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(54) **AUSTENITIC STEEL HAVING HIGH STRENGTH AND FORMABILITY METHOD OF PRODUCING SAID STEEL AND USE THEREOF**

AUSTENITISCHER STAHL MIT HOHER FESTIGKEIT UND VERFORMBARKEIT, VERFAHREN ZU SEINER HERSTELLUNG UND DESSEN VERWENDUNG

ACIER AUSTÉNITIQUE À HAUTE RÉSISTANCE ET PROCÉDÉ POUR SA FABRICATION ET SON UTILISATION

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Description

[0001] The invention relates to an austenitic steel having high strength and good formability for cold rolling. The invention also relates to a method of producing said steel and the use thereof.

[0002] Austenitic steels having a high strength, such as Hadfield steels, comprising manganese (11 to 14%) and carbon (1.1 to 1.4%) as its main alloying elements, have been known for a long time. The original Hadfield steel, containing about 1.2% C and 12% Mn, was invented by Sir Robert Hadfield in 1882. This steel combines high toughness and a reasonable ductility with high work-hardening capacity and, usually, good resistance to wear. However, Hadfield steels do not have good formability due to large amounts of brittle carbides. Due to the high work-hardening rate, the steels are difficult to machine. GB 297420 discloses a cast Hadfield-type steel with additions of aluminium to improve the machinability. The addition of aluminium results in the formation of particles which improve the machinability, particularly machinability by material detaching tools.

[0003] A disadvantage of these types of steel is that they are difficult to cold roll. The high work-hardening rate and the presence of brittle carbides makes the steel work harden very quickly. US Patent 2,448,753 attempted to solve this problem by repeatedly heating, quenching, pickling and cold-rolling the hot rolled material until the desired cold rolled thickness is reached. However, this is a very costly process.

[0004] US 5,431,753 discloses a process for manufacturing a cold rolled steel having a manganese content of between 15 and 35%, up to 1.5% in carbon and between 0.1 and 3.0% of Aluminium. A lower manganese content is disclosed to be undesirable.

[0005] SU621782 A1 discloses an alloy for cores intended for the production of rods of high speed steels with internal channels, wherein the alloy has a composition containing in wt% C 0.7-0.9, Si 0.1-0.2, Ni 2.0-2.5, Mn 12-13, Al 1.0-1.5 and the balance being Fe.

[0006] It is an object of the invention to provide an austenitic steel having high strength and good formability which can be cold rolled to its final thickness without an intermediate annealing step.

[0007] It is also an object of the invention to provide an austenitic steel having improved strength and formability.

[0008] It is also an object of the invention to provide an austenitic steel having high strength and formability which can be produced in an economical way.

[0009] At least one of these objects can be reached by a steel for cold rolling consisting of in weight percent

- 0.05 to 0.75% C
- 11.0 to 14.9% Mn
- 1.0 to 5.0% Al
- 0 to 2.5% Ni

the remainder being iron and unavoidable impurities, wherein the microstructure comprises at least 80% in volume of austenite, and wherein (Ni+Mn) is from 11.0 to 15.9%.

[0010] The carbon content of the steel according to the invention is much lower than the Hadfield steels, which is known to be about 1.2%. The contribution of the alloying elements is believed to be as follows hereinafter. Carbon inhibits the formation of ϵ -martensite by increasing the Stacking Fault Energy (SFE). Stacking faults are precursors to ϵ -martensite, so increasing the SFE decreases the tendency to form ϵ -martensite. The lower carbon content results in a lower tendency to form embrittling phases and/or precipitates during cooling after rolling, and the lower carbon content in comparison to Hadfield steels is also beneficial for the weldability of the steel. In addition carbon improves the stability of the austenite since carbon is an austenite stabilising element.

[0011] The main deformation mechanisms in the austenitic steel according to the invention are strain induced twinning and transformation induced plasticity.

[0012] Manganese improves the strength of the steel by substitutional hardening and it is an austenite stabilising element. Lowering the manganese content results in a reduction of the SFE of the alloy and hence in a promotion of strain induced twinning. The manganese range according to the invention provides a stable or meta-stable austenite at room temperature.

[0013] Aluminium reduces the activity of carbon in austenite in steels according to the invention. The reduction in carbon activity increases the solubility of carbon in austenite, thereby decreasing the driving force for precipitation of carbides, particularly of (FeMn)-carbides, by reducing the carbon super-saturation. Aluminium also reduces the diffusivity of carbon in austenite and thereby reduces the susceptibility to dynamic strain ageing during deformation processes such as cold rolling. The lower diffusivity also leads to a slower formation of carbides, and thus prevents or at least hinders the formation of coarse precipitates. Since higher aluminium contents also lead to a higher SFE, the tendency for strain induced twinning is lowered at increasing Aluminium levels. Consequently, a decrease in carbon content can be compensated by an increase in aluminium content with regard to the suppression of the formation of ϵ -martensite and the prevention or hindering of the formation of brittle carbides, particularly (FeMn)-carbides. These carbides are

believed to contribute to poor workability of the steels according to the invention and their formation has thus to be avoided. So the combination of a reduced carbon activity and a reduced carbon diffusivity lead to a reduced or no formation of brittle carbides, particularly (FeMn)-carbides, and therefore to an improved formability and also an improved cold rollability. It was found that below 1 % aluminium the suppression of ϵ -martensite was insufficient, and at levels

exceeding 5% aluminium, the SFE becomes too high, thereby adversely affecting the twinning deformation mechanism. [0014] Since aluminium is also a ferrite stabilising element, the influence on the austenite stability of the aluminium additions has to be compensated for by manganese and other austenite stabilising elements. Manganese can, at least partly, be replaced by elements which also promote austenite stability such as nickel. It is believed that Nickel has a beneficial effect on the elongation values and impact strength.

[0015] Since the amount of alloying additions is kept as low as possible whilst maintaining favourable cold rolling and mechanical properties, the austenite is meta-stable and the microstructure of the steel may not be fully austenitic. The microstructure in the steel according to the present invention as a function of composition may comprise a mixture of ferrite and austenite with components of martensite.

[0016] Upon deforming the steel according to the invention, a beneficial combination of the deformation mechanisms of plasticity induced by twinning and plasticity induced by transformation under the influence of deformation provides excellent formability, whereas the lower strain hardening and work hardening rate as compared to conventional Hadfield steel in combination with a lower susceptibility to dynamic strain ageing as a result of the aluminium addition and the absence of coarse and/or brittle carbides results in good cold-rolling and forming properties. It has been found that the favourable cold rolling and mechanical properties are already obtained when the microstructure comprises at least 80% in volume of austenite. The steel according to the invention also has a good galvanisability as a result of the absence of silicon as an alloying element, i.e. in the sense of a deliberate addition of silicon for alloying purposes. In addition, there is no risk of low melting silicon oxide, thereby preventing the occurrence of sticking silicon oxides on the surface of the hot rolled strip. It should be noted that the steel not only has excellent cold-rollability, but that similar excellent properties in terms of strength and formability are obtained in its pre-cold rolling state, i.e. for instance in its as-hot-rolled state, but also in the recrystallised state after cold-rolling and annealing.

[0017] In an embodiment of the invention (Ni+Mn) is at most 14.9%. This embodiment allows the steel to be produced in a more economical way, because the amount of expensive alloying elements is reduced.

[0018] In an embodiment of the invention the microstructure comprises at least 80%, preferably at least 85%, more preferably at least 90% and even more preferably at least 95% in volume of austenite. The inventor found that a further improvement of the cold rolling and mechanical properties could be obtained if the steel was chosen such that the austenite content in the microstructure comprises at least 80%, preferably at least 85%, more preferably at least 90% and even more preferably at least 95% in volume of austenite. Due to the meta-stability of the austenite, and the occurrence of transformation induced plasticity, the amount of austenite tends to decrease during subsequent processing steps. In order to ensure good formability and high strength, even during a later or its last processing step, it is desirable to have an austenite content which is as high as possible at any stage of the processing.

[0019] It was found that the amount of austenite is favourably influenced by selecting the carbon content to be at least 0.10% or at least 0.15%, but preferably to be at least 0.30% and more preferably at least 0.50%.

[0020] In an embodiment of the invention, the carbon content of the steel is at most 0.75% preferably at most 0.70%. It was found that the weldability of the steel is improved by limiting the carbon content. It was found that a steel having a carbon content of at most 0.75% preferably at most 0.70% or even more preferably of at most 0.65% provides a good balance between the mechanical properties and the risk of martensite formation. In an embodiment of the invention, the carbon content is between 0.15 and 0.75%, preferably between 0.30 and 0.75%. From an economic point of view, the properties point of view, and a process control point of view, this range provides stable conditions.

[0021] In an embodiment of the invention the nickel content is at most 1.25%. It is believed that nickel has a beneficial effect on the elongation values and impact strength. It has been found that at Nickel additions exceeding 2.5% the effect saturates. Since Nickel is also an expensive alloying element, the amount of Nickel is to be kept as low as possible if the demands to elongation values and/or impact strength are somewhat relaxed. In an embodiment of the invention the Nickel content is at most 0.10%, preferably at most 0.05%.

[0022] In an embodiment of the invention the aluminium content is at most 4.0 %. This embodiment limits the increase in stacking-fault energy by the addition of Aluminium, whilst still maintaining favourable properties.

[0023] In an embodiment of the invention the manganese content is at least 11.5%, preferably at least 12.0%. This embodiment allows a more stable austenite to be formed.

[0024] In an embodiment of the invention the manganese content is at most 14.7%. This embodiment allows a further reduction in costs of the steel according to the invention.

[0025] In an embodiment, the steel according to the invention is provided in the form of a continuously cast slab with a typical thickness of between 100 and 350 mm, or in the form of a continuously cast thin slab with a typical thickness of between 50 and 100 mm. Preferably, the steel according to the invention is provided in the form of a continuously cast and/or hot rolled strip, preferably with a typical thickness between 0.5 and 20 mm, more preferably between 0.7

and 10 mm. Even more preferably the strip thickness is at most 8 mm or even at most 6 mm.

[0026] In an embodiment, the steel according to the invention is provided in the form of a hot rolled steel having a thickness between 0.5 and 20 mm, preferably between 0.7 and 10 mm, more preferably the strip thickness is at most 8 mm, or even more preferably between 0.8 and 5 mm.

[0027] It was found that this type of hot-rolled steel has excellent tensile strength and formability which renders it particularly useful for applications where these properties are called for, for instance in automotive and other transport applications.

[0028] According to a second aspect of the invention, there is provided a method of producing an austenitic steel strip, having an austenite content as described above, comprising the steps of:

- providing molten steel having a composition as described above;
- casting said steel into a continuously cast thin slab with a thickness of between 50 and 100 mm, or into a strip-cast strip with a thickness of between 0.5 and 20mm;
- providing a hot-rolled strip by hot rolling the continuously cast thin slab or the strip-cast strip to the desired hot rolled thickness

[0029] In view of the composition of the steel according to the invention, the molten steel will most likely be provided by an EAF-process. The molten steel is then subsequently cast in a mould so as to obtain a solidified steel in a form suitable for hot rolling. This form may be an ingot which after slabbing and reheating is suitable for hot rolling. It may also be a continuously cast thick or thin slab having a typical thickness of between 50 and 300 mm. Also, the form suitable for hot rolling may be a continuously cast strip, such as obtained after strip casting using some form of strip-casting device, such as twin-roll casting, belt-casting or drum casting. In order to convert the cast microstructure into a wrought microstructure, hot deformation such as rolling of the solidified steel is required. This can be done in a conventional rolling mill comprising a single conventional rolling stand or a plurality of rolling stands, in the latter case usually in a tandem set-up. In case the deformation of the cast steel has to be obtained using a low amount of thickness reduction, such as after strip casting, the method as disclosed in EP 1 449 596 A1 may be used to generate a substantial amount of deformation in a steel strip without reducing the thickness of the strip to the same extent. This method comprises a rolling process wherein the steel product is passed between a set of rotating rolls of a rolling mill stand in order to roll the steel product, characterised in that the rolls of the rolling mill stand have different peripheral velocities such that one roll is a faster moving roll and the other roll is a slower moving roll, in that the peripheral velocity of the faster moving roll is at least 5% higher and at most 100% higher than that of the slower moving roll, in that the thickness of the steel product is reduced by at most 15% per pass, and in that the rolling takes place at a maximum temperature of 1350°C.

[0030] In an embodiment of the invention the hot-rolled strip is cold-rolled to the desired final thickness, preferably wherein the cold-rolling reduction is between 10 to 90%, more preferably between 30 and 85, even more preferably between 45 and 80%.

[0031] In an embodiment of the invention, the cold-rolled strip is annealed after cold rolling to the desired final thickness in a continuous or batch annealing process. This annealing treatment results in a substantially recrystallised product.

[0032] In an embodiment of the invention, the cold-rolled strip is galvanised. The absence of silicon as an alloying element, i.e. in the sense of a deliberate addition of silicon for alloying purposes, is beneficial for the galvanisability of the austenitic steel. The adherence of the zinc layer to the substrate is thereby greatly improved.

[0033] The steel according to the invention may be annealed at annealing temperatures between 550 to 1100°C, preferably between 650 to 1100°C either in a batch annealing process, in which case the maximum annealing temperature is preferably between 550 and 800°C, preferably between 650 and 800°C, more preferably at least at 700 and/or below 780°C, or in a continuous annealing process, in which case the maximum annealing temperature is at least 600°C, preferably wherein the maximum annealing temperature is between 700 and 1100°C, more preferably below 900°C. After the cold rolling step and/or the annealing step the strip may be subjected to a temper rolling process.

[0034] According to a third aspect an austenitic steel strip or sheet is provided as described above, produced according to a process as described above. These steels provide excellent strength and good formability in any process stage.

[0035] The resulting steel strips may be processed to blanks for further processing such as a stamping operation or a pressing operation in a known way.

[0036] The steel may be used to produce parts for automotive applications, both in the load bearing parts, such as chassis parts or wheels, but also in the outer parts, such as body parts. The steel is also suitable for the production of tubes and pipes, particularly for low temperature application. Due to its large forming potential, the steel is very well suited for shaping by hydroforming or similar processes. Its high work hardening potential and work hardening rate makes the steel suitable for producing products wherein the steel is subjected to impact loads.

[0037] The invention will now be explained in more detail below with reference to the following non limitative examples and steels, of which the composition is given in Table 1 (a hyphen indicating that the element is present only as an unavoidable impurity and/or, in the case of aluminium, for killing the steel).

Table 1: Steels according to the invention (in wt. %).

Material	C	Mn	Al	Ni
Hadfield	1.2	12	-	-
1	0.63	13.2	2.6	-
2	0.63	14.5	2.6	-
3	0.55	14.5	3.5	-
4	0.30	13.9	4.5	-
5	0.90	14.5	1.5	-
6	0.63	12	2.6	2.5
7	0.15	14.2	4.5	-
8	0.05	14.5	4.5	-
9	0.66	14.1	2.2	-
10	0.52	14.9	3.2	-
11	0.59	11.9	2.4	2.6
12	0.95	14.5	2.5	-

The composition of steels 5, 11 and 12 does not fall within the scope of the invention.

[0038] Rolled ingots of 30 mm thickness were reheated to a temperature of 1220°C (except for steel 12 where a reheating temperature of 1070 °C was used in view of the ductility of the steel) and subsequently hot-rolled to a gauge of 3 mm using a 7-pass rolling schedule. A finishing temperature of 900°C was used. The coiling temperatures ranged from 600°C to 680°C. Details of the finishing schedule are summarised in table 2 below.

Table 2: Summary of Hot Rolling

Reheating Temperature	Rolling Schedule	Finishing Temperature	Coiling Temperature
1220 °C	30>22>15>10>7>5>3.8>3 (mm)	900 °C	680 - 600 °C

[0039] Quenching after coiling to avoid carbide embrittlement proved to be not necessary due to the carefully chosen chemical composition, particularly the low C-level or the Al-addition.

[0040] Cold rolling of the 3 mm hot-rolled samples was undertaken without difficulty to provide cold-rolled samples of 1.5, 1.3 mm or 1 mm gauge respectively. Annealing of small samples at various conditions and subsequently determining the extent of recrystallisation using hardness testing was undertaken to determine the batch annealing conditions. This revealed that a minimum temperature of 700°C with a soak time of 4 hours was adequate to achieve substantially complete recrystallisation. In order to provide a reasonable safety margin, a minimum annealing temperature of 715°C for 4 hours or 730°C for 4 hours is preferable for batch-type annealing to provide complete recrystallisation. It should be noted that the annealing time and annealing temperature for batch annealing are exchangeable to a certain degree, reference is made to EP 0 876 514.

[0041] Samples were removed from all plates and these were batch annealed (see table 4).

[0042] The tensile properties in the rolling direction for steel 1 and steels 9-12 are shown in tables 3 and 4.

[0043] Different levels of cold reduction appear to have little effect on the driving force for recrystallisation. Fluctuations in coiling temperature between 600°C and 680° also appear to have little effect. The tensile tests were performed on a standard tensile specimen and a gauge length of 80 mm was used, except for steel 12, where a gauge length of 50 mm was used. The tensile tests were performed according to EN 10002-1 in the longitudinal direction.

Table 3: Tensile Results of Hot Rolled Samples

Mechanical Properties - Hot Rolled							
	Gauge (mm)	Coiling Temperature (°C)	Rp (N/mm ²)	Rm (N/mm ²)	A80 (*=A50) %	n (10-20)	r(20)
1	3	600	414	793	58	0.38	0.81

(continued)

Mechanical Properties - Hot Rolled							
	Gauge (mm)	Coiling Temperature (°C)	Rp (N/mm ²)	Rm (N/mm ²)	A80 (*=A50) %	n (10-20)	r(20)
1	3	680	448	787	52	0.34	0.76
9	3	630	425	784	49	0.32	0.85
10	3	670	496	797	41	0.37	1.02
11	3	620	413	866	31	n.d.	0.98
12	3	620	581	861	8 (*)	n.d.	1.81

Table 4: Tensile Results of Cold Rolled Samples

Mechanical Properties - Cold Rolled and Annealed Steel									
	Gauge (mm)	Coiling Temperature (°C)	Cold Reduction (%)	Annealing Time/Temp (°C & hours)	(N/mm ²)	Rm (N/mm ²)	A80 (*=A50) %	n (10-20)	r(20)
1	1.3	625	56	730/4	443	814	47	0.38	0.81
1	1.3	660	56	730/4	438	830	48	0.39	0.81
1	1	660	66	730/4	453	831	45	0.38	0.81
1	1	660	66	760/8	420	760	29	0.38	0.79
9	1.3	630	56	715/4	510	930	51 (*)	0.39	1.10
10	1.3	610	56	715/4	520	851	44 (*)	0.36	1.27
11	1.3	640	56	715/4	441	855	42 (*)	0.39	0.90
12	1.5	620	52	715/4	438	874	28 (*)	0.27	1.14

[0044] It is of course to be understood that the present invention is not limited to the described embodiments and examples described above, but encompasses any and all embodiments within the scope of the description and the following claims.

Claims

1. Austenitic steel having high strength and good formability for cold rolling consisting of in weight percent

- 0.05 to 0.75 %C
- 11.0 to 14.9% Mn
- 1.0 to 5.0% Al
- 0 to 2.5% Ni

the remainder being iron and unavoidable impurities, wherein the microstructure comprises at least 80% in volume of austenite, and wherein (Ni+Mn) is from 11.0 to 15.9%

2. Steel according to claim 1, wherein the microstructure comprises at least 85%, preferably at least 90%, and more preferably at least 95% in volume of austenite.

3. Steel according to claim 1 or 2 wherein the carbon content is between 0.30 and 0.75%

4. Steel according to any of the preceding claims, wherein the nickel content is at most 0.05%.

5. Steel according to any of the preceding claims, wherein the aluminium content is at most 4.0 %.

6. Steel according to any of the preceding claims, wherein the manganese content is at least 11.5%, preferably at least 12.0%.

7. Steel according to any of the preceding claims, wherein the manganese content is at most 14.7%.
8. Steel according to any one of the preceding claims, provided in the form of a hot rolled steel strip having a thickness between 0.5 and 20 mm, preferably between 0.7 and 10 mm, more preferably the strip thickness is at most 8 mm, or even more preferably between 0.8 and 5 mm.
9. Method of producing an austenitic steel strip, having an austenite content according to claim 1 or 2, comprising the steps of
 - providing molten steel having a composition according to any one of claims 1 to 7;
 - casting said steel in the form of a continuously cast thin slab with a thickness of between 50 and 100 mm, or into a strip-cast strip with a thickness of between 0.5 and 20 mm;
 - providing a hot-rolled strip by hot rolling the continuously cast thin slab or the continuously strip-cast strip to the desired hot rolled thickness.
10. Method according to claim 449, wherein the hot-rolled strip is cold-rolled to the desired final thickness, preferably wherein the cold-rolling reduction is between 10 to 90%, more preferably between 30 and 85, even more preferably between 45 and 80%.
11. Method according to claim 10, wherein the cold-rolled strip is annealed after cold rolling to the desired final thickness in a continuous or batch annealing process.
12. Method according to any one of claims 9 to 11, wherein the strip-cast strip is obtained after strip casting using a twin-roll casting, belt-casting or drum-casting device.
13. Method according to one of claims 9 to 12, wherein the hot rolling comprises a rolling process wherein the steel product is passed between a set of rotating rolls of a rolling mill stand in order to roll the steel product, **characterised in that** the rolls of the rolling mill stand have different peripheral velocities such that one roll is a faster moving roll and the other roll is a slower moving roll, **in that** the peripheral velocity of the faster moving roll is at least 5% higher and at most 100% higher than that of the slower moving roll, **in that** the thickness of the steel product is reduced by at most 15% per pass, and **in that** the rolling takes place at a maximum temperature of 1350°C.
14. Method according to any one of claims 9 to 13 wherein the steel is galvanised.

Patentansprüche

1. Austenitischer Stahl mit einer hohen Festigkeit und guten Verformbarkeit zum Kaltwalzen, in Gewichtsprozent bestehend aus:
 - 0,05 bis 0,75% C,
 - 11,0 bis 14,9% Mn,
 - 1,0 bis 5,0% Al,
 - 0 bis 2,5% Ni,wobei der Rest Eisen und unvermeidbare Unreinheiten ist, wobei die Mikrostruktur wenigstens 80 Volumenprozent Austenit umfasst, und wobei (Ni+Mn) zwischen 11,0 und 15,9% liegt.
2. Stahl nach Anspruch 1, wobei die Mikrostruktur wenigstens 85 Volumenprozent, vorzugsweise wenigstens 90 Volumenprozent und am meisten bevorzugt wenigstens 95 Volumenprozent Austenit umfasst.
3. Stahl nach Anspruch 1 oder 2, wobei der Kohlenstoffanteil zwischen 0,30 und 0,75% liegt.
4. Stahl nach einem der vorstehenden Ansprüche, wobei der Nickelanteil höchstens 0,05% beträgt.
5. Stahl nach einem der vorstehenden Ansprüche, wobei der Aluminiumanteil höchstens 4,0% beträgt.
6. Stahl nach einem der vorstehenden Ansprüche, wobei der Mangananteil bei wenigstens 11,5%, vorzugsweise bei

wenigstens 12,0% liegt.

7. Stahl nach einem der vorstehenden Ansprüche, wobei der Mangananteil höchstens 14,7% beträgt.

8. Stahl nach einem der vorstehenden Ansprüche, vorgesehen in Form eines heißgewalzten Stahlbands mit einer Dicke zwischen 0,5 und 20 mm, vorzugsweise zwischen 0,7 und 10 mm, wobei die Banddicke darüber hinaus bevorzugt 8 mm beträgt, oder wobei eine Dicke zwischen 0,8 und 5 mm noch mehr bevorzugt ist.

9. Verfahren zur Herstellung eines austenitischen Stahlbands mit einem Austenitgehalt nach Anspruch 1 oder 2, die folgenden Schritte umfassend:

- Bereitstellen einer Stahlschmelze mit einer Zusammensetzung nach einem der Ansprüche 1 bis 7;
- Gießen des Stahls in die Form einer stranggegossenen Dünnbramme mit einer Dicke zwischen 50 und 100 mm oder eines bandgegossenen Bands mit einer Dicke zwischen 0,5 und 20 mm;
- Bereitstellen eines heißgewalzten Bands durch Heißwalzen der stranggegossenen Dünnbramme oder des stranggegossenen, bandgegossenen Bands in der gewünschten heißgewalzten Dicke.

10. Verfahren nach Anspruch 9, wobei das heißgewalzte Band auf die gewünschte finale Dicke kaltgewalzt wird, wobei die Reduzierung durch Kaltwalzen vorzugsweise zwischen 10 und 90% liegt, darüber hinaus bevorzugt zwischen 30 und 85% und noch mehr bevorzugt zwischen 45 und 80%.

11. Verfahren nach Anspruch 10, wobei der kaltgewalzte Stahl nach dem Kaltwalzen auf die gewünschte finale Dicke in einem Durchlaufglüh- oder Haubenglühprozess gegläht wird.

12. Verfahren nach einem der Ansprüche 9 bis 11, wobei das bandgegossene Band nach dem Bandgießen erhalten wird unter Verwendung einer Doppelwalzenguss-, einer Bandguss- oder einer Trommelgussvorrichtung.

13. Verfahren nach einem der Ansprüche 9 bis 12, wobei das Heißwalzen einen Walzprozess umfasst, wobei das Stahlprodukt zwischen einer Anordnung sich drehender Walzen eines Walzwerkgestells hindurchgeführt wird, um das Stahlprodukt zu walzen, **dadurch gekennzeichnet, dass** die Walzen des Walzwerkgestells unterschiedliche Umfangsgeschwindigkeiten aufweisen, so dass eine Walze eine sich schneller bewegende Walze ist und die andere Walze eine sich langsamer bewegende Walze ist, wobei die Umfangsgeschwindigkeit der sich schneller bewegenden Walze wenigstens 5% höher und höchstens 100% höher ist als die Geschwindigkeit der sich langsamer bewegenden Walze, wobei die Dicke des Stahlprodukts je Durchlauf um höchstens 15% verringert wird, und wobei das Walzen bei einer Temperatur von höchstens 1350 °C erfolgt.

14. Verfahren nach einem der Ansprüche 9 bis 13, wobei der Stahl verzinkt ist.

Revendications

1. Acier austénitique ayant une haute résistance et une bonne aptitude au formage pour le laminage à froid comportant, en pourcentage pondéral

- de 0,05 à 0,75 % de C
- de 11,0 à 14,9 % de Mn
- de 1,0 à 5,0 % d'Al
- de 0 à 2,5 % de Ni

le reste étant du fer et des impuretés inévitables, la microstructure comprenant au moins 80 % en volume d'austénite, et (Ni+Mn) étant compris entre 11,0 et 15,9 %

2. Acier selon la revendication 1, la microstructure comprenant au moins 85 %, de préférence au moins 90 % et, de préférence encore au moins 95 % en volume d'austénite.

3. Acier selon la revendication 1 ou 2, la teneur en carbone étant comprise entre 0,30 et 0,75 %.

4. Acier selon l'une quelconque des revendications précédentes, la teneur en nickel étant au plus de 0,05 %.

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5. Acier selon l'une quelconque des revendications précédentes, la teneur en aluminium étant au plus de 4,0 %.
6. Acier selon l'une quelconque des revendications précédentes, la teneur en manganèse étant d'au moins 11,5 %, de préférence d'au moins 12,0 %.
7. Acier selon l'une quelconque des revendications précédentes, la teneur en manganèse étant au plus de 14,7 %.
8. Acier selon l'une quelconque des revendications précédentes, fourni sous la forme d'une bande d'acier laminé à chaud d'une épaisseur comprise entre 0,5 et 20 mm, de préférence entre 0,7 et 10 mm, de préférence encore l'épaisseur de bande étant au plus de 8 mm, ou encore plus de préférence entre 0,8 et 5 mm.
9. Procédé de production d'une bande d'acier austénitique, ayant une teneur en austénite selon la revendication 1 ou 2, comprenant les étapes consistant à
- fournir de l'acier en fusion ayant une composition selon l'une quelconque des revendications 1 à 7 ;
couler ledit acier sous la forme d'acier d'une mince dalle coulée en continu ayant une épaisseur comprise entre 50 et 100 mm, ou d'une bande coulée en bande mince ayant une épaisseur comprise entre 0,5 et 20 mm ;
fournir une bande laminée à chaud par laminage à chaud de la mince dalle coulée en continu ou de la bande coulée en bande mince en continu à l'épaisseur laminée à chaud souhaitée.
10. Procédé selon la revendication 9, la bande laminée à chaud étant laminée à froid à l'épaisseur finale souhaitée, de préférence la réduction par laminage à froid étant comprise entre 10 et 90 %, encore de préférence entre 30 et 85, encore plus de préférence entre 45 et 80 %.
11. Procédé selon la revendication 10, la bande laminée à froid étant recuite après laminage à froid à l'épaisseur finale souhaitée dans un processus de recuit en continu ou par lots.
12. Procédé selon l'une quelconque des revendications 9 à 11, la bande coulée en bande mince étant obtenue après la coulée en bande mince à l'aide d'un dispositif de coulage à double rouleau, de coulage à courroie ou de coulage à tambour.
13. Procédé selon l'une des revendications 9 à 12, le laminage à chaud comprenant un processus de laminage, le produit d'acier étant passé entre un ensemble de rouleaux rotatifs d'un cadre de laminoir afin de rouler le produit d'acier, **caractérisé en ce que** les rouleaux du cadre de laminoir ont différentes vitesses périphériques de sorte qu'un rouleau est un rouleau se déplaçant plus vite et l'autre rouleau est un rouleau se déplaçant plus lentement, **en ce que** la vitesse périphérique du rouleau se déplaçant plus vite est au moins 5 % plus élevée et au moins 100 % plus élevée que celle du rouleau se déplaçant plus lentement, **en ce que** l'épaisseur du produit d'acier est réduite au plus de 15 % par passage, et **en ce que** le laminage a lieu à une température maximale de 1350 °C.
14. Procédé selon l'une quelconque des revendications 9 à 13, l'acier étant galvanisé.

REFERENCES CITED IN THE DESCRIPTION

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