



Certification of Accuracy

I, Kari Parrott, hereby attest that I am a translator fluent in English and French, that I have translated the attached document from French to English, and that to the best of my knowledge, ability and belief this translation is a true, accurate and complete translation of the original French document that was provided to me.

The document is designated as:

Patent No. FR2833504

Signature of Translator

July 28, 2024

Date

(19) FRENCH REPUBLIC

—————

**INSTITUT NATIONAL DE LA
PROPRIÉTÉ INDUSTRIELLE
("NATIONAL INSTITUTE OF
INDUSTRIAL PROPERTY")**

—————

PARIS

—————

(11) **Publication No:** **2 833 504**

(to be used only for
reproduction orders)

(21) **National registration No.:** **01 16185**

(51) Int Cl⁷: **B21 D 53/26**, C 21 D 8/02, C 22 C 38/32,
38/38

(12) **PATENT APPLICATION** **A1**

(22) Filing date: 14.12.01.	(71) Applicant(s): USINOR Société anonyme - FR.
(30) Priority:	
(43) Date on which the application was made available to the public: 20.06.03 Bulletin 03/25.	(72) Inventor(s): LAURENT, JEAN PIERRE; DERUY, SYLVAIN; and DEVROC, JACQUES.
(56) List of documents cited in the preliminary research report: Please refer to the end of this document	(73) Holder(s):
(60) Apparent references to other national documents:	(74) Agent(s):
(54) HOT-FORMING METHOD, IN PARTICULAR FOR OBTAINING ALL OR PART OF A MOTOR VEHICLE WHEEL	

(57) Process for hot-forming and, in particular, obtaining of all or part of a motor vehicle wheel, such as, for example, a wheel disc, characterized in that a pre-coated, hot-rolled steel sheet for heat treatment is used in a hot-stamping operation.



Hot-forming process, in particular obtaining all or part of a motor vehicle wheel.

The present invention concerns obtaining a part by a hot-forming process and in particular the production of all or part of a motor vehicle wheel.

5 Wheel discs are currently produced either by cold-forming a sheet metal blank or by flow-forming.

When forming a disc from a sheet metal blank, it is necessary to carry out several forming operations, requiring the use of several stamping tools. The number of stamping tools is on the order of 7, 8 or 9.

10 The main disadvantages of the present cited technique are as follows:

- Each change of shape requires the machining or manufacture of 7 to 9 different pairs of tools.
- Each manufacturing change involves dismantling, then assembling and adjusting 7 to 9 tools, as well as setting up the associated presses.
- 15 – These numerous tools need to be stored.
- The cost of tool manufacture makes it impossible to produce small series economically.
- It is not possible to produce very thick parts.

20 In the case of obtaining wheel discs by flow-forming, for example, productivity is lower than for stamping, which limits mass production.

In both techniques:

- The use of forming oil or lubricant is imperative and requires degreasing before painting.
- These oils and effluents need to be stored and treated.

25 In terms of the desired features:

- The increase in mechanical features leads to a reduction in formability, which limits the shape of discs, and generates increased springback, which adversely affects dimensional guarantees.

– Increasing mechanical features requires the use of ever more powerful presses.

– Temporary corrosion protection, e.g. before painting a stamped disc, requires the part to be oiled and then degreased. It is also necessary to remove the forming oil before painting, which entails a cost and an ecological risk.

The object of the invention is to produce a part by hot-stamping in a single pass while respecting the dimensional guarantees and allowing complex shapes to be obtained.

The subject matter of the invention is the obtaining of a part by a hot-forming process and in particular the obtaining of all or part of a motor vehicle wheel such as a wheel disc, characterized in that a pre-coated, hot-rolled steel sheet for heat treatment is used in a hot-stamping operation.

Other features of the invention are:

– the steel sheet is a pre-coated, hot-rolled or cold-rolled steel sheet of the following general composition by weight:

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%

other features of the invention are:

– the coating is aluminum-based,

– preferably, the steel sheet is a pre-coated, hot-rolled or cold-rolled steel sheet with 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%

phosphorus < 0.05%

5 sulfur < 0.03%

0.0005% < boron < 0.01%

– in the weight composition of the sheet, the ratio of the titanium content to the nitrogen content is greater than 3.42,

10 – the metal bath of the coating comprises, in its basic composition by weight, 9% to 10% silicon, 2% to 3.5% iron, the remainder of the bath being composed of aluminum and impurities,

– the metal bath of the coating comprises 2% to 4% iron in its basic composition by weight,

15 – the metal bath of the coating may contain 0 to 50% zinc in its basic composition by weight.

The following description will make the invention clear.

The problem posed is to produce a part using a hot-forming process, and in particular to obtain all or part of a motor vehicle wheel such as, for example, a wheel disc for a light or heavy vehicle, or a wheel disc and part of the wheel rim, in a single
20 pass, while complying with dimensional guarantees and producing complex shapes.

From FR patent application No. 98 08793 a coated hot- and cold-rolled steel sheet with very high strength after heat treatment is known. Also known from FR patent application No. 98 16477 is a process for producing a part from a strip of rolled and, in particular, hot-rolled steel sheet.

25 According to the invention, a particularly important use of a sheet metal and of the process presented has been demonstrated, in obtaining a part by a hot-forming process and, in particular, obtaining all or part of a motor vehicle wheel in a single hot-stamping pass, whereas the techniques used to date require numerous, complex tools, as well as numerous forming operations.

30 Contrary to known industrial practice, the inventors have obtained, in a single pass, by hot-stamping of a pre-coated, hot-rolled steel sheet, a wheel disc which was

previously produced in 7 or 8 stamping operations, the pre-cut sheet plane having the following general composition by weight:

	0.15% < carbon < 0.5%
	0.5% < manganese < 3%
5	0.1% < silicon < 0.5%
	0.01% < chromium < 1%
	titanium < 0.2%
	aluminum < 0.1%
	phosphorus < 0.1%
10	sulfur < 0.05%
	0.0005% < boron < 0.08%

The use of a pre-coated steel for heat treatment allows for a significant gain in fatigue strength to be obtained, with no welding problems and enhanced corrosion resistance after painting.

Furthermore, the process and the steel used allow for a significant weight reduction and increased fatigue life. Finally, the resulting disc may be welded and painted without modifying the existing lines.

Preferably the steel sheet has the following composition by weight:

	0.15% < carbon < 0.5%
20	0.8% < manganese < 1.5%
	0.1% < silicon < 0.35%
	0.01% < chromium < 1%
	titanium < 0.1%
	aluminum < 0.1%
25	phosphorus < 0.05%
	sulfur < 0.03%
	0.0005% < boron < 0.01%

the metal sheet ensures very high mechanical strength after heat treatment, and the aluminum-based coating provides high corrosion and fatigue resistance.

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

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

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

In one example, steel according to the invention containing 0.231% 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% calcium in the form of a sheet is coated with an aluminum-based layer approximately 25 μm thick prior to heat treatment.

The sheet metal blank is heated in a furnace to a temperature of between 750°C and 1000°C, and more generally to a temperature of between 850°C and 950°C, for a time varying according to thickness. For a thickness of 2 mm, the sheet metal blank remains in the furnace for 6 minutes. The temperature rise rate is in excess of 3°C/s. Because of the coating, it is not necessary to use an inert atmosphere furnace.

When the sheet metal blank is reheated, the coating combines with the substrate to form an intermetallic alloy. The alloying, through interdiffusion, leads to an increased thickness of the layer which, for the treatment specified above, generally corresponds to a 50% increase.

The hot sheet metal blank is then transferred to the cooled or uncooled tool, depending on the cycle rate, sheet thickness, and target cooling rate, for shaping. There must be no blank clamping pressure in order to avoid tearing the sheet metal due to its low strength at high temperature. The deformation speed must be sufficient to avoid deforming the steel at temperatures below 400°C.

The wheel disc thus obtained is held in the tool until it reaches a temperature of less than 200°C, and preferably less than 100°C, in order to comply with the dimensional guarantees. The average cooling rate must be greater than 27°C/s between the furnace outlet temperature and 400°C, if the substrate's target structure is martensitic. If the average cooling rate is lower than this value, bainite, ferrite, or even perlite may appear. Different structures and therefore different properties may thus be obtained, depending on the targeted cooling rate.

Nevertheless, the best fatigue results are obtained with a fully martensitic steel structure.

Due to hot-forming, there is no damage to the metallurgical structure. This has a beneficial effect on fatigue resistance, as it eliminates internal defects that may serve as fatigue crack initiators. There is no need to add forming lubricant, as the pre-coating acts as a lubricant.

The resulting part may be directly subjected to the painting cycle. If this is not the case, there is no need to apply temporary corrosion protection, as the alloy layer slows down the onset of corrosion. During the thermal cycle, the coating, whether alloyed or not, protects the steel from oxidation and decarburization.

The alloy layer formed on the part has a hardness gradient. Starting from the outermost layer and moving towards the sheet, the hardness varies from 750HV0.1 to 300HV0.1 at the coating-sheet interface, then increases to around 500HV0.1 in the sheet, when the steel structure is fully martensitic. The 300HV0.1 layer, by stopping cracks, gives the part increased fatigue resistance.

If one uses the steel of the proposed solution but not pre-coated, a significant degradation of the average endurance limit is noted, as shown in Table 1 below, mainly due to decarburization of the steel. The proposed solution, due to the presence of the pre-protection, avoids this phenomenon. Fatigue tests in alternating planar bending show a significant gain.

Table 1.

Steel	Rp0.2 (MPa) Transverse	Rm (MPa) Transverse	Number of cycles for validating the limitation of the endurance limit (millions of cycles)	Average endurance limit (MPa)
USIDUR 355 comparison example	432	514	1. 106	279
USIFORM 800 comparison example	766	872	2. 106	388
Obtained according to the invention,	980	1490	2. 106	249

uncoated				
Obtained according to the invention	980	1480	2. 106	439

With respect to USIDUR 355 sheet metal, commonly used industrially for producing wheel discs, the gain in service life and weight is 40%. With respect to the above-mentioned grade used for wheel discs, the endurance limit shows a gain of
5 over 12%.

The advantages of obtaining a part by a hot-forming process and in particular obtaining all or part of a motor vehicle wheel are as follows:

- producing a wheel disc in a single forming pass,
- due to the high degree of hot-formability, only a single tool is
10 required, making it possible to mass-produce complex parts such as styling wheels economically,
- a very good dimensional guarantee since there is no springback as in the case of cold-stamping or flow-forming,
- high mechanical features after quenching in the stamping tool
15 enable significant weight reduction,
- the pre-coating provides added protection against corrosion and wear,
- increased formability when the sheet metal blank is heated, enabling hot-forming of thicknesses that would normally only be possible by
20 flow-forming,
- a deformation may take place in the hot austenitic phase without damage, which ensures better fatigue resistance by eliminating the internal defects usually created during cold deformation,
- pre-coating eliminates the need to lubricate the sheet during hot-
25 forming, thus eliminating the need for degreasing prior to painting,
- due to the coating, there is no need to apply temporary corrosion protection to parts awaiting painting,
- unlike zinc-based coatings, the non-heat-treated pre-coating does not degrade fatigue resistance, and even increases it,

- impact behavior is enhanced by the use of the type of steel selected,
- the heat-treated pre-coating requires no special welding equipment or precautions.

5 Other parts may also benefit from this method. Particular mention should be made of fatigue-dimensioned parts for connecting to the ground such as suspension arms, wheel arms, etc.

CLAIMS.

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

2. Process according to claim 1, characterized in that the steel sheet is a pre-coated, hot-rolled steel sheet of the following general composition by weight:

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 aluminum-based.

4. Process according to claim 1, characterized in that preferably the steel sheet is a pre-coated, hot-rolled or cold-rolled steel sheet 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 5. Process according to claim 1, characterized in that, in the composition by weight of the sheet, the ratio of the titanium content 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 composition by weight, 9% to 10% silicon, 2% to 3.5% iron, the remainder of the bath being composed of aluminum and impurities.

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

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

2833504



PRELIMINARY RESEARCH REPORT
 established on the basis of the last claims filed
 before the start of research

National Registration No.

FA 611824
 FR 0116185

DOCUMENTS CONSIDERED RELEVANT		Claim(s) concerned	Classification assigned to the invention by The INPI
Category	Citation of the document with indication, where necessary, of the relevant parts		
D,X	FR 2 780 984 A (LORRAINE LAMINAGE) January 14, 2000 (2000-01-14) * the entire document * ---	1-8	B21D53/26 C21D8/02 C22C38/32 C22C38/38
D,X	FR 2 787 735 A (LORRAINE LAMINAGE) June 30, 2000 (2000-06-30) * the entire document * ---	1	
A	US 4 397 345 A (RAMARATNAM KRISHNASNAMY ET AL) August 9, 1983 (1983-08-09) -----		
			TECHNICAL AREAS SEARCHED (Int.CL.7)
			B21D
Research completion date August 14, 2002		Examiner Peeters, L	
CATEGORY OF CITED DOCUMENTS X: particularly relevant on its own Y: particularly relevant in combination with another document in the same category A: technological background O: non-written disclosure P: inserted document		T: theory or principle behind the invention E: patent document with a date prior to the filing date and which was not published until the filing date or a later date. D: cited in the application L: cited for other reasons &: member of the same family, corresponding document	

1

EPO FORM 1503 12.99 (P04C14)

Patent document cited in the research report	Publication date	Member(s) of the family of patent(s)	Publication date
FR 2780984 A	14-JAN-2000	FR 2780984 A1	14-JAN-2000
		BR 9902712 A	08-MAR-2000
		EP 0971044 A1	12-JAN-2000
		JP2000038640 A	08-FEB-2000
		US 6296805 B1	02-OCT-2001
FR 2787735 A	30-JUN-2000	FR 2787735 A1	30-JUN-2000
		EP 1013785 A1	28-JUN-2000
US 4397345 A	09-AUG-1983	NONE	