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(54) **HIGH STRENGTH BAKE-HARDENABLE LOW DENSITY STEEL AND METHOD FOR PRODUCING SAID STEEL**

HOCHFESTER, HÄRTBARER STAHL VON GERINGER DICHTE UND VERFAHREN ZUR HERSTELLUNG DES BESAGTEN STAHLS

ACIER HAUTE RÉSISTANCE À FAIBLE DENSITÉ DURCISSABLE PAR CUISSON ET PROCÉDÉ DE PRODUCTION DE CET ACIER

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Description

[0001] The invention relates to a high strength bake-hardenable low density steel and to a method for producing said steel.

[0002] In the continuing efforts to reduce the carbon emissions of vehicles the steel industry, together with the car manufacturers, continue to strive to steels which allow weight reduction without affecting the processability of the steels and the safety of the finished product. To meet future CO_2-emission requirements, the fuel consumption of automobiles has to be reduced. One way towards this reduction is to lower the weight of the car body. A steel with a low density and high strength can contribute to this. At the same thickness, the use of a low density steel reduces the weight of car components. A problem with known high strength steels is that their high strength compromises the formability of the material during forming of the sheet into a car component.

[0003] Ordinary high strength steels, for example dual phase steels, allow use of thinner sheets and therefore weight reduction. However, a thinner part will have a negative effect on other properties such as stiffness, crash - and dent resistance. These negative effects can only be solved by increasing the steel thickness, thus negating the effect of the downgauging, or by changing the geometry of the component which is also undesirable.

[0004] It is an object of this invention to provide a low density steel with a high strength in the finished component combined with excellent formability prior to forming the car component.

[0005] It is also an object of this invention to provide a high strength steel with excellent stiffness and dent resistance.

[0006] One or more of these objects can be reached by providing a ferritic steel strip or sheet comprising, in weight percent,

- up to 0.01 % C_total;
- at most 0.2 % Si;
- 0.1 to 1.0 % Mn;
- from 5 to up to 10 % Al;
- up to 0.010% N;
- up to 0.01 % S;
- up to 0.1 % P;

at least one of

- 0.005 to 0.019% Ti;
- 0.008 to 0.08% Nb;
- 0.002 to 0.1% V;
- 0.004 to 0.1% Zr;

- optionally between 5 and 50 ppm B;

- remainder iron and inevitable impurities;

wherein C_solute = C_Z total

- Minimum[X,Y]
- Maximum[Z,0]
- (12/93)*Nb
- (12/91)*Zr
- (12/51)*V;

wherein

- X = 2*12/(2*32)*S;
- Y = 2*12/(4*48)*(Ti-48/14*N);
- Z = 12/48*(Ti-48/14*N-4*48/(2*32)*S);

wherein

Minimum[X,Y] = lower value of X and Y and Minimum[X,Y] = zero if Y is negative;
Maximum[Z,0] = higher value of zero and Z;

and wherein C_solute is at least 0.0005 (5 ppm).

[0007] All percentages are in weight percent, unless otherwise indicated. For the sake of avoiding any misunderstanding, the formulae given above, when typed in in a commercial spreadsheet programme such as Microsoft Excel will result in the correct interpretation of the formulae. For instance 12/93*Nb is correctly interpreted as (12/93)*Nb as the skilled person will recognise the atomic masses of carbon (12) and Nb (93) in this formula. This is the same for the other numbers in the formulae (mutatis mutandis). So, superfluously:

$$X = 2 \cdot \left(\frac{12}{2 \cdot 32}\right) \cdot S$$

$$Y = 2 \cdot \left(\frac{12}{4 \cdot 48}\right) \cdot \left(Ti - \left(\left(\frac{48}{14}\right) \cdot N\right)\right)$$

$$Z = \left(\frac{12}{48}\right) \cdot \left(Ti - \left(\left(\frac{48}{14}\right) \cdot N\right) - \left(4 \cdot \frac{48}{(2 \cdot 32)} \cdot S\right)\right)$$

[0008] The steel according to the invention has a tailored chemical composition to allow the steel to contain carbon in solid solution (C_solute) after the annealing and optional galvanising step. This carbon in solid solution allows the steel to be bake-hardenable e.g. in a paint-baking cycle. The car component is formed from the steel coming of the mill, and the component is painted and baked after it has been formed into its final shape.

[0009] In addition, the steel according to the invention combines the good formability prior to forming a car component, i.e. before the paint-baking operation, with a higher strength after the paint-baking operation.

[0010] The inventors found that for the steel to be bake-hardenable in a paint baking cycle at least 5 ppm of solute carbon (C_solute) must be present in steel. At lower amounts of solute carbon the effect is negligible or not reproducible.

[0011] The level of solute carbon may also not exceed a critical upper value because the steel is preferably free from natural ageing. Natural ageing is the spontaneous ageing of a supersaturated solid solution at room temperature and involves a spontaneous change in the physical properties of the steel, which occurs on being held at atmospheric temperatures after hot- or cold rolling or after a final heat treatment, e.g. during transport to or storage at a customers prior to processing the strip. This natural ageing involves changes of the mechanical properties which are considered undesirable as they lead to unpredictable variations in processability during the forming of the car components. Also, the surface quality may be adversely affected due to the formation of so-called Lüder-lines. Also, too high a carbon level in solid solution may result in a deterioration of the formability prior to bake-hardening.

[0012] For that reason a maximum value of 50 ppm of solute carbon is preferable. A more suitable maximum is 40 ppm of solute carbon (i.e. 0.004%).

[0013] In an embodiment of the invention C_solute is at least 0.0010 (10 ppm) and/or at most 0.0030 (30 ppm). This achieves a stable process and reproducible properties.

[0014] Nitrogen, in particularly free nitrogen (i.e. nitrogen in solid solution), is not desirable but unavoidable in steel making. Titanium can be optionally added to bound nitrogen into TiN. The large amount of aluminium in the steel can also ensure that all nitrogen is bound. This means that the matrix is substantially free of nitrogen in solid solution.

[0015] Boron is optionally added to the steel. Its presence is not mandatory, but it may help to suppress any tendency for secondary work embrittlement. If added, a minimum amount of 5 ppm boron is required.

[0016] The manganese content is at least 0.1%. In another embodiment the aluminium content is at least 6 % and/or at most 9%, preferably at most 8%.

[0017] The steel is preferably calcium treated. The chemical composition may therefore also contain calcium in an amount consistent with a calcium treatment.

[0018] In the steels according to the invention the amount of carbon in solid solution is controlled by the addition of microalloying elements (Ti, Nb, V, Zr) in combination with excellent control of the total carbon content in the steel.

[0019] The amount of Ti or Nb should be strictly controlled. Too much titanium or niobium will combine with carbon to form carbides or, in the presence of sulphur, carbosulphides. As a consequence of this, no solute carbon is available and no bake-hardenability.

[0020] The amount of carbon in solid solution according to this invention is calculated by subtracting from the total carbon content C_total the precipitates comprising carbon as follows:

C_solute = C_ total

- Minimum[X,Y]
- Maximum[Z,0]
- (12/93)*Nb
- (12/91)*Zr
- (12/51)*V;

wherein

X= 2*12/(2*32)*S;

Y = 2*12/(4*48)*(Ti-48/14*N);

Z = 12/48*(Ti -48/14*N - 4*48/(2*32)*S);

Wherein

Minimum[X,Y] = lower value of X and Y and Minimum[X,Y] = zero if Y is negative;
Maximum[Z,0] = higher value of zero and Z.

[0021] For the interpretation of these formulae see herein above. The addition of Ti is beneficial for binding nitrogen, but not strictly necessary. Up to 0.019% Ti can be added into the steel, mainly to bind nitrogen into TiN and secondarily to control the amount of solute carbon. The titanium content must 0.019% or lower, e.g. at most 0.018% or 0.015% or even at most 0.012%.
[0022] If titanium is added as an alloying element, a suitable minimum value for the titanium content is 0.005%. If added, then a suitable minimum value for Nb is 0.008%. If added, then for V and Zr suitable minimum values are 0.002 and 0.004 respectively.
[0023] According to a preferable embodiment the composition of the ferritic steel according to the invention has a base composition where no titanium is added to the steel, and any titanium present is an unavoidable impurity.
[0024] Titanium, as an alloying element or as an inevitable impurity, will first form TiN. If there is excess nitrogen, then the remaining nitrogen will be bound to aluminium. If there is excess titanium, then the remaining titanium will form $Ti_4C_2S_2$ until all titanium is consumed. The factor Minimum[X,Y] calculates how much carbon is consumed by the formation of $Ti_4C_2S_2$ after all free nitrogen was bound to TiN. If the calculation results in a negative value for Y, then the factor is to be set to zero.
[0025] If there is no titanium at all, no TiN or $Ti_4C_2S_2$ will be formed and then Minimum[X,Y] amounts to zero. The factor Maximum[Z,0] determines how much carbon is bound to titanium after accounting for the formation of TiN and $Ti_4C_2S_2$.
[0026] The other three factors account for the formation of NbC, ZrC and VC, and thereby together with the factors Minimum[X,Y] and Maximum[Z,0] determine the amount of solute carbon in the steel.
[0027] By adding no or only small amounts of titanium and/or a specified amount of Nb, there will be sufficient solute carbon available for bake hardening. By controlling the level of solute carbon below 50 ppm, and preferably below 40 ppm, the steel according to the invention is bake hardenable and nature-aging resistant.
[0028] According to a second aspect, a method for producing a ferritic steel strip is provided comprising the steps of:

- providing a steel slab or thick strip by:
  - continuous casting, or
  - by thin slab casting, or
  - by belt casting, or
  - by strip casting;
- optionally followed by reheating the steel slab or strip at a reheating temperature of at most 1250°C;
- hot rolling the slab or thick strip and finishing the hot-rolling process at a hot rolling finishing temperature of at least

850°C;

- coiling the hot-rolled strip at a coiling temperature of between 550 and 750°C.

[0029] In preferable embodiment the coiling temperature is at least 600°C and/or the hot rolling finishing temperature is at least 900°C.

[0030] This hot-rolled strip can be subsequently further processed in a process comprising the steps of:

- cold-rolling the hot-rolled strip at a cold-rolling reduction of from 40 to 90% to produce a cold-rolled strip;
- annealing the cold-rolled strip in a continuous annealing process with a peak metal temperature of between 700 and 900°C;
- optionally galvanising the annealed strip in a hot-dip galvanising or electro-galvanising or a heat-to-coat process.

[0031] The hot-rolled strip is usually pickled and cleaned prior to the cold-rolling step. In an embodiment the peak metal temperature in the continuous annealing process is at least 750°C, preferably at least 800°C.

[0032] In an embodiment the cold rolling reduction is at least 50%.

[0033] In an embodiment the thickness of the hot-rolled strip is between 1 and 5 mm and/or the thickness of the cold-rolled strip is between 0.4 and 2 mm.

[0034] In an embodiment of the invention the hot-rolled strip is annealed in a continuous annealing step and optionally galvanised in a hot-dip galvanising step. The annealing may also take place in a so called heat-to-coat cycle. In a heat-to-coat cycle the hot-rolled steel is reheated to a temperature sufficient for performing the hot-dip galvanising, but not to a temperature as high as the conventional continuous annealing step. During the reheating the carbon, which may have precipitated during the slow cooling of the hot rolled coil after hot rolling is brought into solid solution again. After annealing and/or galvanising the steel has to be fast cooled to avoid precipitation of the carbon in solid solution. When using this galvanised steel sheet for producing a car component or other product by forming, followed by painting and baking, then the paint-baking also ensures the strength increase associated with the paint-baking cycle.

[0035] The invention is now further explained by means of the following, non-limiting examples.

[0036] Steels were produced and processed into cold-rolled steel sheets having a thickness of 1 mm. The hot rolled strip had a thickness of 3.0 mm. The chemical composition of the steels is given in Table 1.

Table 1 - Chemical composition (I = invention, R = reference)

Steel	C	Al	Mn	N	Ti	Nb	S	C_solute	
1	0.0020	7.0	0.20	0.0035	0.000	0.000	0.004	0.0020	R
2	0.0020	7.0	0.20	0.0030	0.010	0.000	0.004	0.0020	I
3	0.0040	7.0	0.20	0.0030	0.000	0.020	0.004	0.0014	I
3a	0.0040	6.9	0.20	0.0025	0.005	0.010	0.001	0.0031	I
4	0.0030	8.0	0.20	0.0030	0.010	0.010	0.004	0.0017	I
5	0.0040	7.5	0.20	0.0040	0.000	0.020	0.004	0.0014	I
6	0.0050	6.5	0.25	0.0030	0.010	0.020	0.004	0.0024	I
7	0.0050	6.0	0.20	0.0030	0.010	0.040	0.005	0.0000	R
8	0.0050	6.8	0.20	0.0030	0.100	0.000	0.005	0.0000	R
9	0.0050	7.0	0.20	0.0030	0.010	0.050	0.005	0.0000	R

[0037] The steels were produced by casting a slab and reheating the slab at a temperature of at most 1250°C. This temperature is the maximum temperature, because at higher reheating temperatures excessive grain growth may occur. The finishing temperature during hot rolling was 900°C, coiling temperature 650°C followed by pickling and cold rolling (67%) and continuous annealing at a peak metal temperature of 800°C and hot-dip-galvanising. Steel 3a also contained 16 ppm B.

Table 2 - Mechanical properties before and after the paint-baking cycle

	As-produced			After 2% + 170°C/20min		
steel	YLD (MPa)	UTS (MPa)	A80 (%)	YLD	WH(MPa)	BH (MPa)
1	340	460	32	420	35	45
2	345	465	31	425	35	45
3	351	470	30	426	36	39
4	420	530	17	498	34	44
5	408	518	18	483	35	40
6	349	468	29	424	35	40
7	295	420	34	330	35	0
8	359	475	29	394	35	0
steel	YLD (MPa)	UTS (MPa)	A80 (%)	YLD	WH (MPa)	BH (MPa)
9	362	480	29	398	36	0
3a	371	460	27	457	34	52
WH= workhardening due to 2% prestrain BH = Bake-hardening due to 20min at 170°C						

[0038] The results presented in Table 2 clearly demonstrate that the presence of solute carbon at levels of 14 to 24 or to 31 ppm results in an increase of about 40 MPa on top of the work-hardening and the base strength of the steel. The inventors found this effect to be present at solute carbon levels between 5 and 50 ppm.

Claims

1. Ferritic steel strip or sheet comprising, in weight percent,
up to 0.01 % C_total;
at most 0.2% Si;
0.1 to 1.0 % Mn;
from 5 to up to 10 % Al;
up to 0.010% N;
up to 0.01 % S;
up to 0.1 % P;
at least one of

- 0.005 to 0.019 %Ti
- 0.008 to 0.08 % Nb;
- 0.002 to 0.1 % Zr;
- 0.004 to 0.1 % V;

optionally between 5 and 50 ppm B;
remainder iron and inevitable impurities;
wherein C_solute = C_total

- Minimum[X,Y]
- Maximum[Z,0]
- (12/93)*Nb
- (12/91)*Zr
- (12/51)*V;

wherein

$$X = 2 \cdot \left(\frac{12}{2 \cdot 32} \right) \cdot S$$

$$Y = 2 \cdot \left(\frac{12}{4 \cdot 48} \right) \cdot \left(Ti - \left(\left(\frac{48}{14} \right) \cdot N \right) \right)$$

$$Z = \left(\frac{12}{48} \right) \cdot \left(Ti - \left(\left(\frac{48}{14} \right) \cdot N \right) - \left(4 \cdot \frac{48}{(2 \cdot 32)} \cdot S \right) \right)$$

wherein

Minimum[X,Y] = lower value of X and Y and Minimum[X,Y] = zero if Y is negative;
Maximum[Z,0] = higher value of zero and Z;
and wherein C_solute is at least 0.0005 (5 ppm).

2. Steel according to claim 1 wherein C_solute is at most 0.0050 (50 ppm).

3. Steel according to any one of the preceding claims wherein Al is at least 6 % and/or at most 9%, preferably at most 8%.

4. Steel according to any one of the preceding claims wherein C_total is at least 0.0010 % (10 ppm).

5. Steel according to any one of the preceding claims wherein C_solute is at least 0.0010% (10 ppm) and/or at most 0.0040% (40 ppm), preferably at most 0.0030% (30 ppm).

6. Steel according to any one of the preceding claims wherein N is at most 0.005% (50 ppm).

7. Steel according to any one of the preceding claims wherein the specific density of the steel is between 6800 and 7300 kg/m^3.

8. Method for producing a ferritic steel strip according to any one of claims 1 to 7 comprising the steps of:

• providing a steel slab or thick strip by:

◦ continuous casting, or
◦ by thin slab casting, or
◦by belt casting, or
◦ by strip casting;

• optionally followed by reheating the steel slab or strip at a reheating temperature of at most 1250°C;
• hot rolling the slab or thick strip and finishing the hot-rolling process at a hot rolling finishing temperature of at least 850°C;
• coiling the hot-rolled strip at a coiling temperature of between 550 and 750°C.

9. Method according to claim 8 wherein the hot-rolled strip carbon is reheated in:

• a continuous annealing step, optionally followed by hot-dip galvanising followed by fast cooling, or
• a heat-to-coat step, followed by hot-dip galvanising and fast cooling.

10. Method for producing the ferritic steel strip comprising the steps of

• cold-rolling the ferritic steel strip of claim 8 at a cold-rolling reduction of from 40 to 90% to produce a cold-rolled strip;
• annealing the cold-rolled strip in a continuous annealing process with a peak metal temperature of between

700 and 900°C;
• optionally galvanising the annealed strip in a hot-dip galvanising or electro-galvanising or a heat-to-coat process.

11. Method according to claim 10 wherein the peak metal temperature in the continuous annealing process is at least 750°C, preferably at least 800°C.

12. Method according to any one of claims 10 to 11 wherein the cold rolling reduction is at least 50%.

13. Method according to any one of claims 9 to 12 wherein the thickness of the hot-rolled strip is between 1 and 5 mm and/or wherein the thickness of the cold-rolled strip is between 0.4 and 2 mm.

Patentansprüche

1. Ferritisches Stahlband oder -blech, in Gewichtsprozent aufweisend
bis zu 0.01 % C_gesamt;
höchstens 0.2 % Si;
0.1 bis 1.0 % Mn;
5 bis zu 10 % Al;
bis zu 0.010 % N;
bis zu 0.01 % S;
bis zu 0.1 % P;
mindestens eines von

- 0.005 bis 0.019 % Ti;
- 0.008 bis 0.08 % Nb;
- 0.002 bis 0.1 % V;
- 0.004 bis 0.1 % Zr;

optional zwischen 5 und 50 ppm B;
Rest Eisen und unvermeidliche Eisenbegleiter;
wobei C_gelöst = C_gesamt

- Minimum [X,Y]
- Maximum [Z,0]
- (12/93)*Nb
- (12/91)*Zr
- (12/51)*V;

wobei

$$X = 2 \cdot \left(\frac{12}{2 \cdot 32}\right) \cdot S$$

$$Y = 2 \cdot \left(\frac{12}{4 \cdot 48}\right) \cdot \left(Ti - \left(\left(\frac{48}{14}\right) \cdot N\right)\right)$$

$$Z = \left(\frac{12}{48}\right) \cdot \left(Ti - \left(\left(\frac{48}{14}\right) \cdot N\right) - \left(4 \cdot \frac{48}{(2 \cdot 32)} \cdot S\right)\right)$$

wobei

Minimum [X,Y] = unterer Wert von X und Y und Minimum [X,Y] = Null, wenn Y negativ ist;

Maximum [Z,0] = höherer Wert von Null und Z;
und wobei C_gelöst mindestens 0.0005 (5 ppm) beträgt.

2. Stahl nach Anspruch 1, wobei C_gelöst höchstens 0.0050 (50 ppm) beträgt.

3. Stahl nach einem der vorhergehenden Ansprüche, wobei Al mindestens 6 % und/oder höchstens 9 %, bevorzugt höchstens 8 % beträgt.

4. Stahl nach einem der vorhergehenden Ansprüche, wobei C_gesamt mindestens 0.0010 % (10 ppm) beträgt.

5. Stahl nach einem der vorhergehenden Ansprüche, wobei C_gelöst mindestens 0.0010 % (10 ppm) und/oder höchstens 0.0040 % (40 ppm), bevorzugt höchstens 0.0030 % (30 ppm) beträgt.

6. Stahl nach einem der vorhergehenden Ansprüche, wobei N höchstens 0.005 % (50 ppm) beträgt.

7. Stahl nach einem der vorhergehenden Ansprüche, wobei die spezifische Dichte des Stahls zwischen 6800 und 7300 kg/m^3 liegt.

8. Verfahren zur Erzeugen eines ferritischen Stahlbands nach einem der Ansprüche 1 bis 7, aufweisend die Schritte zum:

- Bereitstellen einer Stahlbramme oder eines dicken Stahlbands durch:
    - Stranggießen, oder
    - durch Dünnbrammengießen, oder
    - durch gießen auf ein umlaufendes Gießband, oder
    - durch Bandgießen;
- optional gefolgt von Nacherwärmen der Stahlbramme oder des Stahlbands bei einer Nacherwärmungstemperatur von höchstens 1250 °C;
- Warmwalzen der Bramme oder des dicken Stahlbands und Abschließen des Warmwalzprozesses bei einer Warmwalz-Endbearbeitungstemperatur von mindestens 850 °C;
- Aufwickeln des warmgewalzten Stahlbands bei einer Wickeltemperatur zwischen 550 und 750 °C.

9. Verfahren nach Anspruch 8, wobei das warmgewalzte Kohlenstoffstahlband nacherwärmt wird in:

- einem kontinuierlichen Glühschritt, optional gefolgt von Feuerverzinkung gefolgt von Schnellkühlung, oder
- einem Schritt von Erwärmung-zur-Beschichtung, gefolgt von Feuerverzinkung und Schnellkühlung.

10. Verfahren zum Erzeugen des ferritischen Stahlbands, aufweisend die Schritte zum

- Kaltwalzen des ferritischen Stahlbands nach Anspruch 8 mit einer Kaltwalz-Reduktion von 40 bis 90 % zum Erzeugen eines kaltgewalzten Stahlbands;
- Glühen des kaltgewalzten Stahlbands in einem kontinuierlichen Glühprozess mit einer Metall-Höchsttemperatur zwischen 700 und 900 °C;
- optionalen Verzinken des geglühten Stahlbands in einem Feuerverzinkungs- oder galvanischen Verzinkungsprozess oder einem Prozess von Erwärmung-zur-Beschichtung.

11. Verfahren nach Anspruch 10, wobei die Metall-Höchsttemperatur in dem kontinuierlichen Glühprozess mindestens 750 °C, bevorzugt mindestens 800 °C beträgt.

12. Verfahren nach einem der Ansprüche 10 bis 11, wobei die Kaltwalz-Reduktion mindestens 50 % beträgt.

13. Verfahren nach einem der Ansprüche 9 bis 12, wobei die Dicke des warmgewalzten Stahlbands zwischen 1 und 5 mm beträgt und/oder wobei die Dicke des kaltgewalzten Stahlbands zwischen 0.4 und 2 mm beträgt.

Revendications

1. **1.** Bande ou feuille d'acier ferritique comprenant en pourcentage de poids jusqu'à 0.01 % du total de C (C_total); au plus de 0.2 % de Si; 0.1 à 1.0 % de Mn; de 5 à 10 % d'Al; jusqu'à 0.010 % de N; jusqu'à 0.01 % de S; jusqu'à 0.1 % de P; au moins un élément parmi

   - 0.005 à 0.019 % de Ti;
   - 0.008 à 0.08 % de Nb;
   - 0.002 à 0.1% de V;
   - 0.004 à 0.1 % de Zr;

   éventuellement entre 5 et 50 ppm de B; le reste étant composé de fer et des inévitables impuretés; où C_soluté = total de C

   - Minimum[X,Y]
   - Maximum[Z,0]
   - (12/93)*Nb
   - (12/91)*Zr
   - (12/51)*V;

   où,

$$X = 2 \cdot \left(\frac{12}{2 \cdot 32}\right) \cdot S$$

$$Y = 2 \cdot \left(\frac{12}{4 \cdot 48}\right) \cdot \left(Ti - \left(\left(\frac{48}{14}\right) \cdot N\right)\right)$$

$$Z = \left(\frac{12}{48}\right) \cdot \left(Ti - \left(\left(\frac{48}{14}\right) \cdot N\right) - \left(4 \cdot \frac{48}{(2 \cdot 32)} \cdot S\right)\right)$$

   où,

   Minimum[X,Y] = valeur inférieure de X et Y et Minimum[X,Y] = zéro si Y est négatif; Maximum[Z,0] = valeur supérieure de zéro et Z; et où C_soluté est d'au moins 0.0005 (5 ppm).

2. **2.** Acier selon la revendication 1 où C_soluté est au plus de 0.0050 (50 ppm).

3. **3.** Acier selon l'une quelconque des revendications précédentes, où Al est au moins de 6 % et/ou au plus de 9%, de préférence au plus de 8%.

4. **4.** Acier selon l'une quelconque des revendications précédentes, où le total de C est au moins de 0.0010 % (10 ppm).

5. **5.** Acier selon l'une quelconque des revendications précédentes, où C_soluté est au moins de 0.0010% (10 ppm) et/ou au plus de 0.0040% (40 ppm), de préférence au plus de 0.0030% (30 ppm).

6. Acier selon l'une quelconque des revendications précédentes, où N est au plus de 0.005% (50 ppm).

7. Acier selon l'une quelconque des revendications précédentes, où le poids spécifique de l'acier est compris entre 6800 et 7300 kg/m^3.

8. Procédé de production d'une bande d'acier ferritique selon l'une quelconque des revendications 1 à 7 comprenant les phases consistant à :

- fournir une brame d'acier ou une bande épaisse d'acier par ;
  - coulage continu, ou
  - coulage à brames minces, ou
  - coulage à bandes continues ou
  - coulage en bandes minces ;
- suivi éventuellement du réchauffage de la brame ou de la bande d'acier à une température de réchauffage d'au plus 1250°C ;
- laminage à chaud de la brame ou de la bande épaisse et finition du procédé de laminage à chaud à une température de finition de laminage à chaud d'au moins 850°C ;
- bobinage de la bande laminée à chaud à une température de bobinage comprise entre 550 et 750°C.

9. Procédé selon la revendication 8 où le carbone en bandes laminées à chaud est réchauffé lors :

- d'une phase de recuit continue, éventuellement suivie d'une galvanisation par immersion à chaud, avant refroidissement rapide ou
- une phase de chauffage et d'enrobage, suivie d'une galvanisation par immersion à chaud et refroidissement rapide.

10. Procédé de production de la bande d'acier ferritique comprenant les phases suivantes :

- laminage à froid de la bande d'acier ferritique selon la revendication 8 dans une réduction par laminage à froid de 40-90% pour obtenir une bande laminé à froid ;
- recuit de la bande laminée à froid dans un procédé de recuit continu pour avoir un pic de température de métal compris entre 700 et 900°C ;
- éventuellement galvanisation de la bande recuite dans une galvanisation par immersion à chaud ou électro-zingage ou un procédé de chauffage et d'enrobage.

11. Procédé selon la revendication 10, où le pic de température de métal dans le procédé de recuit continu est d'au moins 750°C, de préférence d'au moins 800°C.

12. Procédé selon l'une quelconque des revendications 10 à 11, où la réduction par laminage à froid est d'au moins 50 %.

13. Procédé selon l'une quelconque des revendications 9 à 12, où l'épaisseur de la bande laminée à chaud est comprise entre 1 et 5 mm et/où l'épaisseur de la bande laminée à froid est comprise entre 0.4 et 2 mm.