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(54) **HOT ROLLED STEEL HAVING LOW COMPRESSIVE STRENGTH LOSS AFTER BEING PROCESSED INTO STEEL PIPE, AND MANUFACTURING METHOD THEREFOR**

(57) Provided are a hot rolled steel having a small compressive strength loss after being processed into a steel pipe, and a manufacturing method therefor. The hot rolled steel of the present invention comprises, by wt%, 0.15% or less of carbon (C), 2.5% or less of silicon (Si), 2.0% or less of manganese (Mn), 0.05% or less of alu-

minum (Al), nitrogen (N) and boron (B) in a sum of 0.002-0.008%, and the balance of Fe and other inevitable impurities, wherein $250 < 450C + 95Si + 70Mn$ is satisfied, the microstructure is a mixed structure of ferrite and pearlite, the average size of grains of the ferrite is 8-25 μm , and a value defined by relation 1 is less than 20%.

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Description

Technical Field

5 **[0001]** The present disclosure relates to a hot rolled steel having low compressive strength loss after being processed into a steel pipe, and a manufacturing method therefor.

Background Art

10 **[0002]** Recently, as a next-generation transportation system, research into a high-speed vacuum tube train known as a hyperloop has been actively conducted both domestically and internationally. The high-speed vacuum tube train is basically a transportation means in the form of moving a train within the vacuum tube. That is, since the high-speed vacuum tube train system minimizes air resistance by maintaining an interior of the tube in a vacuum state, it is a transportation means based on the concept that the train may run at high speed.

15 **[0003]** According to recent trends, it is known that metal steel pipes are more advantageous than concrete in terms of maintaining a vacuum in a tube. In addition, in consideration of the strength and manufacture costs of tube materials, it is true that steel pipes are the most suitable.

[0004] As a basic method of manufacturing a steel pipe, if a hot rolled material is required, a method of using a steel pipe prepared by welding a material after the material is subject to a separate heat treatment and a bending process in the form of a steel pipe is known.

20 **[0005]** On the other hand, in the case of metal materials, it is well known that materials subjected to tensile stress once are affected by the Bauschinger effect in which the yield strength of compressive stress decreases. According to a steel pipe manufacturing process, a steel material receives tensile stress in a circumferential direction of a steel pipe during a bending process, which may result in a compressive strength loss in the same circumferential direction after processing. Compressive strength loss in the circumferential direction of the steel pipe not only may cause shape deformation after processing a material, but also cause serious defects that may lead to tube collapse in emergency situations. Therefore, in the steel pipe material for a tube, a steel material that can minimize compressive strength loss needs to be applied.

30 [Related Art Document]

[Patent Document]

35 **[0006]** (Patent Document 1) International Publication No. WO2005080621A1

Summary of Invention

Technical Problem

40 **[0007]** An aspect of the present disclosure is to provide a hot rolled steel having low compressive strength loss after being processed into a steel pipe, and a manufacturing method therefor.

[0008] The subject of the present disclosure is not limited to the above. A person skilled in the art would have no difficulty in understanding the further subject matter of the present disclosure from the general content of this specification.

Solution to Problem

[0009] According to an aspect of the present disclosure,

50 a hot rolled steel having small compressive strength loss after being processed into a steel pipe may include, by wt%, 0.15% or less of carbon (C), 2.5% or less of silicon (Si), 2.0% or less of manganese (Mn), 0.05% or less of aluminum (Al), nitrogen (N) and boron (B) in a sum of 0.002 to 0.008%, and a balance of Fe and inevitable impurities, wherein $250 < 450C + 95Si + 70Mn$ is satisfied,

a microstructure is a mixed structure of ferrite and pearlite, the average grain size of the ferrite is 8 to 25 μm , and when tensile strength under a 0.3% stretching condition is referred to as $\sigma_{Tensile}$ and compressive strength when the stretched and deformed material is compressed by 0.2% again is referred to as $\sigma_{compressive}$, a value is less than 20% defined in the following Relational Expression 1.

[0010]

[Relational Expression 1]

$$\frac{(\sigma_{Tensile} - \sigma_{compressive})}{(\sigma_{Tensile})} \times 100$$

[0011] The tensile strength $\sigma_{Tensile}$ of the hot rolled steel may be 385 MPa or more, and impact toughness at 0°C may be 50 J or more.

[0012] In addition, according to an aspect of the present disclosure,

[0013] A method for manufacturing a hot rolled steel having small compressive strength loss after being processed into a steel pipe may include: finish hot-rolling a steel slab including the above-described composition at a finish temperature of 950 to 1030°C; and

cooling the finish hot-rolled steel sheet to a temperature within a range of 580 to 730°C at a cooling rate of 5 to 50°C and coiling the finish hot-rolled steel sheet, wherein a temperature change of the cooled hot-rolled steel sheet is controlled to be within 20°C for 3 seconds immediately before coiling it.

Advantageous Effects of Invention

[0014] According to an aspect of the present disclosure, there may be provided a steel having small compressive strength loss after being processed into a steel pipe, in which when tensile strength under a 0.3% stretching condition is referred to as $\sigma_{Tensile}$ and compressive strength when the stretched and deformed material is compressed by 0.2% again is referred to as $\sigma_{compressive}$, a value is less than 20% defined in the above-described Relational Expression 1.

Best Mode for Invention

[0015] Hereinafter, exemplary embodiments in the present disclosure will be described.

[0016] The present disclosure relates to technology for manufacturing a steel having low compressive strength loss during manufacturing of a steel pipe, and specifically, the steel including: by wt%, 0.15% or less of carbon (C), 2.5% or less of silicon (Si), 2.0% or less of manganese (Mn), 0.05% or less of aluminum (Al), nitrogen (N) and boron (B) in a sum of 0.002 to 0.008%, and a balance of Fe and inevitable impurities, wherein $250 < 450C + 95Si + 70Mn$ is satisfied, a microstructure is a mixed structure of ferrite and pearlite, an average grain size of the ferrite is 8 to 25 μm , and when tensile strength under a 0.3% stretching condition is referred to as $\sigma_{Tensile}$ and compressive strength when the stretched and deformed material is compressed by 0.2% again is referred to as $\sigma_{compressive}$, a value is less than 20% defined in the Relational Expression 1.

[Steel Composition]

[0017] First of all, steel composition components of steel for manufacturing a steel pipe of the present disclosure and reasons for limitation thereof will be described. Hereinafter, "%" refers to "% by weight" unless otherwise specified.

· Carbon (C): 0.15% or less

[0018] Carbon (C) is a representative hardenability improving element and is an element that effectively contributes to securing the strength of steel. Accordingly, the present disclosure may include carbon (C) in a range or more satisfying $250 < 450C + 95Si + 70Mn$ from a viewpoint of securing the strength of a vacuum tube structure. On the other hand, when the content of carbon (C) is excessively added, toughness of the steel may decrease and weldability may decrease. Accordingly, the present disclosure may limit an upper limit of the carbon (C) content to 0.15%. More preferably, the upper limit of the content of carbon (C) is limited to 0.12%.

· Silicon (Si): 2.5% or less

[0019] Silicon (Si) is an element contributing to the deoxidation of steel. Accordingly, the present disclosure may include silicon (Si) of $250 < 450C + 95Si + 70Mn$ or more to secure the cleanness and strength of steel. On the other hand, when silicon (Si) is excessively added, high-temperature strength of a material may be increased to cause a problem in a continuous casting process, and the surface quality of a product may be deteriorated by preventing separation of

surface scale. Accordingly, the present disclosure may limit an upper limit of the content of silicon (Si) to 2.5%. More preferably, the upper limit of the content of silicon (Si) is limited to 2.0%.

·Manganese (Mn): 2.0% or less

[0020] Since manganese (Mn) is an element contributing to improving the hardenability of steel, the present disclosure may include manganese (Mn) of $250 < 450C + 95Si + 70Mn$ or more to secure the strength of steel. On the other hand, when manganese (Mn) is excessively added, toughness of the steel may be deteriorated and weldability may be reduced. Accordingly, the present disclosure may limit an upper limit of the content of manganese (Mn) to 2.0%. More preferably, the upper limit of the manganese (Mn) content is limited to 1.8%.

·Aluminum (Al): 0.05% or less

[0021] Aluminum (Al) is an element that easily reacts with oxygen, and is a representative element used in a deoxidation reaction during a steelmaking process. However, when aluminum (Al) is present in steel, since there is a concern of generating an inclusion, it is preferable to control aluminum (Al) so that aluminum (Al) does not remain in the steel as much as possible. Accordingly, the present disclosure may limit an upper limit of the content of aluminum (Al) to 0.05%.

· Contents of Nitrogen (N) and boron (B) in a sum of: 0.002% to 0.008%

[0022] Nitrogen (N) and boron (B) are interstitial solid solution elements, and although their content in steel is lower than that of other elements, they have a relatively large effect on physical properties. The present inventors have found that the sum of the two element contents is related to a compressive strength loss of the material. That is, when the sum of the two elements exceeds 0.008%, by wt%, it was confirmed that it is considerably difficult to control a value defined in Relational Expression 2 described below to be less than 20. Furthermore, it is not preferable to control the sum of the two elements to be less than 0.002% due to high possibility for a cost increase in terms of material component control.

[0023] Accordingly, in order to control the value defined in Relational Expression 2 described below to be less than 20 in an economical manner, the sum of the contents of the two elements may be limited to 0.002 to 0.008%, by wt%. More preferably, the sum of the contents of the two elements is limited to 0.003 to 0.007%, by wt%.

[0024]

$$\cdot 250 < 450C + 95Si + 70Mn$$

[0025] In the present disclosure, it is required to control the contents of carbon (C), manganese (Mn), and silicon (Si) so as to satisfy the aforementioned inequation. If a calculation value of $450C + 95Si + 70Mn$ is 250 or less, material strength may be deteriorated.

[Steel Microstructure]

[0026] The steel of the present disclosure consists of a mixed structure of ferrite and pearlite.

[0027] In the present disclosure, a fraction of the ferrite may be 60 to 90%, in area %, and a fraction of the pearlite may be 10 to 40%, in area %.

[0028] The present inventors have repeatedly studied a method for reducing a compressive strength loss after stretching a steel material, and as a result, they found that it is advantageous to reduce compressive strength loss when the size of ferrite particles in the steel material is large. However, when an average grain size of the ferrite is 25 μm or more, since the impact toughness is too low for the ferrite to be applied as a structure material, an upper limit of the average grain size is limited to 25 μm . Furthermore, in order to realize a target compressive strength loss reduction in the present disclosure, since it was confirmed that the average crystal grain diameter needs to be 8 μm or more, a lower limit was set to 8 μm .

[Property of Steel]

[0029] When tensile strength under a 0.3% stretching condition is referred to as σ_{Tensile} and compressive strength when the stretched and deformed material is compressed by 0.2% again is referred to as $\sigma_{\text{compressive}}$, the steel of the present disclosure may represent a compressive strength loss of less than 20% defined in the following Relational Expression 1.

[0030]

[Relational Expression 1]

$$\frac{(\sigma_{Tensile} - \sigma_{compressive})}{(\sigma_{Tensile})} \times 100$$

[0031] The present inventors simulated a situation in which a hot-rolled steel is subjected to tensile stress during steel pipe processing and a situation in which the corresponding steel pipe is subjected to compressive stress in an actual use environment, and as a result of the simulation, they found that the tensile stress is 0.3% and the compressive deformation is 0.2%, respectively. In addition, in order to avoid the risk of shape deformation and rapid collapse of the steel pipe during processing, they confirmed that it is necessary to control the value defined in the Relational Expression 1 to be less than 20%.

[0032] Meanwhile, in order for a steel pipe-processed material of the present disclosure to be used as a structural material, it is important to secure a certain level of strength and toughness. Accordingly, the steel of the present disclosure may have a tensile strength $\sigma_{Tensile}$ of 385 MPa or more and an impact toughness at 0°C of 50 J or more.

[Method for Manufacturing Steel]

[0033] Next, a method of manufacturing a hot rolled steel with little loss of compressive strength after processing a steel pipe of the present disclosure will be described.

[0034] The method for manufacturing steel according to the present disclosure includes: finish hot-rolling a steel slab including the above-described composition at a finish temperature of 950 to 1030°C; and cooling the finish hot-rolled steel sheet to a temperature within a range of 580 to 730°C at a cooling rate of 5 to 50°C and coiling the finish hot-rolled steel sheet, and a temperature change of the steel sheet is controlled to be within 20°C for 3 seconds immediately before coiling the cooled hot-rolled steel sheet.

[0035] First, in the present disclosure, the steel slab having the above-described composition is finish hot-rolled at a finish temperature of 950 to 1030°C.

[0036] The finish hot-rolling temperature is an operational factor that has a large effect on the austenite grain size (AGS) of the material. In general, the AGS is known to have a very high correlation with the ferrite grain size (FGS), which is a cooling structure. In other words, when the AGS is coarse, the FGS is coarse and vice versa. The present inventors of the present disclosure found that in order to control the FGS to be 8 to 25 μm , the finish hot-roll pressing temperature should be 950°C or more and 1030°C or less. When the finish hot-rolling temperature is less than 950°C, the AGS becomes very fine and the FGS also comes out to be less than 8 μm . Conversely, when the finish hot-rolling temperature exceeds 1030°C, the FGS may exceed 25 μm , which may be disadvantageous in terms of impact toughness.

[0037] Then, in the present disclosure, the finish hot-rolled steel sheet is cooled to a temperature within a range of 580 to 730°C at a cooling rate of 5 to 50°C and then coiled.

[0038] The cooling rate when cooling the finish hot-rolled steel sheet affects the FGS, a surface scale, and material deviation inside the steel sheet. When the cooling rate is less than 5°C/s, the FGS becomes more than 25 μm , and the surface scale is thick, which may result in a decrease in a steel sheet recovery. On the other hand, when the cooling rate exceeds 50°C/s, there may be a problem in that the FGS may become finer to less than 8 μm .

[0039] In addition, a cooling end temperature during the cooling is relevant to high temperature strength for coiling a coil and the FGS for steel. When the cooling end temperature is less than 580°C, the strength of the steel during the coiling is high, which may result in a facility load problem during the coiling, and may cause the FGS to be less than 8 μm . On the other hand, when the cooling end temperature exceeds 730°C, the FGS exceeds 25 μm , which may cause a compressive strength loss value according to the impact toughness and Relational Expression 1 described above to be 20% or more. Accordingly, in the present disclosure, the hot-rolled steel sheet needs to be cooled at a cooling end temperature of 580 to 730°C.

[0040] Meanwhile, the surface temperature of the cooled steel sheet is increased by heat recuperation, and the present inventors have found that when the steel sheet is coiled during the heat recuperation process, this affects the final FGS. Although an exact principle thereof is unknown, the inside and outside of the steel sheet reach thermal equilibrium during the heat recuperative process, and in this case, when stress is applied during the coiling, it is determined that the FGS is affected by factors such as dislocation. In consideration of this, in the present disclosure, the temperature change of the steel sheet for 3 seconds immediately before the coiling is limited to less than 20°C. This is because the FGS may exceed 25 μm if the temperature change of the steel sheet exceeds 20°C for 3 seconds immediately before the coiling.

Mode for Invention

[0041] Hereinafter, the present disclosure will be described in detail through embodiments.

(Example)

[0042] After heating each steel slab provided with alloy compositions of Table 1 at a temperature within a range of 1250°C, a hot rolled steel sheet having the thickness of 10mm was produced by controlling the finish hot-rolling temperature, the cooling rate after the hot rolling, the cooling end temperature, and the temperature change of the steel sheet for 3 seconds immediately before the coiling. In addition, for each of the manufactured steel sheets, the FGS was measured in the microstructure thereof and shown in Table 3 below, and compressive strength loss value was measured to show results thereof in Table 3 below. In addition, the impact toughness at 0°C for each of the manufactured hot rolled steel sheet was measured, and results thereof were also shown in Table 3.

[0043] Meanwhile, in Table 3 below, the FGS was measured using an optical microscope with 500X magnification after etching each specimen by a Nital etching manner, but tensile and compression tests were basically conducted in accordance with ASTM Standard E606-04, and $\sigma_{Tensile}$ and $\sigma_{compressive}$ measured compressive strength loss using the value defined in the present disclosure. In addition, the impact toughness was measured by a V-notch impact test method of KS B 0810. Meanwhile, in Tables 2 and 3 below, Inventive Examples 1 to 9 had a mixed structure of ferrite and pearlite, and Comparative Examples 1 to 14 also had a mixed structure of ferrite and pearlite.

[Table 1]

Steel Sheet No.	Steel Composition Element (wt%)							A*
	C	Si	Mn	Al	N	B	N+B	
1	0.06	1.8	0.8	0.04	0.0027	0.0005	0.0032	254.0
2	0.12	1.2	1.3	0.02	0.0061	0.0002	0.0063	259.0
3	0.1	1.5	1.1	0.03	0.0014	0.0008	0.0022	264.5
4	0.05	2.0	1.1	0.01	0.0068	0.0003	0.0071	289.5
5	0.15	1.6	1.2	0.05	0.0077	0.0003	0.0080	303.5
6	0.08	2.2	1.2	0.03	0.0016	0.0004	0.0020	329.0
7	0.08	2.5	1.0	0.02	0.0041	0.0012	0.0053	343.5
8	0.1	2.0	1.6	0.02	0.0027	0.0006	0.0033	347.0
9	0.13	1.8	2.0	0.03	0.0021	0.0007	0.0028	369.5
10	0.05	1.5	1.2	0.04	0.0037	0.0011	0.0048	249.0
11	0.08	1.4	1.1	0.05	0.0002	0.006	0.0062	246.0
12	0.08	1.5	1.0	0.01	0.0034	0.0003	0.0037	248.5
13	0.12	1.3	1.3	0.02	0.0070	0.0011	0.0081	268.5
14	0.08	2.2	1.1	0.03	0.0076	0.0006	0.0082	322.0
* In Table 1, A* is 450C + 95Si + 70Mn.								

[Table 2]

Steel Sheet No.	Division	Condition of manufacturing steel sheet			
		Finish Hot Rolling Temperature (°C)	Cooling Speed (°C/s)	Cooling End Temperature (°C)	Temperature Change of Steel Sheet for 3 Seconds Immediately before Coiling (°C)
1	IE 1	992	29	690	15
2	IE 2	1030	12	620	20

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(continued)

Steel Sheet No.	Division	Condition of manufacturing steel sheet			
		Finish Hot Rolling Temperature (°C)	Cooling Speed (°C/s)	Cooling End Temperature (°C)	Temperature Change of Steel Sheet for 3 Seconds Immediately before Coiling (°C)
3	IE 3	987	34	664	3
4	IE 4	950	18	730	8
5	IE 5	966	17	703	12
6	IE 6	1022	5	580	7
7	IE 7	1013	22	616	6
8	IE 8	975	44	686	12
9	IE 9	998	50	643	10
10	CE 1	967	25	585	15
11	CE 2	1015	20	650	14
12	CE 3	1028	16	725	18
13	CE 4	1030	33	620	26
14	CE 5	1022	22	580	27
4	CE 6	949	16	728	10
5	CE 7	1031	15	701	6
4	CE 8	951	4	726	16
5	CE 9	963	51	710	13
4	CE 10	948	18	579	8
5	CE 11	966	17	731	12
1	CE 12	995	25	687	21
2	CE 13	1022	16	615	22
*In Table 2, IE: Inventive Example, CE: Comparative Example.					

[Table 3]

Steel Sheet No.	Division	FGS (μm)	σ_{Tensile} (MPa)	$\sigma_{\text{compressive}}$ (MPa)	B* (%)	Impact Toughness (J)
1	IE 1	21	386	320	17	52
2	IE 2	18	387	317	18	53
3	IE 3	15	392	314	20	54
4	IE 4	8	431	362	16	60
5	IE 5	25	385	339	12	50
6	IE 6	10	433	368	15	57
7	IE 7	13	452	371	18	54
8	IE 8	16	453	390	14	53
9	IE 9	19	462	388	16	52
10	CE 1	15	384	319	17	54
11	CE 2	17	382	313	18	53

(continued)

Steel Sheet No.	Division	FGS (μm)	σ_{Tensile} (MPa)	$\sigma_{\text{compressive}}$ (MPa)	B* (%)	Impact Toughness (J)
12	CE 3	20	383	314	18	52
13	CE 4	7	387	306	21	64
14	CE 5	6	433	338	22	65
4	CE 6	7	431	340	21	62
5	CE 7	26	385	339	12	49
4	CE 8	27	431	362	16	48
5	CE 9	7	385	300	22	56
4	CE 10	6	431	340	21	65
5	CE 11	26	385	339	12	48
1	CE 12	26	386	324	16	48
2	CE 13	26	387	329	15	47
In Table 3, B represents compressive strength loss value (%) defined in Relational Expression 1.						

[0044] In Table 3, IE: Inventive Example, CE: Comparative Example.

[0045] As shown in Tables 1 to 3, in the case of Inventive Examples 1 to 9 in which not only the steel composition components but also the steel manufacturing conditions satisfy the scope of the present disclosure, it can be seen that the FGS is within a range of 8 to 25 μm and compressive strength loss value defined in Relational Expression 1 was less than 20%, which was excellent. In addition, it can be seen that as the impact toughness value at 0°C was 50(J) or more, a toughness value was excellent.

[0046] On the other hand, in Comparative Examples 1 to 3, under the steel manufacturing conditions, the tensile strength σ_{Tensile} of the hot rolled steel sheet manufactured at a value of 450C+95Si+70Mn of 250 or less in the steel composition components within the scope of the present disclosure was not good below 385 MPa.

[0047] In Comparative Examples 4 and 5, the steel manufacturing conditions were within the scope of the present disclosure, but the N+B content in the steel composition components deviated from the scope of the present disclosure, and from this, it can be seen that the FGS of the manufactured hot rolled steel sheet was less than 8 μm and the compressive stress loss value was more than 20%, which were not good.

[0048] In addition, in Comparative Example 6, the steel composition component was within the scope of the present disclosure, but the finish hot-rolling temperature was considerably low, from which it can be seen that the FGS of the manufactured hot rolled steel sheet was less than 8 μm and the compressive stress loss value was more than 20%, which were not good. In addition, Comparative Example 7 was a case in which the finish hot-rolling temperature was too high, and the FGS of the manufactured hot rolled steel sheet exceeded 25 μm and the impact toughness value was less than 50 (J), which were not good.

[0049] In addition, Comparative Example 8 was a case in which the steel composition component was within the scope of the present disclosure, but the cooling rate was too small in the steel manufacturing condition, and the FGS of the manufactured hot rolled steel sheet exceeded 25 μm and the impact toughness value was less than 50 (J), which were not good. In addition, in Comparative Example 9, as the cooling rate was too high, it can be seen that the FGS of the manufactured hot rolled steel sheet was less than 8 μm and the compressive stress loss value was 20% or more, which were not good.

[0050] In addition, Comparative Example 10 was a case in which the steel composition component was within the scope of the present disclosure, but the cooling end temperature was too low in, and the FGS of the manufactured hot rolled steel sheet was less than 8 μm and the compressive stress loss value was more than 20%, which were not good. In addition, in Comparative Example 11, as the cooling end temperature was too high, the FGS of the manufactured hot rolled steel sheet exceeded 25 μm and the impact toughness value was less than 50 (J), which were not good.

[0051] Furthermore, Comparative Examples 12 and 13 were a case in which the steel composition component was within the scope of the present disclosure, but the temperature change of the steel sheet for 3 seconds immediately before the coiling exceeded 20% in the steel manufacturing condition, and the FGS of the manufactured hot rolled steel sheet exceeded 25 μm and the impact toughness value was less than 50 (J), which were not good.

[0052] As described above, preferred embodiments of the present disclosure have been described in the detailed description, but various changes and modifications may be suggested to one skilled in the art without departing from

the scope of the present disclosure. Therefore, the scope of present disclosure should not be limited to the described embodiments and should be determined not only by the claims described below but also by equivalents thereof.

Claims

1. A hot rolled steel having small compressive strength loss after being processed into a steel pipe, the hot rolled steel comprising:

by wt%, 0.15% or less of carbon (C), 2.5% or less of silicon (Si), 2.0% or less of manganese (Mn), 0.05% or less of aluminum (Al), nitrogen (N) and boron (B) in a sum of 0.002 to 0.008%, and a balance of Fe and inevitable impurities, wherein $250 < 450C + 95Si + 70Mn$ is satisfied, a microstructure is a mixed structure of ferrite and pearlite, an average grain size of the ferrite is 8 to 25 μm , and when tensile strength under a 0.3% stretching condition is referred to as $\sigma_{Tensile}$ and compressive strength when the stretched and deformed material is compressed by 0.2% again is referred to as $\sigma_{compressive}$, a value is less than 20% defined in the following Relational Expression 1.

[Relational Expression 1]

$$\frac{(\sigma_{Tensile} - \sigma_{compressive})}{(\sigma_{Tensile})} \times 100$$

2. The hot rolled steel having small compressive strength loss after being processed into a steel pipe of claim 1, wherein the tensile strength $\sigma_{Tensile}$ of the hot rolled steel is 385 MPa or more, and impact toughness at 0°C is 50 J or more.

3. A method for manufacturing a hot rolled steel having small compressive strength loss after being processed into a steel pipe, the method comprising:

finish hot-rolling a steel slab including, by wt%, 0.15% or less of carbon (C), 2.5% or less of silicon (Si), 2.0% or less of manganese (Mn), 0.05% or less of aluminum (Al), nitrogen (N) and boron (B) in a sum of 0.002 to 0.008%, and a balance of Fe and inevitable impurities at a finish temperature of 950 to 1030°C; and cooling the finish hot-rolled steel sheet to a temperature within a range of 580 to 730°C at a cooling rate of 5 to 50°C and coiling the finish hot-rolled steel sheet, wherein a temperature change of the cooled hot-rolled steel sheet is controlled to be within 20°C for 3 seconds immediately before coiling it.

4. The method for manufacturing a hot rolled steel having a small compressive strength loss after being processed into a steel pipe of claim 3, wherein in the coiled hot rolled steel, a microstructure is a mixed structure of ferrite and pearlite, and an average grain size of the ferrite is 8 to 25 μm , and when tensile strength under a 0.3% stretching condition is referred to as $\sigma_{Tensile}$ and compressive strength when the stretched and deformed material is compressed by 0.2% again is referred to as $\sigma_{compressive}$, a value is less than 20% defined in the following Relational Expression 1.

[Relational Expression 1]

$$\frac{(\sigma_{Tensile} - \sigma_{compressive})}{(\sigma_{Tensile})} \times 100$$

5. The method for manufacturing a hot rolled steel having a small compressive strength loss after being processed into a steel pipe of claim 4, wherein the tensile strength $\sigma_{Tensile}$ of the hot rolled steel is 385 MPa or more, and impact toughness at 0°C is 50 J or more.

INTERNATIONAL SEARCH REPORT

International application No.

PCT/KR2021/016979

A. CLASSIFICATION OF SUBJECT MATTER C22C 38/00(2006.01)i; C22C 38/02(2006.01)i; C22C 38/04(2006.01)i; C22C 38/06(2006.01)i; C21D 9/46(2006.01)i; C21D 8/02(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 38/00(2006.01); C21D 8/02(2006.01); C21D 9/46(2006.01); C21D 9/56(2006.01); C22C 38/14(2006.01) 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: 열간압연(hot rolling), 권취(coiling), 페라이트(ferrite), 펄라이트(pearlite), 입경(grain size)																		
C. DOCUMENTS CONSIDERED TO BE RELEVANT <table border="1"> <thead> <tr> <th>Category*</th> <th>Citation of document, with indication, where appropriate, of the relevant passages</th> <th>Relevant to claim No.</th> </tr> </thead> <tbody> <tr> <td>Y</td> <td>JP 2018-095904 A (JFE STEEL CORP.) 21 June 2018 (2018-06-21) See paragraphs [0046], [0050] and [0056] and claims 1 and 4.</td> <td>1-5</td> </tr> <tr> <td>Y</td> <td>KR 10-2015-0122779 A (JFE STEEL CORPORATION) 02 November 2015 (2015-11-02) See paragraph [0131], claim 5 and figure 1.</td> <td>1-5</td> </tr> <tr> <td>A</td> <td>KR 10-2012-0097174 A (HYUNDAI STEEL COMPANY) 03 September 2012 (2012-09-03) See paragraph [0052] and claims 1 and 3.</td> <td>1-5</td> </tr> <tr> <td>A</td> <td>JP 09-049050 A (KOBELITE LTD.) 18 February 1997 (1997-02-18) See claims 1-2.</td> <td>1-5</td> </tr> <tr> <td>A</td> <td>JP 2016-148063 A (JFE STEEL CORP.) 18 August 2016 (2016-08-18) See paragraphs [0035]-[0036].</td> <td>1-5</td> </tr> </tbody> </table>	Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.	Y	JP 2018-095904 A (JFE STEEL CORP.) 21 June 2018 (2018-06-21) See paragraphs [0046], [0050] and [0056] and claims 1 and 4.	1-5	Y	KR 10-2015-0122779 A (JFE STEEL CORPORATION) 02 November 2015 (2015-11-02) See paragraph [0131], claim 5 and figure 1.	1-5	A	KR 10-2012-0097174 A (HYUNDAI STEEL COMPANY) 03 September 2012 (2012-09-03) See paragraph [0052] and claims 1 and 3.	1-5	A	JP 09-049050 A (KOBELITE LTD.) 18 February 1997 (1997-02-18) See claims 1-2.	1-5	A	JP 2016-148063 A (JFE STEEL CORP.) 18 August 2016 (2016-08-18) See paragraphs [0035]-[0036].	1-5
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☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.																		
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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.

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