



Certification of Accuracy

I, Michael L. Magee, hereby attest that I am a translator fluent in English and German, that I have translated the attached document from German 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 German document that was provided to me.

The document is designated as:

European Patent No. EP1865086, entitled "Use of a steel flat product produced from a manganese boron steel and method of its production"

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Signature of Translator

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Date

Description

[0001] The invention relates to use of a flat steel product produced from a manganese-boron steel, and a method for producing same.

[0002] MnB steels of the type used according to the invention are employed in particular in the field of automobile manufacturing to produce components which in addition to low weight are to have high strength.

[0003] The stringent safety requirements imposed on the deformation behavior of recent automobiles in the event of a collision may be met at the present time by using higher-strength steels to produce the components that are particularly critical for the deformation behavior of the vehicle body during an accident. The problem, however, is that high-strength steels generally have inadequate formability, and have a tendency to spring back when undergoing cold forming to produce the particular component.

[0004] In practice, this problem is overcome by deforming sheets, made from higher-strength steels, in the warm state in the so-called "hot pressing" process to produce the particular component. This procedure has proven to be successful, and also allows the production of more complexly shaped body and chassis parts made of high-strength steels.

[0005] Manganese-boron steels of the type under discussion, as standardized in EN 10083-3, have proven to be particularly suited for hot press deformation. These steels have good hardening capability, which allows reliable process control for the hot pressing and which in the course of the hot **[press]** deformation enables martempering in the tool in a cost-effective manner without additional cooling.

[0006] An MnB steel that has proven suitable in practice for the purposes summarized above is known by the name "22MnB5," and has been given the material number 1.5528 in Stahlschlüssel [Key to Steel], 2004 edition. Commercially available 22MnB5 steel typically contains, in addition to iron and unavoidable impurities, the following substituents (in wt. %): 0.220-0.250% C, 1.2-1.4% Mn, 0.2-0.3% Si, up to 0.02% P, up to 0.005% S, 0.020-0.050% Al, 0.020-0.050% Ti, 0.11-0.2% Cr, 0.002-0.0035% B, and in each case up to 0.1% Mo, Cu, and Ni (Material Data Sheet 11-112 from Salzgitter Flachstahl GmbH, November 2005 edition).

[0007] For hot-rolled sheet steels provided with an Al coating and having a corresponding composition, EP 0 971 044 B1 discloses an alloy specification according to which an MnB steel, in addition to iron and unavoidable impurities, has the following composition (in wt. %): a carbon content greater than 0.20% but less than 0.5%, a manganese content greater than 0.5% but less than 3%, a silicon content greater than 0.1% but less than 0.5%, a chromium content greater than 0.01% but less than 1%, a titanium content less than 0.2%, an aluminum content less than 0.1%, a phosphorus content less than 0.1%, a sulfur content less than

0.05%, and a boron content greater than 0.0005% but less than 0.08%. A sheet steel provided with an Al coating, disclosed as an exemplary embodiment in EP 0 971 044 B1, accordingly has the following composition (in wt. %): 0.21% C, 1.14% Mn, 0.020% P, 0.0038% S, 0.25% Si, 0.04% Al, 0.009% Cu, 0.020% Ni, 0.18% Cr, 0.0040% N, 0.032% Ti, 0.003% B, and 0.0050% Ca. After heat treatment, the strength of this sheet steel is stated to be greater than 1500 MPa.

[0008] Furthermore, a sheet steel for structural components of automobile bodies is known from JP 2004-211197, which in addition to iron and unavoidable impurities has the following composition (in wt. %): 0.20-0.35% C, 0.01-1.0% Si, 0.3-2.0% Mn, 0.01-0.10% Al, greater than 1-5% Ni, 0.005-0.1% Ti, 0.0005-0.005% B, 0.001-0.01% N, up to 0.02% P, up to 0.01% S, and up to 0.01% O. When this alloy meets the condition " $Ti/47.88 - N/14.01 \leq 0.001$ " for the Ti and N contents, the condition " $0 \leq Al/26.98 - N/14.01 \leq 0.0015$ " for the Al and N contents, and the condition " $-28.8 \times C^2 + 38.0 \times C + 1.7 \times Si + 7.5 \times Mn + 1.4 \times Ni + 43.2 \times Cr + 8.7 \times Cu + 53.5 \times S + 57.1 \times P + 17.9 \geq 35$ " for the C, Si, Mn, Ni, Cr, Cu, S, and P contents, the sheet steel in question is stated to have particularly good hardening capability after hot forming, and at the same time, particularly good behavior upon a sudden impact.

[0009] The conventional MnB steels stated above have the common feature that, although they each have high strength and good hardening capability, their strength after the hot pressing results from the carbon dissolved in the martensite lattice, while their good hardening capability is primarily determined by the Mn and Cr contents, supplemented by B.

[0010] However, the residual elongation at fracture of the known steels is typically only 5-6%. Meeting the increasingly stringent requirements for the collision behavior of vehicle bodies, however, requires steels which in addition to high strength also have improved elongation behavior of the component produced from such a steel after the hot pressing.

[0011] In addition to the prior art discussed above, EP 1 160 346 A1 describes a high-strength, hot-dip galvanized sheet steel with excellent cladding adhesion and press formability, as well as a method for producing such sheet steel. The sheet steel is made of a steel which, in addition to iron and unavoidable impurities, has the following composition (in wt. %): C: 0.05 to 0.2%, Si: 0.2 to 2.0%, Mn: 0.2 to 2.5%, Al: 0.01 to 1.5%, Ni: 0.73 to 5.0%, P: < 0.03%, and S: < 0.02%, and optionally one or more of the following substituents: Cu: < 0.2%, B: 0.0002 to 0.01%, Co: < 0.3%, Sn: < 0.3%, Mo: < 0.5%, Cr: < 1%, V: < 0.3%, Ti: < 0.06%, Nb: < 0.06%, rare earth metals: < 0.05%, Ca: < 0.05%, Zr: < 0.05%, Mg: < 0.05%, Zn: < 0.02%, W: < 0.05%, As: < 0.02%, N: < 0.03%, and O: < 0.05%. At the same time, the ratio of Si to Al is to be set in such a way that the condition " $0.4 (\%) < Si + 0.8 Al (\%) \leq 2.0\%$ " is met. Likewise, the volume percentage of retained austenite in the sheet steel is to be 2 to 20%. By then setting the ratio of Ni, Cu, Co, Sn, to Si, Al at the sheet steel surface in 0.5 μ m of the sheet steel surface layer

so that the condition " $\text{Ni} + \text{Cu} + \text{Co} + \text{Sn} (\%) \geq 1/4 \text{ Si} + 1/3 \text{ Al} (\%)$ " is met, the intent is for a Zn cladding layer that is alloyed in a certain manner to adhere particularly well to the flat steel product. For this purpose, the cladding layer contains Al: < 1%, optionally Fe: 8 to 15%, and optionally one or more substituents selected from Mn: < 0.02%, Pb: < 0.01%, and Fe: < 0.2%. When the optional 8 to 15% Fe is not contained in the Zn cladding layer, the Zn layer may also contain Sb: < 0.01%, Ni: < 3.0%, Cu: < 1.5%, Sn: < 0.1%, Co: < 0.1%, Cd: < 0.01%, and Cr: < 0.05%. The principle that is utilized according to this prior art thus presumes certain minimum contents of Si and Al, whereas the combination of the Mn and B contents play only a subordinate role. Instead, as shown in the exemplary embodiments and explanations set forth in EP 1 60 346 A1, the Cu content is particularly important.

[0012] Lastly, a method for producing a higher-strength heavy plate is known from JP 2005-336541, which is at least 70 mm thick and is made of a steel having the following composition (in wt. %): 0.04-0.20% C, 0.002-0.003% B, and 0.0003-0.0025% Ca, and the remainder iron and unavoidable impurities, wherein the ratio of the carbon content C% to the boron content B% in the steel is set so that the condition " $0.1 < \text{C}\% + 100 \times \text{B}\% \leq 0.32$ " is met. At the same time, certain conditions are to be met for the bainite portion of the sheet steel. Adding Ca is intended to improve the toughness in the heat-affected zone of a weld seam that is formed during welding of the heavy plate. It is apparent that for heavy plate of this type, neither its property spectrum nor its dimensions make it suitable for hot pressing.

[0013] Proceeding from the prior art explained above, the object of the invention, therefore, is to provide use of a flat steel product which due to its composition and properties is particularly suited for producing components that reliably meet the requirements imposed in practice on components that are produced from such flat steel products, such as steel strips or steel sheets. In addition, a method for producing such a flat steel product is provided.

[0014] With regard to the use, this object has been achieved in that, for producing a hot-pressed component, according to the invention a manganese-boron steel is used which has the following composition (in wt. %): 0.1-0.20% C, 0.05-0.30% Si, 0.8-1.8% Mn, 0.5-1.8% Ni, up to 0.015% P, up to 0.003% S, 0.0002-0.0080% B, and the remainder iron and unavoidable impurities. In addition, the MnB steel according to the invention may optionally contain 0.01-0.1% Ti, 0.01-0.05% Al, 0.002-0.005% N, in each case in combination or individually. A hot-pressed component that uses such a flat steel product according to the invention has a tensile strength R_m of at least 1000 MPa, and an elongation at fracture A_{80} greater than 10%.

[0015] In contrast to the MnB steels conventionally used for the hot pressing, in which the mechanical properties are determined primarily by the C, Mn, and Cr contents, in the alloy concept according to the invention the fraction of Cr has been omitted.

[0016] Instead, MnB steel used according to the invention contains Ni in order to significantly

increase the elongation at fracture and toughness of components, produced from the steel used according to the invention, in a hardened state that is obtained after hot press deformation. At the same time, the presence of Ni improves the hardening capability of MnB steels used according to the invention, so that is possible to reduce the Mn content and to omit the addition of Cr, which is critical with regard to its influence on the residual elongation capability.

[0017] The C content of steels used according to the invention has also been modified in such a way that to the benefit of improved elongation capability, the martensitic hardness produced in the course of the hot pressing is reduced, or the components obtained after the hot pressing have a bainitic structure, which likewise has a positive effect on the toughness and elongation at fracture of components produced from steel that is used according to the invention. If importance is attached to increased strength of the steel used according to the invention, within the scope of the invention the C content may be set in the range of 0.15-0.20 wt. %. In contrast, for a steel that has less strength but particularly good residual elongation capability and toughness, even after the hot press deformation and the hardening that takes place as a result, a C content of 0.10-0.15 wt. % has proven advantageous.

[0018] The residual elongation and hardening capability of the steel used according to the invention may also be influenced by modifying the Mn content. A reduced Mn content in the range of 0.8-1.6 wt. % is conducive to improved residual elongation capability, while a Mn content of 1.0-1.8 wt. % results in improved hardening capability of the steel used according to the invention.

[0019] The residual elongation and the hardening capability of the steel used according to the invention may likewise be set by a suitable adjustment of the nickel content. Thus, a lower Ni content in the range of 0.5-1.8 wt. %, in particular in the range of 0.8-1.5 wt. %, results in greater hardening capability, and at the same time, improved toughness, thereby together achieving improved residual elongation.

[0020] A steel used according to the invention, having high strength and improved residual elongation after hardening achieved in the course of hot forming, accordingly has the following composition (in wt. %): 0.15-0.2% C, 0.05-0.30% Si, 0.8-1.6% Mn, 0.5-1.0% Ni, maximum 0.015% P, maximum 0.003% S, 0.0002-0.0080% B, and the remainder iron and unavoidable impurities.

[0021] A steel used according to the invention, having lower strength but further improved residual elongation after hardening achieved in the course of hot forming, accordingly has the following composition (in wt. %): 0.10-0.15% C, 0.05-0.30% Si, 1.0-1.8% Mn, 0.8-1.8% Ni, maximum 0.015% P, maximum 0.003% S, 0.0002-0.0080% B, and the remainder iron and unavoidable impurities.

[0022] Regardless of which of the various variants, possible within the scope of the alloy

used according to the invention, are used, the hardness-increasing effect of boron in a steel used according to the invention occurs in particular when the B content is at least 0.0008 wt. %.

[0023] The flat steel product used according to the invention may be a hot-rolled or cold-rolled steel strip or steel sheet. Steel strips or sheet steels having a composition as used according to the invention are very well suited for surface finishing by applying a metallic coating. This coating may be applied, for example, by hot-dip aluminizing or hot-dip galvanizing, or by a combination of these methods. In addition, the corrosion protection obtained in each case from the metallic coating may be further improved by additionally providing the flat steel product used according to the invention with an organic or inorganic coating.

[0024] Lastly, with regard to the production method, the object stated above has been achieved by a method for producing a flat steel product used according to the invention, in which the following work steps are carried out:

- smelting of a steel melt having a composition corresponding to that of the flat steel product used according to the invention,
- casting the melt to form slabs or thin slabs,
- hot-rolling of the slabs or thin slabs at a hot-rolling final temperature of 850-900°C to form a hot-rolled strip,
- coiling of the hot-rolled strip at coiling temperatures of 560-600°C.

[0025] For further processing, the obtained hot-rolled strip may be descaled in a manner known per se, for example by pickling. If the obtained flat steel product is to be directly supplied to a component as a hot-rolled strip from the forming, a metallic coating as corrosion protection may now be applied as described above. Alternatively, after the pickling that is carried out if needed, the hot-rolled strip may be cold-rolled to form a cold-rolled strip. To ensure complete recrystallization, the degree of cold rolling that is achieved, preferably without intermediate annealing, should be at least 40%.

[0026] The invention is explained below with reference to exemplary embodiments.

[0027] Two steel melts S1, S2 used according to the invention were smelted in a conventional converter; the compositions of the steel melts are given in Table 1. In addition, the composition of a conventional 22MnB5 steel V is provided in Table 1 for comparison.

[0028] The steel melts S1, S2 were subsequently cast in a likewise conventional casting-

rolling line to form thin slabs.

[0029] Hot-rolled strips were subsequently hot-rolled from the thin slabs thus obtained. The hot-rolling final temperature was 850°C. The hot-rolled strips obtained were subsequently coiled at a coiling temperature of 560°C.

[0030] After the coiling, the hot-rolled strips were pickled and cold-rolled to form cold-rolled strips. The cold rolling was performed without intermediate annealing in order to minimize the production costs. The cold-rolling degree (decrease in thickness achieved by the cold rolling divided by the thickness of the hot-rolled strip to be cold-rolled) obtained in the course of the cold rolling was 40%.

[0031] Samples that were sectioned off from the obtained cold-rolled strips were subsequently provided with a metallic coating by hot-dip aluminizing. In a first sample, the metallic coating was made up of 89-92 wt. % Al, and the remainder Si. A second sample was provided with a coating containing 55 wt. % Al, 43.4 wt. % Zn, and 1.6 wt. % Si by hot-dip aluminizing.

[0032] Other samples that were sectioned off from the obtained cold-rolled strips were subjected to hot-dip galvanizing, in which a first sample was coated with a pure zinc layer (Zn content at least 99 wt. %), and a second sample was coated with a layer of 95 wt. % Zn, and the remainder Al. A third sample was coated, in a manner likewise known per se, by galvannealing with a pure zinc layer.

[0033] The samples treated in this way were formed into body components by hot press forming. The components thus obtained had tensile strengths in each case of greater than 1000 MPa and elongations at fracture A_{80} of at least 10%. By providing a coating layer that was applied by cataphoretic dip coating, followed by drying, it was possible to increase the lower yield strength by at least 80 MPa without changing the strength and elongation at fracture of the components.

[0034] A martensitic, bainitic, or mixed martensitic-bainitic structure was present in the obtained components, depending on the particular temperature control in the tool used for the hot press deformation.

[0035] In Figure 1, the hardness profiles calculated for the steels S1, S2 according to the Jominy **[sic; Jominy]** test are compared to the hardness profile of the steel V having a conventional composition. The respective hardness H is plotted as a function of the respective distance A from the quenched surface.

Table 1

	S1	S2	V
C	0.20	0.15	0.233
Si	0.24	0.24	0.24
Mn	1.00	1.00	1.23
P	< 0.015	< 0.015	0.018
S	< 0.001	< 0.001	0.001
Al	0.03	0.03	0.035
N	0.003	0.003	0.0031
Ni	0.65	0.65	0.023
Ti	0.033	0.033	0.033
B	0.0025	0.0025	0.0022
Cr	< 0.05	< 0.05	0.14

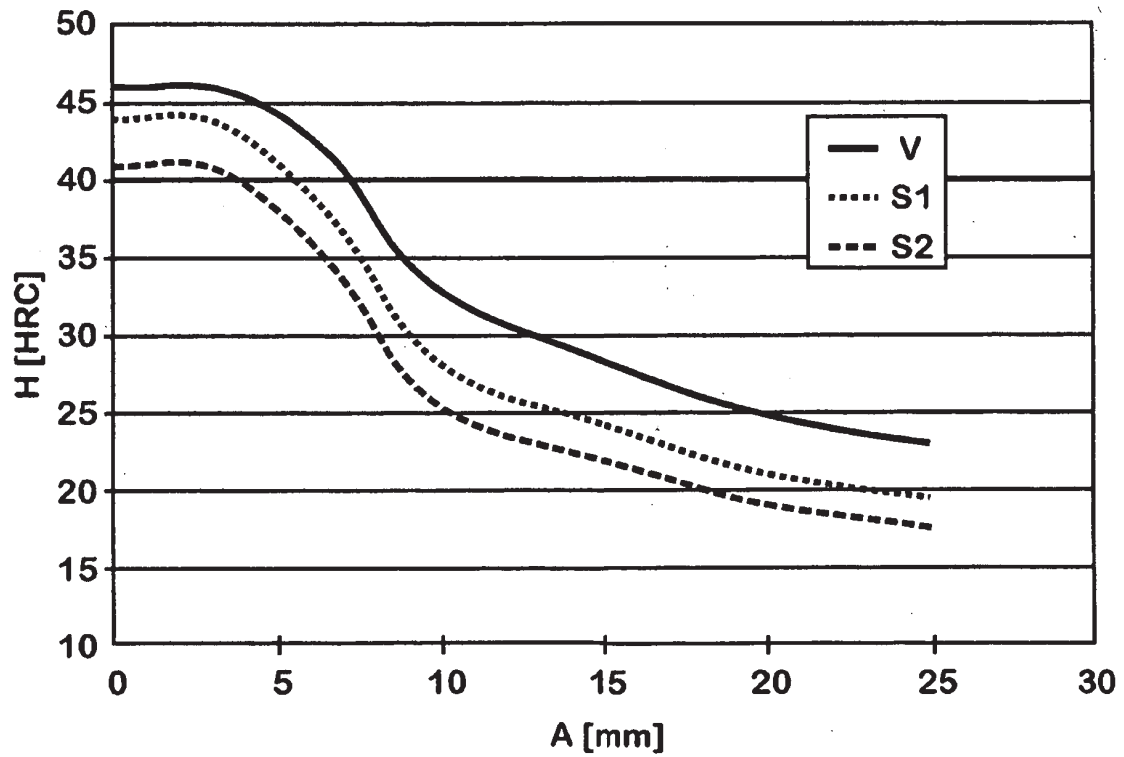


Figure 1