



(11) **EP 2 109 692 B1**

(12) **EUROPEAN PATENT SPECIFICATION**

(45) Date of publication and mention
of the grant of the patent:
27.10.2010 Bulletin 2010/43

(51) Int Cl.:
C22C 38/58 (2006.01) C22C 38/38 (2006.01)

(21) Application number: **08710001.2**

(86) International application number:
PCT/IB2008/050499

(22) Date of filing: **12.02.2008**

(87) International publication number:
WO 2008/099336 (21.08.2008 Gazette 2008/34)

(54) **AUSTENITIC STAINLESS STEEL**

AUSTENITISCHER EDELSTAHL

ACIER INOXYDABLE AUSTÉNITIQUE

(84) Designated Contracting States:
**AT BE BG CH CY CZ DE DK EE ES FI FR GB GR
HR HU IE IS IT LI LT LU LV MC MT NL NO PL PT
RO SE SI SK TR**

(30) Priority: **12.02.2007 IT RM20070069**

(43) Date of publication of application:
21.10.2009 Bulletin 2009/43

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Description

[0001] The present invention refers to the field of low-nickel nickel-chromium-manganese-copper-nitrogen steels.

[0002] As it is known, 3XX series austenitic stainless steels, like, e.g., AISI 304 having a substantially austenitic microstructure at room temperature, are highly appreciated for their high ductility and moldability, their corrosion resistance and workability.

[0003] However, these steels exhibit a mechanical strength not sufficient for structural uses finalized to the making of light-weight structures, like e.g. those of the automotive field (such as chassis, shock absorbers, suspensions).

[0004] Another relevant drawback of these alloys is their high cost, owing to the remarkable amounts of nickel required to stabilize the austenitic phase at room temperature.

[0005] Therefore, in the relevant field there is the need to decrease the amount of nickel in order to reduce the costs of these alloys, and improve their corrosion resistance and mechanical strength, assuring a high cold formability.

[0006] Attempts at partially replacing nickel with elements such as carbon, manganese, copper or nitrogen, highlighted the drawback that nickel reduction entails formation of delta-ferrite and, during cold working, formation of an excessive amount of martensite, which may entail undesired effects such as delayed cracking.

[0007] In US 3,615,365 an austenitic stainless steel is described, composed mainly of manganese, chromium and nickel, containing small yet significant amounts of carbon, silicon, copper and nitrogen. Alloy elements are combined in critical proportions so as to assure a good hot workability thanks to the full control of the amounts of delta-ferrite present and of resulting martensite (both below 10%). The alloy has the following composition: up to about 0.12% carbon, from about 5 to about 8.5% manganese, up to about 2% silicon, from about 15 to about 17.5% chromium, from about 3.5 to about 6.5% nickel, from about 0.75 to about 2.5% copper, up to about 0.05% nitrogen, the remainder being, occasional impurities apart, iron.

[0008] This alloy, as for manganese content, exhibits a lower limit of 5%, since a content lower than this value might require a higher content of expensive nickel, or excessive amounts of copper, making the alloy hot-short. Moreover, for manganese an upper limit of 8.5% is recommended, taking into account that between manganese and copper there should be maintained a proportion suitable to prevent hot-shortness induced by too high Cu contents.

[0009] JP 6 235 049 discloses an austenitic steel of 0.03-0.12 C, 0.05-1.0 Si, 10.0-17.0 Mn, 0.0,4-0.10P, 0.5-6.0 Ni, 16.0-19.5 Cr, 0.5-2.5 Mo, 0.25-0.34 N, and 0.0001-0.1 AL, balance iron.

[0010] According to US 3,615,365, higher nickel or manganese contents should be required, unless at least 0.75% copper is added in order to stabilize the alloy against martensite formation during deformation. However, by adding more than 2.5% copper the above-mentioned hot-shortness drawback occurs.

[0011] According to this document, nickel reduction below the lower limit of the range indicated therein should be compensated for, by increasing the amount of manganese and/or copper to prevent formation of martensite and of an excess of delta-ferrite. Concomitantly, Mn and Cu contents should be balanced to the upper limit of the ranges indicated for these alloy elements, i.e., to about 8% Mn and 2-2.5% Cu, in order to assure sufficient stability of the austenitic phase and a good combination of mechanical and corrosion resistance properties.

[0012] From this context derives the technical prejudice that high (>8%) Mn contents entail negative effects on corrosion resistance, particularly of pitting or crevice type.

[0013] Unexpectedly, it has now been observed that in the austenitic stainless steels of the invention, for low nickel contents, ranging from 3.5 to 4.2%, Mn percents may range from 10.5 to 11.5%, therefore being higher than those envisaged in the above-mentioned prior art, without prejudice of mechanical and corrosion resistance properties and with the advantage of increasing nitrogen solubility, thereby contributing to prevent the appearance of porosities, even in the presence of higher contents of this element.

[0014] Given the marked contribution to austenitic phase stabilization provided by nitrogen, which is maintained at high levels thanks to the presence of high Mn contents, there may be increased also the content of Cr, a notoriously alpha-genic element, from 15-17.5% to 17.6-18.3%, with the advantageous effect of improving the corrosion resistance.

[0015] Austenitic phase stabilization is also achieved in the alloy, thanks to the high N content (0.25-0.40%). This high nitrogen content entails an improvement of the corrosion resistance (in particular by pitting) and of the mechanical properties, by effect of the strengthening induced by its interstitial solid solution. The high concentration of nitrogen, thanks to its enhanced solubility, by effect of the increase of the Mg percent, prevents formation of porosities, in particular superficial ones.

[0016] Moreover, there is a second class of Cr-Mn-Ni-based 2XX series austenitic stainless steels that, with a reduced Ni content, partially solve the problem of reducing the costs of alloy elements, and in particular of Ni.

[0017] 2XX series steels, though possessing a mechanical strength higher than that of series 3XX steels, exhibit however reduced corrosion resistance and lower formability.

[0018] All of the hereto-shown drawbacks of the state of the art can be overcome by the steel of the present invention, which anyhow exhibits a delta-ferrite content lower than 10% and a martensite content, resulting from the working, lower than 10%.

[0019] For applications requiring improved toughness, preferably the lower limit of the nickel range is 3.8%.

[0020] The function of the individual elements in the alloy according to the present invention is reported hereinafter.

[0021] Carbon, though being a strong stabilizer for the austenitic phase, cannot be used in high (>0.1%) contents in order not to cause an excessive decrease of intergranular corrosion resistance and not to create weldability problems.

[0022] Chromium fosters corrosion resistance and enhances nitrogen solubility, preventing the appearance of porosities. Chromium content cannot be higher than 19% in order to avoid effects of its alphagenic character and tendency to form undesired intermetallic phases.

[0023] Nickel is the primary austenitizing element. A reduction of its content in the alloy, in order to meet economic and strategic needs, should foresee the introduction of replacing elements that may compensate for the consequent reduction in the gammagenic character of the alloy.

[0024] Manganese has a marked stabilizing effect on the austenitic phase and considerably enhances nitrogen solubility, thereby contributing to prevent appearance of porosities. Balancing of Mn and other alloy elements of the steel of this invention, such as S and N, even in the presence of relatively high copper values, prevents problems related to hot-shortness and allows to obtain a corrosion resistance comparable to the more expensive AISI 304.

[0025] Copper, besides fostering formation of austenitic phase and contributing to its stability, improves the resistance of stainless steels towards generalized corrosion. As already seen in the foregoing, copper content should not be higher than 3% in order to prevent hot workability problems.

[0026] Silicon is an important element, both for the fluidifying effect it exerts on the metal bath and for oxidation resistance. Due to its alphagenic character, it should be limited to 0.60% and, at higher contents, may create problems during pickling. However, for a good steel castability it should be present in contents higher than 0.15%.

[0027] Nitrogen is a strong stabilizer of the austenitic phase, moreover determining an improvement of pitting corrosion resistance. However, due to its reduced solubility in the liquid phase, nitrogen cannot be introduced in the alloy by conventional casting methods in contents sufficient to completely replace nickel. An important effect of nitrogen is the strengthening, induced by its interstitial solid solution, bringing about strength characteristics tendentially higher than the AISI 3XX class.

[0028] Molybdenum, in the percent range indicated, besides acting as alphagenic element and increasing nitrogen solubility in the alloy, is essential for the improvement of corrosion resistance and, in particular, of pitting corrosion resistance. However, a high percent of this element would not allow nickel to be decreased to desired levels. In this regard, it has to be pointed out that, in the context of the invention, molybdenum percents lower than the lower limit of the indicated range should be considered as impurities.

[0029] Boron, in the percent range indicated and suitably balanced with nitrogen, is effective at improving cold formability and mechanical strength (yield). In this regard, it has to be pointed out that, in the context of the invention, boron percents lower than the lower limit of the indicated range should be considered as impurities.

[0030] Sulphur, in the composition range according to the invention and suitably balanced with manganese, also contributes to improve hot workability.

[0031] Phosphor, in the composition range according to the invention, has no negative effect on mechanical properties and corrosion resistance.

[0032] The composition of the steel according to the present invention is as follows: C 0.02-0.06; Cr 17.8-18.3; Ni 3.8-4.2; Mn 10.5-11.7; Cu 1.8-2.2; Si 0.15-0.40; N 0.25-0.33; S $\leq$ 0.01; P $\leq$ 0.03, and optionally Mo 0.2-1.0 and B 0.001-0.003, the remainder being, unavoidable impurities apart, iron.

[0033] The present invention is not limited to the low-nickel austenitic stainless steel described hereto. It extends also to a process for preparing rolled sections of austenitic stainless steel and to the rolled sections having the composition according to the invention.

[0034] Therefore, subject-matter of the present invention is also a process for producing rolled sections of low-nickel austenitic stainless steel, characterized by subjecting a steel containing the following components expressed as percent by weight:

C 0.02-0.10; Cr 17.6-19.0; Ni 3.5-4.5; Mn 10.5-12.5; Cu 1.5-3.0; Si 0.15-0.60; N 0.25-0.40; S $\leq$ 0.01; P $\leq$ 0.03, and optionally Mo 0.2-1.0 and B 0.001-0.003, the remainder being unavoidable impurities apart, iron,

to the following operations:

- continuous casting in an ingot mold with a casting rate ranging from 0.5 to 5 m/min and a steel overheating at the casting ranging from 10 to 60°C;
- solidification of said steel cast in the form of slabs having a thickness ranging from 50 to 250 mm, with a cooling rate such as to complete solidification in a time ranging from 30 to 900 s;
- heat equalization treatment of said slabs at a temperature ranging from 1150 to 1400°C;
- hot rolling of said slabs, with a start-of-rolling temperature ranging from 950 to 1250°C and an end-of-rolling tem-

perature ranging from 750 to 1150°C, so as to obtain said rolled sections.

[0035] Preferred embodiments of this process are given in claims 3 and 4.

[0036] Preferably, the above-described process is applied to a steel having the following composition expressed as percent by weight: C 0.02-0.06; Cr 17.8-18.3; Ni 3.8-4.2; Mn 10.5-11.7; Cu 1.8-2.2; Si 0.15-0.40; N 0.25-0.37; S $\leq$ 0.01; P $\leq$ 0.03, and optionally Mo 0.2-1.0 and B 0.001-0.003, the remainder being unavoidable impurities apart, iron.

[0037] The above-described process, applied to steel having the chemical composition of the present invention, increases the content of nitrogen in solution thanks to the high solidification rate and high casting rate.

[0038] The greater amount of nitrogen in solution with respect to the traditional casting cycle allows to reduce Ni content and concomitantly increase the mechanical characteristics of the steel.

[0039] Further advantages of said cycle are represented by the reduction of interdendritic segregation, the reduction of the content of delta-ferrite and the more homogeneous in-matrix dispersion thereof. Moreover, these advantages contribute to give high isotropy, and therefore improved cold formability, to the rolled sections thus produced.

[0040] It was observed that the steels and the rolled sections according to the invention exhibit the following values of yield strength based on a 0.2 percent permanent set (Rp0.2), ultimate tensile strength (Rm), ultimate elongation (A) and Erichsen Index (E.I.).

[0041] Steels according to the invention: Rp0.2 (MPa) 400-450; Rm (MPa) 690-800; A (%) 35-50; I.E. (mm) >10.5.

[0042] Rolled sections according to the invention: Rp0.2 (MPa) 400-550; Rm (MPa) 730-850; A (%) 30-45; I.E. (mm) >10.3.

[0043] Therefore, in addition to reduced production costs, these rolled sections exhibit mechanical properties higher than those of conventional AISI 3XX steel products, and, production costs being substantially equal, analogous formability and corrosion resistance higher than that of conventional AISI 2XX steel products.

[0044] A general description of the present invention has been given hereto. With the aid of the following examples, hereinafter there will be given further details of specific embodiments of the invention, aimed at making better understood the objects, features, advantages and application modes thereof.

Example 1

[0045] In the following Table 1 there are reported the chemical compositions of steels according to the present invention and of conventional comparison steels.

[0046] In Table 2 there are reported mechanical strength, formability and corrosion resistance data for the steels of Table 1.

[0047] As it is evident from analysis of Tables 1 and 2, steels according to the invention exhibit mechanical strength higher than that of conventional steels taken into account, high corrosion resistance and good formability properties.

TABLE 1

	B	C	Cr	Cu	Mn	Mn	N	N	P	S	E
Invention steel											
A	0,0007*	0,0032	17,65	1,67	11,05	0,13*	0,274	3,85	0,026	0,002	0,23
B	0,0009*	0,0043	15,09	2,01	10,34	0,89	0,268	4,01	0,026	0,001	0,22
C	0,0020	0,0053	17,01	1,02	11,64	0,03*	0,282	3,90	0,024	0,001	0,15
D	0,0018	0,0052	18,10	1,92	10,51	0,11*	0,330	3,01	0,028	0,002	0,23
E	0,0022	0,0026	17,00	2,05	10,85	0,15*	0,280	3,07	0,023	0,001	0,26
comparison steel											
F (AISI 201)	0,0008	0,019	18,15	0,25	0,45	0,06	0,166	3,66	0,032	0,001	0,38
G (NSI 304)	0,0013	0,052	18,02	0,32	1,23	0,15	0,054	7,99	0,029	0,001	0,41
* At the level indicated, for the purposes of the invention, it should be considered an unavoidable impurity											

TABLE 2

	Yield strength as Rp0.2 (MPa)	Ultimate tensile strength (MPa)	Ultimate elongation (%)	Erichsen Index (mm) Samples 1.5 mm thick	Pitting potential (mV/SCE)
A	432,4	739,2	43,6	11,2	350
A-1	395,4	702,6	46,5	10,8	354
B	426,8	714,7	48,8	10,9	75
C	426,8	749,1	44,8	12,2	370
C-1	406,5	705,5	42,5	11,4	368
D	513,9	831,5	44,9	11,7	391
E	433,9	730,4	44,1	12,1	373
F (AISI 201)	343,2	811,5	50,9	13,8	286
G (AISI 304)	268,6	615,9	56,4	13,2	452

EXAMPLE 2

[0048] According to the present invention a steel was made, complying with the chemical composition denoted by A in Table 1.

[0049] This steel was cast by means of continuous casting technology, making slabs having a 220mm-thickness.

[0050] The resulting steel has, as shown in Table 2, a yield strength as Rp0.2 improved with respect to that of the conventional steels shown in Table 1 and denoted by F and G.

[0051] Members intended for the automotive field, in particular bumper cross members, were made with this steel.

[0052] This steel was cast by means of continuous casting technology, making slabs having a 220mm-thickness.

[0053] Continuous casting occurs in an ingot mold with a casting rate of 1m/min and a steel overheating at the casting of 40°C.

[0054] Solidification of this steel, cast in the form of slabs, occurs with a cooling rate such as to complete solidification in 600 s.

[0055] Heat equalization treatment of the slabs occurs at a temperature of 1280°C.

[0056] Hot rolling of the slabs is performed with a start-of-rolling temperature of 1100°C and an end-of-rolling temperature of 950°C, so as to obtain said rolled sections.

[0057] In an attempt at providing a further comparative exemplification, a steel was made complying, in terms of composition, with the chemical composition denoted by A in Table 1, and this steel was cast by a thermo-mechanical treatment differing from the thermo-mechanical cycle proposed by the present invention.

[0058] The resulting steel has, as shown in Table 2, case A-1, a yield strength as Rp0.2 lower than that of steel A obtained according to the thermo-mechanical treatment complying with what is subject-matter of the present invention.

EXAMPLE 3

[0059] According to the present invention a steel was made, complying with the chemical composition denoted by C in Table 1.

[0060] This steel was cast by means of a traditional casting technology, making slabs having a 220mm-thickness.

[0061] The resulting steel has, as shown in Table 2, an improved formability/ability to undergo drawing (Erichsen Index) with respect to steel A of Table 1.

[0062] With this steel there were made, by means of forming and hydroforming techniques, members intended for the automotive field, in particular suspension arms.

[0063] This steel was cast by means of a continuous casting technology, making slabs having a 180mm-thickness.

[0064] Continuous casting occurs in an ingot mold with a casting rate of 0.8m/min and a steel overheating at the casting of 50°C.

[0065] Solidification of this steel, cast in the form of slabs, occurs with a cooling rate such as to complete solidification in 750 s.

[0066] Heat equalization treatment of the slabs occurs at a temperature of 1310°C.

[0067] Hot rolling of the slabs is performed with a start-of-rolling temperature of 1160°C and an end-of-rolling temper-

ature of 980°C, so as to obtain said rolled sections.

[0068] In an attempt at providing a further comparative exemplification, a steel was made complying, in terms of composition, with the chemical composition denoted by C in Table 1, and this steel was cast by a thermo-mechanical treatment differing from the thermo-mechanical cycle proposed by the present invention.

[0069] The resulting steel has, as shown in Table 2, case C-1, a yield strength as Rp0.2 lower than that of steel C obtained according to the thermo-mechanical treatment complying with what is subject matter of the present invention.

EXAMPLE 4

[0070] According to the present invention, a steel strip having chemical composition D, according to Table 1, is produced:

- by continuous casting in an ingot mold, with a casting rate of 3.5m/min and a steel overheating at the casting of 40°C;
- with solidification of the steel, cast in the form of slabs having a 60 mm-thickness, with a cooling rate such as to complete solidification in a 180 s-time;
- with heat equalization treatment of said slabs at a temperature of 1280°C;
- with hot rolling of said slab, with a start-of-rolling temperature of 1140°C and an end-of-rolling temperature of 950°C, so as to obtain a rolled section according to the invention.

[0071] This steel has a nitrogen content higher than that of the steels having compositions A and C. Moreover, it possesses a mechanical strength and a corrosion resistance higher than those of the same steels having compositions A and C.

[0072] Members intended for the automotive field, in particular reinforcement bars, were made with this steel.

Claims

1. A low-nickel austenitic stainless steel, containing the following components expressed as percent by weight: C 0.02-0.06; Cr 17.8-18.3; Ni 3.8-4.2; Mn 10.5-11.7; Cu 1.8-2.2; Si 0.15-0.40; N 0.25-0.33; S ≤ 0.01; P ≤ 0.03, and optionally Mo 0.2-1.0 and B 0.001-0.003, the remainder being, unavoidable impurities apart, iron.

2. A process for producing rolled sections of low-nickel austenitic stainless steel, **characterized by** subjecting a steel, containing the following components expressed as percent by weight:

C 0.02-0.10; Cr 17.6-19.0; Ni 3.5-4.5; Mn 10.5-12.5; Cu 1.5-3.0; Si 0.15-0.60; N 0.25-0.40; S ≤ 0.01; P ≤ 0.03, and optionally Mo 0.2-1.0 and B 0.001-0.003, the remainder being, unavoidable impurities apart, iron,

to the following operations:

- continuous casting in an ingot mold with a casting rate ranging from 0.5 to 5 m/min and a steel overheating at the casting ranging from 10 to 60°C;
- solidification of said steel cast in the form of slabs having a thickness ranging from 50 to 250 mm, with a cooling rate such as to complete solidification in a time ranging from 30 to 900 s;
- heat equalization treatment of said slabs at a temperature ranging from 1150 to 1400°C;
- hot rolling of said slabs, with a start-of-rolling temperature ranging from 950 to 1250°C and an end-of-rolling temperature ranging from 750 to 1150°C, so as to obtain said rolled sections.

3. A process for producing rolled sections of low-nickel austenitic stainless steel, **characterized by** subjecting a steel containing the following components expressed as percent by weight:

C 0.02-0.10; Cr 17.6-19.0; Ni 3.5-4.5; Mn 10.5-12.5; Cu 1.5-3.0; Si 0.15-0.60; N 0.25-0.40; S ≤ 0.01; P ≤ 0.03, and optionally Mo 0.2-1.0 and B 0.001-0.003, the remainder being iron and the unavoidable impurities, to the following operations:

- continuous casting in an ingot mold with a casting rate ranging from 3 to 5 m/min and a steel overheating at the casting ranging from 20 to 50°C;
- solidification of said steel cast in the form of slabs having a thickness ranging from 50 to 120 mm, with a cooling rate such as to complete solidification in a time ranging from 30 to 300 s;

- heat equalization treatment of said slabs at a temperature ranging from 1200 to 1350°C;
- hot rolling of said slabs, with a start-of-rolling temperature ranging from 1000 to 1200°C and an end-of-rolling temperature ranging from 850 to 1100°C,
- obtainment of the hot-rolled sections.

4. The process for producing rolled sections of low-nickel austenitic stainless steel, according to claim 3, wherein nickel concentration range is 3.8-4.5%.

5. The process for producing rolled sections of low-nickel austenitic stainless steel, according to claim 3 or 4, wherein a steel containing the following components expressed as percent by weight: C 0.02-0.06; Cr 17.8-18.3; Ni 3.8-4.2; Mn 10.5-11.7; Cu 1.8-2.2; Si 0.15-0.40; N 0.25-0.37; S ≤ 0.01; P ≤ 0.03, and optionally Mo 0.2-1.0 and B 0.001-0.003, the remainder being, unavoidable impurities apart, iron, is subjected to the following operations:

- continuous casting of said steel in an ingot mold with a casting rate ranging from 3 to 5 m/min and a steel overheating at the casting ranging from 20 to 60°C;
- solidification of said steel cast in the form of slabs having a thickness ranging from 50 to 90 mm, with a cooling rate such as to complete solidification in a time ranging from 30 to 300 s;
- heat equalization treatment of said slabs at a temperature ranging from 1150 to 1300°C;
- hot rolling of said slabs, with a start-of-rolling temperature ranging from 950 to 1200°C and an end-of-rolling temperature ranging from 850 to 1050°C;
- obtainment of the hot-rolled sections.

6. Rolled sections, **characterized by** being made of low-nickel austenitic stainless steel according to claim 1.

Patentansprüche

1. Austenitischer Edelstahl mit niedrigem Nickelgehalt, der die folgenden Bestandteile enthält, ausgedrückt als Gewichtsprozente: C 0,02 - 0,06; Cr 17,8 - 18,3; Ni 3,8 - 4,2; Mn 10,5 - 11,7; Cu 1,8 - 2,2; Si 0,15 - 0,40; N 0,25 - 0,33; S ≤ 0,01; P ≤ 0,03 und gegebenenfalls Mo 0,2 - 1,0 und B 0,001 - 0,003, wobei der Rest, neben unvermeidbaren Verunreinigungen, Eisen ist.

2. Verfahren zur Herstellung von gewalzten Formstählen aus austenitischem Edelstahl mit niedrigem Nickelgehalt, **dadurch gekennzeichnet, dass** ein Stahl, der die folgenden Bestandteile enthält, ausgedrückt als Gewichtsprozente:

C 0,02 - 0,10; Cr 17,6 - 19,0; Ni 3,5 - 4,5; Mn 10,5 - 12,5; Cu 1,5 - 3,0; Si 0,15 - 0,60; N 0,25 - 0,40; S ≤ 0,01; P ≤ 0,03 und gegebenenfalls Mo 0,2 - 1,0 und B 0,001 - 0,003, wobei der Rest, neben unvermeidbaren Verunreinigungen, Eisen ist,

den folgenden Arbeitsgängen unterzogen wird:

- Strangguss in einer Blockkokille mit einer Gießgeschwindigkeit, die von 0,5 bis 5 m/min reicht, und einer Stahlüberhitzung bei dem Gießen, die von 10 bis 60 °C reicht;
- Verfestigung des Stahlgusses in der Form von Brammen mit einer Dicke, die von 50 bis 250 mm reicht, mit einer Kühlgeschwindigkeit, so dass die Verfestigung in einem Zeitraum, der von 30 bis 900 s reicht, abgeschlossen wird;
- Wärmeausgleichbehandlung der Brammen bei einer Temperatur, die von 1150 bis 1400 °C reicht;
- Warmwalzen der Brammen mit einer Ausgangswalztemperatur, die von 950 bis 1250 °C reicht, und einer Endwalztemperatur, die von 750 bis 1150 °C reicht, um die gewalzten Formstähle zu erhalten.

3. Verfahren zur Herstellung von gewalzten Formstählen aus austenitischem Edelstahl mit niedrigem Nickelgehalt, **dadurch gekennzeichnet, dass** ein Stahl, der die folgenden Bestandteile enthält, ausgedrückt als Gewichtsprozente:

C 0,02 - 0,10; Cr 17,6 - 19,0; Ni 3,5 - 4,5; Mn 10,5 - 12,5; Cu 1,5 - 3,0; Si 0,15 - 0,60; N 0,25 - 0,40; S ≤ 0,01; P ≤ 0,03 und gegebenenfalls Mo 0,2 - 1,0 und B 0,001 - 0,003, wobei der Rest Eisen und die unvermeidbaren Verunreinigungen ist, den folgenden Arbeitsgängen unterzogen wird:

- Strangguss in einer Blockkokille mit einer Gießgeschwindigkeit, die von 3 bis 5 m/min reicht, und einer Stahlüberhitzung bei dem Gießen, die von 20 bis 50 °C reicht;
- Verfestigung des Stahlgusses in der Form von Brammen mit einer Dicke, die von 50 bis 120 mm reicht, mit einer Kühlgeschwindigkeit, so dass die Verfestigung in einem Zeitraum, der von 30 bis 300 s reicht, abgeschlossen wird;
- Wärmeausgleichbehandlung der Brammen bei einer Temperatur, die von 1200 bis 1350 °C reicht;
- Warmwalzen der Brammen mit einer Ausgangswalztemperatur, die von 1000 bis 1200 °C reicht, und einer Endwalztemperatur, die von 850 bis 1100 °C reicht,
- Erhalten der warmgewalzten Formstähle.

4. Verfahren zur Herstellung von gewalzten Formstählen aus austenitischem Edelstahl mit niedrigem Nickelgehalt nach Anspruch 3, wobei der Nickelkonzentrationsbereich 3,8 - 4,5 % ist.

5. Verfahren zur Herstellung von gewalzten Formstählen aus austenitischem Edelstahl mit niedrigem Nickelgehalt nach Anspruch 3 oder 4, wobei ein Stahl, der die folgenden Bestandteile enthält, ausgedrückt als Gewichtsprozente: C 0,02 - 0,06; Cr 17,8 - 18,3; Ni 3,8 - 4,2; Mn 10,5 - 11,7; Cu 1,8 - 2,2; Si 0,15 - 0,40; N 0,25 - 0,37; S ≤ 0,01; P ≤ 0,03 und gegebenenfalls Mo 0,2 - 1,0 und B 0,001 - 0,003, wobei der Rest Eisen, neben unvermeidbaren Verunreinigungen, ist, den folgenden Arbeitsgängen unterzogen wird:

- Strangguss des Stahls in einer Blockkokille mit einer Gießgeschwindigkeit, die von 3 bis 5 m/min reicht, und einer Stahlüberhitzung bei dem Gießen, die von 20 bis 60 °C reicht;
- Verfestigung des Stahlgusses in der Form von Brammen mit einer Dicke, die von 50 bis 90 mm reicht, mit einer Kühlgeschwindigkeit, so dass die Verfestigung in einem Zeitraum, der von 30 bis 300 s reicht, abgeschlossen wird;
- Wärmeausgleichbehandlung der Brammen bei einer Temperatur, die von 1150 bis 1300 °C reicht;
- Warmwalzen der Brammen mit einer Ausgangswalztemperatur, die von 950 bis 1200 °C reicht, und einer Endwalztemperatur, die von 850 bis 1050 °C reicht;
- Erhalten der warmgewalzten Formstähle.

6. Gewalzte Formstähle, **dadurch gekennzeichnet, dass** sie aus austenitischem Edelstahl mit niedrigem Nickelgehalt nach Anspruch 1 hergestellt sind.

Revendications

1. Acier inoxydable austénitique à faible teneur en nickel, contenant les composants suivants exprimés en pour cent en poids : C 0,02-0,06 ; Cr 17,8-18,3 ; Ni 3,8-4,2 ; Mn 10,5-11,7 ; Cu 1,8-2,2 ; Si 0,15-0,40 ; N 0,25-0,33 ; S ≤ 0,01 ; P ≤ 0,03, et de manière facultative Mo 0,2-1,0 et B 0,001-0,003, le reste représentant du fer, sans compter les impuretés inévitables.

2. Procédé pour la production de profilés laminés en acier inoxydable austénitique à faible teneur en nickel, **caractérisé par** le fait de soumettre un acier, contenant les composants suivants exprimés en pour cent en poids :

C 0,02-0,10 ; Cr 17,6-19,0 ; Ni 3,5-4,5 ; Mn 10,5-12,5 ; Cu 1,5-3,0 ; Si 0,15-0,60 ; N 0,25-0,40 ; S ≤ 0,01 ; P ≤ 0,03, et de manière facultative Mo 0,2-1,0 et B 0,001-0,003, le reste représentant du fer, sans compter les impuretés inévitables, aux opérations suivantes :

- couler en continu dans une lingotière avec une vitesse de coulage dans la plage de 0,5 à 5 m/min et soumettre l'acier à une surchauffe lors du coulage, à une température dans la plage de 10 à 60 °C ;
- solidifier ledit acier coulé sous la forme de brames possédant une épaisseur dans la plage de 50 à 250 mm, avec une vitesse de refroidissement telle que l'on obtient une solidification complète dans un laps de temps qui se situe dans la plage de 30 à 900 secondes ;
- soumettre lesdites brames à un traitement d'égaleisation thermique à une température qui se situe dans la plage de 1150 à 1400 °C ;
- laminier à chaud lesdites brames, avec une température de début de laminage qui se situe dans la plage de 950 à 1250 °C et une température de fin de laminage qui se situe dans la plage de 750 à 1150 °C, de façon à obtenir lesdits profilés laminés.

3. Procédé pour la production de profilés laminés en acier inoxydable austénitique à faible teneur en nickel, **caractérisé par** le fait de soumettre un acier, contenant les composants suivants exprimés en pour cent en poids :

C 0,02-0,10 ; Cr 17,6-19,0 ; Ni 3,5-4,5 ; Mn 10,5-12,5 ; Cu 1,5-3,0 ; Si 0,15-0,60 ; N 0,25-0,40 ; S $\leq$ 0,01 ; P $\leq$ 0,03, et de manière facultative Mo 0,2-1,0 et B 0,001-0,003, le reste représentant du fer, sans compter les impuretés inévitables, aux opérations suivantes :

- couler en continu dans une lingotière avec une vitesse de coulage dans la plage de 3 à 5 m/min et soumettre l'acier à une surchauffe lors du coulage, à une température dans la plage de 20 à 50 °C ;
- solidifier ledit acier coulé sous la forme de brames possédant une épaisseur dans la plage de 50 à 120 mm, avec une vitesse de refroidissement telle que l'on obtient une solidification complète dans un laps de temps qui se situe dans la plage de 30 à 300 secondes ;
- soumettre lesdites brames à un traitement d'égalisation thermique à une température qui se situe dans la plage de 1200 à 1350 °C ;
- laminier à chaud lesdites brames, avec une température de début de laminage qui se situe dans la plage de 1000 à 1200 °C et une température de fin de laminage qui se situe dans la plage de 850 à 1100 °C ;
- obtenir les profilés laminés.

4. Procédé pour la production de profilés laminés en acier inoxydable austénitique à faible teneur en nickel, selon la revendication 3, dans lequel la plage de concentration du nickel s'élève de 3,8 à 4,5 %.

5. Procédé pour la production de profilés laminés en acier inoxydable austénitique à faible teneur en nickel, selon la revendication 3 ou 4, dans lequel on soumet un acier, contenant les composants suivants exprimés en pour cent en poids :

C 0,02-0,06 ; Cr 17,8-18,3 ; Ni 3,8-4,2 ; Mn 10,5-11,7 ; Cu 1,8-2,2 ; Si 0,15-0,40 ; N 0,25-0,37 ; S $\leq$ 0,01 ; P $\leq$ 0,03, et de manière facultative Mo 0,2-1,0 et B 0,001-0,003, le reste représentant du fer, sans compter les impuretés inévitables, aux opérations suivantes :

- couler en continu ledit acier dans une lingotière avec une vitesse de coulage dans la plage de 3 à 5 m/min et soumettre l'acier à une surchauffe lors du coulage, à une température dans la plage de 20 à 60 °C ;
- solidifier ledit acier coulé sous la forme de brames possédant une épaisseur dans la plage de 50 à 90 mm, avec une vitesse de refroidissement telle que l'on obtient une solidification complète dans un laps de temps qui se situe dans la plage de 30 à 300 secondes ;
- soumettre lesdites brames à un traitement d'égalisation thermique à une température qui se situe dans la plage de 1150 à 1300 °C ;
- laminier à chaud lesdites brames, avec une température de début de laminage qui se situe dans la plage de 950 à 1200 °C et une température de fin de laminage qui se situe dans la plage de 850 à 1050 °C ;
- obtenir les profilés laminés.

6. Profilés laminés, **caractérisés par le fait qu'**on les obtient à partir d'acier inoxydable austénitique à faible teneur en nickel selon la revendication 1.

REFERENCES CITED IN THE DESCRIPTION

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