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(54) **AUSTENITE STEEL MATERIAL HAVING SUPERIOR DUCTILITY**
AUSTENITSTAHL MATERIAL MIT ERHÖHTER DEHNBARKEIT
MATÉRIAU D'ACIER AUSTÉNITIQUE À DUCTILITÉ SUPÉRIEURE

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Description

[Technical Field]

[0001] The present invention relates to austenite steels having excellent wear resistance, corrosion resistance, or non-magnetic performance as well as ductility, as steels used for industrial machines and in structures requiring ductility and wear resistance, superconducting application devices and general electric devices requiring non-magnetic properties, in the mining, transportation, and storage sectors as well as in oil and gas industries such as steel for an expansion pipe, steel for a slurry pipe, or sour resistant steel.

[Background Art]

[0002] Recently, demand for austenitic steels (non-magnetic steels) for use as structural materials in superconducting application devices, such as a linear motor car track and a fusion reactor, and general electric devices, has increased. A typical example of non-magnetic steel is AISI 304 (18Cr-8Ni base) austenitic stainless steel. However, AISI 304 austenitic stainless steel may be uneconomical because the yield strength thereof is low and large amounts of expensive elements, such as Cr and Ni, are included therein. In particular, with respect to a structural material requiring stable non-magnetic properties according to a load, such austenitic steels may exhibit magnetic properties due to a ferromagnetic ferrite phase induced by deformation-induced transformation and thus, there may be limitations in the uses and applications thereof.

[0003] High-manganese austenitic steels have been continuously developed, in which expensive nickel in the austenitic stainless steels is replaced by manganese. With respect to the high-manganese austenitic steels, it is essential to secure stability of an austenite structure through appropriate changes in contents of manganese and carbon. In the case that the content of manganese is high, a stable austenite structure may be obtained even with a low content of carbon. However, in the case that the content of manganese is low, a large amount of carbon must be added for austenitization. As a result, carbides are precipitated by forming a network along austenite grain boundaries at high temperatures and the precipitates may rapidly decrease physical properties of the steel, in particular, ductility. JP 02 270 937 discloses high Mn steel with good contact fatigue properties.

[0004] In order to inhibit the precipitation of carbides having a network form, a method of performing a solution treatment at a high temperature or manufacturing high-manganese steel by rapid cooling to room temperature after hot working has been suggested. However, in the case that the steel is thick or changes in manufacturing conditions are not facilitated as in the case in which welding is essentially accompanied, the precipitation of carbides having a network form may not be inhibited and as a result, physical properties of the steel may rapidly deteriorate. Also, segregation due to alloying elements, such as manganese and carbon, inevitably occurs during solidification of an ingot or billet of high-manganese steel and segregation becomes severe during post-processing such as hot rolling. Eventually, partial precipitation of carbides occurs in a network form along an intensified segregation zone in a final product, thereby promoting non-uniformity of a microstructure and deteriorating physical properties.

[0005] In order to inhibit the precipitation of carbides in the segregation zone, increasing the content of manganese may be a method generally used. However, this may eventually cause increases in an alloy amount and manufacturing costs, and thus, research into the addition of elements effective in inhibiting carbide formation with respect to manganese has been required for resolving the foregoing limitations. Also, since a level of corrosion resistance of high-manganese steel may decrease in comparison to that of a general carbon steel due to the addition of manganese, applications in fields requiring corrosion resistance may be limited, and thus, research into improving corrosion resistance of high-manganese steel has also been required.

[Disclosure]

[Technical Problem]

[0006] An aspect of the present invention provides an alloy having improved ductility and wear resistance by stabilizing austenite through appropriate control of contents of carbon and manganese and economically inhibiting generation of carbides in a network form that may be formed at austenite grain boundaries.

[Technical Solution]

[0007] According to an aspect of the present invention, there is provided an austenite steel having excellent ductility including: 8 wt% to 15 wt% of manganese (Mn); 3 wt% or less excluding 0 wt% of copper (Cu); a content of carbon (C) satisfying relationships of $33.5C + Mn \geq 25$ and $33.5C - Mn \leq 23$; and iron (Fe) as well as unavoidable impurities as a

remainder.

[0008] At this time, the steel includes 2 to 8 wt% or less (excluding 0 wt%) of chromium (Cr).

[0009] Also, the steel may further include 0.05 wt% or less (excluding 0 wt%) of titanium (Ti) and 0.1 wt% or less (excluding 0 wt%) of niobium (Nb).

[0010] Yield strength of the steel may be 500 MPa or more.

[0011] The steel may further include 0.002 wt% to 0.2 wt% of nitrogen (N).

[0012] A microstructure of the steel may include austenite having an area fraction of 95% or more.

[0013] Magnetic permeability of the steel may be 1.01 or less at a tensile strain of 20%.

[Advantageous Effects]

[0014] According to an aspect of the present invention, austenite is stabilized and generation of carbides in a network form at austenite grain boundaries is inhibited by adding copper (Cu) favorable to inhibition of carbide formation with respect to manganese and appropriately controlling contents of carbon and manganese, and thus, ductility and wear resistance may be improved and corrosion resistance of steel may also be improved through the addition of chromium (Cr).

[Description of Drawings]

[0015] The above and other aspects, features and other advantages of the present invention will be more clearly understood from the following detailed description taken in conjunction with the accompanying drawings, in which:

FIG. 1 is a graph showing composition ranges of carbon and manganese of the present invention;

FIG. 2 is a photograph showing an example of a microstructure of a steel sheet according to the present invention; and

FIG. 3 is a photograph showing another example of a microstructure of a steel sheet according to the present invention.

[Best Mode]

[0016] The present invention may provide an austenite steel having excellent ductility by stabilizing austenite and inhibiting generation of carbides in a network form at austenite grain boundaries through controlling contents of carbon, manganese, and copper in a component system.

[0017] According to an aspect of the present invention, there is provided a steel having excellent ductility including 8 wt% to 15 wt% of manganese (Mn), 3 wt% or less, excluding 0 wt%, of copper (Cu), a content of carbon (C) satisfying relationships of $33.5C + Mn \geq 25$ and $33.5C - Mn \leq 23$, and iron (Fe) as well as unavoidable impurities as a remainder.

Manganese (Mn): 8 wt% to 15 wt%

[0018] Mn, as the most important element added to a high-manganese steel as in the present invention, is an element acting to stabilize austenite. In consideration of a content of carbon controlled for improving non-magnetic properties in the present invention, Mn may be included in an amount of 8% or more so as to stabilize austenite. That is, in the case that a content of Mn is 8 wt% or less, an austenite structure may not be sufficiently obtained because ferrite, a ferromagnetic phase, becomes a main structure. Also, in the case that the content of Mn is greater than 15 wt%, a stable austenite structure may not be maintained because unstable ϵ -martensite is formed and easily transformed into ferrite according to deformation. As a result, magnetic properties may increase and fatigue properties may deteriorate, and also, a decrease in corrosion resistance, difficulty in a manufacturing process, and increases in manufacturing costs may be obtained due to the excessive addition of manganese.

Carbon (C): $33.5C + Mn \geq 25$ and $33.5C - Mn \leq 23$

[0019] C is an element that allows an austenite structure to be obtained at room temperature by stabilizing austenite and has an effect of increasing strength and wear resistance of steel. In particular, carbon functions to decrease M_s or M_d , a transformation point from austenite to martensite by a cooling process or working.

[0020] A content of C in the present invention may simultaneously satisfy relationships of $33.5C + Mn \geq 25$ and $33.5C - Mn \leq 23$ and content ranges of carbon and manganese controlled in the present invention may be confirmed in FIG.

1. In the case that a value of $33.5C + Mn$ is less than 25, an alpha-martensite structure, a ferromagnetic phase, may be formed because stabilization of austenite is insufficient, and thus, a sufficient amount of an austenite structure may not be obtained. In the case that a value of $33.5C - Mn$ is greater than 23, carbides are excessively formed at grain boundaries because the content of C becomes excessively high, and thus, physical properties of a material may rapidly deteriorate.

Therefore, the contents of carbon and manganese are required to be controlled in the foregoing ranges and as a result, sufficient austenite may be secured and the inhibition of carbide formation may be possible. Therefore, ductility and non-magnetic properties may be improved.

5 Copper (Cu): 3 wt% or less (excluding 0 wt%)

[0021] Cu has very low solubility in carbide and low diffusivity in austenite, and thus, is concentrated at an interface between the austenite and the nucleated carbide. As a result, Cu effectively delays growth of the carbide by inhibiting diffusion of carbon and eventually, has an effect of inhibiting carbide formation. However, since hot workability of steel may be decreased in the case that a content of Cu is greater than 3 wt%, an upper limit thereof may be limited to 3 wt%. In particular, in order to sufficiently obtain the effect of inhibiting carbide formation, Cu may be added to an amount of 0.3 wt% or more, and for example, it is more effective to maximize the foregoing effect in the case that Cu is added in an amount of 2 wt% or more.

[0022] At this time, corrosion resistance of the steel may be additionally improved by further including 8 wt% or less (excluding 0 wt%) of chromium (Cr).

Chromium (Cr): 2 to 8 wt% or less.

[0023] In general, manganese is an element decreasing corrosion resistance of steel and corrosion resistance of the steel having the foregoing range of Mn may be lower than that of a general carbon steel. However, in the present invention, corrosion resistance may be improved by the addition of Cr. Also, ductility may be increased by stabilizing austenite through the addition of Cr having the foregoing range and strength may also be increased by solution strengthening.

[0024] In the case that a content of Cr is greater than 8 wt%, manufacturing costs may not only increase, but also, resistance to sulfide stress corrosion cracking may be decreased by forming carbides along grain boundaries as well as carbon dissolved in a material and a sufficient fraction of austenite may not be obtained due to formation of ferrites. Therefore, an upper limit thereof may be limited to 8 wt%. In order to maximize the effect of improving corrosion resistance, Cr is added in an amount of 2 wt% or more. Corrosion resistance is improved by the addition of Cr and thus, the steel of the present invention may be widely used in a steel for a slurry pipe or sour resistance steel.

[0025] Also, yield strength of the steel may be further improved by including 0.05 wt% or less (excluding 0 wt%) of titanium (Ti) and 0.1 wt% or less (excluding 0 wt%) of niobium (Nb) and thus, the steel having a yield strength of 500 MPa or more may be obtained.

Titanium (Ti): 0.05 wt% or less (excluding 0 wt%)

[0026] Ti combines with nitrogen to form TiN and thus, exhibits an effect of increasing yield strength of steel by inhibiting growth of austenite grains at high temperatures. However, in the case that Ti is added excessively, physical properties of the steel may be deteriorated due to coarsening of titanium precipitates. Therefore, an upper limit thereof may be limited to 0.05 wt%.

Niobium (Nb): 0.1 wt% or less (excluding 0 wt%)

[0027] Nb is an element increasing strength through dissolution and precipitation hardening effects, and in particular, may improve yield strength through grain refinement during low-temperature rolling by increasing a recrystallization stop temperature (T_{nr}) of steel. However, in the case that Nb is added in an amount of greater than 0.1 wt%, physical properties of the steel may be rather deteriorated due to formation of coarse precipitates. Therefore, an upper limit thereof may be limited to 0.1 wt%.

[0028] Also, in the case that the steel further includes 0.002 wt% to 0.2 wt% of nitrogen (N), the effect of the present invention may be further improved.

Nitrogen (N): 0.002 wt% to 0.2 wt%

[0029] Nitrogen is an element stabilizing austenite with carbon and also, may improve strength of steel through solution strengthening. In the case that unstable austenites are formed, N greatly deteriorates physical properties and non-magnetic properties by inducing deformation induced transformation into ϵ -martensite and α -martensite according to deformation. Therefore, physical properties and non-magnetic properties of the steel may be improved by stabilizing austenite through appropriate addition of nitrogen.

[0030] In the case that a content of N is less than 0.002 wt%, the effect of stabilization may not be anticipated, and in

the case that the content of N is greater than 0.2 wt%, physical properties of the steel may be deteriorated due to formation of coarse nitrides.

[0031] Therefore, the content of N may be limited to a range of 0.002 wt% to 0.2 wt%. For example, in the case that N is added to an amount of 0.05 wt% or more, non-magnetic properties may be more effectively improved through the stabilization of austenite.

[0032] In the present invention, iron (Fe) and other unavoidable impurities are included as a remainder. However, since unintended impurities may be inevitably incorporated from raw materials or a surrounding environment during a typical steelmaking process, the unintended impurities may not be excluded. Since the unintended impurities are obvious to those skilled in the art, detailed descriptions thereof are not particularly provided in the present specification.

[0033] Austenite is a main phase in the steel of the present invention having the foregoing composition and austenite may be included in an area fraction of 95% or more. In the case that the foregoing composition is satisfied, a targeted fraction of an austenite structure may be obtained without performing rapid cooling (water cooling) in order to inhibit grain boundary carbide precipitation, a limitation in a typical steel. That is, a targeted microstructure may be formed in the steel almost without dependency on a cooling rate and as a result, high ductility and wear resistance may be obtained. Also, corrosion resistance may be improved through the addition of Cr having the foregoing range and strength may be improved through solution strengthening.

[0034] Further, the steel may have a magnetic permeability of 1.01 or less at a tensile strain of 20%. In the present invention, non-magnetic properties are improved by stably securing austenite, and in particular, excellent non-magnetic properties may be obtained by allowing very low magnetic permeability to be obtained even at a tensile strain of 20% through the addition of nitrogen. For example, non-magnetic properties may be further improved by controlling magnetic permeability to have a value of 1.005 or less at a tensile strain of 20%.

[0035] In the present invention, a slab satisfying the foregoing component system may be manufactured according to a typical method of manufacturing steel, and for example, the slab of the present invention may be manufactured by rough rolling and finishing rolling after reheating the slab and then cooling.

[Mode for Invention]

[0036] Hereinafter, the present invention will be described in detail, according to an embodiment. However, the following individual examples are merely provided to allow for a clearer understanding of the present invention, rather than to limit the scope thereof.

(Embodiment)

[0037] Slabs satisfying component systems and composition ranges described in Tables 1 and 4 were manufactured through a series of hot rolling and cooling processes, and microstructures, elongations, strengths, and magnetic permeabilities thereof were then measured, and the results thereof are presented in the following Table 2. The results of corrosion rate tests according to dipping experimentations are presented in Table 3 below and weight losses of samples in accordance with wear experimentations (ASTM G65) are presented in Table 4 below.

[Table 1]

Category (wt%)	C	Mn	Cu	Cr	Ti	Nb	N	35.5C+Mn	35.5C-Mn
Example 1	0.66	10	1.06	-	-	-	-	32	12
Example 2	0.83	9.98	1.08	-	-	-	-	38	18
Example 3	0.5	14	0.37	-	-	-	-	31	3
Example 4	0.79	10.84	1.21	-	0.017	0.021	-	37	16
Example 5	0.63	10.25	1.12	1.5	-	-	-	31	11
Example 6	0.93	11.05	1.34	1.47	-	-	-	42	20
Example 7	0.83	9.92	1.28	0.98	-	-	-	38	18
Example 8	0.92	12.01	0.71	1.23	-	-	-	43	19
Inventive Example 9	0.6	14.25	0.26	5.07	-	-	-	34	6
Inventive Example 10	0.72	12.54	2.35	2.07	-	-	-	37	12
Inventive Example 11	0.79	11.2	1.38	2.53	0.014	0.02	-	38	15

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(continued)

Category (wt%)	C	Mn	Cu	Cr	Ti	Nb	N	35.5C+Mn	35.5C-Mn
Inventive Example 12	0.82	10.95	0.95	3.15	0.016	0.02	-	38	17
Example 13	0.64	12.12	1.37	1.85	0.015	0.018	0.13	34	9
Comparative Example 1	0.39	9.94	-	-	-	-	-	23	3
Comparative Example 2	0.9	10	-	-	-	-	-	40	20
Comparative Example 3	0.2	17	-	-	-	-	-	24	-10.3
Comparative Example 4	1.2	10	-	-	-	-	-	50	30
Comparative Example 5	0.9	10	3.5	-	-	-	-	40	20
Comparative Example 6	0.9	10.1	1.25	10	-	-	-	40	20
Comparative Example 7	0.05	19	-	-	-	-	-	21	-17
Comparative Example 8	0.02	17	0.5	1.2	-	-	-	18	-16

[Table 2]

Category	Austenite fraction (area%)	Elongation (%)	Yield strength (MPa)	Magnetic permeability (before deformation)	Magnetic permeability (after 20% tensile strain)
Example 1	98	22.5	376	1.002	1.012
Example 2	99	25.6	357	1.002	1.01
Example 3	99	27.3	362	1.001	1.009
Example 4	99	26.4	574	1.001	1.002
Example 5	99	25.7	395	1.002	1.01
Example 6	99	28.7	402	1.002	1.01
Example 7	99	28.4	386	1.002	1.01
Example 8	99	27.6	392	1.001	1.009
Inventive Example 9	99	35.6	472	1.001	1.009
Inventive Example 10	100	37.2	630	1.002	1.002
Inventive Example 11	99	28.1	592	1.002	1.01
Inventive Example 12	99	30.6	605	1.002	1.01
Example 13	99	32.2	577	1.001	1.003
Comparative Example 1	65	4	336	5 or more	Non measurable
Comparative Example 2	78	4.6	352	1.001	Non measurable
Comparative Example 3	68	32	303	1.002	5 or more
Comparative Example 4	72	4.3	358	1.002	Non measurable

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(continued)

Category	Austenite fraction (area%)	Elongation (%)	Yield strength (MPa)	Magnetic permeability (before deformation)	Magnetic permeability (after 20% tensile strain)
Comparative Example 5	Non measurable	Non measurable	Non measurable	Non measurable	Non measurable
Comparative Example 6	72	3.8	520	1.002	Non measurable
Comparative Example 7	41	31	297	1.002	5 or more
Comparative Example 8	38	27	312	1.002	5 or more

[Table 3]

Category	Corrosion rate (mm/year)	
	3.5% NaCl, 50°C, 2 weeks	0.05 M H ₂ SO ₄ , 2 weeks
Example 5	0.12	0.42
Example 6	0.11	0.41
Example 7	0.12	0.42
Example 8	0.12	0.42
Inventive Example 9	0.06	0.33
Inventive Example 10	0.06	0.35
Inventive Example 11	0.09	0.40
Inventive Example 12	0.07	0.37
Example 13	0.11	0.43
Comparative Example 1	0.14	0.48
Comparative Example 2	0.16	0.48
Comparative Example 3	0.15	0.47
Comparative Example 4	0.16	0.48
Comparative Example 5	Non measurable	Non measurable
Comparative Example 6	0.03	0.27
Comparative Example 7	0.15	0.45
Comparative Example 8	0.14	0.43

[Table 4]

Category (wt%)	C	Mn	Si	Ni	Cu	Cr	Ti	Nb	N	Weight loss (g)
Example 1	0.66	10			1.06	-	-	-	-	0.59
Example 2	0.83	9.98			1.08	-	-	-	-	0.61
Example 3	0.5	14			0.37	-	-	-	-	0.65
Example 4	0.79	10.84			1.21	-	0.017	0.021	-	0.63
Example 5	0.63	10.25	-	-	1.12	1.5	-	-	-	0.65

(continued)

Category (wt%)	C	Mn	Si	Ni	Cu	Cr	Ti	Nb	N	Weight loss (g)
Example 6	0.93	11.05	-	-	1.34	1.47	-	-	-	0.59
Example 7	0.83	9.92	-	-	1.28	0.98	-	-	-	0.58
Example 8	0.92	12.01	-	-	0.71	1.23	-	-	-	0.57
Inventive Example 9	0.6	14.25	-	-	0.26	5.07	-	-	-	0.61
Inventive Example 10	0.72	12.54	-	-	2.35	2.07	-	-	-	0.54
Inventive Example 11	0.79	11.2	-	-	1.38	2.53	0.014	0.02	-	0.57
Inventive Example 12	0.82	10.95	-	-	0.95	3.15	0.016	0.02	-	0.58
Example 13	0.64	12.12	-	-	1.37	1.85	0.015	0.018	0.13	0.62
Comparative Example 9	0.45	0.6	0.25	-	-	-	-	-	-	0.75
Comparative Example 10	0.066	1.5	0.2	0.15	-	0.1	0.012	0.04	-	1.32
Comparative Example 11	0.36	1.5	0.26	-	-	0.2	0.011	0.012	-	0.9
Comparative Example 12	0.9	12	0.5	-	-	-	-	-	-	0.59

[0038] Examples 1 to 13 were steels illustrating the component systems and composition ranges controlled, and it may be understood that deterioration of physical properties due to grain boundary carbide formation were not obtained even by slow cooling. Specifically, since area fractions of austenite were 95% or more and magnetic permeabilities were stably maintained even at a tensile strain of 20%, non-magnetic properties as well as elongations and yield strengths were excellent. Also, since weight losses of the samples were low, wear resistance may be secured.

[0039] In particular, in Inventive Examples 5 to 13, it may be understood that corrosion resistances were also improved because corrosion rates were slow in the corrosion evaluation tests according to additional addition of Cr. That is, it may be confirmed that Examples 5 to 13 had effects of improving corrosion resistance better than those of Examples 1 to 4 in which Cr was not added. Further, it may be understood that Inventive Example 10 had a better effect of improving corrosion resistance, because Cu was added to an amount of 2 wt% or more, a more desirable amount. Also, in Examples 4 and 11 to 13, yield strengths were improved by further additions of Ti and Nb, and thus, were 500 MPa or more.

[0040] In contrast, Comparative Example 1 had a value of $33.5C+Mn$ of 23, which did not correspond to the range controlled in the present invention. A content of carbon as an austenite-stabilizing element was insufficient and as a result, targeted austenite structure and elongation were not obtained due to formation of a large amount of martensites.

[0041] Also, in Comparative Example 2, contents of manganese and carbon corresponded to the ranges controlled in the present invention. However, since a large amount of carbides were formed along grain boundaries due to copper not being added, austenite was formed in an area fraction of less than 95%. Thus, it may be confirmed that targeted microstructure and elongation may not be obtained.

[0042] Further, Comparative Example 3 had a value of $33.5C+Mn$ of 24, which did not correspond to the range controlled in the present invention. In particular, since ϵ -martensite, a semi-stable phase, was formed due to a high manganese content, an austenite structure having a targeted area fraction may not be obtained. Since the semi-stable ϵ -martensite phase was easily transformed into deformation-induced martensite during subsequent deformation, very high magnetic permeability may be obtained at a tensile strain of 20%. Thus, it may be confirmed that non-magnetic properties were poor.

[0043] Comparative Example 4 had a value of $33.5C-Mn$ of 30, which did not correspond to the range controlled in the present invention. In particular, since carbides having a network form formed at grain boundaries due to excessive addition of carbon, austenite was formed in an amount of less than 95%. Thus, a targeted microstructure may not be obtained and as a result, elongation was very low.

[0044] In Comparative Example 5, contents of manganese and carbon corresponded to the ranges controlled in the present invention. However, since hot workability was rapidly deteriorated due to the addition of Cu in an amount above the range controlled in the present invention, severe cracks were generated during hot working, and thus, a sound rolled material may not be obtained. As a result, measurements were not possible through experimentations.

[0045] In Comparative Example 6, contents of manganese and carbon also corresponded to the ranges controlled in the present invention. However, since Cr carbides precipitated along grain boundaries due to addition of Cr in an amount above the range controlled in the present invention, a targeted fraction of austenite may not be obtained, and as a result, it may be confirmed that ductility was deteriorated.

[0046] In Comparative Examples 7 and 8, values of $33.5C+Mn$ were respectively 21 and 18, which deviated from the

range of the present invention. In particular, since ε -martensite, a semi-stable phase, was excessively formed due to a high manganese content and a low C content, a fraction of austenite was very low. As a result, the semi-stable ε -martensite was easily transformed into deformation-induced α -martensite, a ferromagnetic structure, during deformation to increase magnetic permeability and thus, it may be confirmed that non-magnetic properties were poor.

[0047] Comparative Example 9 had a composition of AISI 1045 steel, a general carbon steel for machine structural use. Since a content of Mn was very low and Cu was not added, a weight loss of the sample according to the wear test was 0.75 g, and it may be confirmed that a wear amount was relatively larger than those of Inventive Examples.

[0048] Comparative Example 10 had a composition of API X70 grade steel. Likewise, since a content of Mn was very low and Cu was not added, a weight loss of the sample was greater than 1 g, and it may be confirmed that wear resistance was very poor.

[0049] Comparative Example 11 had a composition of API K55 grade steel. Likewise, since a content of Mn was very low and Cu was not added, a weight loss of the sample was 0.9 g, and it may be confirmed that wear resistance was very poor.

[0050] Comparative Example 12 was a high-manganese austenitic Hadfield steel widely used as a wear resistant steel. Since contents of C and Mn were sufficient, weight loss according to the wear test was 0.59 g, and thus, excellent wear resistance properties were obtained. However, since the inhibition of carbide formation was not facilitated due to no addition of Cu and water cooling must be performed after a long austenitization treatment at a high temperature in order to inhibit the carbide formation, there may be a limitation in a thickness of applied steel and there may have many constraints in manufacturing steel such as difficulty in using in a weld structure. Also, since Cr was not added, corrosion resistance targeted in the present invention may not be secured.

[0051] FIG. 2 is a micrograph of a steel sheet manufactured according to Inventive Example 1 and FIG. 3 is a micrograph of a steel sheet manufactured according to Inventive Example 5. Since almost all structures were austenitic, it may be confirmed that stabilization of austenite may be effectively achieved by control of the component system and the composition range of the present invention.

[0052] While the present invention has been shown and described in connection with the exemplary embodiments, it will be apparent to those skilled in the art that modifications and variations can be made without departing from the scope of the invention as defined by the appended claims.

Claims

1. An austenite steel having excellent ductility comprising:

8 wt% to 15 wt% of manganese (Mn);
 3 wt% or less, excluding 0 wt%, of copper (Cu);
 a content of carbon (C) satisfying relationships of $33.5C + Mn \geq 25$ and $33.5C - Mn \leq 23$;
 2 wt% to 8 wt% of chromium (Cr);
 and optionally one or more selected from 0.05 wt% or less, excluding 0 wt%, of titanium (Ti), 0.1 wt% or less, excluding 0 wt%, of niobium (Nb) and 0.002 wt% to 0.2 wt% of nitrogen (N),
 and iron (Fe) as well as unavoidable impurities as a remainder.

2. The austenite steel having excellent ductility of claim 1, wherein yield strength of the steel is 500 MPa or more.

3. The austenite steel having excellent ductility of claim 1, wherein a microstructure of the steel comprises austenite having an area fraction of 95% or more.

4. The austenite steel having excellent ductility of claim 1, wherein magnetic permeability of the steel is 1.01 or less at a tensile strain of 20%.

Patentansprüche

1. Austenitischer Stahl mit ausgezeichneter Duktilität, Folgendes umfassend:

8 Gew.-% bis 15 Gew.-% Mangan (Mn);
 3 Gew.-% oder weniger, mit Ausnahme von 0 Gew.-%, Kupfer (Cu);
 einen Gehalt an Kohlenstoff (C), der die Beziehungen $33,5C + Mn \geq 25$ und $33,5C - Mn \leq 23$ erfüllt;
 2 Gew.-% bis 8 Gew.-% Chrom (Cr);

und optional ein oder mehr Element/e, das bzw. die aus 0,05 Gew.-% oder weniger, mit Ausnahme von 0 Gew.-%, Titan (Ti), 0,1 Gew.-% oder weniger, mit Ausnahme von 0 Gew.-%, Niob (Nb) und 0,002 Gew.-% bis 0,2 Gew.-% Stickstoff (N) ausgewählt ist bzw. sind, und Eisen (Fe) sowie unvermeidbare Verunreinigungen als Rest.

2. Austenitischer Stahl mit ausgezeichneter Duktilität nach Anspruch 1, wobei die Streckgrenze des Stahls 500 MPa oder mehr beträgt.
3. Austenitischer Stahl mit ausgezeichneter Duktilität nach Anspruch 1, wobei eine Mikrostruktur des Stahls Austenit mit einem Flächenanteil von 95% oder mehr umfasst.
4. Austenitischer Stahl mit ausgezeichneter Duktilität nach Anspruch 1, wobei eine magnetische Permeabilität des Stahls 1,01 oder weniger bei einer Zugbelastung von 20% beträgt.

Revendications

1. Acier austénitique présentant une excellente ductilité, comprenant :

8 % en poids à 15 % en poids de manganèse (Mn) ;
 3 % en poids ou moins, à l'exclusion de 0 % en poids, de cuivre (Cu),
 une teneur en carbone (C) satisfaisant à des relations de $33,5 \text{ C} + \text{Mn} \geq 25$ et $33,5 \text{ C} - \text{Mn} \leq 23$;
 2 % en poids à 8 % en poids de chrome (Cr) ;
 et facultativement un ou plusieurs éléments sélectionnés parmi 0,05 % en poids ou moins, à l'exclusion de 0 % en poids, de titane (Ti), 0,1 % en poids ou moins, à l'exclusion de 0 % en poids, de niobium (Nb) et 0,002 % en poids à 0,2 % en poids d'azote (N),
 et du fer (Fe) ainsi que des impuretés inévitables comme reste.

2. L'acier austénitique présentant une excellente ductilité de la revendication 1, sachant que la limite d'élasticité de l'acier est de 500 MPa ou plus.
3. L'acier austénitique présentant une excellente ductilité de la revendication 1, sachant qu'une microstructure de l'acier comprend de l'austénite ayant une fraction de surface de 95 % ou plus.
4. L'acier austénitique présentant une excellente ductilité de la revendication 1, sachant qu'une perméabilité magnétique de l'acier est de 1,01 ou moins à un effort de traction de 20 %.

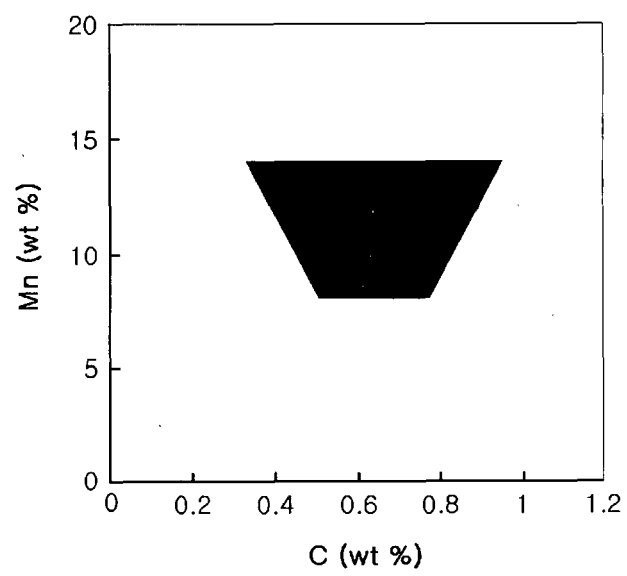


FIG. 1

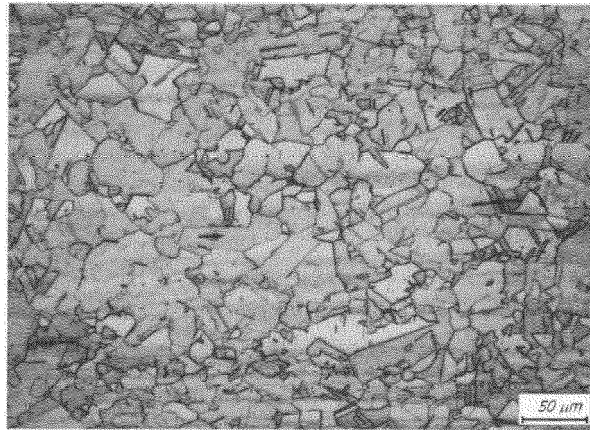


FIG. 2

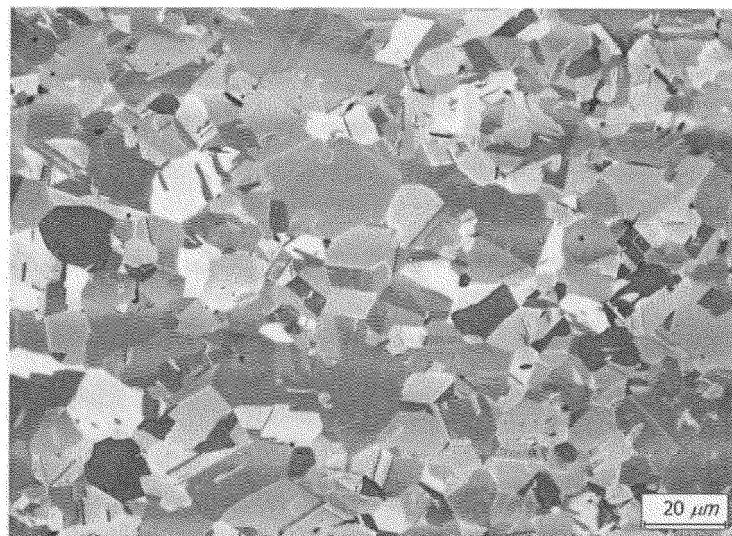


FIG. 3

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

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