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(54) **STEEL ALLOY FOR A LOW-ALLOY HIGH-STRENGTH STEEL**

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(57) **ABSTRACT**

A low alloy high-strength carbide-free bainitic steel for producing strips, sheets and pipes is disclosed with the following chemical composition (in weight %) 0.10-0.70 C, 0.25-4.00 Si, 0.05-3.00 Al, 1.00-3.00 Mn, 0.10-2.00 Cr, 0.001-0.50 Nb, 0.001-0.025 N, max 0.15 P, max 0.05 S, remainder iron and steel tramp elements with optional addition of one or more elements of Mo, Ni, Co, W, Nb, Ti, or V and Zr and rare earths with the proviso the for avoiding primary precipitations of AlN the condition $Al \times N < 5 \times 10^{-3}$ (weight %) and for suppressing the cementite formation the condition $Si + Al > 4 \times C$ (weight %) are satisfied.

Oversaturated austenite

upper bainites
 higher temperatures)

lower bainites
(lower temperatures)

bainitic ferrite with fine
residual austenite lamellas
(invention)
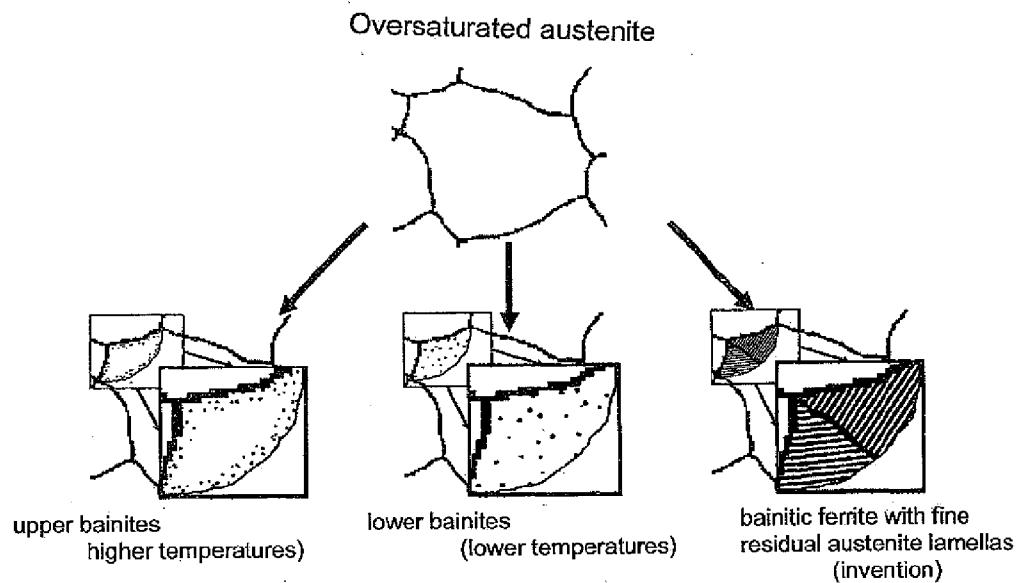
Figure 1:   Microstructure classification bainite

Ferrite and perlite

Al, Si

C, Mn, Cr

Bainite

Al   C, Mn   Al

M_s

C, Mn, Mo, Si

Temperature

Time
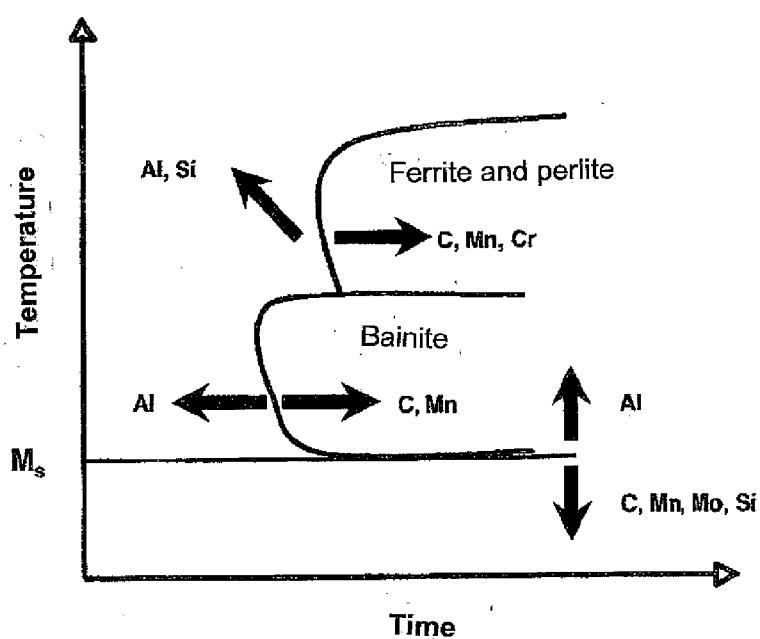
Figure 2:   Schematic representation of the transformation behavior
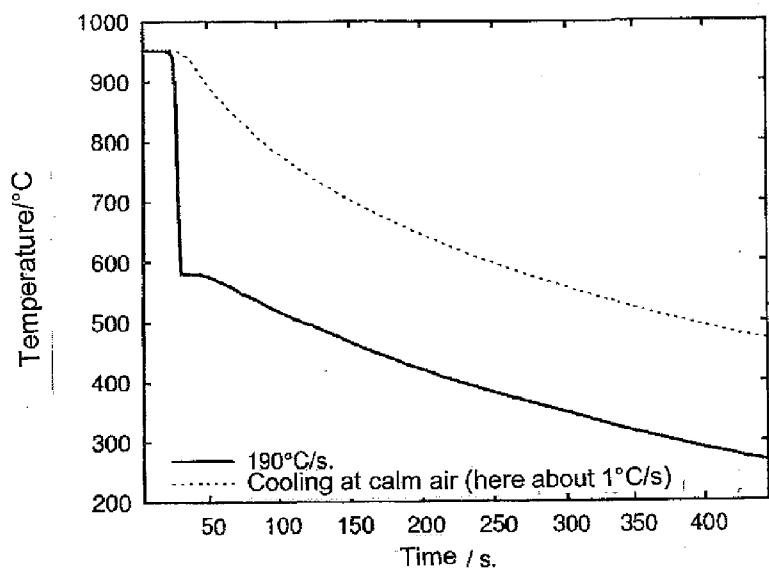
Figure 3: Temperature course of the cooling of steel sheets of the test melt 17 (cooling at calm air and with quenching)
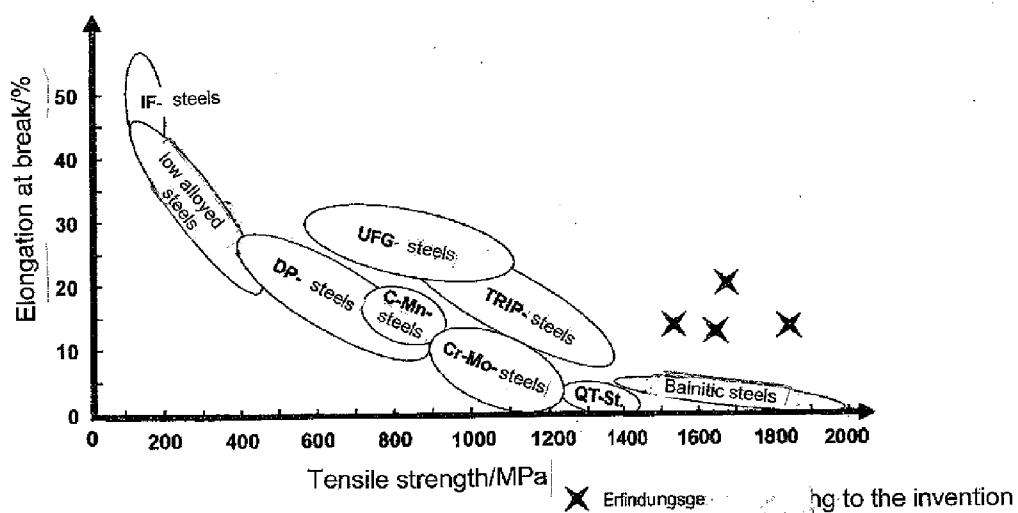
Figure 4: Mechanical characteristic values of the examined test alloys compared to conventional and high-strength steels
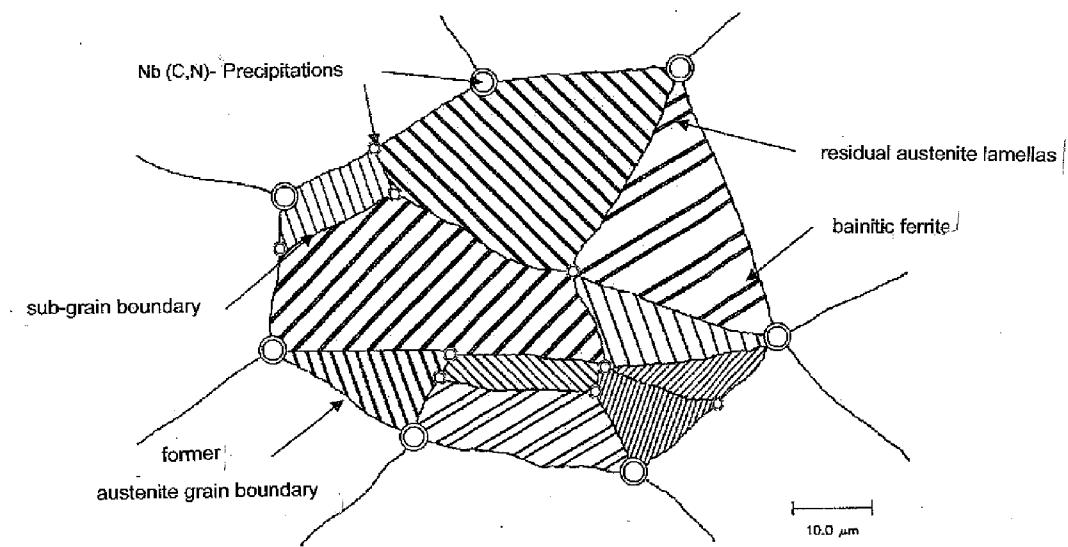
Figure 5:   Schematic representation of the microstructure: former austenite grain with Nb(C, N) - precipitations and sub-grain structures of various orientations.
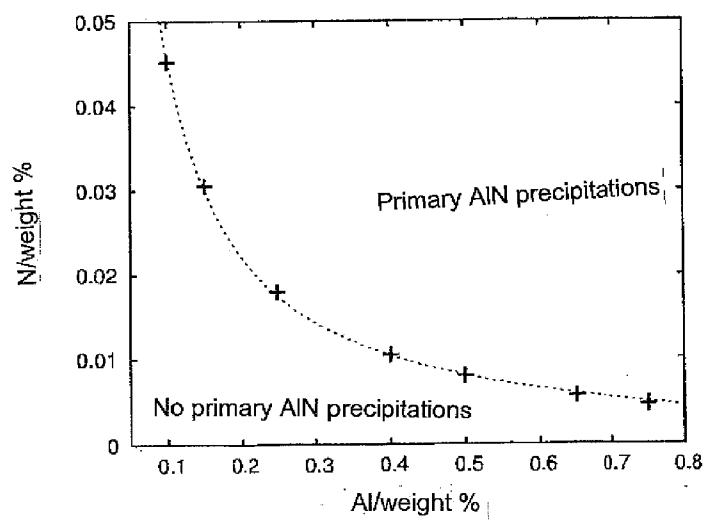
Figure 6:   Results of calculations for predicting the primary precipitations of Aluminum nitride (AlN)
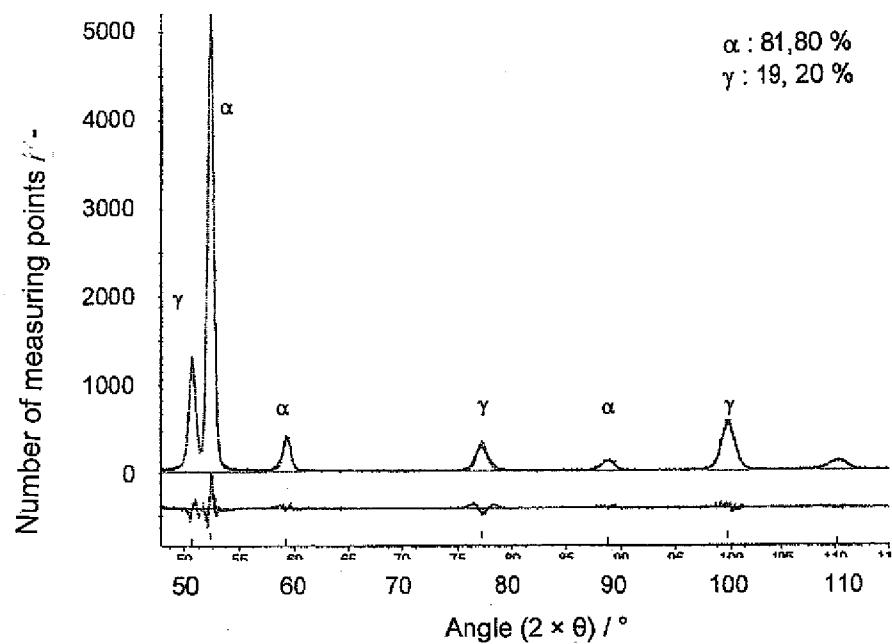
Figure 7:   x-ray spectrum of an alloy according to the invention

STEEL ALLOY FOR A LOW-ALLOY HIGH-STRENGTH STEEL

[0001] The invention relates to a steel alloy for a low alloy high strength steel which at the same time is tenacious and has excellent wear resistance according to patent claim 1.

[0002] In particular, the invention relates to pipes, strips and sheets made of this alloy, from which for example components for the automobile industry such as vehicle bodies, components of support structures or airbag tubes and cylinder tubes are produced. In the field of construction-machine industry, wear plates made of this alloy can for example be used in case of high wear requirements for excavator shovels. Such steels are also used for applications where sudden impact energies have to be absorbed, for example as bullet proof armor.

[0003] Pipes produced from this alloy can be configured as welded pipes that are produced from hot or cold strip or in a seamlessly, and which depending on the case can have a cross section which deviates from the circular shape.

[0004] Construction pipes or plates made of this alloy can also be used for welded steel constructions that are exposed to particularly high stress for example in crane construction, bridge construction, hoist construction and heavy-duty vehicle construction.

[0005] The demands for ever higher strength and improved processing properties and component properties while at the same time reducing weight and/or costs have lead among other things to the development of ultra-fine grained duplex steels which are also known under the name "Super Bainite" as carbide-free steels. The generation of such a microstructure consisting of bainitic ferrite with residual austenite lamellae is schematically shown in FIG. 1 in contrast to the upper and lower bainite microstructure.

[0006] Characteristic for these steels is for example a strength of 1000 to about 2000 MPa, an elongation at brake of at least 5% depending on the strength and an extremely fine (nano) structured bainitic microstructure with portions of residual austenite.

[0007] The approach for generating this ultra-fine microstructure is based on the phase transformation at low temperatures in the bainite region while avoiding the precipitation of cementite and formation of martensite. Suppression of carbides that precipitate in the bainite such as cementite is necessary because on one hand, these have a strong embrittling effect as possible fracture inducers thereby preventing achieving the required tenacity, and on the other hand, the proportions of stabilized austenite, which are necessary for achieving the properties according to the invention, cannot be established.

[0008] The economic use of these steels is impeded, however, because at these low transformation temperatures the transformation kinetic is strongly decelerated which depending on the alloy composition, in particular with increasing carbon content, can lead to longer isothermal holding times of many hours up to one or more days. Such long processing times are, however, not acceptable for an economic production of components so that alloy concepts were pursued as solutions to accelerate the transformation.

[0009] An alloy composition which requires such a long isothermal transformation time of up to 48 hours is known from WO 2009/0-75494. It is also disadvantageous that this steel contains expensive nickel, molybdenum, boron and titanium beside carbon and iron and the achievable tenacities are not yet sufficient for the described fields of application.

[0010] Carbide-free bainitic steels for rail tracks are for example known from DE 696 31 953 T2. Beside manganese, chromium and further elements such as molybdenum nickel vanadium wolfram titanium and boron, the steel alloy disclosed there has a silicon content between 1 and 3%.

[0011] This publication also mentions that beside silicone the addition of aluminum can reduce or suppress the formation of carbides in the bainite and can stabilize the remaining residual austenite. This steel also allows overcoming the disadvantage of a long transformation time, wherein a corresponding bainitic microstructure can be generated by continuous cooling at air (air hardening) alone.

[0012] This steel is configured for the demands on rail tracks that are exposed to strong wear stress, however it cannot be used or is uneconomical for strips, sheets and pipes for the mentioned field of application because in these cases beside the demands on wear resistance, the strength and tenacity requirements also have to be met. In addition, due the their compact cross section, the cross sectional dimensions of rails significantly differ from those of strips, sheets and pipes which requires adjustment of the alloying concept with regard to the material properties to be achieved after air cooling of the steel. A disadvantage of the known steel is also the expensive addition of titanium and other alloy elements such as nickel, molybdenum and wolfram.

[0013] A further problem in the known steels is that no information regarding the nitrogen content are given which adversely affects material properties in particular through formation of aluminum nitrides when aluminum is added.

[0014] As a result of the addition of aluminum due to the great affinity to the nitrogen present in the steel, coarse aluminum nitrides are formed during solidification which precipitate primarily in the steel which has a very negative effect on the ductility notch impact toughness the bursting behavior and the service life of the steel and with this significantly deteriorates the mechanical properties.

[0015] As a result, this known steel alloy in which instead of silicone, aluminum or in addition further aluminum is added, is rendered unusable in praxis because the amount of precipitations and size of deleterious aluminum nitrides is dependent on the respective nitrogen and aluminum content in the steel and, because the nitrogen is not taken into account, the concrete material properties cannot be predicted. In addition, the achievable tenacities for the described field of application according to the invention are also not sufficiently high.

[0016] The demands on the mechanical properties of the steel alloy that have to be satisfied can be summarized as follows:

Strength: 1250 to 2500 MPa

[0017] Elongation at break above 12%

Notch impact toughness at −20° C.: at least 15 J

[0018] Object of the invention is to set forth a steel alloy for a low alloy, high-strength carbide-free bainitic steel which is tenacious and wear resistant for producing strips, sheets and

pipes, which on one hand is more cost effective than the known steel alloys and on the other hand ensures uniform material properties which meet the demands such as strength, elongation at break, tenacity etc. In addition, these material properties are also to be achieved when cooling at stationary air by air hardening.

[0019] This object is solved based on the preamble of claim 1 together with the characterizing features. Advantageous refinements are the subject matter of the sub claims.

[0020] According to the teaching of the invention, a steel alloy with the following chemical composition is proposed (in weight %):

0.10-0.70 C

0.25-4.00 Si

0.05-3.00 Al

1.00-3.00 Mn

0.10-2.00 Cr

0.001-0.50 Nb

0.001-0.025 N

max. 0.15 P

max 0.05 S

[0021] remainder iron with smelting related contaminations with optional addition of one or more elements of Mo, Ni, Co, W, Nb, Ti, or V and Zr and rare elements with the proviso that for avoiding primary precipitations of AlN the condition $Al \times N < 10^{-3}$ (weight %) and for suppressing cementite formation the condition $Si+Al>4 \times C$ (weight %) are satisfied.

[0022] Optionally rare earths and reactive elements such as Ce, Hf, La, Re, Sc and/or Y of a\overall up to 1 weight % can be added.

[0023] In the puddle lump or slab state, steels according to the invention have already after cooling at air a strength (R_m) of over 1250 MPa, an elongation at break of over 12% and a tenacity (KBZ) at −20° C. of at least 15 J (cf. Table 1). The microstructure consists of carbide-free bainite and residual austenite with a proportion of at least 75% bainitic ferrite, at least 10% residual austenite and up to maximally 5% martensite (or martensite phase and/or decomposed austenite).

[0024] The steel alloy according to the invention is based on the development of the carbide-free bainitic steel form DE 6906 953 T2 and WO 2009/075494 A1.

[0025] Tests that were carried out in the context of the present invention have surprisingly shown that compared to known steel alloys for achieving the demanded material properties already can be achieved by an air hardening by targeted addition of aluminum in the range of 0.05 to 3.0 weight % and niobium in the range of 0.001 to 0.5 weight % beside an excellent material strength and wear resistance, very good tenacity can be achieved. In particular, the addition of niobium results in a significant improvement of the tenacity properties through grain refinement, so that this alloy meets the high requirements regarding mechanical properties and wear resistance.

[0026] Also, as a result of the advantageous addition of chromium in the range of 0.10 to 2.00 weight %, the kinetic of the ferrite formation can be decisively controlled so that the formation of coarse polygonal ferrite bodies, which can adversely affect the material properties, can be effectively avoided. Important in this regard is the interaction between aluminum and chromium. While aluminum accelerates the ferritic and bainitic transformation, addition of chromium delays the ferritic transformation (cf. FIG. 2). Targeted combination of these two elements, allows controlling the kinetic of the ferrite and bainite formation.

[0027] Beside the known advantageous effect of adding aluminum on avoiding carbide precipitations in the bainite, tests have shown that the addition of aluminum compared to silicone significantly accelerates the kinetic of the bainitic transformation. The latter also increases with increasing contents of aluminum which mean that the tenacity and strength of the steel according to the invention is significantly improved after continuous cooling compared to steel which are only alloyed with silicone, i.e., higher tenacity and strength values can be achieved. Advantageous are cooling rates greater than 10° C./s in order to achieve the demanded combination of mechanical properties also in thicker sheets (for example above 10 mm); the demanded mechanical properties can also be achieved by means of cooling at stationary air in the case of thinner sheets or by adjusting the alloying concept. The influence of different alloying elements on the kinetic of the transformation is shown in FIG. 2. The effects of C, Si, Al, Mn, Cr and Mo on the transformation kinetic of ferrite, perlite and bainite and on the martensite start temperature are shown schematically.

[0028] According to the invention, compared to the known steel, it is strictly necessary for achieving these advantageous properties that the nitrogen content does not exceed the stated upper limit of 0.025%, better 0.015% or optimally 0.010 weight % in order to minimize the number and size of the deleterious aluminum nitrides as primary precipitations in the steel, wherein in addition the condition $Al \times N < 5 \times 10^{-3}$ has to be satisfied. Otherwise, a minimal content of nitrogen of 0.001 weight %, optimally 0.0020 is required in order to enable a required niobium carbonitride formation for increasing tenacity by grain refinement.

[0029] The tested alloy compositions and the determined mechanical characteristics are shown in Table 1. All samples where heated to about 950° C. and then cooled at stationary air or subjected to accelerated cooling. The required cooling speed is selected depending on the sheet thickness and the composition. As the results of the mechanical sampling show, the demanded properties could not be achieved with the sample melt 14 due to the too low Cr content. The test melt 16 satisfied the demands due to the greater sheet thickness of 12 mm only after accelerated cooling. Typical temperature profiles for the cooling at stationary air or with quenching are shown in FIG. 3.

[0030] In FIG. 4 some of the tested test melts and their mechanical characteristics and cooling conditions are shown in comparison to the conventional and high strength steel materials. It can be seen that in the developed steel the region of higher strength materials at improved stretch properties.

TABLE 1

Alloy compositions in weight % and mechanical charateristic values of the tested alloys

		C	Si	Mn	P	S	Al	Cu	Cr	Ni	Mo	V	Ti	Nb	Co	B	W	N
											Element content/weight %							
Test steels	16	0.299	1.110	1.975	0.015	0.002	0.107	—	0.751	—	0.105	—	—	0.021	—	—	—	0.003
according to the invention	17	0.396	3.040	1.938	0.016	0.003	0.280	—	0.751	—	0.104	—	—	0.020	—	—	—	0.005
Test steels	05	0.197	1.260	2.230	0.012	0.002	0.500	—	0.082	—	0.260	—	—	—	—	—	—	0.003
not-according to the invention	14	0.231	1.080	1.937	0.013	0.002	0.092	—	0.098	—	0.105	—	—	0.020	—	—	—	0.004
	16	0.299	1.110	1.975	0.015	0.002	0.107	—	0.751	—	0.105	—	—	0.021	—	—	—	0.003

		Sheet thickness/ mm	Cooling rates/ C. °/s	Rp0.2	Rm	Ag	A	KBZ/J @ RT	@ 0	@ –20	@ –40	@ –60
				/MPa		/%		Mechanical properties				
Test steels	16	12.0	025	1021	1670	13.2	19.8	69	56	48	42	30
according			210	1214	1531	02.3	13.3	52	35	34	25	18
to the	17	12.0	020	1254	1648	02.3	12.3	31	25	15	11	08
invention			190	1104	1884	08.1	13.7	39	25	20	15	12
Test steels	05	12.5	001	0760	1094	08.5	19.3	47		27		
not-according	14	09.0	030	0578	1136	13.3	17.2	16	15	12		
to the invention	16	12.0	001	0796	1352	11.3	18.0	16	10	08		08

[0031] The results confirm the excellent mechanical properties (strength and tenacity of the steel alloy according to the invention already for semi-finished products such as puddle lumps or slabs) in the hardened state (Table 1).

[0032] As essential element, aluminum plays an important role which beside accelerating the transformation kinetic also suppresses the carbide precipitation in the bainite in combination with silicone, as a result, residual austenite is stabilized because carbon only has a limited solubility in the ferrite. A high proportion of residual austenite of at least 10% in the bainite causes beside the extremely fine lamellar microstructure the excellent mechanical properties. The different microstructure components were determined by scanning electron microscopy, wherein a mean lamellar interspacing of 300 nm was determined. A schematic representation of a previous austenite grain with substructure (such as for example sub grains) with fine lamellar microstructure is schematically shown in FIG. 5. Here, the previous austenite grain structure is stabilized via Nb(C,N) precipitations.

[0033] With corresponding proportions of residual austenite a so called TRIP-effect can then also be advantageously used. Steels which usually are referred to by the term TRIP ("Transformation Induced Plasticity") are steels which at the same time have a very high strength and a high ductility, which makes them especially suited for cold forming. These properties are obtained owing to their special microscopic structure, wherein the deformation-induced martensite formation and the work hardening associated therewith is inhibited and the ductility is increased. The effect of the TRIP effect is optimal for a residual austenite proportion of about 1 to 20%.

[0034] In the following, the alloying concept according to the invention is explained in more detail.

[0035] Carbon: for reason of sufficient strength of the material the minimal content should not be below 0.10 weight %. With regard to a sufficiently low martensite start temperature and with this the establishment of a very fine microstructure, however still good weldability, the carbon content should not be above 0.70 weight %. Carbon contents between 0.15 and 0.60 weight % have proven advantageous, wherein optimal properties are achieved when the carbon content is between 0.18 and 0.50 weight %.

[0036] Aluminum/silicone: the essential element for achieving the demanded material properties after continuous cooling is aluminum which strongly accelerates the transformation kinetic.

[0037] In order to achieve this effect the aluminum content should be at leas 0.05% weight % but maximally 3.00% weight % because otherwise coarse polygonal ferrite bodies could form which in turn adversely affect the material properties. If the aluminum content is too low the bainitic transformation becomes too slow so that the formation of martensite is promoted which adversely affects the elongation at break and the notch impact toughness. For a sufficient suppression of carbides in the bainite, silicone at contents of 0.25 to 4.00 weight % can be added. Good material properties are achieved at aluminum contents between 0.07 and 1.50 weight % and optimal ones between 0.09 and 0.75 weight %. Corresponding silicone contents are between 0.50 to 1.75 weight % or between 0.75 and 1.50 weight %.

[0038] As a result of the targeted addition of chromium of at least 0.10 to 2.00 weight % the ferritic transformation can be decelerated and via a combination with aluminum the kinetic of the ferrite and bainite formation can be controlled in a targeted manner. Advantageous chromium contents are between 0.10 to 1.75 weight % or between 0.10 and 1.50 weight %.

[0039] Manganese: the addition of Manganese in the range of 1.00 to 3.00 weight % results in dependence on the respective demands on the steel alloy as a compromise between strength, which can be achieved by higher additions, and a sufficient tenacity which can be

achieved at lower contents. With regard to a very good or optimal property combination, the manganese content should be between 1.50 and 2.50 weight % or between 1.70 and 2.70 weight %.

[0040] Niobium/nitrogen: A niobium content of 0.001 to 0.50 weight % has to be established for ensuring formation of Nb(C,N). The resulting grain refinement contributes to a significant improvement of the tenacity properties. In addition a nitrogen content of 0.001 to 0.025 weight % is recommended for forming Nb(N) because NbN is more stable than NbC and thus leads to an increased grain refinement. Advantageous niobium contents are 0.001 to 0.10 or 0.001 to 0.05 weight % at advantageous nitrogen contents of 0.001 to 0.015 or 0.002 to 0.010 weight %. In addition, adding nitrogen prevents excessive binding of C via Nb because otherwise the austenite stabilizing effect of C could be lost.

[0041] If needed for example molybdenum (up to 1.00 weight %), nickel (up to 5.00 weight %) cobalt (up to 2.00 weight %) or wolfram (up to 1.50 weight %) can be added as solid solution hardener for further increasing strength. As an alternative or in addition micro-alloying elements such as vanadium at up to 0.2 weight % and/or titanium up to 0.10 weight % can be added. A total content of Ti, V of max 0.20 weight % and Ni, Mo, Co, W, Zr of max 5.50 weight % should be observed. In order to take advantage of the effect of these alloy elements, a minimal content of 0.01 weight % should be observed.

[0042] Rare earths and reactive elements: rare earths and reactive elements such as Ce, Hf, La, Re, Sc and/or Y can be optionally added to achieve an optimal lamellar interspacing and thus for further increase of strength and tenacity at total contents of up to 1 weight %. If necessary a total content of 20 ppm should be added.

[0043] In the alloy composition the following conditions should be adhered to for achieving the demanded material properties in particular of the mechanical technological properties for the transformation kinetic and the transformation behavior (FIG. 2) the stabilizing of the residual austenite and the martensite start temperature while taking the cooling rate into account wherein in the mentioned empirically determined formulas the contents of C, Mn, Si, Al, Cr and Mo in weight % and T as cooling rate in ° C./s have to be inserted. The units of the coefficients that are used in the formula are to be selected according to the variables used in the formula.

[0044] Kinetic of the Ferritic Transformation:
For adhering to or setting the mechanical-technical properties and in particular for avoiding the formation of the coarse polygonal ferrite grains which adversely affect the material properties, the following condition has to be satisfied:

$$(35 \times C) + (10 \times Mn) - Si - (5 \times Al) + Cr > 134/\dot{T} + 10$$

[0045] Kinetic of the Bainitic Transformation:
The following equation for the kinetic of the bainitic transformation has to be established to achieve a suitable microstructure with very finely configured bainitic ferrite/residual austenite lamellae for the mechanical technological properties:

$$400 \times \exp[(-7 \times C) - (4 \times Mn) + 8Al + 3]/\dot{T} > 1$$

[0046] Martensite Start Temperature (° C.):
for avoiding greater martensitic microstructure proportions which deteriorate the mechanical technological properties the martensite start temperature has to be determined as follows:

$$525 - (350 \times C) - (45 \times Mn) - (16 \times Mo) - (5 \times Si) + (15Al)$$
$$<<400$$

[0047] For stabilizing the residual austenite, formation of cementite has to be suppressed. This is achieved by a targeted alloying with Si and Al because both elements have a very low solubility in cementite. For this, the following condition has to be satisfied:

$$Si + Al > 43 \times C$$

[0048] For avoiding deleterious primary AlN precipitations, the following condition has to be satisfied:

$$Al \times N > 5 \times 10^{-3}$$

In FIG. 6, this relationship is again shown schematically.

[0049] Transformation Capacity:
For establishing the properties according to the invention on the basis of the describe microstructure a complete austenization of the steels according to the invention has to be achieved prior to the final heat treatment (cf. FIG. 1).

[0050] In order to achieve the demanded combination of the mechanical properties (strength ductility and tenacity) the following relationship of the ferrite and austenite formers is to be satisfied:

$$C + Si/6 + Mn/4 + (Cr + Mo)/3 > 1.$$

[0051] The microstructure of the steel according to the invention consist of ferrite and residual austenite lamellae. It can have proportions of martensite of up to 5% (or martensite/austenite phase and/or decomposed austenite). The two most important characteristics of the microstructure which significantly influence the mechanical properties of the steel are the lamella spacing and the proportion of residual austenite. The smaller the lamellar interspacing and the higher the proportion of residual austenite the higher are the strength and elongation at break of the material.

[0052] In order to achieve the demanded high strength of the material of at least 1250 to 2500 MPa the average lamellar interspacing should be smaller than 750 nm, advantageously smaller than 500 nm.

[0053] In order to achieve the stretch values of at least 12% (and elongation at break) a residual austenite proportion of at least 10% and a martensite proportion of at most 5% should be present.

[0054] In order to achieve the high tenacity by grain refinement by means of niobium carbonitride formation, the average previous austenite grain size should not exceed a value of 100 μm.

[0055] Because the microstructure is very fine, the components of the microstructure can hardly be distinguished from each other microscopically so that depending on the case a combination of electron microscopy and x-ray diffraction has to be used.

[0056] The components of the microstructure can be distinguished by means of scanning electron microscopy. In this way, an average lamellar interspacing of about 300 nm was determined.

[0057] The result of an x-ray diffraction measurement is shown in FIG. 7. From the intensity distribution of the x-ray spectrum, the crystal structure of the present microstructure components and their phase proportions can be determined.

[0058] Residual austenite proportions between 10% and 20% were determined using the x-ray diffraction method.

What is claimed is:

1. A steel alloy for a low alloy high-strength carbide-free bainitic steel for producing strips, sheets and pipes with the following chemical composition (in weight %):

0.10-0.70 C

0.25-4.00 Si

0.05-3.00 Al

1.00-3.00 Mn

0.10-2.00 Cr

0.001-0.50 Nb

0.001-0.025 N

max 0.15 P

max 0.05 S

remainder iron and steel tramp elements with optional addition of one or more elements of Mo, Ni, Co, W, Nb, Ti, or V and Zr and rare earths with the proviso the for avoiding primary precipitations of AlN the condition Al×N<5×10^{-3} (weight %) and for suppressing the cementite formation the condition Si+Al>4×C (weight %) is satisfied.

2. The steel alloy according to claim 1, having the following contents in weight %:

0.15-0.60 C

0.50-1.75 Si

0.07-1.50 Al

1.50-2.50 Mn

0.10-1.75 Cr

0.001-0.10 Nb

0.001-0.015 N

3. The steel alloy according to claim 2, having the following contents in weight %:

0.18-0.50 C

0.75-1.5 Si

0.09-0.75 Al

1.70-2.50 Mn

0.10-1.5% Cr

0.001-0.05 Nb

0.002-0.010 N

4. The steel alloy according to claim 2, having the following contents in weight percent:

max. 5.00 Ni

max. 1.00 Mo

max. 2.00 Co

max. 1.50 W

max. 0.10 Ti

max. 0.20 V

wherein the total content of Ti, V is maximally 0.20% and the total content of Ni, Mo, Co, W is maximally 5.50 weight %.

5. The steel alloy according to claim 1, wherein the microstructure consists of carbide free bainite and residual austenite with a proportion of at least 75% bainite at least 10% residual austenite and up to maximally 5% martensite.

6. The steel alloy according to claim 1, wherein for achieving demanded material properties the following conditions for transformation kinetic martensite start temperature and microstructure formation are adhered to:

ferritic transformation kinetic with C, Mn, Si and Al corresponding to the element contents in weight % and T to a cooling rate in C/s:

$(35 \times C) + (10 \times Mn) - Si - (5 \times Al) + Cr > 13/\dot{T} + 10$

bainitic transformation kinetic with C, Mn and Al corresponding to the element contents in weight % and T to the cooling rate in C/s:

$400 \times \exp[(-7 \times C) - (4 \times Mn) + 8Al + 3]/\dot{T} > 1$

martensite start temperature with, C, Mn, Si Al and Mo correspond to the element contents in weight %:

$525 - (350 \times C) - (45 \times Mn) - (16 \times Mo) - (5 \times Al) << 400$

stabilization of residual austenite with C, Si and Al corresponding to the element contents in weight %):

$Si + Al > 4 \times C$

avoiding primary AlN precipitations with Al and N corresponding to the element contents in weight %:

$Al \times N < 5 \times 10^{-3}$

satisfying the demanded combination of the mechanical properties:

$C + Si/6 + Mn/4 + Cr + Mo)/3 > 1$

7. The steel alloy according to claim 1, characterized in that an average distance of residual austenite lamellas is less than 750 nm.

8. The steel alloy according to claim 7, wherein the average distance of the residual austenite lamellas is less than 500 nm.

9. The steel alloy according to claim 1 for use in production of hot or cold rolled strips sheet metals pipes profiles or for forged parts for the automobile industry, construction industry and machine construction and rods and wires.

10. The steel alloy according to claim 1 for use in wear parts and parts for armors.

* * * * *