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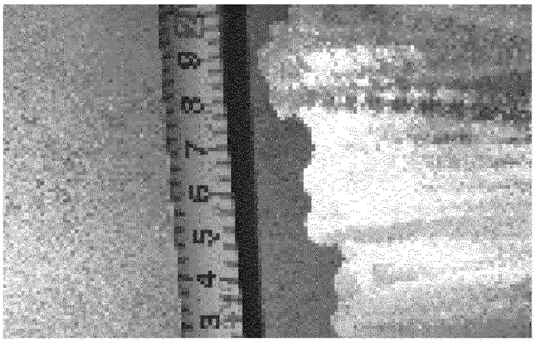
(54) CRYOGENIC AUSTENITIC HIGH MANGANESE STEEL HAVING EXCELLENT SURFACE QUALITY AND MANUFACTURING METHOD THEREFOR

(57) A cryogenic austenitic high manganese steel having excellent surface quality according to an aspect of the present invention comprises: in weight%, 0.4-0.5% of C; 23-26% of Mn; 0.03-0.5% of Si; 3-5% of Cr; 0.05% or less of Al; 0.05% or less of S; 0.5% or less of P; and 0.005% or less of B; and the balance being Fe and unavoidable impurities, and contains 95 area% or more of austenite as a microstructure, wherein under cross-sectional observation using a microscope, the number of surface flaws formed at a depth of 10 μm or more from the surface may be 0.0001 or less per unit area (mm 2) from among the surface flaws observed in an area from the surface to a t/8 (where t means product thickness (mm)) point.

[FIG. 2]



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Description

[Technical Field]

[0001] The present disclosure relates to a cryogenic austenitic high manganese steel appropriate for a fuel tank, a storage tank, a ship membrane, a transport pipe, and the like, for storage and transport of liquefied petroleum gas, liquefied natural gas and the like, and a manufacturing method therefor, and more particularly, to a cryogenic austenitic high manganese steel in which surface quality is effectively secured by suppressing formation of grooves in a surface, and a manufacturing method therefor.

[Background Art]

[0002] An austenitic high manganese (Mn) steel has high toughness because an austenite phase is stable, even at room temperature or cryogenic temperature, by adjusting contents of manganese (Mn) and carbon (C) , which are elements that increase phase stability of austenite. Therefore, the austenitic high manganese (Mn) steel may be used as a material of a fuel tank, a storage tank, a ship membrane, a transport pipe, and the like, for storage and transport of liquefied petroleum gas, liquefied natural gas and the like requiring cryogenic properties.

[0003] However, since the high manganese (Mn) steel contains a large amount of manganese (Mn) , which has a strong oxidation tendency, some of grain boundary oxidations formed at the time of reheating a slab are removed as scale, but some of the grain boundary oxidations may grow into cracks at the time of hot rolling and remain as surface flaws on a surface of a product. Therefore, at the time of manufacturing the high manganese (Mn) steel, a process of grinding the surface of the product is necessarily involved, which is not preferable in terms of economic efficiency and productivity.

(Related Art Document)

[0004] (Patent Document 1) Korea Patent Laid-Open Publication No. 10-2015-0075275 (published on July 3, 2015)

[Disclosure]

[Technical Problem]

[0005] An aspect of the present disclosure is to provide a cryogenic austenitic high manganese steel in which surface quality is effectively secured by suppressing formation of grooves in a surface, and a manufacturing method therefor.

[0006] An object of the present disclosure is not limited to the abovementioned contents . Those skilled in the art will have no difficulty in understanding an additional object of the present disclosure from the general contents of the present specification.

[Technical Solution]

[0007] According to an aspect of the present disclosure, a cryogenic austenitic high manganese steel having excellent surface quality contains: by wt%, 0.4 to 0.5% of C, 23 to 26% of Mn, 0.03 to 0.5% of Si, 3 to 5% of Cr, 0.05% or less of Al, 0.05% or less of S, 0.5% or less of P, 0.005% or less of B, a balance Fe, and inevitable impurities; and 95 area% or more of austenite as a microstructure, wherein at the time of observing a cross section using an optical microscope, the number of surface flows formed at a depth of 10 μm or more from a surface among surface flaws observed in a region from the surface to a point of t/8 (here, t refers to a product thickness (mm)) is 0.0001 or less per unit area (mm^2).

[0008] The cryogenic austenitic high manganese steel may further contain 0.7wt% or less of Cu.

[0009] A yield strength of the cryogenic austenitic high manganese steel may be 400 MPa or more and a Charpy impact toughness of the cryogenic austenitic high manganese steel at -196°C may be 41 J or more.

[0010] According to another aspect of the present disclosure, a manufacturing method for a cryogenic austenitic high manganese steel having excellent surface quality includes: reheating a slab in a temperature range of 1000 to 1300°, the slab comprising: by wt%, 0.4 to 0.5% of C, 23 to 26% of Mn, 0.03 to 0.5% of Si, 3 to 5% of Cr, 0.05% or less of Al, 0.05% or less of S, 0.5% or less of P, 0.005% or less of B, a balance Fe, and inevitable impurities; rough-rolling the reheated slab to provide a rough rolled bar; and finish-rolling the rough rolled bar in a temperature range of 750 to 1000°C to provide a hot rolled material, wherein a reheating temperature (T_{SR}) of the slab and a rolling reduction (R_{RM}) of the rough rolling are controlled so as to satisfy the following Relational Equation 1,

[Relational Equation 1]

$$R_{RM}/T_{SR} > 0.15$$

(In Relational Equation 1, R_{RM} and T_{SR} refer to a rolling reduction (mm) of rough rolling and a reheating temperature (°C) of the slab, respectively).

[0011] The slab may further contain 0.7wt% or less of Cu.

[0012] The finish-rolled hot rolled material may be accelerated-cooled to 600°C or lower at a cooling speed of 10°C/s or more.

[0013] The technical solution does not enumerate all of the features of the present disclosure, and various features of the present disclosure and advantages and effects according to the various features will be understood in more detail with reference to the following specific exemplary embodiments.

[Advantageous Effects]

[0014] As set forth above, according to an exemplary embodiment in the present disclosure, an austenitic high manganese steel having excellent surface quality while having physical properties particularly suitable for a cryogenic application may be provided.

[0015] In addition, according to an exemplary embodiment in the present disclosure, an austenitic high manganese steel material of which productivity and economical efficiency may be secured by securing excellent surface quality without involving a subsequent process such as grinding, and a manufacturing method therefor may be provided.

[Description of Drawings]

[0016]

FIG. 1 is a photograph of a surface of Specimen 1.
FIG. 2 is a photograph of a surface of Specimen 3.
FIG. 3 is a photograph obtained by cutting Specimen 1 in a thickness direction and then observing a cross section of Specimen 1 with an optical microscope.

[Best Mode for Invention]

[0017] The present disclosure relates to a cryogenic austenitic high manganese steel and a manufacturing method therefor, and exemplary embodiments in the present disclosure will hereinafter be described. Exemplary embodiments in the present disclosure may be modified to have several forms, and it is not to be interpreted that the scope of the present disclosure is limited to exemplary embodiments described below. Exemplary embodiments in the present disclosure are provided in order to further describe the present disclosure in detail to those skilled in the art to which the present disclosure pertains.

[0018] Hereinafter, compositions of a steel according to the present disclosure will be described in more detail. Hereinafter, unless otherwise indicated, % indicating a content of each element is based on weight.

[0019] A cryogenic austenitic high manganese steel having excellent surface quality according to an exemplary embodiment in the present disclosure may contain, by wt%, 0.4 to 0.5% of C, 23 to 26% of Mn, 0.03 to 0.5% of Si, 3 to 5% of Cr, 0.05% or less of Al, 0.05% or less of S, 0.5% or less of P, 0.005% or less of B, a balance Fe, and inevitable impurities. In addition, the cryogenic austenitic high manganese steel material having excellent surface quality according to an exemplary embodiment in the present disclosure may further contain 0.7wt% or less of Cu.

Carbon (C) : 0.4 to 0.5%

[0020] Carbon (C) is an element that is effective in stabilizing austenite in a steel and securing strength by solid solution strengthening. Therefore, in the present disclosure, a lower limit of a content of carbon (C) may be limited to 0.4% in order to secure low-temperature toughness and strength. A preferable lower limit of a content of carbon (C) may be 0.41%, and a more preferable lower limit of the content of carbon (C) may be 0.43%. The reason is that when the content of carbon (C) is less than 0.4%, a yield strength may be decreased, austenite stability may be decreased, such that ferrite or martensite may be formed, and low-temperature toughness may be decreased. On the other hand, when the content of carbon (C) exceeds a predetermined range, excessive carbide may be formed at the time of cooling after rolling. Thus, in the present disclosure, an upper limit of the content of carbon (C) may be limited to 0.5%. A preferable upper limit of a content of carbon (C) may be 0.49%, and a more preferable upper limit of the content of carbon (C) may be 0.47%.

Manganese (Mn): 23 to 26%

[0021] Manganese (Mn) is an important element that serves to stabilize austenite. Therefore, in the present disclosure, a lower limit of a content of manganese (Mn) may be limited to 23% in order to achieve such an effect. That is, the cryogenic austenitic high manganese steel having excellent surface quality according to an exemplary embodiment in the present disclosure contains 23% or more of manganese (Mn) , and austenite stability may thus be effectively increased. Therefore, formation of ferrite, ε-martensite, and α'-martensite may be suppressed to effectively secure low-temperature toughness. A more preferable lower limit of the content of manganese (Mn) may be 23.1%. On the other hand, when the content of manganese (Mn) is a predetermined level or more, an austenite stability increase effect is saturated, while a manufacturing cost is significantly increased, and internal oxidation is excessively generated during hot rolling, such that surface quality may become inferior. Thus, in the present disclosure, an upper limit of the content of manganese (Mn) may be limited to 26%. A more preferable upper limit of the content of manganese (Mn) may be 25.5%.

Silicon (Si) : 0.03 to 0.5%

[0022] Silicon (Si) is a deoxidizing agent like aluminum (Al), and is an element that is indispensably added in a trace amount. However, when silicon (Si) is excessively added, oxide may be formed at a grain boundary to reduce high-temperature ductility and cause a crack or the like, thereby deteriorating surface quality. Therefore, in the present disclosure, an upper limit of a content of silicon (Si) may be limited to 0.5%. A more preferable upper limit of the content of silicon (Si) may be 0.45%. On the other hand, an excessive cost is required in order to reduce the content of silicon (Si) in the steel. Thus, in the present disclosure, a lower limit of the content of silicon (Si) may be limited to 0.03%. A more preferable lower limit of the content of silicon (Si) may be 0.04%.

Chromium (Cr) : 3 to 5%

[0023] Chromium (Cr) is an element that contributes to an increase in strength through solid solution strengthening in austenite. In addition, chromium (Cr) is an element that has excellent corrosion resistance and thus effectively contributes to prevention of deterioration of surface quality due to high-temperature oxidation. Therefore, in the present disclosure, a lower limit of a content of chromium (Cr) may be limited to 3% in order to achieve such an effect. A preferable lower limit of a content of chromium (Cr) may be 3.1%, and a more preferable lower limit of the content of chromium (Cr) may be 3.3%. On the other hand, when the content of chromium (Cr) is a predetermined level or more, a cryogenic toughness decreases due to generation of carbide is problematic. Thus, in the present disclosure, an upper limit of the content of chromium (Cr) may be limited to 5%. A preferable upper limit of the content of chromium (Cr) may be 4.5%, and a more preferable upper limit of the content of chromium (Cr) may be 4.0%.

Sulfur (S) : 0.05% or less

[0024] Sulfur (S) is not only an impurity element that is inevitably introduced, but is also an element that causes a hot shortness defect due to formation of inclusions. Therefore, in the present disclosure, an upper limit of a content of sulfur (S) may be actively suppressed, and a preferable upper limit of the content of sulfur (S) may be 0.05%.

Phosphorus (P): 0.5% or less

[0025] Phosphorus (P) is not only an impurity element that is inevitably introduced, but is also an element that is easily segregated and an element that causes cracking during casting or deteriorates weldability. Therefore, in the present disclosure, an upper limit of a content of phosphorus (P) may be actively suppressed, and a preferable upper limit of the content of phosphorus (P) may be 0.5%.

Boron (B): 0.005% or less

[0026] Boron (B) is an element that contributes to improvement of surface quality by an effect of suppressing an intergranular fracture through strengthening of a grain boundary, but is also an element that deteriorates toughness and weldability due to formation of coarse precipitates, or the like, when it is excessively added. Therefore, in the present disclosure, 0.0)05% or more of boron (B) may be contained in order to achieve surface quality improving effect, but an upper limit of a content of boron (B) may be limited to 0.005% in order to prevent the deterioration of the weldability.

Copper (Cu): 0.7% or less

[0027] Copper (Cu) is an austenite stabilizing element, is an element that stabilizes austenite along with manganese (Mn) and carbon (C) , and is an element that contributes to improvement of low-temperature toughness. In addition, since copper (Cu) is an element of which a solid solubility in carbide is very low and diffusion in austenite is slow, copper (Cu) is an element that is concentrated on an interface between austenite and carbide and surrounds a nuclear of fine carbide to effectively suppress generation and growth of carbide due to additional diffusion of carbon (C) . Therefore, in the present disclosure, a predetermined content of copper (Cu) may be additionally added in order to achieve such an effect. A lower limit of a content of copper (Cu) may be 0.3%, a preferable lower limit of the content of copper (Cu) may be 0.35% , and a more preferable lower limit of the content of copper (Cu) may be 0.4%. However, when the content of copper (Cu) is a predetermined level or more, deterioration of surface quality due to hot shortness may be problematic. Thus, in the present disclosure, an upper limit of the content of copper (Cu) may be limited to 0.7%. A preferable upper limit of the content of copper (Cu) may be 0.65% , and a more preferable upper limit of the content of copper (Cu) may be 0.6%.

[0028] The cryogenic austenitic high manganese steel having excellent surface quality according to an exemplary embodiment in the present disclosure may contain the balance Fe and other inevitable impurities, in addition to the components described above. However, in a general manufacturing process, unintended impurities may inevitably be mixed from a raw material or the surrounding environment, and thus, these impurities may not be completely excluded. Since these impurities are known to those skilled in the art, all the contents are not specifically mentioned in the present specification. In addition, addition of effective components other than the compositions described above is not excluded.

[0029] The cryogenic austenitic high manganese steel having excellent surface quality according to an exemplary embodiment in the present disclosure contains 95 area% or more of austenite as a microstructure, and at the time of observing a cross section using an optical microscope, the number of surface flows formed at a depth of 10 μm or more from a surface among surface flaws observed in a region from the surface to a point of t/8 (here, t refers to a product thickness (mm)) may be 0.0001 or less per unit area (mm^2) . Here, an observation region refers to an arbitrary rectangular region formed on a cross section of the steel, and one surface of the observation region may be positioned adjacent to a surface of the steel. That is, a height of the observation region is t/8 (t is a product thickness (mm)) , and a surface flaw number density may be calculated using the number of surface flaws having a depth of a predetermined level or more among flaws formed in the observation region.

[0030] That is, in the cryogenic austenitic high manganese steel having excellent surface quality according to an exemplary embodiment in the present disclosure, formation of surface flaws on a product surface is actively suppressed through strict process condition control as described below. Therefore, surface quality is effectively secured, such that a subsequent process such as a grinding process or the like may be omitted, and economical efficiency and productivity of a product may thus be effectively secured.

[0031] In addition, since the cryogenic austenitic high manganese steel having excellent surface quality according to an exemplary embodiment in the present disclosure has a yield strength of 400 MPa or more and a Charpy impact toughness of 41 J or more at -196°C, an austenitic high manganese steel particularly appropriate as a material of a fuel tank, a storage tank, a ship membrane, a transport pipe, and the like, for storage and transport of liquefied petroleum gas, liquefied natural gas and the like requiring cryogenic properties may be provided.

[0032] A manufacturing method according to the present disclosure will hereinafter be described in more detail.

[0033] The cryogenic austenitic high manganese steel having excellent surface quality according to an exemplary embodiment in the present disclosure may be manufactured by reheating a slab having the composition described above in a temperature range of 1000 to 1300°C, rough-rolling the reheated slab to provide a rough rolled bar, and finish-rolling the rough rolled bar in a temperature range of 750 to 1000°C to provide a hot rolled material, wherein a reheating temperature (T_{SR}, °C) of the slab and a rolling reduction (R_{RM}, mm) of the rough rolling are controlled so as to satisfy the following Relational Equation 1:

[Relational Equation 1]

$$R_{RM}/T_{SR} > 0.15.$$

Slab Reheating

[0034] A steel composition of the slab corresponds to the steel composition of the austenitic high manganese steel described above, and a description for the steel composition of the slab is thus replaced by the description for the steel composition of the austenitic high manganese steel described above.

[0035] The slab having the steel composition described above may be uniformly heated in a temperature range of 1000 to 1300°C. A thickness of the slab provided in the reheating of the slab may be about 250 mm, but the scope of the present disclosure is not necessarily limited thereto.

[0036] In order to prevent a rolling load from being excessively applied in subsequent hot rolling, a lower limit of a slab reheating temperature may be limited to 1000°C. In addition, as a heating temperature increases, the ease of hot rolling is secured, but when a steel in which a content of manganese (Mn) is high is heated at a high temperature, grain boundary oxidation may be severely generated in the steel. Thus, in the present disclosure, an upper limit of the slab reheating temperature may be limited to 1300°C.

Hot Rolling

[0037] After a slab reheating process, a hot rolling process of rough-rolling the reheated slab to be a rough rolled bar and finish-rolling the rough rolled bar in a temperature range of 750 to 1000°C to provide a hot rolled material may be involved. As a finish rolling temperature of hot rolling becomes higher, a deformation resistance decreases, such that the ease of rolling is secured, but as the finish rolling temperature becomes higher, deterioration of surface quality due to grain boundary oxidations is caused. Thus, the finish rolling temperature of the present disclosure may be limited to 750 to 1000°C.

[0038] Since the austenitic high manganese steel according to the present disclosure contains a large amount of manganese (Mn) having strong oxidizing properties, grain boundary oxidations are inevitably generated even when a temperature of a heating furnace is limited. Even though some of the formed grain boundary oxidations are removed as scales during the reheating of the slab, the remaining grain boundary oxidations grow into cracks during hot rolling to form surface flaws on a surface of a product, such that surface quality of the product is deteriorated.

[0039] The inventors of the present disclosure came to the conclusion that it is effective to make a structure fine by allowing recrystallization to occur as quickly as possible after heating the slab in order to minimize growth of grain boundary oxidations remaining on a surface of the slab into cracks during hot rolling, through an in-depth study. However, an increase in a deformation speed is the most effective in order to promote the recrystallization, and the increase in the deformation speed is a factor that may be achieved through an increase in a rolling reduction of rough rolling, but when the rolling reduction excessively increases, separately from minimizing the growth of grain boundary oxidations into cracks, damage to a facility due to an excessive rolling load, or the like, may be problematic.

[0040] Therefore, the inventors of the present disclosure have derived the following Relational Equation 1 for controlling a rolling load of hot rolling to be a threshold value or less while actively suppressing the formation of the surface flaws of the product through repeated experiments.

[Relational Equation 1]

$$R_{RM}/T_{SR} > 0.15$$

(In Relational Equation 1, R_{RM} and T_{SR} refer to a rolling reduction (mm) of rough rolling and a reheating temperature (°C) of the slab, respectively)

[0041] That is, in the present disclosure, a rolling reduction of rough rolling with respect to a temperature of a heating furnace is controlled to be in a predetermined range as in the above Relational Equation 1, such that when the temperature of the heating furnace is high, the rolling reduction of the rough rolling may be relatively increased to suppress growth of grain boundary oxidations into surface flaws during hot rolling, and when the temperature of the heating furnace is low, the rolling reduction of the rough rolling may be relatively decreased to decease a rolling load applied to a rolling mill during hot rolling. Thus, an optimal slab heating condition and hot rolling condition may be provided.

Accelerated Cooling

[0042] After the hot rolling process, the finish-rolled hot rolled material may be accelerated-cooled to 600°C or lower at a cooling rate of 10°C/s or more. Since the austenitic high manganese steel according to the present disclosure contains 3 to 5% of chromium (Cr) and C, a cooling rate of the hot rolled material is controlled to be 10°C/s or more to effectively prevent a decrease in low-temperature toughness due to carbide precipitation. In addition, in general accelerated-cooling, it is difficult to implement a cooling rate exceeding 100°C/s due to characteristics of a facility. Thus, in the present disclosure, an upper limit of the cooling rate may be limited to 100°C/s.

[0043] In addition, even though the hot rolled material is cooled at the cooling rate of 10°C/s or more, when the cooling is stopped at a high temperature, it is highly likely that carbides will be generated and grown. Thus, in the present disclosure, a cooling stop temperature may be limited to 600°C or less.

[0044] The austenitic high manganese steel manufactured as described above contains 95 area% or more of austenite as a microstructure, and at the time of observing a cross section using an optical microscope, the number of surface flaws formed at a depth of 10 μm or more from a surface may be 0.0001 or less per unit area (mm^2) with respect to a cross-sectional area from the surface to a point of t/8 (here, t refers to a product thickness (mm)), and the austenitic high manganese steel may have a yield strength of 400 MPa or more and a Charpy impact toughness of 41 J or more at -196°C.

[Mode for Invention]

[0045] Hereinafter, the present disclosure will be described in more detail through Inventive Example. However, it is to be noted that Inventive Example to be described later is for illustrating and embodying the present disclosure and is not intended to limit the scope of the present disclosure.

(Inventive Example)

[0046] Slabs having a thickness of 250 mm were manufactured using steels having compositions of Table 1, and specimens were manufactured and prepared under process conditions of Table 2. Each specimen was prepared by performing finish-rolling in a temperature range of 750 to 1000°C, and performing accelerated-cooling to 600°C or lower at a cooling rate of 10°C/s or more. For each specimen, impact absorption energy, a yield strength, and whether or not surface flaws have been formed, were evaluated, and evaluation results were shown together in Table 2 . The impact absorption energy was evaluated at -196°C using a plate-shaped specimen having a notch of 2 mm in accordance with ASTM E23, which is a standard test method. A tensile test was evaluated with a one-way tensile tester by processing a plate-shaped specimen conforming to ASTM E8/E8M, which is a standard test method. A depth and the number of surface flaws were evaluated by cutting a specimen in a thickness direction to prepare the specimen according to ASTM E112, and then measuring a depth of the largest surface flaw in an observation region and the number of surface flaws having a depth of 10 μm or more per unit area in the observation region using an optical microscope.

[Table 1]

Division	Mn	Cr	C	Cu	B	Si	P	S.Al	S
1	23.2	3.5	0.44	0.50	0.0012	0.041	0.027	0.036	0.0014
2	24.6	3.4	0.46	0.52	0.0028	0.311	0.014	0.039	0.0013
3	25.2	3.4	0.45	0.49	0.0026	0.318	0.017	0.043	0.0015
4	24.8	3.4	0.45	0.48	0.0029	0.300	0.017	0.033	0.0013
5	24.8	3.4	0.45	0.48	0.0029	0.300	0.017	0.033	0.0014
6	24.8	3.4	0.45	0.48	0.0029	0.300	0.017	0.033	0.0015
7	24.8	3.4	0.45	0.48	0.0029	0.300	0.017	0.033	0.0013
8	24.0	3.4	0.44	0.43	0.0030	0.270	0.013	0.023	0.0014
9	24.0	3.4	0.44	0.43	0.0030	0.270	0.013	0.023	0.0015

[Table 2]

Division	Reheating Temperature (°C)	Rolling Reduction (mm) of Rough Rolling	Relational Equation 1 (R_{RM}/T_{SR})	Impact Absorption Energy (J, @-196°C)	Yield Strength (MPa)	Maximum Surface Flaw Depth (μm)	Number of Surface Flaws (Number/m^2)	Remark
1	1300	132	0.102	123	458	30	0.03	Comparative Example
2	1174	130	0.111	90	464	28	0.02	Comparative Example
3	1120	180	0.161	96	465	0	0	Comparative Example
4	1150	105	0.091	86	486	32	0.03	Comparative Example
5	1162	135	0.116	84	514	30	0.03	Comparative Example
6	1155	175	0.152	84	514	0	0	Inventive Example
7	1199	203	0.170	84	495	0	0	Inventive Example
8	1198	207	0.173	71	529	0	0	Inventive Example
9	1130	207	0. 184	70	531	0	0	Inventive Example

[0047] It may be confirmed that in a case of Specimens 3, 6 to 9 that satisfy Relational Equation 1, surface flaws are not generated, such that surface quality is excellent, while in a case of Specimens 1, 2, 4, and 5 that do not satisfy Relational Equation 1, surface flaws are generated, such that surface quality is inferior and a subsequent process such as grinding needs to be requisitely involved in order to secure the surface quality.

[0048] FIG. 1 is a photograph of a surface of Specimen 1, and FIG. 2 is a photograph of a surface of Specimen 3. It can be seen as a result of observation with the naked eyes that a large amount of fine surface flaws were formed in Specimen 1, while surface flaws were not formed in Specimen 3, such that excellent surface quality was secured. In addition, FIG. 3 is a photograph obtained by cutting Specimen 1 in a thickness direction and then observing a cross section of Specimen 1 with an optical microscope, and it may be confirmed from FIG. 3 that surface flaws were formed on a surface side of Specimen 1 in a direction inclined with respect to a thickness direction of Specimen 1.

[0049] While the present disclosure has been described in detail through exemplary embodiment, other types of exemplary embodiments are also possible. Therefore, the technical spirit and scope of the claims set forth below are not limited to exemplary embodiments.

Claims

1. A cryogenic austenitic high manganese steel having excellent surface quality, comprising:

   by wt%, 0.4 to 0.5% of C, 23 to 26% of Mn, 0.03 to 0.5% of Si, 3 to 5% of Cr, 0.05% or less of Al, 0.05% or less of S, 0.5% or less of P, 0.005% or less of B, a balance Fe, and inevitable impurities; and
   95 area% or more of austenite as a microstructure,
   wherein at the time of observing a cross section using an optical microscope, the number of surface flows formed at a depth of 10 μm or more from a surface among surface flaws observed in a region from the surface to a point of t/8 (here, t refers to a product thickness (mm)) is 0.0001 or less per unit area (mm^2) .

2. The cryogenic austenitic high manganese steel of claim 1, further comprising 0.7wt% or less of Cu.

3. The cryogenic austenitic high manganese steel of claim 1, wherein a yield strength of the cryogenic austenitic high manganese steel is 400 MPa or more and a Charpy impact toughness of the cryogenic austenitic high manganese steel at -196°C is 41 J or more.

4. A manufacturing method for a cryogenic austenitic high manganese steel having excellent surface quality, comprising:

   reheating a slab in a temperature range of 1000 to 1300°, the slab comprising: by wt%, 0.4 to 0.5% of C, 23 to 26% of Mn, 0.03 to 0.5% of Si, 3 to 5% of Cr, 0.05% or less of Al, 0.05% or less of S, 0.5% or less of P, 0.005% or less of B, a balance Fe, and inevitable impurities;
   rough-rolling the reheated slab to provide a rough rolled bar; and
   finish-rolling the rough rolled bar in a temperature range of 750 to 1000°C to provide a hot rolled material,
   wherein a reheating temperature (T_{SR}) of the slab and a rolling reduction (R_{RM}) of the rough rolling are controlled so as to satisfy the following Relational Equation 1,

   [Relational Equation 1]

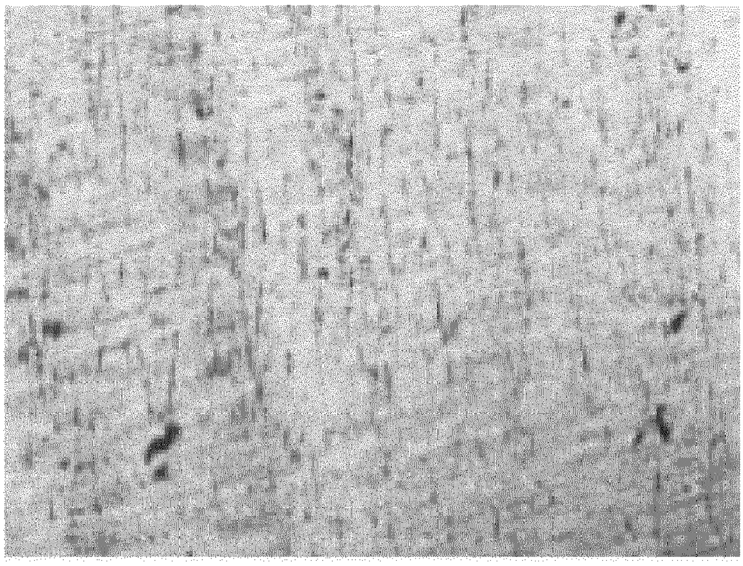
   $$R_{RM}/T_{SR} > 0.15,$$

   (In Relational Equation 1, R_{RM} and T_{SR} refer to a rolling reduction (mm) of rough rolling and a reheating temperature (°C) of the slab, respectively).

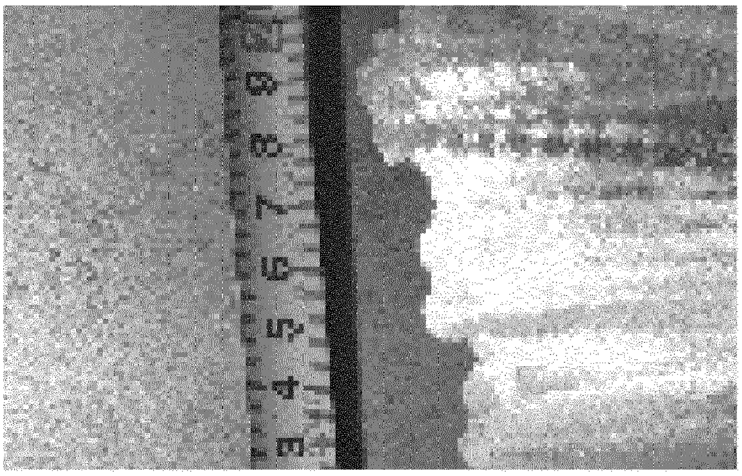
5. The manufacturing method of claim 4, wherein the slab further comprises 0.7wt% or less of Cu.

6. The manufacturing method of claim 4, wherein the finish-rolled hot rolled material is accelerated-cooled to 600°C or lower at a cooling speed of 10°C/s or more.

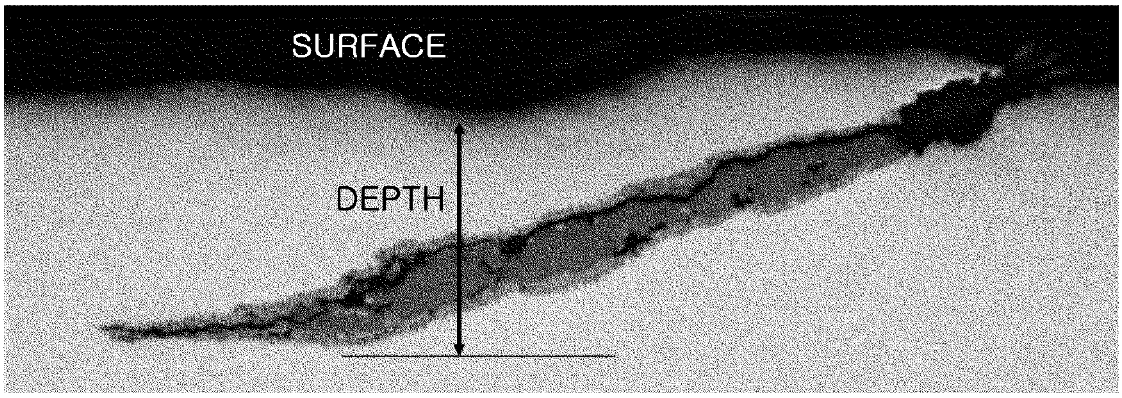
[FIG. 1]



[FIG. 2]



[FIG. 3]



INTERNATIONAL SEARCH REPORT

International application No.
PCT/KR2019/014170

A. CLASSIFICATION OF SUBJECT MATTER

C22C 38/38(2006.01)i, C22C 38/20(2006.01)i, C22C 38/32(2006.01)i, B21B 3/00(2006.01)i, B21B 1/16(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

C22C 38/38; B21B 1/22; B21B 3/00; B32B 15/04; C21D 6/00; C21D 8/00; C21D 8/02; C21D 9/48; C22C 38/00; C22C 38/04; C22C 38/20; C22C 38/32; B21B 1/16

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Korean utility models and applications for utility models: IPC as above
Japanese utility models and applications for utility models: IPC as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
eKOMPASS (KIPO internal) & Keywords: high manganese, austenite, roughing mill, reheating, reduction

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	KR 10-2017-0075657 A (POSCO) 03 July 2017 See paragraphs [0093]-[0102] and claims 1, 3-6.	1-6
A	KR 10-2000-0041265 A (POHANG IRON & STEEL CO., LTD.) 15 July 2000 See claims 1-2.	1-6
A	JP 2011-246817 A (ARCELORMITTAL FRANCE) 08 December 2011 See claims 1, 3.	1-6
A	KR 10-2018-0070383 A (POSCO) 26 June 2018 See claims 1-6.	1-6
A	US 10041156 B2 (POSCO) 07 August 2018 See claims 1-6.	1-6

☐ Further documents are listed in the continuation of Box C.　☒ See patent family annex.

* Special categories of cited documents:
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- "&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
05 FEBRUARY 2020 (05.02.2020)	**05 FEBRUARY 2020 (05.02.2020)**

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Information on patent family members

International application No.
PCT/KR2019/014170

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