Fig. 3b

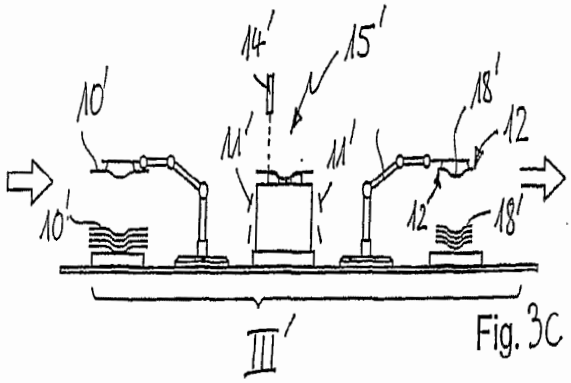

Fig. 3c

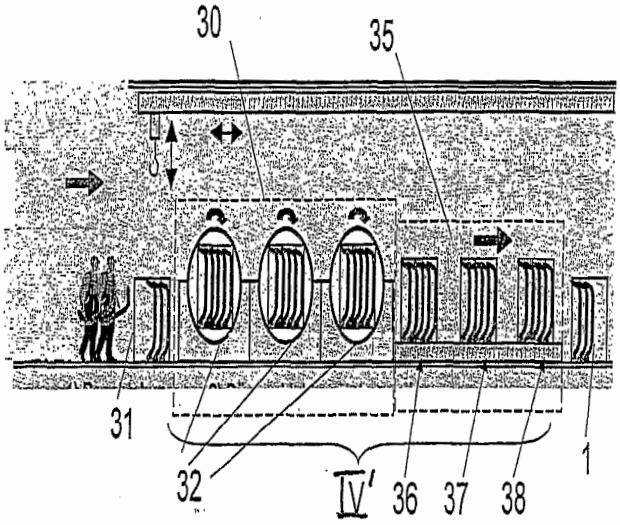

Fig. 3d

INTERNATIONAL SEARCH REPORT

International Application No
PCT/EP2004/008087

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 B21D35/00 C21D1/673 C21D9/46

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 B21D C21D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal, WPI Data, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	DE 101 35 647 C (DAIMLER CHRYSLER AG) 25 July 2002 (2002-07-25) figures 1a,1b	1-9
A	DE 101 49 221 C (BENTELER AUTOMOBILTECHNIK GMBH) 8 August 2002 (2002-08-08) cited in the application claim 1; figures 1-3	1-9
A	DE 100 49 660 A (DAIMLER CHRYSLER AG ; BENTELER AUTOMOBILTECHNIK GMBH (DE)) 25 April 2002 (2002-04-25)	1-7
X	column 7, line 35 - column 7, line 57; claim 24	8,9
A	DE 43 07 563 A (BAYERISCHE MOTOREN WERKE AG) 23 September 1993 (1993-09-23) column 2, line 37 - column 2, line 44	8,9

-/--

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

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Date of the actual completion of the international search	Date of mailing of the international search report
11 November 2004	29/11/2004

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Vinci, V

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INTERNATIONAL SEARCH REPORT

International Application No
PCT/EP2004/008087

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
P,A	WO 2004/033126 A (DAIMLER CHRYSLER AG ; FISCHER UWE (DE); MEHRHOLZ RALF (DE); BRODT MART) 22 April 2004 (2004-04-22) figures 1a-1e	1-9

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INTERNATIONAL SEARCH REPORT

›rmation on patent family members

Interr[redacted]nal Application No
PCT/EP2004/008087

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
DE 10135647 C	25-07-2002	DE 10135647 C1	25-07-2002
DE 10149221 C	08-08-2002	DE 10149221 C1	08-08-2002
		EP 1300475 A2	09-04-2003
		US 2003066582 A1	10-04-2003
DE 10049660 A	25-04-2002	DE 10049660 A1	25-04-2002
		EP 1195208 A2	10-04-2002
		JP 3553536 B2	11-08-2004
		JP 2002178069 A	25-06-2002
		US 2002069506 A1	13-06-2002
DE 4307563 A	23-09-1993	DE 4307563 A1	23-09-1993
WO 2004033126 A	22-04-2004	DE 10254695 B3	15-04-2004
		WO 2004033126 A1	22-04-2004

Form PCT/ISA/210 (patent family annex) (January 2004)

INTERNATIONALER RECHERCHENBERICHT

Internationales Aktenzeichen
PCT/EP2004/008087

A. KLASSIFIZIERUNG DES ANMELDUNGSGEGENSTANDES
IPK 7 B21D35/00 C21D1/673 C21D9/46

Nach der Internationalen Patentklassifikation (IPK) oder nach der nationalen Klassifikation und der IPK

B. RECHERCHIERTE GEBIETE

Recherchierter Mindestprüfstoff (Klassifikationssystem und Klassifikationssymbole)
IPK 7 B21D C21D

Recherchierte aber nicht zum Mindestprüfstoff gehörende Veröffentlichungen, soweit diese unter die recherchierten Gebiete fallen

Während der internationalen Recherche konsultierte elektronische Datenbank (Name der Datenbank und evtl. verwendete Suchbegriffe)

EPO-Internal, WPI Data, PAJ

C. ALS WESENTLICH ANGESEHENE UNTERLAGEN

Kategorie°	Bezeichnung der Veröffentlichung, soweit erforderlich unter Angabe der in Betracht kommenden Teile	Betr. Anspruch Nr.
A	DE 101 35 647 C (DAIMLER CHRYSLER AG) 25. Juli 2002 (2002-07-25) Abbildungen 1a,1b	1-9
A	DE 101 49 221 C (BENTELER AUTOMOBILTECHNIK GMBH) 8. August 2002 (2002-08-08) in der Anmeldung erwähnt Anspruch 1; Abbildungen 1-3	1-9
A	DE 100 49 660 A (DAIMLER CHRYSLER AG ; BENTELER AUTOMOBILTECHNIK GMBH (DE)) 25. April 2002 (2002-04-25)	1-7
X	Spalte 7, Zeile 35 - Spalte 7, Zeile 57; Anspruch 24	8,9
A	DE 43 07 563 A (BAYERISCHE MOTOREN WERKE AG) 23. September 1993 (1993-09-23) Spalte 2, Zeile 37 - Spalte 2, Zeile 44	8,9

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[X] Weitere Veröffentlichungen sind der Fortsetzung von Feld C zu entnehmen

[X] Siehe Anhang Patentfamilie

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Datum des Abschlusses der internationalen Recherche	Absendedatum des internationalen Recherchenberichts
11. November 2004	29/11/2004

Name und Postanschrift der Internationalen Recherchenbehörde	Bevollmächtigter Bediensteter
Europäisches Patentamt, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Vinci, V

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INTERNATIONALER RECHERCHENBERICHT

Internationales Aktenzeichen
PCT/EP2004/008087

C.(Fortsetzung) ALS WESENTLICH ANGESEHENE UNTERLAGEN

Kategorie°	Bezeichnung der Veröffentlichung, soweit erforderlich unter Angabe der in Betracht kommenden Teile	Betr. Anspruch Nr.
P,A	WO 2004/033126 A (DAIMLER CHRYSLER AG ; FISCHER UWE (DE); MEHRHOLZ RALF (DE); BRODT MART) 22. April 2004 (2004-04-22) Abbildungen 1a-1e	1-9

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INTERNATIONALER RECHERCHENBERICHT

Angaben zu Veröffentlichungen, die zur selben Patentfamilie gehören

Internales Aktenzeichen
PCT/EP2004/008087

Im Recherchenbericht angeführtes Patentdokument		Datum der Veröffentlichung	Mitglied(er) der Patentfamilie		Datum der Veröffentlichung
DE 10135647	C	25-07-2002	DE	10135647 C1	25-07-2002
DE 10149221	C	08-08-2002	DE	10149221 C1	08-08-2002
			EP	1300475 A2	09-04-2003
			US	2003066582 A1	10-04-2003
DE 10049660	A	25-04-2002	DE	10049660 A1	25-04-2002
			EP	1195208 A2	10-04-2002
			JP	3553536 B2	11-08-2004
			JP	2002178069 A	25-06-2002
			US	2002069506 A1	13-06-2002
DE 4307563	A	23-09-1993	DE	4307563 A1	23-09-1993
WO 2004033126	A	22-04-2004	DE	10254695 B3	15-04-2004
			WO	2004033126 A1	22-04-2004

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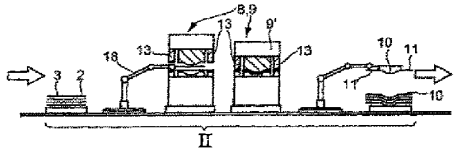
(54)【発明の名称】プレス焼入れ部品及びその製造方法

(57)【要約】
本発明は、プレス焼入れ部品、より詳細には自動車の車体のプレス焼入れ部品を製造する方法に関し、該部品は、前記方法により製造されるプレス焼入れ部品の他に、非焼入れの、高温で変形可能な鋼板製半製品（２）で構成される。本発明的方法は様々な工程を含む。半製品（２）は、第１被膜（３３）でプレコートされており、冷間成形法、特に絞り加工によって部品ブランク（１０）を成形するのに使用される。部品ブランク（１０）の縁端側は、製造される部品（１）にほぼ一致する輪郭形状（１２’）を形成するよう切断される。切断された部品ブランク（１７）は、熱間成形器具（２３）内で加熱されかつプレス焼入れされる。その後、プレス焼入れされた部品ブランク（１８）には、被覆工程で第２の耐食被膜（３４）が施される。



【特許請求の範囲】
【請求項1】
プレス焼入れ部品、特に車両車体構成部品を、非焼入れの熱間加工可能な鋼板製半製品（２）から製造する方法であって、
第１被膜（３３）でプレコートされた前記半製品（２）から、冷間成形法、特に絞り加工によって、部品ブランク（１０）が成形されるステップと、
該部品ブランク（１０）が、縁端部で、製造される部品（１）にほぼ一致する輪郭形状（１２’）にトリミングされるステップと、
該トリミングされた部品ブランク（１７）が、熱間成形器具（２３）内で加熱され、プレス焼入れされるステップと、
前記プレス焼入れされた部品ブランク（１８）が、被覆工程で第２の耐食被膜（３４）で被覆されるステップと、
が実行されることを特徴とする、方法。
【請求項2】
プレス焼入れ部品、特に車両車体構成部品を、非焼入れの熱間加工可能な鋼板製半製品（２）から製造する方法であって、
第１被膜（３３）でプレコートされた前記半製品（２）が、熱間成形器具（２３）内で加熱されプレス焼入れされるステップと、
該プレス焼入れされた部品ブランク（１０’）が、縁端部で、製造される部品（１）に一致する輪郭形状（１２）にトリミングされるステップと、
前記プレス焼入れされた部品ブランク（１８’）が、被覆工程で第２の耐食被膜（３４）で被覆されるステップと、
が実行されることを特徴とする、方法。
【請求項3】
前記被膜（３４）は、溶融亜鉛めっき被覆法によって前記プレス焼入れブランク（１８、１８’）へ塗付されることを特徴とする請求項１あるいは２に記載の方法。
【請求項4】
前記被膜（３４）は、熱拡散法によって前記プレス焼入れ部品ブランク（１８、１８’）へ塗付されることを特徴とする請求項１あるいは２に記載の方法。
【請求項5】
前記被膜（３４）は、前記部品ブランク（１８、１８’）の前記プレコート（３３）領域と非被覆領域との両方に溶着されることを特徴とする請求項１～４のいずれか一項に記載の方法。
【請求項6】
被覆された前記部品ブランク（１８、１８’）は、前記被覆工程後、前記被覆工程での残留物が取り除かれることを特徴とする請求項１～５のいずれか一項に記載の方法。
【請求項7】
被覆された前記部品ブランク（１８、１８’）は、前記被覆工程の後、焼戻しされることを特徴とする請求項１～６のいずれか一項に記載の方法。
【請求項8】
耐食被膜（３３）を施された非焼入れの熱間加工可能な鋼板製の半製品（２）から成形されたプレス焼入れ部品、特に車両車体構成部品であって、請求項１～７のいずれか一項に記載の方法により製造されることを特徴とするプレス焼入れ部品。
【請求項9】
第１のアルミニウム含有被膜とその上に配置された第２の亜鉛含有被膜とからなる被覆が、前記部品上に溶着されることを特徴とする請求項８に記載のプレス焼入れ部品。

【発明の詳細な説明】
【技術分野】
【0001】
本発明は、独立請求項の前段によるプレス焼入れ部品及びプレス焼入れ部品の製造方法

に関する。
【背景技術】
【0002】
車両の構造においては、車体部品の強度と剛性について厳しい要求が益々課されるようになっている。しかし同時に、軽量化のために、材料の厚さの削減も目指している。高強度及び超高強度素材は相反する要求を満たす解決策を提供し、これらの素材は、非常に高強度で同時に薄い材料厚さの部品の製造を可能にする。これらの材料の場合、従来の熱間成形中の加工パラメータの適切な選択によって、部品の強度と靭性の値を具体的に設定することが可能である。
【0003】
こうした材料には、例えば、Ｕｓｉｂｏｒ　１５００という登録商標でユシノール（Ｕｓｉｎｏｒ）社が販売しているプレコートホウ素鋼がある。スチールには、その後の熱処理過程で特に有利な錆止め特性を示す、ＡｌＳｉ被膜が施されている。
【0004】
熱間成形を用いてこうした部品を製造するには、まず最初に、板材がコイルから切り取られ、その後この板材は、スチール素材の変態温度より高い温度で加熱され、この温度を超えると材料構造はオーステナイト状態になり、加熱された状態で成形器具の中へ挿入され、所望の部品の形状に成形され、所望の成形状態が機械的に固定されている間冷却され、部品の焼戻し又は焼入れが行われる。
【0005】
部品は、実際の熱間成形の前に、しばしば予備成形工程又はトリミング工程にかけられる。このことは、例えば特許文献１に記載されている。しかし、このような方法は、普通に塗付されたコイルの被膜は予備成形中に損傷されるので、腐食に関連する問題を提起する。従って、特にＡｌＳｉ被膜を施したＵｓｉｂｏｒ　１５００　ＰＣのようなプレコートされた高強度鋼の場合、部品の従来の予備成形又はトリミングは、省略される。
【0006】
【特許文献1】独国特許発明第　１０１　４９　２２１　Ｃ１号明細書
【発明の開示】
【発明が解決しようとする課題】
【0007】
本発明の目的は、プレコートされた熱間加工可能な鋼材のために信頼性の高い錆止めを可能にするプレス焼入れ部品及びプレス焼入れ部品の製造方法とを特定することである。
【課題を解決するための手段】
【0008】
この目的は、本発明に従って独立請求項１、２及び８の特徴により達成される。
【0009】
プレス焼入れ部品を製造するための本発明による方法の第１の実施形態は、次の工程を含む：部品ブランクは、冷間成形法、特に絞り加工によって、半製品から成形される；部品ブランクは、縁端部で、製造される部品にほぼ一致する輪郭形状にトリミングされる；トリミングされた部品ブランクは、熱間成形器具内で加熱されかつプレス焼入れされる；プレス焼入れされた部品ブランクは、被覆工程で耐食被膜によって被覆される。
【0010】
本発明のこの構成は、まず部品製造工程において、焼入れされた部品の最終トリミングは加工が複雑で費用がかかるが、このトリミングを省くことが可能となるように構成されることを可能にする。縁端領域は、部品が非焼入れの状態で既に切り落とされてしまい、熱間成形中における従来の方法のように加熱及び焼入れ加工後までそのままにしておかない。仕掛品は既に柔軟な状態でトリミングされているので、必要とされる切断力は焼入れ材料を冷間切断するためよりもかなり小さく、切断器具の材料磨耗の軽減及び維持費用の削減をもたらす。さらに、高強度素材を非焼入れ状態でトリミングすると、これらの材料の高切欠き感度のために、急に亀裂を成す危険性が低下する。

【0011】
半製品に施されたプレコートは、焼入れ工程中のトリミング済部品ブランクから薄片がはがれ落ちるのを回避し、焼入れ中の不活性雰囲気のための要件は軽減可能である。これに加えてプレコートは、焼入れ中の材料の脱炭を防止する。本発明によると、焼入れ工程の後さらに別の耐食被膜が塗付されるので、部品は完全に、すなわち縁端部も被覆される。
【0012】
プレス焼入れ部品を製造する本発明による方法の別の実施形態では、次の工程が実施される：第１被膜でプレコートされた半製品は、熱間成形器具内で加熱されかつプレス焼入れされる；このようにプレス焼入れされた部品ブランクは、縁端部で、製造される部品に一致する輪郭形状にトリミングされる；プレス焼入れされ、トリミングされた部品ブランクは、被覆工程で第２の耐食被膜を被覆される。
【0013】
この実施形態では、焼入れ部品は、好ましくはレーザー切断加工もしくはウォータージェット切断加工を用いてトリミングされるので、それによって部品縁端部の高品質なトリミングの実現を可能にする。その後の第２耐食被膜の塗付により、部品はさらにトリミングされた縁端部付近の腐食からも確実に保護されるようになる。
【0014】
溶融亜鉛めっき被覆法によりプレス焼入れブランクに被膜が塗付される場合、亜鉛の耐食被膜は、製造工程に適切に統合可能な被覆工程によって、塗付されるようにすることも可能である。
【0015】
被膜が熱拡散法によってプレス焼入れ部品ブランクへ塗付される場合、容易に制御可能な、亜鉛もしくは亜鉛合金の被膜が塗付される加工法が使用されることも可能で、この方法は複雑な部品の幾何学的形状や縁端部被覆にとっても、適している。被膜厚は、数μｍ～１００μｍ超まで、具体的に設定されるようにすることも可能である。部品の熱応力は僅かである。部品は、大きさ、寸法、構成、複雑性、及び重量に関わりなく、被覆されることが可能である。プレコートは、熱間成形中の部品ブランクから薄片のはがれ落ちを実質的に防止するので、被覆工程前のドライクリーニングによる洗浄、特にガラス粒子又は亜鉛粒子によるプレス焼入れ部品ブランクのブラストは、省くことが可能である。それによって工程ステップは省略され、部品の微粒子によるブラストに起因する極僅かではあるが妨げになる可能性のある部品の歪みは、さらに回避される。
【0016】
アルミ含有被膜、好ましくはＡｌＳｉ被膜と、亜鉛含有被膜とによるプレコート中、２つの被膜の間に良好な密着性が得られる。これに加えて、水素脆化に対する材料の良好な保護が得られ、亜鉛は特にこの水素脆化に対して材料を保護することができる。プレコートの第１被膜に塗付される第２被膜は、縁端被覆と、例えば予備成形中に過剰な摩擦のためにプレコートの第１被膜がはがれた又はクラックが入った領域の被覆と、を提供する。
【0017】
被覆工程後、被覆された部品ブランクから被覆工程の残留物が取り除かれた場合、例えば超音波によって不動態化された場合、被膜、特に塗料の下塗り剤又は塗料そのものにとって、良好な付着土台を生成する表面が形成される。
【0018】
被覆部品ブランクは、被覆工程後、好適に焼戻しされる。これは、部品ブランクが亜鉛含有被膜で被覆される場合、付着土台として適した酸化物が表面に形成されるので、特に有利である。
【0019】
本発明によるプレス焼入れ部品、特に車両車体構成部品は、非焼入れの熱間加工可能な鋼板製の半製品で構成されており、本発明による方法の少なくとも１つの発展形態により製造される。このような部品は、大量の大規模生産に特に適した方法で製造されることが

可能であり、優良な錆止めを備えた部品の重量の好適な削減を兼ね備えている。
【0020】
本発明のさらなる利点及び構成は、さらなる請求項及び以下の記述から得られる。
【0021】
以下、図面に示す例示された実施形態を参照して、本発明をより詳細に説明する。
【発明を実施するための最良の形態】
【0022】
図１ａ～図１ｅは、半製品２から三次元成形されたプレス焼入れ部品１を製造するための本発明による方法を、概略的に示している。例示された本実施形態では、使用される半製品２は、巻き戻されるコイル５を切り取った板材３である。あるいはその代わりに、使用される半製品２は、複合材シート、例えば、独国特許出願公開第　１００　４９　６６０　Ａ１号明細書に記載のようなものでもよく、これはベースシート及び少なくとも１枚の補強シートで構成される。さらに、使用される半製品２は、異なる材料厚及び／又は異なる材料組成のシートが複数一緒に溶接されて構成される特別調整されたブランクであってもよい。あるいはその代わりに、半製品２は三次元に成形された板金部品でもよく、該部品はあらゆる所望の成形法で製造され、本発明による方法を用いて、さらに別の成形を受け、強度及び／又は剛性の増加がもたらされる。
【0023】
半製品２は非焼入れの熱間加工可能な鋼板で構成される。特に好ましい材料は焼戻しホウ素鋼であり、例えば、Ｕｓｉｂｏｒ　１５００、Ｕｓｉｂｏｒ　１５００　Ｐ、又はＵｓｉｂｏｒ　１５００　ＰＣなどがあり、これらの登録商標でユシノール（Ｕｓｉｎｏｒ）社により販売されている。
【0024】
第１工程ステップＩでは、板材３（図１ａ）は、プレコートされた熱間加工可能な板材で構成されるコイル５の巻き戻されて真直ぐに伸ばされた部分から切り取られる。被膜は、アルミニウム又はアルミニウム合金、特にアルミニウム・シリコン合金Ａｌ Ｓｉの被膜が好ましい。この時点で、熱間加工可能な材料は非焼入れ状態であり、そのため板材３は、従来の機械的切断手段４、例えば往復剪断機を用いて、問題なく切り取られることが可能である。大規模生産で使用する場合、板材３は、打ち抜きプレス機６を用いて大きさに合わせて好適に切断され、該プレス機は、コイル５の自動的供給、及び自動打ち抜き、及び切り取られた板材３の取り出しを、確実に行う。この方法で切り取られた板材３は、図２ａの概略的斜視図に示されている。
【0025】
切り取られた板材３は、スタック７上に堆積され、積み重ねられた形で冷間成形ステーション８へ供給される（図１ｂ）。ここで、第２工程ステップＩＩでは、冷間成形器具８、例えば２段階深絞り加工器具９を用いて、板材３から部品ブランク１０が成形される。部品の幾何学的形状の高品質な成形を確保できるように、板材３は、成形される部品１の外側輪郭１２を越えて突き出ている縁端領域１１を有する。この冷間成形加工（工程ステップＩＩ）の工程では、部品ブランク１０はほぼ有効形状に成形される。この場合、「ほぼ有効形状」とは、巨視的材料の流れを伴う仕上がり部品１が、これらの部分の幾何学的形状が冷間成形加工の完了後に部品ブランク１０において完全に成形されることを意味する。従って、冷間成形加工の完了後に部品１の三次元形状を生成するために必要なのは、最小限度の（局部的）材料の流れを要する僅かな形状の適合だけである。部品ブランク１０は図２ｂに示す。
【0026】
部品１の複雑性次第で、ほぼ有効形状への成形は、単一の深絞り加工工程で実行されてもよく、又は複数の段階で実行されてもよい（図１ｂ）。冷間成形加工に続いて、部品ブランク１０は、切断装置１５内へ挿入され、そこでトリミングされる（工程ステップＩＩＩ、図１ｃ）。この時点の材料は、まだ非焼入れ状態であり、従ってトリミングは、例えば、切断ブレード、刃、及び／又は打ち抜き器具等の、従来の機械的切断手段１４で実施

されてもよい。

【0027】

図１ｃに示すように、独立した切断装置１５がトリミング用に設けられてもよい。あるいはその代わりに、切断手段１４が深絞り加工器具９の最終段階９’に組み込まれてもよく、それによって最終深絞り加工段階９’において、部品ブランク１０の仕上げ成形の他に、縁端トリミングが実行されてもよい。

【0028】

ほぼ有効形状にトリミングされた部品ブランク１７は、板材３から冷間成形加工及びトリミング（工程ＩＩ及びＩＩＩ）によって生成され、このトリミング済部品ブランク１７は、三次元形状及び輪郭形状１２’に関して、部品１の所望の形状から僅かしか逸脱していない。切り落とされた縁端領域１１は、切断装置１５内で取り除かれ、部品ブランク１７（図２ｃ）は切断装置１５からマニピュレーター１９を用いて取り出され、次の工程ステップＩＶへ送られる。

【0029】

特に有利な代替方法では、工程ＩＩ及びＩＩＩは１つの処理ステーションに統合され、そこで成形及び切断が完全に自動化された方法で実施される。部品ブランク１７は、処理ステーションから自動化された方法で取り出されてもよく、あるいは部品ブランク１７は手動で取り出され、積み重ねられてもよい。

【0030】

その後の工程ステップＩＶ（図１ｄ）では、トリミング済部品ブランク１７は熱間成形領域２６で熱間成形にかけられ、その工程において部品１の最終形状へ成形され、焼入れされる。トリミング済部品ブランク１７は、マニピュレーター２０を用いて連続炉２１内へ挿入され、そこで変態温度を超えるオーステナイト状態の温度へ加熱され、鋼のタイプによって７００℃～１１００℃の温度加熱に対応する。好ましいホウ素鋼素材、特にＵｓｉｂｏｒ　１５００Ｐ、にとって、好適な範囲は９００℃～１０００℃である。連続炉の雰囲気は、不活性ガスの添加によって不活性になるが、しかし、板材３のプレコートは既に板材の表面全体に対して少なくとも薄片のはがれ落ちを防止している。

【0031】

トリミング済部品ブランク１７の輪郭形状１２’の被覆されていない断面部は、部品ブランク１７の面積の極僅かな部分でしかないので、その後塗付される被膜の付着性は実質的に影響されない。周辺雰囲気に不活性をもたらすのに適した不活性ガスは、例えば、二酸化炭素又は窒素である。

【0032】

その後、加熱されたトリミング済部品ブランク１７は、マニピュレーター２２を用いて熱間成形器具２３内へ挿入され、その中でトリミング済部品ブランク１７の三次元形状及び輪郭形状１２’に所望の大きさが与えられる。トリミング済部品ブランク１７は、既にほぼ有効形状な寸法になっているので、熱間成形中に必要な形状の適合は僅かである。熱間成形器具２３内で、トリミング済部品ブランク１７は仕上げ成形され、急速冷却され、その結果、きめの細かいマルテンサイト又はベイナイトの素材構造が固定される。この工程は部品ブランク１８の焼入れに相当し、材料強度の具体的固定化を可能にする。こうした焼入れ工程の詳細は、例えば独国特許出願公開第　１００　４９　６６０　Ａ１号明細書に記載されている。部品ブランク１７全体及び部品ブランク１７の局部的に選択された点の両方とも焼入れを受けてもよい。部品ブランク１８の所望の焼入れ具合が達成された場合、焼入れ部品ブランク１８は熱間成形器具２３からマニピュレーターを用いて取り出され、必要なであれば、さらなる処理が行われるまで積み重ねられる。部品ブランク１０は、熱間成形加工前にほぼ有効形状へトリミングされていること、及び熱間成形器具２３における輪郭形状１２’の形状の適合を考慮すると、部品１８は熱間成形加工の完了後には既に仕上がり部品１の所望の外側輪郭２４を有しており、従って時間のかかる部品縁端部のトリミングは熱間成形後は必要ない。

【0033】

熱間成形の工程において部品ブランク１８の急速な焼入れを実現するために、部品ブランク１８は、冷却された熱間成形器具２３内で焼入れされてもよい。プレコートの被膜３３は表面から薄片がはがれ落ちるのを防いでくれるので、その後のクリーニングは省略してもよい。

【0034】

焼入れ部品ブランク１８のレーザー切断は実行される必要がないので、製造方法のサイクルタイムは有利に短い。製法手順では、今度は部品ブランク１８の冷却がボトルネックとなる可能性がある。ボトルネックを緩和するために、空気焼入れ又は水焼入れ材料が部品１に使用されてもよい。その後、部品ブランク１８は、部品ブランク１８の十分な熱安定性、剛性、及び関連する寸法の正確性が達成されるまで、冷却されるだけでよい。その後部品ブランク１８は、器具２３から取り出され、それによってさらなる熱処理加工が器具２３の外で空気中又は水中で実施され、そして該器具２３は非常に速く数秒後には別の部品ブランク１７を受け入れて利用可能となる。

【0035】

さらなる工程ステップＶ（図１ｅ）では、プレス焼入れ部品ブランク１８は、部品１の腐食を防止する被膜３４による被覆工程で被覆される。この目的のために、ドラム３１にはプレス焼入れ部品ブランク１８と亜鉛含有粉、好ましくは亜鉛合金もしくは亜鉛混合物、とが充填され、閉じられて、被覆装置３０の中へ挿入される。部品ブランク１８は、そこでドラム３１をゆっくり回転させながら、約５～１０Ｋ／分で約３００℃まで加熱される。この熱拡散法では、亜鉛もしくは亜鉛合金が部品ブランク１８の表面全体を覆うように実質的には均一に分布され、表面と結合する。板材３のアルミニウム含有プレコートの場合、プレコート、特にＡｌＳｉと、亜鉛含有被膜３４との間に良好な密着性を形成する。同時に、非被覆の切断縁端部は亜鉛含有被膜３４で被覆される。

【0036】

粉末の組成、時間及び温度によって、部品ブランク１８上に均一な被膜厚が現れ、被膜厚は数μｍ～１００μｍ超、好ましくは５μｍ～１２０μｍの間で所望のとおり設定されてもよい。被膜３４は溶接可能で、ＢＴＲ１６５の部品１にとって、引張り強度は１３００ＭＰａより大きくなり得る。熱拡散法では、残留物又は環境に対する排出物は実質的に発生しない。

【0037】

被覆工程は、隣接する不動態化処理ステーション３５における不動態化作業によって完了され、その間、ドラム３１は、被覆装置３０から取り外され、冷却ステーション３６で冷却され、洗浄ステーション３７で被膜粉の残留物が除去され、焼戻しステーション３８で約２００℃の温度で約１時間かけて焼戻され、その工程中、被膜３４は不動態化される。必要があれば、適切な不動態化添加物が添加されてもよい。仕上げられ、錆止めされた部品１は、その後ドラム３１から取り出されてよい。

【0038】

別の構成では（工程ステップＶ’、図１ｆ）、亜鉛含有被膜３４が、被覆領域４０内において溶融亜鉛めっき被覆法によってプレス焼入れ部品ブランク１８に塗付される。部品ブランク１８は、浸漬ハウジング４１内に吊り下げられ、該ハウジングは、被膜領域４０の複数のステーションを通り抜けて部品ブランク１８を搬送する。フラックスステーション４２では、部品ブランク１８は、適切に温度管理された、好ましくは塩化亜鉛を入れた約３６０℃の、フラックス漕内に吊り下げられ、その後乾燥ステーション４３内で、好ましくは８０℃で乾燥され、それから亜鉛めっき漕４４内に約４００～４５０℃で浸漬され亜鉛めっきされる。仕上げられた部品１は、その後浸漬ハウジング３１から取り出される。

【0039】

図３ａ～図３ｄは、半製品２、特に、プレコートされた板材３から、三次元成形されたプレス焼入れ部品１を製造する代替方法手順を概略的に示している。ここでも、図１ａ～図１ｅの例示された実施形態と同様の方法で、第１加工工程で、打ち抜きプレス機６内に

おいて、プレコートされた熱間加工可能な金属板から板材３が切り取られる（図３ａ）。被覆された板材３は、その後熱間成形加工を受ける（図３ｂ）。このために、板材３はマニピュレーター２０’を用いて連続炉２１’内へ挿入され、その中で板材３は、オーステナイト状態の変態温度を超える温度まで加熱される。加熱された板材３はその後熱間成形器具２３’内へ挿入され、その中で、所望の三次元形状の部品ブランク１０’が板材３から成形され、その工程において、部品ブランク１０’は急速に冷却され、（部品の幅に全体にわたって又は局部的に）焼入れされる。連続炉２１’及び熱間成形器具２３’は、不活性ガス雰囲気２６’内に配置されてもよいが、しかし、板材３のプレコートが、表面全体にわたって板材３から薄片がはがれ落ちるのを回避する。

【0040】

その後、焼入れ部品ブランク１０’は切断装置１５’へ転送され（図３ｃ）、その中で部品ブランク１０’は、輪郭形状１２を備えたブランク１８’を生成するために、縁端部でトリミングされる。トリミングは、好ましくはレーザー１４’で実行される。切り落とされた縁端領域１１’は処分される。その後に続く図３ｄ工程ステップＩでは、プレス焼入れされ被覆されたブランク１８’は、図１ｅ又は図１ｆの加工工程Ｖ又はＶ’にそれぞれ同様の方法で、被覆装置３０内で被覆される。

【0041】

プレス焼入れされ、被覆された部品１は、特に車両構造内の車体構成部品として適しており、これら車体構成部品は大量に生産される。本発明による方法は、サイクルタイムの短い有利な工程管理を可能にし、全加工工程が産業化の可能性を有する。プレコートされた材料の使用にも関わらず、従来の予備成形を使用することが可能である。追加の耐食被膜をその後塗付することにより、従来の成形及びトリミングは、高強度素材の場合でも可能であり、それによって、図１による製造方法を使用する場合、大量に行うには費用がかかるレーザー切断も、費用節減的方法に置き換えられることが可能である。これらの製造方法によって、板金部品は、それらの製造に関して、従来の成形シミュレーションの展開において既に実証可能である。さらに、縁端被覆の利点を備えた、プレコート３３の耐食特性と被膜３４の特性との好適な組み合わせもあり、特に、亜鉛被膜３４と組み合わせたＡｌＳｉ被膜３３の場合が好適である。このような部品から組み立てられた車両内では、部品は従来の板金部品よりかなり薄いので、部品の重量の削減により燃料消費が削減され、同時に、部品は非常に高い強度を有するので、パッシブセーフティが増大される。

【図面の簡単な説明】

【0042】

【図1】プレス焼入れ部品を製造する本発明による方法の図式を示す。

【図1a】板材を大きさに合わせて切断（ステップＩ）

【図1b】冷間成形（ステップＩＩ）

【図1c】縁端部のトリミング（ステップＩＩＩ）

【図1d】熱間成形（ステップＩＶ）

【図1e】被覆（ステップＶ）

【図1f】代替被覆法（ステップＶ’）

【図2】部品の製造中の選択された中間段階の斜視図を示す。

【図2a】プレコートされた半製品

【図2b】プレコートされた半製品から成形された部品ブランク

【図2c】トリミングされた部品ブランク

【図2d】被覆された部品ブランク

【図3】プレス焼入れ部品を製造する別の方法手順を示す。

【図3a】板材を大きさに合わせて切断（ステップＩ’）

【図3b】熱間成形（ステップＩＩ’）

【図3c】縁端部のトリミング（ステップＩＩＩ’）

【図3d】被覆（ステップＩＶ’）

【図1a】

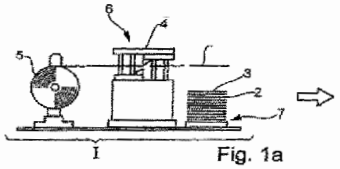


Fig. 1a

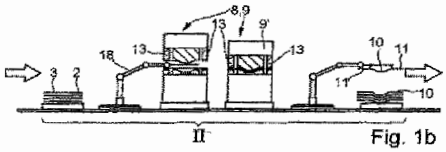


Fig. 1b

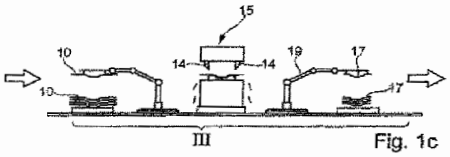


Fig. 1c

【図1b】

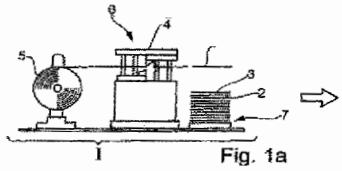


Fig. 1a

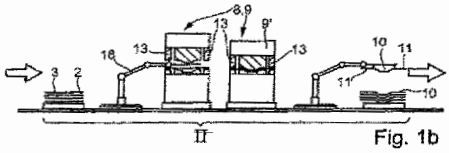


Fig. 1b

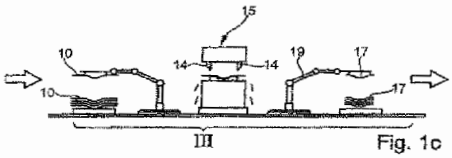


Fig. 1c

【図1c】

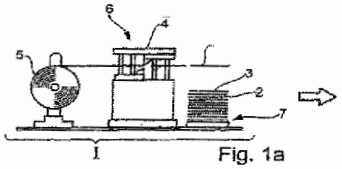


Fig. 1a

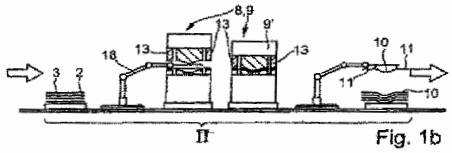


Fig. 1b

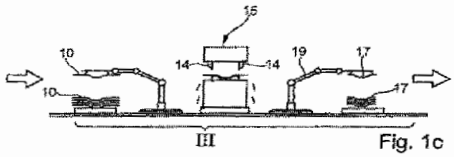


Fig. 1c

【図1d】

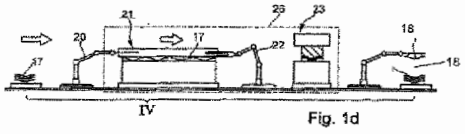


Fig. 1d

【図1e】

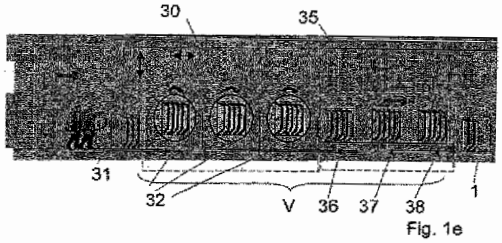


Fig. 1e

【図1f】

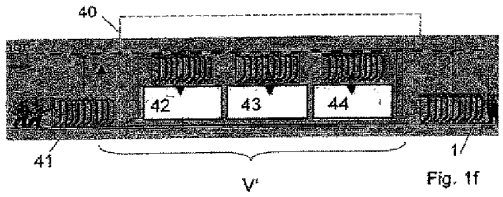


Fig. 1f

【図2a】

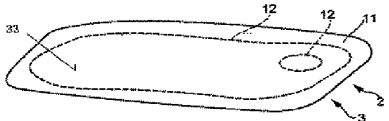


Fig. 2a

【図2b】

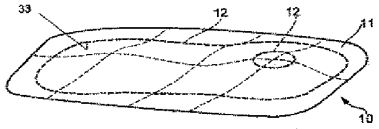


Fig. 2b

【図2c】

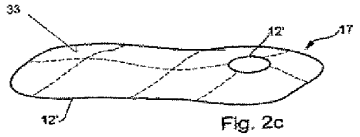


Fig. 2c

【図2d】

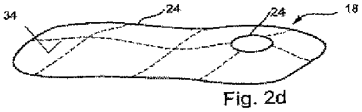
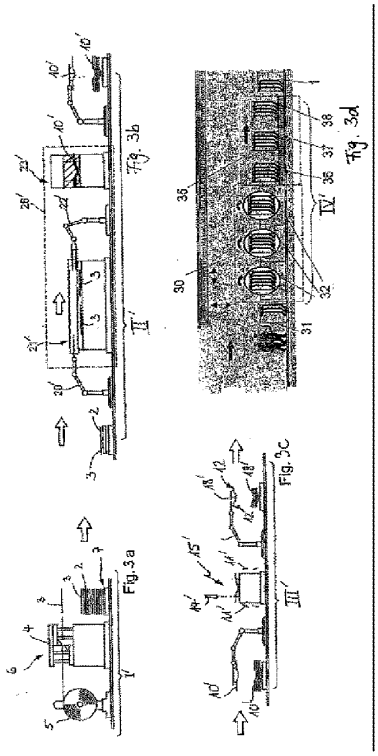
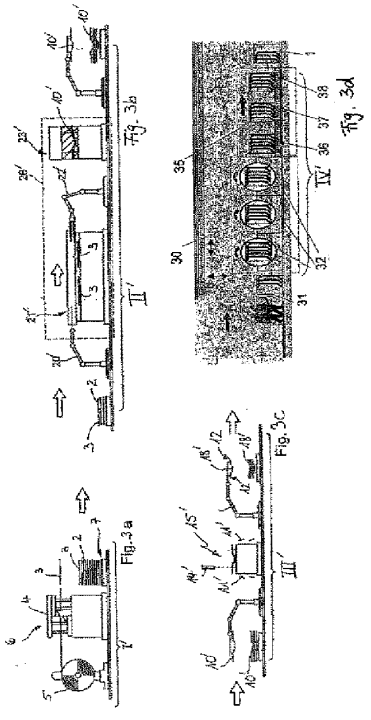


Fig. 2d

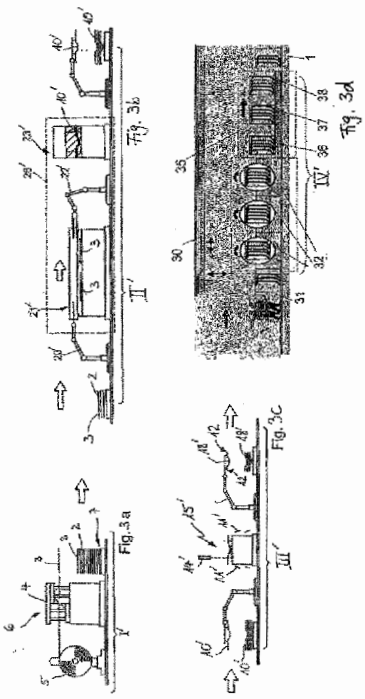
【図3a】



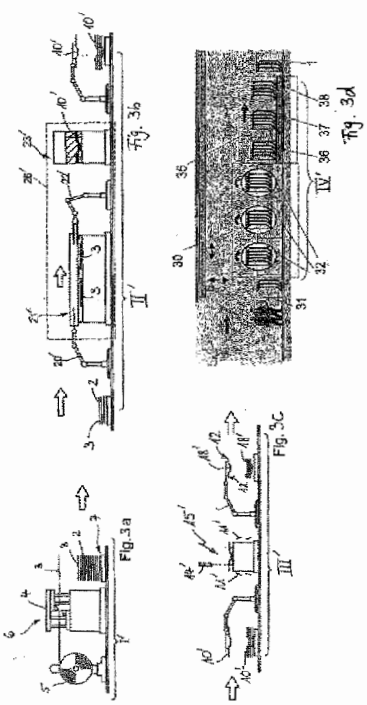
【図3b】



【図3c】



【図3d】



INTERNATIONAL SEARCH REPORT

International Application No
PCT/EP2004/008087

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 B21D35/00 C21D1/673 C21D9/46

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols).
IPC 7 B21D C21D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal, WPI Data, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	DE 101 35 647 C (DAIMLER CHRYSLER AG) 25 July 2002 (2002-07-25) figures 1a,1b	1-9
A	DE 101 49 221 C (BENTELER AUTOMOBILTECHNIK GMBH) 8 August 2002 (2002-08-08) cited in the application claim 1; figures 1-3	1-9
A	DE 100 49 660 A (DAIMLER CHRYSLER AG ; BENTELER AUTOMOBILTECHNIK GMBH (DE)) 25 April 2002 (2002-04-25)	1-7
X	column 7, line 35 - column 7, line 57; claim 24	8,9
A	DE 43 07 563 A (BAYERISCHE MOTOREN WERKE AG) 23 September 1993 (1993-09-23) column 2, line 37 - column 2, line 44	8,9

-/--

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
11 November 2004	29/11/2004

Name and mailing address of the ISA	Authorized officer
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INTERNATIONAL SEARCH REPORT

International Application No
PCT/EP2004/008087

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
P,A	WO 2004/033126 A (DAIMLER CHRYSLER AG ; FISCHER UWE (DE); MEHRHOLZ RALF (DE); BRODT MART) 22 April 2004 (2004-04-22) figures 1a-1e	1-9

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INTERNATIONAL SEARCH REPORT

ormation on patent family members

International Application No
PCT/EP2004/008087

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
DE 10135647 C	25-07-2002	DE 10135647 C1	25-07-2002
DE 10149221 C	08-08-2002	DE 10149221 C1	08-08-2002
		EP 1300475 A2	09-04-2003
		US 2003066582 A1	10-04-2003
DE 10049660 A	25-04-2002	DE 10049660 A1	25-04-2002
		EP 1195208 A2	10-04-2002
		JP 3553536 B2	11-08-2004
		JP 2002178069 A	25-06-2002
		US 2002069506 A1	13-06-2002
DE 4307563 A	23-09-1993	DE 4307563 A1	23-09-1993
WO 2004033126 A	22-04-2004	DE 10254695 B3	15-04-2004
		WO 2004033126 A1	22-04-2004

Form PCT/ISA/210 (patent family annex) (January 2004)

INTERNATIONALER RECHERCHENBERICHT

Internationales Aktenzeichen
PCT/EP2004/008087

A. KLASSIFIZIERUNG DES ANMELDUNGSGEGENSTANDES
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IPK 7　B21D　C21D

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EPO-Internal, WPI Data, PAJ

C. ALS WESENTLICH ANGESEHENE UNTERLAGEN

Kategorie*	Bezeichnung der Veröffentlichung, soweit erforderlich unter Angabe der in Betracht kommenden Teile	Betr. Anspruch Nr.
A	DE 101 35 647 C (DAIMLER CHRYSLER AG) 25. Juli 2002 (2002-07-25) Abbildungen 1a,1b	1-9
A	DE 101 49 221 C (BENTELER AUTOMOBILTECHNIK GMBH) 8. August 2002 (2002-08-08) in der Anmeldung erwähnt Anspruch 1; Abbildungen 1-3	1-9
A	DE 100 49 660 A (DAIMLER CHRYSLER AG ; BENTELER AUTOMOBILTECHNIK GMBH (DE)) 25. April 2002 (2002-04-25)	1-7
X	Spalte 7, Zeile 35 - Spalte 7, Zeile 57; Anspruch 24	8,9
A	DE 43 07 563 A (BAYERISCHE MOTOREN WERKE AG) 23. September 1993 (1993-09-23) Spalte 2, Zeile 37 - Spalte 2, Zeile 44	8,9

-/--

[X] Weitere Veröffentlichungen sind der Fortsetzung von Feld C zu entnehmen　[X] Siehe Anhang Patentfamilie

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Datum des Abschlusses der internationalen Recherche	Absendedatum des internationalen Recherchenberichts
11. November 2004	29/11/2004
Name und Postanschrift der Internationalen Recherchenbehörde Europäisches Patentamt, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax (+31-70) 340-3016	**Bevollmächtigter Bediensteter** Vinci, V

Formblatt PCT/ISA/210 (Blatt 2) (Januar 2004)

INTERNATIONALER RECHERCHENBERICHT

Internationales Aktenzeichen
PCT/EP2004/008087

C.(Fortsetzung) ALS WESENTLICH ANGESEHENE UNTERLAGEN

Kategorie°	Bezeichnung der Veröffentlichung, soweit erforderlich unter Angabe der in Betracht kommenden Teile	Betr. Anspruch Nr.
P,A	WO 2004/033126 A (DAIMLER CHRYSLER AG ; FISCHER UWE (DE); MEHRHOLZ RALF (DE); BRODT MART) 22. April 2004 (2004-04-22) Abbildungen 1a-1e	1-9

Formblatt PCT/ISA/210 (Fortsetzung von Blatt 2) (Januar 2004)

INTERNATIONALER RECHERCHENBERICHT

Angaben zu Veröffentlichungen, die zur selben Patentfamilie gehören

Internationales Aktenzeichen
PCT/EP2004/008087

Im Recherchenbericht angeführtes Patentdokument		Datum der Veröffentlichung	Mitglied(er) der Patentfamilie		Datum der Veröffentlichung
DE 10135647	C	25-07-2002	DE 10135647	C1	25-07-2002
DE 10149221	C	08-08-2002	DE 10149221	C1	08-08-2002
			EP 1300475	A2	09-04-2003
			US 2003066582	A1	10-04-2003
DE 10049660	A	25-04-2002	DE 10049660	A1	25-04-2002
			EP 1195208	A2	10-04-2002
			JP 3553536	B2	11-08-2004
			JP 2002178069	A	25-06-2002
			US 2002069506	A1	13-06-2002
DE 4307563	A	23-09-1993	DE 4307563	A1	23-09-1993
WO 2004033126	A	22-04-2004	DE 10254695	B3	15-04-2004
			WO 2004033126	A1	22-04-2004

Formblatt PCT/ISA/210 (Anhang Patentfamilie) (Januar 2004)

(51)Int.Cl.　　ＦＩ　　テーマコード（参考）
　　Ｃ２１Ｄ　1/18　　Ｐ

(81)指定国　　AP(BW,GH,GM,KE,LS,MW,MZ,NA,SD,SL,SZ,TZ,UG,ZM,ZW),EA(AM,AZ,BY,KG,KZ,MD,RU,TJ,TM),EP(AT,BE,BG,CH,CY,CZ,DE,DK,EE,ES,FI,FR,GB,GR,HU,IE,IT,LU,MC,NL,PL,PT,RO,SE,SI,SK,TR),OA(BF,BJ,CF,CG,CI,CM,GA,GN,GQ,GW,ML,MR,NE,SN,TD,TG),AE,AG,AL,AM,AT,AU,AZ,BA,BB,BG,BR,BW,BY,BZ,CA,CH,CN,CO,CR,CU,CZ,DE,DK,DM,DZ,EC,EE,EG,ES,FI,GB,GD,GE,GH,GM,HR,HU,ID,IL,IN,IS,JP,KE,KG,KP,KR,KZ,LC,LK,LR,LS,LT,LU,LV,MA,MD,MG,MK,MN,MW,MX,MZ,NA,NI,NO,NZ,OM,PG,PH,PL,PT,RO,RU,SC,SD,SE,SG,SK,SL,SY,TJ,TM,TN,TR,TT,TZ,UA,UG,US,UZ,VC,VN,YU,ZA,ZM,ZW

(72)発明者　マーティン・ブロート
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Ｆターム(参考)　4K027 AA05　AB05　AB42　AB48　AC12　AC72
　　4K042 AA25　BA01　BA02　BA13　CA02　DA01　DA02　DB07　DC02　DC03
　　DD02　DD05　DE02　DE03

Espacenet

Bibliographic data: JPH11156293 (A) — 1999-06-15

PRECOATED ALUMINUM ALLOY SHEET EXCELLENT IN FORMABILITY AND CORROSION RESISTANCE

Inventor(s): KADA YOSHIMI; UEDA KOHEI; NISHIMURA KAZUMI; NISHIOKA RYOJI ± (KADA YOSHIMI, ; UEDA KOHEI, ; NISHIMURA KAZUMI, ; NISHIOKA RYOJI)

Applicant(s): NIPPON STEEL CORP ± (NIPPON STEEL CORP)

Classification: **- international:** ***B05D7/14; C22C21/06;*** (IPC1-7): B05D7/14; C22C21/06

- cooperative:

Application number: JP19970321073 19971121 Global Dossier

Priority number(s): JP19970321073 19971121

Abstract of JPH11156293 (A)

PROBLEM TO BE SOLVED: To produce a precoated aluminum alloy sheet suitable for an automobile body without the coating film being released or cracked even when used for the part to be formed to a high degree, good in appearance and excellent in formability and corrosion resistance. SOLUTION: This precoated aluminum alloy sheet excellent in formability and corrosion resistance has a chemical film on one or both sides of an aluminum alloy sheet contg. >=0.5 wt.% Mg and further a resin coating film thereon. The resin film has an elastic proportional limit in a tensile test and 20-300 kg/mm<2> tensile elastic modulus. The resin coating film should have 15% elastic limit elongation and an yield elongation in the tensile test.

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DESCRIPTION JPH11156293

[0001]

BACKGROUND OF THE INVENTION 1. Field of the Invention The present invention relates to a precoated aluminum alloy sheet excellent in formability and corrosion resistance for use in a part for forming a product by drawing such as an inner plate and an outer plate for automobiles, Coated aluminum alloy sheet.

[0002]

2. Description of the Related Art As an automobile material to be used for forming a product by performing drawing such as an inner plate and an outer plate for automobiles, for example, Japanese Patent Application Laid-Open No. 9-193286 discloses a method of applying a specific resin coating By coating the membrane, a precoated steel sheet excellent in draw formability is disclosed.

[0003]

On the other hand, in recent years, aluminum or aluminum alloy plates have been increasingly

used for car bodies in order to reduce the weight of the car body. In applying the precoated aluminum alloy sheet to the drawing portion, in the conventional technique, a coating film with a high elongation rate by a tensile test of a coating film and a coating film with a good T-bending test result are selected, and a cylindrical diaphragm or a square tube throttling test And applied it to the drawing section with good evaluation results.

[0004]

However, Japanese Unexamined Patent Publication No. 9-193286 is a technique for a steel plate. In the case of an aluminum alloy plate, the chemical conversion property is poor as compared with the steel plate, and corrosion resistance is also lowered when the chemical conversion treatment is bad .

[0005]

Drawing is a deformation mode in which tensile and compressive distortion is generated in an aluminum alloy sheet, has good bending workability, and is sufficiently applied to drawing in a coating film which merely stretches In many cases, the coating film peels off after processing. SUMMARY OF THE INVENTION An object of the present invention is to provide a precoated aluminum alloy sheet excellent in draw formability with no appearance of coating film peeling, cracking of a coating film and the like when a precoated aluminum alloy sheet is applied to a drawing part It is in.

[0006]

DISCLOSURE OF THE INVENTION The present inventors have studied various resin coating films in order to obtain a precoated aluminum alloy sheet excellent in draw formability. As a result, it was found that by specifying the physical properties of the resin coating film, it can be sufficiently adapted for drawing. The present invention is based on this finding and its gist is as follows.

[0007]

(1) A precoated aluminum alloy sheet having a chemical conversion treatment film on one side or both sides of an Mg-containing aluminum alloy plate of 0.5 wt% or more and further coated with a resin coating film thereon, wherein the resin coating film A precoated aluminum alloy sheet excellent in moldability and corrosion resistance characterized by having an elastic proportion limit in a tensile test and having a tensile modulus of 20 to 300 kg / mm 2.

[0008]

(2) The precoated aluminum alloy sheet as described in (1) above, which is excellent in formability and corrosion resistance, characterized in that the resin coating film has an elastic limit elongation of 15% or less in a tensile test. (3) The precoated aluminum alloy sheet as described in (1) or (2) above, wherein the resin coating film has a yield point elongation in a tensile test.

[0009]

(4) A panel material for an automobile body which is excellent in formability and corrosion resistance, characterized by using any one of the precoated aluminum alloy plates (1) to (3).

[0010]

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS The aluminum alloy sheet to be applied to the precoated aluminum alloy sheet of the present invention is an Mg-containing aluminum alloy sheet of 0.5 wt% or more, which is not particularly restricted, but in particular 5000 Based aluminum alloy plate or 6000 series aluminum alloy plate is preferable.

[0011]

On the aluminum alloy sheet, it is necessary to have a chemical conversion treatment film in order to have good coating film adhesion and corrosion resistance. The chemical conversion treatment film may be either a chromate film or a nonchromate film including a zinc phosphate film. The chromate film or nonchromate film is preferably 5 to 150 mg / m 2, and the zinc phosphate film is preferably 0.5 to 2 g / m 2. If the chemical conversion coating amount is less

than the lower limit value, the corrosion resistance becomes insufficient. On the other hand, if it exceeds the upper limit value, the adhesion will decrease.

[0012]

In the precoated aluminum alloy sheet of the present invention, the tensile properties of the resin coating film to be coated on the aluminum alloy plate are defined in order to improve the draw formability. The resin coating film of the present invention has an elastic proportion limit in the tensile test and restricts the tensile elastic modulus to the range of 20 to 300 kg / mm <2> in order to secure draw formability. A resin coating film deviating from this condition is not preferable because sufficient drawability can not be obtained and wrinkles are peeled off or peeled off at the drawing portion.

[0013]

In the resin coating film, it is preferable to set the elastic limit elongation to 15% or less in order to make the draw formability good, and above this range, cracking will occur at the corner portion at the corner portion undesirably. On the other hand, the total elongation is preferably 15% or more. In addition, the resin coating film preferably has a yield point elongation when subjected to a tensile test, in order to further improve the drawability. If it has a yield point elongation, the film does not crumple or peel off at the drawing part when crimped, and does not crack at the corner part.

[0014]

The reason why the tensile properties of the resin coating film is defined as described above is unknown for the reason why drawability is excellent, but when the aluminum alloy plate receives tensile and compression in the draw forming mode, the aluminum alloy sheet Of the resin coating film also deforms smoothly following the deformation of the aluminum alloy sheet, so that the above conditions are considered to work well. The resin used as a coating film is not particularly limited, but polyester resin, acrylic resin, epoxy resin, or the like can be used. In order to impart the tensile properties to these resins, means for increasing the Tg of the resin coating film, adding a curing agent to the resin, increasing the baking temperature of the coating film to increase the crosslinking density of the coating film, etc. The tensile properties are obtained by combining these as necessary.

[0015]

EXAMPLES The A6009 alloy and the A5182 alloy plate having a plate thickness of 1.0 mm were subjected to a chemical conversion treatment, a polyester-based primer coating film was applied thereon to a thickness of 5 μm, and a coating having mechanical characteristic values shown in Table 1 The film was coated with a film thickness of 15 μm to prepare a precoated aluminum alloy plate. After that, a rectangular tube molding test was carried out and the destruction form of the coating film at the corner narrowed part was observed. As a coating film, a paint based on a high molecular weight polyester resin was used.

[0016]

Regarding the mechanical property value of the coating film, firstly a coating film was coated on a Teflon sheet with a bar coater to a film thickness of 15 μm, and after baking, the coating film was peeled off from the Teflon sheet to prepare a free film of the coating film A test piece of 10 mm × 50 mm was prepared from the film and subjected to a tensile test. The tensile test was conducted at room temperature at a tensile speed of 10 mm / min using "TENSILON CT-10T" manufactured by Orientec Co., Ltd., and tensile properties were obtained from the load-elongation of the coating film.

[0017]

The prismatic squeezing conditions were as follows: a punch size: □ 70 mm, a punch shoulder R: 2 mm, a punch corner R: 10 mm, using a blank size: □ 140 mm, BHF: 5 t, molding height: 30 mm, The appearance of the corner narrowed portion was observed and judged according to the following criteria. : No peeling of the coating film or cracking of the coating film was observed. ○: Coating film peeling and cracking of the coating film were observed a little, but there was no problem. Δ: Coating film peeling and film cracking were both observed. X: Coating film peeling, coating Table 1 shows the evaluation results in which film cracking is greatly observed. As is apparent from this table, the elastic proportion limit exists in the stress-elongation diagram, the coating film having the tensile elastic modulus of 20 to 300 kg / mm 2 is excellent in draw formability, the appearance is good, the coating film peeling, the coating film Cracks are not observed. In addition, as long as the resin has a limit elongation of elasticity of 15% or less and / or a yield point elongation appears and a total elongation is 15% or more, the resin has

satisfactory drawability and in particular, a resin satisfying all the above conditions , Peeling of the coating film and cracking of the coating film are not observed at all.

[0018]

Intercoat paint (film thickness 35 μm) and top coat (film thickness 35 μm) similar to panel materials for automobiles were applied to the precoated aluminum alloy, and then corrosion resistance and adhesion were performed. The corrosion resistance was evaluated by cross-cutting with a NT cutter on the top coat painted film, followed by one cycle of salt spray (5% NaCl aqueous solution, 35 ° C., 24 hr) → wet test (50 ° C. 85% RH, 120 hr) , 8 cycles were carried out and the maximum expansion width of the swelling width of the coating film from the cross-cut portion was evaluated. Evaluation was evaluated as ○: swollen width less than 1 mm, Δ: blister width 1 mm or more and less than 3 mm, ×: swollen width 3 mm or more.

[0019]

Coating adhesion was evaluated by immersing the sample on which the top coat was applied for 10 days in distilled water at 40 ° C. and immediately cutting the coating so that 100 squares of 1 mm × 1 mm square were cut with NT cutter, The remainder of the grid of the grid was observed. Evaluation was made as follows: A: no cross-cut peeling, Δ: cross-cut area peeling area was less than 5%, x: cross-cut peeling area was 5% or more.

[0020]

As described above, the precoated aluminum alloy sheet of the present invention does not cause peeling of the coating film or cracking of the coating film even by drawing processing by specifying the tensile properties of the coating film. This makes it possible to use a precoated aluminum alloy sheet even in severe forming processing parts such as deep drawing and the application of the precoated aluminum alloy sheet is expanded. In addition, products currently used for prefabricated aluminum alloy sheets for bending processing can also be manufactured by drawing, the degree of freedom also increases in terms of product design, and the processing shape can be selected in a wider range. Therefore, it can be said that the present invention is an invention of extremely high industrial value.

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CLAIMS JPH11156293

[1]

1. A precoated aluminum alloy sheet having a chemical conversion treatment film on one side or both sides of an Mg-containing aluminum alloy plate of 0.5 wt% or more and further coated with a resin coating film thereon, wherein in the tensile test the resin coating film A precoated aluminum alloy sheet excellent in formability and corrosion resistance characterized by having an elastic proportion limit and having a tensile modulus of 20 to 300 kg / mm 2.

2.

The precoated aluminum alloy sheet excellent in moldability and corrosion resistance according to claim 1, wherein the resin coating film has an elastic limit elongation of 15% or less in a tensile test.

3.

A precoated aluminum alloy sheet excellent in formability and corrosion resistance according to claim 1 or 2, wherein the resin coating film has a yield point elongation in a tensile test.

4.

A panel material for an automobile body which is excellent in formability and corrosion resistance, characterized by using the precoated aluminum alloy plate according to any one of claims 1 to 3.

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(54)【発明の名称】　成形性及び耐食性に優れたプレコートアルミニウム合金板

(57)【要約】

【課題】　厳しい成形加工部に使用しても、塗膜剥離や割れなどが発生せず、外観良好な、成形性及び耐食性に優れた、自動車ボディ用に適したプレコートアルミニウム合金板の提供。

【解決手段】　０．５ｗｔ％以上のＭｇ含有アルミニウム合金板上の片面もしくは両面に、化成処理皮膜を有し、更にその上に樹脂塗膜を被覆したプレコートアルミニウム合金板であって、樹脂塗膜が引張試験において弾性比例限界を有し、かつ２０～３００ｋｇ／ｍｍ^{2}の引張弾性率を有することを特徴とする成形性及び耐食性に優れたプレコートアルミニウム合金板である。前記樹脂塗膜は、更に弾性限界伸びが１５％以下であること、また、引張試験において降伏点伸びを有することが好ましい。

【特許請求の範囲】
【請求項1】　0．5wt%以上のMg含有アルミニウム合金板上の片面もしくは両面に、化成処理皮膜を有し、更にその上に樹脂塗膜を被覆したプレコートアルミニウム合金板であって、樹脂塗膜が引張試験において弾性比例限界を有し、かつ20～300kg／mm² の引張弾性率を有することを特徴とする成形性及び耐食性に優れたプレコートアルミニウム合金板。
【請求項2】　樹脂塗膜が引張試験において15%以下の弾性限界伸びを有することを特徴とする請求項1に記載の成形性及び耐食性に優れたプレコートアルミニウム合金板。
【請求項3】　樹脂塗膜が引張試験において降伏点伸びを有することを特徴とする請求項1または2に記載の成形性及び耐食性に優れたプレコートアルミニウム合金板。
【請求項4】　請求項1～3いずれかのプレコートアルミニウム合金板を使用することを特徴とする成形性及び耐食性に優れた自動車ボディ用パネル材。
【発明の詳細な説明】
【0001】
【発明の属する技術分野】本発明は、自動車用の内板や外板など絞り加工を行うことで製品を成形する部位に用いる成形性及び耐食性の優れたプレコートアルミニウム合金板、特に、自動車ボディ用プレコートアルミニウム合金板に関する。
【0002】
【従来の技術】自動車用の内板や外板など絞り加工を行うことで製品を成形する部位に用いる自動車材料としては、例えば、特開平9－193286号公報には、鋼板に特定の樹脂塗膜を被覆することにより、絞り成形性に優れたプレコート鋼板が開示されている。
【0003】他方、最近では、車体の軽量化を狙ってアルミニウムまたはアルミニウム合金板を車体に使用することが多くなっている。絞り加工部へプレコートアルミニウム合金板を適応する際には、従来技術では塗膜の引張試験による伸び率の高い塗膜やT折り曲げ試験結果の良い塗膜を選択し、円筒絞りや角筒絞り試験を実施して評価結果の良いものを絞り加工部に適用してきた。
【0004】しかしながら、特開平9－193286号公報は、鋼板用の技術であり、アルミニウム合金板の場合、鋼板に比べて化成処理性が悪く、化成処理が悪い場合には耐食性も低下してしまう問題がある。
【0005】
【発明が解決しようとする課題】絞り加工は、アルミニウム合金板に引張と圧縮の歪みが発生する変形様式であり、曲げ加工性が良く、単に伸びるだけの塗膜では絞り加工に十分に適用されず、加工後に塗膜が剥離してしまう場合が多い。そこで、本発明の目的は、絞り加工部にプレコートアルミニウム合金板を適応した場合に塗膜剥離や塗膜割れ等が発生せず外観良好な絞り成形性の優れたプレコートアルミニウム合金板を提供することにある。
【0006】
【課題を解決するための手段】本発明者らは、絞り成形性に優れたプレコートアルミニウム合金板を得るために種々の樹脂塗膜について検討した。その結果、樹脂塗膜の物理的性質を特定することによって絞り成形に十分適応できることを知見した。本発明は、この知見に基づくものであって、その要旨は下記のとおりである。
【0007】（1）0．5wt%以上のMg含有アルミニウム合金板上の片面もしくは両面に、化成処理皮膜を有し、更にその上に樹脂塗膜を被覆したプレコートアルミニウム合金板であって、樹脂塗膜が引張試験において弾性比例限界を有し、かつ20～300kg／mm² の引張弾性率を有することを特徴とする成形性及び耐食性に優れたプレコートアルミニウム合金板。
【0008】（2）樹脂塗膜が引張試験において15%以下の弾性限界伸びを有することを特徴とする前記（1）に記載の成形性及び耐食性に優れたプレコートアルミニウム合金板。
（3）樹脂塗膜が引張試験において降伏点伸びを有することを特徴とする前記（1）または（2）に記載の成形性及び耐食性に優れたプレコートアルミニウム合金板。
【0009】（4）前記（1）～（3）いずれかのプレコートアルミニウム合金板を使用することを特徴とする成形性及び耐食性に優れた自動車ボディ用パネル材。
【0010】
【発明の実施の形態】本発明のプレコートアルミニウム合金板に適用するアルミニウム合金板は、0．5wt%以上のMg含有アルミニウム合金板で、特に制約するものではないが、特に自動車用に適した5000系アルミニウム合金板や6000系アルミニウム合金板が好ましい。
【0011】アルミニウム合金板上には、良好な塗膜密着性及び耐食性を有するために、化成処理皮膜を有する必要がある。化成処理皮膜は、クロメート皮膜あるいはリン酸亜鉛皮膜を含むノンクロメート皮膜いずれでもよい。クロメート皮膜あるいはノンクロメート皮膜は5～150mg／m² 、リン酸亜鉛皮膜は0．5～2g／m² が好ましい。化成処理皮膜量が下限値以下であると耐食性が不十分となる。また、上限値を超えると密着性が低下してしまう。
【0012】本発明のプレコートアルミニウム合金板においては、絞り成形性を良好とするために、アルミニウム合金板上に被覆する樹脂塗膜の引張特性を規定する。本発明の樹脂塗膜は、絞り成形性を確保するために、引張試験において弾性比例限界を有し、かつ引張弾性率を20～300kg／mm² の範囲に制約する。この条件から外れる樹脂塗膜では、絞り成形性を十分に得ること

はできず、絞り部で塗膜にしわがよったり剥離するため好ましくない。

【００１３】上記樹脂塗膜は、絞り成形性を良好とするために弾性限界伸びを１５％以下とすることが好ましく、これ以上では成形したときにコーナー部で塗膜に割れが生じてしまい好ましくない。一方、全伸びについては、１５％以上が好ましい。また、上記樹脂塗膜は、引張試験した際に、降伏点伸びを有することが、さらに絞り成形性を良くするために好適である。降伏点伸びを有すると、成形したときに塗膜に絞り部でしわがよったり剥離したり、コーナー部で割れたりしない。

【００１４】以上のように樹脂塗膜の引張特性を規定することによって、絞り成形性が優れる理由は、不明であるが、絞り成形様式の引張と圧縮をアルミニウム合金板が受けた際に、アルミニウム合金板上の樹脂塗膜もアルミニウム合金板の変形にうまく追従して変形するために上記条件がうまく作用しているものと考えられる。塗膜として用いる樹脂は、特に制約するものではないが、ポリエステル樹脂、アクリル樹脂、エポキシ樹脂等を用いることができる。これら樹脂に上記引張特性を付与するには、樹脂塗膜のＴｇを上げる、樹脂に硬化剤を添加する、塗膜の焼き付け温度を高くすることで塗膜の架橋密度を上げる等の手段が挙げられ、これらを必要に応じて組み合わせることによって前記引張り特性が得られる。

【００１５】

【実施例】板厚１．０ｍｍのＡ６００９合金及びＡ５１８２合金板上に化成処理を施し、その上にポリエステル系プライマー塗膜を５μｍ塗装し、その上に表１に示す機械特性値を持った塗膜を膜厚：１５μｍ塗装し、プレコートアルミニウム合金板を作成した。その後に角筒成形試験を行い、コーナー絞り部の塗膜の破壊形態を観察した。塗膜には高分子ポリエステル系樹脂をベースとした塗料を用いた。

【００１６】塗膜の機械特性値については、まず塗膜をテフロンシート上にバーコーターで膜厚：１５μｍ塗装し、焼き付け後、テフロンシートより塗膜を剥離して塗膜のフリーフィルムを作成し、このフリーフィルムから１０ｍｍ×５０ｍｍの試験片を作成し、引張試験を実施した。引張試験条件はオリエンテック社製「テンシロンＣＴ－１０Ｔ」を用いて室温で引張スピード１０ｍｍ／ｍｉｎで行い、塗膜の荷重－伸びより引張特性を得た。

【００１７】角筒絞り条件は、ポンチサイズ：□７０ｍｍ、ポンチ肩Ｒ：２ｍｍ、ポンチコーナーＲ：１０ｍｍの金型を使い、ブランクサイズ：□１４０ｍｍ、ＢＨＦ：５ｔ、成形高さ：３０ｍｍで実施し、成形品のコーナー絞り部の外観観察を行い、以下の基準で判定した。

◎：塗膜剥離、塗膜割れが認められない

○：塗膜剥離、塗膜割れが少し認められるが問題ないレベル

△：塗膜剥離、塗膜割れが共に認められる

×：塗膜剥離、塗膜割れが共に大いに認められる

評価結果を表１に示す。この表から明らかなように、応力－伸び線図で弾性比例限が存在し、引張弾性率が２０～３００ｋｇ／ｍｍ^2 の塗膜が絞り成形性に優れ、外観が良く、塗膜剥離、塗膜割れが認められない。また、弾性限界伸びが１５％以下、および／または、降伏点伸びが現れ全伸びが１５％以上、であるような樹脂であれば、更に絞り成形性が良く、特に前記すべての条件を満たす樹脂であれば塗膜剥離、塗膜割れが全く認められない。

【００１８】また、プレコートアルミニウム合金に、自動車用のパネル材と同様の中塗り塗装（膜厚３５μｍ）及び上塗り塗装（膜厚３５μｍ）を施したのち、耐食性及び密着性を行った。耐食性は上塗り塗装を施した塗膜にＮＴカッターでクロスカットを入れた後、塩水噴霧（５％ＮａＣｌ水溶液、３５℃、２４ｈｒ）→湿潤試験（５０℃ｘ８５％ＲＨ、１２０ｈｒ）を１サイクルとして、８サイクル実施し、クロスカット部からの塗膜の膨れ幅の最大膨れ幅によって評価した。評価は、○：膨れ幅１ｍｍ未満、△：膨れ幅１ｍｍ以上３ｍｍ未満、×：膨れ幅３ｍｍ以上で判断した。

【００１９】塗膜密着性は、上塗り塗装を施したサンプルを４０℃の蒸留水に１０日間浸漬後、直ちに塗膜にＮＴカッターで１ｍｍ角の碁盤目が１００個できるようにカットを入れ、テープ剥離後の碁盤目の残り具合を観察した。評価は、○：碁盤目の剥離なし、△：碁盤目の剥離面積が５％未満、×：碁盤目の剥離面積が５％以上で判断した。

【００２０】

【表１】

表　1

No	化成処理	弾性限界伸び(%)	引張弾性率 (kg/mm²)	降伏点伸び	全伸び(%)	絞り成形外観	耐食性	密着性	備考
1	C	4.0	306	無	4.0	○	○	○	本発明
2	A	13.7	242	無	13.7	○	△	△	
3	B	13.7	242	無	13.7	○	○	○	
4	C	13.7	242	無	13.7	○	○	○	
5	D	13.7	242	無	13.7	○	○	○	
6	E	15.8	242	有	57.2	○	○	△	
7	F	15.8	242	有	57.2	○	△	△	
8	G	15.8	242	有	57.2	○	○	○	
9	H	15.8	242	有	57.2	○	○	○	
10	I	3.7	242	有	15.2	◎	○	○	
11	J	3.7	242	有	15.2	◎	△	△	
12	K	3.7	242	有	15.2	◎	○	○	
13	C	10.0	100	有	17.1	◎	○	○	
14	C	13.6	27	有	55.6	◎	○	○	
15	C	60.0	18	無	60.0	△	○	○	比較例
16	C	4.1	366	無	4.1	×	○	○	
17	C	比例弾性なし			9.0	×	○	○	
18	C	比例弾性なし			42.5	×	○	○	
19	C	比例弾性なし			63.4	△	○	○	
20	C	比例弾性なし			232.6	△	○	○	

化成処理：A；クロメート　2mg／m²
B；クロメート　5mg／m²
C；クロメート　50mg／m²
D；クロメート　150mg／m²
E；クロメート　250mg／m²
F；リン酸亜鉛　0．1g／m²
G；リン酸亜鉛　0．5g／m²
H；リン酸亜鉛　1．2g／m²
I；リン酸亜鉛　2．0g／m²
J；リン酸亜鉛　3．0g／m²
K；Zr酸　50mg／m²

【0021】

【発明の効果】以上説明した通り、本発明のプレコートアルミニウム合金板は、塗膜の引張特性を規定することにより、絞り成形加工を行っても塗膜剥離や塗膜割れが発生しない。これにより、深絞り加工など厳しい成形加工部にもプレコートアルミニウム合金板を使用する事が可能となり、プレコートアルミニウム合金板の適用用途が広まる。また、現在プレコートアルミニウム合金板を折り曲げ加工で使用している製品についても、絞り成形で製造する事が可能となり、製品のデザイン面でも自由度が増し、加工形状をより広範囲に選択できる。従って、本願発明は工業的価値の極めて高い発明であるといえる。

フロントページの続き

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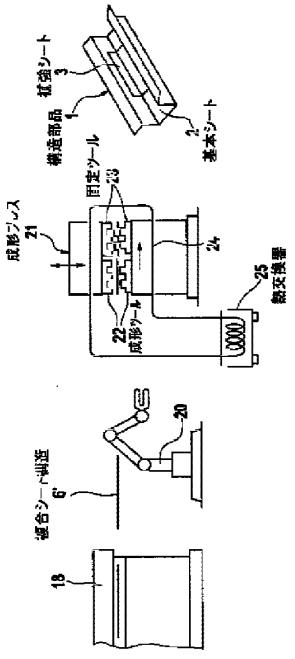
(54)【発明の名称】　局所的に補強されたシート・メタル成形品を製造する方法

(57)【要約】
【課題】　一般的なシート・メタル成形品製造方法を改良すること。
【解決手段】　パッチングされた(patched)複合シート構造（６’）が共成形(joint forming)の前に、材料の成形温度よりも高い温度に加熱され、その後、閉鎖された成形ツール（２２）内で冷却され、あるいは後段の固定ツール（２３）内で冷却され、所望の成形状態が機械的に固定される。



【特許請求の範囲】

【請求項１】　基本シートと、基本シートよりも小さく、局所的に配置された少なくとも１枚の補強シートとからなる三次元形状の構造部品を製造する方法であって、構造部品の基本シートが、平坦な状態または不完全に成形された予備成形状態で、その後の補強点用の所定の点で補強シートに連結され、パッチングされた複合シート構造の各部がその後、開閉可能な成形ツールによって成形プレス内で共成形される方法において、パッチングされた(patched)複合シート構造（６、６’）が共成形(joint forming)の前に、材料の成形温度よりも高い温度に加熱され、その後、閉鎖された成形ツール（２２）内で冷却され、あるいは後段の固定ツール（２３、２６）内で冷却され、所望の成形状態が機械的に固定されることを特徴とする方法。

【請求項２】　パッチングされた複合シート構造（６’）の部品が構造変形温度(Structural transformation temperature)よりも高い温度に加熱され、前記構造変形温度よりも高い温度では、材料構造がオーステナイト状態になることを特徴とする、請求項１に記載の方法。

【請求項３】　パッチングされた複合シート構造（６’）が、共成形の前に、８５０℃から９３０℃の間の温度範囲内の特定の温度に加熱されることを特徴とする、請求項１に記載の方法。

【請求項４】　少なくとも１枚の補強シート（３’）または補強シートのうちの少なくとも１枚自体が、基本シート（２）上の所定の点で寸法的に正確に支持され、かつ前記基本シート（２）に固定できるように、補強ビード(reinforcing beads)（７）を取り付けることによって基本シート（２）と組み合わされる前に、予備成形されることを特徴とする、請求項１に記載の方法。

【請求項５】　加熱された複合シート構造（６’）を加熱装置、特に炉（１８）から抜き出すことと、定義された位置の複合シート構造（６’）を、開放された成形ツール（２２）に、その閉鎖を開始するまで投入し続けることが、３秒未満、好ましくは２秒未満（タイムスパンＥ）で行われることを特徴とする、請求項１に記載の方法。

【請求項６】　成形ツール（２２）の閉鎖を開始してから成形が完了するまでの間に、定義された位置で、開放された成形ツール（２２）に投入された、加熱された複合シート構造（６’）の共成形が少なくとも３秒から５秒（タイムスパンＳ）で行われることを特徴とする、請求項１に記載の方法。

【請求項７】　共成形された複合シート構造の冷却が、成形ツールに対する少なくとも第１の冷却段階において、内側から確実に冷却された（３３、３４）成形ツール（２２）に接触させることによって行われることを特徴とする、請求項１に記載の方法。

【請求項８】　共成形の後で、閉鎖された成形ツール（２２）内に残っているパッチングされた複合シート構造が、少なくとも約５００℃に冷却されることを特徴とする、請求項７に記載の方法。

【請求項９】　共成形の後で、閉鎖された成形ツール（２２）内に残っているパッチングされた複合シート構造が、まず少なくとも約５００℃に冷却され、その後、閉鎖状態において、正確な寸法を有するインプレッション(impression)によって固定ツールの両側の表面上に収容された成形済みの複合シート構造に接触し、引き続き複合シート構造の所望の成形状態を機械的に固定する隣接する開閉可能な固定ツール（２３、２６）に移送され、その時点で形成済み複合シート構造で優勢な高温状態で、固定ツールと一体化されたトリミング・ツールによってトリミングされ、固定ツールの確実に冷却されたインプレッションによって引き続き冷却されることを特徴とする、請求項１に記載の方法。

【請求項１０】　共成形の後で、パッチングされた複合シート構造の確実な冷却が、まず成形ツール（２２）内で行われ、その後、移送のために起こる短時間の中断を除き、複合シート構造の所望の成形状態が常に機械的に固定された状態で、開閉可能な固定ツール（２３、２６）のシーケンス、すなわち、閉鎖状態において正確な寸法を有するインプレッションにより各ケースで固定ツールの両側の表面上に収容された成形済みの複合シート構造に接触する隣接する開閉可能な固定ツール（２３、２６）のシーケンスによって行われ、固定ツール（２３、２６）から固定ツール（２６）に渡された複合シート構造が、固定ツール（２３、２６）のインプレッションにより複数の連続するステージ（Ｚ）で少なくとも１５０℃に冷却され、前記インプレッションが内側から確実に冷却されることを特徴とする、請求項１に記載の方法。

【請求項１１】　共成形の後で、パッチングされた複合シート構造が、成形ツール（２２）のみ、またはその後の固定ツール（２３、２６）のシーケンスとの協働によって、２０秒から４０秒、好ましくは約２５秒から３０秒の間冷却されることを特徴とする、請求項１または１０に記載の方法。

【請求項１２】　成形済みの複合シート構造でマルテンサイト材料構造を得るために、複合シート構造が、少なくとも８００℃から５００℃の間の温度範囲で急速に、すなわち、８００℃から５００℃に４秒未満の時間で冷却されることを特徴とする、請求項１に記載の方法。

【請求項１３】　成形済みの複合シート構造でベイナイト材料構造を得るために、複合シート構造が、少なくとも８００℃から５００℃の間の温度範囲で比較的ゆっくりと、厳密には、８００℃から５００℃に、４秒よりも長いタイムスパンで冷却されることを特徴とする、請求項１に記載の方法。

【請求項１４】　補強シート（３、３’）が基本シート（２）に取り付けられる前に、少なくとも１枚のシート（２）が、硬質はんだ（４）を用いて接触面上にそれを覆うように配置され、硬質はんだが、成形温度への加熱時に融解され、共成形された複合シート構造が、少なくとも硬質はんだ（４）が完全に凝固するまで冷却され、成形状態が、閉鎖された成形ツール（２２）内で機械的に固定されることを特徴とする、請求項１に記載の方法。

【請求項１５】　硬質はんだ（４）を備える少なくとも１枚のシート（２）の接触面が、余分の硬質はんだ（４）を備え、この余分（３５）の硬質はんだが、共成形中に補強シート（３）の縁部に現われることを特徴とする、請求項１４に記載の方法。

【請求項１６】　硬質はんだ（４）が塗布される前に、基本シート（２）と補強シート（３、３’）の両方の接触面が、硬質はんだ付けのために、クリーニングされ及び／又は活性化されることを特徴とする、請求項１４に記載の方法。

【請求項１７】　硬質はんだ（４）がペースト状で塗布されることを特徴とする、請求項１４に記載の方法。

【請求項１８】　硬質はんだがチップ形状で付与されることを特徴とする、請求項１４に記載の方法。

【請求項１９】　硬質はんだが、形状に従ってパンチングされたはんだ付けフォイル・ブランク(foil blank)の形で付与されることを特徴とする、請求項１４に記載の方法。

【請求項２０】　凝固温度が少なくとも５００℃、好ましくは少なくとも５５０℃である硬質はんだ（４）が使用されることを特徴とする、請求項１４に記載の方法。

【請求項２１】　硬質はんだ（４）が塗布され、補強シート（３、３’）が基本シート（２）上の画定された位置に配置された後で、補強シートと基本シートが、単一の点（５）によって暫定的に互いに固定されることを特徴とする、請求項１４に記載の方法。

【請求項２２】　パッチングされた複合シート構造（６）の加熱が、炉（１８）内の保護ガス雰囲気（保護ガス１９）で行われることを特徴とする、請求項１または１４に記載の方法。

【請求項２３】　基本シート（２）および／または補強シート（３、３’）が、以下にリストされた合金組成を有する水焼入れ熱処理可能な(water-hardening heat-treatable)鋼からなり、以下のリストにおいて、含有量は重量%で表されており、基本金属としての鉄に付加される量であることを特徴とする、請求項１または１４に記載の方法：

炭素：　　０．２３～０．２７%、
ケイ素：　　０．１５～０．５０%、
マンガン：　　１．１０～１．４０%、
クロム：　　０．１０～０．３５%、
モリブデン：　　０～０．３５%、
チタン：　　０．０３～０．０５%、
アルミニウム：　０．０２～０．０６%、
リン：　　最大０．０２５%、
硫黄：　　最大０．０１%、および
他の合計：　　０．００２０～０．００３５%。

【請求項２４】　基本シート（２）および／または補強シート（３、３’）が、腐食しないように無機物をプリコーティングされ、以下にリストされた合金組成を有する鋼からなり、以下のリストにおいて、含有量は重量%で表されており、基本金属としての鉄に付加される量であることを特徴とする、請求項１に記載の方法：

炭素：　　０．２０～０．２５%、
ケイ素：　　０．１５～０．３５%、
マンガン：　１．１０～１．３５%、
クロム：　　０．１０～０．３５%、
チタン：　　０．０２～０．０５%、
硫黄：　　最大０．０８%、および
他の合計：　０．００２～０．００４%。

【請求項２５】　複合シート構造の材料強度が、共加熱成形プロセスに組み込まれた熱処理によって約１３００ＭＰａ～１６００ＭＰａに高められることを特徴とする、請求項１または１４に記載の方法。

【請求項２６】　車体の乗員セルに組み込まれる中空部材用の局所的に補強されたシェル部品が、この方法によって製造されることを特徴とする、請求項１または１４に記載の方法。

【請求項２７】　車両のシャシに組み込まれる中空部材用の局所的に補強されたシェル部品が、この方法によって製造されることを特徴とする、請求項１または１４に記載の方法。

【発明の詳細な説明】

【０００１】

【発明の属する技術分野】本発明は、たとえば、ドイツ特許第４３０７５６３Ａ１号で知られているようにギャザリング可能な、請求項１の前提節による、特に車体の構造部品としての、局所的に補強されたシート・メタル成形品を製造する方法に関する。

【０００２】

【従来の技術】自動車の車体の重量を削減するために、車体のシート・メタル構造部品において力が作用する点に局所的に補強された補強シートを設け、構造部品全体を厚いシートで製造する必要をなくすことが知られている。シート・メタルシェルで形成された中空部材の曲げ抵抗を高めるには、中空部材の比較的長い領域にわたって延びる補強シートを少なくとも１つのシート・メタルシェルの内側または外側に一体化することができる。補強のために、一定の断面を有する補強チューブもすでに中空部材に埋め込まれている。しかし、この補強チューブは、中空部材の形状にほぼ従っているが、中空部材の

断面を完全に覆っているわけではなく、ウェブプレートを介するかあるいは直接、中空部材の壁に特定の点でのみ連結されている。中空部材の剛性を高めるこの種の構造は、たとえば、横からの衝突に備えて乗用車の車体の中央ピラー上に設けられている。通常、この場合も、重量上の理由で、中空部材の継手または連結点、すなわち、交差部で、局所的に絞られた補強物を横中空部材の壁に組み込むと有利である。

【０００３】従来、基本シートおよび補強シートが別々に深絞りされ、その後、これらの部品ワークが溶接されて完全な構造部品が形成され、したがって、２つの別々な絞り工程および成形工程、別々な２組のツール、および三次元形状のシート・メタル部品を組み立てるための独立の工程が前提とされている。これらはすべて、時間およびコストがかかる。

【０００４】ドイツ特許第４３０７５６３Ａ１号で知られている、自動車の車体用の局所的に補強されたシート・メタル構造部品を製造する方法では、構造部品の基本シートを形成するシートビレットが局所的に、すなわち、所定の点で平坦な状態で、好ましくはより強度の高いより小さな補強シートに連結され、その後、この主として平面状の複合シート構造がプレスにおいてまとめて深絞りされる。補強シート自体は、事前に部分的に成形し、たとえば、補強ビードを設けることができる。補強シートは、輪郭形状においてこのように設計され、深絞り後に、補強シートが力が作用する点を最適に覆うように位置決めされる。用途に応じて、補強シートは基本シートよりも高い強度を有することができ、この目的のために、補強シートの壁厚を大きくし、かつ／または材料の品質を高めることができる。いくつかの状況では、複数の層が好ましくは、ある程度異なるサイズを有する、補強シートの多層設計も推奨される。

【０００５】基本シートビレットおよび補強シートを連結する技法として、ドイツ特許第４３０７５６３Ａ１号は特に、硬化またはプレス組立て（いわゆるクリンチング(clinching)）を引用しており、これは、基本的に、成形工程または任意の固定要素、たとえば、パンチインナットやパンチインボルトの取付けにこの組立て技法を組み込むことができるので、特に有利であるとみなされる。この場合、いくつかの状況では、成形プレス内の基本シートの後の定義された位置に補強シートを配置するだけでよい。また、溶接連結技法および接着連結技法についても述べられており、これらの連結技法に関しては、特に、構造部品の表面が影響を受けないことが強調されている。この文献において、基本シートおよび補強シートの相互接触表面を腐食から保護しなければならないことが容易に認識されよう。というのは、その後これらの表面に施される塗料またはワックスによる腐食防止では水分の進入から永久的に保護することはできないからである。したがって、基本シートおよび補強シートの少なくとも一方の側が亜鉛めっきされたシートを使用するか、あるいはその代わりに、プラスチックまたは金属で作られた保護フィルムを接触点に挿入することが推奨されている。任意の接着層の腐食防止作用も強調されている。

【０００６】実際、基本部品と補強部品を別々に成形する、上記で概略的に説明した手順と比べて、ドイツ特許第４３０７５６３Ａ１号で知られている方法は、深絞り工程が単一の一様なワークサイクルと組み合わせられるので、ずっと費用的に有効である。しかし、一方、欠点として、特に、補強シートがより高い強度を有するか、あるいは場合によっては補強シート自体が多層設計を有するときに、この目的のために非常に高い成形力が必要である。このため、応力が高くなり、したがって、成形プレスの個々の部品の弾性変形度が高くなり、したがって、作業精度が低下し、成形プレスおよびプレスの有効寿命が短くなる。より高い応力またはプレス部品のより高い弾性変形度は、プレス部品をこれに対応して寸法付けすることによって補強することができる。ただし、この場合、プレスのコストが高くなる。しかし、ツールの磨耗の増大を補償することはできず、したがって同様に、製造される構造部品のピースコストが高くなる。

【０００７】本明細書で評価される、パッチングされた複合シートを共成形する既知の技法では、それによって実現することのできる補強度が限られていることを想起されたい。これは、補強シートの成形力または絞り力を補強シートにかなりの程度に伝達するには、基本シートを介し、補強シートの周辺に取り付けられた基本シートと補強シートとの間の連結点を介して間接的に伝達するしかないからである。補強シートが基本シートと比べて材料強度が高いか、あるいは壁厚が大きいか、あるいはその両方のために、基本シートよりも抵抗がかなり高い場合、基本シートと共に所望の方法で成形することはできない。局所的に特に高い補強度を実現する場合、基本シートおよび補強シートをそれぞれの場合に別々に成形し、その後、２つの部品を互いに溶接して複合部品を形成しなければならない。

【０００８】補強シートを基本シートと共に成形して構造部品を形成するか、それとも導入部で述べたように、基本シートおよび補強シートをそれぞれの場合に別々に成形し、その後２つの成形品を組み立てて構造部品を形成するかにかかわらず、重量上の理由で基本シートの壁厚が薄くなることが意図され、したがって、同様に腐食が低減されることに鑑みて、基本シートと補強シートの接触点に有効な腐食保護機構を有し、構造部品の有効寿命が短くなる可能性を回避することが特に重要である。ドイツ特許第４３０７５６３Ａ１号で知られている方法による各シートの接触点における有効な腐食保護機構は、腐食保護膜を介在させても確実に確保することはできない。厳密に言えば、基本シートと補強シートとの間

のパンクチフォーム連結点（クリンチまたは点溶接）によって、介在する腐食保護膜が破壊され、したがって、毛管作用によって進入する水分により、ちょうど連結点で腐食が起こり、やがて比較的薄い基本シートに穴があくことがある。塗料およびワックスによる腐食防止にもかかわらず、車体の保護されている内側領域でも、蒸散水が形成されることと、毛管作用のために、車体基本シートと補強シートとの間の接触表面に水分が進入することを予期しなければならない。

【０００９】ドイツ特許第４３０７６５３Ａ１号による既知の方法の上記の重要な評価に基づいて、システムに固有のこの方法の欠点を以下のように要約することができる。

－　共成形すべきシートの成形の程度が限られている。

－　共成形されるシートの回復挙動が大きい。

－　このため、構造部品の寸法精度がかなり低い。

－　成形力が補強シートに間接的に伝達されるので、補強点で実現できる補強度が限られている。

－　共成形時のプレス力が高く、したがって投資コストが高い。

－　ツールが激しく磨耗し、したがって、ピースコストが高くなる。

－　組立体表面に対する腐食保護が限られている。

【００１０】ドイツ特許第１９５２９８８１Ｃ１号は、シートが高温状態のときに深絞りされ、成形準備完了状態で、その後の熱処理によってばね鋼の硬度にされる硬化可能なばね鋼で深絞り部品を製造することを開示している。ただし、このような工程をどこでどのように行うかは述べられていない。深絞りに続く熱処理では、部品が反り、したがって、寸法および／または形状に関連する顕著な延展を受ける恐れがある。このこととは別に、構成要素に対する局所的に激しく変動する応力の場合、応力が最大になる点に対応して壁厚を設計しなければならず、したがって、応力が比較的弱い点で壁厚の寸法が過度に大きくなる。理論的には、その後、補強シートを溶接することによってこの成形品を局所的に補強することが考えられるが、基本シートの硬度および／または補強シートの強度が局所的に溶接部で失われるので、これは不都合である。使用するシートの強度が高い場合、はんだ付け、接着結合、クリンチングなど他の連結技法を除外するのが適切である。なぜなら、これらの連結技法を実施すると必ず基本シートおよび／または硬化された材料が損なわれ（はんだ付け、クリンチング）、あるいはこれらの連結技法では必要な強度が与えられないからである。埋め込みシートの所望の補強効果を実現するために、連結点は、硬化された基本シートと少なくともほとんど同じ強度を有する必要がある。したがって、ドイツ特許第１９５２９８８１Ｃ１号による既知の方法は、以下の欠点を有する。導入部で述べた参考文献に関する文を部分的に引用することができる。

－　壁厚が一様であるために軽量の構成しかできない。

－　局所的な補強が不可能である。

－　熱処理のために構造部品の寸法精度が比較的低い。

【００１１】

【発明が解決しようとする課題】本発明の目的は、以下の基準に関して一般的な製造方法を改良することである。

－　この方法の成果に関して、基本シートまたは非補強構成要素と比べてより高い局所補強度を単一の製造ステップで実現できるようにする。

－　この方法の結果に関して、成形品の従来よりも高い加工精度を実現できるようにする。

－　この方法を実施する手段に関して、成形ツールおよび成形プレスが予期されるよりも低い応力を受けるようにし、その範囲内で正当な有効寿命が予期できるようにする。

【００１２】

【課題を解決するための手段】包括的な方法に基づき、本目的は、本発明により請求項１の特性を決定する特徴によって達成される。これらの特徴によって、本発明により、パッチング複合シートが、加熱状態で所望の形状に成形され、成形状態を機械的に維持したまま、定義されたように成形ツール上で冷却される。

【００１３】本発明は、新規の軽量構成の概念を得る費用効果の大きい方法を提供する。これを説明するため、まず、ボディが軽量であることによって、自動車の性能（運転の楽しさ）と燃料消費（コスト・レベル）が本質的に相互に決定されるので、これが顧客の利益に直接つながることを思い起こすとよい。他方、乗員の安全性を高めるために、自動車のボディは乗員セルの領域をできる限り剛性にして、この効果がより重量の大きいボディに向くようにすべきである。更に、重量に関するこれら２つの相反する要件は、ボディのコストに直接関係する。一方でのコストと他方での重量とは互いに反対に増加する傾向がある。すなわち、ボディの設計がより軽量になるほど一般に製造コストがより高くなるが、利用できる軽量構成寸法の範囲を使い果たす程度がより低いボディ構成を、より大きい費用効果で製造することができる。しかし、このボディの機能、コスト、重量の関係のネットワーク内で、鋼製の構造部品の発明による加熱成形によって、適度なコストでの軽量構成を可能にする新しい境界状態が設定され、同時にその機能が増加する。本発明による製造方法の可能性および効果は下記の通りである。

－　費用効果の大きい軽量な構成が可能になる。

－　高強度および可能な最高強度の材料を使用することができる。達成できる材料強度は、従来の最大値に比べて約３倍に増加させることができる。

－　高強度の材料を使用しているにもかかわらず、高度の成形を容易に実現することができる。

－　基本シートの所望の程度の補強を、広い範囲内で実現することができる。
－　従来のシート・メタル・シェル構成と、これに関する設計および補修ノウハウとを維持することができる。後者により基盤構造の重要性が確実になる。
－　補強材が依然として必要となる限り、これらを１つのシェルに組み入れ、かつ後者の製造に組み入れることができる。
－　加熱成形により、成形プロセス後のシート・メタル部品の回復動作が無視できるものとなるため、製作精度が増加する。低い製作公差を容易に実現することができる。
－　成形ツールと構造部品との調整に関する費用は、単純なシート・メタル部品の成形の場合よりも高くなることはなく、低くなる。
－　設備投資、必要な機械時間、輸送および在庫管理のコストが削減される。
【００１４】本発明によるこの効果のリストには、種々の出典の従来技術から集めた効果の概要について共同の超過分を構成するものが含まれている。すなわち下記の点が相互の効果として特に強調される。
－　高強度の材料を使用しているにもかかわらず、高度の成形を容易に実現することができる。
－　基本シートの所望の程度の補強を、広い範囲内で実現することができる。
－　加熱成形により、成形プロセス後のシート・メタル部品の回復動作が無視できるものとなるため、製作精度が増加する。低い製作公差を容易に実現することができる。
【００１５】従って、製造された構造部品を、基本シートと補強シートとの間の接触領域の腐食からより効果的に保護することができる。本発明の適宜の実施形態では、補強シートが基本シートに取り付けられる前に、少なくとも１枚のシートの接触表面に表面を覆うように硬質はんだが設けられ、それにより両方の接触表面が予め清浄にされるので有利である。パッチング複合シート構造を成形温度まで加熱する際に（これは炉の保護ガス雰囲気中で行われることが好ましい）、塗布された硬質はんだが溶解する。成形プロセス中、密着した無孔のはんだ接合部が、共に変形され押圧されたシート・メタル部品により製造される。硬質はんだは、表面を覆うように接触域を塞ぎ、その後確実に湿気の侵入を防いで非常に効果的な腐食保護を提供する。硬質はんだは、成形中に補強シートの縁部に絞り出される余剰分をもって塗布されることが好ましい。はんだ付けにより、補強シートと基本シートとを連結するステップが成形プロセス中に容易に組み入れられる。例えば、はんだ塗布後かつ加熱前に補強シートと基本シートとの間に設置された１つの連結点により、処理中に補強シートと基本シートとが互いに所望の位置を明確に維持し、例えば互いに関して所定の位置から外れることが確実にできないようにすることのみが必要となる。
【００１６】本発明の更なる適宜の実施形態はサブクレームから集めることができ、更に、図面に例として示される種々の方法図および詳細により本発明を以下に説明する。
【００１７】
【発明の実施の形態】図１、図２に共に示す方法は、立体形状の構造部品１の製造に役立つものであり、構成部品１は基本シート２と、より小さく局所的に配置された補強シート３とからなる。この場合、構造部品の基本シート２が、平らな状態で次の補強点に対して所定の点で補強シート３に連結され、このようにパッチングされた複合シート構造６の部品が、図３に示すように、開閉可能な成形ツール２２により成形プレス２１内で連続して共に成形される。
【００１８】製品および方法の結果に関して製造方法を改良するため、また方法を行う手段に関してこれを緩和するために、本発明により、パッチング複合シート構造６が、共に成形される前に材料の成形温度を超える温度まで加熱され、加熱状態では適度のツール応力で所望の形状に形成され、続いて、閉じたままの成形ツール２２および／または次の固定および切取りツール２３内に機械的に固定された所望の成形状態で、定義されたように冷却され、結果として本質的に加熱処理される。
【００１９】図１、２に図示した設備は、本発明による方法を実行するために、それぞれの場合に基本シート用コイル１２および補強シート用コイル１３の巻き戻し装置を提供している。巻き戻されたシートは、まっすぐにされた後に、持上げシアー(shears)１４、１５で個々の基本シート（ビレット）２および更に間欠的に処理される個々の補強シート（ビレット）３とに分けられる。２つのコイル１２、１３は異なる幅のシート（ブランク）２、３に従い異なる幅となっている。個々のシート厚さは、一方で基本シートの補強していない領域の構造部品にかかる負荷に応じて決められ、他方で所望の補強効果に応じて決められ、個々の件について最適となるようにしなければならない。補強シートは、通常、基本シートよりも薄い。しかし、補強シートが基本シートよりも厚く局所的な補強が大きい場合も容易に想定できる。ある状況においては、一方を他方に重ねた大きさの異なる２枚の補強シートからなる多層補強材を有し、補強が層の数に従って外側縁部からステップ内で増加することが適切であることがここで明らかになる。
【００２０】補強シートの剛性に関し、この接合部においてさえ、材料の強度、シート厚さおよび／または層の数だけでなく、適宜の構造堅さによってもこれが影響を受けることを指摘することができる。正確には、図４の例示により、補強シート３’自体は、基本シート２との組合せ前に補強ビード７を取り付けられることにより予

備成形され、それにより構造的に堅くなる。しかし、この場合、予備成形された補強シート３’をそれにもかかわらず基本シート２上の所定の点に正確な寸法で確実に載せることができ、そこに固定することができる点に注意しなければならない。

【００２１】材料に関し、両シートは同一のまたは類似した材料からなることが好ましい。それ自体公知で、業界で深絞りシートとして入手可能であり、基本シート２および／または補強シート３、３’として考慮できる２つの異なる材料を以下に提示する。すなわち、一方はドイツの会社であるＢｅｎｔｅｌｅｒ　AGの、業界名ＢＴＲ　１６５として販売されている水焼入れ加熱処理が可能な鋼をこれに関して挙げることができる。この鋼は以下に挙げる合金の組成を有し、基本の金属である鉄に加えられる合金パートナーの含有量を重量%で理解することができる。

炭素：	０．２３～０．２７%
珪素：	０．１５～０．５０%
マンガン：	１．１０～１．４０%
クロム：	０．１０～０．３５%
モリブデン：	０　～０．３５%
チタン：	０．０３～０．０５%
アルミニウム：	０．０２～０．０６%
リン：	最大　０．０２５%
硫黄：	最大　０．０１%、および
その他合計：	０．００２０～０．００３５%

【００２２】他方、フランスの会社であるＳｏｌｌａｃ　ＳＡのシートも推奨できる。これは腐食に対して無機的にプリコーティングされており、業界名２２ＭｎＢ５として販売されている。シートを無機的にプリコーティングすること（加熱処理中に基本材料内に部分的に拡散して三相の積層材料Ａｌ／Ｓｉ／Ｆｅを形成するアルミニウム／珪素コーティング）により、加熱中のシートのスケーリング(scaling)および脱炭が防止され、シートの酸洗いおよびリン酸塩処理が不要となる。コーティングにより従来の溶接が容易にできるようになる。コーティングされていないシートは、以下に挙げる合金組成を有する鋼からなり、基本の金属である鉄に加えた含有量を同様に重量%で理解することができる。

炭素：	０．２０～０．２５%
珪素：	０．１５～０．３５%
マンガン：	１．１０～１．３５%
クロム：	０．１０～０．３５%
チタン：	０．０２～０．０５%
硫黄：	最大　０．００８%、および
その他合計：	０．００２～０．００４%

【００２３】図１、２に示す方法図は、２つのブランクの硬質はんだ連結を提供する。従って、図１に示す例示的な実施形態では、アプリケータ・ロボット１６によって、例えばスプレー可能なペースト状に塗布された硬質はんだ塗布部４が、基本シート・ビレット２の所定の表面上に局所的に設けられている。この接合部では、他の形状の硬質はんだ塗布、例えば形状に従ってパンチングされたはんだフォイル・ブランクの位置へ塗布することや、チップの位置に広げまたは塗布することも想定できる点に注目してもよい。シート・メタル部品の硬質はんだ付け連結に関し、それはある状況では有利になり、更に、図１には示されていないが、基本シートおよび補強シートの両方の接触表面を硬質はんだ４の塗布前に清浄にし、および／または硬質はんだ付けのために活性化する場合に、有利となる。更に、完全にするために、硬質はんだを補強シート３の接触表面に追加して塗布し、または別法として塗布してもよいことに言及する。硬質はんだ４はいくらかの余剰分をもって適切に塗布されるので、シート・メタル部品の普通の加熱成形中、硬質はんだの溶解後にこの余剰分が補強シート３の縁部に絞り出される。図４およびその縁部に絞り出されたはんだの余剰分３５を参照のこと。この硬質はんだの余剰分の絞出しはガスの封入をなくして無孔のはんだ接合部を提供するだけでなく、補強シートの縁部が、縁部に集められメニスカス(meniscus)としてそこに生じる余剰分３５により効果的にシールされ、基本シートへの段付き移行が壁の厚さおよび切欠き作用に関してやや緩和される。

【００２４】硬質はんだの塗布後、シート・メタル部品２、３を、必要なシートの互いに所望の位置に従って定義された位置に、一方を他方に重ねて置く。これは補助装置を用いて効率的にかつ確実に行うことができる。続いて２枚のシートは、シート・メタル部品の相対位置を確実にするために、溶接ロボット１７を用いて、好ましくは１つの仮付け点５のみにより一時的に互いに固定される。

【００２５】シートの、または（コーティングされていないシートを使用した場合）シートの表面全体の、コーティングされていない境界面のスケーリングを防ぐために、このようにパッチングされた複合シート構造６の部品が、連続流炉１８に自動的に導入され、この炉の雰囲気は例えばガス・ボトルからの保護ガス１９を特にかつ十分に加えることにより不活性化される。保護ガスは、例えば二酸化炭素および／または窒素とすることができる。炉内では、複合シート構造は、材料の構造変態温度を超えるまで（通常は８５０～９３０℃の温度範囲内の特定の温度）加熱され、それを超えると材料の構造がオーステナイト状態となる。その結果、特定の冷却により材料を加熱処理することが可能となり、それにより達成できる材料強度の設定が可能となる。

【００２６】連続流炉の充填は、例えば炉用として公知の自動充填装置を用いて行うことができる。この場合、複合シート構造が炉内のグリップ互換定義された位置に確実にあり、シートに歪みがなく、火格子により支持されるほぼ全表面の平らな位置にあることに注意しなけれ

ばならない。対比すると、加熱した複合シート構造６’が炉から成形ツール内に急速に搬送されるので、炉１８から複合シート構造を摘出するために処理ロボット２０が設けられている。この処理ロボットは、定義された位置に既に置かれている加熱した複合シート構造６’を、炉内の所定の点で把持し、直後にそれを定義された位置内と同様に、開いた成形ツール２２内に導入する。この時間は、成形ツール２２が閉じ始めるまでの、たったの数秒間である。従って導入は２秒以下で終了することが好ましい（図６のプロセス開始時の時間Ｅ（導入）を参照のこと）ので、それにより生じる工作物の冷却はわずかであり、対応したより高い炉温度を選択することによって見越しておくことができる。

【００２７】図３でより詳細に示される例示的な実施形態では、成形ツール２２が、下部固定部内で、一般に１つの平面、通常は水平面に延びる固定された留め縁部をもつ雌の金型３０で構成されている。成形ツールの上部の持ち上げ可能な可動部分は、持ち上げ可能に可動となるよう別個に駆動できる留め装置３２(holding-downdevice)をもつ雄の金型３１からなり、その平面支持面が雌の金型の留め縁部に平行に配置されている。加熱した複合シート構造６’が開放した成形ツール内に導入されると、複合シート構造はまず外側のみの雌の金型の留め縁部上に置かれ、後者のインプレッションを自由にわたる。ツールを閉じる際には、まず留め装置３２が複合シート構造の縁部上に載せられ、縁部が特定の引張りにより締付け状態から滑り出ることができるように、予め決定できる締付け力で後者を締め付ける。それにより縁部の締付けが留め装置３２によって生じた後にのみ、雄の金型が複合シート構造上に設置されて、成形動作が開始する。

【００２８】加熱成形中、留め装置３２を絶縁すべきである。しかし、加熱成形は、留め装置がシートを急速に冷却することを妨げるので、留め装置なしで行うことが好ましい。

【００２９】雄の金型３１が持続して下降する結果、導入された加熱複合シート構造６’のシート・メタル部品が共に成形される。通常の厚いシート厚さにかかわらず、複合シート構造が加熱状態にあるので、一方での成形プレス２１に加わる力と、他方での成形ツール表面上で有効な摩擦力とがかなり低くなっている。従って通常の深絞り動作のための従来のプレス構造を使って、従来通りのコスト・レベルで作業を行うことができる。

【００３０】補強シート３は、確実に定位置に置かれているが、実際には基本シート２上に留めずに置かれており、一般に引張りがなくてもしわのないように所望の形状に成形することができる。これは、通常生じるように、補強すべき構造部品の域が、空間的にわずかにカーブした外形を有している場合に特に当てはまる。成形ツールを閉じるためおよびそれを成形するための時間Ｓ（図６参照）は、成形ツール２２を閉じ始めてから複合シート構造が完全に成形されるまでを数えて、非常に急速に複合シート構造の導入直後に生じる。この本質的な段階は、少なくとも３～５秒で終了する。認められているように、複合シート構造が成形ツールのインプレッションと部分的に接触するため、この時間の方が処理ロボットの熱保持トングを除いて複合シート構造が外気のみと接触する導入段階の間よりも、接触点での複合シート構造の熱損失が局所的に大きくなる。しかし下部の雌の金型３０のインプレッションは、初めは複合シート構造に全く接触せず、成形プロセスのまさに終了時にしか接触しない。更に、上部の雄の金型３１は、初めに複合シート構造に部分的に、および成形の程度が一般にいずれにしてもかなりわずかしかない領域のみで接触する。インプレッションにより接触していない、あるいはまだ接触していない領域では、加熱した複合シート構造が淀んだ空気に囲まれて、熱損失に対してその程度まで絶縁される。いずれにしても、複合シート構造は、成形段階の間に適度にのみ冷却され、成形ツールのインプレッションと部分的に接触するにもかかわらず、小さい力で大きく容易に加熱成形される。プレスと成形ツールを解放することに加えて、加熱形成は更に、（冷間成形と比べて）実質的により高度な複合シート構造の成形を１回の成形工程で行うことができるという、相当の利点を有している。

【００３１】成形ツールを閉じた結果として、複合シート構造の部品が共に加熱状態で所望の形状になった後、成形された複合シート構造は直後に冷却され、複合シート構造はこの冷却時間中に所望の成形状態に機械的に固定される。冷却の結果、硬質はんだが凝固してはんだ接合部にその後負荷がかかるだけでなく、定義された冷却により、使用する材料が特に加熱処理され、対応して特定の材料強度がそこに設定される。更に、必要な所望の状態での冷却中に成形されたシートを機械的に固定することにより、はんだ接合部は硬質はんだの凝固段階で閉じたままとなる。更に、加熱処理にかかわらず、複合シート構造の成形状態が確実に安定し正確な寸法となるだけでなく、回復傾向もなくなる。その結果、小さな寸法および／または形状に関連した塗布量をもつ非常に精密な工作物が製造される。

【００３２】成形ツールで成形された複合シート構造の特定の冷却を可能にするために、図３の例示により、雌の金型３０と雄の金型３１とのインプレッションに、表面近くを通り冷却回路２４に組み入れられる冷却ダクト３３、３４が設けられ、その冷却剤を図示しないポンプにより確実に循環することができる。加熱された冷却剤を、冷却回路に組み入れられた熱交換器２５により再び冷却することができ、この場合に使用される冷エネルギーは、例えば冷蔵アセンブリにより、または適宜の排水口（配水管、川）からの冷用水により印加される。例示

した実施形態では、冷却中、工作物にすじの影響(streak effect)ができる限り残らないようにするために、一方の雌の金型の冷却ダクト３３と他方の雄の金型の冷却ダクト３４とを互いに交差させて配置している。

【００３３】以下で明らかになる理由により、図１、２による方法図に示す例では、冷却が２つの連続するステージで行われる。第１の冷却段階は成形ツール２２自体が確実に冷却されたインプレッションと接触することにより生じ、この第１の冷却段階の目標温度については２つの考察が決定的となる。一方では、複合構造でのシートの硬質はんだ連結の場合、最初に溶解した硬質はんだは少なくとも硬質はんだ４が完全に凝固するまで冷却されなければならず、成形された複合シート構造が同時に機械的に固定され、この凝固が希望通りの速さまたは希望通りの遅さで行われるようにする。他方、特定の材料の強度は加熱処理により達成することができ、その目的で、当該鋼に関して、５００℃の目標温度と特定の冷却率が重要となる。従って、普通の成形後に、閉じたままの成形ツール２２内に残るパッチング複合シート構造が、少なくとも約５００℃まで冷却されることは重要である。更に、融点だけでなく、特に凝固点、すなわち使用される硬質はんだの固相温度が５００℃を十分に超えることが重要である。

【００３４】維持すべき冷却率に関し、以下のことを適用できる。成形された複合シート構造内のマルテンサイト材料構造は、可能な最高強度が構造部品に必要とされ、延性は全く必要ないかわずかしか必要でない場合に適切となり得る。このような場合、加熱成形複合シート構造は８００～５００℃の温度範囲で急速に、すなわち８００℃から５００℃まで４秒未満で冷却されなければならない。

【００３５】しかし、クラッシュの際の構造部品の良好な故障動作を意図して、材料の高い延性に関連したかなり高い強度を達成することが通常の目的である。この場合、目標は成形された複合シート構造内のベイナイト材料構造である。このため、工作物は８００～５００℃の温度範囲でかなりゆっくりと、正確には８００℃から５００℃まで４秒よりも長い時間で冷却されなければならない。

【００３６】工作物が形成ツール内に残り、固定状態が維持されている間、特に制御されない構造変化なしに、工作物を容易に処理および／または保管できる温度まで前記工作物が続けて冷却されることが考えられる。ツールと一体化した冷却が効率的に設計される場合、このために必要な全体の冷却時間は、シートの厚さ、工作物の大きさ、および最終温度に応じて約２０～４０秒となり、大部分の場合には２５～３０秒の範囲となる。製造のパイロット・プラントまたは小さなバッチ・サイズの場合、このような１ステージ冷却が明らかに適切である。しかし、通常はこのタイプの構造部品は大量に必要とされ、効率的な質量製造を設定しなければならない。この推定に基づき、工作物を複数ステージで、少なくとも２ステージで冷却することが適切である。

【００３７】従って図２による方法図は、工作物を切り取るという必要な動作を約５００℃の上昇した温度でも行うことができ、これは特に材料強度が増加した場合には切断ツールをかなり解放することを示す。他方、２ステージ冷却の利点は、成形ツールが新たな複合シート構造を受けるために再びより急速に解放され、すなわち周期時間が短くなり製造が合理化されることである。

【００３８】２ステージ冷却では、普通の成形後、閉じたままの成形ツール２２に残る間に、パッチング複合シート構造がまず特定の時間平均温度勾配に沿って約５００℃まで冷却され、次に成形プレス内で隣接する開閉可能な固定ツール２３内に搬送される。２つの隣接するツール、正確には、一方の成形ツール２２と他方の固定ツール２３とが順次のツールのように成形プレス２１内に配置され、それ自体公知の搬送装置により連結され、この搬送装置は、プレスの開放時に、工作物を隣接するツールから同期して持ち出し、次のツールまたはプレスの外に配置された保管場所に渡す。

【００３９】固定ツールに受けられる複合シートはその中で、同様に、閉じた状態で、両側でその表面を覆って、寸法的に正確なインプレッションと接触し、したがって複合シート構造の望ましい形成状態が、機械的に固定されるように維続する。詳細には図示しないが、トリミング・ツールが固定ツール２３に一体化される。トリミング・ツールによって、形成された複合シート構造は、効果的な高温状態でトリミングされる。特に、もはや不要となった基本シートの留めまたは圧延縁部が切り取られる。この目的のためのトリミング装置はそれ自体よく知られており、やはり図示することはない。固定ツールのインプレッションは同様に、表面近傍で一体化された冷却ダクトにより能動的に冷却されて、その結果、接触により機械的に形状固定されたワークピースから継続して熱を抜き取ることができるようになる。冷却中のすじ効果を回避するために、固定ツールの場合、上側および下側に配置された冷却ダクトを互いに横切るように配置することが好都合である。固定およびトリミング・ツールが連結されたとき、現れるワークピース形状は機械的方法によってのみ獲得される、すなわち、力の作用の下で固定ツールの表面上で形成および摩擦的作業が行われることはない。したがって、固定ツールは、軽量構造として設計され、強度がより低い材料、たとえばアルミニウムから構成することが可能である。特に、固定ツールの表面は閉じている必要はない。対照的に、ダクト開口のグリッドをツール表面に向かって一体化することにより、ワークピースは冷却流体、特に冷却エアにより直接作用されることが可能である。水分のミストおよび／または液体エアを冷却エアと混合することにより、熱

伝達媒体としてのエアと共に、非常に高い冷却速度を実現できる。上記にすでに述べた、約２５〜３０秒の冷却時間が、２ステージ冷却の場合にも達成される。ただし、冷却時の移送に起因する中断は含まれていない。

【００４０】２ステージ冷却後、加熱成形された構造部品は、硬質はんだ付けされた補強部品と共に、トリミングされた状態で引き出してさらに処理することができる。ワークピースは、強度が高く、軽量で、部品コストが安く、寸法および形状関連の精度が高いという特徴を有する。熱処理を共通の加熱成形工程と統合することにより、複合シート構造の材料強度は約１３００〜１６００ＭＰａまで高めることができる。材料強度が高いことにより、先のようにして局所的に補強された構造部品は、軽量構造に対して、特に車両本体の乗員セルに一体化された中空部材用のシェル部品として非常に好適である。車両構造内の他の使用分野は、車両のシャシに一体化された中空部材用の局所補強シェル部品である。

【００４１】可能なだけサイクル・タイムを短くしたために、本目的は必然的に、特に構造変化が抑制されないということなしに、形成プレス内の形成済みワークピースを容易に取扱いおよび／または保存可能な温度にまで冷却するということになる。そのような温度は通常、１００〜１５０℃とみなされる。一般には、そのような温度にある部品はマニュアルで扱うことはできない。したがって、冷却ゾーンに沿った冷却エアにより成形プレスの外側でさらに冷却することが勧められる。その場合は、ワークピースは、熱ひずみを回避するために共形の通過可能にされた支持シェルにより支持されるべきである。この場合、冷水ミストおよび／または特に室温により近い液体エアを冷却エアに加えてよい。

【００４２】図１および２による方法図に関し、やはり完全となることを目的として該方法の種々の変更形態について記載する。

【００４３】形成されたシート・メタル部品２および３の硬質はんだ付け連結を加熱成形により特に有利に組み合わせられるにもかかわらず、該方法は、この型の連結に依拠するものではない。硬質はんだ付け連結ではなく、溶接による連結を考慮してもよく、現行溶接接合のすべてが本明細書で関係するものである。これに関して、スポット溶接、ＭＩＧ／ＭＡＧ溶接またはレーザ溶接について言及することになる。この場合、図１の方法図において、硬質はんだの塗布が不要となり、代わりに、溶接作業が溶接ロボット１７によってより包括的に行われ、ある状況では他の溶接手段で行われる。上記すべての連結点または溶接シーム片は、補強シートの縁部に位置することになる。一般には、溶接スポット１つだけまたは数個だけにより補強シートを基本シートに対して連結することが原理的にまず可能であり、形成後のみに完全な耐荷重連結を実現することが可能である。しかし、加熱成形の前であったとしても、様々な理由により、補強シートと基本シートを一体に少なくとも縁部領域で完全に溶接することが勧められる。一方で、平坦な状態で、シートはより簡単に取り扱うことが可能であり、より効率的かつより高いプロセス信頼性のもとで溶接することが可能である。他方、すでに熱処理済みのシートが続けて溶接される変更例と比較すると、溶接が熱処理をも経るとすれば、その方が好ましい。最後に、関係するシートが互いに確実に連結されるとすれば、その方が形成プロセスにとって好ましい。シリコーン手段または同様な封止材料によりシートを互いに封止することが可能である。

【００４４】方法の別の変更例において、熱形成後の複合シート構造の冷却速度は、局所的に必要とされる別の材料強度によって異なるものである。構造部品の手順に基づいた衝突挙動の理由により、高い延性および低い強度がその中で局所的に現れる適用例が想定される。このタイプの領域は、これらの点で冷却されないか、または極めて遅く冷却される熱形成複合シート構造によって容易に実現できる。ただし、低強度領域から所望の高い材料強度を有する領域までの移行領域の冷却を持続することによって、低強度点（高温）から高強度領域（低温）への焼戻し効果がないことを確実にするように注意が必要である。

【００４５】次いで、図５および図６に関連して、加熱成形され局所的に補強された構造部品を生産するための４ステージ方法の変更例を取り扱う。詳細を図５に示す方法図は、図２による図例に主として対応しており、可能な限りの参照が、上記に概説した方法に関連した記述（ｓｔａｔｅｍｅｎｔ）に対してなされるものとする。ただし、成形プレス２１’は、ちょうど４ステージとなり、２ステージだけを備えた図２の成形プレス２１とはステージ数で異なっている。成形プレス２１’の始めの２個のステージは、やはり成形プレス２１の２個の単一ステージに主として等しい、すなわち、同様にまず、成形プレス２１’において、能動的に冷却された成形ツール２２が設けられ、同様に、冷却された固定ツールおよびトリミング・ツール２３がそれに続く。図２による特徴と比較すると、成形プレス２１’の詳細な特徴は、より長い成形プレス２１’内に、同様に冷却され、一方が他方に等距離をおいて後続する、別の２個の固定ツール２６が配置されていることである。それらは、トリミング装置を含まないという点で、固定およびトリミング・ツール２３と異なるだけである。

【００４６】成形プレス２１’に統合された４個のツール２２、２３、２６および２６により、加熱成形複合シート構造を連続する４個のステージで冷却することが可能になり、このため、図２に示す方法図による２ステージ冷却と比較して、サイクル・タイムを半分に短縮することになる。４個のツールのインプレッションは、両側で実質的に表面全体でワークピースと接触し、各ケース

においてそれらを高信頼度で所望の形状に固定する。ワークピースを直接または間接に能動冷却することにより、それらから熱を迅速に取り去ることが可能である。図３に示したように成形ツール２２のインプレッションは一体化された冷却ダクトにより能動冷却され、一方、固定ツール２３および２６は冷却ダクトのグリッドを担持し、これらはインプレッションの成形画定表面の向かって開放されており、その結果、冷却媒体、すなわちエア、エア／水分ミスト混合物、エア／液体エア混合物がワークピースに対して直接作用できる。さらに、ツールはすべて、移送装置によって互いに連結されて、ワークピースがツールからツールへ断続的に送られるようになっている。

【００４７】４ステージ冷却を用いた方法における手順を図６と関連して以下に説明する。図６は、平均ワークピース温度に関連して未定量化である温度／時間のグラフ、すなわち成形およびその後のマルチ・ステージ冷却の際の時間における温度プロフィルを示す。

【００４８】時間点ゼロは、パッチングされた複合シート構造が約９３０℃で炉１８から引き出された瞬間を指定している。短い引出し段階Ｅの間、シートはすでに幾分か冷却され、少なくとも約８５０℃で開放成形ツール２２に送られる。

【００４９】導入動作Ｅが過ぎると、プレスの作業サイクルが開始される。これについて、図６は、成形プレス２１’を経由して断続的に導かれるワークピースの、連続する４つのサイクルＺと、関連する温度プロフィルとを示す。各サイクルは、閉鎖段階Ｓ、固定段階Ｆ、および開放段階Ｏから構成される。少なくとも成形ツール２２において、閉鎖段階Ｓではまだ、ワークピースが冷却されたインプレッションと表面全体で接触することはないので、その結果、インプレッションの冷却作用は閉鎖および成形段階中は十分に行き渡ることはない。ワークピースが固定ツール２３および２６に配置されるその後のサイクルＺの際も、十分な冷却作用は、閉鎖動作Ｓが終了したときにのみ開始される。

【００５０】ツールを閉鎖する動作が終了し次第、成形ツールの場合、パッチングされた複合シート構造の加熱成形もこの時点で終了し、固定段階Ｆが開始され、その間に、ツールのインプレッションをワークピースに緊密に接触させることによって、後者の事実上の冷却がそれぞれのサイクル内で行われる。硬質はんだ付けがツール開放後に保持されるように、たとえば部分的に裂けることがないように、加熱成形に続く第１の固定および冷却段階で、ワークピースは硬質はんだの凝固温度E_Lの下へ十分に冷却されなければならない。さらに、ワークピースで所望の材料強度が得られるように、第１の固定および冷却段階で、ワークピースは約５００℃まで冷却し、同時に時間に対する特定の温度勾配を維持しなければならない。固定および冷却段階Ｆは、サイクル・タイムＺの大部分を占めるので、サイクル・タイムＺに対してクリティカルである。

【００５１】一サイクル内の固定および冷却段階が終了し次第、成形プレスおよび、それと共に、ツールが開放される。すなわち、開放段階Ｏである。ツールが部分的に開放されても、移送装置は、ツール内でワークピースを露出されてまま把持し、それらを雌型から取り外して、後続のツールの雌型に移送し、順序にしたがってそこに載置して、次の閉鎖動作がすでに開始されることになる。この開放段階Ｏの際、ワークピースはそれぞれの下側ツール部品のインプレッション内にゆるく載置されているだけであり、上面にも、または下側から領域全体にかけてもそれぞれのインプレッションに接触することがないので、開放段階の間でも、インプレッションの冷却作用は適度に行われるだけである。

【００５２】ワークピースと冷却媒体の間の温度勾配を低減するために、さらなる後方でのサイクル中の冷却速度は、より大きな温度差のもとで行われる、さらなる前方での冷却動作中よりも低くしてある。

【００５３】

【発明の効果】以上のように本発明によれば、基本シートまたは非補強構成要素と比べて、より高い局所補強度を単一の製造ステップで実現でき、また、成形品の従来よりも高い加工精度を実現できる。更に、成形ツールおよび成形プレスが予期されるよりも低い応力を受けるようにし、その範囲内で正当な有効寿命が予期できるものである。

【図面の簡単な説明】

【図１】補強シートが基本シートに硬質はんだ付けされた、基本シートと補強シートの普通の加熱成形の第１の例示的な実施形態による方法図である。

【図２】図１と共に、補強シートが基本シートに硬質はんだ付けされた、基本シートと補強シートの普通の加熱成形の第１の例示的な実施形態による方法図である。

【図３】図１、図２による確実に冷却した成形ツールを拡大して示した部分断面図である。

【図４】補強ビードを備えた補強シートが基本シートとの組合わせ前に予備成形される、パッチング複合シート構造の更に例示的な実施形態の横断面図である。

【図５】普通の加熱成形後に一連の確実に冷却した固定ツールのステップで基本シートと補強シートとが冷却される、基本シートと補強シートとの加熱成形を一部のみ示した更なる方法図である。

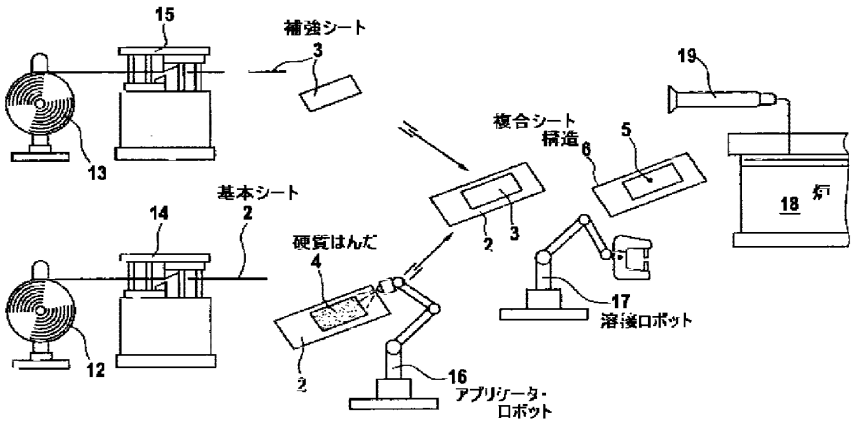
【図６】図５による方法の設備で製造される成形品の、製造中の温度分布を示す温度／時間グラフである。

【符号の説明】

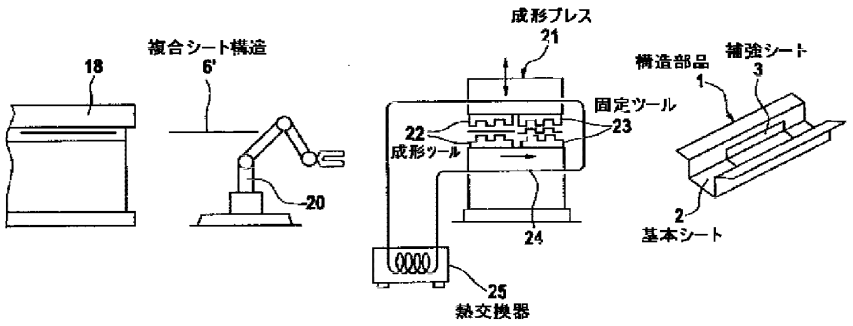
２　基本シート
３、３’　補強シート
４　硬質はんだ
５　仮付け点

6、6’　パッチング複合シート構造
7　補強ビード
18　連続流炉
19　保護ガス
22　成形ツール
23、26　固定ツール
33、34　冷却ダクト
35　余剰分
E　時間

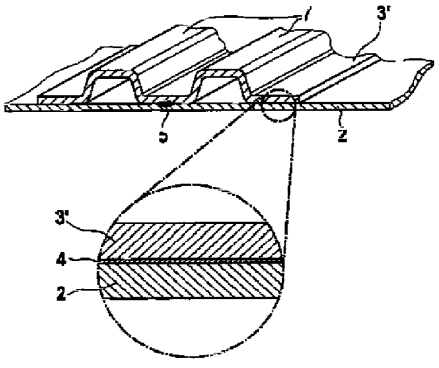
【図1】



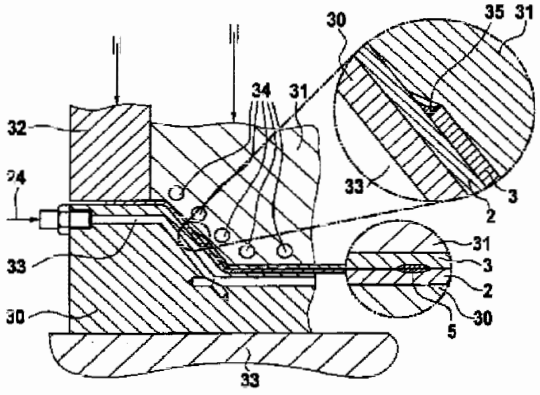
【図2】



【図4】



【図3】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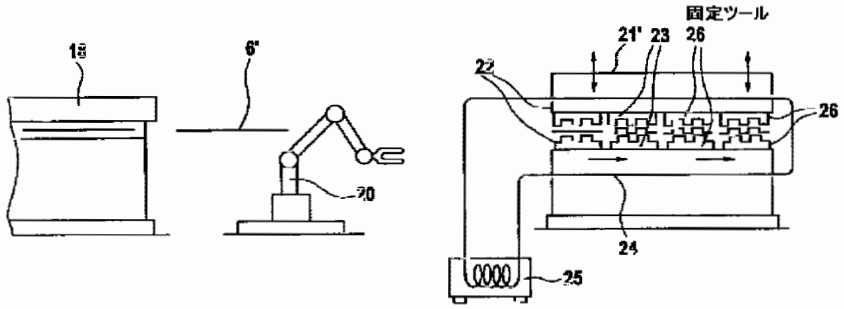
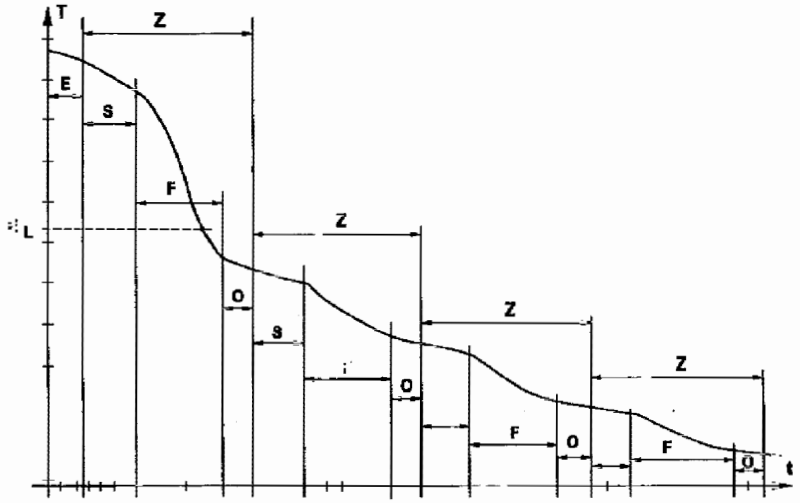
【図5】


固定ツール
21'
23
26
22
26
18
6'
20
24
25

【図6】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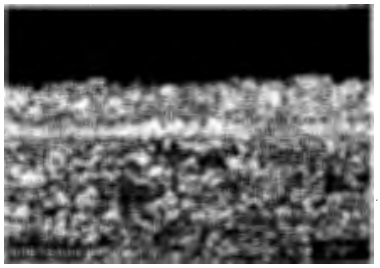
(54)【発明の名称】熱処理後に極めて高い耐性を有する被覆鋼部材の製造法

(57)【要約】
本発明は、熱間圧延または冷間圧延による帯鋼を原材料とする機械的性質に非常に優れた部材の製造法であって、アルミニウムまたはアルミニウム合金による該帯鋼の予備被覆と、予備被覆を施した帯鋼の冷間変形と、場合によって行う部材の最終形状に合わせた余分な金属板の切断と、鋼と被覆との界面から金属間化合物を生成し鋼をオーステナイト化するための部材の加熱と、装置への部材の移送と、冷却後に鋼がマルテンサイト構造、ベイナイト構造またはマルテンサイト－ベイナイト構造となるような速度で行う装置内での部材の冷却とを含む製造法に関する。予備被覆は、電気めっき、化学もしくは物理蒸着、または共圧延によって行う。



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【特許請求の範囲】
【請求項1】
熱間圧延または冷間圧延による帯鋼から機械的性質に非常に優れた部材を製造する方法であって、
該帯鋼にアルミニウムまたはアルミニウム合金による予備被覆を施す工程と、
該被覆を施した帯鋼を冷間で変形させる工程と、
該部材の最終的な幾何学形状に合わせて余分な板部を場合によって取り除く工程と、
該部材表面に鋼と予備被覆との界面から金属間化合物が形成され、鋼がオーステナイト化されるように該部材を加熱する工程と、
該部材を装置に移動する工程と、
冷却後に鋼がマルテンサイト構造もしくはベイナイト構造またはマルテンサイト－ベイナイト構造を持つような速度で該部材を装置内で冷却する工程と、
を連続して含む製造法において、
該加熱の前には該帯鋼と予備被覆との界面が金属間相を含んでおらず、該予備被覆が少なくとも１つのアルミニウムもしくはアルミニウム合金の電気めっき工程によって、少なくとも１つのアルミニウムもしくはアルミニウム合金の化学蒸着工程によって、少なくとも１つのアルミニウムもしくはアルミニウム合金の物理蒸着工程によって、または該帯鋼をアルミニウム箔もしくはアルミニウム合金箔とともに圧延する少なくとも１つの共圧延によって形成され、該少なくとも１つの予備被覆工程は単独でも組み合わせでも行うことができることを特徴とする、製造法。
【請求項2】
前記冷間変形の一般化ひずみが少なくとも前記部材の１カ所で２０％超であることを特徴とする、請求項１に記載の製造法。
【請求項3】
請求項１または２に従って製造される、帯鋼から得られる機械的性質に非常に優れた部材の陸上自動車の構造部材または安全部材の製造のための使用。

【発明の詳細な説明】
【技術分野】
【0001】
本発明は、高い機械的強度と優れた耐食性を持つ熱間圧延または冷間圧延被覆鋼部材の製造に関する。
【背景技術】
【0002】
ある種の用途では、高い機械的強度、優れた耐衝撃性、優れた耐食性を兼ね備えた鋼部材を作り出すことが望まれる。これらの特徴の兼備は、軽量化著しい車両を製造することが目標とされる自動車産業にあっては特に望ましい。その目標は、とりわけ、非常に優れた機械的性質を持つ鋼材を使用することによって果たすことができるものであり、たとえば、自動車の貫入防止部材、構造部材または安全部材（フェンダークロスメンバー、ドアまたはセンターピラーの補強材、サスペンションアーム（ｗｈｅｅｌ　ａｒｍｓ））などでは上述の性質が要求される。
【0003】
特許ＦＲ２８０７４４７は、５００　ＭＰａ前後の引張り強さを有する母材の鋼板を金属の予備被覆を施した状態で用意し、冷間絞りや冷間ロール成形などの冷間成形加工を行い、さらに熱処理を加えた後に部材の幾何学形状に合った形状の装置の中で鋼板を急冷する製造法を開示している。この熱処理の加熱段階では、当初の予備被覆が母材の鋼と合金化することによって部材の表面に金属間被覆が形成される。これにより、機械的強度が１５００ＭＰａ超などの耐食性部材を得る。
【0004】
母材の鋼板に対しては、溶融めっき法などによってアルミニウムまたはアルミニウム合金の予備被覆を施すことができる。しかし、場合によっては、この方法の実施に制約が生

じることがある。熱処理前の部材に対して行われる冷間成形加工の際、一部の区域がより大きな変形を受け、それによって基材と予備被覆との界面に局所的な剥離の形で損傷が生じる可能性がある。その場合、その後の熱処理によって界面の合金層の周辺にスケールを生じる可能性がある。このスケールの存在は母材の鋼とアルミニウムを含む予備被覆との十分な合金化のためには有害である。

【0005】

さらに、アルミナイズ処理を施した部材は、冷間成形後、それに続く合金化のための熱処理の前に余分な材料を取り去るため、その切断、押抜きまたは型取りを行うことがある。溶融めっきによるアルミニウム系予備被覆の存在は切削工具の損耗の原因となることが考えられる。

【0006】

また、溶融アルミニウムめっきを施した鋼板の予備被覆は標準厚さと比べて厚さにばらつきを生じる可能性がある。合金化のための熱処理の際の加熱は、典型的には数分というごく短時間で行われることから、厚さの超過が過大である場合には、被覆の合金化が不完全となる。通常の予備被覆の融点は、アルミニウムの場合で６６０℃、１０％のケイ素／アルミニウム合金の場合で５８０℃であることから、被覆が厚い方の側では、部材がオーステナイト化温度に達する以前に早すぎる溶融が起こる可能性がある。一般に熱処理は、部材がローラの上を移動する形の炉で行われるため、ローラの表面が予備被覆の部分的溶融によって生じる層で汚染され、炉の正しい動作に支障を来たすことになる。また、予備被覆の不完全な合金化はその後の電気泳動の工程にも有害である。

【発明の開示】

【発明が解決しようとする課題】

【0007】

本発明の目的は上述の諸問題を解決することにある。本発明がとりわけその目的とするのは、アルミニウムまたはアルミニウム合金の予備被覆を施した熱間圧延または冷間圧延による鋼部材の製造法において、合金化処理前に事前の冷間での大きな変形を許容しつつ、それによって合金化処理に関して事後のリスクを生じることのない鋼部材の製造法を提供することである。本発明の目的は、合金化のための熱処理に先立つ機械加工の際の工具の損耗を減らすことにある。また、本発明は、熱処理の後、アルミニウムまたはアルミニウム合金の予備被覆の完全な合金化を得ることも目的とする。

【課題を解決するための手段】

【0008】

そのため、本発明は、熱間圧延または冷間圧延による帯鋼を原材料とする機械的性質に非常に優れた部材を製造するための以下の連続した工程を含む方法をその対象とする。

【0009】

帯鋼にアルミニウムまたはアルミニウム合金による予備被覆を施す。この予備被覆は、以下に示す方法をそれぞれ単独で、または組み合わせて行うことによる１つまたは複数の工程によって行うことができる。

１つまたは複数のアルミニウムまたはアルミニウム合金の電気めっき工程による予備被覆。

１つまたは複数のアルミニウムまたはアルミニウム合金の化学蒸着工程による予備被覆。

１つまたは複数のアルミニウムまたはアルミニウム合金の物理蒸着工程による予備被覆。

帯鋼をアルミニウムまたはアルミニウム合金箔とともに圧延する１つまたは複数の共圧延工程による予備被覆。

これらの予備被覆法を実施することで、帯鋼と予備被覆との界面に金属間相は生じない。

【0010】

被覆を施した帯鋼を冷間で変形させる。

【0011】
当該部材の最終的な幾何学形状に合わせて板材の余分な部分を場合によって取り除く。
【0012】
部材を炉などで加熱することで、部材表面に鋼と予備被覆との界面から金属間化合物を形成し、鋼をオーステナイト化する。この熱処理の加熱段階では、当初の予備被覆層が母材の鋼と合金化することによって部材の表面に金属間被覆が形成されるが、この合金化は予備被覆層の全厚にわたって得られる。
【0013】
加熱後、部材を装置に移動する。加熱段階から部材が装置と接触するまでの移動時間は、その間にオーステナイトの変態が起こることのない十分に短いものである。装置の幾何学形状および設計は、処理する部材および急冷の度合いに合わせたものとされる。特に、装置は、工程の生産性を向上させ、および／または急冷の度合いを高めるため、流体の循環などによって冷却することができる。締付けの力を加えれば、部材と装置とを密着させ、それによって伝導による冷却の効率化と変形の最小化を図ることができる。装置内における部材の冷却は、鋼が冷却後にマルテンサイト構造もしくはベイナイト構造またはマルテンサイトーベイナイト構造となるような速度で行う。
【0014】
一実施形態では、冷間変形による一般化ひずみは少なくとも部材の１カ所において２０％を超える。
【0015】
また、本発明は、上述の実施方法のいずれか１つに基づいて製造される、帯鋼から得られる機械的性質に非常に優れた部材を陸上自動車の構造部材または安全部材の製造に使用することもその対象とする。
【発明を実施するための最良の形態】
【0016】
本発明のその他の特徴および利点は、例を示しながら行う以下の説明を通して明らかになるであろう。
【0017】
従来の製造法における鋼と被覆との界面の変化を調べた。この目的のため、重量比率で以下のような組成を持つ厚さ１．２または２ｍｍの鋼部材について検討した。
炭素：０．１５～０．２５％
マンガン：０．８～１．５％
ケイ素：０．１～０．３５％
クロム：０．０１～０．２％
チタン：＜０．１％
リン：＜０．０５％
硫黄：＜０．０３％
Ｂ：０．０００５～０．０１％
【0018】
これらの部材を以下のものを含むアルミニウム系めっき浴に漬け、従来の溶融めっき法による予備被覆を施した。
ケイ素：９～１０％
鉄：２～３．５％
残りはアルミニウムおよび不可避の不純物である。
【0019】
鋼を６６０℃超で純粋なアルミニウム浴に接触させると、$FeAl_3$－Fe_2Al_5などを含め、金属間合金の厚い層が極めて急速に形成されることが知られている。この層は変形に対する適応性が低いため、１０％のケイ素を浴に追加することによってこの中間層の厚さを減らすことができる。図１は、ビッカース硬さが６００～８００の金属間層の厚さが約７ミクロンであり、その層の上を覆うアルミニウム系金属層の厚さが約１５ミクロ

ンであることを示している。

【0020】

予備被覆を施した部材はナカジマ式試験片を使って冷間変形にかけられ、一軸引張りや等二軸引張りなど、様々な方法で試験片に外力が加えられた。あらかじめ光溶着させた円形パターンの格子を使って、様々な地点で主ひずみε１およびε２、すなわち基準座標系におけるひずみが測定された。その様々な地点の一般化ひずみ

【数1】

$$\bar{\varepsilon}=\frac{2}{\sqrt{3}}\sqrt{(\varepsilon_1^2+\varepsilon_1\varepsilon_2+\varepsilon_2^2)}$$

がそこから導き出された。

【0021】

同時に、その様々な地点における予備被覆の挙動が観察された。観察の結果、１０％前後の一般化ひずみまででは、中間層に細かく規則的に亀裂が生じているが、それを覆う上層の金属アルミニウム層には影響は出ていないことが明らかになった。その後、９００℃の炉で５～７分間の熱処理を行い、水冷式の装置内で急冷すると、当初の予備被覆は完全に合金化し、その限られた範囲の亀裂のネットワークも消失する（図３）。一般化ひずみが２０％を超えると、金属間層が断片化し（図２）、場所によってアルミニウム系金属被覆が劣化する。その場合、その後の合金化のための熱処理によってスケール層が成長したり、鋼表面の脱炭を来たしたりする可能性があるが（図４）、これらは、塗装など、その後の部材の加工にとって有害となる。

【0022】

このように、大きなひずみを生じる冷間変形加工の実施は、従来のアルミニウム系予備被覆では問題を生じる可能性がある。この問題は、鋼とアルミニウムとの界面に金属間相が含まれなければ解決することが本発明の枠組みの中で既に実証されている。これは、アルミニウムまたはアルミニウム合金がその面心立方構造による固有の延性を有していることにより、予備被覆を施された鋼材が著しい冷間変形によっても界面または予備被覆の劣化を来たすことがなく、そのためにその後の合金化処理が最適な条件のもとで行われることによる。

【0023】

アルミニウムまたはアルミニウム合金の予備被覆は、電気めっき、物理蒸着、化学蒸着、または、帯鋼をアルミニウム箔またはアルミニウム合金箔とともに圧延する共圧延によって形成する。これら各種の工程により、合金化処理前の母材の鋼と予備被覆の間に金属間層のない部材を得る。本発明による方法は、同じ予備被覆の工程を１回だけ、または数回にわたって適用することによって行うことができる。また、本発明による方法は、被覆の様々な方法および様々な特徴に固有の利点が生かされるように、各種予備被覆工程を順次組み合わせて行うことができる。

【0024】

本発明による方法を適用することにより、冷間成形加工の後の部材に対する切断、押抜きまたは型取り作業の実施が容易になる。実際のところ、合金化処理で再加熱しなければならない金属の量を減らす目的での中間段階における機械加工工程の有用性が明らかになる可能性がある。本発明では、従来の方法にあった硬い（ビッカース硬さ６００～８００）金属間層が存在しないことによってこの中間段階における機械加工が容易となる。その結果、切削工具の損耗も少なくなる。

【0025】

さらに、本発明による予備被覆工程によって得られる被覆は厚さがきわめて規則的である。たとえば、蒸着法による予備被覆の条件では、１５～２０ミクロンの範囲の厚さの被覆を１ミクロンオーダの厚さのばらつきで得ることができる。

【0026】

溶融アルミニウムめっきの場合、顕微鏡断面測定による予備被覆の厚さのばらつきは、２５ミクロンの平均厚さに対しておよそ±１０ミクロンであることができる。生産性を最大限にするため、合金化のための熱処理の際の加熱はできるだけ迅速に行われることが望ましい。厚さ超過があることがわかっている場合には、合金化が完全に行われるように加熱段階が延長されることがある。ある一定の熱処理に関して、過大な厚さ超過があることがわかっていない場合には、合金化が不完全となり、予備被覆の部分的な溶融に至る可能性がある。

【0027】

本発明による予備被覆工程は厚さのばらつきを小さくし、それによって溶融のリスクを減らし、炉の動作安定性を高める。

【0028】

さらに、オーステナイト化後、装置内での急冷処理によって鋼にマルテンサイトもしくはベイナイト構造またはマルテンサイト－ベイナイト構造が与えられる。鋼の組成、とりわけその炭素含有量や、マンガン、クロム、ホウ素の含有量によって、本発明による部材において得られる最大強度は１２００～１７００ＭＰａの範囲で変わる。

【0029】

完全または部分的なマルテンサイト構造は局所的な応力集中効果に対する感受性が本質的に高いことが知られているが、本発明によれば、金属間層がないために切断はよりきれいに行えることから、急冷処理後の切断縁の切欠き効果は比較的小さい。

【0030】

そのため、本発明は、冷間変形を高いレベルまで行うことができることから、優れた性質を備えながら、より複雑な形状を持つ被覆部材の製造を可能とするものである。本発明の実施は、合金化処理前の冷間変形の一般化ひずみ度が２０％を超える場合に特に有利であり、中間の切断作業における工具の損耗を減らし、最終的な合金化処理の効率を高めることができる。

【図面の簡単な説明】

【0031】

【図1】冷間変形前の鋼と溶融めっきしたアルミニウム合金被覆との界面の例を示す図である。

【図2】冷間で２０％超の一般化ひずみが生じた後の同じ界面の変化を示す図である。

【図3】冷間変形を行わない場合の鋼と溶融めっきしたアルミニウム合金被覆との界面の合金化処理後の例を示す図である。

【図4】２０％超の冷間変形後に合金化処理を行った表面層を示す図である。

【図1】

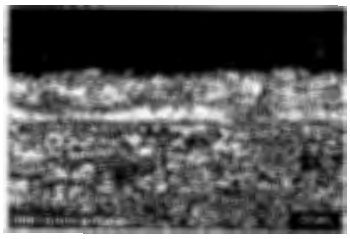

Figure 1

【図2】

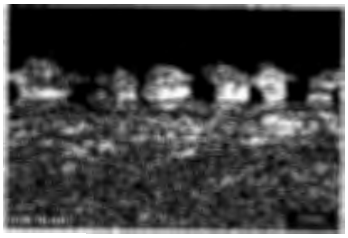

Figure 2

【図3】

Figure 3

【図4】

Figure 4

INTERNATIONAL SEARCH REPORT

International application No
PCT/FR2006/000466

A. CLASSIFICATION OF SUBJECT MATTER
INV. C23C22/78 C23F17/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
C21D C25D C23F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal, PAJ, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 6 197 132 B1 (ANDERSSON-DRUGGE ING-MARIE) 6 March 2001 (2001-03-06). column 1, lines 5-11 column 2, lines 1-12,35-67; figures 2,4; example 2 column 4, lines 10-13 claims 1-4	1-3
Y	US 6 296 805 B1 (LAURENT JEAN-PIERRE ET AL) 2 October 2001 (2001-10-02) column 3, line 60 - column 4, line 17	1

-/--

[X] Further documents are listed in the continuation of Box C. [X] See patent family annex.

* Special categories of cited documents :

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
23 June 2006	30/06/2006

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Handrea-Haller, M

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International application No
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C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	EP 1 403 388 A (THYSSENKRUPP STAHL AG) 31 March 2004 (2004-03-31) page 2, paragraphs 1,10 page 3, paragraphs 13,14 page 4, paragraph 26 page 5, paragraph 33 page 6, paragraphs 40,45,46 claims 1,12,13,15,18,21,22	1-3
Y	US 3 214 820 A (SMITH EDWIN J ET AL) 2 November 1965 (1965-11-02) column 1, lines 9,10,68-72 column 2, lines 41-54 column 3, lines 1-20 column 4, lines 6-17,35-37 column 5, lines 5-9,41-50 column 6, lines 45-47,51,66,67 claims 1-3,8,11	1-3
Y	FR 857 779 A (COSTE & COMPAGNIE) 28 September 1940 (1940-09-28) the whole document	1-3
Y	DE 102 24 319 A1 (BENTELER AUTOMOBILTECHNIK GMBH) 18 December 2003 (2003-12-18) column 1, paragraphs 1,4 column 1, paragraph 6 - column 2, paragraphs 7-9,11,13 column 3, paragraph 17 - column 4, paragraph 23 claims 1,3-6	1-3
Y	GB 1 489 618 A (SUMITOMO METAL IND LTD) 26 October 1977 (1977-10-26) page 1, lines 7-9,25-46 page 2, lines 1-12; examples 2,4 claims 1-4,6-8	1-3
Y	WO 99/55469 A (WEIRTON STEEL CORPORATION) 4 November 1999 (1999-11-04) the whole document	1-3
A	DE 12 90 024 B (INTERLICENCE S. A) 27 February 1969 (1969-02-27) the whole document	1-3
A	EP 1 013 785 A (SOLLAC) 28 June 2000 (2000-06-28) the whole document	1-3

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/FR2006/000466

Patent document cited in search report		Publication date	Patent family member(s)			Publication date
US 6197132	B1	06-03-2001	DE	69712636	D1	20-06-2002
			DE	69712636	T2	12-12-2002
			EP	0944744	A1	29-09-1999
			ES	2176765	T3	01-12-2002
			JP	2000517002	T	19-12-2000
			SE	508150	C2	07-09-1998
			SE	9603152	A	01-03-1998
			WO	9808986	A1	05-03-1998
US 6296805	B1	02-10-2001	AT	240419	T	15-05-2003
			BR	9902712	A	08-03-2000
			CA	2276911	A1	09-01-2000
			DE	69907816	D1	18-06-2003
			DE	69907816	T2	11-03-2004
			DK	971044	T3	11-08-2003
			EP	0971044	A1	12-01-2000
			ES	2196740	T3	16-12-2003
			FR	2780984	A1	14-01-2000
			JP	2000038640	A	08-02-2000
			PT	971044	T	29-08-2003
EP 1403388	A	31-03-2004	AU	2003267418	A1	23-04-2004
			WO	2004031418	A2	15-04-2004
US 3214820	A	02-11-1965	BE	643299	A	03-08-1964
			DE	1527572	A1	23-07-1970
			GB	1056131	A	25-01-1967
			LU	45354	A1	04-08-1964
			NL	6400848	A	10-08-1964
FR 857779	A	28-09-1940	NONE			
DE 10224319	A1	18-12-2003	NONE			
GB 1489618	A	26-10-1977	DE	2461730	A1	10-07-1975
			FR	2256258	A1	25-07-1975
WO 9955469	A	04-11-1999	NONE			
DE 1290024	B	27-02-1969	NONE			
EP 1013785	A	28-06-2000	FR	2787735	A1	30-06-2000

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RAPPORT DE RECHERCHE INTERNATIONALE

Demande internationale n°
PCT/FR2006/000466

A. CLASSEMENT DE L'OBJET DE LA DEMANDE
INV. C23C22/78 C23F17/00

Selon la classification internationale des brevets (CIB) ou à la fois selon la classification nationale et la CIB

B. DOMAINES SUR LESQUELS LA RECHERCHE A PORTE

Documentation minimale consultée (système de classification suivi des symboles de classement)
C21D C25D C23F

Documentation consultée autre que la documentation minimale dans la mesure où ces documents relèvent des domaines sur lesquels a porté la recherche

Base de données électronique consultée au cours de la recherche internationale (nom de la base de données, et si cela estréalisable, termes de recherche utilisés)
EPO-Internal, PAJ, WPI Data

C. DOCUMENTS CONSIDERES COMME PERTINENTS

Catégorie*	Identification des documents cités, avec, le cas échéant, l'indication des passages pertinents	no. des revendications visées
Y	US 6 197 132 B1 (ANDERSSON-DRUGGE ING-MARIE) 6 mars 2001 (2001-03-06) colonne 1, ligne 5-11 colonne 2, ligne 1-12,35-67; figures 2,4; exemple 2 colonne 4, ligne 10-13 revendications 1-4	1-3
Y	US 6 296 805 B1 (LAURENT JEAN-PIERRE ET AL) 2 octobre 2001 (2001-10-02) colonne 3, ligne 60 - colonne 4, ligne 17	1

-/--

[X] Voir la suite du cadre C pour la fin de la liste des documents

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Date à laquelle la recherche internationale a été effectivement achevée	Date d'expédition du présent rapport de recherche internationale
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RAPPORT DE RECHERCHE INTERNATIONALE

Demande internationale n°
PCT/FR2006/000466

C(suite). DOCUMENTS CONSIDERES COMME PERTINENTS

Catégorie*	Identification des documents cités, avec, le cas échéant, l'indication des passages pertinents	no. des revendications visées
Y	EP 1 403 388 A (THYSSENKRUPP STAHL AG) 31 mars 2004 (2004-03-31) page 2, alinéas 1,10 page 3, alinéas 13,14 page 4, alinéa 26 page 5, alinéa 33 page 6, alinéas 40,45,46 revendications 1,12,13,15,18,21,22	1-3
Y	US 3 214 820 A (SMITH EDWIN J ET AL) 2 novembre 1965 (1965-11-02) colonne 1, ligne 9,10,68-72 colonne 2, ligne 41-54 colonne 3, ligne 1-20 colonne 4, ligne 6-17,35-37 colonne 5, ligne 5-9,41-50 colonne 6, ligne 45-47,51,66,67 revendications 1-3,8,11	1-3
Y	FR 857 779 A (COSTE & COMPAGNIE) 28 septembre 1940 (1940-09-28) le document en entier	1-3
Y	DE 102 24 319 A1 (BENTELER AUTOMOBILTECHNIK GMBH) 18 décembre 2003 (2003-12-18) colonne 1, alinéas 1,4 colonne 1, alinéa 6 - colonne 2, alinéas 7-9,11,13 colonne 3, alinéa 17 - colonne 4, alinéa 23 revendications 1,3-6	1-3
Y	GB 1 489 618 A (SUMITOMO METAL IND LTD) 26 octobre 1977 (1977-10-26) page 1, ligne 7-9,25-46 page 2, ligne 1-12; exemples 2,4 revendications 1-4,6-8	1-3
Y	WO 99/55469 A (WEIRTON STEEL CORPORATION) 4 novembre 1999 (1999-11-04) le document en entier	1-3
A	DE 12 90 024 B (INTERLICENCE S. A) 27 février 1969 (1969-02-27) le document en entier	1-3
A	EP 1 013 785 A (SOLLAC) 28 juin 2000 (2000-06-28) le document en entier	1-3

Formulaire PCT/ISA/210 (suite de la deuxième feuille) (avril 2005)

RAPPORT DE RECHERCHE INTERNATIONALE

Renseignements relatifs aux membres de familles de brevets

Demande internationale n° PCT/FR2006/000466

Document brevet cité au rapport de recherche		Date de publication	Membre(s) de la famille de brevet(s)		Date de publication
US 6197132	B1	06-03-2001	DE	69712636 D1	20-06-2002
			DE	69712636 T2	12-12-2002
			EP	0944744 A1	29-09-1999
			ES	2176765 T3	01-12-2002
			JP	2000517002 T	19-12-2000
			SE	508150 C2	07-09-1998
			SE	9603152 A	01-03-1998
			WO	9808986 A1	05-03-1998
US 6296805	B1	02-10-2001	AT	240419 T	15-05-2003
			BR	9902712 A	08-03-2000
			CA	2276911 A1	09-01-2000
			DE	69907816 D1	18-06-2003
			DE	69907816 T2	11-03-2004
			DK	971044 T3	11-08-2003
			EP	0971044 A1	12-01-2000
			ES	2196740 T3	16-12-2003
			FR	2780984 A1	14-01-2000
			JP	2000038640 A	08-02-2000
			PT	971044 T	29-08-2003
EP 1403388	A	31-03-2004	AU	2003267418 A1	23-04-2004
			WO	2004031418 A2	15-04-2004
US 3214820	A	02-11-1965	BE	643299 A	03-08-1964
			DE	1527572 A1	23-07-1970
			GB	1056131 A	25-01-1967
			LU	45354 A1	04-08-1964
			NL	6400848 A	10-08-1964
FR 857779	A	28-09-1940	AUCUN		
DE 10224319	A1	18-12-2003	AUCUN		
GB 1489618	A	26-10-1977	DE	2461730 A1	10-07-1975
			FR	2256258 A1	25-07-1975
WO 9955469	A	04-11-1999	AUCUN		
DE 1290024	B	27-02-1969	AUCUN		
EP 1013785	A	28-06-2000	FR	2787735 A1	30-06-2000

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4K037 EA02 EA06 EA11 EA15 EA23 EA25 EA27 EA31 EB05 EB08
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C21D 9/42	(2006.01)	C21D	9/42		4K037
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C21D 1/18	(2006.01)	C21D	1/18	K	

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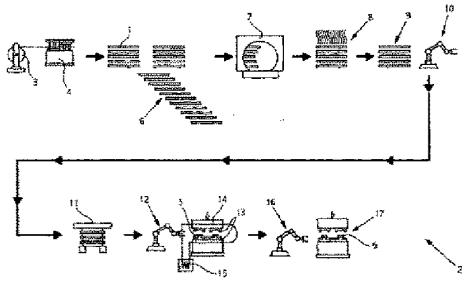
最終頁に続く

(54)【発明の名称】鋼板を変形して構成部品を製造する方法およびその方法を実施する装置

(57)【要約】
本発明は、変形する前に第１の熱処理によってオーステナイト化して被覆層厚さを生長させた焼戻し鋼からなる被覆鋼板を変形することで構成部品を製造する方法に関する。発明の目的はプロセスを最適化し、プロセスの中断によって起こされるスクラップ鋼板の発生を防止することにある。このため急速に冷却したあと熱処理鋼板１を一時収容し、構成部品５への変形の前に直接、再度短時間でオーステナイト化温度に加熱し、組織変態があった後で鋼板１を変形および硬化させる。鋼板の第２の加熱は誘導加熱で加熱するのが好ましい。
【選択図】図１



【特許請求の範囲】
【請求項1】
焼戻し鋼板からなる好ましくはアルミニウムで被覆された被覆鋼板を変形することで構成部品を製造する方法であって、変形の前に第１の方法ステップで鋼板は第１の炉に導びかれてオーステナイト化され、第１の炉における鋼板の炉内滞留時間は組織変態のほかに被覆層厚さの生長が行われるように選択される方法において、
熱処理された鋼板（１）を急速に冷却し、引き続き一時収容するステップと、
構成部品（５）に変形する前に直接第２の炉（１１）においてオーステナイト化温度で鋼板（１）を再度短時間で加熱するステップと、
生じた組織変態の後で鋼板（１）を変形および硬化させるステップと
からなることを特徴とする方法。
【請求項2】
第１の炉（７）における炉内滞留時間は９分から３０分の間であることを特徴とする請求項１に記載の方法。
【請求項3】
第２の炉（１１）においてオーステナイト化温度で鋼板（１）の加熱を繰り返す際には、炉内滞留時間は、組織変態のみが生じて被覆層厚さの生長はこれ以上生じないように選択されることを特徴とする請求項１に記載の方法。
【請求項4】
第２の炉（１１）における炉内滞留時間は１０秒から２分３０秒の間であることを特徴とする請求項３に記載の方法。
【請求項5】
第１の炉（７）における鋼板（１）の加熱は電気またはガスに基づいて行われ、これに対し第２の炉（１１）における加熱は誘導加熱によって行われることを特徴とする請求項１に記載の方法。
【請求項6】
第１の加熱は鋼板あるいは薄板製造者のもとで行われ、これに対し第２の熱処理はさらなる処理を行う企業、例えば自動車製造業者のもとで行われることを特徴とする請求項１に記載の方法。
【請求項7】
第２の熱処理の間では鋼板（１）の表面が異なる強さで加熱されることを特徴とする請求項１に記載の方法。
【請求項8】
鋼板（１）は第２の炉（１１）で再度加熱される前に少なくとも補強薄板を適用して局部的に補強されることを特徴とする請求項１に記載の方法。
【請求項9】
鋼板（１）としてテイラーブランクが使用されることを特徴とする請求項１に記載の方法。
【請求項10】
請求項１ないし９のいずれか１項に記載の方法を実施する装置であって、
コイル（３）から鋼板（１）を作る工具（４）と、
鋼板（１）の被覆層厚さの生長を引き起こすことを含んで第１の熱処理をする第１の炉（７）と、
鋼板（１）の冷却領域（８）と、
鋼板（１）の一時収容場（９）と、
鋼板（１）を再度熱処理する第２の炉（１１）と、
プレス成形装置（１４）と冷却装置（１５）を備えた変形／焼戻し工具（１３）と、
最終輪郭切断および穴切断を行う切断装置
とから構成されることを特徴とする装置。

【請求項11】
第１の炉（７）では電気および／またはガスに基づき熱処理が行われ、第２の熱処理は誘導炉（１１）で行われることを特徴とする請求項１０に記載の装置。
【請求項12】
一時収容場（９）と変形／焼戻し工具（１３）との間に配置された搬送装置（１０）に誘導子が組み込まれることを特徴とする請求項１１に記載の装置。
【請求項13】
鋼板（１）に少なくとも補強薄板が、特に溶接で適用される場所が冷却領域（８）と第２の炉（１１）との間に配置されることを特徴とする請求項１０に記載の装置。

【発明の詳細な説明】
【技術分野】
【0001】
本発明は請求項１の前提部に記載の焼戻し鋼からなる好ましくはアルミニウムで被覆された被覆鋼板を変形することで構成部品を製造する方法に関する。さらに本発明はその方法を実施する装置に関する。
【背景技術】
【0002】
技術の現状では硬化処理に関連して焼戻し鋼板からなる鋼板を変形する種々な方法が一般に知られている。いわゆる「直接」変形方法の場合、炉、好ましくは通過炉内で保護ガス雰囲気のもとで焼戻し鋼から平坦な鋼板がオーステナイト化される。例えば、品質が２２ＭｎＢ５の焼戻し鋼が使用され、オーステナイト化のため９５０℃で数分間熱せられる。続いて、好ましくは自動化された搬送装置を使用し、オーステナイト化された熱い平坦な鋼板が連続処理のために冷却された変形／焼戻し工具に投入される。この工具は構成部品がプレスであり、これを閉じる際に熱い鋼板は最終形状の構成部品に変形し、閉鎖された工具で適用された閉鎖圧力のもとで比較的急速に冷却されて硬化される。硬化された構成部品は工具から取り出されるが、被覆されない薄板の場合が問題となり、洗浄ステップ

で、例えばサンドまたは鋼球によってスケールが除去される（例えばアルミニウム被覆薄板は十分に耐食性がありスケール発生が阻止されるので、被覆された構成部品の場合にはスケール除去は不必要となる）。引き続き、変形して硬化が完了した構成部品の最終輪郭切断および穴切断が好ましくはレーザー切断で行われる。いわゆるプレスと結びついた機械的切断も考えられる。

【0003】

炉における熱処理の間に、例えば出口状態で約２５μｍ厚さのアルミニウム被覆が約４５μｍの被覆厚さに生長し、鋼板の基礎材料に直接接して鉄が拡散したＡｌＳｉ層が形成されて、本来の防食機能を満たす比較的硬くて脆いＡｌＳｉ層となる。

【0004】

鋼板の熱処理に関する典型的な方法経過は変形の流れで例えば図１の時間－温度グラフに示す。使用する焼戻し鋼の品質、薄板の厚さ、出口の被覆層厚さなどに応じて、もちろん図１に示す値は一定の変動も伴う（熱処理下限／上限１８，１９）。したがって鋼板が３０分以下の炉内滞留時間にわたって炉内に存在することは簡単に考えられる。

【0005】

使用する炉はしばしば、形状ネットまたは鋼板受け入れ部を備えたいわゆる通過炉または格子を備えた格子スライド炉であり、鋼板を支持して、ガスバーナによって約２分以内でオーステナイト化する温度まで加熱し、引き続き電気加熱によって数分間この温度に保持する。ガスバーナは出力が大きいのが利点であるが、これに対し電気加熱は制御が良好であるのが利点となる。

【0006】

図１によると鋼板は炉内で約９５０℃の基準温度に加熱されてこの温度で保持される。オーステナイト化は約７２０℃以上の温度で実施される。炉内滞留時間は通常は約９分とされ、鋼板は最初の数分以内で基準温度まで加熱される。それに続く約７分で硬化に必要な基礎材料の再生アニールが行われ、体心立方フェライト／パーライト組織から面心立方オーステナイトになる。その上、ＡｌＳｉ保護層を十分に生長させるため前記の時間間隔は特に重要となる。

【0007】

特に炉内における鋼板の最小赤熱温度および最大炉内滞留時間に関し、プロセスで良好な部品が提供される、すなわち炉から取り出された鋼板がまだ変形プロセスおよびさらなる用途に活用できる、多少とも狭い限界が確かに存在する。さらなる経過において障害が現れるとすると、それは鋼板を炉から取り出して変形／焼戻し工具へのさらなる搬送中のとき、あるいは最終輪郭切断および穴切断の場所内にあるときであり、したがって障害が存在する間、鋼板はこれ以上炉から取り出すことができず、通常は最大許容炉内滞留時間を超え、炉内に存在する鋼板はすべて不良品となるので、取り出して処理しなければならない。

【発明の開示】

【発明が解決しようとする課題】

【0008】

本発明の課題は、焼戻し鋼板からなる被覆鋼板を変形することで構成部品を製造するこの種の方法において、プロセス経過の最適化を達成し、特に場合によっては起こりうるプロセス障害の際のコストのかかる不良鋼板の発生量を防止することである。

【課題を解決するための手段】

【0009】

この課題は方法に関しては請求項１に記載の特徴およびこれに従うさらなる特徴によって解決され、発明による方法を実施する装置に関しては請求項１０に記載の特徴によって解決される。

【発明の効果】

【0010】

発明による方法には様々な利点がある。鋼板の炉内滞留時間および炉外のプロセスの経

過障害に関してもはや左右されない。経過を分離することによって、鋼板変形の本来のプロセスのため、より少ない面積ニーズおよびより少ないインフラストラクチュアが生じる。焼戻し鋼板の緩衝／一時収容が可能となり、特にＡｌＳｉ層に影響を及ぼす熱処理が鋼板製造業者あるいは薄板納入業者でも簡単に行われる。

【0011】

このような別の場所の連続する熱処理はＥＰ０９４６３１１Ｂ１およびＤＥ１０２１２４００Ｃ１で開示されているようにすでに公知である。誘導加熱による赤熱処理もすでに技術の現状であり、例えば後者の文献に述べられている。

【0012】

発明による有利な実施形態およびさらなる形態はそれぞれ従属請求項に記載される。

【発明を実施するための最良の形態】

【0013】

以下に発明を実施形態に基づいて詳細に説明する。

図１に、このために適した装置２を使用して焼戻し鋼からなる被覆鋼板１を変形することで構成部品５を作る本発明による方法の経過の概略を示す。巻回された状態で供給される鋼、いわゆるコイル３から工具４を使用して鋼を広げて平坦にし、完成した構成部品５に必要な寸法の鋼板１に打抜きあるいは切断される。そこから鋼板１は緩衝領域６に導かれる。この一時収容は必ずしも必要ではなく、むしろ鋼板１は工具４を出た後、第１の炉７に直接導くことができ、ここで図２の温度－時間グラフによる熱処理を行う。第１の炉７の直後に冷却領域８が設けられ、ここで鋼板１は急冷されて熱処理の最終段階を経過する。冷却領域８を出て熱処理を終えた鋼板１は一時収容場９に導かれる。

【0014】

第１の炉７は構造の観点から、すでに述べた通過炉、カルッセル（Karussell）炉などにすることができる。

熱処理の個々の段階は図２に言及してすでに背景技術の項で始めに説明した。第１の炉７における比較的緩慢に行われる基準温度への加熱および残りの炉内滞留時間はオーステナイト化を引き起こしトポグラフィ（被覆層構造、被覆層厚さ）を変化させるため約９分の合計炉内滞留時間になる。鋼板を使用不可にしないため、経験によると最大炉内滞留時間は３０分を超えてはならない。鋼板１の冷却領域８への搬送およびそこでの急速冷却は比較的短い時間内で行われ、残りの冷却は一時収容場９において室温ＲＴで行われる。熱処理の最後には鋼板１はマルテンサイト組織になる。

【0015】

適切な搬送装置１０、例えば連結アームロボットを使用して鋼板１は誘導炉１１に導かれ、そこから、さらなる搬送装置１２、例えば再度連結アームロボットによって連続工程に適し冷却された変形／焼戻し工具１３に入れられる。この工具にはプレス成形装置１４および冷却装置１５が付設される。プレス成形装置１４を閉じるときに高温の鋼板１は構成部品５に変形され、閉鎖された変形／焼戻し工具１３において閉鎖力が適用される際、急速に冷却され、これによって硬化する。方法の最終ステップにおいて各構成部品５は搬送装置１６によって切断装置１７に導かれ、変形と硬化が終わった構成部品５の最終輪郭切断および穴切断が好ましくはレーザー切断を使用して行われる。勿論、適切な切断刃によって機械的手段でこれを行うこともできる。

【0016】

誘導炉１１および後続の変形／焼戻し工具１３で行われる鋼板１の熱処理を図３における温度－時間グラフで熱変形曲線２０および熱処理下限／上限１８、１９によって示す。この熱処理では鋼板の誘導炉１１内滞留時間が短いのが特徴となる。基準温度（オーステナイト化温度）への加熱が数秒（約１０秒）内で生じ、それに続く約１０秒から最大２分までの短い炉内滞留時間が加わって組織変態が進む。第１の炉７ですでに被覆の厚さと被覆構造の変化が生じたので、これ以上必要ではない。誘導炉１１における極めて短い炉内滞留時間の後、鋼板は変形／焼戻し工具１３に導かれ、ここで変形のほかに急速冷却が冷却領域８と同じように（熱変形曲線２０と同じ経過で）進行する。変形／焼戻し工具１３

を出ると、構成部品５はマルテンサイト組織になっており、室温ＲＴにおける冷却がさらなる搬送中あるいは切断装置１７内で行われる。

【0017】

この方法で、最初に約５００から６００Ｎ／ｍｍ^{2}の引張強さであった鋼板１が約１３００から１５００Ｎ／ｍｍ^{2}の引張強さの構成部品５に変形される。

発明の有利なさらなる構成によると、誘導炉１１で鋼板１を部分的に異なった強さに加熱することが考えられ、この結果、これが所望される場合には、変形され急速冷却された構成部品５が部分的に異なった強さを備えることになる。

【0018】

さらに、第２の熱処理（誘導炉１１）の前に、例えば補強薄板（当て板）を溶接して局部的に補強することが可能であり有利になる。このように当て板された結合薄板は第２の炉に導かれ、その後、変形／焼戻し工具１３に導かれる。このことは原材料の特性および形状精度に全体として好ましい効果を及ぼす。

【0019】

発明による方法はテイラー（Tailored）ブランク板を使用する際にも適用でき有利である。

発明の重要な利点は方法の個々のステップを分離する可能性にある。炉７における第１の熱処理は鋼板あるいは薄板製造業者ですでに行われ、したがってそのように予め処理された鋼板１がさらなる処理を行う企業（例えば自動車製造業者）に用意される（一時収容場９）。

【0020】

発明のさらに有利なさらなる構成において、搬送装置１０に誘導子を配属するか搬送装置１０に構造的に組み入れることが考えられ、その結果、変形／焼戻し工具１３への搬送の間に鋼板１の熱処理が進行する。分離した誘導炉１１およびこれに続くさらなる搬送装置１２はそれによって省略することができる。

【図面の簡単な説明】

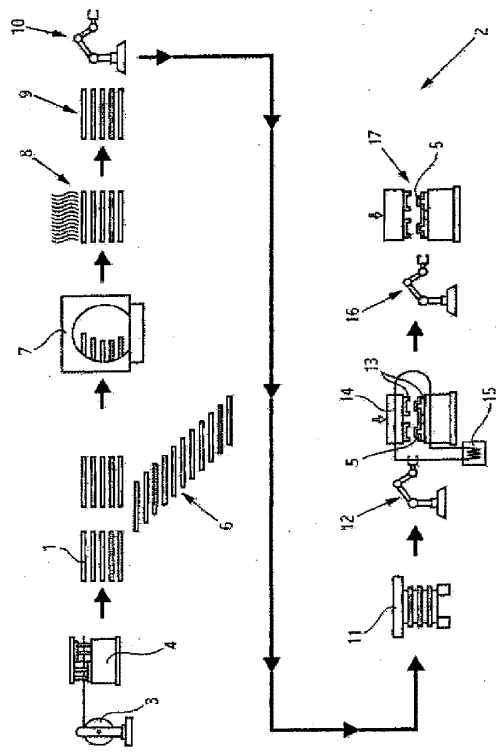
【0021】

【図1】鋼板の変形によって構成部品を製造する発明による方法の経過を示す。

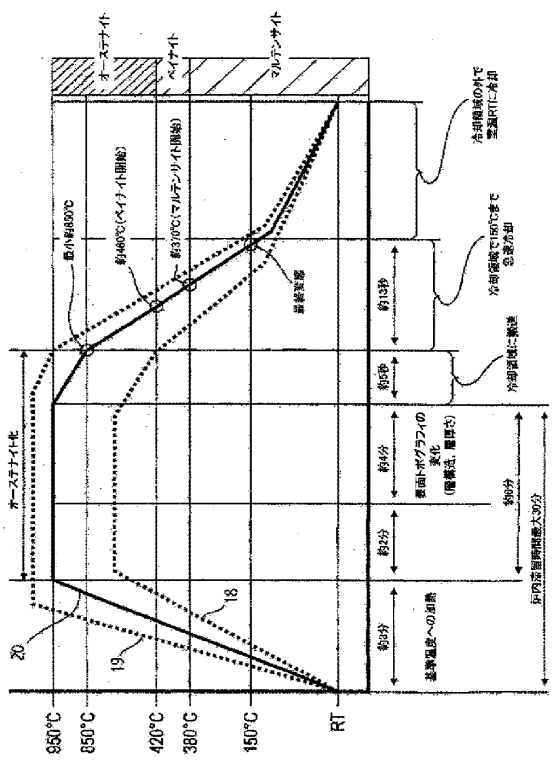
【図2】第１の鋼板熱処理の温度－時間グラフを示す。

【図3】第２の鋼板熱処理の温度－時間グラフを示す。

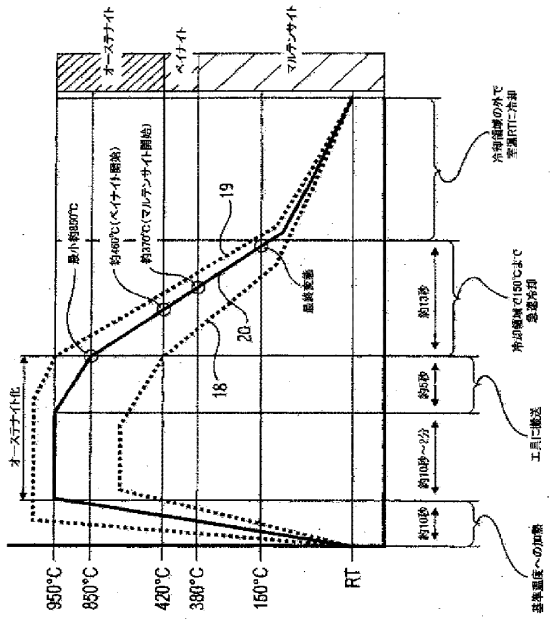
【図1】



【図2】



【図3】



INTERNATIONAL SEARCH REPORT

International Application No
PCT/EP2005/000853

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 C21D9/46

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 C21D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal, PAJ, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP 1 380 666 A (NISSAN MOTOR CO., LTD) 14 January 2004 (2004-01-14) the whole document	1-13
A	PATENT ABSTRACTS OF JAPAN vol. 2003, no. 11, 5 November 2003 (2003-11-05) -& JP 2003 181549 A (NIPPON STEEL CORP), 2 July 2003 (2003-07-02) the whole document	1-13
A	US 4 517 229 A (NICKOLA ET AL) 14 May 1985 (1985-05-14) the whole document	1-13

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
25 April 2005	06/05/2005

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Swiatek, R

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INTERNATIONAL SEARCH REPORT

International Application No
PCT/EP2005/000853

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 6 185 977 B1 (SCHIESSL GERHARD ET AL) 13 February 2001 (2001-02-13) cited in the application the whole document	1-13
A	DE 102 12 400 C1 (BENTELER AUTOMOBILTECHNIK GMBH) 3 April 2003 (2003-04-03) cited in the application the whole document	1-13

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INTERNATIONAL SEARCH REPORT
Information on patent family members

International Application No
PCT/EP2005/000853

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 1380666 A	14-01-2004	JP 2004043887 A	12-02-2004
		CN 1472068 A	04-02-2004
		EP 1380666 A1	14-01-2004
		US 2004009366 A1	15-01-2004
JP 2003181549 A	02-07-2003	CN 1531604 A	22-09-2004
		WO 02103073 A2	27-12-2002
US 4517229 A	14-05-1985	AT 36874 T	15-09-1988
		CA 1223158 A1	23-06-1987
		DE 3473775 D1	06-10-1988
		EP 0149655 A1	31-07-1985
		JP 5055594 B	17-08-1993
		JP 60501765 T	17-10-1985
		WO 8500386 A1	31-01-1985
		US 4837091 A	06-06-1989
		US 4666794 A	19-05-1987
US 6185977 B1	13-02-2001	DE 19653543 A1	25-06-1998
		DE 59702545 D1	30-11-2000
		WO 9828097 A1	02-07-1998
		EP 0946311 A1	06-10-1999
		ES 2151299 T3	16-12-2000
		JP 2001506543 T	22-05-2001
DE 10212400 C1	03-04-2003	FR 2837216 A1	19-09-2003

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INTERNATIONALER RECHERCHENBERICHT

Internationales Aktenzeichen
PCT/EP2005/000853

A. KLASSIFIZIERUNG DES ANMELDUNGSGEGENSTANDES
IPK 7　C21D9/46

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Recherchierter Mindestprüfstoff (Klassifikationssystem und Klassifikationssymbole)
IPK 7　C21D

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EPO-Internal, PAJ, WPI Data

C. ALS WESENTLICH ANGESEHENE UNTERLAGEN

Kategorie*	Bezeichnung der Veröffentlichung, soweit erforderlich unter Angabe der in Betracht kommenden Teile	Betr. Anspruch Nr.
A	EP 1 380 666 A (NISSAN MOTOR CO., LTD) 14. Januar 2004 (2004-01-14) das ganze Dokument	1-13
A	PATENT ABSTRACTS OF JAPAN Bd. 2003, Nr. 11, 5. November 2003 (2003-11-05) -& JP 2003 181549 A (NIPPON STEEL CORP), 2. Juli 2003 (2003-07-02) das ganze Dokument	1-13
A	US 4 517 229 A (NICKOLA ET AL) 14. Mai 1985 (1985-05-14) das ganze Dokument	1-13

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Name und Postanschrift der Internationalen Recherchenbehörde	Bevollmächtigter Bediensteter
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A	US 6 185 977 B1 (SCHIESSL GERHARD ET AL) 13. Februar 2001 (2001-02-13) in der Anmeldung erwähnt das ganze Dokument ----	1-13
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Im Recherchenbericht angeführtes Patentdokument		Datum der Veröffentlichung	Mitglied(er) der Patentfamilie		Datum der Veröffentlichung
EP 1380666	A	14-01-2004	JP	2004043887 A	12-02-2004
			CN	1472068 A	04-02-2004
			EP	1380666 A1	14-01-2004
			US	2004009366 A1	15-01-2004
JP 2003181549	A	02-07-2003	CN	1531604 A	22-09-2004
			WO	02103073 A2	27-12-2002
US 4517229	A	14-05-1985	AT	36874 T	15-09-1988
			CA	1223158 A1	23-06-1987
			DE	3473775 D1	06-10-1988
			EP	0149655 A1	31-07-1985
			JP	5055594 B	17-08-1993
			JP	60501765 T	17-10-1985
			WO	8500386 A1	31-01-1985
			US	4837091 A	06-06-1989
			US	4666794 A	19-05-1987
US 6185977	B1	13-02-2001	DE	19653543 A1	25-06-1998
			DE	59702545 D1	30-11-2000
			WO	9828097 A1	02-07-1998
			EP	0946311 A1	06-10-1999
			ES	2151299 T3	16-12-2000
			JP	2001506543 T	22-05-2001
DE 10212400	C1	03-04-2003	FR	2837216 A1	19-09-2003

Formblatt PCT/ISA/210 (Anhang Patentfamilie) (Januar 2004)

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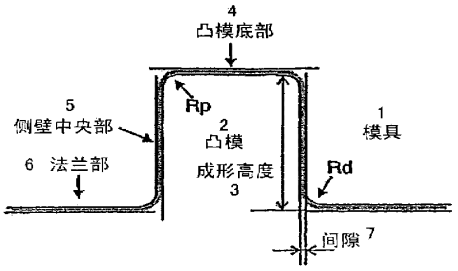
权利要求书 1 页 说明书 8 页 附图 1 页

[54] 发明名称

热成形法与热成形构件

[57] 摘要

从高强度钢板，通过热冲压而制作兼具稳定的强度和韧性的热冲压构件。在热冲压时的冷却过程中，以临界冷却速度以上冷却至 Ms 点，从 Ms 点至 200℃的温度范围的冷却速度为 25～150℃/s。热冲压构件的维氏硬度为，低于(最高淬火硬度－10)，且在(最高淬火硬度－100)以上。



1－模具
2－凸模
3－成形高度
4－凸模底部
5－侧壁中央部
6－法兰
7－间隙

1、一种热成形法，其特征在于，是对本质上具有如下钢组成的钢板，加热至 Ac_3 点以上并保持后，进行对最终制品形状的成形的方法，所述钢板，以质量%计，含有 C：0.15～0.45%、Mn：0.5～3.0%、Cr：0.1～0.5%、Ti：0.01～0.1%、B：0.0002～0.004%、Si：0.5%以下、P：0.05%以下、S：0.05%以下、Al：1%以下、N：0.01%以下；并且还含有 Ni：2%以下、Cu：1%以下、Mo：1%以下、V：1%以下、以及 Nb：1%以下的 1 种或 2 种以上；剩余部为 Fe 和不可避免的杂质，在成形中或者从成形后的成形温度的冷却之时，到达成形构件的 Ms 点的冷却速度在临界冷却速度以上，并且，以从 Ms 点到 200℃的平均冷却速度为 25～150℃/s 冷却而进行淬火处理。

2、根据权利要求 1 记载的热成形方法，其特征在于，所述成形采用冲压成形用金属模具而进行。

3、根据权利要求 1 或 2 记载的热成形法，其特征在于，所述成形在采用冲压成形用金属模具成形后，在金属模具间注入水而进行冷却。

4、一种热成形构件，其特征在于，由本质上具有如下的钢组成的钢板而构成，所述钢板，以质量%计，含有 C：0.15～0.45%、Mn：0.5～3.0%、Cr：0.1～0.5%、Ti：0.01～0.1%、B：0.0002～0.004%、Si:0.5%以下、P：0.05%以下、S：0.05%以下、Al:1%以下、N：0.01%以下；还含有 Ni：2%以下、Cu：1%以下、Mo：1%以下、V：1%以下、以及 Nb：1%以下的 1 种或 2 种以上；剩余部为 Fe 和不可避免的杂质，其热成形后的硬度，以维氏硬度计，低于最高淬火硬度-10，并且在最高淬火硬度-100 以上。

5、根据权利要求 4 记载的热成形构件，其特征在于，所述热成形为热冲压成形。

热成形法与热成形构件

技术领域

本发明涉及以汽车的车身结构部件、行走部分部件等为首要的机械结构部件等的热成形构件，及其制造所使用的热成形方法。若进一步详述，则本发明涉及热冲压构件与为此的热冲压方法。

以下，以热冲压成形为例对本发明进行说明，但是本发明也可以适用于辊轧成形、锻造等的压力成形以外的热成形。

背景技术

近年来，为了汽车的轻量化，而寻求例如拉伸强度在 590MPa 以上的钢材的高强度化，以削减使用重量的努力在进行着。在汽车广泛使用的薄钢板中，在如此的倾向之下，随着钢板强度的增加，冲压成形性降低，制造复杂的形状变得困难。具体地说，即随着强度增加而延展性降低，会发生在加工度高的部位产生破断，回弹和壁翘曲变大，尺寸精度劣化这样的问题。

因此，高强度、特别是拉伸强度在 780MPa 级以上钢板的情况，不容易作为利用冷加工方法的冲压成形而制造部件。如果不是冲压成形而利用辊轧成形，虽然可以进行上述的高强度钢板的加工，但是辊轧成形只能适用于在纵长方向具有同样的剖面的部件，限定了能够适用的制品的形状。

另一方面，如英国专利第 1490535 号所公开，在冲压成形加热的钢板的热冲压法中，因为在高温加热钢板，钢板的材质软化而变为高延展性，所以在加热状态下可以尺寸精度良好地成形复杂的形状。此外，将钢板加热至奥氏体区域温度，通过在金属模具内急冷的金属模具冷却，能够同时完成马氏体相变的钢板的高强度化，即淬火。

不过，在热冲压法的金属模具冷却中，构件的淬火硬度，在 2%C 材的情况下 Hv400～490 很不充分，而且存在构件中的硬度偏差非常大这样的

问题。

在 Advanced Materials & Processes、Vol.146、No.6、12/94、p.16 中，介绍了由瑞典的 plunger 公司开发的热压机技术，记载了从 980℃进行模具淬火(die quench)（金属模具内急冷）。金属模具温度，因为没有与加热相关的记载，所以推定为常温～数十℃。

在特開平 8-269615 号中，所公示的急速淬火用热轧钢板由以下成分构成：含有 C：0.18～0.30%、Si：0.01～1.0%、Mn：0.2～1.5%、P：0.03%以下、S：0.02%以下、sol.Al:0.08%以下、Cr：0.1～0.5%、B：0.0006～0.0040%、N：0.01%以下；在此情况下，还含有 Cu：0.5%以下、Ni：0.3%以下、Ti：0.01～0.05%中的至少一种；剩余部为铁。此钢板，在冷加工之后，由高频淬火而使之高强度化。

发明内容

本发明提供一种，通过热成形法能够从高强度钢板制造出兼具稳定的强度与韧性的热成形构件，及制作其的热成形法。

更具体地说，本发明提供以汽车的车身结构部件、行走部分部件等为首要的机械结构部件等的热成形构件，和其制造所使用的热冲压方法。

根据本发明，成形后的冷却时，例如在金属模具冷却时，通过将 Ms 点（从奥氏体到马氏体开始生成的温度）以下的温度区域的平均冷却速度控制在一定范围内，而能够通过热成形制造兼具稳定的强度和韧性的热成形构件。

在 1 形态中，本发明涉及一种热成形方法，将本质上具有如下钢组成的钢板，加热至 Ac_3 点以上并保持后，进行对最终制品形状的成形，所述钢板，以质量%计，含有 C：0.15～0.45%、Mn：0.5～3.0%、Cr：0.1～0.5%、Ti：0.01～0.1%、B：0.0002～0.004%、Si：0.5%以下、P：0.05%以下、S：0.05%以下、Al：1%以下、N：0.01%以下；并且还含有 Ni：2%以下、Cu：1%以下、Mo：1%以下、V：1%以下、以及 Nb：1%以下的 1 种或 2 种以上；剩余部为 Fe 和不可避免的杂质。根据本发明，在成形中或者从成形后的成形温度的冷却之时，到达成形构件的 Ms 点的冷却速度在临界冷却速度以上，并且，以从 Ms 点到 200℃的平均冷却速度为 25～150℃/s，进行冷

却，淬火处理。并且，在本发明中，临界冷却速度为上部临界冷却速度的意思。

在其他的形态中，本发明涉及由具有上述钢组成的钢板而构成的热成形构件。此热成形构件，热成形后的硬度，以维氏硬度低于（最高淬火硬度-10），并且在（最高淬火硬度-100 以上）。

在本发明的最佳形态中，热成形是采用冲压成形用金属模具而进行的热冲压成形。

根据本发明能够制作兼具稳定的强度与韧性的热冲压构件。因此，本发明大大地有助于作为高强度钢板的冲压成形构件的用途的扩大。

附图说明

图 1 是帽成形法的模式的说明图。

图 2 是表示临界冷却速度的测定用试验片的形状的模式图。

具体实施方式

在本发明中采用所述的钢组成和成形条件的理由如下。在本发明中，表示钢组成，即钢的化学组成的“%”是表示“质量%”。

1.基材钢板的组成

C：0.15～0.45%

碳（C），是提高钢板的淬火性，且在淬火后，主要决定强度的非常重要的元素。此外，是降低 Ac_3 点，促进淬火处理温度的低温化的元素。不过，C 含量低于 0.15%此效果不充分，另一方面，若 C 含量超过 0.45%，则淬火部的韧性劣化显著。优选 C 含量的下限为 0.16%，上限为 0.35%。

Mn：0.5～3.0%

锰（Mn），是提高钢板的淬火性，且在淬火后对用于稳定确保强度非常有效果的元素。此外，是降低 Ac_3 点，促进淬火处理温度的低温化的元素。不过，Mn 含量低于 0.5%此效果不充分，另一方面，若 Mn 含量超过 3.0%则此效果饱和，此外会导致淬火部的韧性劣化。优选 Mn 含量为 0.8～2.0%。

Cr：0.1～0.5%

铬（Cr），是提高钢板的淬火性，且在淬火后，对用于稳定确保强度

有效果的元素。不过，Cr 含量低于 0.1%此效果不充分，另一方面，若 Cr 含量超过 0.5%则此效果饱和，只会导致成本增长。优选 Cr 含量为 0.15～0.30%。

Ti：0.01～0.1%

钛（Ti），是提高钢板的淬火性，且在淬火后，对用于稳定确保强度有效果的元素。此外，还具有使淬火部的韧性提高的效果。不过，Ti 含量低于 0.01%此效果不充分，另一方面，若 Ti 含量超过 0.1%则此效果饱和，只会导致成本增长。优选 Ti 含量为 0.015～0.03%。

B：0.0002～0.004%

硼（B），是提高钢板的淬火性，且在淬火后，进一步提高强度的稳定确保效果的重要的元素。不过，B 含量低于 0.0002%此效果不充分，另一方面，若 B 含量超过 0.004%则此效果饱和，且导致成本增加。优选 B 含量为 0.0005～0.0025%。

Si：0.5%以下；P：0.05%以下；S：0.05%以下；Al：1%以下；N：0.01%以下

这些元素，任一个均能提高钢板的淬火性，且具有提高淬火后的强度的稳定化的效果。不过，若其含量超过上述的各自的上限，则此效果饱和，反而导致成本增加。

Ni：2%以下；Cu：1%以下；Mo：1%以下；V：1%以下；Nb：1%以下的 1 种或 2 种以上

这些元素，因为也是提高钢板的淬火性，且在淬火后，对强度的稳定确保有效果的元素，所以使之含有 1 种或 2 种以上。不过，超过各自的上限值而使之含有其效果也很小，且因为徒然导致成本增加，所以各合金元素的含量设在上述的范围。

在本发明使用的钢板中，在成形之前的加热之时，加热至奥氏体温度区域，因为使奥氏体相变发生，在加热前的室温的机械的性质不重要，所以对加热前的金属组织没有特别的限制。因此，作为基材钢板，使用热轧钢板、冷轧钢板、镀层钢板的任意一种都可以，对其制造方法没有特别限定。作为镀层钢板，以镀铝系钢板（即镀铝和镀铝合金钢板）与镀锌系钢板（即镀锌和镀锌合金钢板）为例示。镀层钢板，可以用电镀钢板，也可

以用熔融镀钢板。并且，也可以使用合金化熔融镀锌钢板。

2. 加热条件和保持时间

在热冲压时的金属模具冷却中，为了对成形构件、即热冲压构件进行成形后的淬火处理，所以首先将基材钢板加热到奥氏体温度区域，需要使基材钢板形成一次奥氏体相。为此，加热至 Ac_3 点以上，并在此温度在通常的条件下保持 1 分钟以上。保持时间的上限没有特别地设定，但考虑到实际的生产上的效率，优选保持时间的上限为 10 分钟左右。

3. 热冲压时的冷却速度

热冲压中（金属模具内）或热冲压后（脱模后）的冷却速度，在热冲压构件中是用于得到稳定的强度和韧性，具有非常重要作用的参数。

为了赋予热冲压构件稳定的强度和韧性，将热冲压后的组织不完全形成马氏体组织，而形成自动回火马氏体组织十分重要。为了成为此自动回火马氏体组织，在热冲压或热冲压后的冷却阶段，以临界冷却速度以上而冷却至 Ms 点，使扩散相变不会发生，且从 Ms 点到 200℃的温度范围，以平均冷却速度 25～150℃/s 这样缓慢的冷却速度进行冷却。通过如此的冷却，由于马氏体相变在发生的同时被回火，所以得到强度的偏差很少，且能够得到韧性优异的马氏体组织。从 Ms 点到 200℃的优选平均冷却速度为 30～120℃/s。

4. 在热冲压法中的成形方法

作为在热冲压法中的成形的形态，有弯曲加工、拉深成形、张出成形、扩孔成形、法兰成形等。并且，如果具有在与成形同时或紧接其后冷却钢板的机构，则本发明也适用于冲压成形以外的成形法，例如辊轧成形。

5. 热冲压构件

通过所述的热冲压法所制作的构件，形成强度的偏差很少，且具有韧性优异的回火马氏体组织的构件。并且，所得到的强度，由于作为回火马氏体组织的强度，若换言之以硬度（Hv），则比（最高淬火硬度-10）更低，但是，因为没有过度回火，所以具有（最高淬火硬度-100）以上的硬度。Hv 的值若比（最高淬火硬度-10）高则韧性降低，若比（最高淬火硬度-100）低则强度降低。优选 Hv 的值为（最高淬火硬度-20）以下，（最高淬火硬度-80）以上。

在此，所谓的“最高淬火硬度”，是在加热到900℃的盐浴中将此材料保持10分钟之后，实施水冷处理时所能得到的硬度。

6.热冲压成形时的冷却方法

通常，因为钢制金属模具被保持在常温或数十℃左右的温度，所以在热冲压成形之时，由此钢金属模具完成冲压成形构件的冷却。因此可知，为了使冷却速度变化，可以改变金属模具的尺寸而使热容量变化。

并且，改变金属模具的材质为不同种类的金属（例如铜等）也能够使冷却速度变化。在金属模具尺寸、材质都没有改变时，采用水冷型的金属模具而改变其时的冷却水量，由此也能够改变冷却速度。在此情况下，例如，采用切割了数处预制槽的金属模具，通过在冲压中让水流经于槽而改变冷却速度，或在冲压成形中途抬起冲压机，在其间让水流动也能够改变冲压成形构件的冷却速度。

因此，在Ms点的前后使冷却速度变化的方法被认为是如下方法。

（1）在紧接Ms点到达之后，移动热容量的不同的金属模具或室温状态的金属模具，而改变冷却速度。

（2）水冷金属模具的情况，在紧接Ms点到达之后，使在金属模具中流动的水量变化，而改变冷却速度。

（3）在紧接Ms点到达之后，让水在金属模具与构件之间流动，以使此水量变化，而改变冷却速度。

实施例

以下的实施例虽然用以例示本发明，但是本发明并不受到由此的任何限制。

在本例中，以具有表1所示的组成的钢板（板厚：1.0mm）作为基材钢板。此钢板，是在实验室熔炼的钢胚通过热轧、冷轧而制造的钢板。此外在钢号No.2中，采用镀覆模拟装置如同实施熔融镀锌（每一面的Zn附着量为60g/m^2），此后，进行合金化处理（镀膜中的Fe含量为15质量%）。

将此钢板切割为40W×60L（mm）的尺寸，在大气气氛的加热炉内，进行900℃×5分钟的加热之后，从加热炉取出，紧接其后，用平板的钢制金属模具，进行热冲压成形。在钢种No.2中，进行使冷却条件变化的热冲压成形（试验No.2、5、6）。

对所得到的热冲压构件，进行维氏硬度测定（荷重 9.8N，测定次数：5）。并且在钢板贴装热电偶，也进行冲压成形后的冷却速度的测定。在冷却速度中，主要是改变金属模具尺寸而使冷却速度变化。

并且，在试验 No.2 中，钢板温度到达 Ms 点，紧接其后在金属模具间注入水以调节冷却速度。

在最高淬火硬度中，将在加热到 900℃的盐浴中将此材料保持 10 分钟之后，实施水冷处理时所能得到的硬度作为最高淬火硬度。

将所得到的结果，与以下面的方法而测定的各钢号的 Ac_3 点、Ms 点、和临界冷却速度一起，由表 2 集中表示。

从热轧钢板切割直径 3.0mm、长 10mm 的圆柱试验片（图 2），在大气中以 10℃/s 的升温速度加热至 950℃，在此温度保持 2 分钟之后，以各种的冷却速度冷却到室温。此时的加热，通过测定冷却中的试验片的热膨胀变化，而测定 Ac_3 点、Ms 点。并且，对所得到的试验片进行了维氏硬度测定（荷重 49N，测定次数：5）和组织观察，由其结果估算临界冷却速度。

表 1

钢号 No.	化学组成（质量%，剩余部：实质上为 Fe）														
	C	Si	Mn	P	S	Cu	Ni	Cr	Mo	V	Ti	Nb	Al	B	N
1	0.16	0.02	1.36	0.019	0.004	0.01	0.01	0.19	—	0.01	0.03	—	0.06	0.0013	0.008
2	0.21	0.25	1.20	0.008	0.002	0.01	0.02	0.20	—	0.01	0.02	0.01	0.05	0.0007	0.005
3	0.33	0.11	1.53	0.001	0.001	—	—	0.20	—	—	0.02	—	0.04	0.0015	0.001
4	0.42	0.11	1.51	0.001	0.001	—	—	0.20	0.01	—	0.02	—	0.04	0.0014	0.001

表 2

试验 No.	钢号 No.	Ac3 点（℃）	Ms 点（℃）	临界冷却速度（℃/s）	至 Ms 点的实测冷却速度（℃/s）	M 点～200℃的平均冷却速度（℃/s）	热冲压后的硬度（HV）	最高淬火硬度（HV）	金属模具尺寸（t×W×Lmm）	备考
1	1	860	450	25	60	40	418	461	50×400×400	发明例
2	2	823	410	17	60	100	451	501	50×400×400*1	
3	3	823	390	10	60	40	560	652	50×400×400	
4	4	785	370	10	60	30	683	750	50×400×400	
5	2	823	410	17	60	22*3	390	501	50×50×400	比较例
6	2	823	410	17	60	200*3	500	501	50×50×400*2	

*1 紧接 Ms 点之后向金属模具间注入水

*2 紧接 Ms 点之后上升冲压机，立即将试验片投入水槽

*3 本发明的范围外的条件

在作为本发明例的试验 No.1～4 中，因为从 Ms 点至 200℃的平均冷却速度适当，所以得到的硬度比（最高淬火硬度-10）更低，并且比（最高淬火硬度-100）更高。

作为比较例的试验 No.5，以临界冷却速度以上进行冷却，但因为从 Ms 点至 200℃的平均冷却速度缓慢，所以无法得到充分的硬度。并且，还有作为比较例的试验 No.6，因为从 Ms 点至 200℃的平均冷却速度过快，所以变得过硬。在此，“过硬”意味着，不是硬度的绝对值高，而是接近最高淬火硬度。

在作为本发明例的试验 No.2 的钢板中，在大气气氛的加热炉内进行 900℃×5 分钟的加热，从加热炉取出，进行帽型的热冲压成形（坯料尺寸：1.0t×80W×320L（mm））。

由图 1 表示此时的帽成形法的模式图。采用的热冲压条件为成形高度 70mm；Rd（锻模肩部 R）8mm；Rp（凸模肩部 R）8mm；间隙 1.0mm；折皱压力 12.7kN。

并且，在热冲压成形品的凸模底部、侧壁中央部、法兰部中，进行维氏硬度测定（荷重 9.8N，测定次数：5）。此外，在各部位贴装热电偶，测定其各部位的冷却速度。结果由表 3 集中表示。

表 3

	Ms 点～200℃的平均冷却速度（℃/s）	热冲压后的硬度（HV）
凸模底部	55	460
侧壁中央部	100	471
法兰部	120	480

因为在各部位，从 Ms 点至 200℃的平均冷却速度适当，所以能够得到良好的硬度。并且可知在相同的构件中的硬度的偏差也小。

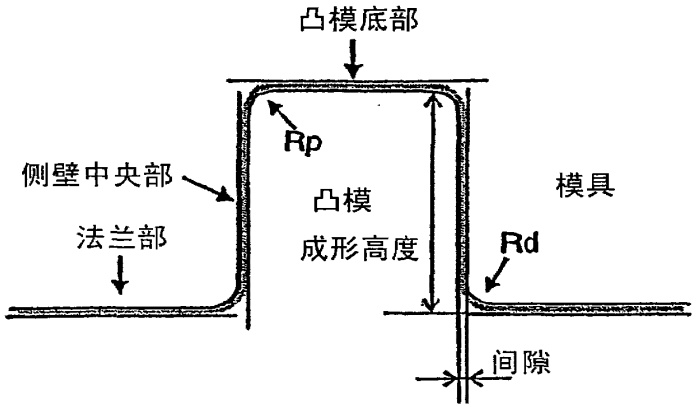


图 1

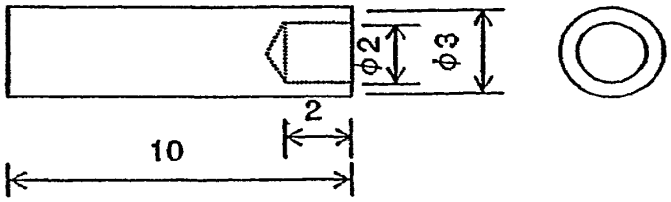


图 2

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(54) **Hot dip aluminum coated chromium alloy steel.**

(57) Continuous hot dip aluminum coated fertitic chromium alloy steel strip. Strip is cleaned by heating to a temperature no greater than about 650° C in a direct fired furnace. The cleaned strip is further heated in a protective atmosphere containing at least 95% by volume hydrogen, cooled in the protective hydrogen atmosphere to near or slightly above the melting point of an aluminum coating metal, and passed into a bath of the aluminum coating metal. The low direct fired furnace cleaning temperature and hydrogen protective atmosphere provides good wetting of a chromium alloy steel surface to prevent uncoated areas or pin holes in the aluminum coated layer.

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HOT DIP ALUMINUM COATED CHROMIUM ALLOY STEEL

BACKGROUND OF THE INVENTION

This invention relates to a continuously hot dipped metallic coated ferritic chromium alloy ferrous base strip and a process to enhance the wetting of the strip surface with molten aluminum.

Hot dip aluminum coated steel exhibits a high corrosion resistance to salt and finds various applications in automotive exhaust systems and combustion equipment. In recent years, exhaust system requirements have increased with respect to durability and aesthetics. For this reason, there has become a need to increase high temperature oxidation resistance and salt corrosion resistance by replacing aluminum coated low carbon or low alloy steels with aluminum coated chromium alloy steels. For high temperature oxidation, at least part of the aluminum coating layer can be diffused into the iron base by the heat during use to form an Fe-Al alloy layer. If uncoated areas are present in the aluminum coating layer, accelerated oxidation leading to a perforation of the base metal may result if the Fe-Al alloy is not continuously formed on the base metal. For lower temperatures, the aluminum coating layer acts as a barrier protection for atmospheric conditions and as a cathodic coating in high salt environments. Again, if uncoated areas are present, accelerated corrosion may occur leading to failure of the coated structure.

It is well known to hot dip metallic coat low carbon steel strip without a flux by subjecting the strip to a preliminary treatment which provides a clean surface free of oil, dirt and iron oxide which is readily wettable by the coating metal. One type of preliminary in-line anneal treatment for low carbon steel is described in U.S. patent 3,320,085 issued to C. A. Turner, Jr. The Turner process, also known as the Selas process, for preparation of low carbon steel strip for hot dip metallic coating includes passing the strip through a direct fired furnace having an atmosphere heated to a temperature of at least 2400°F (1316°C). The atmosphere is formed from the gaseous products of combustion of fuel and air and has no free oxygen. The fuel-air ratio is controlled to provide the necessary reducing characteristics for effecting cleaning of the steel strip. The fuel-air ratio is regulated to provide a slight excess of fuel so that there is no free oxygen but excess combustibles in the form of carbon monoxide and hydrogen. Maintaining a furnace atmosphere of at least 1316°C having at least 3% excess combustibles is reducing to steel up to 1700°F (927°C). Turner teaches his cleaned strip is then passed through a sealed delivery duct having a neutral or protective atmosphere prior to passing the cleaned strip into a coating pot. For coating with molten zinc, Turner teaches heating the strip up to 1000°F (538°C). For coating with molten aluminum, Turner teaches heating the strip within the temperature range of 1250-1300°F (677-704°C) in the direct fired furnace since the atmosphere is still reducing to the steel at these temperatures.

Modern direct fired furnaces include an additional furnace section normally heated with radiant tubes. This furnace section contains the same neutral or reducing protective atmosphere, e.g. 75% nitrogen - 25% hydrogen, as the delivery duct described above.

U.S. patent No. 3,925,579 issued to C. Flinchum et al describes an in-line pretreatment for hot dip aluminum coating low alloy steel strip to enhance wettability by the coating metal. The steel contains one or more of up to 5% chromium, up to 3% aluminum, up to 2% silicon and up to 1% titanium, all percentages by weight. The strip is heated to a temperature above 1100°F (593°C) in an atmosphere oxidizing to iron to form a surface oxide layer, further treated under conditions which reduce the iron oxide whereby the surface layer is reduced to a pure iron matrix containing a uniform dispersion of oxides of the alloying elements.

The problems associated with nonwetting of aluminum coatings onto ferritic chromium alloy steel are also well known. Hot dip aluminum coatings have poor wetability to ferritic chromium alloy steel base metals and normally have uncoated or bare spots in the aluminum coating layer. By poor adherence is meant flaking or crazing of the coating during bending the strip. To overcome the adherence problem, some have proposed heat treating the aluminum coated steel to anchor the coating layer to the base metal. Others lightly reroll the coated chromium alloy steel to bond the aluminum coating. Finally, those concerned about uncoated spots have generally avoided continuous hot dip coating. Rather, batch type hot dip coating or spray coating processes have been used. For example, after a chromium alloy steel article has been fabricated, it is dipped for an extended period of time within an aluminum coating bath to form a very thick coating layer.

U.S. patent 4,675,214 issued to F. M. Kilbane et al, incorporated herein by reference, proposes a solution for enhancing the wetting of ferritic chromium alloy steel strip continuously coated with hot dip aluminum coatings. The Kilbane process includes cleaning a ferritic chromium alloy steel and passing the

cleaned steel through a protective hydrogen atmosphere substantially void of nitrogen prior to entry of the steel into an aluminum coating bath. This process resulted in improved wetting of ferritic chromium alloy steel so long as the steel was not cleaned by heating to an elevated temperature in a direct fired furnace. According to Turner, a direct fired furnace having an atmosphere with at least 3% combustibles heated to 2400° F (1316° C) is reducing to steel up to 1700° F (927° C). Nevertheless, heating ferritic chromium alloy steel at temperatures about 1250° F (677° C) and above in a direct fired furnace whose atmosphere has no free oxygen and subsequently passing the steel through a protective atmosphere of substantially pure hydrogen immediately prior to hot dip coating with aluminum still had large uncoated areas. Not being bound by theory, it is believed a direct fired furnace atmosphere having no free oxygen does have significant oxidizing potential due to the presence of water and apparently is oxidizing to the chromium contained in a chromium alloy ferrous strip. The chromium oxide formed on the surface of the strip apparently is not removed sufficiently by the protective hydrogen atmosphere prior to entry into the coating bath thereby preventing complete wetting of the strip surface.

BRIEF SUMMARY OF THE INVENTION

The invention relates to a continuous hot dip aluminum coated ferritic chromium alloy steel strip heated in a direct fired furnace by the combustion of fuel and air wherein the gaseous products of combustion have no free oxygen. The surface of the strip is heated to a temperature sufficient to remove oil, dirt, iron oxide, and the like but below a temperature causing excessive oxidation of chromium in the strip base metal. The strip is further heated in another furnace portion and is cooled, if necessary, to near or slightly above the melting point of an aluminum coating metal. The strip is then passed through a protective atmosphere of at least 95% by volume hydrogen and then into a molten bath of the aluminum coating metal to deposit a layer of the coating metal on the strip.

It is a principal object of this invention to form hot dip aluminum coated ferritic chromium alloy steels having enhanced wetting by the coating metal.

It is another object of the invention to form a hot dip aluminum coating on a chromium alloy steel strip cleaned in a direct fired furnace.

It is a further object of the invention to form a hot dip aluminum coating on a deep drawing chromium alloy steel strip that is annealed in-line on the coating line.

One feature of the invention is to clean a ferritic chromium alloy steel strip having enhanced wetting by an aluminum coating by heating the strip in a direct fired furnace on an aluminum coating line below a temperature creating excessive oxidation of chromium contained in the strip.

Another feature of the invention is to further heat the cleaned chromium alloy steel strip to a fully annealed condition in another furnace portion having a protective atmosphere containing at least about 95% by volume hydrogen.

Another feature of the invention is to supply less than 80% of the total thermal energy required to fully anneal the deep drawing ferritic chromium alloy steel strip in the direct fired furnace of the aluminum coating line.

Another feature of the invention is to maintain the cleaned chromium alloy steel strip in a protective atmosphere containing at least about 95% by volume hydrogen, less than 200 ppm oxygen, and having a dew point less than +40° F (+4° C) until the cleaned strip is passed into the aluminum coating metal.

Another feature of the invention is to fully anneal and cool the heated chromium alloy steel strip in a protective atmosphere containing at least 95% by volume hydrogen having a dew point no greater than 0° F (-18° C), pass the strip through a snout containing a protective atmosphere containing at least 97% by volume hydrogen having a dew point no greater than -20° F (-29° C), and then dip the strip into the aluminum coating metal.

Advantages of the invention are elimination of uncoated areas and Improved adherence to ferritic chromium alloy steel strip cleaned in a direct fired furnace and continuously hot dip coated with aluminum.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a schematic view of a ferrous base strip being processed through a hot dip aluminum coating line incorporating the present invention;

FIG. 2 is a partial schematic view of the coating line of FIG. 1 showing an entry snout and coating pot.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to FIG. 1, reference numeral 10 denotes a coil of steel with strip 11 passing therefrom and around rollers 12, 13 and 14 before entering the top of first furnace section 15. First furnace section 15 is a direct fired type heated by the combustion of fuel and air. The ratio of fuel and air is in a proportion so that the gaseous products of combustion have no free oxygen and preferably at least 3% by volume excess combustibles. The atmosphere in furnace 15 is heated preferably to greater than 2400°F (1316°C) and strip 11 maintained at sufficient speed so that the strip surface temperature is not excessivley oxidizing to chromium while removing surface contaminants such as rolling mill oil films, dirt, iron oxide, and the like. Except for a brief period of time as explained in detail later, the strip should not be heated to a temperature above about 1200°F (649°C) and preferrably not above about 1150°F (621°C) while in furnace 15.

The second section of the furnace denoted by numeral 16 may be of a radiant tube type. The temperature of strip 11 is further heated to at least about the melting point of an aluminum coating metal, i.e. 1200°F (649°C), and up to about 1750°F (955°C) reaching a maximum temperature at about point 18. A protective atmosphere including at least about 95% by volume hydrogen preferably is maintained in furnace section 16 as well as succeeding sections of the furnace described below.

Sections 20 and 22 of the furnace are cooling zones. Strip 11 passes from furnace portion 22, over turndown roller 24, through snout 26 and into coating pot 28 containing molten aluminum. The strip remains in the coating pot a very short time, i.e. 2-5 seconds. Strip 11 containing a layer of coating metal on both sides is vertically withdrawn from coating pot 28. The coating layers are solidified and the coated strip is passed around turning roller 32 and coiled for storage or further processing as a coil 34. As noted above, furnace sections 20, 22 and 26 contain the protective hydrogen atmosphere.

Referring now to FIG. 2, snout 26 is protected from the atmosphere by having its lower or exit end 26a submerged below surface 44 of aluminum coating metal 42. Suitably mounted for rotation are pot rollers 36 and 38 and stabilizer roller 40. The weight of coating metal 42 remaining on strip 11 as it is withdrawn from coating pot 28 is controlled by finishing means such as jet knives 30. Strip 11 is cooled to a temperature near or slightly above the melting point of the aluminum coating metal in furnace portions 20, 22 and 26 before entering coating pot 28. This temperature may be as low as 1150°F (620°C) for aluminum alloy coating metals, e.g. Type 1 containing about 10% by weight silicon, to as high as about 1350°F (732°C) for commercially pure aluminum coating metal, e.g. Type 2.

The apparatus shown in FIG. 2 is for two-side coating using air finishing. As will be understood by those skilled in the art, finishing using a sealed enclosure containing a nonoxidizing atmosphere may also be used.

Hydrogen gas of commercial purity may be introduced into the furnace sections through inlets 27 in snout 26 preferrably to achieve a protective hydrogen atmosphere containing less than about 200 ppm oxygen and having a dew point no greater than +40°F (+4°C). Depending upon factors such as hydrogen flow rate and furnace volume, additional hydrogen inlets may be required in furnace sections 16, 20 and 22.

Ferritic chromium alloy steels as defined herein include iron based magnetic materials characterized by a body centered cubic structure and having about .5 weight % or more chromium. For example, the present invention has particular usefulness for hot dip aluminum coated ferritic stainless steel having up to about 35% by weight chromium and is used in automotive exhaust applications including heavy gauge engine exhaust pipes having thicknesses of 1.2 mm or more, foil having thicknesses less than .25 mm cold reduced from aluminized strip used as catalyst supports for catalytic converters, and fully annealed strip deeply drawn into parts requiring light weight aluminum coatings, e.g. no greater than 185 gm/m^2 total both sides, such as manifolds, muffler parts, catalytic converters, resonators, and the like. By full annealing is meant the strip is heated to at least about 830°C in furnace 16 and will have at least about 25% elongation as measured in a tensile test.Type 409 ferritic stainless steel is particularly preferred as the starting material for the present invention. This steel has a nominal composition of about 11% by weight chromium, about 0.5% by weight silicon, and remainder essentially iron. More broadly, a ferritic steel containing from about 10.0% to about 14.5% by weight chromium, about 0.1% to 1.0% by weight silicon, and remainder essentially iron, is preferred.

The following are nonlimiting examples illustrating the invention:

Example 1

A 1.02 mm thick by 122 cm wide Type 409 stainless steel strip was coated with pure molten aluminum coating (Type 2) at a temperature of 699-704 °C using the coating line in FIGS. 1 and 2. Hydrogen of commercial purity was flowed at a rate of about 380 m^3/hr into snout 26 and an atmosphere of 75% by volume nitrogen and 25% by volume hydrogen was maintained in furnace portion 16. The dew point of the pure protective hydrogen atmosphere in snout 26 was initially +48 °F (+9 °C). The fuel to air ratio in direct fired furnace portion 15 was controlled to have about 5% by volume excess combustibles. For various strip speeds and temperatures, the following visual observations were made:

Sample	Speed (m/min)	DFF(°C)*	RT(°C)**	Oxide***	Coating Condition
A	37	760	917	Dark Blue	random un-coated areas
B	46	704	917	Light Blue	random un-coated areas
C	55	649	871	Gold	uncoated strip edge only
D	37	649	871	Gold	good coating

* Strip temperature in furnace portion 15.
** Strip temperature in furnace portion 16
*** Surface appearance as strip 11 passed from furnace 15

As demonstrated above, a ferritic chromium alloy steel is oxidized when heated to a temperature of at least 649 °C in an atmosphere of combustion products having no free oxygen. The dew point of the hydrogen atmosphere in snout 26 increased to a maximum of about +58 °F (+14 °C) as a result of at least some of the iron and/or chromium oxide being reduced to metal and water by the hydrogen atmosphere. Samples A and B heated to at least 704 °C in the direct fired furnace were excessively oxidized and not properly wetted by the aluminum coating metal. The amount of oxidation to the strip when heated to 649 °C in the direct fired furnace was marginally excessive as demonstrated by poor coating wetting along one edge of Sample C. Using a very dry protective hydrogen atmosphere, e.g. dew point no greater than 0 °F (-19 °C), throughout furnace portions 16, 20, 22 and snout 26 probably would have sufficiently removed the oxide on Sample C to result in better wetting of the aluminum coating metal. Contrary to conventional wisdom for low carbon steel, ferritic chromium steel is readily oxidized in an atmosphere having no free oxygen and excess combustibles when heated to at least 649 °C.

Example 2

A 1.64 mm thick by 94 cm wide coil of Type 409 stainless steel was coated with 183 gm/m^2 of Type 2 aluminum (total both sides) under similar conditions to that of Example 1 except the pure protective hydrogen atmosphere also was maintained in furnace portion 16 and cooling zones 20, 22. Prior to passing this coil through the coating line, the dew point of the hydrogen atmosphere in snout 26 was -9 °F (-23 °C). The following coating observations were made for various strip temperatures:

Sample	DFF(°C)	RT(°C)	Coating Appearance
A	817	908	poor,frequent uncoated spots
B	620	841	good,infrequent uncoated spots

Example 3

Three coils of Type 409 stainless steel were processed and coated with 137 gm/m^2 Type 2 aluminum (total both sides) under similar conditions as in Example 2 except the dew point of the hydrogen atmosphere in snout 26 was -50° F (-46° C) and the dew point in radiant tube furnace portion 16 was -4° F (-20° C). The following coating observations were made for various strip temperatures:

Sample	Thickness (mm)	Width (cm)	DFF(° C)	RT(° C)	Coating Appearance
A	1.4	117	676	892	Some uncoated spots
B	1.3	91	677	902	Scattered uncoated spots esp.10 cm from one edge
C	1.4	76	604	871	No uncoated spots

As clearly demonstrated in Examples 1-3, heating the strip to temperatures of at least 676° C in the direct fired furnace caused excessive oxidation of the strip. Using a very dry protective hydrogen atmosphere throughout the furnace portions 16, 20, 22 and snout 26 did not sufficiently remove the oxides to achieve good coating metal wetting. On the other hand, heating the strip to no greater than about 650° C in the direct fired furnace and further heating the strip to temperatures greater than about 830° C in the radiant tube furnace resulted in adherent aluminum coatings having minimal uncoated areas on a fully annealed strip capable of being deeply drawn without flaking or crazing the coating.

Example 4

A 1.08 mm thick by 76 cm wide Type 409 stainless steel coil was also successfully continuously hot dip coated with 119 gm/m^2 (total both sides) of an aluminum alloy (Type 1) containing 9% by weight silicon. Operating conditions were the same as in Example 2. The strip was heated to about 627° C in furnace portion 15 and to 829° C in furnace portion 16. Very few uncoated areas were observed.

Examples 5-10

Examples 5 through 10 are for .38 mm thick by 12.7 cm wide strip for ferritic, low carbon, titanium stabilized steels containing 2.01, 4.22 and 5.99% by weight chromium. These samples were continuously hot dip aluminum coated (Type 2) on a laboratory coating line similar to that shown in FIGS. 1 and 2 and under conditions similar to those for Example 2. Weights of coating were not measured.

No.	% Cr	Speed (m/min)	DFF (° C)*	% H_2**	Condition
5	2.01	7.6	1204	25	Poor Coating
6	4.22	12.2	1093	25	Poor Coating
7	5.99	12.2	1193	25	Poor Coating
8	2.01	9.1	1227	100	Very good coating
No.	% Cr	Speed (m/min)	DFF (° C)*	% H_2**	Condition
9	4.22	9.1	1238	100	Good coating
10	5.99	9.1	--	100	Good coating

* Furnace Zone temperatures

** Hydrogen content in protective atmosphere

While strip temperatures out of the direct fired furnace were not measured, the data clearly supports the use of a 100% by volume hydrogen atmosphere in all areas of the furnace except the direct fired portion.

Since the chromium content was lowered in Examples 5-10 from previous examples (11% by weight), it is reasonable to expect less dependence on direct fired furnace strip exit temperature with the lower chromium alloys (2, 4, 6% by weight). In other words, there would be less oxidation potential with less chromium content.

As noted above, a direct fired atmosphere of the gaseous products of combustion of fuel and air having no free oxygen is oxidizing to ferritic chromium alloy steel at about 1200°F (649°C). Accordingly, the strip temperature in direct fired furnace 15 should not exceed this temperature, particularly for ferritic stainless steel having chromium content of 10% by weight or more. Preferably, this strip cleaning temperature should not exceed about 1150°F (621°C). Nevertheless, the strip temperature on occasion will exceed 649°C resulting from strip width and/or gauge changes. Brief exclusions, i.e. less than 10 minutes of temperature about or slightly above 649°C, can be tolerated by carefully controlling the protective atmosphere conditions throughout furnace portion 16, cooling zones 20, 22 and snout 26. By maintaining a protective atmosphere containing at least about 95% by volume hydrogen in furnace portion 16, cooling zones 20, 22 and snout 26, minimal oxidization of strip 11 in furnace portion 15 can be removed. In this regard, we have determined it to be especially beneficial to maintain extremely low dew points in the protective hydrogen atmosphere to compensate for water formation as iron and/or chromium oxide is reduced by hydrogen in the protective atmosphere. Preferably, the protective atmosphere in snout 26 contains at least 97% by volume hydrogen and the dew point should not exceed about -20°F (-29°C). A dew point of 0°F (-18°C) preferably should be maintained in furnace portion 16 and cooling zones 20, 22.

As disclosed in U.S. patent 4,675,214, the reactivity of the aluminum coating metal increases at elevated temperatures. Accordingly, maintaining the aluminum coating at 1280-1320°F (693-716°C) also helps to remove any residual surface oxide not removed by the protective atmosphere. However, removal of oxide from the strip surface while submerged in the aluminum coating metal bath is undesirable because the reduced oxide forms aluminum oxide (dross) on the surface of the coating bath. Aluminum oxide can also cause uncoated areas by attachment as fragments to the strip as it emerges from the coating pot preventing metallurgical bonding of the aluminum coating metal to the steel strip.

The teachings of the present invention are especially important when high strip temperatures, e.g greater than 830°C, are required for full annealing to produce deep drawing strip for high formability products. For high temperature annealing for low carbon steel strip, up to about 90% of the total heat input to the strip is accomplished in the direct fired portion of the furnace. The tables below show the percent of total thermal content achieved in the direct fired furnace portion for low carbon steel (prior art) and for ferritic chromium alloy steel (invention).

Prior Art								
t(mm)	w(cm)	tXw	s(mpm)	T_1(°C)	T_2(°C)	MW/Hr. To T_1	MW/Hr. To T_2	% T_2*
.81	76	62	95	760	857	3.9	4.4	88.4
1.40	76	106	64	749	857	4.4	5.0	87.0
1.75	86	151	43	760	857	4.3	4.9	88.4
Invention								
.81	76	62	64	624	831	2.1	2.9	74.5
1.40	76	106	40	628	832	2.3	3.1	74.8
1.75	86	151	33	631	849	2.8	3.8	73.6

t = strip thickness
w = strip width
s = strip speed through furnace
T_1 = strip temperature in direct fired furnace
T_2 = strip temperature in radiant tube heated furnace

* = % total thermal content

As demonstrated above, nearly 90% of total thermal content for fully annealed low carbon steel is achieved in the direct fired portion of the furnace while less than 80% of total thermal content for fully

annealed hot dip aluminum coated chromium alloy steel can be achieved in the direct fired portion of the furnace if excessive oxidation is to be avoided. In other words, for fully annealed strip of the invention, the maximum allowed direct fired furnace strip temperature must be less than that necessary to provide at least 80% of total thermal input.

Various modifications can be made to the invention without departing from the spirit and scope of it so long as the chromium alloy steel strip is not heated to a temperature excessively oxidizing to the strip in a direct fired furnace and is passed through a protective atmosphere containing at least about 95% by volume hydrogen prior to entry into the coating metal bath. For example, the hydrogen atmosphere can be used throughout any heating and cooling portions of the coating line between the direct fired furnace and the coating pot delivery duct. The coating metal can include pure aluminum and aluminum base alloys. The coating metal weight may be controlled by finishing in air or a sealed enclosure. Therefore, the limits of the invention should be determined from the appended claims.

Claims

1. A method of continuous hot dip coating a steel strip with aluminum, comprising the steps of:
heating a ferritic chromium alloy steel strip in an atmosphere formed by the gaseous products of the combustion of fuel and air wherein said atmosphere has no free oxygen and the temperature of said strip is insufficient to excessively oxidize chromium in said strip,
passing said strip through a protective atmosphere having at least about 95% by volume hydrogen,
dipping said strip into a molten bath of an aluminum coating metal to deposit a coating layer on said strip,
said coating layer being substantially free of uncoated areas and tightly adherent to said cleaned strip.

2. A method of continuous hot dip coating a steel strip with aluminum, comprising the steps of:
heating a ferritic chromium alloy steel strip in an atmosphere formed by the gaseous products of the combustion of fuel and air wherein said atmosphere has no free oxygen and the temperature of said strip is insufficient to excessivley oxidize chromium in said strip,
further heating said strip to a temperature no less than about the melting point of an aluminum coating metal,
cooling said strip if necessary to near or slightly above said melting point,
passing said strip through a protective atmosphere having at least about 95% by volume hydrogen,
dipping said strip into a molten bath of said coating metal to deposit a coating layer on said strip,
said coating layer being substantially free of uncoated areas and tightly adherent to said strip.

3. A method of continuous hot dip coating a steel strip with aluminum, comprising the steps of:
heating a ferritic chromium alloy steel strip to a temperature no greater than about 650 °C by direct combustion of fuel and air wherein the gaseous products of said combustion have no free oxygen,
further heating said strip to a temperature of at least about 830 °C, cooling said strip to a temperature near or slightly above the melting point of an aluminum coating metal,
passing said strip through a protective atmosphere having at least about 95% by volume hydrogen,
dipping said strip into a molten bath of said coating metal to deposit a coating layer on said strip,
said coating layer being substantially free of uncoated areas and tightly adherent to said strip.

4. The method of claim 3 wherein said strip is heated to no greater than about 621 °C by said direct combustion of fuel and air.

5. The method of claim 3 wherein said strip is further heated to a temperature of 845 °C to 955 °C in said atmosphere.

6. The method of claim 3 wherein said strip is cooled in said atmosphere.

7. The method of claim 3 wherein said atmosphere has less than about 200 ppm oxygen and a dew point of less than about +4 °C.

8. The method of claim 3 wherein said coating metal is substantially pure aluminum.

9. The method of claim 3 wherein said strip includes at least 10% by weight chromium.

10. A method of continuous hot dip coating a steel strip with aluminum, comprising the steps of:
heating a ferritic chromium alloy steel strip in a first furnace portion of the direct fired type,
further heating said strip in a second furnace portion,
said heating in said first furnace portion providing less than 80% of the total thermal content of said strip after said further heating in said second furnace portion,
cooling said strip to a temperature near or slightly above the melting point of an aluminum coating metal,
passing said strip through a protective atmosphere having at least about 95% by volume hydrogen,
dipping said strip into a molten bath of said coating metal to deposit a coating layer on said strip,

said coating layer being substantially free of uncoated areas and tightly adherent to said strip.

11. A method of continuous hot dip coating a steel strip with aluminum, comprising the steps of:
heating a ferritic chromium alloy steel strip in a first furnace portion of the direct fired type,
the temperature of said strip being insufficient to excessively oxidize the chromium in said strip,
fully annealing said strip by further heating to a temperature no less than about 830° C in a second furnace portion,
said strip temperature in said first furnace portion providing less than 80% of the total thermal content required for said full annealing of said strip,
cooling said strip in a protective atmosphere containing at least about 95% by volume hydrogen to a temperature near or slightly about the melting point of an aluminum coating metal,
dipping said strip into a molten bath of said coating metal to deposit a coating layer on said strip,
said coating layer being substantially free of uncoated areas and tightly adherent to said strip.

12. The method of claim 11 wherein said strip temperature in said first furnace portion is less than about 650° C.

13. The method of claim 12 wherein said second furnace portion contains said atmosphere.

14. The method of claim 13 wherein said cooled strip is maintained in said atmosphere containing at least about 97% by volume hydrogen until dipped into said bath.

15. The method of claim 14 wherein said atmosphere contains less than 200 ppm oxygen and has a dew point less than about -18° C.

16. A method of continuous hot dip coating a steel strip with aluminum, comprising the steps of:
heating a ferritic chromium alloy steel strip in a first furnace portion of the direct fired type,
the temperature of said strip being insufficient to excessively oxidize the chromium in said strip,
fully annealing said strip in a second furnace portion by heating said strip to a temperature no less than about 830° C.,
cooling said strip to near or slightly above the melting point of an aluminum coating metal,
passing said strip through a protective atmosphere containing at least about 95% by volume hydrogen,
dipping said strip into a molten bath of said coating metal to deposit a coating layer on said strip,
said coating layer being substantially free of uncoated areas and tightly adherent to said strip.

17. The method of claim 16 wherein said strip is maintained in said atmosphere during said full annealing and said cooling.

18. The method of claim 17 wherein said atmosphere has less than 200 ppm oxygen and a dew point less than about -18° C.

19. A method of continuous hot dip coating a steel strip with aluminum, comprising the steps of:
heating a ferritic chromium alloy steel strip in a first furnace portion of the direct fired type to a temperature no greater than about 650° C,
further heating said strip to a temperature at least about 830° C in a second furnace portion containing a protective atmosphere of at least about 95% by volume hydrogen having a dew point no greater than -18° C,
cooling said strip in said atmosphere to near or slightly above the melting point of an aluminum coating metal,
passing said strip through an enclosed snout containing said atmosphere and into a molten bath of said coating metal to deposit a coating layer on said strip,
said atmosphere in said snout having at least about 97% by volume hydrogen having a dew point no greater than -29° C,
said coating layer being substantially free of uncoated areas and tightly adherent to said strip.

20. A deep drawable aluminum coated strip made by the process of claim 16.

21. The strip of claim 20 including at least 10% by weight chromium having high corrosion resistance to salt and high temperature oxidation resistance.

FIG. 1

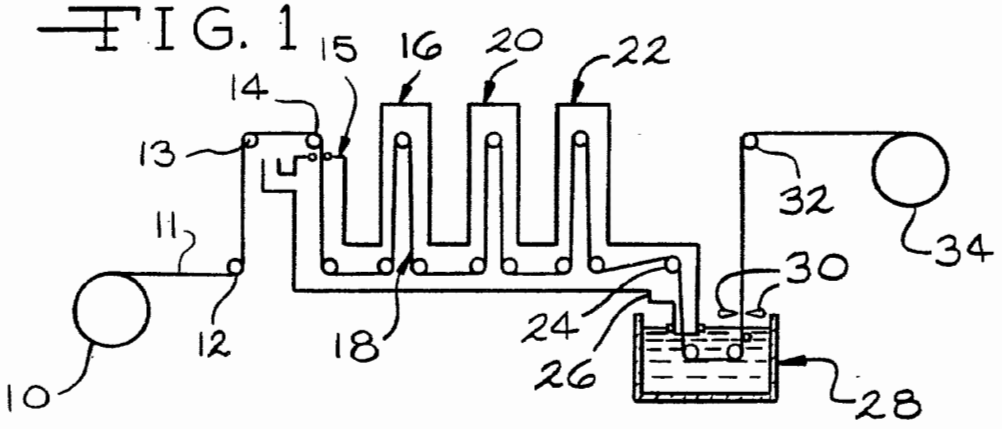
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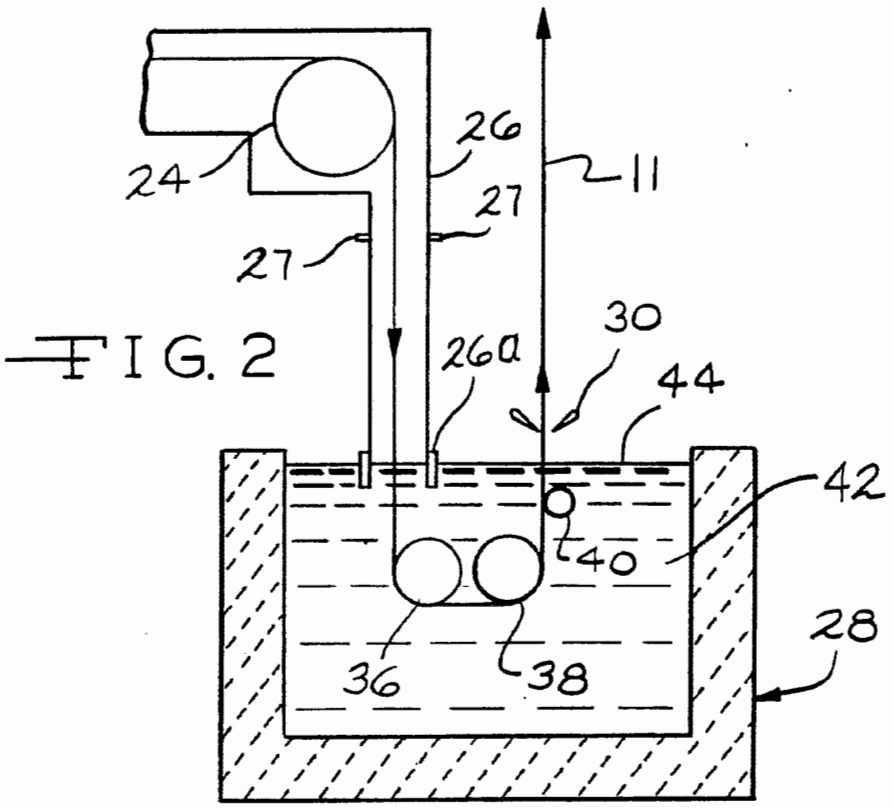
FIG. 2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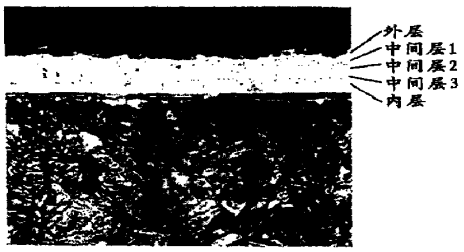
[54] 发明名称 镀铝结构件和生产方法

[57] 摘要

一种镀铝结构件，包含一个形成于钢基体层上的 Al－Si－Fe 合金层。该合金层包括一个硬度小于或等于钢基体层硬度的软质区域，该软质区域从钢基体层表面向合金层表面延伸大于或等于合金层厚度的 50％的深度范围。该 Al－Si－Fe 合金层具有小于或等于 500mg/dm^2 的氧化物重量。



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1、一种镀铝结构件，包括：

一个钢基体层；和

一个形成于钢基体层表面上的Al-Si-Fe合金层，该合金层包含一个从钢基体层表面向合金层表面延伸的，硬度小于或等于钢基体层的硬度、且厚度大于或等于合金层厚度的50％的软质区域，该Al-Si-Fe合金层具有小于或等于500mg/dm^{2}的氧化物重量。

2、如权利要求1所述的镀铝结构件，其中，Al-Si-Fe合金层具有包含一个与钢基体层相邻的内层、和一个形成合金层表面的外层的多层结构。

3、如权利要求2所述的镀铝结构件，其中，该内层为多层结构中最软的层。

4、如权利要求2所述的镀铝结构件，其中，该内层包含85～95％的Fe，并且内层的Hv硬度比合金层的平均硬度软20％或更多。

5、如权利要求2所述的镀铝结构件，其中，Al-Si-Fe合金层的多层结构进一步包括一个包含25～40％Al的中间层，且该中间层的硬度比钢基体层低。

6、如权利要求2所述的镀铝结构件，其中，Al-Si-Fe合金层的多层结构进一步包括多个中间层，至少一个中间层包含25～40％Al，并且硬度低于钢基体层。

7、如权利要求2所述的镀铝结构件，其中，Al-Si-Fe合金层的外层比钢基体层硬。

8、如权利要求2所述的镀铝结构件，其中，外层包含35～50％的Fe。

9、一种镀铝结构件，包括：

一个钢基体层；和

一个形成于钢基体层表面上的Al-Si-Fe合金层，该Al-Si-Fe合金层具有多层结构，所述多层结构包括一个与钢基体相邻的内层，一个形

成合金层表面的外层，以及一个形成于内层和外层之间的中间层，所述内层包含85～95％的Fe，所述中间层包含25～40％的Al，且所述的外层的硬度比钢基体层大。

10、一种镀铝结构件的生产方法，包括:

以 1～10℃/sec 范围内的加热速率加热热浸镀铝钢板;

将该热浸镀铝钢板在 900～950℃的温度范围内升高的温度下保持 2～8 分钟;

以 5～15℃/sec 范围内的冷却速率将该热浸镀铝钢板冷却至 700～800℃的温度范围内的温度;

在 700～800℃的温度范围内将该热浸镀铝钢板成型成预定形状;和

以 20～100℃/sec 范围内的冷却速率将形成预定形状的热浸镀铝钢板从 700～800℃的温度范围内迅速冷却至低于或等于 300℃的较低温度。

镀铝结构件和生产方法

发明背景

本发明涉及一种镀铝结构件及其生产方法。更具体地说，本发明涉及一种通过对镀铝钢板进行热处理和成型加工、并且用Al-Si-Fe合金的合金层进行镀覆以提高成型性、可焊接性和抗腐蚀性的镀铝结构件、例如用于汽车的结构件。

日本专利申请公开No.2000-204463公开了一种热浸镀铝钢板，这种钢板由于其氧化膜而具有优异的抗腐蚀性，并且由于不含有例如铅等重金属而对于环境的影响较小，从这一角度看，这种钢板可以用于汽车的油箱、消音器、隔热板等。

发明概述

包含在热浸镀铝钢板中的在与钢基体交界处的硬质Al-Fe合金层在成型性方面或多或少都存在一些问题。进而，该合金层在成型加工中易于开裂，并且因此有时需要进行其它的处理以便确保足够的抗腐蚀性。由于镀铝层的熔点低并且单一的铝表面层的热传导性不充分，所以焊接性能是另一个问题。因此，热浸镀铝钢板在应用上受到限制。

本发明的一个目的是提供一种在抗腐蚀性、成型性能和焊接性能上具有优点、并且在汽车领域具有更广泛应用的镀铝结构件和生产方法。

根据本发明的一个方案，一种镀铝结构件包括：一个钢基体层；和一个形成于钢基体层的表面上的Al-Si-Fe合金层，该合金层包含一个从钢基体层的表面向合金层表面延伸的，硬度小于或等于钢基体层的硬度、且厚度大于或等于合金层厚度的50％的软质区域，该Al-Si-Fe合金层具有小于或等于500mg/dm^{2}的氧化物重量。

根据本发明的另一个方案，一种镀铝结构件的生产方法包括：以在1～10℃/sec的范围内的加热速率加热热浸镀铝钢板的第一方法要

素；和使热浸镀铝钢板在900～950℃的温度范围内的升高的温度下保持2～8分钟的第二方法要素；以在5～15℃/sec范围内的冷却速率将热浸镀铝钢板冷却至700～800℃的温度范围内的温度的第三方法要素；在700～800℃的温度范围内将该热浸镀铝钢板成型成预定形状的第四方法要素；以及以20～100℃/sec范围内的冷却速率将形成预定形状的热浸镀铝钢板从700～800℃的温度范围内迅速冷却至低于或等于300℃的较低温度的第五方法要素。

附图简要说明

图1是表示在根据本发明实施方案的测试1中使用的试样的形状和尺寸的透视图，用以对成型性能进行评价。

图2A是表示测试1的实例No.1中的一个结构件中的镀层的微观结构的照片。

图2B是表示测试1中的实例No.2中的一个结构件中的镀层的微观结构的照片。

图3是表示本发明实施方案中的结构件点焊中的连续焊点性能与普通的热浸镀铝钢板相比较的图解。

图4是表示实施方案中的测试1的结果的表1。

图5是表示实施方案中的测试3的结果的表2。

发明的详细说明

通常，热浸镀铝钢板是通过将带材连续浸入熔融铝的槽中。根据镀覆金属的成分，热浸镀铝钢板被大致分成两类。其中一种采用纯铝作为镀覆金属（用于抗大气腐蚀性能），另一种采用除了Al之外还包含Si的Al-Si合金作为镀覆金属（用于耐热性能）。根据本发明的一个实施例，采用包含Si添加剂（大约3～11％的Si）的耐热镀覆钢板。

向镀层中添加Si，用以抑制镀铝工艺过程中在钢和镀层之间界面的硬质Al-Fe合金层的生长，并且因此用于提高Al镀层的附着力和抗腐蚀性。在这种热浸镀铝钢板中，在Al镀层和钢基体层之间的交界中形成Al-Si-Fe合金层。

当在特定条件下，对这种类型的热浸镀铝钢板进行热处理时，Al-Si-Fe层会生长并全面扩展直到到达表面为止。图2A表示在镀铝钢板的一个例子中的剖面结构，该镀铝钢板包含由于热处理而生长至表面的这种Al-Si-Fe层。

在由于热处理而使Al-Si-Fe生长的过程中，Al镀层的钢基体层之间的相互扩散产生各种Al-Si-Fe三元金属间化合物、例如αFeAlSi相（alpha FeAlSi）、βFeAlSi相（beta FeAlSi）和γFeAlSi相（gamma FeAlSi）。通过热处理形成的Al-Si-Fe合金层具有由这些金属间化合物构成的层状结构，并且在可成型性能、抗腐蚀性和焊接性能方面具有优点。

当Al-Si-Fe合金层的硬度超过钢基体的硬度时，由于削弱了涂层的可塑性，并且增加了镀层中开裂的可能性，Al-Si-Fe合金层对钢板在成型工艺中的成型性能和抗腐蚀性产生不利影响。因此，在本实施例中，在钢和镀层之间的交界处或附近，形成具有比钢基体的硬度低的不太硬的或软质层。该软质层可以防止在任何情况下产生的裂纹从表面向钢基板更深地延伸。在本实施例中，该软质层的厚度等于或大于合金镀层总厚度的50％。从位于或接近与钢基体的交界的位置处延伸至或超过镀层深度的中间处的厚的软质层，有效地用于防止裂纹的发展并保证足够的抗腐蚀性。

以氧化物形式包含在镀覆合金层中的氧，在电解沉积过程中导致产生气孔，因此如果氧的量增加，则使镀层和沉积薄膜之间的附着力削弱。因此，使氧化物的质量或氧化物的重量等于或小于500mg/dm^2。在本说明书中，如后面所述，"氧化物重量"被定义为，在950℃下进行热处理之后的试样质量和在热处理之前的试样质量之间的质量差。

层状结构的形成机理并不完全清楚。目前，本发明的发明人等假设：（1）将试样保持在升高的温度下将导致Fe的扩散，并且在镀层中产生Fe和Si的浓度梯度。（2）在这种情况下，促使镀层合金相转变成由各个深度处的成分确定的稳定化合物相，从而在不同的深度区域中形成不同的化合物层。（3）因此，通过控制加热升高的温度和在该升

高的温度下的保持时间，改变了Fe的扩散量并且改变了转变成稳定化合物的程度。

由于Fe从钢基体层的扩散，与钢基体层相邻的该Al-Si-Fe合金层被软化，并且与钢的附着更为紧密，并因此更容易成型。具体地，Fe含量的优选范围是85～95%。当Fe含量在这一范围内时，与钢基体接触的软质层的硬度等于或小于镀层平均硬度的80%（300～400Hv）。当Fe的含量小于85%时，由Fe的扩散产生的上述良好效果不够充分。当Fe的含量大于95%时，Fe的扩散过度，并且使Al的含量太低，无法获得在多层结构中的最外层中的抗腐蚀性。在本说明书中，除非另有说明，否则百分比%用于表示"质量%"（质量百分比）。

通过热处理和Fe从钢基体的扩散，使Al-Si-Fe合金层软化。然而，Fe的过度扩散将使Al的含量降低到抗腐蚀性所需的水平以下。从抗腐蚀性的角度考虑，为了保持最低限度的Al含量，并且为了形成比钢基体材料更软的层，至少在三层或更多层的多层结构中的一层中，优选将Al的含量设定在25～40%的范围内。当Al含量小于25%时，抗腐蚀性不足。当Al含量为40%或更大时，软质层的成型变得困难，并且与钢基体的附着力变差。

在包含三层或更多组成或成分不同的次级层的多层结构的情况下，在与钢基体层相邻的最内层和形成镀层表面的最外层之间存在一个或多个中间层。优选地，该中间层或至少一个中间层含有25～40% Al。

通过从钢基体材料扩散而来的Fe与铝镀层的合金化，提高了焊接性能。合金化的Al-Si-Fe镀层的熔点高于通过热浸镀形成的Al镀层，从而可以在低电流条件下进行焊接。进而，在点焊时防止镀覆金属与焊接电极的附着，有利地改善了连续点焊的状况。

通过将Al-Si-Fe镀层全部合金化成多层结构、例如具有含有不同合金组成的五个层的五层结构，改善了热稳定性。包含硬质最外层的多层结构的优点是，即使在用于高张力材料的很大的压力下，仍可以在点焊中保持与焊枪的良好接触。

当Fe的含量随着铝镀层和从金属基体扩散而来的Fe之间的合金化过程而增加时，镀层的热传导率减小，并且可以以低电流进行焊接。通过使镀层表面或最外层中的Fe的浓度在35～50％的范围内，可以将可焊接性能和抗腐蚀性结合起来。通过形成具有多层结构的Al-Si-Fe层，或者通过形成具有Fe含量的浓度梯度的Al-Si-Fe层，可以形成具有在这一范围内的表面Fe浓度的镀层。当最外层的Fe的浓度小于35％时，焊接性能的改善不充分。当最外层中的Fe浓度大于50％时，Al含量相对减小并且抗腐蚀性下降。

通过下述工艺，可以获得如上面所述、在表面上具有Al-Si-Fe合金层的镀铝结构件。首先，将镀层中含有Si的耐热热浸镀铝钢板以1～10℃/sec的速率加热至900～950℃的温度范围内的一个温度下，并且在该升高的温度下保持2～8分钟的保持时间(或持续时间)。在这种情况下，当热浸镀铝钢板被以比10℃/sec快的加热速率加热至高于900℃的温度时，铝镀层会产生局部熔融。当加热速率低于1℃/sec时，该镀层会被氧化。当试样保持的升高温度低于900℃时，钢基体材料中的奥氏体化过程太慢，无法获得作为结构件的足够强度。当升高的温度大于950℃时，镀层产生不希望出现的氧化作用，并且Fe的扩散过度以至到达镀层的表面。当在升高的温度下保持的时间短于2分钟时，Al-Si-Fe合金层的形成变得不充分。当在升高的温度下保持的时间比8分钟长时，镀层产生氧化，并且对电解沉积镀膜的粘附产生不利影响。

在保持在上述温度范围内的热处理之后，将钢板从加热炉送至成型压力机。在输送过程中，开始冷却。在这种情况下，热处理之后的冷却速率需要在5～15℃/sec的范围内，以便在预定的温度下进行成型加工并从预定的温度快速冷却。当冷却速率低于5℃/sec时，镀层的氧化变得显著。对于比15℃/sec更高的速率冷却，需要进行强制冷却。

制成所需形状的成型操作是在700～800℃的温度范围下开始的。在成型操作之后，将成型的板材从700～800℃以20～100℃/sec的速率，迅速冷却到低于或等于300℃的温度。通过这种迅速冷却，使钢基体材料冷却，同时保持通过热处理形成的Al-Si-Fe合金层，并且获得所需形

状的镀铝结构件。热处理的上述条件对于钢基体材料的淬火硬化也是足够的，所以对于增强材料强度是有效的。由于需要再加热并且加速了镀层的氧化，所以不需要在高于800℃下开始成型操作。当在低于700℃的温度下开始成型操作时，对于马氏体转变而言的淬火温度太低。当成型操作之后的冷却速率低于20℃/sec时，向马氏体的转变不充分，并且Fe的扩散过度。当成型操作之后的冷却速率比100℃/sec块时，由于需要改善生产设备中的冷却系统所以成本易于显著增加。快速冷却至小于或等于300℃的温度有效的防止留下铁素体相、并且促进马氏体转变的充分进行。

下面对实施方案的实际例子进行说明。

（测试1）在下述条件下生产镀铝或铝化结构件，并且对成型性能、抗腐蚀性和焊接性能进行研究。

[待测试的热浸镀铝钢板]

用于镀覆的原料板材成分：0.22%C、0.22%Si、1.0%Mn、0.015%P、0.007%S。

板材厚度：1.4mm.

铝镀层中的Si浓度：5%.

铝镀层的厚度：10～20μm.

[测试过程]从上述热浸镀铝钢板上切下一个宽度160mm、长度160mm的平板，在下述条件下进行热处理，并且成图1中所示的形状。然后，对合金镀层的成分、硬度、成型性能、抗腐蚀性和焊接性能进行研究。

<热处理条件>

加热速率：	8℃/sec
加热温度：	900～950℃
保持时间：	2～10min
首次冷却速率：	7℃/sec
成型开始温度：	720℃
快速冷却开始温度：	720℃

二次冷却速率: 30℃/sec

冷却结束的温度: 100℃

[测试结果]表1表示出了测试的结果。在表1中的所有情况下，镀层中最软的层是与钢基体材料的钢基体层相邻的层。表1包括：一个生产条件列，该列被分为升高的温度列和保持时间列；一个镀层结构和成分（%）列，该列被分为组分和硬度列、内层（INNER）列、第一中间层（INTER1）列、第二中间层（INTER2）列、第三中间层（INTER3）列和外层（OUTER）列；一个钢基体材料的硬度（Hv）列；一个镀层的硬度（Hv）列，该列被分为最软层列、平均列、和较基体材料软化的范围（%）的列；一个氧化物重量（mg/dm^2）列；一个成型性能列；一个抗腐蚀性列；和一个焊接性能列。

<成型性能>成型操作之后，在Al-Si-Fe合金层中检查裂纹。没有到达钢基体层裂纹的测试试样被评价为合适，并且标为圆圈。具有一条或多条到达钢基体层裂纹的试样被评价为不合适，并且标为叉。除了No.2结构件之外，试样均表现出良好成型性能，No.2结构件镀覆过硬的镀层，该镀层的平均硬度比钢基体材料的硬度大，并且该镀层在延伸至大于合金层厚度的50%的整个深度范围的区域中的硬度都更大。作为一个典型的例子，图2A表示没有裂纹的No.1结构件中的镀层的微观结构，并且图2B表示产生开裂的No.2结构件中的镀层微观结构。

<抗腐蚀性>对所生产的结构件进行由JIS Z2371确定的盐雾腐蚀试验（SST），以评价每个结构件的抗腐蚀性。结果，No.3结构件表现出较差的抗腐蚀性，在No.3结构件中，由于在升高的温度下保持的时间过长所以Fe的扩散过度，并且因此在最外层中的铝含量太低。

<焊接性能>在下述条件下对所生产的结构件进行连续的点焊。当连续焊点的数目增加时，通常熔核直径会减小并且焊接强度倾向于降低。因而，在下述焊接条件下进行点焊，直到焊点数目达到比JIS Z3140中的A级判断标准小的数目为止。根据连续焊点的数目确定焊接性能。由于NO.3结构件的连续焊点的数目为大约500，在判断标准的水平之下，所以No.3结构件被判断为不合适并且用X标出。对于除了No.3结构

件之外的结构件，焊点数目最高达到3000，达到满足判断标准的水平，并且在该点结束点焊。因此，除No.3试样之外结构件用圆圈标为合适。因此，测试的结果表示当热处理的保持时间太长并且Fe的扩散使镀层软化时，如No.3试样那样，焊接能力下降。该No.3试样的抗腐蚀性和焊接性能均较差。然而，No.3试样的成型性能良好。因此，No.3试样仍适合于一些应用。

[焊接条件]

基体材料: 镀铝钢板(厚1.2mm)和具有440MPa抗拉强度的类型的GA材料(厚2.0mm)

压力:	5.98kN
预压:	50Hz
上升:	3Hz
通电:	9kA ×18Hz
保持:	21Hz

(测试2)通过采用以与测试1的试样No.1相同的方式进行热处理的热浸镀铝钢板，和作为比较例的不进行热处理的热浸镀铝钢板对在下述条件下进行连续点焊的特征进行比较。图3表示对于实施例,试样和比较试样的测试2的结果。不进行热处理的热浸镀铝钢板的试样表现出大约500点，而根据本发明的例子的试样表现出3000点或更多。

(测试条件)

基体材料: 镀铝钢板(1.2t)和具有440MPa的抗拉强度的GA材料(2.0t)

压力:	610kgf
预压:	50cyc
上升:	3cyc
通电:	9kA ×18cyc
保持:	21cyc

(测试3)将热浸镀铝钢板在950℃下保持不同长度的时间，以形成Al-Si-Fe合金层，并且在合金层上进行电解沉积镀覆。然后，对试样

进行检测，以考察合金层中的氧化物重量和涂覆性能(paintability)之间的关系。结果表示在表2中。在此，氧化物重量被定义为在加热之前通过化学平衡进行质量测量的结果和加热之后质量测量的结果之间的质量差。

从表2可知，当氧化物重量大于500mg/dm^{2}时，在沉积镀膜中产生的气孔变得明显。在受到气孔损害的试样中，镀膜的粘附力不充分，并且通过电解沉积涂覆不能充分提高抗腐蚀性。

在根据本发明实施方案的镀铝结构件中，钢基体或基体层上的Al-Si-Fe合金层防止在钢基体和镀层之间形成硬质层，并且取而代之地在深度方向上形成范围很宽的较软区域。而且，该合金层的氧化物重量低。因此，本实施方案可以提高成型性能和涂覆性能，并且通过平衡Al含量和Fe含量，同时获得抗腐蚀性和焊接性能。

在根据本发明实施方案的生产方法中，对镀覆有包含Si的热浸铝镀层的钢板进行热处理，形成所需形状，并且迅速冷却。因此，该生产方法可以提高抗腐蚀性、涂覆性能、焊接性能和成型性能。

本申请以2002年7月11日申请的日本专利申请No.2002－202770为基础。该日本专利申请No.2002-202770的全部内容在此被引入作为参考。

尽管上面通过参考本发明的特定实施方案已经对本发明进行了说明，但是本发明不限于上述实施方案。根据上述技术，本领域技术人员可以对上述实施方案作出各种改进和改变。本发明的范围参照下面的权利要求进行限定。

图1

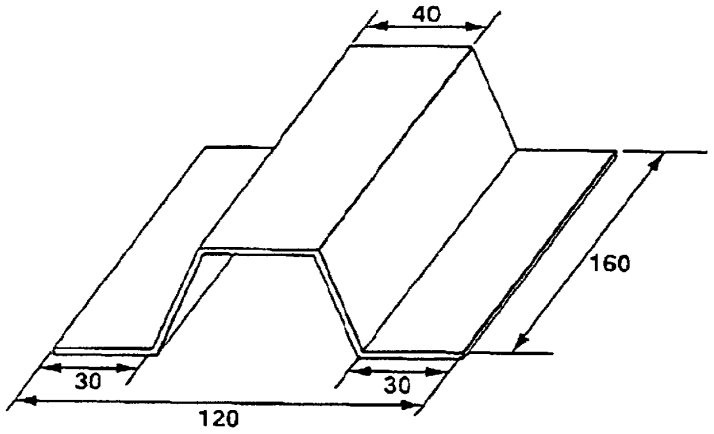

图2A

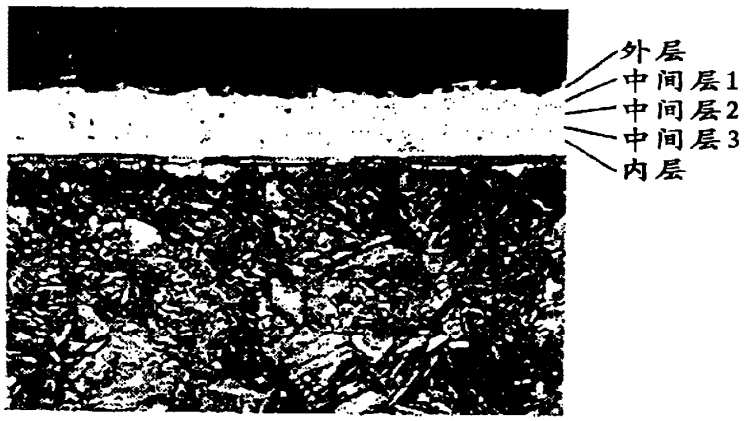

图2B

图 3

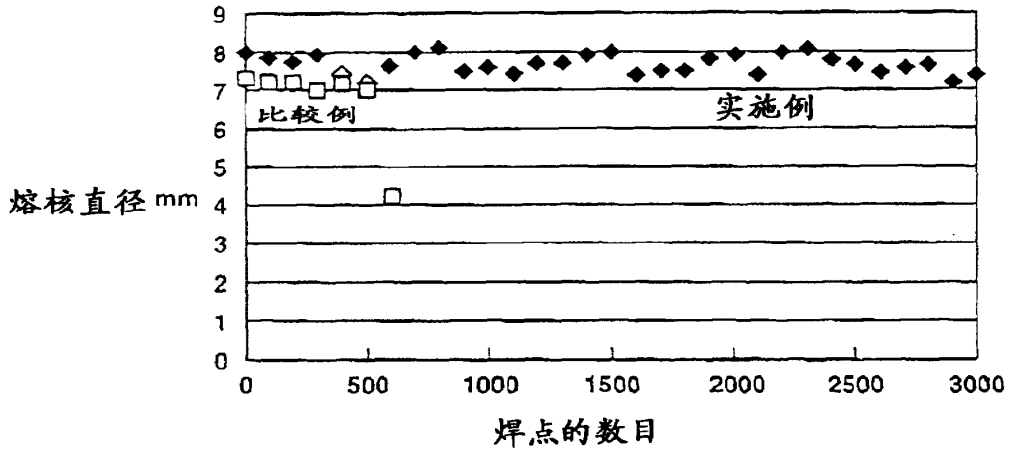
熔核直径 mm
9
8
7
6
5
4
3
2
1
0
比较例
实施例
0
500
1000
1500
2000
2500
3000
焊点的数目

图4

表1

No.	生产		镀层结构和成份（%）						钢基体硬度 (Hv)	镀层硬度（Hv）			氧化物重量 (mg/dm²)	成形性能	抗腐蚀性	焊接性能
	升高的温度 (℃)	保持时间 (min.)	组份和硬度	INNER	INTER 1	INTER 2	INTER 3	OUTER		最软	平均	软化范围 (%)				
1	920	3	Al	7.7	31.0	48.4	31.6	54.8	450	310	415	51	300	○	○	○
			Si	2.0	3.9	1.2	5.7	0.8								
			Fe	89.6	65.9	50.1	62.0	44.5								
			Hv	310	360	750	700	800								
2	900	2	Al	27.2	48.4	31.6		54.9	415	380	455	22	275	×	○	○
			Si	4.1	1.2	5.7	—	0.8								
			Fe	67.2	50.1	61.9		44.1								
			Hv	380	760	720	—	810								
3	930	10	Al	9.4				11.6	400	305	385	78	550	○	×	×
			Si	1.3	—	—	—	1.8								
			Fe	88.4				85.7								
			Hv	305	—	—	—	410								
4	950	5	Al	6.0	27.8	51.9	30.4	47.4	440	280	400	59	385	○	○	○
			Si	1.5	4.3	0.6	5.3	2.2								
			Fe	90.7	66.7	46.8	63.1	49.8								
			Hv	280	340	720	690	800								
5	900	4	Al	3.2	54.5	33.4		54.5	440	300	410	56	335	○	○	○
			Si	0.4	2.5	15.3	—	6.8								
			Fe	94.3	42.7	51.4		38.4								
			Hv	300	740	700	—	810								

图5

表2

加热温度 (℃)	保持时间 (min.)	氧化物重量 (mg/dm²)	附着力	
			气孔	横切测试
950	3	290	无	○
	5	385	无	○
	10	540	有	×
	15	690	有	×
	20	760	有	×
	25	790	有	×
	30	805	有	×

Espacenet

Bibliographic data: FR2720079 (A1) — 1995-11-24

Hot dip coating steel with aluminium (alloy)

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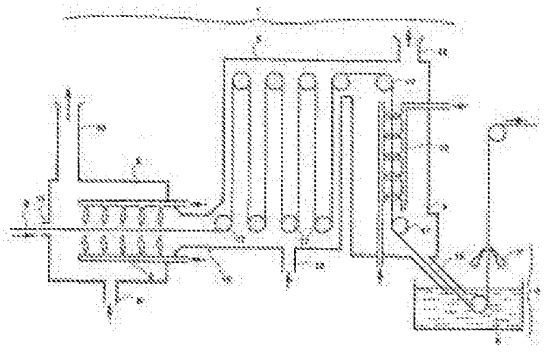
Abstract of FR2720079 (A1)

A steel strip containing at least 0.1 wt.% Mn is pretreated prior to hot dip coating with Al or Al alloy. During the pretreatments which consist of cleaning, heat treatment and cooling, the atmosphere is maintained as completely non-reducing. Coating esp. stainless and alloy steels. By avoiding the use of hydrogen containing atmospheres, the process becomes more economic and the security of the process is improved.



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DESCRIPTION FR2720079

The present invention relates to a method for coating aluminum or aluminum alloys by hot dipping a piece, in particular a strip, of steel containing at least 0.1% by weight of manganese, in particular Of stainless steel and / or alloy.

In general, in order to carry out a metal coating by dipping a steel part, the part to be coated is prepared and quenched in a coating bath, that is to say a bath of molten metal.

The preparation of said part generally comprises a number of successive treatments.

Thus, for example, to prepare the said part, its surface is cleaned, heated and then cooled. The cleaning of the surface can be carried out in particular by chemical treatment of degreasing, by heat treatment called preheating or even by physical treatment. Intended to recrystallize the steel which composes the part; It is thus carried out for a time and in accordance with a temperature profile determining the mechanical properties of said part.

The cooling is intended to bring the temperature of the part to a temperature close to that of the bath of molten metal; It is generally conducted under a jet of cold gas.

When the coating is based on aluminum and the parts to be coated are made of stainless steel and / or alloy, in particular containing at least 0.1% manganese, it is known to carry out the preparation of the part, in particular the last Such as heating and cooling, under a reducing atmosphere, in particular containing hydrogen.

Indeed, the part to be coated has on the surface traces of oxides of the alloying elements of said stainless steel and / or alloy; The cleaning treatment, particularly when carried out by preheating, further oxidizes said surface; It is known that these oxides, and in particular chromium oxides, can prevent the molten metal in the bath from properly wetting the surface of the strip at the moment of dipping, which is detrimental to the quality of the coating obtained, in particular at the level of its adherence to the piece and its geometrical homogeneity.

This arrangement concerning the atmosphere of the preparation treatments is therefore useful for reducing the oxides of the alloying elements of the steel, in particular chromium, which are located on the surface of the part to be coated and for substantially improving the quality of the coating In particular with regard to its adhesion to the workpiece and its geometrical homogeneity.

Thus, it is known to use hydrogen in large proportions in the cooling and heating atmosphere in order to reduce, at the surface of the part to be coated, the oxides initially present or which have formed during the previous treatments of the preparation; But the use of hydrogen presents serious economic and safety disadvantages.

French Pat. No. 2,664,617, filed on July 16, 1990 in the names of SOLLAC and UGINE SA, describes such a process and has the advantage over prior art methods of avoiding the use of atmospheres Reducing agents containing high proportions of hydrogen, in the preparation of a part to be coated, in particular at the time of cooling.

This document describes a preparation process for the aluminum coating by dipping a stainless steel strip in which said strip is preheated in a non-oxidizing atmosphere at a lower temperature than in the prior art, said strip In a non-oxidizing atmosphere which may be reductive and contain hydrogen, and said strip is cooled in a non-reactive atmosphere, such as nitrogen, and may contain hydrogen.

Thus, due to a lower temperature and a non-oxidizing atmosphere during preheating, the formation of oxides on the surface of the strip is limited and the subsequent treatments can

advantageously be carried out under less reducing atmospheres, thus containing less hydrogen than Those which are commonly used before, while obtaining a coating of aluminum of good quality, in particular of good adhesion and good homogeneity.

Nevertheless, in this process, the counterpart of the lower temperature and the non-oxidizing atmosphere of the preheating may be a reduction in the quality of the cleaning, in particular when bodies that clog the surface of the part, in particular fat bodies, Are not completely decomposed under these new preheating conditions.

It may also be necessary to extend the duration of the preheating treatment to obtain a sufficient quality of the cleaning, but this lengthening of the treatment time is detrimental to the productivity.

Moreover, in particular for heating and cooling treatments, it is often necessary to use hydrogen, although obviously in smaller proportions than before; Therefore, the disadvantages associated with the use of hydrogen have not been totally eliminated and which relate to the safety and cost of the installations.

The object of the invention is to avoid the use of hydrogen during the preparation of a part, in particular a strip, of stainless steel and / or alloy containing at least 0.1% manganese for a coating with Tempered aluminum or aluminum alloys.

Another object of the invention is to facilitate the processing of the preparation of such a strip, and in particular to ensure both the quality of the cleaning and the productivity.

To this end, the subject of the invention is a process for the coating of aluminum or aluminum alloy by hot dipping of a piece, in particular of a strip, of steel containing at least 0.1% by weight Of manganese, in particular of stainless and / or alloyed steel, in which the strip is prepared before coating in a sequence of treatments carried out under a controlled atmosphere and then the strip is quenched in a bath of molten aluminum or aluminum alloy, characterized In that said atmospheres are all non-reducing.

The process according to the invention may comprise one or more of the following characteristics: the hydrogen concentrations of the atmospheres of the said treatments are all less than or equal to 4%, the said treatments are thermal treatments, Cooling, the heating and cooling atmospheres

contain more than 96% nitrogen.

BRIEF DESCRIPTION OF THE DRAWINGS The invention will now be described in more detail with reference to the accompanying drawing, which shows a schematic view of a preparation installation and a continuous dip coating installation of a metal strip.

As shown in the single FIGURE, the continuous preparation plant designated as a whole by the reference 1 comprises a preheating furnace 2, a heat treatment furnace 3, a cooling chamber 4, Installed upstream of a dip coating installation designated as a whole by the reference 5; It comprises web support rollers 17 distributed throughout the installation and defining the web path.

The dip coating installation 5 is known per se and will not be described herein in detail; In a conventional manner, it comprises a soaking vessel containing the coating bath 6, made of aluminum or molten aluminum alloy, and spinning ejectors 7.

The preheating furnace 2 is a direct flame furnace having an air inlet 8, burner ramps 9 arranged on either side of the strip path, and a gas discharge, in particular combustion ; The preheating furnace 2 further comprises a strip inlet 11 and a strip outlet 12 opening directly into the heat treatment furnace 3.

The heat treatment furnace 3 is equipped with radiant tubes and a controlled atmosphere, in particular by a treatment gas inlet 13; Its outlet opens directly into the cooling chamber 4.

The cooling chamber 4 is provided with ramps of cooling gas ejectors 14 arranged on either side of the strip path, the ejectors of which are oriented towards the strip path; The cooling chamber 4 is also provided with a gas exhaust chimney 15 and opens out via a strip outlet channel 16 below the level of the free surface of the liquid metal 6 of the coating installation 5.

The preparation plant also includes means for measuring the temperature of the atmosphere and the strip, means for measuring dew points and for controlling the humidity level, which are installed in the preheating furnace 2, Heat treatment furnace 3, and the cooling chamber 4; These means are known per se and are not shown here.

The cooling gas ejector ramps 14 and the treatment gas inlet 13 are connected to gas supply means which are not shown here.

In order to proceed with the dip coating of a band B of stainless steel and / or alloy containing at least 0.1% manganese, said strip is prepared according to the following sequence: said strip is preheated between the burner ramps 9 of A preheating furnace 2 supplied with an excess of at least 2% of fuel with respect to the stoichiometric combustion conditions in a non-oxidizing atmosphere, the temperature of which is generally between 8000C and 13000C; In this way, the temperature of the strip at the outlet of the preheating furnace 2 is greater than the decomposition temperature of the bodies which are clogging the surface of the strip, in particular fatty substances, and generally situated between 4000C and 7000C; The surface of said strip is then cleaned.

The said strip is heat-treated in the heat treatment furnace 3 for a time sufficient for the measured temperature of said strip at the outlet of the heat treatment furnace 3 to be greater than the recrystallization temperature of the stainless steel and / or alloy Of the strip, that is to say generally between 7500C and 9500C, and in order to obtain the required mechanical properties of the strip; The temperature of the atmosphere of the heat treatment furnace is thus established between 8500C and 10000C and, moreover, its dew point between -450C and -250C.

This heat treatment is carried out under a non-reducing atmosphere; By means of the gas supply means, a non-reducing treatment gas, in this case nitrogen containing less than 0.1% hydrogen, is injected into the heat treatment furnace 3 via the gas inlet 13, Such that said furnace 3 is under overpressure with respect to the preheating furnace 2 and the cooling chamber 4.

Without departing from the invention, it is possible to use as nitrogen-treating gas containing 4% hydrogen; Even at these concentrations, the use of hydrogen does not have any drawbacks with regard to the safety and cost of the installations.

Said strip is cooled between the ramps of cooling gas ejectors 14 in the cooling chamber 4 under a non-reducing atmosphere; By virtue of the gas supply means, the ramps 14 are in fact supplied with non-reducing cooling gas, in this case nitrogen at ambient temperature containing less than 0.1% hydrogen, at a flow rate such that the measured temperature Of the strip at the outlet of said chamber 4 is close to that of the bath of molten metal 6, that is to say generally between 6700C and 7000C; The dew point is set between -300C and -150C.

The cooling and, in part, treatment gases are evacuated via the exhaust stack 15; The other part of the process gas is discharged via the exhaust stack 10 of the preheating furnace 2.

The strip emerges from the preparation installation 1 via the outlet channel 16 of the cooling chamber 4 and therefore immediately dips into the liquid metal bath 6 of the coating installation 5.

Thus, during the preparation of the strip for the coating, since there is no upper limit temperature for preheating, it is advantageously possible to carry out a higher temperature to ensure both the quality of the cleaning and a good productivity .

Thus, during the preparation of the strip for the coating, the use of hydrogen and the disadvantages associated with its use, in terms of safety and cost, are avoided completely.

The handling of the strip preparation treatments for the dip coating is greatly facilitated.

After the strip has been prepared, the strip is then dipped by a method known per se which is not described herein in detail; The wiper ejectors 7 are in particular adjusted to obtain the desired coating thickness, for example about twenty micrometers.

The Applicant was surprised to note that while the strip preparation treatments were all carried out in the absence of hydrogen and in a non-reducing atmosphere, the coating of aluminum or aluminum alloy made by dipping according to Methods otherwise known to have good geometric homogeneity and good adhesion to the stainless steel and / or alloy band B provided that said steel contains at least 0.1% manganese; This result is all the more surprising since the preparation conditions are not able to totally prevent the formation of oxides or even to reduce them to the surface of the strip.

EXAMPLE 1 A strip of alloy steel with a thickness of 1 mm having a manganese content of 0.178% is taken.

The other alloying elements are in particular: Si: 0.37% - Cr 0.84% - Al: 0.9% - Ti: 0.32% - Nb: 0.21%.

Using the installation described above, the process according to the invention is carried out under the following conditions of preparation and coating: Preheating furnace 2: - strip temperature at the outlet of the furnace: 6500C.

Heater oven 3 - Outlet temperature of oven: 8500 C.

- composition of the atmosphere: Nitrogen.

- dew point: -300C.

Cooling chamber 4 - strip temperature at chamber outlet: 6800C.

- composition of the atmosphere: Nitrogen.

- dew point: -250C.

Coating bath 6 - composition: Al: 87.6% - Si: 9.1% - Fe: 3.3%.

- immersion time: 3 s.

The wiping ejectors 7 are set to load the strip about 120 g / m 2 in double face with a coating which has the following composition: Al: 86.8% Si: 6% Fe: 7.2%.

The adhesion and the homogeneity in the thickness of the coating are then measured by the following methods: - ASTM standard adhesion test No. A 463 488: the method consists in folding at a temperature of 1800 ° C a sample of coated strip with a diameter corresponding to two Times the thickness of the sample; The test is positive if no scaling of the coating can be detected after folding.

The adhesion tests carried out on samples of the strip thus prepared and coated according to the invention are positive.

- Measurement of thickness or load of coating according to ASTM standard nOA 428-99: the method is based on the weight measurement of several samples before and after chemical stripping of the coating.

The loading measurements carried out on three samples of the strip, thus prepared and coated according to the invention, gave 120 g / m 2 as the results; 123 g / m2; 121 g / m2 ... and correspond to good homogeneity.

EXAMPLE 2 A strip of stainless steel F17T of thickness 1.4 mm having a manganese content of 0.45% is taken.

The other alloying elements are in particular: Cr: 17.7% - Si 0.44% - Ti: 0.29% - Nb: 0.62%.

Using the installation described above, the process according to the invention is carried out under the same preparation and coating conditions as in Example 1.

The wiping ejectors 7 are set to load the strip about 120 g / m 2 in double face with a coating which has the following composition: Al: 86.8% Si: 6% Fe: 7.2%.

The adherence and the homogeneity in thickness of the coating are then measured by the same methods as in Example 1. The adhesion tests carried out on samples of the strip thus prepared and coated according to the invention are positive.

The load measurements carried out on three samples of the strip, thus prepared and coated according to the invention, gave 122 g / m 2 as the results; 124 g / m2; 121 g / m2 ... and correspond to good homogeneity.

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CLAIMS FR2720079

CLAIMS

1.

A method for hot-dip coating a workpiece, in particular a strip, made of steel containing at least 0.1% by weight of manganese, in particular of stainless steel and / or alloy, in which the strip is prepared before coating According to a sequence of treatments carried out under a controlled atmosphere and then the strip is quenched in a bath of aluminum or of a molten aluminum alloy, characterized in that the atmospheres of said treatments are all non-reducing.

2.

Process according to claim 1, characterized in that the hydrogen concentrations of the atmospheres of said treatments are all less than or equal to 4%.

3.

Process according to claim 1 or 2, characterized in that said treatments are heat treatments.

4.

A process according to claim 3, characterized in that, when said treatment sequence includes heating and cooling, the heating and cooling atmospheres contain more than 96% nitrogen.

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(60) **Références à d'autres documents nationaux apparentés :**

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(73) **Titulaire(s) :**

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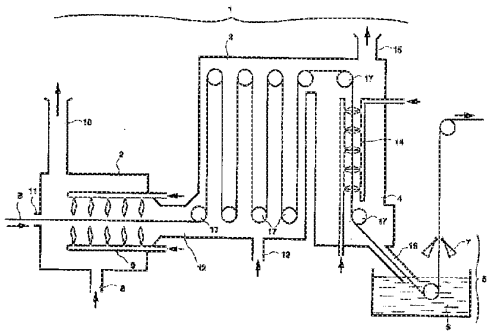
(54) Procédé de revêtement d'aluminium par trempe à chaud d'une pièce, notamment d'une bande, en acier contenant au moins 0,1 % en poids de manganèse, notamment en acier inoxydable et/ou allié.

(57) Dans ce procédé, on prépare la bande avant le revêtement suivant une séquence de traitements sous atmosphères toutes non réductrices puis on trempe la bande dans un bain d'aluminium ou d'alliage d'aluminium fondu. Simplification et sécurité de la préparation pour le revêtement au trempé.



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La présente invention est relative à un procédé de revêtement d'aluminium ou d'alliages d'aluminium par trempé à chaud d'une pièce, notamment d'une bande, en acier contenant au moins 0,1% en poids de manganèse, notamment en acier inoxydable et/ou allié.

D'une manière générale, pour procéder à un revêtement métallique au trempé d'une pièce en acier, on prépare la pièce à revêtir et on la trempe dans un bain de revêtement, c'est à dire ici un bain de métal fondu.

La préparation de ladite pièce comporte généralement un certain nombre de traitements successifs.

Ainsi par exemple, pour préparer ladite pièce, on nettoie sa surface, on la chauffe , puis on la refroidit .

Le nettoyage de la surface peut être notamment réalisé par traitement chimique de dégraisssage, par traitement thermique appelé préchauffage, voire par traitement physique .

Le chauffage est destiné à recristalliser l'acier qui compose la pièce ; il est ainsi effectué pendant une durée et selon un profil de température déterminant pour les propriétés mécaniques de ladite pièce.

Le refroidissement est destiné à ramener la température de la pièce à une température proche de celle du bain de métal fondu ; elle est généralement conduite sous jet de gaz froid.

Lorsque le revêtement est à base d'aluminium et que les pièces à revêtir sont en acier inoxydable et/ou allié, notamment contenant au moins 0,1 % de manganèse, il est connu de réaliser la préparation de la pièce, en particulier les dernières étapes comme le chauffage et le refroidissement, sous une atmosphère réductrice, notamment contenant de l'hydrogène.

En effet, la pièce à revêtir présente en surface des traces d'oxydes des éléments d'alliages dudit acier inoxydable et/ou allié ; le traitement de nettoyage, en particulier lorsqu'il est réalisé par préchauffage, oxyde encore davantage ladite surface ; il est connu que ces oxydes, et en particulier les oxydes de chrome, peuvent empêcher le métal fondu du bain de mouiller convenablement la surface de la bande au moment du trempé, ce qui est préjudiciable à la qualité du revêtement obtenu, notamment au niveau de son adhérence à la pièce et de son homogénéité géométrique.

Cette disposition concernant l'atmosphère des traitements de préparation est donc utile pour réduire les oxydes des éléments d'alliages de l'acier, notamment de chrome, qui se trouvent à la surface de la pièce à revêtir et pour améliorer sensiblement la qualité du revêtement au trempé, notamment au niveau de son adhérence à la pièce et de son homogénéité géométrique.

Ainsi, il est connu d'utiliser de l'hydrogène en fortes proportions dans l'atmosphère de refroidissement et de chauffage pour réduire, à la surface de la pièce à revêtir, les oxydes initialement présents ou qui se sont formés lors des traitements précédents de la préparation ; mais l'utilisation d'hydrogène présente de graves inconvénients économiques et de sécurité.

Le brevet français n°2 664 617 déposé le 16/07/90 aux noms des Sociétés SOLLAC et UGINE S.A. décrit un tel procédé et présente l'avantage, par rapport aux procédés de l'art antérieur, d'éviter l'utilisation d'atmosphères réductrices contenant de fortes proportions d'hydrogène, lors de la préparation d'une pièce à revêtir, en particulier au moment du refroidissement.

Ce document décrit un procédé de préparation pour le revêtement d'aluminium au trempé d'une bande d'acier inoxydable dans lequel on préchauffe ladite bande dans une atmosphère non oxydante à une température plus basse que dans l'art antérieur, on chauffe ladite bande dans une atmosphère non oxydante, pouvant être réductrice et contenir de l'hydrogène, et on refroidit ladite bande dans une atmosphère non réactive, comme de l'azote, et pouvant contenir de l'hydrogène.

Ainsi, grâce à une température plus basse et une atmosphère non oxydante au préchauffage, on limite la formation d'oxydes à la surface de la bande et on peut avantageusement effectuer les traitements ultérieurs sous des atmosphères moins réductrices, donc contenant moins d'hydrogène que celles couramment utilisées auparavant, tout en obtenant un revêtement d'aluminium de bonne qualité, en particulier de bonne adhérence et de bonne homogénéité.

Néanmoins, dans ce procédé, la contrepartie de la température plus basse et de l'atmosphère non oxydante du préchauffage peut être une diminution de la qualité du nettoyage, en particulier lorsque des corps encrassant la surface de la pièce, notamment des corps gras, ne sont pas totalement décomposés dans ces nouvelles conditions de préchauffage.

Il peut être également nécessaire de prolonger la durée du traitement de préchauffage pour obtenir une qualité suffisante du nettoyage, mais cet allongement de la durée du traitement est préjudiciable à la productivité.

Par ailleurs, notamment pour les traitements de chauffage et de refroidissement, il reste souvent nécessaire d'utiliser de l'hydrogène, bien qu'évidemment en plus faibles proportions qu'auparavant ; on n'a donc pas totalement supprimé les inconvénients lié à l'utilisation d'hydrogène, et qui concernent la sécurité et le coût des installations.

L'invention a pour but d'éviter l'utilisation d'hydrogène lors de la préparation d'une pièce, notamment d'une bande, en acier inoxydable et/ou allié contenant au moins 0,1 % de manganèse pour un revêtement au trempé d'aluminium ou d'alliages d'aluminium.

L'invention a également pour but de faciliter la conduite des traitements de préparation d'une telle bande, et en particulier d'assurer à la fois la qualité du nettoyage et la productivité.

A cet effet, l'invention a pour objet un procédé de revêtement d'aluminium ou d'alliage d'aluminium par trempé à chaud d'une pièce, notamment d'une bande, en acier contenant au moins 0,1% en poids de manganèse, notamment en acier inoxydable et/ou allié dans lequel on prépare la bande avant le revêtement suivant une séquence de traitements effectués sous atmosphère contrôlée puis on trempe la bande dans un bain d'aluminium ou d'alliage d'aluminium fondu, caractérisé en ce que lesdites atmosphères sont toutes non réductrices.

Le procédé suivant l'invention peut comporter une ou plusieurs des caractéristiques suivantes :

- les concentrations en hydrogène des atmosphères desdits traitements sont toutes inférieures ou égales à 4 %,
- lesdits traitements sont des traitements thermiques,
- lorsque ladite séquence de traitements comporte un chauffage et un refroidissement, les atmosphères de chauffage et de refroidissement contiennent plus de 96 % d'azote.

L'invention va maintenant être décrite plus en détail en regard de la figure annexée , qui représente une vue schématique d'une installation de préparation et d'une installation de revêtement au trempé en continu d'une bande métallique.

Comme représenté à la Figure unique, l'installation de préparation en continu désignée dans son ensemble par la référence 1 comprend :

- un four de préchauffage 2,
- un four de traitement thermique 3,
- une chambre de refroidissement 4,

Ladite installation de préparation est installée en amont d'une installation de revêtement au trempé désignée dans son ensemble par la référence 5 ; elle comporte des rouleaux-support de bande 17 répartis dans toute l'installation et qui définissent le chemin de bande.

L'installation de revêtement au trempé 5 est connue par elle-même et ne sera pas décrite ici en détail ; d'une manière classique, elle comporte un récipient de trempage contenant le bain 6 de revêtement, composé d'aluminium ou d'alliage d'aluminium en fusion, et des éjecteurs d'essorage 7.

Le four de préchauffage 2 est un four à flamme directe comportant une entrée d'air 8, des rampes de brûleurs 9 disposées de part et d'autre du chemin de bande, et une cheminée 10 d'évacuation des gaz, en particulier de combustion ; le four de préchauffage 2 comporte encore une entrée de bande 11 et une sortie de bande 12 débouchant directement dans le four de traitement thermique 3.

Le four de traitement thermique 3 est à tubes radiants et à atmosphère contrôlée, en particulier par une entrée de gaz de traitement 13 ; sa sortie débouche directement dans la chambre de refroidissement 4.

La chambre de refroidissement 4 est dotée de rampes d'éjecteurs de gaz de refroidissement 14 disposées de part et d'autre du chemin de bande, dont les éjecteurs sont orientés vers le chemin de bande ; la chambre de refroidissement 4 est également dotée d'une cheminée d'évacuation des gaz 15 et débouche par un canal de sortie de bande 16 sous le niveau de la surface libre du métal liquide 6 de l'installation de revêtement 5.

L'installation de préparation comporte également des moyens de mesure de température de l'atmosphère et de la bande, des moyens de mesure des points de rosée et de contrôle du taux d'humidité, qui sont installés dans le four de préchauffage 2, le four de traitement thermique 3, et la chambre de refroidissement 4 ; ces moyens sont connus en eux-mêmes et ne sont pas représentés ici.

Les rampes d'éjecteurs de gaz de refroidissement 14 et l'entrée de gaz de traitement 13 sont reliés à des moyens d'alimentation en gaz qui ne sont pas représentés ici.

Afin de procéder au revêtement au trempé d'une bande B d'acier inoxydable et/ou allié contenant au moins 0,1% de manganèse , on prépare ladite bande selon la séquence suivante :

- on préchauffe ladite bande entre les rampes de brûleurs 9 du four de préchauffage 2 alimenté en excès d'au moins 2 % de carburant par rapport aux conditions stoechiométriques de combustion dans une atmosphère non oxydante dont la température est généralement située entre 800°C et 1300°C ; de cette manière, la température de la bande à la sortie du four de préchauffage 2 est supérieure à la température de décomposition des corps encrassant la surface de la bande, notamment des corps gras, et généralement située entre 400°C et 700°C ; la surface de ladite bande est alors nettoyée.

- on traite thermiquement ladite bande dans le four de traitement thermique 3 pendant une durée suffisante pour que la température mesurée de ladite bande à la sortie du four de traitement thermique 3 soit supérieure à la température de recristallisation de l'acier inoxydable et/ou allié de la bande, c'est à dire en général comprise entre 750°C et 950°C, et pour obtenir les propriétés mécaniques requises de la bande ; on établit donc la température de l'atmosphère du four de traitement thermique entre 850°C et 1000°C et, par ailleurs, son point de rosée entre -45°C et -25°C.

On effectue ledit traitement thermique sous une atmosphère non réductrice ; grâce au moyen d'alimentation en gaz, on injecte dans le four de traitement thermique 3 par l'entrée de gaz 13 un gaz de traitement non réducteur, ici de l'azote contenant moins de 0,1% d'hydrogène, à un débit tel que ledit four 3 soit en surpression par rapport au four de préchauffage 2 et à la chambre de refroidissement 4.

Sans se départir de l'invention, il est possible d'utiliser comme gaz de traitement de l'azote contenant 4% d'hydrogène ; même à ces concentrations, l'utilisation d'hydrogène ne présente en effet aucun inconvénient quant à la sécurité et au coût des installations.

- on refroidit ladite bande entre les rampes d'éjecteurs de gaz de refroidissement 14 dans la chambre de refroidissement 4 sous une atmosphère non réductrice ; grâce aux moyens d'alimentation en gaz, on

alimente en effet les rampes 14 en gaz de refroidissement non réducteur, ici de l'azote à température ambiante contenant moins de 0,1% d'hydrogène, à un débit tel que la température mesurée de la bande à la sortie de ladite chambre 4 soit proche de celle du bain de métal fondu 6, c'est à dire en général comprise entre 670°C et 700°C ; on règle le point de rosée entre -30°C et -15°C.

Les gaz de refroidissement et, en partie, de traitement s'évacuent par la cheminée d'évacuation 15 ; l'autre partie des gaz de traitement s'évacue par la cheminée d'évacuation 10 du four de préchauffage 2.

La bande ressort de l'installation de préparation 1 par le canal de sortie 16 de la chambre de refroidissement 4 et trempe donc immédiatement dans le bain de métal liquide 6 de l'installation de revêtement 5.

Ainsi, lors de la préparation de la bande pour le revêtement, puisqu'il n'y a pas de température limite supérieure de préchauffage, on peut avantageusement procéder à une température plus élevée pour assurer à la fois la qualité du nettoyage et une bonne productivité.

Ainsi également, lors de la préparation de la bande pour le revêtement, on évite totalement l'utilisation d'hydrogène et les inconvénients liés à son utilisation, aux plans de la sécurité et des coûts.

La conduite des traitements de préparation de la bande pour le revêtement au trempé est largement facilitée.

Après la préparation de la bande, on procède ensuite au revêtement au trempé de la bande selon un procédé connu en lui-même qui n'est pas décrit ici en détail ; on règle en particulier les éjecteurs d'essorage 7 pour obtenir l'épaisseur de revêtement souhaitée, par exemple de environ vingt micromètres.

La Demanderesse a constaté avec surprise que, alors que les traitements de préparation de la bande ont tous été conduits en l'absence d'hydrogène et en atmosphère non réductrice, le revêtement d'aluminium ou d'alliage d'aluminium réalisé au trempé selon des méthodes connues par ailleurs présente une bonne homogénéité géométrique et une bonne adhérence sur la bande B d'acier inoxydable et/ou allié à condition que ledit acier contienne au moins 0,1 % de manganèse ; ce résultat est d'autant plus surprenant que les conditions de préparation ne sont aptes ni à empêcher totalement la formation d'oxydes, ni même à les réduire à la surface de la bande.

Exemple 1 :

On prend un bande d'acier allié d'épaisseur 1 mm dont la teneur en manganèse est de 0,178 %.

Les autres éléments d'alliage sont notamment : Si : 0,37 % - Cr : 0,84 % - Al : 0,9 % - Ti : 0,32 % - Nb : 0,21 %.

En utilisant l'installation décrite ci-dessus, on procède selon l'invention dans les conditions suivantes de préparation et de revêtement :

. Four de préchauffage 2 :

- température de bande en sortie de four : 650°C.

. Four de chauffage 3 :

- température de bande en sortie de four : 850°C.
- composition de l'atmosphère : Azote.
- point de rosée : -30°C.

. Chambre de refroidissement 4 :

- température de bande en sortie de chambre : 680°C.
- composition de l'atmosphère : Azote.
- point de rosée : -25°C.

. Bain de revêtement 6 :

- composition : Al : 87,6 % - Si : 9,1 % - Fe : 3,3 %.
- durée d'immersion : 3 s.

On règle les éjecteurs d'essorage 7 pour charger la bande de 120 g/m2 environ en double face d'un revêtement qui présente la composition suivante : Al : 86,8 % - Si : 6 % - Fe : 7,2 %.

On mesure ensuite l'adhérence et l'homogénéité en épaisseur du revêtement par les méthodes suivantes :

- Test d'adhérence normalisé ASTM n° A 463 488 : la méthode consiste au pliage à 180°C d'un échantillon de bande revêtue selon un diamètre correspondant à deux fois l'épaisseur de l'échantillon ; le test est positif si aucun écaillage du revêtement ne peut être décelé après pliage.

Les tests d'adhérence effectués sur des échantillons de la bande, ainsi préparée et revêtue selon l'invention, sont positifs.

- Mesure d'épaisseur ou de charge de revêtement selon la norme ASTM n°A 428-99 : la méthode est basée sur la mesure de poids de plusieurs échantillons avant et après décapage chimique du revêtement.

Les mesures de charge effectuées sur trois échantillons de la bande, ainsi préparée et revêtue selon l'invention, donnent comme

résultats : 120 g/m2 ; 123 g/m2 ; 121 g/m2 ... et correspondent à une bonne homogénéité.

Exemple 2 :

On prend un bande d'acier inoxydable F17T d'épaisseur 1,4 mm dont la teneur en manganèse est de 0,45 %.

Les autres éléments d'alliage sont notamment : Cr : 17,7 % - Si : 0,44 % - Ti : 0,29 % - Nb : 0,62 %.

En utilisant l'installation décrite ci-dessus, on procède selon l'invention dans les mêmes conditions de préparation et de revêtement que dans l'exemple 1.

On règle les éjecteurs d'essorage 7 pour charger la bande de 120 g/m2 environ en double face d'un revêtement qui présente la composition suivante : Al : 86,8 % - Si : 6 % - Fe : 7,2 %.

On mesure ensuite l'adhérence et l'homogénéité en épaisseur du revêtement par les mêmes méthodes que dans l'exemple 1 :

- Les tests d'adhérence effectués sur des échantillons de la bande, ainsi préparée et revêtue selon l'invention, sont positifs.
- Les mesures de charge effectuées sur trois échantillons de la bande, ainsi préparée et revêtue selon l'invention, donnent comme résultats : 122 g/m2 ; 124 g/m2 ; 121 g/m2 ... et correspondent à une bonne homogénéité.

REVENDICATIONS

1.- Procédé de revêtement par trempé à chaud d'une pièce, notamment d'une bande, en acier contenant au moins 0,1% en poids de manganèse, notamment en acier inoxydable et/ou allié dans lequel on prépare la bande avant le revêtement suivant une séquence de traitements effectués sous atmosphère contrôlée puis on trempe la bande dans un bain d'aluminium ou d'alliage d'aluminium fondu, caractérisé en ce que les atmosphères desdits traitements sont toutes non réductrices.

2.- Procédé selon la revendication 1 caractérisé en ce que les concentrations en hydrogène des atmosphères desdits traitements sont toutes inférieures ou égales à 4 %.

3.- Procédé selon la revendication 1 ou 2 caractérisé en ce que lesdits traitements sont des traitements thermiques.

4.- Procédé selon la revendication 3 caractérisé en ce que, lorsque ladite séquence de traitements comporte un chauffage et un refroidissement, les atmosphères de chauffage et de refroidissement contiennent plus de 96 % d'azote.

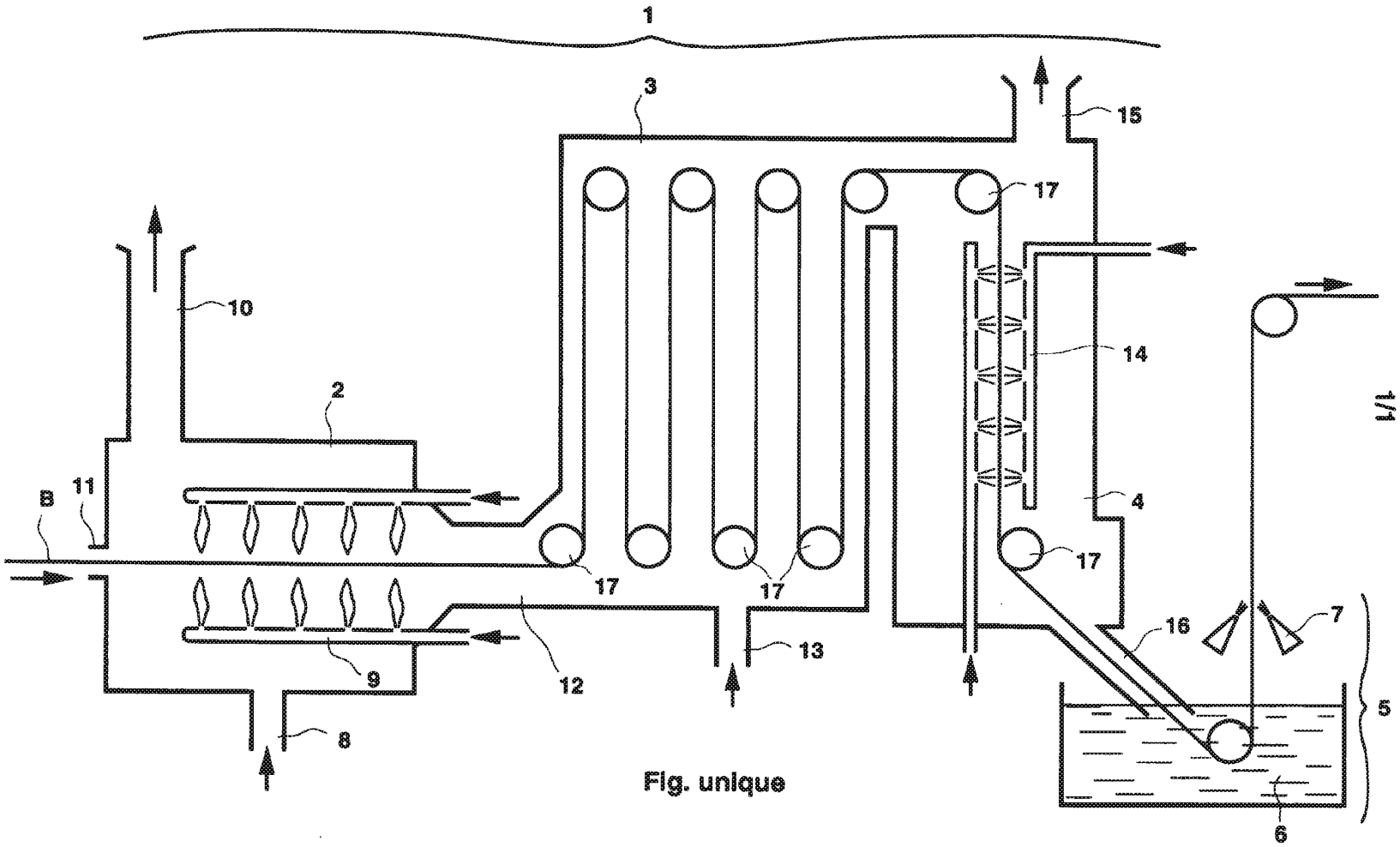

Fig. unique

1/1

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INSTITUT NATIONAL de la PROPRIETE INDUSTRIELLE

RAPPORT DE RECHERCHE PRELIMINAIRE

établi sur la base des dernières revendications déposées avant le commencement de la recherche

2720079

N° d'enregistrement national

FA 499504
FR 9406239

DOCUMENTS CONSIDERES COMME PERTINENTS		Revendication concernée de la demande examinée	
Catégorie	Citation du document avec indication, en cas de besoin, des parties pertinentes		
A	AU-B-24 455 (JOHN LYSAGHT) * page 6, ligne 30 - ligne 33 * * page 8, ligne 24 - ligne 31; revendications 1,7; figures 1,4 *	1-4	
A	FR-A-2 086 302 (N.V. BEKAERT) * page 4, ligne 1 - ligne 16 * * page 5, ligne 23 - ligne 27; revendications 1-3 *	1-4	
A	GB-A-676 198 (MICHEL ALFERIEFF) *document entier*	1-4	
A	PATENT ABSTRACTS OF JAPAN vol. 14, no. 17 (C-675) 16 Janvier 1990 & JP-A-01 259 153 (NIPPON STEEL CORP) 16 Octobre 1989 * abrégé *	1-4	
A	PATENT ABSTRACTS OF JAPAN vol. 5, no. 106 (C-062) 10 Juillet 1981 & JP-A-56 047 554 (NISSHIN STEEL) 30 Avril 1981 * abrégé *	1-4	DOMAINES TECHNIQUES RECHERCHES (Int.Cl.5) C23C
A,D	EP-A-0 467 749 (SOLLAC) * revendications 1,4,12 *	1-4	
A	US-A-4 210 097 (FRED BYRD)		
A	GB-A-2 001 105 (ARMCO STEEL CORPORATION)		
A	PATENT ABSTRACTS OF JAPAN vol. 9, no. 5 (C-260) 10 Janvier 1985 & JP-A-59 157 266 (KAWASAKI SEITETSU) 6 Septembre 1984 * abrégé *		

1

Date d'achèvement de la recherche	Examinateur
29 Décembre 1994	Elsen, D

CATEGORIE DES DOCUMENTS CITES

X : particulièrement pertinent à lui seul
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DESCRIPTION FR1297906

A method of hot forging of steel products and a novel industrial product obtained by this process. It is known that a large number of objects made of steel or ferrous alloys are obtained by hot deformation of pre-heated blanks.

The main difficulty encountered during this manufacture results from the fact that an oxide film spontaneously forms on the metal when it is carried to the deformation temperature in the presence of Atmospheric oxygen.

During the hot deformation, which is obtained either by striking on the blank of the successive blows or by causing a progressive flow of the metal, the oxide film which is not malleable is scaled And comes off by putting a new surface of the metal back into the bubble again. </ P>

The presence of these scabs or oxide films generally designated by the name of scale, offers many disadvantages among which can be mentioned: A decarburization of the superficial layer of the metal, the carbon contained in this layer Being burnt by the oxygen supplied by the oxide; Grain magnification; Intergranular oxidation of the metal underlayer; A poor surface condition of the finished article which requires extensive polishing or cleaning to remove the defective layers both in appearance and dimensions of the part obtained and in terms of metallurgical qualities Of that part; A significant loss of metal by oxidation; A modification of the contents of the superficial layers of filler metals, such as chromium, copper, nickel, etc.

It also happens that the oxide films become embedded in the tools serving to deform the metal and cause too rapid wear or deterioration of these. </ P> As can be seen, these disadvantages are numerous and they have a threefold consequence: lowering the intrinsic qualities of the object obtained, less careful finishing of this article, wear and deterioration of the tooling.

We have already proposed various solutions to try to remedy these drawbacks: It is possible to brush the oxidized blanks during their reheating,

 to remove the oxide layer, Higher temperature and consequently results in greater oxide formation.

It has also been proposed to carry out the reheating of the blank in a controlled non-oxidizing atmosphere, but this solution requires the servitude of expensive equipment and if it makes it possible to reduce the thickness of the oxide films during reheating, In no way suppresses the reoxidation during deformation.

It has been thought to considerably reduce the reheating time by induction heating of the room, but this process is expensive and may not be suitable for parts of any size.

Finally, it was also considered to cover the blank with a protective copper, chromium or copper base coating. Nickel, but such a practice could not develop because it is costly and presents major difficulties.

The present invention relates to a method of manufacturing by deformation of steel parts previously protected from oxidation by a protective layer.

The present invention relates to a novel process for the hot deformation of steel products. This process being essentially characterized in that before the deformation is carried out, the blank is encrusted with an aluminum-based coating preferably made by dipping the blank Of an aluminum base coating preferably made by dipping the blank in a liquid bath of the metal constituting the coating.

In the case of hot deformation of the blanks provided with a protective coating conforming to the

invention, it is found that the coating deforms at the same time as the blank, Makes it possible to obtain excellent protection against oxidation and a defined product itself coated with a thin film of aluminum alloy <B> to </ B> alloy.

This result is unexpected, since it has long been known that at room temperature the iron-aluminum alloys are very fragile and crack when they wish to impose the least deformation on them. In particular, the Fe-Al and Fe 3 -Al compounds have a high hardness and are very fragile.

However, experience has shown that by operating under the conditions conforming to the invention, these aluminum-based alloys have a plasticity comparable to The metal in which the blank is made and that it is possible to retain the protective coating until the last stage of manufacture.

The subject of the present invention is also the novel industrial product which constitutes an object of iron or ferrous alloy obtained by hot deformation in accordance with the process indicated above.

In order to better understand the invention, several embodiments will be described in a non-limiting manner.

To check the deformability of the luminium alloy protective film, which is the main characteristic of the invention, a mild steel tensile test piece, coated with an aluminum-silicon alloy, is taken. <B> to <I> 13 </ I> </ B> 'Ye of silicon; This test piece is heated to a temperature of <1000> 1 </ B> 200 <B> OC, </ B> and then broken.

It is found that the test piece extends from 90 to 100% and that the protective film remains visible over the entire surface of the test piece, Test piece, even in the area located near the break that has been subjected to the necking.

The average analysis of the films indicates about 30 to 50% of Al and 50 to 70% of iron for the coating obtained on a sheet 4 mm soft steel. The thickness of this layer is approximately 0.10 mm after holding for 5 minutes, and 0.05 mm at End of 1 minute of holding in the molten aluminum

bath <99.5 <I>% </ I> at 800 </ B> OC.

By laminating <B> 1000 OC </ B> from 4 to 2 mm thick, the sheet always remains covered with an Al-Fe alloy, but this film contains only < B> 10 </ B> lyso of Al, the thickness always being <0.10 mm. </ P> <p align = "JUSTIFY"> This ability of steel to form with the Al </ B> rich coating during hot deformation of the increasingly diluted alloys, To considerably increase the covering power of the initial layer whose surface thus increases as the deformation of the part increases.

In order to manufacture by heat deformation and conformably to the invention, a product such as a key is firstly laundered Of the blank, either by shot blasting, by sandblasting, or by chemical or electrolytic pickling.

The chemical pickling can for example be achieved by immersing the blank in a dilute hydrochloric acid bath of from 10 to 15 at a temperature of 200 and optionally added Nitric acid, hydrofluoric acid, or tin chloride.

It is also possible to pick the blank from a concentrated zinc chloride base or even from a concentrated zinc chloride stream. Melted directly on the blank.

In this case, when the preform is subsequently quenched in the aluminum bath, an excellent bonding of the alloy layer to the base is achieved, Aluminum oxide due to the presence of the zinc which is combined on the one hand with the iron of the blank and on the other hand the aluminum of the protective layer.

However, since the presence of the aforementioned stream has the disadvantage of producing acid chloride smoke, it is possible, if desired after pickling, to coat the zinc blank, either by Immersion thereof in zinc <B> to </ B> the liquid state, or by electrolysis.

It is important to note that when the blank is subjected to a diffusion process at a higher temperature than at 800 ° C. < / B> the zinc distils and only the aluminum-iron alloy remains on the part.

The blank has been thoroughly etched and is free of any oxide or grease deposits or coatings of

any kind and is carefully dried, preferably by preheating to a temperature of < 100 to </ B> 200 <B> OC, </ B> to remove any moisture without causing a film of oxide.

In order to carry out the protective coating on the aluminum base, the pre-heated blank is immersed in the alloy bath carried at </ B> B> temperature between 600 and 8001, for a time which is in the order of a few seconds when a coating of < 2 microns thick, but which can reach a few minutes in the case of higher thicknesses, for example 0.10-OJ5 mm.

The bath in which the plumbing is quenched may consist of pure aluminum or aluminum alloys and less than 15% silicon, aluminum and less than 20%) Of zinc. Of aluminum and less than 8 per cent of copper, aluminum and less than 57 per cent calcium, or aluminum and about 2 per cent manganese, Nickel, chromium, etc.

However, among all these alloys, it is recommended to use an aluminum alloy and from <3> to </ B> 13% </ B> of silicon, an aluminum alloy and > From 3 </ B> <B> to <I> 5 </ I> </ B> lyo of zinc or pure aluminum.

When removing the blank after its immersion in the aluminum alloy bath, it is necessary to ensure that the films which cover the bath are not entrained with the blank. It is possible to separate these films just before the immersion or the emergence of the blank, either by blowing argon or using thin sheets. It is sometimes necessary to rapidly brush the blank when it is cooled to remove dandruff or lumps from the <B> through </ B> The height of the oxidized layer of the bath may have been deposited.

When the blank is thus covered and preheated, it is placed in an oven which carries the deformation temperature. This temperature is generally higher than 850 OC and can even reach <1250 OC. </ B>

When the blank has been brought to the desired temperature throughout its mass, it is then passed to the press, the lubrication being carried out with graphite or resistant greases < B> to </ B> heat. The forging is stopped at a temperature close to the steel transformation point, but this temperature may be less than the point Ac '(for example 700 or 600) OC). </ B>

In the single FIGURE of the drawing, the variations in the hardness of the surface layers of a

forged flat key made of semi-hard steel are shown, on the one hand according to FIG. And, on the other hand, without coating.

This key is made using a semi-hard steel whose composition is as follows: Carbon <B>: <U> 0.35 </ U> </ B> <I>%; </ I> Manganese <B>: 0.80 lyo; Chrome <B>: 0.80 </ B>%; Vanadium <B>: <I> 0.10%; </ I> Silicon <B>: 0.3 </ B> 17o.

The coating is obtained by immersing the blank for a period of 1 to 2 minutes in a bath at a temperature of 750 to 800.degree. C. </ B> Maximum, having the following composition:
 Al </ B> 98-99%; Fe <B> 0.5 to <I> 1 </ I> </ B> 17o; If 0.5 <B> at 1%. </ B>

In the figure, the distance in mm counted from the surface, from the point at which the hardness was measured, was represented on the abscissa. The numerals representing the Vickers micro-hardness measured with a load of 100 grams were plotted on the ordinate. </ B>

The curve <B> 1 </ B> represents the hardness in the case of the key fabricated according to the invention. Curve 2 shows the hardness in the case of a forged key in a conventional manner.

It should be noted first of all that the hardness of the base metal is about 280 Vickers.

In the case of curve 2, which has a normal forging, the hardness decreases as the soft edge approaches a value of 200 Vickers. This decrease in hardness corresponds to a decarburization of the steel due to the presence of the oxide layer.

On the other hand, in the case of curve <B> 1, </ B>, which corresponds to the key manufactured in conformity with

 According to the invention, the hardness increases considerably as soon as the edge of the workpiece approaches <B> to </ B> less than 0.1 <B> mm </ B> To 400 Vickers at least.

The key obtained according to the invention therefore has a surface coating of very high hardness.

Excellent results have been obtained by forging, in accordance with the invention, a steel knife with chromium and 0.2% carbon, and A steel chisel with <0.6 </ B> 17o of carbon, <B> 0.5 </ B> <I>% of manganese and <B> 0.35 </ B> 51o of silicon.

It will be seen that the objects produced by hot deformation in accordance with the invention have a very hard surface coating which makes it possible to give, The hard layer provides a protection against subsequent corrosion of the object.

Moreover, during the hot forming, the protective coating avoids, as explained above, any oxidation of the underlying metal while facilitating the deformation of the metal.

It will be understood that the embodiments described above are given only by way of examples and will be able to receive any desired modifications without departing for this purpose from the scope of the invention.

Among the various modes of hot plastic deformation, the process described is not limited to striking and forging operations but can also be used for spinning and laminating operations, for example.

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CLAIMS FR1297906

The present invention relates to a novel process for the manufacture of objects made of ferrous metals obtained by hot deformation, in particular in the range from 600 to 600.degree. To 1250 </ B> OG, this process being essentially characterized in that, prior to forging, the blank is coated with an aluminum-based protective layer, this process possibly also having the The following characteristics are taken individually or in combination: <B> 10 </ B> The protective layer is obtained by immersing the previously pickled blank in an aluminum bath 98-99, 9 </ B> 17o or dan, a molten aluminum alloy; For an unalloyed carbon steel blank, a bath consisting of an aluminum alloy and of silicon is used; <B> 30 </ B> For a low alloy steel, a bath containing an aluminum, copper and zinc alloy is used; The coating bath may consist of alloys of aluminum and silicon, zinc, magnesium, copper, calcium, manganese;

 <BR With added nitric acid, hydrofluoric acid and tin chloride, if necessary;

 Before immersion, the blank, after being pickled, is coated with a zinc layer facilitating the attachment of the protective coating <B> to </ B> > Aluminum base; <B> 70 </ B> Before immersion, the blank, after being pickled, is coated with a layer of tin to facilitate attachment of the protective coating to </ B> Al base. B. The new industrial product consisting of an object obtained from a preform by hot deformation, essentially characterized by the fact that most of its Surface is provided with an aluminum-based coating, this coating having a high hardness and allowing the object in question to better withstand <B> to </ B> the attack of the external agents (rust for example) while having a better appearance due to the polishing which it is possible to confer on it in a durable manner.

RÉPUBLIQUE FRANÇAISE

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BREVET D'INVENTION

P.V. n° 863.022 N° 1.297.906

Classification internationale : B 23 *j* — B 23 *k*

Procédé de forgeage à chaud de produits sidérurgiques et produit industriel nouveau obtenu par ce procédé.

M. GASTON BEAUJEU-DUMONTEL résidant en France (Allier).

Demandé le 26 mai 1961, à 16h 29m, à Paris.
Délivré par arrêté du 28 mai 1962.
(*Bulletin officiel de la Propriété industrielle*, n° 27 de 1962.)

(*Brevet d'invention dont la délivrance a été ajournée en exécution de l'article 11, § 7, de la loi du 5 juillet 1844 modifiée par la loi du 7 avril 1902.*)

On sait qu'un grand nombre d'objets en acier ou en alliages ferreux s'obtiennent par déformation à chaud d'ébauches préalablement réchauffées.

La difficulté principale que l'on rencontre lors de cette fabrication découle du fait qu'une pellicule d'oxyde se forme spontanément sur le métal lorsque celui-ci est porté à la température de déformation en présence de l'oxygène atmosphérique.

Lors de la déformation à chaud, qui est obtenue soit en frappant sur l'ébauche des coups successifs, soit en provoquant un écoulement progressif du métal, la pellicule d'oxyde qui est peu malléable s'écaille et se détache en mettant ainsi à nu une nouvelle surface du métal qui à nouveau se réoxyde.

La présence de ces croûtes ou pellicules d'oxyde généralement désignées sous le nom de calamine, offre de nombreux inconvénients parmi lesquels on peut citer :

Une décarburation de la couche superficielle du métal, le carbone contenu dans cette couche étant brûlé par l'oxygène apporté par l'oxyde;

Un grossissement du grain;

Une oxydation intergranulaire de la sous-couche du métal;

Un mauvais état de surface de l'article fini qui exige un polissage ou un nettoyage important pour enlever les couches défectueuses tant au point de vue de l'aspect et des dimensions de la pièce obtenue, qu'au point de vue des qualités métallurgiques de cette pièce;

Une perte importante de métal par oxydation;

Une modification des teneurs des couches superficielles en métaux d'apport, tels que le chrome, le cuivre, le nickel, etc.

Il arrive également que les pellicules d'oxyde s'incrustent dans les outils servant à la déformation du métal et provoquent une usure trop rapide ou une détérioration de ceux-ci.

Comme on le voit, ces inconvénients sont nombreux et ils ont une triple conséquence : abaissement des qualités intrinsèques de l'objet obtenu, finition moins soignée de cet article, usure et détérioration de l'outillage.

On a déjà proposé diverses solutions pour tenter de remédier à ces inconvénients :

Il est possible de brosser les ébauches oxydées lors de leur réchauffage, de manière à enlever la couche d'oxyde, mais une telle opération fait perdre un temps important et provoque une diminution notable de la température de la pièce, ce qui exige un réchauffage à une température plus élevée et entraîne par conséquent une formation plus grande d'oxyde.

On a également proposé d'effectuer le réchauffage de l'ébauche dans une atmosphère contrôlée non oxydante, mais cette solution nécessite la servitude d'équipements coûteux et si elle permet de réduire l'épaisseur des pellicules d'oxyde lors du réchauffage, elle ne supprime en rien la réoxydation en cours de déformation.

On a songé à réduire considérablement le temps de réchauffage en procédant au chauffage de la pièce par induction, mais ce procédé est coûteux et ne peut pas convenir aux pièces de toutes dimensions.

Enfin, on a également songé à recouvrir l'ébauche à l'aide d'un revêtement protecteur à base de cuivre, de chrome ou de nickel, mais une telle pratique n'a pu se développer car elle est coûteuse et présente d'importantes difficultés.

La présente invention concerne un procédé de fabrication par déformation de pièces sidérurgiques préalablement protégées de l'oxydation par une couche protectrice.

La présente invention a pour objet un nouveau procédé de déformation à chaud de produits sidé-

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Prix du fascicule : 2 NF

rurgiques, ce procédé étant essentiellement caractérisé par le fait qu'avant d'effectuer la déformation, on entoure l'ébauche d'un revêtement à base d'aluminium réalisé de préférence par trempage de l'ébauche d'un revêtement à base d'aluminium réalisé de préférence par trempage de l'ébauche dans un bain liquide du métal constituant le revêtement.

Lors de la déformation à chaud des ébauches munies d'un revêtement de protection conforme à l'invention, on constate que le revêtement se déforme en même temps que l'ébauche, ce qui permet d'obtenir une excellente protection contre l'oxydation et un produit défini lui-même revêtu d'une mince pellicule d'alliage à base d'aluminium.

Ce résultat tout à fait inattendu, car on sait depuis longtemps qu'à température ambiante les alliages fer-aluminium sont très fragiles et se fissurent lorsqu'on désire leur imposer la moindre déformation. En particulier, les composés Fe-Al et Fe3-Al présentent une grande dureté et sont très fragiles.

Cependant, l'expérience a montré qu'en opérant dans les conditions conformes à l'invention, ces alliages à base d'aluminium ont une plasticité comparable à celle du métal dans lequel est faite l'ébauche et qu'il est possible de conserver le revêtement protecteur jusqu'au dernier stade de la fabrication.

La présente invention a également pour objet le produit industriel nouveau que constitue un objet en fer ou alliage ferreux obtenu par déformation à chaud conformément au procédé indiqué ci-dessus.

Dans le but de mieux faire comprendre l'invention, on va décrire à titre d'illustration et sans aucun caractère limitatif plusieurs modes de mise en œuvre.

Pour vérifier la capacité de déformation de la pellicule protectrice d'alliage d'aluminium, qui est la caractéristique principale de l'invention, on prend une éprouvette de traction en acier doux, revêtue d'un alliage aluminium-silicium à 13 % de silicium; on chauffe cette éprouvette à une température de 1 000 à 1 200 °C, puis on la casse.

On constate que l'éprouvette s'allonge de 90 à 100 % et que la pellicule protectrice reste visible sur toute la surface de l'éprouvette, même dans la partie située à proximité de la cassure qui a été soumise à la striction.

L'analyse moyenne des pellicules indique environ 30 à 50 % d'Al et 50 à 70 % de fer pour le revêtement obtenu sur une tôle en acier doux de 4 mm. L'épaisseur de cette couche est d'environ 0,10 mm au bout de 5 minutes de maintien, et de 0,05 mm au bout de 1 minute de maintien dans le bain fondu d'aluminium 99,5 % à 800 °C.

Par laminage à 1 000 °C de 4 à 2 mm d'épaisseur, la tôle demeure toujours recouverte d'un alliage Al-Fe, mais cette pellicule ne renferme plus que 10 % d'Al, l'épaisseur étant toujours de 0,10 mm.

Cette faculté de l'acier de former avec le revêtement riche en Al au cours de la déformation à chaud des alliages de plus en plus dilués permet d'augmenter considérablement le pouvoir couvrant de la couche initiale dont la surface augmente ainsi au fur et à mesure de la déformation de la pièce.

Pour fabriquer par déformation à chaud, et conformément à l'invention, un produit tel qu'une clé, on procède tout d'abord au blanchissage de l'ébauche, soit par grenaillage, soit par sablage, soit encore par décapage chimique ou électrolytique.

Le décapage chimique peut par exemple être obtenu en immergeant l'ébauche dans un bain d'acide chlorhydrique dilué de 10 à 15 %, à la température de 20°, et éventuellement additionné d'acide nitrique, d'acide fluorhydrique, ou de chlorure d'étain.

Il est également possible de procéder au décapage de l'ébauche à l'aide d'un flux à base de chlorure de zinc concentré ou même fondu directement sur l'ébauche.

Dans ce cas, lorsque l'ébauche est ultérieurement trempée dans le bain à base d'aluminium, on obtient un excellent accrochage de la couche de l'alliage à base d'aluminium en raison de la présence du zinc qui s'allie d'une part au fer de l'ébauche, et d'autre part à l'aluminium de la couche de protection.

Toutefois, comme la présence du flux précité à l'inconvénient de dégager des fumées acides de chlorure d'aluminium, on peut, si on le désire, après décapage, revêtir l'ébauche de zinc, soit par immersion de celle-ci dans du zinc à l'état liquide, soit par électrolyse.

Il convient de remarquer que lorsque l'ébauche est soumise à un traitement de diffusion à une température supérieure à 800 °C, le zinc distille et il ne reste sur la pièce que l'alliage aluminium-fer.

L'ébauche, ayant été parfaitement décapée et se présentant sans oxyde ni dépôt ou enduit gras d'aucune sorte, est soigneusement séchée, de préférence par un préchauffage à une température d'environ 100 à 200 °C, de manière à chasser toute trace d'humidité sans provoquer la formation d'un film d'oxyde.

Pour effectuer le revêtement protecteur à base d'aluminium, on procède à l'immersion de l'ébauche ainsi préchauffée dans le bain d'alliage porté à une température comprise entre 600 et 800° pendant un temps qui est de l'ordre de quelques secondes lorsqu'on désire un revêtement de 1 à 2 microns d'épaisseur, mais qui peut atteindre quelques minutes dans le cas de plus fortes épaisseurs, 0,10-0,15 mm par exemple.

Le bain dans lequel on trempe l'ébauche peut être constitué par de l'aluminium pur ou par des alliages d'aluminium et de moins de 15 % de silicium, d'aluminium et de moins de 20 % de zinc, d'aluminium et de moins de 8 % de cuivre, d'alu-

minium et de moins de 20 % de calcium, ou encore d'aluminium et d'environ 2 % de manganèse, de nickel, de chrome, etc.

Cependant, parmi tous ces alliages, il est recommandé d'utiliser un alliage d'aluminium et de 3 à 13 % de silicium, un alliage d'aluminium et de 3 à 5 % de zinc ou de l'aluminium pur.

Lorsqu'on retire l'ébauche après son immersion dans le bain d'alliage d'aluminium, il faut veiller à ce que les pellicules qui recouvrent le bain ne soient pas entraînées avec l'ébauche. Il est possible d'écarter ces pellicules juste avant l'immersion ou l'émersion de l'ébauche soit par soufflage d'argon, soit à l'aide de tôles minces. Il est quelquefois nécessaire de procéder également à un brossage rapide de l'ébauche lors de son refroidissement pour enlever les pellicules ou grumeaux que le passage à la hauteur de la couche oxydée du bain a pu déposer.

Lorsque l'ébauche est ainsi recouverte et préchauffée, elle est placée dans un four qui la porte à la température de déformation. Cette température est généralement supérieure à 850 °C et peut même atteindre 1 250 °C.

Lorsque l'ébauche a été portée à la température voulue dans toute sa masse, elle est ensuite passée à la presse, la lubrification étant effectuée avec du graphite ou des graisses résistant à la chaleur. On arrête le forgeage à une température voisine du point de transformation de l'acier, cette température pouvant être cependant inférieure au point Ac^3 (par exemple 700 ou 600 °C).

On a représenté sur la figure unique du dessin les variations de la dureté des couches superficielles d'une clé plate forgée en acier mi-dur, d'une part conformément à l'invention, et d'autre part sans procéder au revêtement.

Cette clé est réalisée à l'aide d'un acier mi-dur dont la composition est la suivante :

Carbone : 0,35 % ;
Manganèse : 0,80 % ;
Chrome : 0,80 % ;
Vanadium : 0,10 % ;
Silicium : 0,3 %.

Le revêtement est obtenu en immergeant l'ébauche pendant une durée de 1 à 2 minutes dans un bain à une température de 750 à 800 °C maximum, ayant la composition suivante :

Al : 98-99 % ;
Fe : 0,5 à 1 % ;
Si : 0,5 à 1 %.

Sur la figure, on a représenté en abscisses la distance en mm comptée à partir de la surface, du point auquel on a mesuré la dureté. On a porté en ordonnées les chiffres représentant la micro-dureté Vickers mesurée avec une charge de 100 g.

La courbe 1 représente la dureté dans le cas de la clé fabriquée conformément à l'invention.

La courbe 2 représente la dureté dans le cas d'une clé forgée d'une manière classique.

On remarque tout d'abord que la dureté du métal de base est d'environ 280 Vickers.

Dans le cas de la courbe 2, qui présente un forgeage normal, la dureté diminue au fur et à mesure que l'on se rapproche du bord tendre vers une valeur de l'ordre de 200 Vickers. Cette diminution de la dureté correspond à une décarburation de l'acier due à la présence de la couche d'oxyde.

On remarque par contre, dans le cas de la courbe 1, qui correspond à la clé fabriquée conformément à l'invention, que la dureté croît très notablement dès que l'on se rapproche à moins de 0,1 mm du bord de la pièce pour atteindre des valeurs allant jusqu'à 400 Vickers au moins.

La clé obtenue conformément à l'invention présente donc un revêtement superficiel d'une très grande dureté.

D'excellents résultats ont été obtenus en forgeant, conformément à l'invention, un couteau en acier comportant 13 % de chrome et 0,2 % de carbone, et un ciseau en acier comportant 0,6 % de carbone, 0,5 % de manganèse et 0,35 % de silicium.

On voit que les objets fabriqués par déformation à chaud conformément à l'invention présentent un revêtement superficiel très dur qui permet de donner à l'objet fini un poli particulièrement intéressant, cette couche dure assurant d'ailleurs une protection contre la corrosion ultérieure de cet objet.

De plus, lors de la formation à chaud, le revêtement protecteur évite, comme cela a été expliqué plus haut, toute oxydation du métal sous-jacent tout en facilitant la déformation du métal.

Il est bien entendu que les modes de mise en œuvre indiqués ci-dessus ne sont donnés qu'à titre d'exemples et pourront recevoir toutes modifications désirables sans sortir pour cela du cadre de l'invention.

Parmi les différents modes de déformation plastique à chaud, le procédé décrit n'est pas limité aux opérations de frappe et de forgeage, mais peut également être utilisé pour celles de filage et de laminage par exemple.

RÉSUMÉ

La présente invention a pour objet :

A. Un nouveau procédé pour fabriquer des objets en métaux ferreux obtenus par déformation à chaud en particulier dans l'intervalle de 600 à 1 250 °C, ce procédé étant essentiellement caractérisé par le fait qu'avant forgeage on enrobe l'ébauche d'une couche de protection à base d'aluminium, ce procédé pouvant présenter en outre les caractéristiques suivantes prises isolément ou en combinaison :

1° La couche protectrice est obtenue en immergeant l'ébauche préalablement décapée dans un bain d'aluminium 98-99,9 % ou dans un alliage d'aluminium en fusion ;

2° Pour une ébauche en acier au carbone non allié on utilise un bain constitué par un alliage d'aluminium et de 13 % de silicium;

3° Pour un acier faiblement allié, on utilise un bain contenant un alliage d'aluminium, de cuivre et de zinc;

4° Le bain de revêtement peut être constitué par des alliages d'aluminium et de silicium, zinc, magnésium, cuivre, calcium, manganèse;

5° L'ébauche est décapée par immersion dans un bain à 20° constitué par de l'acide chlorhydrique à une concentration de 10 à 15 %, additionné d'acide nitrique, d'acide fluorhydrique et de chlorure d'étain si nécessaire;

6° Préalablement à l'immersion, l'ébauche, après avoir été décapée, est revêtue d'une couche de zinc facilitant l'accrochage du revêtement protecteur à base d'aluminium;

7° Préalablement à l'immersion, l'ébauche, après avoir été décapée, est revêtue d'une couche d'étain facilitant l'accrochage du revêtement protecteur à base d'Al.

B. Le produit industriel nouveau que constitue un objet obtenu à partir d'une ébauche par déformage à chaud, essentiellement caractérisé par le fait que la plus grande partie de sa surface est munie d'un revêtement à base d'aluminium, ce revêtement présentant une grande dureté et permettant à l'objet en question de mieux résister à l'attaque des agents extérieurs (rouille par exemple) tout en ayant un meilleur aspect dû au polissage qu'il est possible de lui conférer de manière durable.

GASTON BEAUJEU-DUMONTEL

Par procuration :

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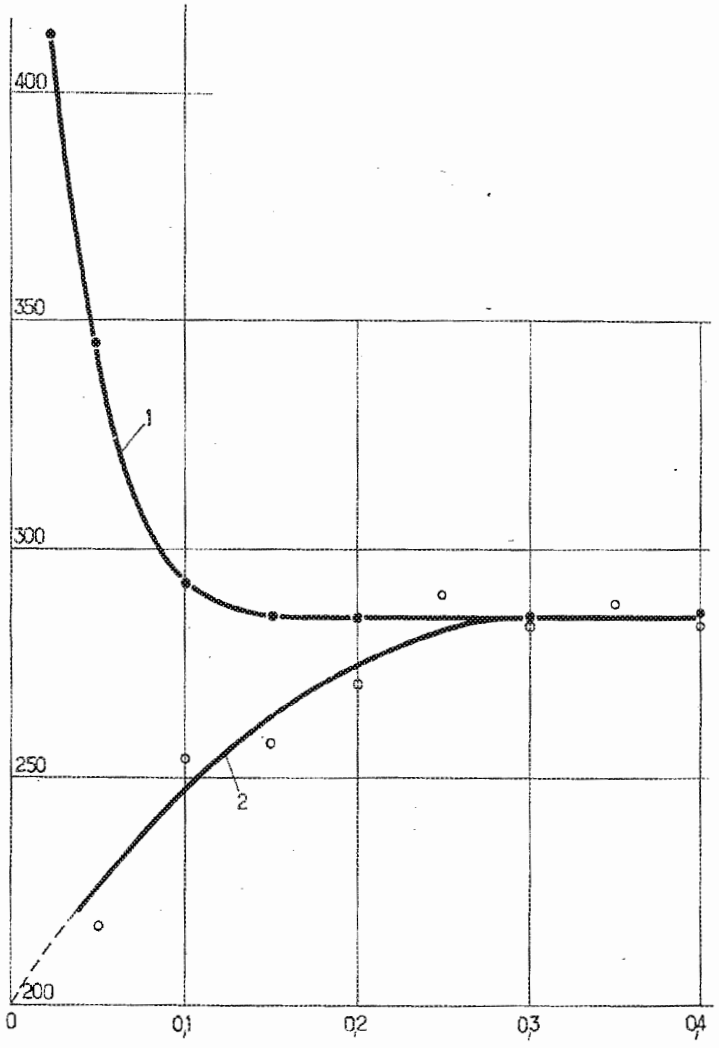
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Process for manufacturing of a part from a hot-rolled sheet

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Abstract not available for FR2787735 (A1)
Abstract of corresponding document: EP1013785 (A1)

A component is produced from a strip of rolled (especially hot-rolled) sheet steel, by coating with aluminum or its alloy and pressing operations. The process involves: (a) coating the rolled sheet with a metal or an alloy assuring protection of the surface and the steel; (b) raising the temperature of the coated sheet for forming; (c) producing, at the surface, an intermetallic alloy composite assuring protection against corrosion and decarburation of the steel, with the intermetallic composite able to assure a lubrication function; (d) forming the coated sheet, notably by pressing; (e) cooling the formed component in order to confer increased hardness of the steel and increased surface hardness in the coating. The metal used for coating the steel sheet is aluminum or an aluminum alloy, so that the intermetallic alloy composite is made up of aluminum, iron and silicon.

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DESCRIPTION FR2787735

Method for producing a workpiece from a strip of sheet steel

Rolled and in particular hot-rolled.

The invention relates to a method for producing a workpiece from a strip of laminated steel sheet, in particular hot-rolled. The steel sheets to be subjected to high temperature forming and / or heat treatment are not delivered coated for considerations of coating resistance during heat treatment. The coating is therefore carried out on a finished part, which requires careful cleaning of the surfaces and of the hollow parts. This cleaning requires the use of acids and bases whose recycling and storage are a major financial burden and pose risks for operators and the environment. In addition, the heat treatment must be carried out under controlled atmosphere in order to avoid decarburization and oxidation of the steel. Then, in the case of hot forming, the scale, by virtue of its abrasive power, damages the shaping tools, which reduces the quality of the dimensionally and aesthetically obtained parts or requires frequent and expensive Tool repairs.

Finally, in order to increase their resistance to corrosion, the parts thus obtained must be subjected to an expensive post-treatment, the application of which is difficult, if not impossible, especially in the case of

Parts having hollows.

SUMMARY OF THE INVENTION The object of the invention is to propose laminated steel sheets from 0.2 mm to about 20 mm thick, coated, in particular after hot rolling, and subjected to shaping, either hot or cold Followed by heat treatment, the temperature increase to be ensured without decarburization of the steel of the sheet without oxidation of the surface of the sheet before, during and after the hot forming and

Or heat treatment.

The invention relates to a method for producing a workpiece from a strip of rolled steel sheet, in particular hot-rolled, which is characterized in that: the laminated sheet is coated with a metal or Of a metal alloy providing protection of the surface and the steel, the coated sheet is subjected to a temperature increase for its shaping, an intermetallic alloy compound is thus produced on the surface, Protection against corrosion, against the decarburization of steel, the intermetallic compound being capable of performing a lubricating function, the shaping is carried out, in particular by stamping, the workpiece is cooled to give high mechanical hardness characteristics of the Steel and high surface hardness of the coating. The other characteristics of the invention are: the hot-rolled sheet is coated after hot rolling and pickling; the metal or the metallic coating alloy is aluminum or a

aluminum alloy.

- intermetallic alloy is a compound based mainly on aluminum, iron and silicon, - metal or metal alloy coating and

hot.

The coated sheet is subjected to a temperature rise of more than 700 ° C. before shaping and / or heat treatment,

The coated sheet is hot stamped.

The part obtained in particular by pressing is cooled to undergo

Quenching, at a rate greater than the critical quenching rate.

The invention also relates to a hot-rolled sheet, in particular a hot-rolled sheet, comprising a coating of metal or a metal alloy deposited on the surface, for the hot production of an intermetallic compound, the intermetallic compound providing a corrosion protection against a barrier against The decarburization of steel from the sheet metal, the lubrication during the hot forming of the sheet metal, and the finished workpiece after shaping and cooling of the high mechanical hardness characteristics of the steel, A high surface hardness of the surface of

Said finished part.

Another characteristic of the invention is: the sheet comprises a surface deposition of aluminum or of an aluminum alloy. The invention also relates to the use of sheet metal in hot forming, in particular by stamping parts having high mechanical characteristics in hardness and high characteristics of

Hardness on the surface ensuring a very good resistance to abrasion.

The description which follows will make the invention well understood.

The process according to the invention consists in coating a steel, in particular hot-rolled, for heat treatment and or hot forming, with a metal or a metal alloy such as aluminum or an aluminum alloy composed, for example, of aluminum And silicon. The metal or metal alloy coating is chosen so as to have corrosion protection and to withstand high temperature. In the case of a heat treatment, or an increase in temperature for shaping, the coating forms an alloy layer having a high resistance to corrosion, abrasion, wear and fatigue. The coating does not modify the formability properties of the steel and thus allows a wide variety of cold and hot shaping. After hot rolling the strip can be pickled and cold-rolled before being coated. In the case where the sheet is cold-rolled,

It can be annealed before being coated.

The laminated sheet can be coated with, for example, the following two types of metal alloy:

Alloy N 1: Si: 9% to 10%; Fe: 2% to 3.5%; Balance: Al and impurities.

Alloy N 2: Fe: 2% to 4%; Balance: Al and impurities.

For the alloy N01, the thickness of the coating is between 5 µm and 100 µm, and preferably between 10 µm and 25 µm. For the N 2 alloy, the thickness of the coating is between 15 µm and 100 µm and preferably between

Pm and 50 µm.

For shaping or heat treatment, the sheet is subjected to a temperature rise preferably comprised between 750 ° C. and 1200 ° C. in an oven comprising an atmosphere requiring no further control due to the oxidation barrier formed by the coating. When the temperature is raised, the aluminum-based coating is transformed into a layer alloyed on the surface comprising different phases depending on the temperature treatment and having a high hardness

Which may exceed 600 HV 100 g.

According to the process of the invention, sheets having a thickness of between 0.2 mm and 20 mm can be produced having good

Shaping properties as well as good corrosion resistance.

The coated sheets delivered have a high resistance to corrosion during temperature rise, shaping,

Heat treatments, and when using the finished formed parts.

In addition to corrosion, the presence of the coating during heat treatments or hot forming processes avoids the decarburization of the base steel. This has an undeniable advantage in the case of hot forming, for example in a pressing press. In fact, the intermetallic alloy formed avoids the formation of the scale, the wear of the tools by the scale, and thus makes it possible to lengthen the average life of said tools. It has been noted that the hot-formed intermetallic alloy has a high temperature lubricant function. Moreover, the protective effect against the decarburization of the intermetallic alloy makes it possible to use a high-temperature furnace exceeding 900 ° C. with an uncontrolled atmosphere, even for heating times of several hours. At the end of the furnace, it is no longer necessary to strike the piece obtained, thus saving due to the removal of the pickling bath

Of the finished parts.

Due to the characteristics of the coating after raising the temperature, the parts obtained have an increased resistance to fatigue, wear, abrasion and corrosion. In addition, the coating is weldable

Before and after raising the temperature.

The steel of the sheet provides, by quenching effect on cooling, the high mechanical characteristics of the part obtained after shaping, the coating being transformed into a hot intermetallic alloy ensuring for its part, due to its qualities of lubricant and Resistance to friction, an improvement in the shaping, in particular, in the

[1]

1O field of hot stamping.

In one embodiment, a sheet of hot-rolled steel sheet of the following composition by weight is used: carbon: 0.15% to 0.25%, manganese: 0.8% to 1.5%, silicon: 1% to 0.35%, chromium: 0.01% to 0.2%, titanium: less than 0.1%, aluminum: less than 0.1%, phosphorus: less than 0.05%, sulfur less Of 0.03%, boron: 0.0005% to 0.01%, the sheet strip is coated with an N 1 or 2 alloy coating, the sheet is austenitized at 950 C prior to forming and quenched in the sheet, The coating serving as a lubricant during shaping, in addition to its functions of protection against cold corrosion, hot

and against decarburization. When tempering, the alloy coating does not interfere with the extraction of heat by the tool and may favor it. After forming and quenching, it is no longer necessary to strike the piece or to protect it.

The basic coating provides protection throughout the process.

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CLAIMS FR2787735

CLAIMS.

[2]

Process for producing a workpiece from a strip of laminated steel sheet, in particular hot-rolled, characterized in that: the laminated sheet is coated with a metal or a metal alloy providing protection of The surface and the steel, the coated sheet is subjected to a temperature increase for its shaping, an intermetallic alloy compound is thus produced on the surface, providing protection against corrosion, against decarburization Of the steel, the intermetallic compound being capable of performing a lubricating function, the shaping is effected in particular by stamping, the shaped part is cooled to impart high mechanical hardness characteristics of the steel and a high surface hardness of coating. 2. Process according to Claim 1, characterized in that the hot-rolled sheet is coated immediately after hot rolling, 3. Process according to Claim 1, characterized in that the metal or the metallic coating alloy is aluminum or an aluminum alloy.

[4]

4. Process according to Claim 1, characterized in that the alloy

Intermetallic compound is a compound based on aluminum, iron and silicon.

5.

Process according to Claim 1, characterized in that the coating of

Metal or metal alloy and made with hot dip.

6.

A process according to claim 1, characterized in that the coated sheet is subjected to a temperature increase of more than 700 ° C before the

Shaping and / or heat treatment.

7.

Method according to Claim 1, characterized in that the coated sheet

Is stamped hot.

8.

Process according to claim 1, characterized in that the part obtained, in particular, by stamping, is cooled to undergo a quench,

Velocity higher than the critical quenching rate.

9.

A hot-rolled sheet, in particular a hot-rolled sheet, having a metal or metal alloy coating deposited on the surface for hot-drawing an intermetallic compound, the intermetallic compound providing a corrosion protection barrier against the decarburization of steel Of the sheet metal, lubrication during the hot forming of the sheet, and on the finished part, after shaping and cooling, the high mechanical properties of steel hardness as well as a

Surface hardness of the surface of said finished part.

10.

Hot-rolled sheet according to claim 9, characterized in that it comprises a surface deposition of aluminum or of an aluminum alloy.

11.

Use of the sheet according to claim 9 or 10 in the arrangement

In particular by stamping parts having high mechanical characteristics in hardness and high characteristics of

Hardness on the surface ensuring a very good resistance to abrasion.

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(60) **Références à d'autres documents nationaux apparentés** :

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(54) PROCEDE DE REALISATION D'UNE PIECE A PARTIR D'UNE BANDE DE TOLE D'ACIER LAMINEE ET NOTAMMENT LAMINEE A CHAUD.

(57) Procédé de réalisation d'une pièce à partir d'une bande de tôle d'acier laminée et notamment laminée à chaud, caractérisée en ce que:

- on revêt la tôle laminée d'un métal ou d'un alliage métallique assurant une protection de la surface et de l'acier,
- on soumet la tôle revêtue à une élévation en température pour sa mise en forme,
- on réalise, de ce fait un composé allié intermétallique, en surface, assurant une protection contre la corrosion, contre la décarburation de l'acier, le composé intermétallique pouvant assurer une fonction de lubrification,
- on effectue la mise en forme notamment par emboutissage,
- on refroidit la pièce formée pour conférer des caractéristiques mécaniques de dureté élevées de l'acier et une dureté superficielle élevée du revêtement.

FR 2 787 735 - A1

Procédé de réalisation d'une pièce à partir d'une bande de tôle d'acier laminée et notamment laminée à chaud.

L'invention concerne un procédé de réalisation d'une pièce à partir d'une bande de tôle d'acier laminée et notamment laminée à chaud.

Les tôles en acier devant subir un formage à haute température et ou un traitement thermique ne sont pas livrées revêtues pour des considérations de tenue du revêtement lors du traitement thermique. Le revêtement est donc effectué sur pièce finie ce qui nécessite un nettoyage soigné des surfaces et des parties creuses. Ce nettoyage requiert l'utilisation d'acides et ou de bases dont le recyclage et le stockage sont une charge financière importante et présentent des risques pour les opérateurs et pour l'environnement. De plus, le traitement thermique doit être effectué sous atmosphère contrôlée afin d'éviter toute décarburation et oxydation de l'acier. Ensuite, dans le cas du formage à chaud, la calamine, de par son pouvoir abrasif, endommage les outils de mise en forme, ce qui diminue la qualité des pièces obtenues du point de vue dimensionnel et esthétique, ou oblige à de fréquentes et coûteuses réparations d'outils. Enfin, pour augmenter leur résistance à la corrosion, les pièces ainsi obtenues doivent recevoir un post traitement coûteux dont l'application est difficile, voire impossible, en particulier dans le cas de pièces comportant des creux.

Le but de l'invention est de proposer des tôles d'acier laminées de 0,2 mm à environ 20 mm d'épaisseur, revêtues notamment après laminage à chaud, et devant subir une mise en forme, soit à chaud, soit à froid suivie d'un traitement thermique, l'élévation de température devant être assurée sans décarburation de l'acier de la tôle, sans oxydation de la surface de ladite tôle, avant, pendant et après la mise en forme à chaud et ou le traitement thermique.

L'invention a pour objet un procédé de réalisation d'une pièce à partir d'une bande de tôle d'acier laminée et notamment laminée à chaud et qui se caractérise en ce que:

- on revêt la tôle laminée d'un métal ou d'un alliage métallique assurant une protection de la surface et de l'acier,
- on soumet la tôle revêtue à une élévation en température pour sa mise en forme,
- on réalise, de ce fait un composé allié intermétallique, en surface, assurant une protection contre la corrosion, contre la décarburation de l'acier, le composé intermétallique pouvant assurer une fonction de lubrification,
- on effectue la mise en forme notamment par emboutissage,
- on refroidit la pièce formée pour conférer des caractéristiques mécaniques de dureté élevées de l'acier et une dureté superficielle élevée du revêtement.

Les autres caractéristiques de l'invention sont:

- on revêt la tôle laminée à chaud après laminage à chaud et décapage,
- le métal ou l'alliage métallique de revêtement est de l'aluminium ou un alliage d'aluminium.
- l'alliage intermétallique est un composé à base principalement d'aluminium, de fer et de silicium,
- le revêtement de métal ou d'alliage métallique et effectué au trempé à chaud.
- la tôle revêtue est soumise à une élévation de température supérieure à 700°C avant la mise en forme et ou le traitement thermique,
- la tôle revêtue est emboutie à chaud.
- la pièce obtenue notamment par emboutissage est refroidie pour subir une trempe, à une vitesse supérieure à la vitesse critique de trempe.

L'invention concerne également une tôle laminée notamment à chaud comportant un revêtement de métal ou d'alliage métallique déposé en surface, pour la réalisation à chaud d'un composé intermétallique, le composé intermétallique assurant, une protection contre la corrosion, une barrière contre la décarburation de l'acier de la tôle, une lubrification lors de la mise en forme à chaud de la tôle, et sur la pièce finie, après mise en forme et refroidissement, des caractéristiques mécaniques de dureté de

l'acier élevées ainsi qu'une dureté superficielle élevée de la surface de ladite pièce finie.

Une autre caractéristique de l'invention est:

- la tôle comporte un dépôt en surface d'aluminium ou d'un alliage d'aluminium.

L'invention concerne encore l'utilisation de la tôle dans la mise en forme à chaud notamment par emboutissage de pièces de hautes caractéristiques mécaniques en dureté et de hautes caractéristiques de dureté en surface assurant une très bonne tenue à l'abrasion.

La description qui suit fera bien comprendre l'invention.

Le procédé selon l'invention consiste à revêtir un acier notamment laminé à chaud, pour traitement thermique et ou formage à chaud, avec un métal ou un alliage métallique tels que de l'aluminium ou un alliage d'aluminium composé par exemple d'aluminium et de silicium. Le revêtement de métal ou d'alliage métallique est choisi de manière à avoir une protection contre la corrosion et de manière à résister à une haute température. Lors d'un traitement thermique, ou d'une élévation de température pour la mise en forme, le revêtement forme une couche alliée présentant une grande résistance à la corrosion, à l'abrasion, à l'usure et à la fatigue. Le revêtement ne modifie pas les propriétés de formabilité de l'acier et autorise ainsi une grande variété de mise en forme à froid et à chaud.

Après laminage à chaud la bande peut être décapée et laminée à froid avant d'être revêtue. Dans le cas ou la tôle est laminée à froid, celle ci peut être recuite avant d'être revêtue.

On peut revêtir la tôle laminée avec, par exemple, les deux types d'alliage métallique suivants:

Alliage N°1: Si: 9% à 10%; Fe: 2% à 3,5%; Solde: Al et des impuretés.

Alliage N°2: Fe: 2% à 4%; Solde: Al et des impuretés.

Pour l'alliage N°1 l'épaisseur du revêtement est compris entre 5 μm et 100 μm, et de préférence entre 10 μm et 25 μm. Pour l'alliage N°2 l'épaisseur

du revêtement est compris entre 15 μm et 100 μm, et de préférence entre 30 μm et 50 μm.

Pour la mise en forme ou le traitement thermique, la tôle est soumise à une élévation de température comprise de préférence entre 750°C et 1200°C dans un four comportant une atmosphère ne nécessitant plus de contrôle du fait de la barrière à l'oxydation formée par le revêtement. Lors de l'élévation de la température, le revêtement à base d'aluminium se transforme en une couche alliée en surface comportant différentes phases dépendant du traitement en température et présentant une grande dureté pouvant dépasser 600 HV 100g.

Selon le procédé de l'invention, on peut produire des tôles dont l'épaisseur est comprise entre 0,2 mm et 20 mm, ayant de bonnes propriétés de mise en forme ainsi qu'une bonne résistance à la corrosion.

Les tôles livrées revêtues, présentent une résistance importante à la corrosion pendant les élévations de température, la mise en forme, les traitements thermiques, et lors de l'utilisation des pièces formées finies.

La présence du revêtement lors de traitements thermiques ou de formages à chaud permet d'éviter en plus de la corrosion, la décarburation de l'acier de base. Cela à un avantage indéniable dans le cas d'une mise en forme à chaud par exemple dans une presse d'emboutissage. En effet, l'alliage intermétallique formé évite, la formation de la calamine, l'usure des outils par la calamine, et permet de ce fait, un allongement de la vie moyenne desdits outils. Il a été remarqué que l'alliage intermétallique formé à chaud, a une fonction de lubrifiant à haute température. De plus, l'effet de protection contre la décarburation de l'alliage intermétallique permet l'usage de four haute température dépassant 900°C ayant une atmosphère non contrôlée, et cela, même pour des temps de chauffe de plusieurs heures.

En sortie de four, il n'est plus nécessaire de décaper la pièce obtenue, d'où une économie du fait de la suppression du bain de décapage des pièces finies.

De par les caractéristiques du revêtement après élévation de température, les pièces obtenues ont une résistance accrue à la fatigue, à l'usure, à l'abrasion et à la corrosion. De plus, le revêtement est soudable avant et après élévation de température.

L'acier de la tôle assure, par effet de trempe au refroidissement, des caractéristiques mécaniques élevées de la pièce obtenue après mise en forme, le revêtement transformé en un alliage intermétallique à chaud assurant pour sa part, du fait de ses qualités de lubrifiant et de résistance aux frottement, une amélioration de la mise en forme, notamment, dans le domaine de l'emboutissage à chaud.

Dans un exemple de réalisation, on utilise une bande de tôle laminée à chaud en acier de composition pondérale suivante:

carbone: 0,15% à 0,25%,

manganèse: 0,8% à 1,5%,

silicium: 0,1% à 0,35%,

chrome: 0,01% à 0,2%,

titane: moins de 0,1%,

aluminium: moins de 0,1%,

phosphore: moins de 0,05%,

soufre: moins de 0,03%,

bore : 0,0005% à 0,01%,

on revêt la bande de tôle d'un revêtement de type alliage N°1 ou 2,

on austénitise la tôle à 950°C avant formage et trempe dans l'outil, le revêtement assurant un rôle de lubrifiant lors de la mise en forme, en plus de ses fonctions de protection contre la corrosion à froid, à chaud et contre la décarburation. Lors de la trempe, le revêtement allié ne gène pas l'extraction de la chaleur par l'outil et peut la favoriser. Après formage et trempe, il n'est plus nécessaire de décaper la pièce ou de la protéger, le revêtement de base assurant la protection tout au long du procédé.

REVENDICATIONS.

1. Procédé de réalisation d'une pièce à partir d'une bande de tôle d'acier laminée et notamment laminée à chaud, caractérisée en ce que:

- on revêt la tôle laminée d'un métal ou d'un alliage métallique assurant une protection de la surface et de l'acier,
- on soumet la tôle revêtue à une élévation en température pour sa mise en forme,
- on réalise, de ce fait un composé allié intermétallique, en surface, assurant une protection contre la corrosion, contre la décarburation de l'acier, le composé intermétallique pouvant assurer une fonction de lubrification,
- on effectue la mise en forme notamment par emboutissage,
- on refroidit la pièce formée pour conférer des caractéristiques mécaniques de dureté élevées de l'acier et une dureté superficielle élevée du revêtement.

2. Procédé selon la revendication 1 caractérisé en ce que on revêt le tôle laminée à chaud immédiatement après laminage à chaud,

3. Procédé selon la revendication 1 caractérisé en ce que le métal ou l'alliage métallique de revêtement est de l'aluminium ou un alliage d'aluminium.

4. Procédé selon la revendication 1 caractérisé en ce que l'alliage intermétallique est un composé à base d'aluminium, de fer et de silicium.

5. Procédé selon la revendication 1 caractérisé en ce que le revêtement de métal ou d'alliage métallique et effectué au trempé à chaud.

6. Procédé selon la revendication 1 caractérisé en ce que la tôle revêtue est soumise à une élévation de température supérieure à 700°C avant la mise en forme et ou le traitement thermique.

7. Procédé selon la revendication 1 caractérisé en ce que la tôle revêtue est emboutie à chaud.

8. Procédé selon la revendication 1 caractérisé en ce que la pièce obtenue notamment par emboutissage est refroidie pour subir une trempe, à une vitesse supérieure à la vitesse critique de trempe.

9. Tôle laminée notamment à chaud comportant un revêtement de métal ou d'alliage métallique déposé en surface, pour la réalisation à chaud d'un composé intermétallique, le composé intermétallique assurant, une protection contre la corrosion, une barrière contre la décarburation de l'acier de la tôle, une lubrification lors de la mise en forme à chaud de la tôle, et sur la pièce finie, après mise en forme et refroidissement, des caractéristiques mécaniques de dureté de l'acier élevées ainsi qu'une dureté superficielle élevée de la surface de ladite pièce finie.

10. Tôle laminée à chaud selon la revendication 9 caractérisée en ce qu'elle comporte un dépôt en surface d'aluminium ou d'un alliage d'aluminium.

11. Utilisation de la tôle selon les revendications 9 ou 10 dans la mise en forme à chaud notamment par emboutissage de pièces de hautes caractéristiques mécaniques en dureté et de hautes caractéristiques de dureté en surface assurant une très bonne tenue à l'abrasion.

REPUBLIQUE FRANÇAISE

2787735

INSTITUT NATIONAL
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RAPPORT DE RECHERCHE PRELIMINAIRE

établi sur la base des dernières revendications déposées avant le commencement de la recherche

N° d'enregistrement national

FA 566530
FR 9816477

DOCUMENTS CONSIDERES COMME PERTINENTS		Revendications concernées de la demande examinée	
Catégorie	Citation du document avec indication, en cas de besoin, des parties pertinentes		
X	FR 1 297 906 A (BEAUJEU-DUMONTEL G.) 23 novembre 1962 (1962-11-23)	9-11	
A	* page 1, colonne 1, alinéa 1 - colonne 2, alinéa 1 * * page 1, colonne 2, alinéa 7 - page 2, colonne 1, alinéa 10 * * page 2, colonne 2, alinéa 9 - page 3, colonne 2, alinéa 4 * * page 3, colonne 2, alinéa 10 * * revendications A.1-A.4,B; figure *	1,3-7	
A	DE 12 52 034 B (SOCIÉTÉ DES ACIÉRIES DE POMPEY) 12 novembre 1967 (1967-11-12) * le document en entier *	1,3-11	
A	GIEREK A. E.A.: "Tauchalitieren - Eigenschaften und Einsatzgebiete" V.D.I. ZEITSCHRIFT, vol. 118, no. 8, avril 1976 (1976-04), pages 19-22, XP002114744 * page 19 * * page 21, colonne 2, alinéa 2 *	1-11	
A	DATABASE WPI Week 9046 Derwent Publications Ltd., London, GB; AN 347101 XP002114745 "Aluminised steel strip production process - involves cooling and hot rolling under compression to improve adhesion of covering to base" & SU 331 284 A (FRUNZE POLY), 9 janvier 1991 (1991-01-09) * abrégé *	1-11	
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DOMAINES TECHNIQUES RECHERCHES (Int.Cl 6)

C23C
B21D

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Date d'achèvement de la recherche	Examinateur
8 septembre 1999	Ceulemans, J

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O : divulgation non-écrite
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RAPPORT DE RECHERCHE PRELIMINAIRE

établi sur la base des dernières revendications déposées avant le commencement de la recherche

DOCUMENTS CONSIDERES COMME PERTINENTS		Revendications concernées de la demande examinée
Catégorie	Citation du document avec indication, en cas de besoin, des parties pertinentes	
A	US 4 655 852 A (RALLIS ANTHONY T) 7 avril 1987 (1987-04-07) * le document en entier *	1-11
A	CH 382 512 A (FELTEN & GUILLEAUME CARLSWREK EISEN UND STAHL A.G.) 30 novembre 1964 (1964-11-30) * le document en entier *	1-11

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Date d'achèvement de la recherche	Examinateur
8 septembre 1999	Ceulemans, J

CATEGORIE DES DOCUMENTS CITES

X : particulièrement pertinent à lui seul
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Electronic Acknowledgement Receipt

EFS ID:	36193929
Application Number:	16413799
International Application Number:	
Confirmation Number:	7637
Title of Invention:	Coated Steel Strips, Coated Stamped Products and Methods
First Named Inventor/Applicant Name:	Pascal DRILLET
Customer Number:	23280
Filer:	William C. Gehris/Simon Steiner
Filer Authorized By:	William C. Gehris
Attorney Docket Number:	11020631.1028con5
Receipt Date:	04-JUN-2019
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Application Type:	Utility under 35 USC 111(a)

Payment information:

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File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Foreign Reference	EP3290199A1.pdf	2490921 ab1a6a92b372ba57d09b2d49d36bb98adc23f643	no	22

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2	Foreign Reference	FR2758571A1.pdf	2366411 3abbe0522c176b8acd18d2cd8bc9f0f389e96749	no	31
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3	Foreign Reference	WO2006097593A1.pdf	1224134 4bb137ffc6fb432bcbe02074490f0d6001eb7bf2	no	20
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4	Foreign Reference	DE102004007071A1.pdf	431568 185410ff839a349f2e5708b7f92cefa6e69e6b9e	no	8
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Information:					
5	Foreign Reference	EP2242863B1.pdf	776012 30ac9fd297016e764167b5519c7bdc1661a2e87a	no	15
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Information:					
6	Foreign Reference	WO2005078144A1.pdf	766317 d63da31ec01b769aaffa8253f08875fad3661169	no	19
Warnings:					
Information:					
7	Foreign Reference	FR2833504A1ff.pdf	1644188 1e5a43a53d688b8c3d9887dcdeb00c3d5b662644	no	23
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8	Foreign Reference	EP1013785A1ff.pdf	991462 dd042572dc4a41ff9878596c88667e195497001c	no	16
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Information:					

9	Foreign Reference	WO2012048841A1.pdf	1023767 1fda2e74ffbaa106bb4b39c9362ffc5662963cd5	no	26
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10	Foreign Reference	WO2012028224A1.pdf	576887 f66e3f55651fe274ff2785cb779d15847d35231c	no	15
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11	Foreign Reference	EP1380666A1.pdf	683640 a73d8134f53c3260a6e43c710ac42d58c7df0e47	no	14
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12	Foreign Reference	EP3290200A1.pdf	2462064 58cb3ab9d8014a29a6a8f050fa8065d0dd16c2e8	no	22
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13	Foreign Reference	WO2008053273A1.pdf	2304830 80f9d93eb1df646d2dff7e3b5980b264824d5c51	no	43
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14	Foreign Reference	RU2040556.PDF	5683700 63287cf497c043f7dd77aae68c823105a4334d11	no	11
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Information:					
15	Foreign Reference	CN1531604A.pdf	2679978 5fbdceb769a4ba6896cc2a9ab7f102b08985e925	no	55
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16	Foreign Reference	WO02103073A2.pdf	3289602 521265a97251e60932f2ba6a07859f7d2b8ff60f	no	70
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17	Foreign Reference	JP3931251B2.pdf	75243 f198cf2a240443b7c728574fe94e855073fc6a69	no	2
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18	Foreign Reference	WO2005009642A1.pdf	1483522 ff752ecb3628d13b07327e8ac7d807b2a1244891	no	30
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19	Foreign Reference	JP2006529002A.pdf	684054 135da50f00f8a6317b2a15a0822503c39594f3fd	no	18
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Information:					
20	Foreign Reference	JPH11156293A.pdf	728823 7fd25c55d10c9f39fa3f716fbdc66832ea5d85a4	no	13
Warnings:					
Information:					
21	Foreign Reference	JP2002178069A.pdf	845701 01f960d2478b821074833c13e5eed49130bc76f5	no	14
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22	Foreign Reference	JP2008537977A.pdf	511152 7528258a397ec0b042641887d82a5289cfc27130	no	14
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23	Foreign Reference	JP2007522345A.pdf	402572 dd013bcc5371cc6542cdfbf77de2f654094ba8f8	no	14
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Information:					
25	Foreign Reference	EP0356783A2.pdf	709404 51fc1dd8895adf844f38650ac1ebcd9a784e4277	no	10
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26	Foreign Reference	CN1472068A.pdf	777950 6c88d517c0c1538262a8efd6283d379f42e31c5b	no	17
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27	Foreign Reference	FR2720079A1.pdf	1808499 b27c62971a9c4b63b40d5a9606544f8d525fa6ad	no	23
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28	Foreign Reference	FR1297906A.pdf	981662 8f23478bc072c11e8a2b9424901bcc2ef20e060a	no	14
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29	Foreign Reference	FR2787735A1.pdf	1558831 616a63f6b03e03151a46d4c482988f15bf8886df	no	20
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30	Non Patent Literature	1D3RaviereetalHotStampingExperimentandNumericalSimulationofPrecoatedUSIBOR1500QuenchableSteels.pdf	1490803 8e79acf99371527f0c31a00243a96161514bc295	no	6
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31	Non Patent Literature	2D11MerkleinMetalEinflussgroessenimPresshaerteprozessTagungsband4ff.pdf	2548803 4a992370a57c763d4228f2aa645979e23a31ea69	no	28
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32	Non Patent Literature	3D12ForschungsvereinigungStahlanwendungeneVFFPARTI.pdf	24797449 beab41e0d8aaa601f4640a450fdaeca370d94ac4	no	75
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33	Non Patent Literature	3iiD26Selfstudyprogramme339VolkswagenPassat.pdf	1897549 030741990832334f0ae7309ce6d597b79eaa6c7d	no	76
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34	Non Patent Literature	4D21ArcelorMittalonlineproductcatalogue.pdf	184759 f686d82f05a0e0d0df48dbc04e336765579ba6b2	no	2
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35	Non Patent Literature	5D21ArcelorMittalonlineproductcatalogue.pdf	619890 1d65cccf1b45d05ddd56e21f184f136b66227586	no	5
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36	Non Patent Literature	6D21ArcelorMittalonlineproductcatalogue-2.pdf	537631 46c7377f1dc0a606bfa897595d9b51cccbba84e9	no	4
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37	Non Patent Literature	7D24AltanHotstampingboronalloyedsteelsforautomotiveparts.pdf	344567 1379326fde02010cfdc422007a44b21b79c94da8	no	2
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38	Non Patent Literature	8D36MerkleinMNeuereEntwicklungenzurUmformunghoechstfesterStahlwerkstoffe.pdf	11542356 a922aca4400334c9291cb91b71996113964 36b2b	no	33
Warnings:					
Information:					
39	Non Patent Literature	9D37TagungsbandSFULeichtbaudurchUmformtechnikProzessketteZumWarmumformenvonBlechen.pdf	14328240 1ae0f7f67db5f451202320553bbabc60a634 5db1	no	40
Warnings:					
Information:					
40	Non Patent Literature	10D43LaurentJPHotformedPrecoatedboronsteelsAsolutionoftheresistanceformabilitysdilemma.pdf	17843277 290a2896b43ee52aee1edc7d4da0ff1692e 6be01	no	15
Warnings:					
Information:					
41	Non Patent Literature	11D39GarciaArandaLRavierPChastelYHotstampingofquenchablesteelsMaterialdataandprocess simulations.pdf	5984794 5c7310f79887355ce5e54b7d61b93c91977 c7b11	no	9
Warnings:					
Information:					
42	Non Patent Literature	12D40MerkleinMCharacterisationoftheFlowPropertiesoftheQuenchenableUltraHighStrengthSteel22MnB5.pdf	1043460 31fea61b50cf37ca1994a34954165762fd86 077d	no	4
Warnings:					
Information:					
43	Non Patent Literature	13D41TurettaATestingmaterialformabilityinhotstampingoperations.pdf	1499333 3f031e4e479090ec8411a054431167bd50f 84b1a	no	6
Warnings:					
Information:					

44	Non Patent Literature	14D42BabbitMSomeHighlightsonNewSteelProductsforAutomotiveUse.pdf	4579756 01e88964f41a49859a16e753e3a91cb184607b7b	no	7
Warnings:					
Information:					
45	Non Patent Literature	15D43LaurentJPHotformedPrecoatedboronsteelsAsolutionoftheresistanceformabilitysdilemma.pdf	17843277 290a2896b43ee52aee1edc7d4da0ff1692e6be01	no	15
Warnings:					
Information:					
46	Non Patent Literature	16D45GarciaArandaLChastelYExperimentsandsimulationofhotstampingofquenchablesteels.pdf	6856393 9ce995452e79689fbbd1b85d68ab7473d5309879	no	8
Warnings:					
Information:					
47	Non Patent Literature	17D33SuehiroMasayoshietalPropertiesofAluminiumcoatedSteelsforHotforming.pdf	1468256 29252daa99b749cd6ca361c07cd2ad95029d96dc	no	6
Warnings:					
Information:					
48	Non Patent Literature	18D47KeffersteinRDevelopmentofsafetyandstructuralautomotivepartsby.pdf	1520964 641d2599d467eb8650c5a5f7d3c5289340e08c9a	no	2
Warnings:					
Information:					
49	Non Patent Literature	19D48GeilfussAKraskaMUntersuchungenzumWarmumformprozessultrahochdesterStaehleFFSMALL.pdf	2894974 66e286cde121afb3890f212150fb1c446b5b1eb4	no	50
Warnings:					
Information:					
50	Non Patent Literature	20D52GehringhoffNeuesteTrendsundEntwicklungeninderWarmumformungausTagungsband.pdf	3773446 542a9484914cc67b02398b6bc206f0c49195edd7	no	11
Warnings:					
Information:					

51	Non Patent Literature	21D54GrotheDubbelTaschenbuchfuerdenMaschinenbau.pdf	2634846 f64228ad36072b177966e0b9cf701dbd0c17885c	no	18
Warnings:					
Information:					
52	Non Patent Literature	22D55PalandTechnischesTaschenbuch7veraenderterNachdruck.pdf	1177587 fe5d3f1c05c12c0999e9153cf865d6467e4fd20a	no	8
Warnings:					
Information:					
53	Non Patent Literature	23D9HeinPetalNeuereEntwicklungeninderBlechumformungunbekannt09Mai2006.pdf	10900407 1b177f82114e519c7de0b64e68c5789c93818cb6	no	51
Warnings:					
Information:					
54	Non Patent Literature	24D31CornetteetalHighStrengthSteelsforAutomotiveSafetyParts.pdf	2016742 08052b82b0a81a871cd03eee38ffe293690b0e40	no	13
Warnings:					
Information:					
55	Non Patent Literature	25D53TechnLieferspecification.pdf	3494826 524ab227b25ea586d935716d4c7c878f52a145f5	no	22
Warnings:					
Information:					
56	Non Patent Literature	26D32VaissiereetalDevelopmentofprecoatedboronsteelforapplicationson.pdf	1022361 b1b4f1db174f97bfa2a25bd07f9537f70dff3438	no	12
Warnings:					
Information:					
57	Non Patent Literature	27D13ProcesverbaaAginBoederonsampletakingoftheVolkswagenPassatSMALL.pdf	13448708 3da041c20c582095be96aff9c7d598c0a812e193	no	45
Warnings:					
Information:					

58	Non Patent Literature	28D25ASTMStandardA463A463M06.pdf	1074966 d17758be734e47f6907cd7dae3db94d7560 54b13	no	7
Warnings:					
Information:					
59	Non Patent Literature	29D17PrelOpinionofBoardonEP2242863B1.pdf	304680 f472c429074f6fe58776fbf9b7ebb37d9d2bf fcf	no	10
Warnings:					
Information:					
60	Non Patent Literature	30D18bDecisionoftheDistrictCourtTheHagueonEP2242863B1translated.pdf	8757112 807a5cf8fea9870a3bf496266351f0e272d7c 641	no	56
Warnings:					
Information:					
		Total Files Size (in bytes):	209028374		

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

<u>New Applications Under 35 U.S.C. 111</u>
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.
<u>National Stage of an International Application under 35 U.S.C. 371</u>
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.
<u>New International Application Filed with the USPTO as a Receiving Office</u>
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
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P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
16/413,799	05/16/2019	Pascal DRILLET	11020631.1028con5	7637

23280 7590 06/04/2019

Davidson, Davidson & Kappel, LLC
589 8th Avenue
16th Floor
New York, NY 10018

EXAMINER	
ART UNIT	PAPER NUMBER
1784	

NOTIFICATION DATE	DELIVERY MODE
06/04/2019	ELECTRONIC

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Notice of the Office communication was sent electronically on above-indicated "Notification Date" to the following e-mail address(es):

ddk@ddkpatent.com

Decision Granting Request for Prioritized Examination (Track I)	**Application No.** 16/413,799	**Applicant(s)** DRILLET et al.	
	Examiner CHERYL P GIBSON BAYLOR	**Art Unit** OPET	**AIA (FITF) Status** No

1. THE REQUEST FILED 16 May 2019 IS **GRANTED** .

The above-identified application has met the requirements for prioritized examination

A. ☑ for an original nonprovisional application (Track I).
B. ☐ for an application undergoing continued examination (RCE).

2. **The above-identified application will undergo prioritized examination**. The application will be accorded special status throughout its entire course of prosecution until one of the following occurs:

A. filing a **petition for extension of time** to extend the time period for filing a reply;

B. filing an **amendment to amend the application to contain more than four independent claims, more than thirty total claims** , or a multiple dependent claim;

C. filing a **request for continued examination** ;

D. filing a notice of appeal;

E. filing a request for suspension of action;

F. mailing of a notice of allowance;

G. mailing of a final Office action;

H. completion of examination as defined in 37 CFR 41.102; or

I. abandonment of the application.

Telephone inquiries with regard to this decision should be directed to CHERYL GIBSON BAYLOR at (571)272-3213. In his/her absence, calls may be directed to Petition Help Desk at (571) 272-3282.

/CHERYL GIBSON BAYLOR/ Paralegal Specialist, OPET	

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Address: COMMISSIONER FOR PATENTS
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Alexandria, Virginia 22313-1450
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APPLICATION NUMBER	FILING or 371(c) DATE	GRP ART UNIT	FIL FEE REC'D	ATTY.DOCKET.NO	TOT CLAIMS	IND CLAIMS
16/413,799	05/16/2019	1784	2020	11020631.1028con5	23	1

CONFIRMATION NO. 7637

FILING RECEIPT

23280
Davidson, Davidson & Kappel, LLC
589 8th Avenue
16th Floor
New York, NY 10018

OC000000108448728

Date Mailed: 05/28/2019

Receipt is acknowledged of this non-provisional utility patent application. The application will be taken up for examination in due course. Applicant will be notified as to the results of the examination. Any correspondence concerning the application must include the following identification information: the U.S. APPLICATION NUMBER, FILING DATE, NAME OF FIRST INVENTOR, and TITLE OF INVENTION. Fees transmitted by check or draft are subject to collection.

Please verify the accuracy of the data presented on this receipt. If an error is noted on this Filing Receipt, please submit a written request for a corrected Filing Receipt, including a properly marked-up ADS showing the changes with strike-through for deletions and underlining for additions. If you received a "Notice to File Missing Parts" or other Notice requiring a response for this application, please submit any request for correction to this Filing Receipt with your reply to the Notice. When the USPTO processes the reply to the Notice, the USPTO will generate another Filing Receipt incorporating the requested corrections provided that the request is grantable.

Inventor(s)

Pascal DRILLET, Rozerieulles, FRANCE;
Dominique Spehner, Balan, FRANCE;
Ronald Kefferstein, Saint Mitre Les Ramparts, FRANCE;

Applicant(s)

ArcelorMittal, Luxembourg, LUXEMBOURG;

Power of Attorney: The patent practitioners associated with Customer Number 23280

Domestic Priority data as claimed by applicant

This application is a CON of 15/606,770 05/26/2017
which is a CON of 13/621,015 09/15/2012 PAT 9708683
which is a DIV of 12/447,777 03/18/2011 PAT 8307680
which is a 371 of PCT/IB06/04019 10/30/2006

Foreign Applications for which priority is claimed (You may be eligible to benefit from the **Patent Prosecution Highway** program at the USPTO. Please see http://www.uspto.gov for more information.) - None.
Foreign application information must be provided in an Application Data Sheet in order to constitute a claim to foreign priority. See 37 CFR 1.55 and 1.76.

Permission to Access Application via Priority Document Exchange: Yes

Permission to Access Search Results: Yes

Applicant may provide or rescind an authorization for access using Form PTO/SB/39 or Form PTO/SB/69 as appropriate.

If Required, Foreign Filing License Granted: 05/23/2019

The country code and number of your priority application, to be used for filing abroad under the Paris Convention, is **US 16/413,799**

Projected Publication Date: 09/05/2019

Non-Publication Request: No

Early Publication Request: No

Title

Coated Steel Strips, Coated Stamped Products and Methods

Preliminary Class

428

Statement under 37 CFR 1.55 or 1.78 for AIA (First Inventor to File) Transition Applications: No

PROTECTING YOUR INVENTION OUTSIDE THE UNITED STATES

Since the rights granted by a U.S. patent extend only throughout the territory of the United States and have no effect in a foreign country, an inventor who wishes patent protection in another country must apply for a patent in a specific country or in regional patent offices. Applicants may wish to consider the filing of an international application under the Patent Cooperation Treaty (PCT). An international (PCT) application generally has the same effect as a regular national patent application in each PCT-member country. The PCT process **simplifies** the filing of patent applications on the same invention in member countries, but **does not result** in a grant of "an international patent" and does not eliminate the need of applicants to file additional documents and fees in countries where patent protection is desired.

Almost every country has its own patent law, and a person desiring a patent in a particular country must make an application for patent in that country in accordance with its particular laws. Since the laws of many countries differ in various respects from the patent law of the United States, applicants are advised to seek guidance from specific foreign countries to ensure that patent rights are not lost prematurely.

Applicants also are advised that in the case of inventions made in the United States, the Director of the USPTO must issue a license before applicants can apply for a patent in a foreign country. The filing of a U.S. patent application serves as a request for a foreign filing license. The application's filing receipt contains further information and guidance as to the status of applicant's license for foreign filing.

Applicants may wish to consult the USPTO booklet, "General Information Concerning Patents" (specifically, the section entitled "Treaties and Foreign Patents") for more information on timeframes and deadlines for filing foreign patent applications. The guide is available either by contacting the USPTO Contact Center at 800-786-9199, or it can be viewed on the USPTO website at http://www.uspto.gov/web/offices/pac/doc/general/index.html.

For information on preventing theft of your intellectual property (patents, trademarks and copyrights), you may wish to consult the U.S. Government website, http://www.stopfakes.gov. Part of a Department of Commerce initiative, this website includes self-help "toolkits" giving innovators guidance on how to protect intellectual property in specific

countries such as China, Korea and Mexico. For questions regarding patent enforcement issues, applicants may call the U.S. Government hotline at 1-866-999-HALT (1-866-999-4258).

LICENSE FOR FOREIGN FILING UNDER

Title 35, United States Code, Section 184

Title 37, Code of Federal Regulations, 5.11 & 5.15

GRANTED

The applicant has been granted a license under 35 U.S.C. 184, if the phrase "IF REQUIRED, FOREIGN FILING LICENSE GRANTED" followed by a date appears on this form. Such licenses are issued in all applications where the conditions for issuance of a license have been met, regardless of whether or not a license may be required as set forth in 37 CFR 5.15. The scope and limitations of this license are set forth in 37 CFR 5.15(a) unless an earlier license has been issued under 37 CFR 5.15(b). The license is subject to revocation upon written notification. The date indicated is the effective date of the license, unless an earlier license of similar scope has been granted under 37 CFR 5.13 or 5.14.

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NOT GRANTED

No license under 35 U.S.C. 184 has been granted at this time, if the phrase "IF REQUIRED, FOREIGN FILING LICENSE GRANTED" DOES NOT appear on this form. Applicant may still petition for a license under 37 CFR 5.12, if a license is desired before the expiration of 6 months from the filing date of the application. If 6 months has lapsed from the filing date of this application and the licensee has not received any indication of a secrecy order under 35 U.S.C. 181, the licensee may foreign file the application pursuant to 37 CFR 5.15(b).

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PATENT APPLICATION FEE DETERMINATION RECORD

Substitute for Form PTO-875

Application or Docket Number: 16/413,799

APPLICATION AS FILED - PART I

FOR	(Column 1) NUMBER FILED	(Column 2) NUMBER EXTRA	SMALL ENTITY RATE($)	SMALL ENTITY FEE($)	OR	OTHER THAN SMALL ENTITY RATE($)	OTHER THAN SMALL ENTITY FEE($)
BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A	N/A			N/A	300
SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A	N/A			N/A	660
EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A	N/A			N/A	760
TOTAL CLAIMS (37 CFR 1.16(i))	23 minus 20 =	* 3			OR	x 100 =	300
INDEPENDENT CLAIMS (37 CFR 1.16(h))	1 minus 3 =	*				x 460 =	0.00
APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is $310 ($155 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).						0.00
MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))							0.00
* If the difference in column 1 is less than zero, enter "0" in column 2.			TOTAL			TOTAL	2020

APPLICATION AS AMENDED - PART II

AMENDMENT A

	(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	SMALL ENTITY RATE($)	SMALL ENTITY ADDITIONAL FEE($)	OR	OTHER THAN SMALL ENTITY RATE($)	OTHER THAN SMALL ENTITY ADDITIONAL FEE($)
Total (37 CFR 1.16(i))	*	Minus	**	=	x =		OR	x =	
Independent (37 CFR 1.16(h))	*	Minus	***	=	x =		OR	x =	
Application Size Fee (37 CFR 1.16(s))									
FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
					TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	

AMENDMENT B

	(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	SMALL ENTITY RATE($)	SMALL ENTITY ADDITIONAL FEE($)	OR	OTHER THAN SMALL ENTITY RATE($)	OTHER THAN SMALL ENTITY ADDITIONAL FEE($)
Total (37 CFR 1.16(i))	*	Minus	**	=	x =		OR	x =	
Independent (37 CFR 1.16(h))	*	Minus	***	=	x =		OR	x =	
Application Size Fee (37 CFR 1.16(s))									
FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
					TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.

** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".

*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".

The "Highest Number Previously Paid For" (Total or Independent) is the highest found in the appropriate box in column 1.

POWER OF ATTORNEY TO PROSECUTE APPLICATIONS BEFORE THE UNITED STATES PATENT AND TRADEMARK OFFICE

This Power of Attorney is submitted by:

Submitter Name: **ArcelorMittal**

Address: **24-26 Boulevard d'Avranches**
1160 Luxembourg
LUXEMBOURG

The Submitter hereby appoints the practitioners at **Davidson, Davidson & Kappel, LLC** associated with the Customer Number:

23280

as its attorney(s) or agent(s) to represent the Submitter before the United States Patent and Trademark Office (USPTO) and to transact all business before the USPTO in connection with any and all applications of which the Submitter is the/an applicant and the/an assignee or entity to whom the inventor(s) is/are obligated to assign.

Please direct all correspondence for any and all applications in which this Power of Attorney is submitted to the address associated with the Customer Number:

23280

The individual(s) whose name(s) and title(s) is/are supplied below is/are authorized to act on behalf of the Submitter.

Date: March 3, 2016

By _____
Name: **Sophie Plaisant**
Title: **Head of Central Patent Team**
Corporate Officer

Date: _____

By _____
Name:
Title:

Doc Code: TRACK1.REQ
Document Description: TrackOne Request

PTO/AIA/424 (04-14)

CERTIFICATION AND REQUEST FOR PRIORITIZED EXAMINATION UNDER 37 CFR 1.102(e) (Page 1 of 1)

First Named Inventor:	Pascal DRILLET	Nonprovisional Application Number (if known):	
Title of Invention:	Coated Steel Strips Coated Stamped Products and Methods		

APPLICANT HEREBY CERTIFIES THE FOLLOWING AND REQUESTS PRIORITIZED EXAMINATION FOR THE ABOVE-IDENTIFIED APPLICATION.

1. The processing fee set forth in 37 CFR 1.17(i)(1) and the prioritized examination fee set forth in 37 CFR 1.17(c) have been filed with the request. The publication fee requirement is met because that fee, set forth in 37 CFR 1.18(d), is currently $0. The basic filing fee, search fee, and examination fee are filed with the request or have been already been paid. I understand that any required excess claims fees or application size fee must be paid for the application.

2. I understand that the application may not contain, or be amended to contain, more than four independent claims, more than thirty total claims, or any multiple dependent claims, and that any request for an extension of time will cause an outstanding Track I request to be dismissed.

3. The applicable box is checked below:

I. ☑ Original Application (Track One) - Prioritized Examination under § 1.102(e)(1)

i. (a) The application is an original nonprovisional utility application filed under 35 U.S.C. 111(a). This certification and request is being filed with the utility application via EFS-Web.

---OR---

(b) The application is an original nonprovisional plant application filed under 35 U.S.C. 111(a). This certification and request is being filed with the plant application in paper.

ii. An executed inventor's oath or declaration under 37 CFR 1.63 or 37 CFR 1.64 for each inventor, **or** the application data sheet meeting the conditions specified in 37 CFR 1.53(f)(3)(i) is filed with the application.

II. ☐ Request for Continued Examination - Prioritized Examination under § 1.102(e)(2)

i. A request for continued examination has been filed with, or prior to, this form.
ii. If the application is a utility application, this certification and request is being filed via EFS-Web.
iii. The application is an original nonprovisional utility application filed under 35 U.S.C. 111(a), or is a national stage entry under 35 U.S.C. 371.
iv. This certification and request is being filed prior to the mailing of a first Office action responsive to the request for continued examination.
v. No prior request for continued examination has been granted prioritized examination status under 37 CFR 1.102(e)(2).

Signature /Cary Kappel/	Date May 16, 2019
Name (Print/Typed) Cary Kappel	Practitioner Registration Number 36561

Note: *This form must be signed in accordance with 37 CFR 1.33. See 37 CFR 1.4(d) for signature requirements and certifications. Submit multiple forms if more than one signature is required.**

☑ *Total of 1 forms are submitted.

Privacy Act Statement

The **Privacy Act of 1974 (P.L. 93-579)** requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether disclosure of these records is required by the Freedom of Information Act.
2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.
3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.
4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).
5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.
6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).
7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (*i.e.*, GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.
8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspection or an issued patent.
9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

PTO/AIA/14 (02-18)
Approved for use through 11/30/2020. OMB 0651-0032
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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	11020631.1028con5
	Application Number	
Title of Invention	Coated Steel Strips, Coated Stamped Products and Methods	

The application data sheet is part of the provisional or nonprovisional application for which it is being submitted. The following form contains the bibliographic data arranged in a format specified by the United States Patent and Trademark Office as outlined in 37 CFR 1.76.
This document may be completed electronically and submitted to the Office in electronic format using the Electronic Filing System (EFS) or the document may be printed and included in a paper filed application.

Secrecy Order 37 CFR 5.2:

☐ Portions or all of the application associated with this Application Data Sheet may fall under a Secrecy Order pursuant to 37 CFR 5.2 (Paper filers only. Applications that fall under Secrecy Order may not be filed electronically.)

Inventor Information:

Inventor 1 Remove

Legal Name

Prefix	Given Name	Middle Name	Family Name	Suffix
	Pascal		DRILLET	

Residence Information (Select One) US Residency ● Non US Residency Active US Military Service

City	Country of Residence [i]
Rozerieulles	FR

Mailing Address of Inventor:

Address 1	9 Chemin de Banauvignes
Address 2	
City	Rozerieulles
State/Province	
Postal Code	57160
Country [i]	FR

Inventor 2 Remove

Legal Name

Prefix	Given Name	Middle Name	Family Name	Suffix
	Dominique		Spehner	

Residence Information (Select One) US Residency ◉ Non US Residency Active US Military Service

City	Country of Residence [i]
Balan	FR

Mailing Address of Inventor:

Address 1	8 rue de la Porte
Address 2	
City	Balan
State/Province	OT
Postal Code	08200
Country [i]	FR

Inventor 3 Remove

Legal Name

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	Application Number	
Title of Invention	Coated Steel Strips, Coated Stamped Products and Methods	

Prefix	Given Name	Middle Name	Family Name	Suffix
	Ronald		Kefferstein	

Residence Information (Select One) US Residency ◉ Non US Residency Active US Military Service

City	Saint Mitre Les Ramparts	Country of Residence [i]	FR

Mailing Address of Inventor:

Address 1	2 rue des Rocaledes		
Address 2			
City	Saint Mitre Les Ramparts	**State/Province**	OT
Postal Code	13920	**Country** [i]	FR

All Inventors Must Be Listed - Additional Inventor Information blocks may be generated within this form by selecting the **Add** button. Add

Correspondence Information:

Enter either Customer Number or complete the Correspondence Information section below.
For further information see 37 CFR 1.33(a).

☐ **An Address is being provided for the correspondence Information of this application.**

Customer Number	23280		
Email Address	ddk@ddkpatent.com	Add Email	Remove Email

Application Information:

Title of the Invention	Coated Steel Strips, Coated Stamped Products and Methods		
Attorney Docket Number	11020631.1028con5	**Small Entity Status Claimed**	☐
Application Type	Nonprovisional		
Subject Matter	Utility		
Total Number of Drawing Sheets (if any)	4	**Suggested Figure for Publication (if any)**	

Filing By Reference:

Only complete this section when filing an application by reference under 35 U.S.C. 111(c) and 37 CFR 1.57(a). Do not complete this section if application papers including a specification and any drawings are being filed. Any domestic benefit or foreign priority information must be provided in the appropriate section(s) below (i.e., "Domestic Benefit/National Stage Information" and "Foreign Priority Information").

For the purposes of a filing date under 37 CFR 1.53(b), the description and any drawings of the present application are replaced by this reference to the previously filed application, subject to conditions and requirements of 37 CFR 1.57(a).

Application number of the previously filed application	Filing date (YYYY-MM-DD)	Intellectual Property Authority or Country [i]

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Publication Information:

☐ Request Early Publication (Fee required at time of Request 37 CFR 1.219)

☐ **Request Not to Publish.** I hereby request that the attached application not be published under 35 U.S.C. 122(b) and certify that the invention disclosed in the attached application **has not and will not** be the subject of an application filed in another country, or under a multilateral international agreement, that requires publication at eighteen months after filing.

Representative Information:

Representative information should be provided for all practitioners having a power of attorney in the application. Providing this information in the Application Data Sheet does not constitute a power of attorney in the application (see 37 CFR 1.32).
Either enter Customer Number or complete the Representative Name section below. If both sections are completed the customer Number will be used for the Representative Information during processing.

Please Select One:	● Customer Number	US Patent Practitioner	◯ Limited Recognition (37 CFR 11.9)
Customer Number	23280		

Domestic Benefit/National Stage Information:

This section allows for the applicant to either claim benefit under 35 U.S.C. 119(e), 120, 121, 365(c), or 386(c) or indicate National Stage entry from a PCT application. Providing benefit claim information in the Application Data Sheet constitutes the specific reference required by 35 U.S.C. 119(e) or 120, and 37 CFR 1.78.
When referring to the current application, please leave the "Application Number" field blank.

Prior Application Status	Pending		Remove
Application Number	Continuity Type	Prior Application Number	Filing or 371(c) Date (YYYY-MM-DD)
	Continuation of	15/606770	2017-05-26

Prior Application Status	Patented		Remove
Application Number	Continuity Type	Prior Application Number	Filing or 371(c) Date (YYYY-MM-DD)
15/606770	Continuation of	13621015	2012-09-15

Prior Application Status	Patented		Remove
Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)
13621015	Division of	12447777	2011-03-18

Prior Application Status	Abandoned		Remove
Application Number	Continuity Type	Prior Application Number	Filing or 371(c) Date (YYYY-MM-DD)
12447777	a 371 of international	PCT/IB06/04019	2006-10-30

Patent Number	Issue Date (YYYY-MM-DD)
9708683	2017-07-18

Patent Number	Issue Date (YYYY-MM-DD)
8307680	2012-11-13

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	Application Number	
Title of Invention	Coated Steel Strips, Coated Stamped Products and Methods	

Additional Domestic Benefit/National Stage Data may be generated within this form by selecting the **Add** button. Add

Foreign Priority Information:

This section allows for the applicant to claim priority to a foreign application. Providing this information in the application data sheet constitutes the claim for priority as required by 35 U.S.C. 119(b) and 37 CFR 1.55. When priority is claimed to a foreign application that is eligible for retrieval under the priority document exchange program (PDX)[i] the information will be used by the Office to automatically attempt retrieval pursuant to 37 CFR 1.55(i)(1) and (2). Under the PDX program, applicant bears the ultimate responsibility for ensuring that a copy of the foreign application is received by the Office from the participating foreign intellectual property office, or a certified copy of the foreign priority application is filed, within the time period specified in 37 CFR 1.55(g)(1).

Remove

Application Number	Country[i]	Filing Date (YYYY-MM-DD)	Access Code[i] (if applicable)

Additional Foreign Priority Data may be generated within this form by selecting the **Add** button. Add

Statement under 37 CFR 1.55 or 1.78 for AIA (First Inventor to File) Transition Applications

☐ This application (1) claims priority to or the benefit of an application filed before March 16, 2013 and (2) also contains, or contained at any time, a claim to a claimed invention that has an effective filing date on or after March 16, 2013.
NOTE: By providing this statement under 37 CFR 1.55 or 1.78, this application, with a filing date on or after March 16, 2013, will be examined under the first inventor to file provisions of the AIA.

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	Application Number	
Title of Invention	Coated Steel Strips, Coated Stamped Products and Methods	

Authorization or Opt-Out of Authorization to Permit Access:

When this Application Data Sheet is properly signed and filed with the application, applicant has provided written authority to permit a participating foreign intellectual property (IP) office access to the instant application-as-filed (see paragraph A in subsection 1 below) and the European Patent Office (EPO) access to any search results from the instant application (see paragraph B in subsection 1 below).

Should applicant choose not to provide an authorization identified in subsection 1 below, applicant **must opt-out** of the authorization by checking the corresponding box A or B or both in subsection 2 below.

NOTE: This section of the Application Data Sheet is **ONLY** reviewed and processed with the **INITIAL** filing of an application. After the initial filing of an application, an Application Data Sheet cannot be used to provide or rescind authorization for access by a foreign IP office(s). Instead, Form PTO/SB/39 or PTO/SB/69 must be used as appropriate.

1. Authorization to Permit Access by a Foreign Intellectual Property Office(s)

A. Priority Document Exchange (PDX) - Unless box A in subsection 2 (opt-out of authorization) is checked, the undersigned hereby **grants the USPTO authority** to provide the European Patent Office (EPO), the Japan Patent Office (JPO), the Korean Intellectual Property Office (KIPO), the State Intellectual Property Office of the People's Republic of China (SIPO), the World Intellectual Property Organization (WIPO), and any other foreign intellectual property office participating with the USPTO in a bilateral or multilateral priority document exchange agreement in which a foreign application claiming priority to the instant patent application is filed, access to: (1) the instant patent application-as-filed and its related bibliographic data, (2) any foreign or domestic application to which priority or benefit is claimed by the instant application and its related bibliographic data, and (3) the date of filing of this Authorization. See 37 CFR 1.14(h)(1).

B. Search Results from U.S. Application to EPO - Unless box B in subsection 2 (opt-out of authorization) is checked, the undersigned hereby **grants the USPTO authority** to provide the EPO access to the bibliographic data and search results from the instant patent application when a European patent application claiming priority to the instant patent application is filed. See 37 CFR 1.14(h)(2).

The applicant is reminded that the EPO's Rule 141(1) EPC (European Patent Convention) requires applicants to submit a copy of search results from the instant application without delay in a European patent application that claims priority to the instant application.

2. Opt-Out of Authorizations to Permit Access by a Foreign Intellectual Property Office(s)

☐ A. Applicant **DOES NOT** authorize the USPTO to permit a participating foreign IP office access to the instant application-as-filed. If this box is checked, the USPTO will not be providing a participating foreign IP office with any documents and information identified in subsection 1A above.

☐ B. Applicant **DOES NOT** authorize the USPTO to transmit to the EPO any search results from the instant patent application. If this box is checked, the USPTO will not be providing the EPO with search results from the instant application.

NOTE: Once the application has published or is otherwise publicly available, the USPTO may provide access to the application in accordance with 37 CFR 1.14.

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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	11020631.1028con5
	Application Number	
Title of Invention	Coated Steel Strips, Coated Stamped Products and Methods	

Applicant Information:

Providing assignment information in this section does not substitute for compliance with any requirement of part 3 of Title 37 of CFR to have an assignment recorded by the Office.

Applicant 1 — Remove

If the applicant is the inventor (or the remaining joint inventor or inventors under 37 CFR 1.45), this section should not be completed. The information to be provided in this section is the name and address of the legal representative who is the applicant under 37 CFR 1.43; or the name and address of the assignee, person to whom the inventor is under an obligation to assign the invention, or person who otherwise shows sufficient proprietary interest in the matter who is the applicant under 37 CFR 1.46. If the applicant is an applicant under 37 CFR 1.46 (assignee, person to whom the inventor is obligated to assign, or person who otherwise shows sufficient proprietary interest) together with one or more joint inventors, then the joint inventor or inventors who are also the applicant should be identified in this section.

Clear

● Assignee	Legal Representative under 35 U.S.C. 117	Joint Inventor
Person to whom the inventor is obligated to assign.	Person who shows sufficient proprietary interest	

If applicant is the legal representative, indicate the authority to file the patent application, the inventor is:

Name of the Deceased or Legally Incapacitated Inventor:

If the Applicant is an Organization check here. ☒

Organization Name	ArcelorMittal		
Mailing Address Information For Applicant:			
Address 1	24-26 Boulevard-d'Avranches		
Address 2			
City	Luxembourg	**State/Province**	OT
Country	LU	Postal Code	L-1160
Phone Number		Fax Number	
Email Address			

Additional Applicant Data may be generated within this form by selecting the Add button. Add

Assignee Information including Non-Applicant Assignee Information:

Providing assignment information in this section does not substitute for compliance with any requirement of part 3 of Title 37 of CFR to have an assignment recorded by the Office.

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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	11020631.1028con5
	Application Number	
Title of Invention	Coated Steel Strips, Coated Stamped Products and Methods	

Assignee 1

Complete this section if assignee information, including non-applicant assignee information, is desired to be included on the patent application publication. An assignee-applicant identified in the "Applicant Information" section will appear on the patent application publication as an applicant. For an assignee-applicant, complete this section only if identification as an assignee is also desired on the patent application publication.

Remove

If the Assignee or Non-Applicant Assignee is an Organization check here. ☐

Prefix	**Given Name**	Middle Name	**Family Name**	Suffix

Mailing Address Information For Assignee including Non-Applicant Assignee:

Address 1			
Address 2			
City		**State/Province**	
Country i		Postal Code	
Phone Number		Fax Number	
Email Address			

Additional Assignee or Non-Applicant Assignee Data may be generated within this form by selecting the Add button. Add

Signature:

Remove

NOTE: This Application Data Sheet must be signed in accordance with 37 CFR 1.33(b). **However, if this Application Data Sheet is submitted with the INITIAL filing of the application and either box A or B is not checked in subsection 2 of the "Authorization or Opt-Out of Authorization to Permit Access" section, then this form must also be signed in accordance with 37 CFR 1.14(c).**

This Application Data Sheet **must** be signed by a patent practitioner if one or more of the applicants is a **juristic entity** (e.g., corporation or association). If the applicant is two or more joint inventors, this form must be signed by a patent practitioner, **all** joint inventors who are the applicant, or one or more joint inventor-applicants who have been given power of attorney (e.g., see USPTO Form PTO/AIA/81) on behalf of **all** joint inventor-applicants.

See 37 CFR 1.4(d) for the manner of making signatures and certifications.

Signature	/Cary Kappel/			Date (YYYY-MM-DD)	2019-05-16
First Name	Cary	Last Name	Kappel	Registration Number	36561

Additional Signature may be generated within this form by selecting the Add button. Add

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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	11020631.1028con5
	Application Number	
Title of Invention	Coated Steel Strips, Coated Stamped Products and Methods	

This collection of information is required by 37 CFR 1.76. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 23 minutes to complete, including gathering, preparing, and submitting the completed application data sheet form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

Privacy Act Statement

The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1 The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C. 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether the Freedom of Information Act requires disclosure of these records.

2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.

3 A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.

4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).

5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent CooperationTreaty.

6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).

7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.

8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspections or an issued patent.

9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

Doc code: Oath
Document Description: Oath or declaration filed

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SUBSTITUTE STATEMENT IN LIEU OF AN OATH OR DECLARATION FOR UTILITY OR DESIGN PATENT APPLICATION (35 U.S.C. 115(d) AND 37 CFR 1.64)

Title of Invention	Coated Steel Strips, Coated Stamped Products and Methods

This statement is directed to:

☐ The attached application,

OR

☒ United States application or PCT international application number 15/606,770 filed on May 26, 2017.

LEGAL NAME of inventor to whom this substitute statement applies:

(*E.g.*, Given Name (first and middle (if any)) and Family Name or Surname)

Dominique Spehner

Residence (except for a deceased or legally incapacitated inventor):

City	State	Country
Balan		FR

Mailing Address (except for a deceased or legally incapacitated inventor):

8 rue de la Porte

City	State	Zip	Country
Balan		08200	FR

I believe the above-named inventor or joint inventor to be the original inventor or an original joint inventor of a claimed invention in the application.

The above-identified application was made or authorized to be made by me.

I hereby acknowledge that any willful false statement made in this statement is punishable under 18 U.S.C. 1001 by fine or imprisonment of not more than five (5) years, or both.

Relationship to the inventor to whom this substitute statement applies:

- ☐ Legal Representative (for deceased or legally incapacitated inventor only),
- ☒ Assignee,
- ☐ Person to whom the inventor is under an obligation to assign,
- ☐ Person who otherwise shows a sufficient proprietary interest in the matter (petition under 37 CFR 1.46 is required), or
- ☐ Joint Inventor.

This collection of information is required by 35 U.S.C. 115 and 37 CFR 1.63. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 1 minute to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

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SUBSTITUTE STATEMENT

Circumstances permitting execution of this substitute statement:

- ☐ Inventor is deceased,
- ☐ Inventor is under legal incapacity,
- ■ Inventor cannot be found or reached after diligent effort, or
- ☐ Inventor has refused to execute the oath or declaration under 37 CFR 1.63.

If there are joint inventors, please check the appropriate box below:

- ■ An application data sheet under 37 CFR 1.76 (PTO/AIA/14 or equivalent) naming the entire inventive entity has been or is currently submitted.

OR

- ☐ An application data sheet under 37 CFR 1.76 (PTO/AIA/14 or equivalent) has not been submitted. Thus, a Substitute Statement Supplemental Sheet (PTO/AIA/11 or equivalent) naming the entire inventive entity and providing inventor information is attached. See 37 CFR 1.64(b).

WARNING:

Petitioner/applicant is cautioned to avoid submitting personal information in documents filed in a patent application that may contribute to identity theft. Personal information such as social security numbers, bank account numbers, or credit card numbers (other than a check or credit card authorization form PTO-2038 submitted for payment purposes) is never required by the USPTO to support a petition or an application. If this type of personal information is included in documents submitted to the USPTO, petitioners/applicants should consider redacting such personal information from the documents before submitting them to the USPTO. Petitioner/applicant is advised that the record of a patent application is available to the public after publication of the application (unless a non-publication request in compliance with 37 CFR 1.213(a) is made in the application) or issuance of a patent. Furthermore, the record from an abandoned application may also be available to the public if the application is referenced in a published application or an issued patent (see 37 CFR 1.14). Checks and credit card authorization forms PTO-2038 submitted for payment purposes are not retained in the application file and therefore are not publicly available.

PERSON EXECUTING THIS SUBSTITUTE STATEMENT:

Name: Sophie Plaisant | Date (Optional): 24 July 2018

Signature:

APPLICANT NAME AND TITLE OF PERSON EXECUTING THIS SUBSTITUTE STATEMENT:

If the applicant is a juristic entity, list the applicant name and the title of the signer:

Applicant Name: ARCELORMITTAL

Title of Person Executing This Substitute Statement: Head of Central Patent Team, Corporate Officer

The signer, whose title is supplied above, is authorized to act on behalf of the applicant.

Residence of the signer (unless provided in an application data sheet, PTO/AIA/14 or equivalent):

City	State	Country
Montreuil		France

Mailing Address of the signer (unless provided in an application data sheet, PTO/AIA/14 or equivalent)

City	State	Zip	Country

Note: Use an additional PTO/AIA/02 form for each inventor who is deceased, legally incapacitated, cannot be found or reached after diligent effort, or has refused to execute the oath or declaration under 37 CFR 1.63.

Privacy Act Statement

The **Privacy Act of 1974 (P.L. 93-579)** requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether disclosure of these records is required by the Freedom of Information Act.
2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.
3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.
4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).
5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.
6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).
7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (*i.e.*, GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.
8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspection or an issued patent.
9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

ASSIGNMENT AND DECLARATION UNDER 37 C.F.R. § 1.63

(For Use with Signed Application Data Sheet)

Title of Invention: COATED STEEL STRIPS, COATED STAMPED PRODUCTS AND METHODS

Attorney Docket No.: 20631.1028CON

This assignment and declaration are directed to (check one):

- ☐ the attached application;
- ☐ the application identified by the attorney docket no. and title of invention given above;
- ☒ United States Application or PCT International Application No. **15/606,770**, filed **May 26, 2017**.

ASSIGNMENT

For good and valuable consideration, the receipt and sufficiency of which are hereby acknowledged, as a below-named inventor I have sold and assigned, and hereby sell and assign, to:

Name of Assignee: ARCELORMITTAL

Address of Assignee: 24-26 Blvd d'Avranches L-1160 Luxembourg, Luxembourg

(hereinafter ASSIGNEE) all right, title, and interest in and to the above-identified invention and United States patent application, including : (i) any and all divisions or continuations thereof, and in and to any and all Letters Patent of the United States that may issue on any such application or for said invention, including any and all reissues or extensions thereof, to be held and enjoyed by said ASSIGNEE, its successors, or assigns to the full end of the term or terms for which any and all such Letters Patent may be granted; (ii) all applications for patents, utility models, and designs which may hereafter be filed for said invention in any country or countries foreign to the United States, together with the right to file such applications and the right to claim for the same the priority rights derived from said United States application under the Patent Laws of the United States, the International Convention for the Protection of Industrial Property, or any other international agreement or the domestic laws of the country in which any such application is filed, as may be applicable, to be held and enjoyed by said ASSIGNEE, its successors, or assigns to the full end of the term or terms for which any and all such patents, utility models, designs or other rights may be granted; and (iii) all forms of industrial property protection, including, without limitation, patents, utility models, inventors' certificates and designs which may be granted for said invention in any country or countries foreign to the United States and all extensions, renewals and reissues thereof, to be held and enjoyed by said ASSIGNEE, its successors, or assigns to the full end of the term or terms for which any and all such patents, utility models, designs or other rights may be granted.

I hereby authorize and request the Director of the U.S. Patent and Trademark Office to issue any and all such Letters Patent to said ASSIGNEE, its successors, or assigns in accordance herewith.

I warrant and covenant that I have the right to sell and assign the interests herein sold and assigned and that I have not executed and will not execute any document or instrument in conflict herewith.

I further covenant and agree that I will communicate to said ASSIGNEE, its successors, legal representatives, or assigns all information known to me relating to said invention or patent application and that I will execute and deliver any papers, make all rightful oaths, testify in any legal proceedings, and perform all other lawful acts necessary or desirable by said ASSIGNEE, its successors, legal representatives, or assigns to perfect title to said invention, to said application including divisions and continuations thereof and to any and all Letters Patent that may be granted therefor or thereon, including reissues or extensions, in said ASSIGNEE, its successors, or assigns, or to assist said ASSIGNEE, its successors, legal representatives, or assigns in obtaining, reissuing, or enforcing Letters Patent of the United States and any and all patents, utility models, designs or other rights that may be granted in the United States or of any country or countries foreign to the United States, for said invention.

DECLARATION

As a below-named inventor, I hereby declare that:

The above-identified application was made or authorized to be made by me.

I believe that I am the original inventor or an original joint inventor of a claimed invention in the application.

I hereby acknowledge that any willful false statement made in this declaration is punishable under 18 U.S.C. § 1001 by fine or imprisonment of not more than five (5) years, or both.

Signature: _____

Inventor: **Pascal DRILLET** Date: 21/6/2017

ASSIGNMENT AND DECLARATION UNDER 37 C.F.R. § 1.63

(For Use with Signed Application Data Sheet)

Title of Invention: COATED STEEL STRIPS, COATED STAMPED PRODUCTS AND METHODS

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- ☐ the attached application;
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(hereinafter ASSIGNEE) all right, title, and interest in and to the above-identified invention and United States patent application, including : (i) any and all divisions or continuations thereof, and in and to any and all Letters Patent of the United States that may issue on any such application or for said invention, including any and all reissues or extensions thereof, to be held and enjoyed by said ASSIGNEE, its successors, or assigns to the full end of the term or terms for which any and all such Letters Patent may be granted; (ii) all applications for patents, utility models, and designs which may hereafter be filed for said invention in any country or countries foreign to the United States, together with the right to file such applications and the right to claim for the same the priority rights derived from said United States application under the Patent Laws of the United States, the International Convention for the Protection of Industrial Property, or any other international agreement or the domestic laws of the country in which any such application is filed, as may be applicable, to be held and enjoyed by said ASSIGNEE, its successors, or assigns to the full end of the term or terms for which any and all such patents, utility models, designs or other rights may be granted; and (iii) all forms of industrial property protection, including, without limitation, patents, utility models, inventors' certificates and designs which may be granted for said invention in any country or countries foreign to the United States and all extensions, renewals and reissues thereof, to be held and enjoyed by said ASSIGNEE, its successors, or assigns to the full end of the term or terms for which any and all such patents, utility models, designs or other rights may be granted.

I hereby authorize and request the Director of the U.S. Patent and Trademark Office to issue any and all such Letters Patent to said ASSIGNEE, its successors, or assigns in accordance herewith.

I warrant and covenant that I have the right to sell and assign the interests herein sold and assigned and that I have not executed and will not execute any document or instrument in conflict herewith.

I further covenant and agree that I will communicate to said ASSIGNEE, its successors, legal representatives, or assigns all information known to me relating to said invention or patent application and that I will execute and deliver any papers, make all rightful oaths, testify in any legal proceedings, and perform all other lawful acts necessary or desirable by said ASSIGNEE, its successors, legal representatives, or assigns to perfect title to said invention, to said application including divisions and continuations thereof and to any and all Letters Patent that may be granted therefor or thereon, including reissues or extensions, in said ASSIGNEE, its successors, or assigns, or to assist said ASSIGNEE, its successors, legal representatives, or assigns in obtaining, reissuing, or enforcing Letters Patent of the United States and any and all patents, utility models, designs or other rights that may be granted in the United States or of any country or countries foreign to the United States, for said invention.

DECLARATION

As a below-named inventor, I hereby declare that:

The above-identified application was made or authorized to be made by me.

I believe that I am the original inventor or an original joint inventor of a claimed invention in the application.

I hereby acknowledge that any willful false statement made in this declaration is punishable under 18 U.S.C. § 1001 by fine or imprisonment of not more than five (5) years, or both.

Signature: _____

Inventor: **Ronald** KEFFERSTEIN Date: 1/7/2017

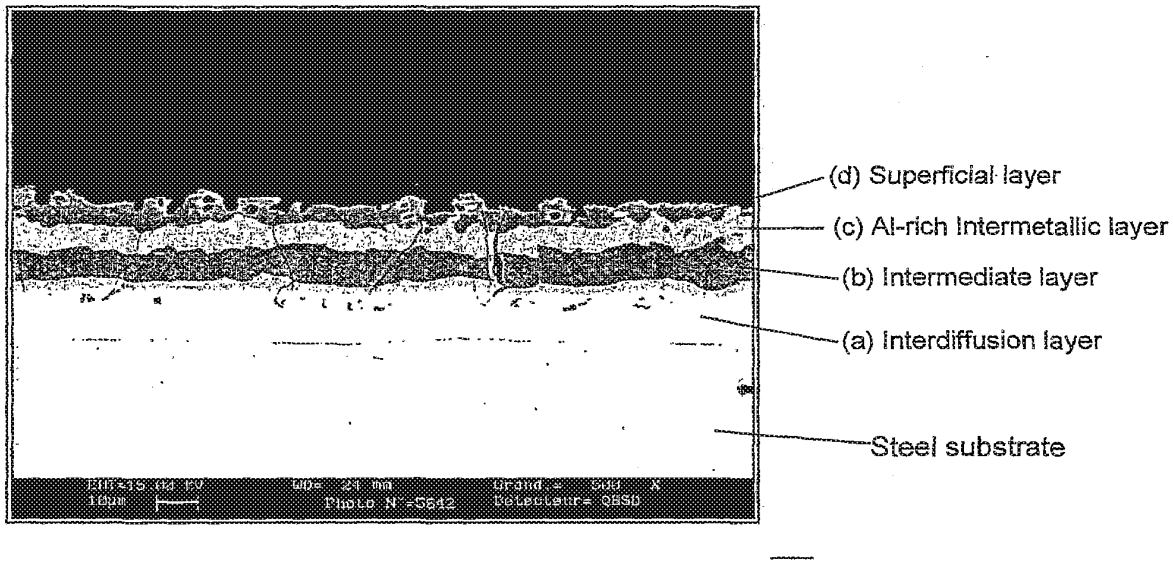

(d) Superficial layer
(c) Al-rich Intermetallic layer
(b) Intermediate layer
(a) Interdiffusion layer
Steel substrate
10µm

Fig. 1

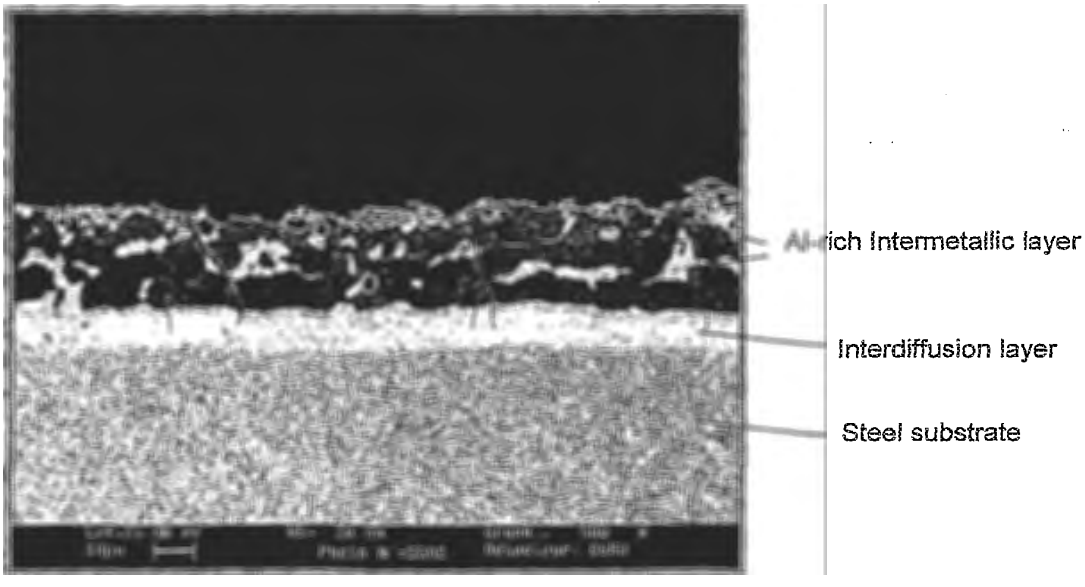
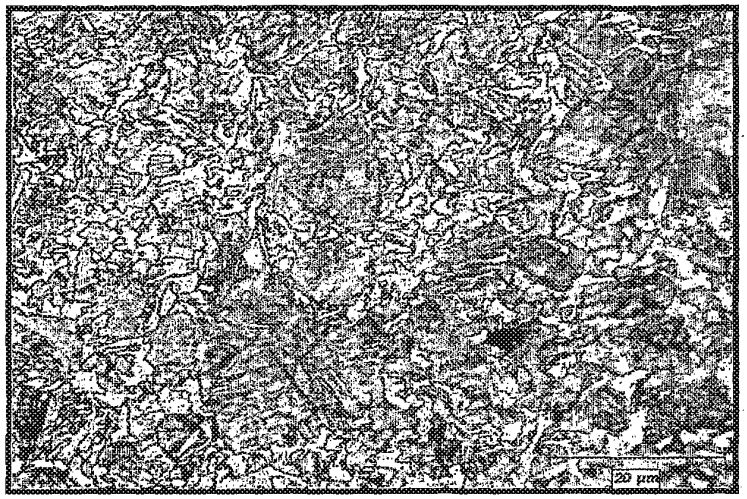
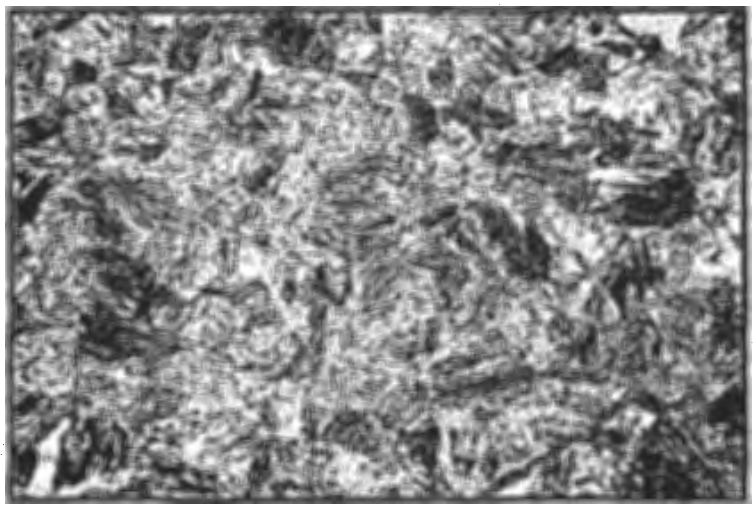

Al-rich Intermetallic layer
Interdiffusion layer
Steel substrate
10µm

Fig.2



10µm

Fig. 3



10 µm

Fig. 4

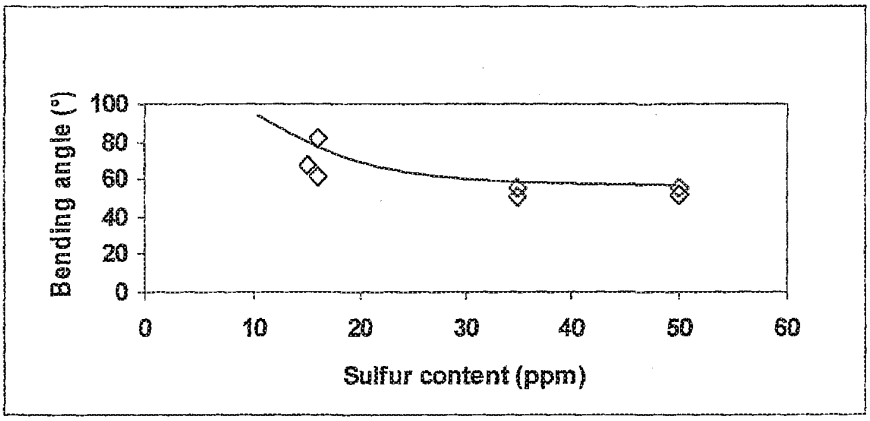

Bending angle (°)
100
80
60
40
20
0
0
10
20
30
40
50
60
Sulfur content (ppm)

Fig. 5

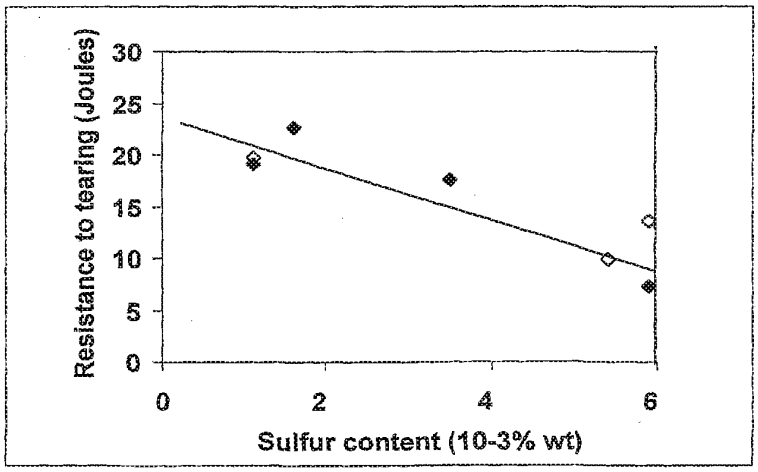

Resistance to tearing (Joules)
30
25
20
15
10
5
0
0
2
4
6
Sulfur content (10-3% wt)

Fig. 6

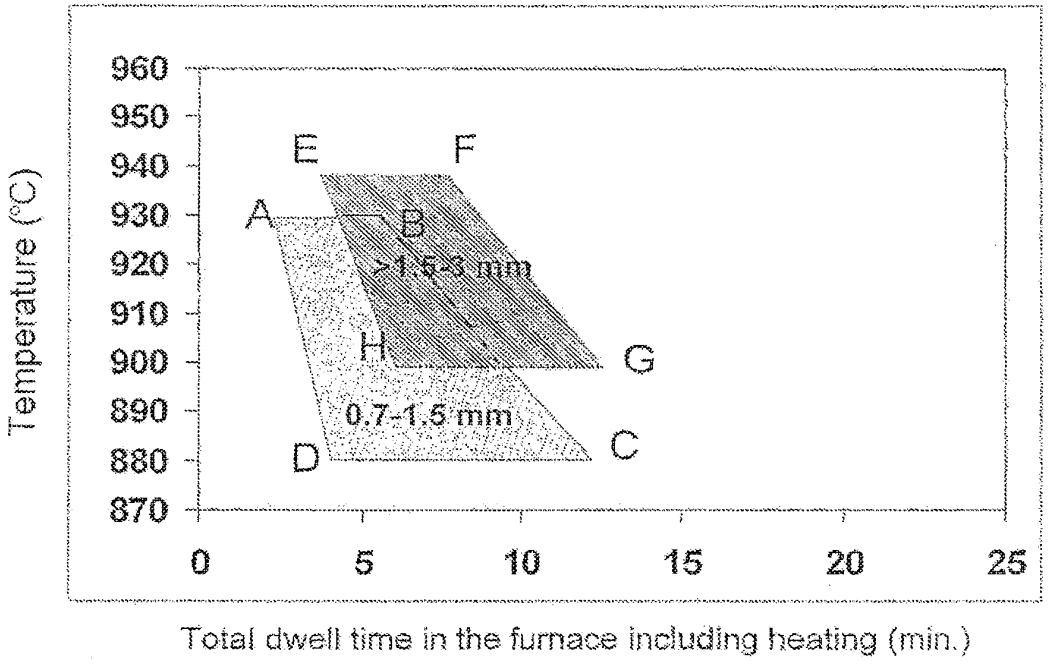

960
950
940
930
920
910
900
890
880
870
Temperature (°C)
0
5
10
15
20
25
Total dwell time in the furnace including heating (min.)
A
B
C
D
E
F
G
H
>1.5-3 mm
0.7-1.5 mm

Fig. 7

ABSTRACT

A pre-coated steel strip is provided. The steel strip includesa strip of base steel having a length, a width, a first side, and a second side. The length of the strip is at least 100m and the width is at least 600mm. An aluminum or an aluminum alloy pre-coating is on at least part of at least one of the first or second sides of the strip of base steel. A thickness t_p of the pre-coating is from 20 to 33 micrometers at every location on at least one of the first or second sides. Processes, coated stamped products and land motor vehicles are also provided.

What is claimed is:

1. A pre-coated steel strip, comprising:

(a) a strip of base steel having a length, a width, a first side, and a second side;

(b) said length of said strip of base steel being at least 100m and said width being at least 600mm, and

(c) an aluminum or an aluminum alloy pre-coating on at least part of one of said first and second sides of said strip of base steel,

wherein a thickness t_p of said pre-coating is from 20 to 33 micrometers at every location on at least one of said first and second sides.

2. A method for making a pre-coated steel strip according to claim 1, wherein the pre-coated steel strip has a thickness of not greater than 3 mm.

3. A process for making a hot stamped coated steel sheet product, comprising:

(A) heating an aluminum- or aluminum alloy pre-coated steel sheet in a furnace preheated to a temperature and during a time defined by trapezoid ABCD having heating time, temperature coordinates of about A (3 minutes, 930°C), B (6 minutes, 930 °C), C (13 minutes, 880 °C) and D (4.5 minutes, 880°C) if thickness of said sheet is greater than or equal to 0.7mm and less than or equal to 1.5mm, and by trapezoid EFGH having heating time, temperature coordinates of about E (4 minutes, 940°C), F (8 minutes, 940°C), G (13 minutes, 900°C), and H (6.5 minutes, 900°C) if thickness of said sheet is greater than 1.5mm and less than or equal to 3mm, at a heating rate V_c between 20 and 700°C comprised between 4 and 12°C/s, to obtain a heated blank;

(B) transferring said heated blank to a die; and

(C) stamping said heated blank in said die, to thereby obtain a hot stamped steel sheet product,

wherein the said heated product is cooled at a rate of at least 50°C/s during an interval between when said product exits said furnace and when said product reaches 400°C.

4. A process according to claim 3, wherein said heated blank is deformed by a quantity higher than 10% during said stamping.

5. A process according to claim 3, wherein the elapsed time between said heated blank exits said furnace and said stamping commences is not more than 10 seconds.

6. A process for making a hot stamped coated steel sheet product, comprising : hot dip pre-coating a steel strip having a first side and a second side with aluminum or aluminum alloy to obtain a pre-coated steel strip, the pre-coating thickness on at least one of said first side and said second side of said strip having a thickness of from 20 to 33 μm at every location on at least one of said first and second sides of said strip;

cutting said pre-coated steel strip to obtain a sheet;

heating the sheet in a pre-heated furnace to obtain a heated blank in which the steel is austenitic;

transferring said heated blank to a die while maintaining said steel in the austenitic phase; and

stamping said heated blank in a die to obtain a hot stamped steel sheet product in which the steel microstructure is martensitic.

7. A hot stamped coated steel sheet product, which is prepared by a process comprising:

(A) providing a pre-coated strip according to claim 1, said strip being pre-coated with aluminum or aluminum alloy ;

(B) cutting said pre-coated steel strip to a predetermined size and shape to obtain a sheet ;

(C) heating said steel sheet in a furnace preheated to a temperature and during a time defined by trapezoid ABCD having heating time, temperature coordinates of about A (3 minutes, 930°C), B (6 minutes, 930 °C), C (13 minutes, 880 °C) and D (4.5 minutes, 880°C) if thickness of said product is greater than or equal to 0.7mm and less than or equal to 1.5mm, and by trapezoid EFGH having heating time, temperature coordinates of about E (4 minutes, 940°C), F (8 minutes, 940°C), G (13 minutes, 900°C), and H (6.5 minutes, 900°C) if thickness of said product is greater than 1.5mm and less than or equal to 3mm, to obtain a heated blank;

(D) transferring said heated blank to a die; and

(E) stamping said heated blank in said die, to thereby obtain a hot stamped steel sheet product,

wherein the elapsed time between said heated blank exits said furnace and said stamping commences is not more than 10 seconds, and wherein said heated product cools at a rate higher than 30°C/s during said stamping.

8. A process for making a hot stamped coated steel sheet product, comprising:

(A) providing a heated blank according to claim 7 ;

(B) transferring said heated blank to a die; and

(C) stamping said heated blank in said die, to thereby obtain a hot stamped steel sheet product,

wherein the elapsed time between said heated blank exits said furnace and said stamping commences is not more than 10 seconds, and wherein said heated product cools at such a rate during said stamping that the steel microstructure is martensitic.

9. The pre-coated steel strip according to claim 1, wherein the base steel comprises the following components by weight based on total weight:

0.15%<carbon<0.5%;

0.5%<manganese<3%;

0.1 %<silicon<0.5%;

0.01 %<chromium<1%;

titanium<0.2%;

aluminum<0.1%;

phosphorus<0.1 %;

sulfur<0.05%;

0.0005%<boron<0.08%;

iron; and

impurities inherent in processing.

10. The pre-coated steel strip according to claim 9, wherein the base steel comprises the following components by weight based on total weight:

0.20%<carbon<0.5%;

0.8%<manganese<1.5%;

0.1%<silicon<0.35%;

0.01%<chromium<1%;

titanium<0.1%;

aluminum<0.1%;

phosphorus<0.05%;

sulfur<0.03%;

0.0005%<boron<0.01%,

iron;

and impurities inherent in processing.

11. The pre-coated steel strip according to claim 9, wherein the base steel comprises 20 ppm or less of sulfur.

12. The pre-coated steel strip according to claim 9, wherein the ratio of titanium to nitrogen in the steel sheet in weight % is in excess of 3.42.

13. The pre-coated steel strip according to claim 1 , wherein the aluminum or aluminum alloy pre-coating comprises from 8% to 11% silicon by weight, from 2% to 4% iron by weight, the remainder being aluminum and impurities inherent in processing.

14. The pre-coated steel strip according to claim 9, wherein the aluminum or aluminum alloy pre-coating comprises from 8% to 11% silicon by weight, from 2% to 4% iron by weight, the remainder being aluminum and impurities inherent in processing.

15. A coated steel stamped product, which comprises:

(a) a strip of base steel having a first side and a second side; and

(b) a coating on at least one of said first side of said strip of base steel and said second side of said strip of base steel, wherein:

(i) said coating results from the interdiffusion between said base steel and aluminium or aluminium alloy pre-coating, and

(ii) said coating comprises, proceeding from base steel outwards,

(1) Interdiffusion layer

(2) Intermediate layer

(3) Intermetallic layer

(4) Superficial layer.

wherein said coating has a thickness greater than 30 micrometers

16. A coated steel stamped product according to claim 15, wherein said layer (1) has a thickness less than 15 micrometers

17. A coated steel stamped product according to claim 15, wherein the said layers (3) and (4) are occupying at least 90% of the level corresponding to the considered said layers and wherein less than 10% of layer (3) is present at the extreme surface of the product

18. A coated steel stamped product according to claim 15, wherein the steel in the strip has a composition according to claim 9.

19. A coated steel stamped product according to claim 15, wherein the steel in the strip has a composition according to claim 10.

20. A coated steel stamped product according to claim 15, wherein the steel has a composition according to claim 11.

21. A coated steel stamped product according to claim 15, wherein the steel has a composition according to claim 12.

22. A coated steel stamped product according to claim 15, the aluminum or aluminum alloy pre-coating comprises from 8% to 11% silicon by weight, from 2% to 4% iron by weight, the remainder being aluminum and impurities inherent in processing.

23. A land motor vehicle comprising the heat treated coated steel product according to claim 7 or 15.

24. A land motor vehicle comprising the heat treated coated steel product produced according to claim 3, 6 or 8.

Coated Steel Strips, Coated Stamped Products and Methods

CROSS REFERENCE TO RELATED APPLICATIONS

[0000.1] This is a Continuation of U.S. Patent Application No. 13/621,015, filed September 15, 2012 which is a Divisional of U.S. Patent Application No. 12/447,777, filed April 29, 2009, which is a National Phase Application of International Patent Application PCT/IB06/004019, filed October 30, 2006. All of the above patent applications are hereby incorporated by reference herein.

[0001] The present invention relates to, among other things, coated steels, methods of making such coated steels, including hot dipping, methods of using such coated steels, stamping blanks prepared from coated steels, stamped products prepared from coated steels, and to various uses of the invention products such as in spot welding, etc.

[0002] Additional advantages and other features of the present invention will be set forth in part in the description that follows and in part will become apparent to those having ordinary skill in the art upon examination of the following or may be learned from the practice of the present invention. The advantages of the present invention may be realized and obtained as particularly pointed out in the appended claims. As will be realized, the present invention is capable of other and different embodiments, and its several details are capable of modifications in various obvious respects, all without departing from the present invention. The description is to be regarded as illustrative in nature, and not as restrictive.

BACKGROUND OF THE INVENTION

[0003] In recent years the use of pre-coated steels in hot-stamping processes for the shaping of parts has become important, especially in the automotive industry. Fabrication of such parts may include the following main steps:

[0004] Pre-coating of a steel sheets, by hot dipping;

[0005] Trimming or cutting for obtaining blanks;

[0006] Heating the blanks in order to obtain alloying of the steel substrate with the pre-coating, as well as the austenitizing of the steel; and

[0007] Hot forming followed by rapid cooling of the part in order to obtain predominantly martensitic structures. See for Example U.S. Pat. No. 6,296,805, incorporated herein by reference.

[0008] Thanks to an alloying of the pre-coating with the steel substrate, which has the effect of creating intermetallic alloys with high melting temperature, the blanks having such coating may be heated in a temperature range where austenitizing of the metallic substrate takes place, allowing further hardening by quenching.

[0009] Heat treatments of the blanks in view of the intermetallic alloying of the coating and austenitizing of the substrate are most frequently performed in furnaces, where blanks are traveling on rollers. The thermal cycles experienced by the blanks include first a heating phase whose rate is a function of parameters such as blank thickness, furnace temperature, traveling speed, and coating reflectivity. After this heating phase, thermal cycles generally include a holding phase, whose temperature is the regulation temperature of the furnace. Problems however are experienced with the furnace operation: the rollers may become fouled by metallic deposits which come from the pre-coating of the blanks. If these deposits are excessive, maintenance of the rollers has to be performed and productivity is decreased.

[0010] Parts obtained after heating and rapid cooling display very high mechanical resistance and may be used for structural applications, for example for automotive industry applications. These parts must be frequently welded with others and high weldability is required. This means that:

[0011] The welding operation should be performable in a sufficiently wide operating range in order to guarantee that an eventual drift of the nominal welding parameters has no incidence on weld quality. For resistance welding, which is very common in the automotive industry, an operating welding range is defined by the combination of parameters: welding current intensity I and force F applied of the parts during welding being among the most important. A proper combination of these parameters helps to ensure that insufficient nugget diameter is not obtained (caused by too low intensity or too low force) and that no weld expulsion occurs.

[0012] The welding operation should also be performed in such a way that high mechanical resistance is obtained on the weld. This mechanical resistance may be evaluated by tests such as by shear-tensile tests or cross-tensile tests.

SUMMARY OF THE INVENTION

[0013] There remains a need for coated steels which may be conveniently used to prepare shaped parts by a stamping process. There also remains a need for coated steels which may be used to prepare shaped parts by a stamping process which are suitable for welding. There also remains a need for processes for preparing such coated steels and stamped parts.

[0014] The inventors have discovered that certain coated steels in which a base steel strip is at least partially coated (sometimes termed "pre-coated," this prefix indicating that a transformation of the nature of the pre-coating will take place during heat treatment before stamping) on at least one side with a coating of either aluminum or an aluminum alloy and in which the coating has a defined thickness and is preferably substantially uniform, are conveniently formed into shaped parts after heating by stamping and are conveniently welded. In addition, the inventors have discovered that the roller fouling problem described above generally arises from an insufficient degree of intermetallic alloying between the substrate and the metallic pre-coating. Furthermore, it was discovered that the location of the fouling of the rollers corresponds to zones of the blanks in contact with the rollers where the metallic pre-coating thickness locally exceeds the average thickness. While not bound by a particular theory, it is believed that if a pre-coating is locally too thick, intermetallic alloying is insufficient and the pre-coating melts, fouling the rollers. Thus, the inventors have discovered that the control of the homogeneity of the pre-coating thickness over the entire sheet within given tolerances is an important factor for obtaining the desired degree of intermetallic alloying, allowing one to improve the resistance to the subsequent melting of the coating during travel on rollers.

[0015] The inventors have also discovered that particularly good weldability of aluminized and hot stamped parts is associated with a special succession of coating layers on the parts, proceeding from steel substrate outwards.

[0016] The inventors have also discovered that a specific combination of transfer time between the heating furnace and the stamping die, the amount of deformation during stamping, the temperature of stamping, the cooling rate of the product during stamping, leads to the fabrication of a part with a fully homogeneous martensitic structure and that an increase in ductility or energy absorption of the parts after stamping is obtained by a reduction of sulfur below a critical value, these two benefits being obtained with or without the invention aluminum/aluminum alloy coating, and with other coatings.

[0017] Accordingly, and in view of the above, it is one object of the present invention to provide novel pre-coated steels strips which may be conveniently processed into stamping blanks.

[0018] It is another object of the present invention to provide novel pre-coated steels strips or sheets which may be conveniently formed into parts by stamping.

[0019] It is another object of the present invention to provide novel coated steels which may be conveniently formed into parts by hot stamping.

[0020] It is another object of the present invention to provide novel methods for making such a coated steel.

[0021] It is another object of the present invention to provide novel stamping blanks which are prepared from such a coated steel.

[0022] It is another object of the present invention to provide novel methods of making such stamping blanks.

[0023] It is another object of the present invention to provide novel stamped parts which are prepared from such a coated steel.

[0024] It is another object of the present invention to provide novel methods of making such stamped parts.

[0025] It is another object of the present invention to provide novel articles of manufacture, such as a motor vehicle, which contain such stamped parts.

[0026] It is another object of the present invention to provide novel stamped parts.

[0027] It is another object of the present invention to provide novel methods of making welded stamped parts.

[0028] It is another object of the present invention to provide novel articles of manufacture, such as a motor vehicle, which contain such welded stamped parts.

[0029] It is another object of the present invention to provide novel welded coated steels and welded stamping blanks.

[0030] It is another object of the present invention to provide novel methods of making such welded coated steels and welded stamping blanks.

[0031] These and other objects, which will become apparent during the following detailed description.

BRIEF DESCRIPTION OF THE DRAWINGS

[0032] FIG. 1 illustrates a preferred embodiment of an invention coated part, after heat treatment and stamping. The succession of layers of the coating on the steel substrate is: (a) interdiffusion layer; (b) intermediate layer; (c) Intermetallic layer; and (d) superficial layer. This arrangement is particularly favorable for the further welding of the part.

[0033] FIG. 2 illustrates a coating of a steel substrate after heat treatment and stamping which does not correspond to the invention. This succession of layers (interdiffusion layer and intermetallic layer) yields inferior results in resistance spot welding.

[0034] FIG. 3 illustrates a microstructure of a steel part, hot stamped and cooled under

conditions not according to the invention.

[0035] FIG. 4 illustrates the microstructure of a steel part, hot stamped and cooled according to a preferred set of conditions according to the invention.

[0036] FIG. 5 illustrates the influence of sulfur on the bending angle of parts after hot stamping.

[0037] FIG. 6 illustrates the influence of sulfur on the initiation energy of fracture of parts after hot stamping.

[0038] FIG. 7 shows conditions of furnace temperature as a function of the total dwell time in the furnace for sheets of total thicknesses of from 0.7-1.5 and 1.5-3 mm that provide particularly favorable coatings for welding.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0039] As noted above, the inventors' discovery that certain coated steels, in which a base steel is at least partially pre-coated on at least one side with a coating of either aluminum or an aluminum alloy and in which the pre-coating has a defined thickness and is substantially uniform, are conveniently formed into shaped parts by stamping, forms one basis for the invention.

[0040] In the context of the present invention, the terms first side (or side 1) and second side (or side 2) of the strip or sheet, etc., of base steel refer to the two large, opposite-facing, surfaces which have a surface area defined by the length and width of the strip of base steel. In contrast, the side edges of the strip of base steel are the two small, opposite-facing, surfaces which have a surface area defined by the length and thickness of the strip. The top and bottom edges of the strip of base steel are the two small, opposite-facing, surfaces which have a surface area defined by the width and thickness of the strip. In the following, t_p designates the thickness of the pre-coating, at any considered location on the sides 1 and 2 of a sheet or a blank. In particular, in the case of sheets coated on two sides 1 and 2, t_{p1} stands for the thickness on side 1, and t_{p2} for the thickness on side 2.

According to a highly preferred embodiment t_p is controlled in a precise range, expressed by (t_{pmin}, t_{pmax}), in order to improve the resistance to the fouling of the rollers. The thickness is preferably controlled, both in the longitudinal (or rolling) direction of the strip or sheet, as well in the transverse direction.

[0041] In relation to the problem of the fouling of rollers, the control of the pre-coating thickness on the side of the sheet or blank which is directly in contact with the rollers is especially important. Because different operations can follow the step of coating the steel sheet (for example hot-dip-coating which provides coated sides 1 and 2), it is preferable to carefully control the pre-coating on both sides of the sheet. For example, after any of coiling, handling, cutting, punching, etc., sides 1 and 2 may be not readily identifiable. But when control of t_p is effected on the two sides of the sheet that has been coated (first side and second side) it is not necessary to track sides 1 and 2 as neither side will foul the roller. In addition, it is not necessary to trim the sheet in order to obtain a preferred smaller sheet having a more uniform homogeneity of pre-coating thickness, thus providing a sheet that is pre-coated by, e.g., hot-dipping. In other words, important benefits are obtained when one controls the pre-coating minimum and maximum thickness of the first side (t_{pmin1}, t_{pmax1}) and the pre-coating minimum and maximum thickness of the second side (t_{pmin2}, t_{pmax2}) of the subject steel sheet or blank.

[0039.1] Hot-dip coated steels are the preferred steels herein. However, regardless of the coating method, the pre-coating thickness on one or both sides of the sheet can be measured and monitored continuously on a coating line directly after the coating operation. This may be realized by devices known per se, such as thickness gages relying on X-Ray absorption. At every moment, the measurement of thickness at a given location may be performed for example on an area of a few hundreds of mm.sup.2, this representing the dimension of the zone irradiated by X-Ray.

[0042] In a preferred embodiment, a plurality of such devices are positioned at different distances in the transverse direction of the strip in order to obtain a profile of the thickness of the pre-coating along the strip width.

[0043] The inventors have discovered that the resistance to the pollution or fouling of the rollers in the furnaces is improved when the minimum and maximum thickness respectively of at least one of the first side (t_{pmin1}, t_{pmax1}) and the second side (t_{pmin2}, t_{pmax2}) are respectively equal to 20 and 33 micrometers (a micrometer is the same as a micron and is a metric unit of length equal to one millionth of a meter). In other words, in a preferred embodiment, at every location on at least one face of the sheet or the blank, the thickness t_p of the pre-coating is preferably from 20-33 micrometers in thickness, including 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31 and 32 micrometers and all ranges and subranges therebetween, and including all numbers between each listed value as if written out in its entirety (e.g., 22.34 micrometers). For hot-dip coating, precise control of this range of pre-coating thickness can be realized on an operating line for example using a system of nozzles blowing gas after coating, for example after exit of the strip or sheet from a bath, and by the flatness of the strip. Number, geometry and location of the nozzles, and flow rates are among the main parameters for a precise control of the thickness t_p. Given the present disclosure, one of ordinary skill in this art can control the pre-coating thickness as described herein without undue labor.

[0044] The invention refers to strips produced in industrial conditions, i.e. where control of pre-coating thickness is effective over a wide surface strip, i.e. with a length greater than 100 m, and with a width greater than 600 mm. In such a way, blanks cut or trimmed out these strips display very high homogeneity of pre-coating thickness, and the settings of the heating treatments in the furnace do not have to be changed for being adapted to eventual variations of this thickness.

[0045] While not bound by a particular theory of operation, the inventors believe that several of the benefits of the invention are related to this pre- coating thickness range, such as the following:

[0046] For a pre-coating thickness less than 20 micrometers, the alloyed layer which is formed during the heating of the blank has an insufficient roughness. Thus, the adhesion of subsequent painting is low on this surface, and the corrosion resistance is decreased.

[0047] If the pre-coating thickness is more than 33 micrometers at a given location on a sheet,

the risk is that the difference of thickness between this location and some other locations where the pre-coating is thinner, becomes too important: The settings of the heating treatment in the furnace may be adapted to the thinner value of the pre-coating, but not to the thicker one. Thus, the alloying reaction forming the intermetallic alloy may take place to an insufficient degree since the mean diffusion distance of the elements in the pre-coating becomes significantly less than the local value of the pre-coating thickness. As a matter of results, alloying will become much more difficult in the external (or superficial) part, particularly in the case of high heating rate.

[0048] Thus, in a first embodiment, the present invention provides certain coated steel strips, which comprise a strip of base steel and a pre-coating of aluminum or an aluminum alloy on at least a part of one side of the strip of the base steel. For many applications, the strip of base steel may comprise any type of steel which may be coated with either aluminum or an aluminum alloy. However, for certain applications, such as a structural part of an automobile, it is preferred that the strip of base steel comprise an ultra high strength steel (UHSS). In such cases, it is particularly preferred that the strip of base steel comprises a boron steel.

[0049] The inventors have also discovered that good welding results are achieved if the coating obtained on parts made out of blanks having undergone intermetallic alloying, austenitizing and hot stamping, displays distinctive features. It must be pointed out that this coating is different from the initial pre-coating, since the thermal treatment causes an alloying reaction with the steel substrate which modifies both the physico-chemical nature and the geometry of the pre-coating: in this regard, the inventors have discovered that particularly good weldability of aluminized and hot stamped parts is associated with the following succession of coating layers on the parts, proceeding from steel substrate outwards:

[0050] (a) Interdiffusion layer,

[0051] (b) Intermediate layer,

[0052] (c) Intermetallic layer,

[0053] (d) Superficial layer See, e.g., FIG. 1. In a preferred embodiment these layers are as follows:

[0054] (a) Interdiffusion layer, preferably with medium hardness (e.g., HV50g between 290 and 410, HV50g designating the hardness measured under a load of 50 grams) In a preferred embodiment this layer has the following composition, by weight: 86-95% Fe, 4-10% Al, 0-5% Si

[0055] (b) Intermediate layer (HV50g around 900-1000 e.g., +/-10%)) In a preferred embodiment this layer has the following composition, by weight: 39-47% Fe, 53-61% Al, 0-2% Si

[0056] (c) Intermetallic layer, with hardness HV50g around 580-650, e.g., +/-10%) In a preferred embodiment this layer has the following composition, by weight: 62-67% Fe, 30-34% Al, 2-6% Si

[0057] (d) Superficial layer (HV50g around 900-1000 e.g., +/-10%)) In a preferred embodiment this layer has the following composition, by weight: 39-47% Fe, 53-61% Al, 0-2% In a preferred embodiment the total thickness of layers (a) to (d) is greater than 30 micrometers. In another preferred embodiment, the thickness of layer (a) is less than 15 micrometers, for example 14, 12, 10, 8, 6, 4, 2, or 1 micrometers, and all whole numbers, ranges and subranges therebetween, and including all numbers between each listed value as if written out in its entirety (e.g., 13.84 micrometers).

[0058] The inventors have discovered that high weldability is especially obtained when layers (c) and (d) are essentially continuous (i.e.: occupying at least 90% of the level corresponding to the considered layer) and when less than 10% of layer (c) is present at the extreme surface of the part. Without being bound by a theory, it is thought that this particular layer disposal, in particular layer (a) and, layers (c) and (d) influence the resistivity of the coating both by their intrinsic characteristics and by the effect of roughness. Thus, current flow, heat generation at the surfaces, and nugget formation in the initial stage of spot welding are affected by this particular arrangement. This favorable layer disposition is obtained for example when aluminum- or aluminum alloy pre-coated steel sheets, whose thickness range from, e.g., 0.7 to 3 mm, are heated for 3 to 13 minutes (this dwell time includes the heating phase and the holding time) in a furnace heated to a temperature of 880 to 940° C. Other conditions leading to such favorable layer dispositions are found in FIG. 7:

[0059] For sheets of total thicknesses greater or equal to 0.7 mm, and less than or equal to 1.5

mm, the preferred treatment conditions: (furnace temperature, total dwell time in the furnace) are illustrated in FIG. 7 by conditions lying within the limits of diagram "ABCD"

For sheets of total thicknesses greater than 1.5 mm, and less than or equal to 3 mm, the preferred treatment conditions: (furnace temperature, total dwell time in the furnace) are illustrated in FIG. 7 by diagram "EFGH". The heating rate V_c is comprised between 4 and 12° C./s for producing a favorable alloyed layer disposition. In this regard, this "heating rate" reflects the temperature rise which is experienced by the pre-coated steel upon being located in the preheated furnace. V_c is defined as the mean heating rate between 20 and 700° C. The inventors have discovered that the control of V_c in this precise range is a key factor, because it controls directly the nature and the morphology of the alloyed layers which are formed. It is here underlined that the heating rate V_c is different from the mean heating rate, which is the heating rate between room temperature and furnace temperature. The rates of 6, 7, 8, 9, 10, and 11° C./s are included as are all numbers, ranges and subranges therebetween, and including all numbers between each listed value as if written out in its entirety (e.g., 7.7° C./s). In this regard, all of the conditions specified within FIG. 7 are incorporated herein by reference thereto. Particularly preferred conditions are:

[0060] (for thicknesses of 0.7-1.5 mm)

[0061] 930° C., from 3 minutes up to 6 minutes;

[0062] 880° C., from 4 minutes 30 seconds up to 13 minutes (for thicknesses of 1.5 to 3 mm)

[0063] 940° C., from 4 minutes up to 8 minutes;

[0064] 900° C., from 6 minutes 30 seconds up to 13 minutes.

[0064.1]A special advantage arises from pre-coatings whose thickness is comprised between 20 and 33 micrometers, since this thickness range yields favorable layer disposal, and since the homogeneity of the pre-coating thickness is associated to an homogeneity of the coating formed after alliation treatment.

[0065] Heated blanks are thereafter transferred to a die, hot stamped to obtain a part or product, and cooled at a rate of more than 30.degree. C./s. The cooling rate is defined here as the mean rate between the exit of the heated blank from the furnace, down to 400° C.

[0066] The strip of base steel is coated with either aluminum or an aluminum alloy. Commercially pure aluminum is known in the art as Type 2 aluminum, while alloys of aluminum

with 5 to 11% by weight of silicon are known in the art as Type 1 aluminum. Silicon is present in order to prevent the formation of a thick iron-metallic intermetallic layer which reduces adherence and formability. Other alloying elements useful with aluminum herein include iron, between 2.5 and 3% by weight, and calcium, between 15 and 30 ppm by weight, including combinations of two or more thereof with aluminum.

[0067] A typical metal bath for an Al--Si coating generally contains in its basic composition by weight, from 8% to 11% silicon, from 2% to 4% iron, the remainder being aluminum or aluminum alloy, and impurities inherent in processing. Typical composition of Al--Si coating is: Al-9.3% Si-2.8% Fe. Invention coatings are not limited to these compositions, however.

[0068] The strip of base steel used herein may be any which can be coated by a conventional coating technique. For example, the strip of base steel may be any hot rolled strip, such as those prepared by hot rolling a steel slab (either with or without subsequent cold rolling). Typically, the strip of base steel will be stored and transported in the form of a coil both before and after the formation of the coating.

[0069] An example of a preferred steel for the strip of base steel is one having the following composition by weight:

[0070] 0.10%<carbon<0.5%

[0071] 0.5%<manganese<3%

[0072] 0.1%<silicon<1%

[0073] 0.01%<chromium<1%

[0074] titanium<0.2%

[0075] aluminum<0.1%

[0076] phosphorus<0.1%

[0077] sulfur<0.05%

[0078] 0.0005%<boron<0.010%, the remainder comprising, consisting essentially of, or consisting of iron and impurities inherent in processing. Use of such a steel provides a very high mechanical resistance after thermal treatment and the aluminum-based coating provides a high resistance to corrosion.

[0079] Particularly preferably, the composition by weight of the steel in the strip of base steel is the following:

[0080] 0.15%<carbon<0.25%

[0081] 0.8%<manganese<1.8%

[0082] 0.1%<silicon<0.35%

[0083] 0.01%<chromium<0.5%

[0084] titanium<0.1%

[0085] aluminum<0.1%

[0086] phosphorus<0.1%

[0087] sulfur<0.05%

[0088] 0.002%<boron<0.005%, the remainder comprising, consisting essentially of, or consisting of iron and impurities inherent in processing.

[0089] A preferred strip herein is 100 m long and 600 mm wide. Preferred thicknesses are 0.7 to 3 mm.

[0090] Even more preferably, in the composition by weight of the sheet, the weight ratio of titanium content with respect to the nitrogen content is in excess of 3.42, believed to be a level at which the boron is no longer able to combine with the nitrogen.

[0091] An example of preferred commercially available steel for use in the strip of base steel is 22MnB5.

[0092] Chromium, manganese, boron and carbon may be added, in the composition of the steel according to the invention, for their effect on hardenability. In addition, carbon makes it possible to achieve high mechanical characteristics thanks to its effect on the hardness of the martensite.

[0093] Aluminum is introduced into the composition, to perform deoxidation in the liquid state and to protect the effectiveness of the boron.

[0094] Titanium, the ratio of the content of which with respect to the nitrogen content should be in excess of 3.42, is introduced for example in order to prevent combining of the boron with the nitrogen, the nitrogen being combined with titanium.

[0095] The alloying elements, Mn, Cr, B, make possible a hardenability allowing hardening in the stamping tools or the use of mild hardening fluids limiting deformation of the parts at the time of thermal treatment. In addition, the composition according to the invention is optimized from the point of view of weldability.

[0096] The steel in the sheet may undergo a treatment for globularization of sulfides performed with calcium, which has the effect of improving the fatigue resistance of the sheet.

[0097] As mentioned above, ultra-high-strength can be provided with the steel sheet coated and hot stamped according to the invention. This high level of strength is sometimes associated with a limited ductility. In applications requiring a higher ductility, in particular when an ability for bending is required from a part or a product, the inventors have discovered that increased ductility can be obtained if sulfur is particularly controlled: when the sulfur level of base steel is lower than or equal to 0.002% (20 ppm), the bending angle can be greater than 60° and enhanced ductility and tearing resistance are obtained on the parts having experienced heat treatment and stamping. Preferred levels include 20, 18, 15, 13, 10, 8, 5, 2, etc ppm sulfur. In fact, this benefit applies to steels in general, and is not limited to coated steels or to steels coated with Al or Al alloy coatings. While not bound by a particular theory, when analyzing causes of premature failure of some parts in bending operations, the inventors observed that failure initiated on sulfide inclusions. It is thus believed that decohesions between inclusions and the martensitic or bainito-martensitic matrix act as stress-concentration factors and trigger further crack propagation in the ductile mode.

[0098] The invention also concerns a process for producing a part starting from an invention coated sheet, then cut into a blank which, after shaping, the coating of the blank is subjected to an increase in temperature at a speed in excess of 4° C./second, but lower than 12° C./second. The heating rate V_c is defined as the mean rate between 20 and 700° C.

[0099] The invention also concerns the use of a hot-rolled steel sheet which then can be cold-rolled and coated, for structural and/or anti-intrusion or substructure parts for a land motor vehicle, such as, for example, a bumper bar, a door reinforcement, a wheel spoke, etc.

[0100] The sheet according to the invention described above can derive, by reason of its processing, from a hot-rolling mill, and possibly may be cold-rerolled again depending on the final thickness desired. It then is coated with an aluminum-based coating, for example by dipping in a bath containing, in addition to the aluminum source/alloy, e.g., from 8% to 11% silicon and from 2% to 4% iron, the sheet having a high mechanical resistance after thermal treatment and a high resistance to corrosion, as well as a good capacity for painting and gluing.

[0101] The coating is preferably controlled as above, and has in particular the function of protecting the basic sheet against corrosion in various conditions. The thermal treatment applied at the time of a hot-forming process or after forming makes it possible to obtain high mechanical characteristics which can exceed 1500 MPa for mechanical resistance and 1200 MPa for yield stress. The final mechanical characteristics are adjustable and depend in particular on the martensite fraction of the structure, on the carbon content of the steel and on the thermal treatment. At the time of thermal treatment performed on a finished part or at the time of a hot-shaping process, the coating forms a layer having a substantial resistance to abrasion, wear, fatigue, shock, as well as a good resistance to corrosion and a good capacity for painting and gluing. The coating makes it possible to avoid different surface-preparation operations such as for steel sheets for thermal treatment not having any coating.

[0102] The steel sheet can be pre-coated by dipping, after pickling, in an aluminum bath containing for example only aluminum or either aluminum and from 8% to 11% silicon and 2% to 4% iron, or only from 2% to 4% iron, or even in an aluminum bath preferably containing from 9% to 10% silicon and 2% to 3.5% iron. The aluminum may be aluminum per se or an aluminum alloy.

[0103] In an example of implementation of a coating of the sheet by dipping in a metal bath containing an aluminum alloy comprising a proportion of approximately 90% aluminum, the

coating layer comprises a first alloy layer in contact with the surface of the steel. This layer, directly in contact with the surface of the sheet, is highly alloyed with iron.

[0104] A second coating layer, on top of the first, contains approximately 90% aluminum and may contain silicon and a small amount of iron, depending on the composition of the bath.

[0105] The first alloy layer may crack when the sheet is submitted to high strains during cold forming operations of the manufacture of parts.

[0106] According to the invention, after the forming of the part, the coating is subjected to an increase in temperature at a speed in excess of 4° C./second. This rise in temperature makes possible a rapid remelting of the aluminum which fills in the cracks generated by the operation of shaping of the part.

[0107] At the time of thermal treatment, the base coating, of aluminum for example, is transformed into a layer alloyed with iron and comprising different phases depending on the thermal treatment and having a considerable hardness which may exceed 600 HV50 g.

[0108] Another advantage of the invention lies in the fact that the diffusion of the iron in the coating is initiated at high temperature. One thus will have a better cohesion between coating and steel in the sheet. In another form of the invention, the thermal treatment may be performed locally, in heavily deformed zones.
According to the invention, the sheet, in the delivery state in a coil or in a is sheet, the thickness of which may range between 0.25 mm and 15 mm, has good forming properties and a good resistance to corrosion as well as a good capacity for painting or gluing. Preferably, the steel sheet or blank has a thickness less than 3 mm, since the cooling rates that may be achieved after quenching are high and help to obtain martensitic structures.

[0109] The steel sheet, a coated product, has a substantial resistance to corrosion in the delivery state, during forming and thermal treatments as well as during usage of the finished part. The presence of the coating at the time of thermal treatment of the parts makes it possible to prevent

any decarburization of the base metal as well as any oxidation. That is an undeniable advantage, in particular in the case of hot forming. Furthermore, heating of the treated part does not require a furnace having a controlled atmosphere to prevent a decarburization.

[0110] Thermal treatment of the metal in the sheet comprising heating at a temperature ranging between Ac1, starting temperature of austenitic transformation when heating, for example 750° C. and 1200° C., in a furnace, for a period which depends on the temperature to be reached and the thickness of the blank. The composition is optimized so as to limit the grain growth at the time of thermal treatment. If the structure sought is completely martensitic, the holding temperature should be in excess of Ac3, for example 840° C., temperature of complete austenitic transformation. The temperature holding should be followed by a cooling adjusted to the final structure sought.

[0111] Blanks are thereafter transferred from the furnace to a stamping press. When the elapsed time between the exit of the blanks from the furnace and the introduction in the stamping press is more 10 seconds, a partial transformation from austenite is susceptible to appear: if obtaining a full martensitic structure is desired, the transfer time between the exit of the furnace and stamping should be less than 10 s.

[0112] The inventors have also discovered that the obtaining of a fully martensitic structure is linked to the amount of deformation in the hot forming operation: the amount of local deformation caused by hot forming is closely linked to the shape of the part or product and may exceed locally 40 or 50% in some particular regions. The inventors found that, when the local strain exceeds a critical value of 10%, the cooling rate must be sufficiently high in order to get a total martensitic transformation. Otherwise, bainitic transformation can take place at a significant amount instead of martensitic transformation. Thus, the risk is that heterogeneous structure appears on parts with complex shape where some locations are much more deformed than others. In this respect, the inventors put into evidence that, on the locations of the parts where the forming strain is higher than 10%, the cooling rate must be increased beyond 50° C./s in order to guarantee full martensitic transformation. The cooling rate is defined as the mean rate between the exit of the heated blank from the furnace, down to 400° C.

[0113] But one may also seek to obtain ferrito-bainitic or ferrito-martensitic structures, by a heating at a temperature ranging between Ac1, for example 750° C. and Ac3, for example 840° C., followed by an appropriate cooling. According to the level of resistance to be achieved and the thermal treatment applied, one or several of these constituents is/are present in variable proportions.

[0114] The modulation of thermal treatment parameters makes it possible to achieve, with a given composition, different levels of hot and cold sheet resistance according to the thickness sought. For the highest resistance levels, the structure is composed predominantly of martensite.

[0115] The steel is particularly suited to the production of structural and anti- intrusion parts.

[0116] The invention thus enables one to produce a hot- or cold-rolled steel sheet of a desired thickness, coated, and affording extensive forming possibilities and which, after thermal treatment performed on the finished part, makes it possible to obtain a mechanical resistance in excess of 1000 MPa, a substantial resistance to shocks, fatigue, abrasion and wear, while retaining a good resistance to corrosion as well as a good capacity for welding, painting and gluing.

[0117] The present invention is described by way of certain exemplary embodiments which are not intended to be limiting.

EXAMPLES

Example 1

[0118] In a first example of implementation, a cold rolled steel sheet, 1.9 mm thick, containing by weight 0.23% carbon, 1.25% manganese, 0.017% phosphorus, 0.002% sulfur, 0.27% silicon, 0.062% aluminum, 0.021% copper, 0.019% nickel, 0.208% chromium, 0.005% nitrogen, 0.038% titanium, 0.004% boron, 0.003% calcium-has been pre-coated with an aluminum-based alloy with composition 9.3% silicon, 2.8% iron, the remainder being aluminum and unavoidable

impurities. According to the conditions of fabrication, namely the settings of the blowing devices on the operating line, sheets of 120 m long and 650 mm wide with various thickness ranges were produced.

[0119] Sheet A (according to the invention): The thickness t_{p1} and t_{p2} on each side of the sheet was controlled to be within the range (20-33) micrometers, at every location of the two faces of the sheet, both in the longitudinal (or rolling) direction and in the transversal direction. Measurement was performed continuously with thickness gages devices relying on X-Ray emission. At every moment, the spot of measurement of each gage was a circular zone of about 20 mm radius. The sheets were afterwards cut into blanks of 1.2.times.0.5 m.sup.2 of overall dimensions.

[0120] Sheet B (reference): On these sheets, the pre-coating thickness had a wider variability since the thickness t_{p1} and t_{p2} on the two sides of the sheet was comprised in the range (30-45) micrometers. Blanks cut out of these sheets exhibit the same pre-coating thickness.

[0121] The blanks were then submitted to heating in a furnace at T=920° C. Heating time was 3 min, with 4 mn holding time. The microstructure is then fully austenitic. Blanks were thereafter transferred from the furnace to a stamping press. When the elapsed time between the exit of the blanks from the furnace and the transfer in the stamping press is more 10 seconds, a partial transformation from austenite was susceptible to appear, thus reducing the mechanical resistance of the stamped part.
The blanks were directly cooled afterwards without hot stamping in order to appreciate the eventual remelting of the coating On series A, no melting of the pre-coating was found. Intermetallic alloying between the pre-coating and the steel substrate occurred completely. On series B, the pre-coating underwent mainly alloying, but some traces of remelting were found, particularly on the former thicker locations of the pre-coating. This partial remelting of the aluminium pre-coating contributes to the progressive fouling of the rollers in the furnace. The sheets according to the invention do not contribute to this progressive buildup on the rollers.

Example 2

[0122] i) Conditions according to the invention: In a second example of implementation, a cold rolled steel sheet, 1.2 mm thick, 120 m long and 650 mm wide, with same composition and same pre-coating as in example 1, has been fabricated. The sheets were afterwards cut into blanks which were heated at 920° C. for 6 mn, this time including the heating phase and the holding time. Heating rate V_c between 20 and 700° C. was 10° C./s. The blanks were finally hot stamped and quenched in order to obtain full martensitic structures. The parts obtained after hot-stamping are covered by a coating, 40 micrometers thick, illustrated at FIG. 1, which has a four layer structure. Starting from the steel substrate, the layers are the following:

[0123] (a) Interdiffusion layer or intermetallic layer, 17 micrometers thick. This layer is itself composed of two sub-layers. Hardness HV50g ranges from 295 to 407, and the mean composition is: 90% Fe, 7% Al, 3% Si.

[0124] (b) Intermediate layer, appearing darker, 8 micrometers thick. This layer has a hardness of 940HV50g and a mean composition, by weight: 43% Fe, 57% Al, 1% Si.

[0125] (c) Intermetallic layer appearing as a pale phase, 8 micrometers thick, displaying a hardness of 610HV50g, a mean composition of 65% Fe, 31% Al, 4% Si

[0126] (d) Darker superficial layer, 7 micrometers thick, 950 HV50g, with a mean composition of 45% Fe, 54% Al, 1% Si Layers (c) and (d) are quasi-continuous, i.e. occupying at least 90% of the level corresponding to the considered layer. In particular, layer (c) does not reach the extreme surface except very exceptionally. Anyway, this layer (c) occupies less than 10% of the extreme surface. ii) Conditions of reference: On the other hand, blanks with the same base material and pre-coating parts were furnace-heated in different conditions: The blanks were heated to 950° C. for 7 minutes, this time including the heating phase. Heating rate V_c was 11° C./s. These conditions correspond to a degree of alloying which is more important than in conditions (i)

[0127] In this coating, the pale intermetallic layer (c), is not continuous and appears as to be scattered within the coating. About 50% of this layer is present at the extreme surface of the part. Moreover, the interdiffusion layer, 10 micrometers thick in contact with the steel substrate is thinner than in the previous case of FIG. 1.

[0128] Resistance spot welding was performed in the two situations i) and ii):

[0129] (i): Coating with quasi-continuous layers (c) and (d), layer (c) occupying less than 10% of the extreme surface

[0130] (ii): Coating with mixed and discontinuous layers, layer (c) occupying more than 10% of the extreme surface Resistance spot welding was performed by superposing two parts and joining them in the following conditions:

[0131] Squeeze force and welding force: 4000 N

[0132] Squeeze time: 50 periods

[0133] Welding and holding time: 18 periods respectively In each condition, the suitable intensity range was determined for obtaining:

[0134] No sputter during welding

[0135] Acceptable nugget size. For the condition i), the weldability range, expressed in terms of current intensity, is 1.4 kA. For the condition ii) the weldability range is extremely small.

[0136] Thus, it may be seen that the coating according to the invention, yields much more satisfactory results.

Example 3

[0137] In a third example of implementation, a cold rolled steel sheet of the example 1 was cut into blanks of 500.times.500 mm.sup.2 which were heated at 920° C., during 6 mn, then hot stamped and cooled in tools, in such conditions that two different cooling rates were obtained:

[0138] (A): Cooling rate: V_A=30° C./s

[0139] (B): Cooling rate: V_B=60° C./s Due to the shape of he parts, different deformation levels .epsilon. were created during hot stamping. In particular, some zones largely strained display deformation levels higher than 30%.

[0140] As illustrated on FIG. 3, metallographic observations reveal that when .epsilon.>10%, partial bainitic or ferritic transformation occurs on parts cooled with V_A=30° C./s, mainly on former austenitic grain boundaries. On the other hand, the parts cooled with V_B=60° C./s display fully martensitic microstructure as illustrated on FIG. 4. The latter structures display superior mechanic resistance and a great homogeneity in the case of mechanical solicitation. Thus, even in products or parts where straining is larger than 10%, the application of cooling according to

the invention guarantees a microstructural and mechanical homogeneity.

Example 4

[0141] In a fourth example of implementation, steel castings containing different values of sulfur, were elaborated. These steels were further hot rolled, then cold rolled steel into sheets, 2.2 mm thick. Sulfur content varies from 11 ppm (0.0011%) to 59 ppm (0.006%) in weight. Apart sulfur, the compositions of these different steel castings comprise in weight: 0.24% carbon, 1.17% manganese, 0.01% phosphorus, 0.25% silicon, 0.045% aluminum, 0.01% copper, 0.02% nickel, 0.2% chromium, 0.04% titanium, 0.003% boron, 0.002% calcium, the remainder being iron and unavoidable impurities. These sheets were pre-coated with an aluminum-based alloy of composition comprising 9.3% silicon, 2.8% iron, the remainder being aluminum and unavoidable impurities. The sheets were afterwards cut into blanks which were heated at 950° C. for 5 mn, then hot stamped and cooled in tools in order to obtain a full martensitic structure. Mechanical resistance exceeded 1450 MPa. Specimens were extracted according to the transverse sense of rolling direction and submitted to a bending test with alternate bending modes. The inventors put into evidence that the critical bending angle (angle at fracture) is closely related to the sulfur content of the steel: when sulfur content is lower than 0.002%, the bending angle exceeds 60°, which indicates higher ductility and energy absorption. Compact Tensile-Test type specimens were also extracted according to the transverse rolling direction in order to measure the resistance to tearing, i.e. the energy which is necessary for the initiation or propagation of an existing crack. The results, illustrated on FIG. 6, indicate that a initiation energy higher than 18 Joules is achieved when sulfur content is lower than 0.002% in weight. As these qualities of high resistance, high energy absorption and weldability are required in automobile industry, the parts or products fabricated according to the invention will be used with profit for such applications.

[0142] While the above description is clear with regard to the understanding of the invention, the following terms as used in the following list of preferred embodiments and claims have the following noted meanings in order to avoid any confusion:

[0143] pre-coating--the material (Al or Al alloy) coated on or located on at least a portion of the strip or sheet, etc., of base steel to form a pre-coating/base composite, the composite not having been subjected to an alliation reaction between the coated Al or Al alloy material and base steel

[0144] alliation--a reaction between the pre-coating and base steel, to produce at least one intermediate layer different in composition from both the base steel and the pre-coating. The alliation reaction happens during the heat treatment immediately preceding hot stamping. The alliation reaction affects the total thickness of the pre-coating. In a highly preferred embodiment the alliation reaction forms the following layers: (a) interdiffusion, (b) intermediate, (c) intermetallic, and (d) superficial as described above;

[0145] pre-coated steel--the pre-coating/base composite, not having been subjected to an alliation reaction between the coated material and base steel;

[0146] coating--the pre-coating after having been subjected to an alliation reaction between the pre-coating and base steel. In a highly preferred embodiment the coating comprises layers (a) interdiffusion, (b) intermediate, (c) intermetallic, and (d) superficial described above;

[0147] coated steel or product--the pre-coated steel or product that has been subjected to an alliation reaction between the pre-coating and base steel. In a highly preferred embodiment the coated steel is a strip or sheet, etc., of base steel having thereon an invention coating comprising layers (a) interdiffusion, (b) intermediate, (c) intermetallic, and (d) superficial described above;
[0148] blank--a shape cut from a strip.
[0149] product--a stamped blank

Electronic Patent Application Fee Transmittal

Application Number:	
Filing Date:	
Title of Invention:	Coated Steel Strips, Coated Stamped Products and Methods
First Named Inventor/Applicant Name:	Pascal DRILLET
Filer:	Cary S. Kappel
Attorney Docket Number:	11020631.1028CON5

Filed as Large Entity

Filing Fees for Track I Prioritized Examination - Nonprovisional Application under 35 USC 111(a)

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
UTILITY APPLICATION FILING	1011	1	300	300
UTILITY SEARCH FEE	1111	1	660	660
UTILITY EXAMINATION FEE	1311	1	760	760
REQUEST FOR PRIORITIZED EXAMINATION	1817	1	4000	4000
Pages:				
Claims:				
CLAIMS IN EXCESS OF 20	1202	3	100	300
Miscellaneous-Filing:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
PUBL. FEE- EARLY, VOLUNTARY, OR NORMAL	1504	1	0	0
PROCESSING FEE, EXCEPT PROV. APPLS.	1830	1	140	140
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				
Miscellaneous:				
		Total in USD ($)		**6160**

Electronic Acknowledgement Receipt	
EFS ID:	36029594
Application Number:	16413799
International Application Number:	
Confirmation Number:	7637
Title of Invention:	Coated Steel Strips, Coated Stamped Products and Methods
First Named Inventor/Applicant Name:	Pascal DRILLET
Customer Number:	23280
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Authorized User	Cary Kappel
The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows: 37 CFR 1.16 (National application filing, search, and examination fees) 37 CFR 1.17 (Patent application and reexamination processing fees)	

37 CFR 1.19 (Document supply fees)

37 CFR 1.20 (Post Issuance fees)

37 CFR 1.21 (Miscellaneous fees and charges)

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	TrackOne Request	TrackOneRequest-EFS.PDF	118261 6afca026592c8637a21469fe04e530f31414b62d	no	2
Warnings:					
Information:					
2	Application Data Sheet	ADS-EFS.PDF	1256750 836709caa09f6b64af0c68207603 4fa2375172d9	no	9
Warnings:					
Information:					
3	Oath or Declaration filed	delclarations.PDF	645621 f97b559f237b6d1d317206eaea3adf8174f39883	no	5
Warnings:					
Information:					
4	Power of Attorney	poa.PDF	68736 fd0ae6785cbb09a6bf74c259681c107e19becc5e	no	1
Warnings:					
Information:					
5	Preliminary Amendment	1028CON5-pre-amend-efs.pdf	137437 1817e802d8236ca4e93b34fdf7be2f432b133656	no	7
Warnings:					
Information:					
6		11020631-1028CON5-APPL-DWGS-EFS.pdf	3712140 9f21c931bfd10674c8156e911a04e17256af4faa	yes	34

	Multipart Description/PDF files in .zip description		
	Document Description	**Start**	**End**

	Drawings-only black and white line drawings		31	34	
	Abstract		30	30	
	Claims		24	29	
	Specification		1	23	
Warnings:					
Information:					
7	Fee Worksheet (SB06)	fee-info.pdf	41654 ed0736a381b52f35b5e65ffb8c757e8346727626	no	2
Warnings:					
Information:					
		Total Files Size (in bytes):	5980599		

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New Applications Under 35 U.S.C. 111
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.
National Stage of an International Application under 35 U.S.C. 371
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.
New International Application Filed with the USPTO as a Receiving Office
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

IN THE UNITED STATES PATENT & TRADEMARK OFFICE

Application of:	ARCELORMITTAL
Inventor(s):	Drillet et al.
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Filed:	HEREWITH
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Title:	Coated Steel Strips, Coated Stamped Products and Methods

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Mail Stop:
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

PRELIMINARY AMENDMENT

Dear Madam or Sir:

Applicant requests that the following amendments be made in the above-identified matter prior to examination thereof:

Amendments to the Specification and Abstract

Please amend the specification as follows:

[0000.1] This is a Continuation of U.S. Patent Application No. 15/606,770 filed May 26, 2017 which is a Continuation of U.S. Patent Application No. 13/621,015, filed September 15, 2012 which is a Divisional of U.S. Patent Application No. 12/447,777, filed April29, 2009, which is a National Phase Application of International Patent Application PCT/IB06/004019, filed October 30, 2006. All of the above patent applications are hereby incorporated by reference herein.

No new matter has been added.

Amendments to the Claims:

The following listing of claims will replace all prior versions and listings of claims in the application:

Listing of Claims:

Claims 1-24 (canceled).

Claim 25 (New) A precoated steel product comprising:

a strip of base steel having a first side and a second side; and

a precoating on at least one of the first side and the second side, the precoating being made of an aluminum alloy and having a controlled thickness to create a precoated steel strip heat treatable to form a coating comprising, proceeding from the base steel outwards:

(a) an Interdiffusion layer,

(b) an Intermediate layer,

(c) an Intermetallic layer, and

(d) a Superficial layer; wherein the coating has a thickness greater than 30 micrometers and wherein said layer (a) has a thickness less than 15 micrometers.

Claim 26 (New) The precoated steel product according to claim 25, wherein the said layers (c) and (d) are quasi continuous by occupying at least 90% of a level corresponding to each said layer and wherein less than 10% of layer (c) is present at an extreme surface of the product.

Claim 27 (New) The precoated steel product according to claim 25, wherein the base steel comprises the following components by weight based on total weight:

0.15%<carbon<0.5%;

0.5%<manganese<3%;

0.1%<silicon<0.5%;

0.01%<chromium<1%;

titanium<0.2%;

aluminum<0.1%;

phosphorus<0.1%;

sulfur<0.05%;

0.0005%<boron<0.08%;

and further comprises iron and impurities inherent in processing.

Claim 28 (New) The precoated steel product according to claim 25, wherein the base steel comprises the following components by weight based on total weight:

0.20%<carbon<0.5%;

0.8%<manganese<1.5%;

0.1%<silicon<0.35%;

0.01%<chromium<1%;

titanium<0.1%;

aluminum<0.1%;

phosphorus<0.05%;

sulfur<0.03%;

0.0005%<boron<0.01%;

and further comprises iron and impurities inherent in processing.

Claim 29 (New) The precoated steel product according to claim 25, wherein the base steel comprises 20 ppm or less of sulfur.

Claim 30 (New) The precoated steel product according to claim 27, wherein the base steel comprises 20 ppm or less of sulfur.

Claim 31 (New) The precoated steel product according to claim 25, wherein a ratio of titanium to nitrogen in the base steel in weight % is in excess of 3.42.

Claim 32 (New) The precoated steel product according to claim 27, wherein a ratio of titanium to nitrogen in the base steel in weight % is in excess of 3.42.

Claim 33 (New) The precoated steel product according to claim 30, wherein a ratio of titanium to nitrogen in the base steel in weight % is in excess of 3.42.

Claim 34 (New). The precoated steel product according to claim 25, wherein the aluminum alloy precoating comprises from 8% to 11% silicon by weight, from 2% to 4% iron by weight, the remainder being aluminum and impurities inherent in processing.

Claim 35 (New). The precoated steel product according to claim 25, wherein said layer (a) has a thickness less than 10 micrometers.

Claim 36 (New). The precoated steel product according to claim 25, wherein a thickness t_p of said precoating is from 20 to 33 micrometers at every location on at least one of said first and second sides.

Claim 37 (New). The precoated steel product according to claim 25, wherein a thickness t_p of said precoating is from 20 to 33 micrometers at every location on both said first and second sides.

Claim 38 (New) The precoated steel product according to claim 34, wherein the aluminum alloy precoating comprises from 9% to 10% silicon by weight.

Claim 39 (New) The precoated steel product according to claim 38, wherein the aluminum alloy precoating comprises from 9.3% silicon by weight.

Claim 40 (New) The precoated steel product according to claim 25, wherein the Interdiffusion layer comprises the following components by weight based on total weight: 86 to 95% Fe, 4 to10% Al, and 0 to 5% Si.

Claim 41 (New) The precoated steel product according to claim 25, wherein the Intermediate layer comprises the following components by weight based on total weight: 39 to 47% Fe, 53 to 61% Al, and 0 to 2% Si.

Claim 42 (New) The precoated steel product according to claim 25, wherein the Intermetallic layer comprises the following components by weight based on total weight: 62 to 67% Fe, 30 to 34% Al, and 2 to 6% Si.

Claim 43 (New) The precoated steel product according to claim 25, wherein the Superficial layer comprises the following components by weight based on total weight: 39 to 47% Fe, 53to 61% Al, and 0 to 2% Si.

Claim 44 (New) The precoated steel product according to claim 40, wherein the Intermediate layer comprises the following components by weight based on total weight: 39 to 47% Fe, 53 to 61% Al, and 0 to 2% Si.

Claim 45 (New) The precoated steel product according to claim 44, wherein the Intermetallic layer comprises the following components by weight based on total weight: 62 to 67% Fe, 30 to 34% Al, and 2 to 6% Si.

Claim 46 (New) The precoated steel product according to claim 45, wherein the Superficial layer comprises the following components by weight based on total weight: 39 to 47% Fe, 53to 61% Al, and 0 to 2% Si.

Claim 47 (New) The precoated steel product according to claim 25, wherein the Interdiffusion layer has a thickness of from 1 micron to 15 microns.

REMARKS

Claims 1-24 are canceled. Claim 25-47 are added. The specification has been amended. No new matter has been added.

Reconsideration and allowance of the present application is respectfully requested.

Respectfully submitted,

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