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(72) Inventors:
• **JEON, Jong Jin**
Pohang-si
Gyeongsangbuk-do 37656 (KR)
• **SHIN, Dong Ik**
Pohang-si
Gyeongsangbuk-do 37669 (KR)

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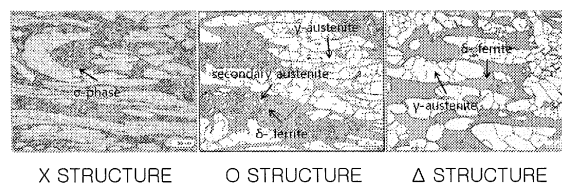
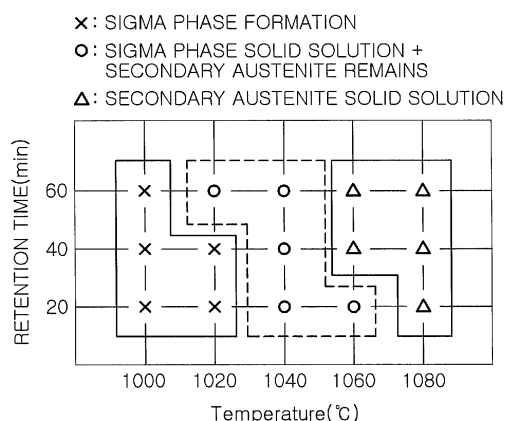
(74) Representative: **Potter Clarkson LLP**
The Belgrave Centre
Talbot Street
Nottingham NG1 5GG (GB)

(71) Applicant: **Posco**
Pohang-si, Gyeongsangbuk-do 37859 (KR)

(54) **SUPER DUPLEX STAINLESS STEEL HAVING EXCELLENT YIELD STRENGTH AND IMPACT TOUGHNESS AND MANUFACTURING METHOD THEREFOR**

(57) The present disclosure relates to super duplex stainless steel having excellent yield strength and impact toughness, wherein a reduction ratio and a heat treatment temperature are controlled so as to improve mechanical properties. The super duplex stainless steel having excellent yield strength and impact toughness according to one embodiment of the present disclosure is thick super duplex stainless steel having a thickness of 30 mm or greater, and includes, in weight%, Cr: 24% to 26%, Ni: 6.0% to 8.0%, Mo: 3.5% to 5.0%, N: 0.24% to 0.32%, and the remainder being Fe and inevitable impurities, wherein a microstructure includes a ferrite phase, an austenite phase and a secondary austenite phase, and grain size is 25 μm or less.

【Fig. 3】



Description

[Technical Field]

[0001] The present disclosure relates to super duplex stainless steel and a method for manufacturing the same, and in particular, to super duplex stainless steel having excellent yield strength and impact toughness, wherein a reduction ratio and a heat treatment temperature are controlled so as to improve mechanical properties.

[Background Art]

[0002] Generally, super duplex stainless steel (UNS S32750) containing 24% to 26% of chromium (Cr), 6.0% to 8.0% of nickel (Ni), 3.0% to 5.0% of molybdenum (Mo) and 0.24% to 0.32% of nitrogen (N) is dual-phase stainless steel formed with a dual-phase structure of austenite and ferrite, and has been used as materials of desulfurization facilities and seawater pipes with very excellent acid resistance and mechanical properties.

[0003] A matrix structure of such super duplex stainless steel has a structure property of a ferrite phase and an austenite phase being formed in an equal ratio. Moreover, super duplex stainless steel has great advantages of exhibiting higher strength compared to austenitic stainless steel and exhibiting excellent resistance for pitting corrosion for chloride ions and stress corrosion cracks.

[0004] However, super duplex stainless steel contains large quantities of chromium (Cr) and molybdenum (Mo) for securing acid resistance, and therefore, when maintained in a 750°C to 850°C region, causes a problem of degrading product qualities such as strengthening brittleness by readily producing a sigma phase, and significantly reducing acid resistance.

[0005] Such a sigma phase is very quickly produced in a specific temperature range (750°C to 850°C), and therefore, when annealing super duplex stainless steel, being delayed in a specific temperature range that readily produces a sigma phase needs to be avoided by controlling a temperature raising rate.

[0006] In view of such a problem, "Method for continuous annealing of super duplex stainless steel with excellent impact toughness and coil shape (Korean Patent Application Laid-Open Publication No. 10-2013-0034350)" and the like specifically disclose a method of avoiding a temperature zone readily producing a sigma phase by raising a temperature from 600°C to an annealing temperature at a temperature raising rate of 10°C/s or higher, and maintaining the temperature at 1,060°C to 1,080°C.

[0007] The annealing method may be normally used in a hot rolled coil having a thickness of 8 mm or less, however, the same heat treatment method may also be used in a thick plate having a thickness of 10 mm or greater. However, there is a problem in that a phenomenon not satisfying 0.2% off-set yield strength of 550 MPa or greater over a plate with various thicknesses from 5 mm to 50 mm frequently occurs.

[Disclosure]

[Technical Problem]

[0008] The present disclosure has been made in view of the above, and is directed to providing super duplex stainless steel having excellent yield strength and impact toughness, wherein a reduction ratio and an annealing condition are controlled so as to improve mechanical properties when manufacturing thick super duplex stainless steel, and a method for manufacturing the same.

[Technical Solution]

[0009] Super duplex stainless steel having excellent yield strength and impact toughness according to one embodiment of the present disclosure relates to thick super duplex stainless steel having a thickness of 30 mm or greater, and includes, in weight%, Cr: 24% to 26%, Ni: 6.0% to 8.0%, Mo: 3.5% to 5.0%, N: 0.24% to 0.32%, and the remainder being Fe and inevitable impurities, wherein a microstructure includes a ferrite phase, an austenite phase and a secondary austenite phase, and a grain size is 25 μ m or less.

[0010] The super duplex stainless steel has the yield strength of 550 MPa or greater.

[0011] A sum of the yield strength and the impact toughness of the super duplex stainless steel is 750 or greater.

[0012] A method for manufacturing super duplex stainless steel having excellent yield strength and impact toughness according to one embodiment of the present disclosure includes casting of preparing a slab including, in weight%, Cr: 24% to 26%, Ni: 6.0% to 8.0%, Mo: 3.5% to 5.0%, N: 0.24% to 0.32%, and the remainder being Fe and inevitable impurities; hot rolling of hot rolling the slab to prepare a thick plate having a thickness of 30 mm or greater; temperature raising of raising a temperature of the thick plate to an annealing temperature to precipitate a CrN phase inside a ferrite

phase, and precipitating a sigma phase and a secondary austenite phase around the CrN phase; and annealing of keeping the secondary austenite phase inside the ferrite phase while solid dissolving the sigma phase and the CrN phase in the ferrite phase.

[0013] The temperature raising is raising the temperature from 700°C to the annealing temperature at a rate of at a rate of 0.11°C/s to 0.17°C/s.

[0014] The annealing anneals for 20 minutes to 60 minutes at a temperature of 1020°C to 1060°C.

[0015] The hot rolling is rolling with a reduction ratio of 80% or greater so that a grain size of a microstructure becomes 25 μm or less.

[Advantageous Effects]

[0016] According to embodiments of the present disclosure, effects of enhancing mechanical properties such as yield strength and impact toughness of thick super duplex stainless steel are obtained by inducing CrN phase precipitation and facilitating secondary austenite phase formation inside a ferrite phase.

[Description of Drawings]

[0017]

FIG. 1 is a graph showing formation behaviors of a sigma phase and a CrN phase depending on a temperature raising rate when annealing.

FIG. 2 shows pictures of a microstructure at temperatures of 800°C, 1000°C and 1040°C depending on a temperature raising rate.

FIG. 3 is a diagram showing a behavior of precipitate depending on an annealing temperature and an annealing time, and its microstructure.

FIG. 4 is a graph showing yield strength and impact toughness depending on an annealing condition.

FIG. 5 is a graph showing a relation between a thick plate thickness (reduction ratio) and a grain size.

FIG. 6 shows pictures comparing microstructures of super duplex stainless steel having excellent yield strength and impact toughness manufactured according to one embodiment of the present disclosure and a comparative sheet.

[Mode for Disclosure]

[0018] Hereinafter, preferred embodiments of the present disclosure will be described in detail with reference to the accompanying drawings, however, the present disclosure is not restricted or limited by the embodiments. For reference, in describing the present disclosure, specific descriptions on related known technologies may not be included when they may unnecessarily evade the gist of the present disclosure, or contents considered to be obvious to those skilled in the art may not be included.

[0019] Super duplex stainless steel having excellent yield strength and impact toughness according to one embodiment of the present disclosure includes, in weight%, Cr: 24% to 26%, Ni: 6.0% to 8.0%, Mo: 3.5% to 5.0%, N: 0.24% to 0.32%, and the remainder being Fe and inevitable impurities.

[0020] Hereinafter, reasons for numerically limiting the content of the components according to embodiments of the present disclosure will be described.

Cr: 24 wt% to 26 wt%

[0021] Chromium (Cr) is a ferrite-stabilizing element, and is an essential element for securing acid resistance as well as performing a main role in securing a ferrite phase. Acid resistance increases when the chromium (Cr) content increase, however, when added in excess of greater than 26%, the content of austenite-forming elements such as high-priced nickel (Ni) increases for maintaining a phase fraction, and as a result, manufacturing costs increase.

[0022] Accordingly, the chromium (Cr) content is preferably limited to a range of 24 wt% to 26 wt%.

Ni: 6.0 wt% to 8.0 wt%

[0023] Nickel (Ni) is an austenite-stabilizing element together with manganese (Mn), copper (Cu) and nitrogen (N), and performs a main role in increasing austenite phase stability. Accordingly, the content is limited to 6.0 wt% to 8.0 wt% for maintaining a phase fraction of the ferrite phase and the austenite phase.

Mo: 3.5 wt% to 5.0 wt%

[0024] Molybdenum (Mo) is an element very effective in improving acid resistance while stabilizing ferrite together with chromium (Cr), but has a disadvantage of being very high-priced. Accordingly, the molybdenum (Mo) content is preferably limited to 3.5 wt% to 5.0 wt%.

N: 0.24 wt% to 0.32 wt%

[0025] Nitrogen (N) is an element greatly contributing to austenite phase stabilization together with carbon (C) and nickel (Ni), and, as one of the elements causing thickening to the austenite phase during annealing, an increase in the acid resistance and high strengthening may be obtained concomitantly when increasing the nitrogen (N) content, however, when the nitrogen (N) content is excessive, surface defects caused by the generation of nitrogen pores may be induced during casting due to an excessive nitrogen (N) solid solubility, and therefore, the nitrogen (N) content is preferably limited to 0.24 wt% to 0.32 wt%.

[0026] In the super duplex stainless steel having excellent yield strength and impact toughness according to one embodiment of the present disclosure, a grain size of a microstructure including a ferrite phase, an austenite phase and a secondary austenite phase is preferably formed as 25 μm or less.

[0027] In addition, yield strength is 550 MPa or greater, and a sum of yield strength and impact toughness is 750 or greater.

[0028] Meanwhile, a method for manufacturing super duplex stainless steel having excellent yield strength and impact toughness according to one embodiment of the present disclosure includes a casting step of preparing a slab by continuously casting molten steel having the above-mentioned composition, a rolling step of hot rolling the slab to produce a thick plate, a temperature raising step of heating the thick plate, and an annealing step.

[0029] In the present disclosure, when annealing the super duplex stainless steel having both an austenite phase and a ferrite phase, a temperature raising rate, annealing temperature and time, and a reduction ratio are controlled to control a microstructure, and more specifically, by controlling a temperature raising rate in the temperature raising step, precipitation of a CrN phase is induced during a temperature rise, and then precipitation of a sigma phase and a secondary austenite phase is induced around the CrN phase, and as the sigma phase precipitated in the temperature raising step is solid dissolved inside the ferrite by controlling annealing temperature and time in the annealing step, the secondary austenite phase remains inside the ferrite phase.

[0030] FIG. 1 is a graph showing formation behaviors of the sigma phase and the CrN phase depending on the temperature raising rate when annealing, and FIG. 2 shows pictures of a microstructure at temperatures of 800°C, 1000°C and 1040°C depending on the temperature raising rate.

[0031] As shown in FIG. 1 and FIG. 2, the temperature raising step according to one embodiment of the present disclosure is preferably raising the temperature from 700°C to the annealing temperature having a temperature range of 1030°C to 1050°C at a rate of 0.11°C/s to 0.17°C/s.

[0032] This is due to the fact that a sigma phase is capable of being formed around the CrN phase while finely precipitating the CrN phase inside the ferrite phase.

[0033] In other words, when the temperature raising rate is greater than 0.17°C/s, CrN phases are not formed inside the ferrite phase near 800°C, and even when the temperature is raised to 900°C to 1000°C, stable sigma phase and secondary austenite phase are formed at an interface between the ferrite phase and the austenite phase, and an effect of achieving a microstructure may not be obtained.

[0034] Meanwhile, when the temperature raising rate is 0.17°C/s or less, CrN phases are finely formed inside the ferrite phase near 800°C, and the CrN phases formed herein act as a nucleation site leading to a formation of sigma phases and secondary austenite phases around the CrN phases as well as at an interface of the austenite/ferrite phases, and as a result, a microstructure may be obtained.

[0035] FIG. 3 is a diagram showing a behavior of precipitate depending on the annealing temperature and the annealing time, and its microstructure, and FIG. 4 is a graph showing yield strength and impact toughness depending on the annealing condition.

[0036] As shown in FIG. 3 and FIG. 4, the annealing step according to one embodiment of the present disclosure is carried out for 20 minutes to 40 minutes at a temperature of 1020°C to 1060°C, and more preferably, the annealing step of the present disclosure varies the annealing time depending on the annealing temperature.

[0037] When the annealing temperature is from 1030°C to 1050°C, the annealing time is from 20 minutes to 40 minutes, when the annealing temperature is from 1020°C to 1030°C, the annealing time is from 40 minutes to 60 minutes, and when the annealing temperature is from 1050°C to 1060°C, the annealing time is from 5 minutes to 20 minutes.

[0038] As a result, by increasing the annealing time even when the temperature is low, a microstructure is obtained by keeping the secondary austenite phase inside the ferrite phase while solid dissolving the sigma phase inside the ferrite phase, and even with a tendency of the sigma phase and the secondary austenite phase becoming a solid solution

as the annealing temperature increases, an effect of achieving a microstructure is obtained by keeping the secondary austenite phase inside the ferrite phase through shortening the annealing time.

[0039] FIG. 5 is a graph showing, when producing a thick plate by rolling a 150 mm slab, a relation between the thick plate thickness (reduction ratio) and a grain size, and FIG. 6 shows pictures comparing microstructures of the super duplex stainless steel having excellent yield strength and impact toughness manufactured according to one embodiment of the present disclosure and a comparative sheet.

[0040] In the hot rolling step according to one embodiment of the present disclosure, a reduction ratio of the slab is preferably 80% or greater.

[0041] As shown in FIG. 5 and FIG. 6, it is seen that, when the slab having a thickness of 150 mm is rolled to a thick plate having a thickness of 10 mm to 35 mm, a grain size increases as a thickness of the thick plate increases.

[0042] Accordingly, a thick steel plate having a thickness of 30 mm or greater has yield strength reduced to 550 MPa, and does not satisfy the ASTM standards. This may be improved through a method of controlling a microstructure, however, by using a reduction ratio of 82.5%, yield strength may be enhanced while forming a grain size of a microstructure as 25 μm or less.

[0043] The super duplex stainless steel having excellent yield strength and impact toughness according to one embodiment of the present disclosure may have a thickness of 30 mm or greater. In other words, the present disclosure may be useful for a thick steel plate. The upper limit of the thickness is not particularly limited, and for example, may be 100 mm, 70 mm or 50 mm.

[0044] Hereinafter, a method of controlling a structure of the super duplex steel having excellent yield strength and impact toughness according to one embodiment of the present disclosure will be described in detail with reference to examples.

[0045] For securing yield strength of 580 MPa or greater and excellent impact toughness while having overall properties in the super duplex steel, the inventors of the present disclosure formed a CrN phase during heat treatment, and then finely precipitated a sigma phase and a secondary austenite phase inside a ferrite phase, by controlling a temperature raising rate to 0.11°C/s to 0.17°C/s or lower during annealing.

[0046] Then, annealing was carried out for 20 minutes to 60 minutes in a temperature range of 1020°C to 1060°C to solid dissolving all the sigma phase while keeping the secondary austenite phase inside the ferrite phase, and as a result, yield strength and impact properties of a thick plate having a thickness of 30 mm or greater were both improved.

[Table 1]

Category	Process Variables				Note
	Slab Thickness (Reduction Ratio)	Temperature Raising Rate (°C/s)	Annealing Temperature (°C)	Annealing Time (min)	
A	77%	1.3	1000	20/40/60	Comparative Example
B	77%	1.3	1020	20/40/60	
C	77%	1.3	1040	20/40/60	
D	77%	1.3	1060	20/40/60	
E	77%	1.3	1080	20/40/60	
F	77%	0.66	1000	20/40/60	
G	77%	0.66	1020	20/40/60	
H	77%	0.66	1040	20/40/60	
I	77%	0.66	1060	20/40/60	
J	77%	0.66	1080	20/40/60	
K	77%	0.33	1000	20/40/60	
L	77%	0.33	1020	20/40/60	
M	77%	0.33	1040	20/40/60	
N	77%	0.33	1060	20/40/60	
O	77%	0.33	1080	20/40/60	
P	77%	0.17	1000	20/40/60	

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(continued)

Category	Process Variables				Note
	Slab Thickness (Reduction Ratio)	Temperature Raising Rate (°C/s)	Annealing Temperature (°C)	Annealing Time (min)	
Q	77%	0.17	1020	20/40/60	
R	77%	0.17	1040	20/40/60	
S	77%	0.17	1060	20/40/60	
T	77%	0.17	1080	20/40/60	
U	82.50%	0.17	1000	20/40/60	
V	V1	82.50%	1020	20	
	V2			40	
	V3			60	
W	82.50%	0.17	1040	20/40/60	Example
X	X1	82.50%	1060	20	Comparative Example
	X2			40	
	X3			60	
Y	82.50%	0.17	1080	20/40/60	

[0047] Table 1 shows a slab thickness (reduction ratio), a temperature raising rate, an annealing temperature and an annealing time for various examples and comparative examples.

[0048] A steel to Y steel that are examples and comparative examples were heated at a rate of 5°C/s to 700°C, and heated at temperature raising rates of 1.3°C/s, 0.66°C/s, 0.33°C/s and 0.17°C/s from 700°C to an annealing temperature, and the annealing temperature was 1000°C, 1020°C, 1040°C, 1060°C and 1080°C, and the annealing time was for 20 minutes, 40 minutes and 60 minutes each, and water cooling was carried out after the heat treatment.

[Table 2]

Category	Reduction ratio(%)	Temperature Raising Rate (°C/s)	Annealing Temperature (°C)	Annealing Time (min)	CrN Phase	Secondary Austenite Phase	Average Grain Size	Note
A to J	77	1.3 to 0.66	1000 to 1080	20 to 60	X	X	41	Comparative Example
K to N	77	0.33	1000 to 1060	20 to 60	○	○	33	
O	77	0.33	1080	20 to 60	○	X	38	
P to S	77	0.17	1000 to 1060	20 to 60	○	○	30	
T to U	77	0.17	1080	20 to 60	○	X	36	
V to X	82.5	0.17	1000 to 1060	20 to 60	○	○	22	Example
Y	82.5	0.17	1080	20 to 60	○	X	26	Comparative Example

[0049] Table 2 shows changes in the microstructure occurring during a temperature raising process when carrying out hot rolling and heat treatment under the conditions described in Table 1.

[0050] As shown in Table 2, it was identified that a CrN phase was not formed during the temperature raising process in A steel to J steel having a temperature raising rate of 0.66°C/s to 1.3°C/s, and a secondary austenite phase was not formed inside a ferrite phase as well resulting in the coarsening of the grain size, which is outside the scope of the present disclosure.

[0051] Meanwhile, in K steel to N steel, a CrN phase was finely formed inside a ferrite phase in the temperature range of 700°C to 800°C during the temperature raising process as the temperature raising rate becomes low of 0.33°C/s, and a secondary austenite phase remained inside the ferrite phase in the temperature range of 1020°C to 1060°C.

[0052] Similar to K steel to N steel, a CrN phase was formed in the case of O steel, however, a secondary austenite phase was solid dissolved and not precipitated as the annealing temperature exceeded 1080°C.

[0053] P steel to U steel had a temperature raising rate of 0.17°C/s, which tends to be similar to K steel to O steel, however, as the amount of CrN phase precipitation increased, the remaining secondary austenite phase increased as well.

[0054] In addition, A steel to U steel had a reduction ratio of 77% resulting in the coarsening of the final microstructure grain, and the size became greater than 25 μm , which is outside the scope of the present disclosure.

[0055] Meanwhile, in V steel to X steel satisfying the embodiments of the present disclosure with a reduction ratio of 82.5%, a temperature raising rate of 0.17°C/s, and an annealing temperature of 1020°C to 1060°C, a secondary austenite phase remained inside a ferrite phase in the temperature region of 1020°C to 1060°C while properly precipitating a CrN phase in the temperature raising process in some of V steel and X steel and all of W steel depending on the annealing time, and most fine structures were secured.

[0056] Meanwhile, it was seen that, like T steel, Y steel was outside the scope of the present disclosure with a secondary austenite phase being solid dissolved with an annealing temperature of 1080°C.

[Table 3]

Category	Reduction Ratio (%)	Temperature Raising Rate (°C/s)	Annealing Temperature (°C)	Annealing Time (min)	Grain Size (μm)	Yield Strength (A)	Impact Toughness (B)	(A+B)	Note
T	77	0.38 to 0.17	1080	40	36to43	536	172	708	Comparative Example
R	77	0.33 to 0.17	1040	40	28to33	569	187	756	
W	82.5	0.33 to 0.17	1040	40	21to24	585	193	778	Example

[0057] Table 3 shows properties for representative steel types (T, R, W) of Table 2.

[0058] Herein, as for the yield strength, a JIS 5 tensile specimen was collected in a 90° direction of the rolling direction and a tensile test was carried out at a crosshead speed of 20 mm/min at room temperature.

[0059] In R steel, the grain became coarse with a reduction ratio of 77%, and the size was greater than 25 μm, a standard value, and particularly in R steel, the yield strength was 536 MPa, which was less than 550 MPa, a standard value, and a sum of the yield strength and the impact toughness was 708 MPa, which was also less than 750 MPa, a standard value, and it was seen that yield strength and impact toughness properties were not enhanced.

[0060] In addition, in T steel, the yield strength and a sum of the yield strength and the impact toughness satisfied the standard values, however, the grain size was greater than 25 μm, a standard value, with a reduction ratio of 77%.

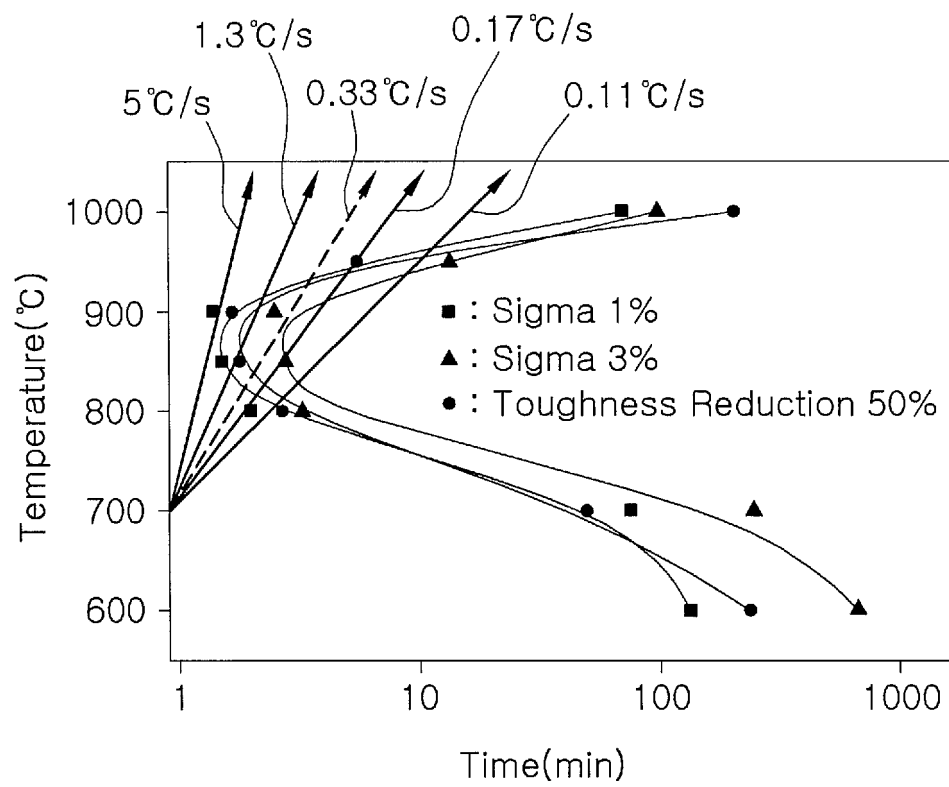
[0061] Meanwhile, in W steel, the reduction ratio was 82.5%, and the annealing temperature, the annealing time and the temperature raising rate satisfied the scope of the present disclosure, and as a result, the grain size was fine with 25 μm or less, and the yield strength and the impact toughness were enhanced with the yield strength being 585 MPa and a sum of the yield strength and the impact toughness being 778 MPa, and it was identified that mechanical properties were enhanced compared to the comparative sheets.

[0062] As described above, the present disclosure has been described with reference to preferred embodiments, however, it is to be understood that those skilled in the art may diversely modify and change the present disclosure within the scope that does not depart from ideas and territories of the present disclosure described in the attached claims.

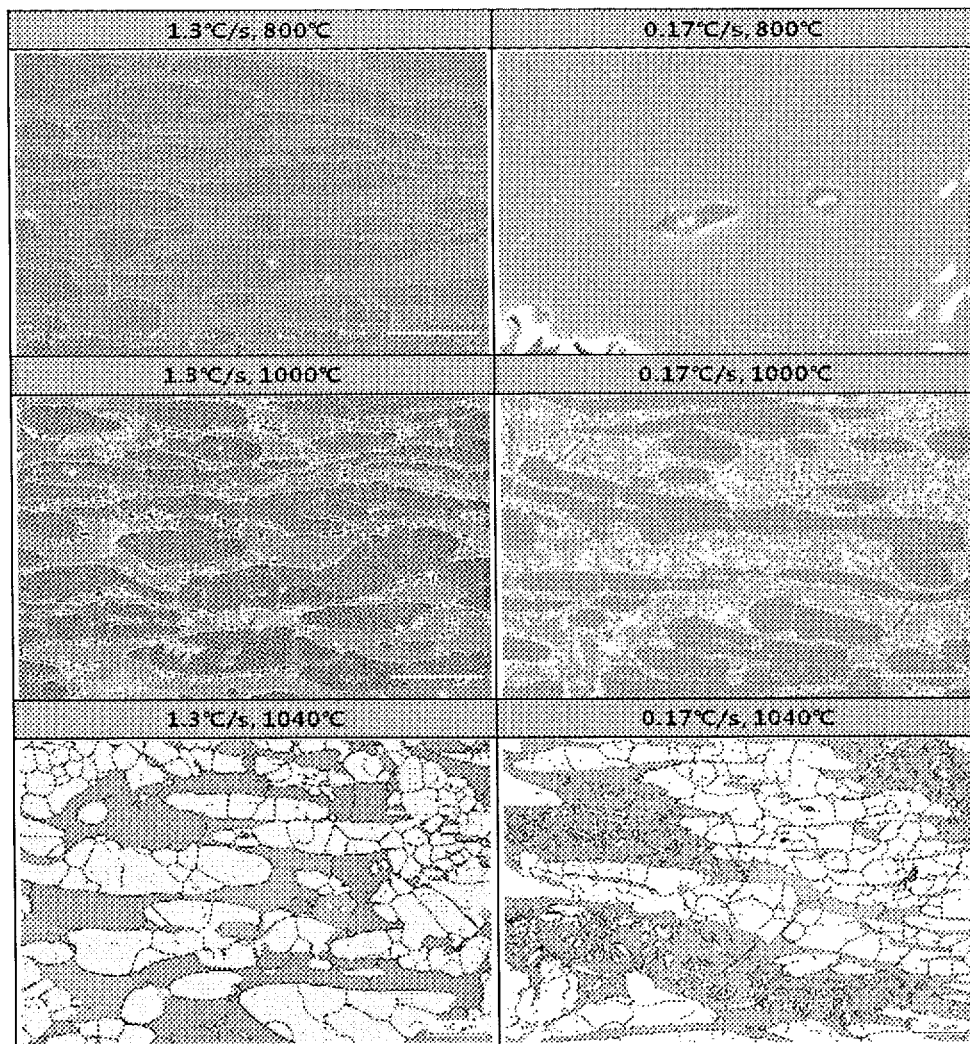
Claims

1. Super duplex stainless steel having excellent yield strength and impact toughness comprising, as thick super duplex stainless steel having a thickness of 30 mm or greater, in weight%, Cr: 24% to 26%, Ni: 6.0% to 8.0%, Mo: 3.5% to 5.0%, N: 0.24% to 0.32%, and the remainder being Fe and inevitable impurities, wherein a microstructure includes a ferrite phase, an austenite phase and a secondary austenite phase, and a grain size is 25 μm or less.
2. The super duplex stainless steel having excellent yield strength and impact toughness of Claim 1, wherein the yield strength of the super duplex stainless steel is 550 MPa or greater.
3. The super duplex stainless steel having excellent yield strength and impact toughness of Claim 2, wherein a sum of the yield strength and the impact toughness of the super duplex stainless steel is 750 or greater.
4. A method for manufacturing super duplex stainless steel having excellent yield strength and impact toughness comprising:
 - casting of preparing a slab including, in weight%, Cr: 24% to 26%, Ni: 6.0% to 8.0%, Mo: 3.5% to 5.0%, N: 0.24% to 0.32% and the remainder being Fe and inevitable impurities;
 - hot rolling of hot rolling the slab to produce a thick plate having a thickness of 30 mm or greater;
 - temperature raising of raising a temperature of the thick plate to an annealing temperature to precipitate a CrN phase inside a ferrite phase, and precipitating a sigma phase and a secondary austenite phase around the CrN phase; and
 - annealing of keeping the secondary austenite phase inside the ferrite phase while solid dissolving the sigma phase and the CrN phase in the ferrite phase.
5. The method for manufacturing super duplex stainless steel having excellent yield strength and impact toughness of Claim 4, wherein the temperature raising is raising a temperature from 700°C to the annealing temperature at a rate of 0.11°C/s to 0.17°C/s.
6. The method for manufacturing super duplex stainless steel having excellent yield strength and impact toughness of Claim 5, wherein the annealing is annealing for 20 minutes to 60 minutes at a temperature of 1020°C to 1060°C.
7. The method for manufacturing super duplex stainless steel having excellent yield strength and impact toughness of Claim 4, wherein the hot rolling is rolling with a reduction ratio of 80% or greater so that a grain size of a microstructure becomes 25 μm or less.

【Fig.1】

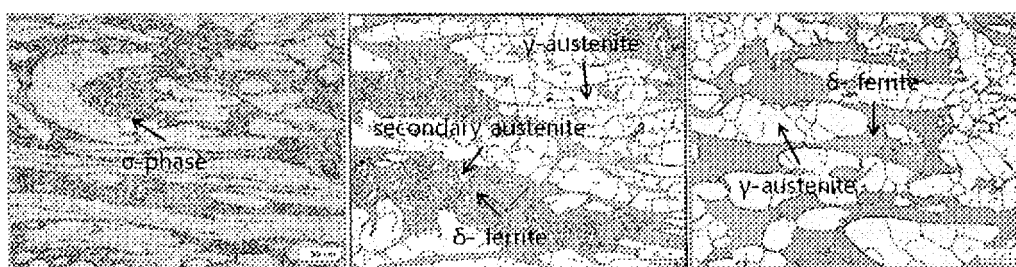
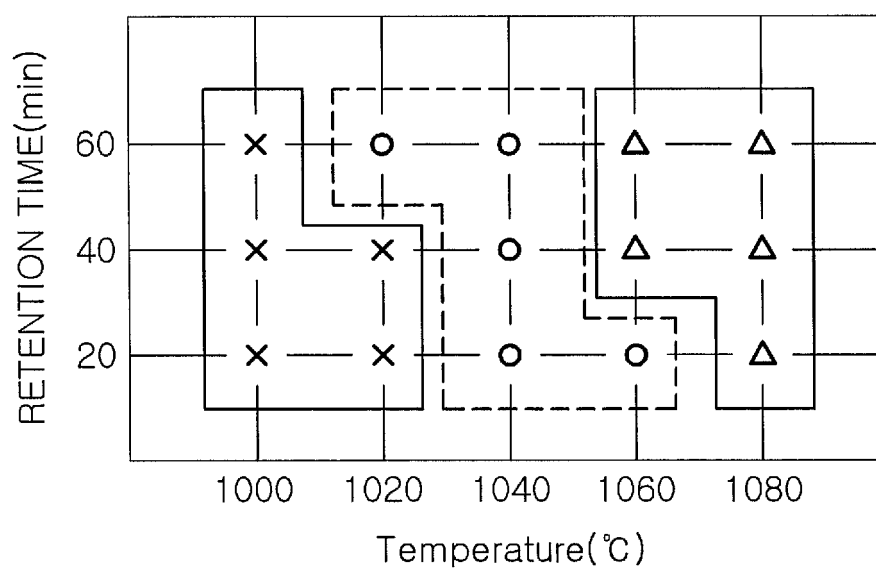


【Fig.2】



【Fig.3】

- ×: SIGMA PHASE FORMATION
 ○: SIGMA PHASE SOLID SOLUTION +
 SECONDARY AUSTENITE REMAINS
 △: SECONDARY AUSTENITE SOLID SOLUTION

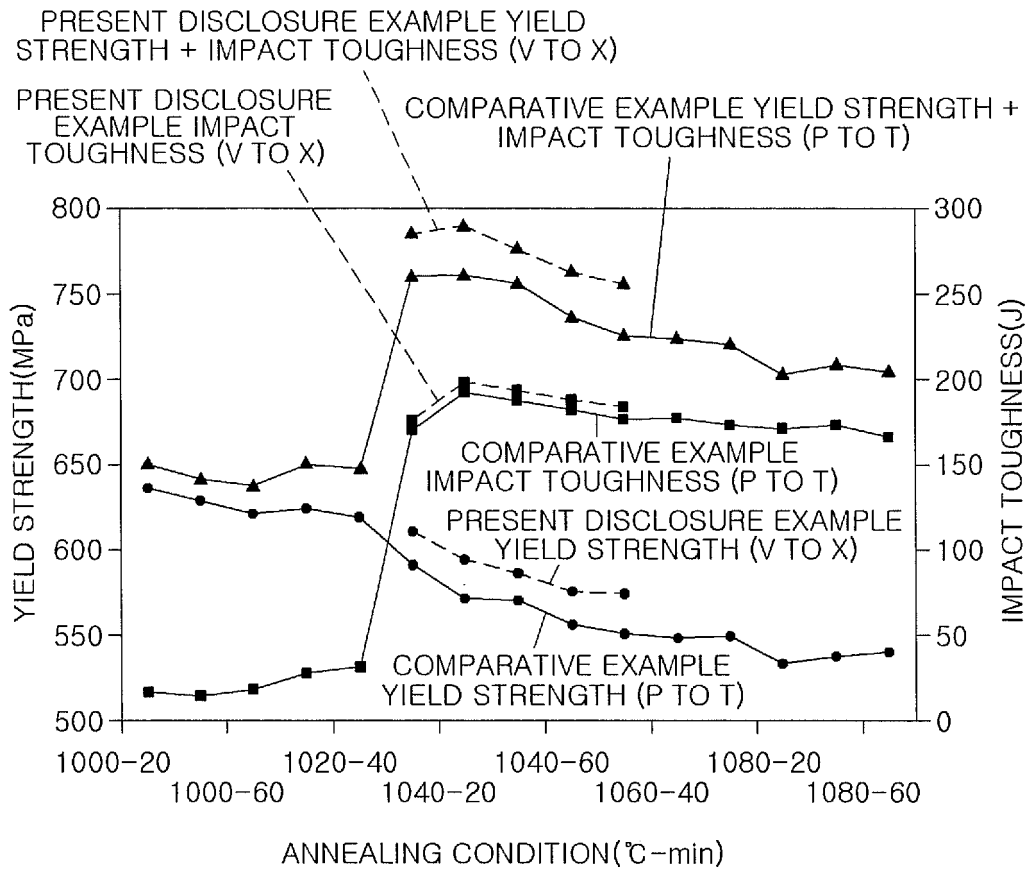


X STRUCTURE

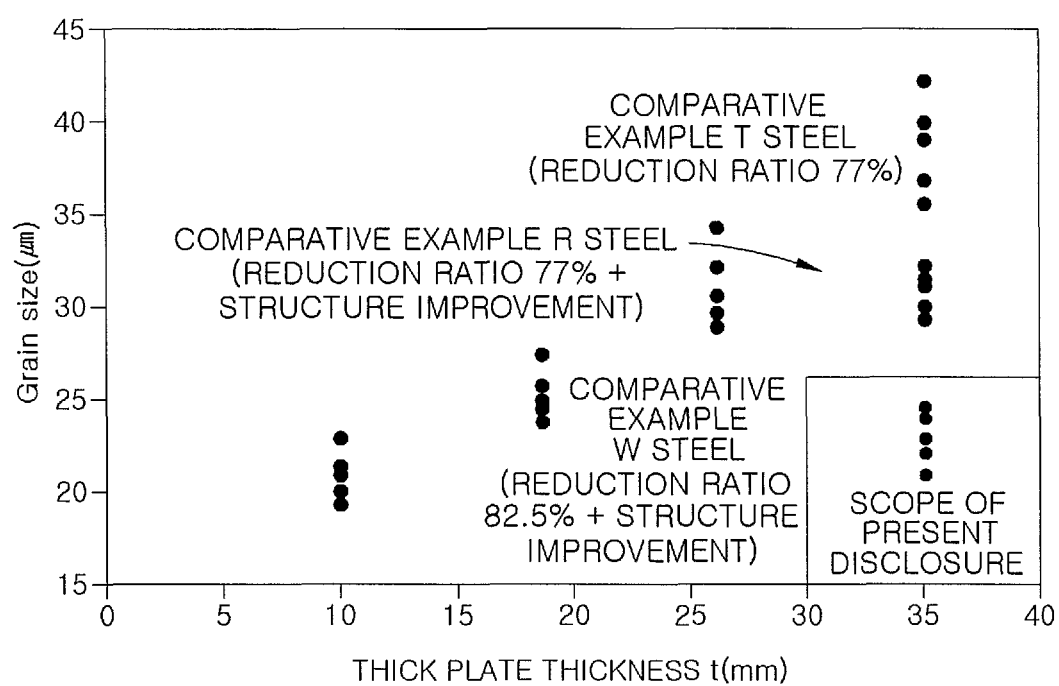
O STRUCTURE

Δ STRUCTURE

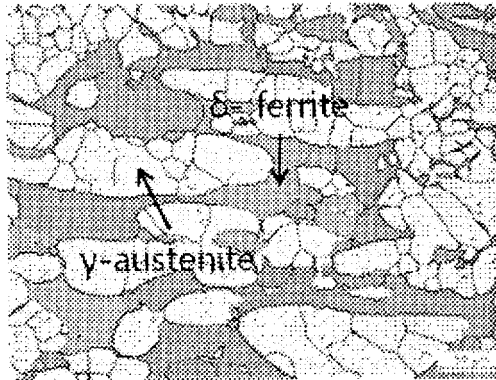
【Fig. 4】



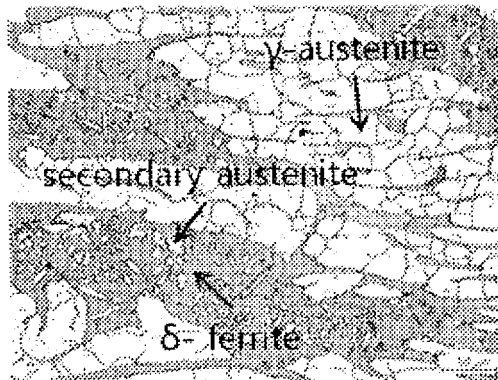
【Fig. 5】



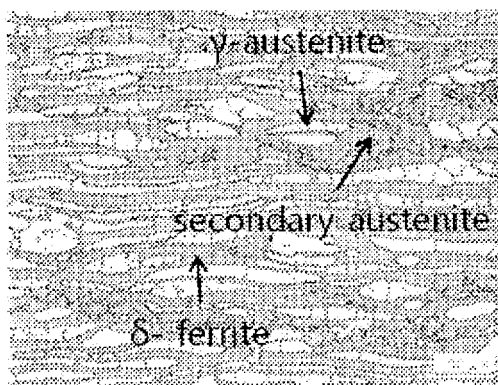
【Fig.6】



COMPARATIVE EXAMPLE T STEEL MICROSTRUCTURE
(REDUCTION RATIO 77%)



COMPARATIVE EXAMPLE R STEEL MICROSTRUCTURE
(REDUCTION RATIO 77% + STRUCTURE IMPROVEMENT)



COMPARATIVE EXAMPLE W STEEL MICROSTRUCTURE
(REDUCTION RATIO 82.5% + STRUCTURE IMPROVEMENT)

INTERNATIONAL SEARCH REPORT

International application No.

PCT/KR2015/014114

A. CLASSIFICATION OF SUBJECT MATTER

C22C 38/44(2006.01)i, C22C 38/18(2006.01)i, C21D 8/02(2006.01)i, C21D 1/26(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 38/44; C21D 1/26; C21D 9/52; B21B 45/02; C22C 38/00; C22C 38/58; C22C 38/42; B21B 45/06; C22C 38/18; C21D 8/02

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: duplex, stainless steel, ferrite, austenite, temperature rising, annealing

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	KR 10-2013-0034350 A (POSCO) 05 April 2013 See paragraph [0027]; and claims 1-5.	4
A		1-3,5-7
A	KR 10-2012-0011098 A (NIPPON STEEL & SUMIKIN STAINLESS STEEL CORPORATION) 06 February 2012 See paragraph [0188]; and claims 6, 7.	1-7
A	KR 10-2011-0086618 A (OUTOKUMPU OYJ) 28 July 2011 See paragraph [0039]; and claim 1.	1-7
A	JP 08-041600 A (PARK, Yong Soo) 13 February 1996 See paragraph [0020]; and claim 1.	1-7
A	KR 10-2012-0056458 A (POSCO) 04 June 2012 See paragraph [0035]; and claims 1-4.	1-7

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

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"g" document member of the same patent family

Date of the actual completion of the international search

01 APRIL 2016 (01.04.2016)

Date of mailing of the international search report

04 APRIL 2016 (04.04.2016)

Name and mailing address of the ISA/KR


 Korean Intellectual Property Office
 Government Complex-Daejeon, 189 Seonsa-ro, Daejeon 302-701,
 Republic of Korea

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Authorized officer

Telephone No.

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.

PCT/KR2015/014114

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International application No.

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