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(54) **AUSTENITIC STAINLESS STEEL HAVING IMPROVED PROCESSABILITY**

(57) Disclosed is an austenitic stainless steel with increased workability. The austenitic stainless steel includes, based on % by weight, silicon (Si): 0.1 to 0.65 %, manganese (Mn): 0.2 to 3.0 %, nickel (Ni): 6.5 to 10.0 %, chromium (Cr): 16.5 to 20.0 %, copper (Cu): 6.0 % or less (excluding 0), the sum of carbon (C) and nitrogen (N): 0.08 % or less (excluding 0), and the remainder being Fe and unavoidable impurities, wherein the austenitic

stainless steel has a work hardening rate of 1500 MPa or less within a true strain range of 0.15 to 0.4. Therefore, when a sink bowl and the like are processed using the austenitic stainless steel, the true strain and work hardening rate of which are controlled, the occurrence of delayed fracture in a molded corner thereof, which has been subjected to a large amount of processing, can be prevented.

[FIG. 2]



EP 3 396 001 A1

Description

[Technical Field]

5 **[0001]** The present invention relates to an austenitic stainless steel having increased workability, and more particularly to an austenitic stainless steel having increased workability without defects, such as delayed fracture, when worked into a complicated shape.

[Background Art]

10 **[0002]** The present invention relates to stainless steel used in a sink bowl, etc. More particularly, the present invention relates to stainless steel having excellent workability without the occurrence of delayed fracture upon working into a sink bowl.

15 **[0003]** Stainless steel is generally used in sink bowls for kitchens. Here, specific general-purpose stainless steels are used. Such stainless steels are widely used because they do not have problems in being molded into general sink bowl shapes.

20 **[0004]** However, to enhance market competitiveness, many attempts have recently been made to design a sink bowl in various and complicated shapes. In this case, when conventionally used stainless steels are directly applied, a molded sink bowl may exhibit delayed fracture as illustrated in FIG. 1. FIG. 1 is a photograph of a corner of a sink bowl, made of a conventional austenitic stainless steel, after being processed.

[0005] Delayed fracture, which occurs after a certain period after working a steel sheet, mainly occurs in parts, which have been subjected to a large amount of processing, along processed shapes.

25 **[0006]** Although austenitic stainless steel generally has high workability, it exhibits delayed fracture, such as an aging crack, when a working rate thereof exceeds the limit. Such cracks occur after several minutes to several months after deep drawing of austenitic stainless steel. The cracks linearly proceed in a deep drawing direction, but, microscopically, proceed in a zigzag shape regardless of grains/grain boundaries of the austenitic stainless steel.

[0007] Therefore, the present invention provides stainless steel having excellent workability without the occurrence of defects, such as delayed fracture, when worked into a complicated shape.

30 **[0008]** (Patent Document 0001) Korean Patent Application Publication No. 10-2014-0131214

[Disclosure]

[Technical Problem]

35 **[0009]** Embodiments of the present invention provide an austenitic stainless steel pipe having excellent workability, without the occurrence of delayed fracture, when worked into a sink bowl.

[Technical Solution]

40 **[0010]** In accordance with an aspect of the present invention, the above and other objects can be accomplished by the provision of an austenitic stainless steel with increased workability including, based on % by weight, silicon (Si): 0.1 to 0.65 %, manganese (Mn): 0.2 to 3.0 %, nickel (Ni): 6.5 to 10.0 %, chromium (Cr): 16.5 to 20.0 %, copper (Cu): 6.0 % or less (excluding 0), the sum of carbon (C) and nitrogen (N): 0.08 % or less (excluding 0), and the remainder being Fe and unavoidable impurities, wherein the austenitic stainless steel has a work hardening rate of 1500 MPa or less within a true strain range of 0.15 to 0.4.

45 **[0011]** In accordance with an embodiment of the present invention, the austenitic stainless steel may include carbon (C) and nitrogen (N) in an amount of 0.05 % or less (excluding 0).

[0012] In accordance with an embodiment of the present invention, the austenitic stainless steel may include carbon (C) and nitrogen (N) in an amount of 0.03 % or less (excluding 0).

50 **[0013]** In accordance with an embodiment of the present invention, the austenitic stainless steel may have an ASTM grain size number of 8 or less.

[0014] In accordance with an embodiment of the present invention, the austenitic stainless steel may have a ferritic or martensitic phase fraction of less than 1 %.

55 [Advantageous Effects]

[0015] Embodiments of the present invention provide an austenitic stainless steel, the true strain and work hardening rate of which are controlled, to be capable of preventing the occurrence of delayed fracture in a molded corner, which

has been subjected to a large amount of processing, when worked into a sink bowl, etc.

[Description of Drawings]

[0016]

FIG. 1 is a photograph of a corner of a sink bowl after working a conventional austenitic stainless steel.

FIG. 2 is a photograph of a corner of a sink bowl after working an austenitic stainless steel according to an embodiment of the present invention.

FIG. 3 is a graph illustrating a correlation between the true strain and the work hardening rate of an austenitic stainless steel according to an embodiment of the present invention.

[Best Mode for Carrying Out the Invention]

[0017] An austenitic stainless steel with increased workability according to an embodiment of the present invention includes, based on % by weight, silicon (Si): 0.1 to 0.65 %, manganese (Mn): 0.2 to 3.0 %, nickel (Ni): 6.5 to 10.0 %, chromium (Cr): 16.5 to 20.0 %, copper (Cu): 6.0 % or less (excluding 0), the sum of carbon (C) and nitrogen (N): 0.08 % or less (excluding 0), and the remainder being Fe and unavoidable impurities and has a work hardening rate of 1500 MPa or less within a true strain range of 0.15 to 0.4 .

[Mode for Carrying Out the Invention]

[0018] Hereinafter, embodiments of the present invention will be described in detail with reference to the accompanying drawings. The following embodiments are provided to fully convey the spirit of the present invention to a person having ordinary skill in the art to which the present invention belongs. The present invention is not limited to the embodiments shown herein but may be embodied in other forms. For the sake of clarity of the present invention, portions, which are unrelated to the present invention, are omitted, and the sizes of components may be slightly exaggerated to help understanding of the present invention.

[0019] An austenitic stainless steel with increased workability according to an embodiment of the present invention includes, based on % by weight, silicon (Si): 0.1 to 0.65 %, manganese (Mn): 0.2 to 3.0 %, nickel (Ni): 6.5 to 10.0 %, chromium (Cr): 16.5 to 20.0 %, copper (Cu): 6.0 % or less (excluding 0), the sum of carbon (C) and nitrogen (N): 0.08 % or less (excluding 0), and the remainder being Fe and unavoidable impurities.

[0020] Hereinafter, reasons behind numerical limitations of ingredients constituting the austenitic stainless steel with increased workability of the present invention are described.

[0021] Silicon (Si) is added in an amount range of 0.1 to 0.65 % by weight.

[0022] Si is an element essentially added for deoxidation. When the content of Si is too low, the cost of a steelmaking process is high. Accordingly, the content of Si is limited to 0.1 % or more.

[0023] However, when the content of Si is too high, since Si is a solid solution strengthening element, strength is increased to harden a material and Si combines with oxygen to form an inclusion, whereby corrosion resistance is decreased. Accordingly, an upper limit of Si is limited to 0.65 %.

[0024] Manganese (Mn) is added in an amount range of 0.2 to 3.0 % by weight.

[0025] Mn, which is essentially added for deoxidation, increases the stability of an austenitic phase, reduces a generation amount of ferrite or martensite, and lowers a work hardening rate, is added in an amount of 0.2 % or more.

[0026] However, when Mn, as a solid solution strengthening element, is added in too high a content, the strength of a steel may increase and the corrosion resistance of a material may be decreased. Accordingly, an upper limit of Mn is limited to 3.0 %.

[0027] Nickel (Ni) is added in an amount range of 6.5 to 10.0 % by weight.

[0028] When Ni is added along with chromium (Cr), corrosion resistance, such as pitting corrosion resistance, may be effectively improved. In addition, when the content of Ni increases, the softening and work hardening rate of an austenite steel may be decreased. In addition, Ni, which increases the stability of an austenitic phase and reduces a ferrite or martensite generation amount in a steel pipe, is added in an amount of 6.5 % or more so as to maintain austenite balance.

[0029] However, when the content of Ni is excessively high, the cost of steel increases. Accordingly, an upper limit of Ni is limited to 10.0 %.

[0030] Chromium (Cr) is added in an amount range of 16.5 to 20.0 % by weight.

[0031] Cr, which is an essential element in increasing the corrosion resistance of stainless steel, should be added in

an amount of 16.5 % or more for general purposes.

[0032] However, when Cr, as a solid solution strengthening element, is added in too high a content, costs increase. Accordingly, an upper limit of Cr is limited to 20.0 %.

[0033] Copper (Cu) is added in an amount range of 6.0 % by weight or less (excluding 0).

[0034] Since Cu lowers the softening and work hardening rate of an austenite steel and a ferrite or martensite generation amount in steel, it is preferred to add the same.

[0035] However, when Cu is added in too high a content, hot workability may be decreased, an austenitic phase may be rather hardened, costs may increase, and manufacturing difficulties may increase. Accordingly, an upper limit of Cu is limited to 6.0 %.

[0036] The sum of carbon (C) and nitrogen (N) should be added in an amount of 0.08 % by weight or less (excluding 0).

[0037] C and N, which are interstitial solid solution strengthening elements, harden austenitic stainless steel. When the content of C and N is high, a modified organic martensite generated during processing is hardened, whereby a work hardening degree of a material increases.

[0038] Accordingly, the content of C and N should be limited. In the present invention, the content of the sum of C and N is limited to 0.08 % or less. To prevent hardening of a material, the content of C and N may be preferably 0.05 % or less (excluding 0), more preferably 0.03 % or less (excluding 0).

[0039] In addition, the austenitic stainless steel has a work hardening rate of 1,500 MPa or less in a true strain range of 0.15 to 0.4.

[0040] FIG. 2 is a photograph of a corner of a sink bowl after working an austenitic stainless steel according to an embodiment of the present invention. FIG. 2 illustrates that, when the stainless steel manufactured by the method proposed in the present invention is applied to a sink bowl worked into the same shape as that illustrated in FIG. 1, delayed fracture is not exhibited also in a molded corner of the sink bowl which has been subjected to a large amount of processing.

[0041] FIG. 3 is a graph illustrating a correlation between the true strain and the work hardening rate of an austenitic stainless steel according to an embodiment of the present invention. FIG. 3 illustrates true strain-dependent work hardening rates of a conventional stainless steel and stainless steel of the present invention which have been subjected to a uniaxial tensile test. It can be observed that, in a true strain range of 0.15 to 0.4, the conventional stainless steel exhibits an increased work hardening rate of 1,500 MPa or more, whereas an increased work hardening rate of the stainless steel according to the present invention is maintained at 1,500 MPa or less.

[0042] When stainless steel is worked, work hardening occurs. Since delayed fracture occurs when an amount of processing is large, work hardening was examined in a true strain range of 0.15 to 0.4 in the present invention.

[0043] Work hardening is quantitatively expressed as a work hardening rate which is a ratio of a true stress change in stainless steel to a true strain change in the stainless steel. Referring to FIG. 3, it can be confirmed that, in the case of the conventional stainless steel, a work hardening rate is 1,500 MPa or more in a true strain range of 0.15 to 0.4.

[0044] Referring to FIG. 3, a work hardening rate is controlled to 1,500 MPa or less in a true strain range of 0.15 to 0.4 in the present invention, whereby delayed fracture does not occur also after processing and, accordingly, a stainless steel having excellent workability is obtained.

[0045] To calculate a work hardening rate, a plate was worked into a tensile specimen according to JIS13B and JIS5 standards, and then the processed tensile specimen was subjected to a uniaxial tensile test until it was broken. The work hardening rate was calculated using a true strain value and a true stress value obtained through this test. The standard for the tensile test is not specifically limited, and the standards are only provided as examples. To test delayed fracture, a plate may be worked into a sink bowl shape or in a simple cup shape with a diameter of 50 mm and a height of 100 mm.

[0046] For example, the stainless steel may have an ASTM grain size number of 8 or less. The grain size is measured at a longitudinal cross section of the stainless steel pipe.

[0047] For example, the stainless steel may have a ferritic phase fraction of less than 1 %, and a martensitic phase fraction of less than 1 %. That is, the stainless steel has a ferrite or martensite fraction of less than 1 %, as measured by a magnetization method.

[0048] Hereinafter, the present invention will be described in detail by describing exemplary embodiments of the invention.

Examples

[0049] An austenitic stainless steel slab including ingredients of each of Inventive Examples 1 to 11 and Comparative Examples 1 and 2 as summarized in Table 1 below was manufactured through continuous casting. Subsequently, the austenitic stainless steel slab was subjected to hot rolling, and cold rolling into a total reduction ratio of 50 %, thereby manufacturing a cold-rolled steel sheet.

[Table 1]

	Ingredients (% by weight)						
	C	Si	Mn	Ni	Cr	Cu	N
Inventive Example 1	0.012	0.3	0.7	7.8	16.9	3.01	0.008
Inventive Example 2	0.010	0.3	1.2	9.6	16.8	0.00	0.010
Inventive Example 3	0.010	0.3	1.2	8.7	16.9	3.00	0.010
Inventive Example 4	0.010	0.3	1.2	9.6	16.9	2.98	0.010
Inventive Example 5	0.009	0.6	1.2	7.5	17.0	2.98	0.010
Inventive Example 6	0.010	0.3	1.8	7.6	16.8	3.00	0.010
Inventive Example 7	0.010	0.3	1.1	7.6	17.2	3.03	0.010
Inventive Example 8	0.010	0.3	2.2	7.6	16.9	3.00	0.010
Inventive Example 9	0.012	0.3	0.7	7.8	16.9	3.01	0.008
Inventive Example 10	0.010	0.3	1.2	9.6	16.8	0.00	0.010
Inventive Example 11	0.010	0.6	1.2	7.6	16.9	5.00	0.010
Comparative Example 1	0.040	0.6	1.2	8.1	18.1	0.00	0.040
Comparative Example 2	0.030	0.6	1.2	7.6	16.9	5.00	0.030

[0050] Subsequently, the cold-rolled steel sheet was worked into a sink bowl, and a work hardening rate of the steel sheet was measured. After working the steel sheet into a sink bowl, the occurrence of delayed fracture was observed with the naked eye. Results are summarized in Table 2 below.

[Table 2]

	Work hardening rate (MPa)	Delayed fracture
Inventive Example 1	1033	X
Inventive Example 2	1020	X
Inventive Example 3	1029	X
Inventive Example 4	1433	X
Inventive Example 5	1604	X
Inventive Example 6	961	X
Inventive Example 7	1193	X
Inventive Example 8	1204	X
Inventive Example 9	1036	X
Inventive Example 10	1013	X
Inventive Example 11	992	X
Comparative Example 1	2106	○
Comparative Example 2	1601	○

[0051] Tables 1 and 2 show that delayed fracture does not occur in stainless steels manufactured according to the ingredient ranges and work hardening rates proposed in the present invention. On the other hand, it can be confirmed that, in the case of Comparative Examples 1 and 2 in which conventional stainless steels are used, a work hardening rate is not 1,500 MPa or less and delayed fracture occurs under the same conditions.

[0052] FIG. 1 is a photograph of a corner of a sink bowl after working an austenitic stainless steel according to Comparative Example 1, FIG. 2 is a photograph of a corner of a sink bowl after working an austenitic stainless steel

according to Inventive Example 1, and FIG. 3 is a graph illustrating a correlation between the true strain and the work hardening rate of an austenitic stainless steel according to each of Comparative Example 1 and Inventive Example 1.

[0053] Referring to FIGS. 1 to 3 and Table 2, it can be confirmed that the austenitic stainless steels according to the present invention do not exhibit delayed fracture, also after being processed, within the true strain and work hardening rate ranges.

[0054] While the present invention has been described with reference to exemplary embodiments, it is to be understood that the invention is not limited thereto. Those skilled in the art will understand that various changes and modifications may be made within the spirit and scope of the appended claims.

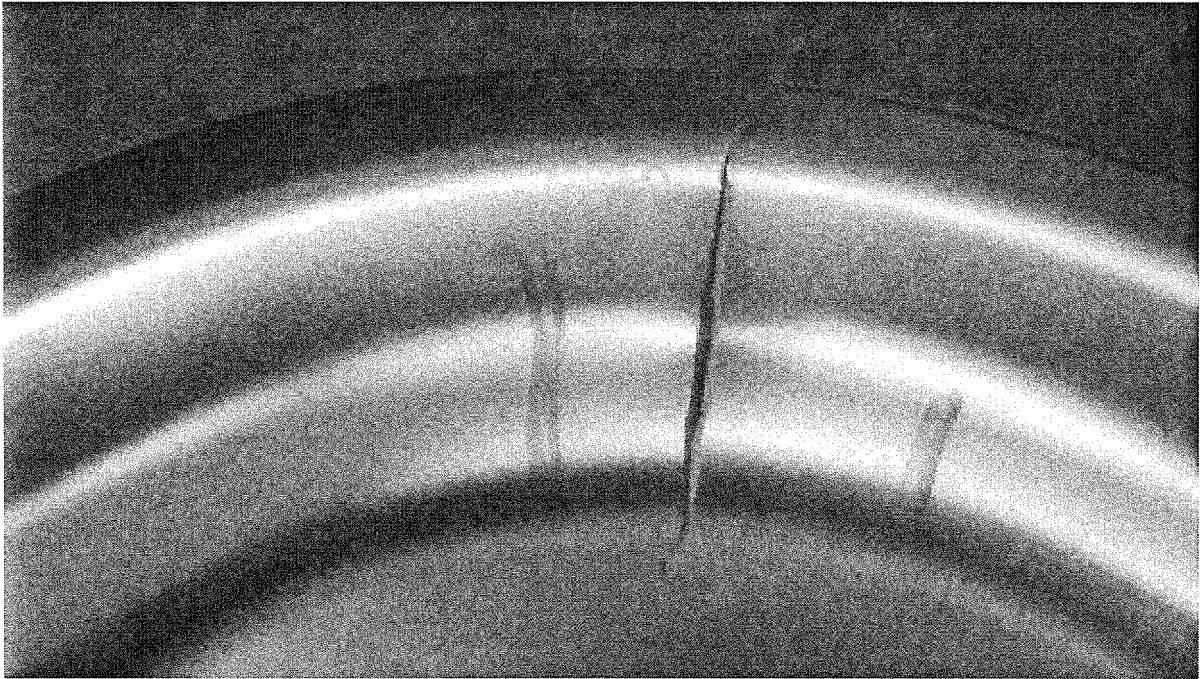
[Industrial Applicability]

[0055] Austenitic stainless steel according to embodiments of the present invention has industrial applicability in that it is applicable to a sink bowl for kitchens, etc.

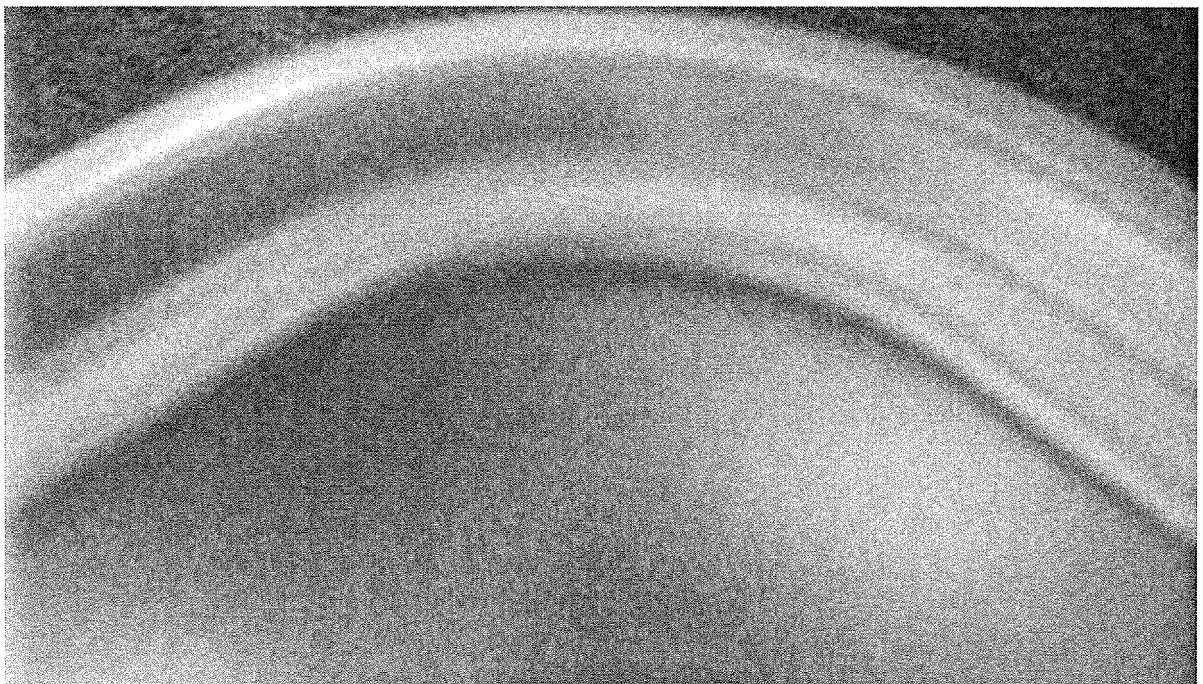
Claims

1. An austenitic stainless steel with increased workability, comprising, based on % by weight, silicon (Si): 0.1 to 0.65 %, manganese (Mn): 0.2 to 3.0 %, nickel (Ni): 6.5 to 10.0 %, chromium (Cr): 16.5 to 20.0 %, copper (Cu): 6.0 % or less (excluding 0), the sum of carbon (C) and nitrogen (N): 0.08 % or less (excluding 0), and the remainder being Fe and unavoidable impurities, wherein the austenitic stainless steel has a work hardening rate of 1500 MPa or less within a true strain range of 0.15 to 0.4.
2. The austenitic stainless steel according to claim 1, comprising carbon (C) and nitrogen (N) in an amount of 0.05 % or less (excluding 0).
3. The austenitic stainless steel according to claim 2, comprising carbon (C) and nitrogen (N) in an amount of 0.03 % or less (excluding 0).
4. The austenitic stainless steel according to claim 1, wherein the austenitic stainless steel has an ASTM grain size number of 8 or less.
5. The austenitic stainless steel according to claim 1, wherein the austenitic stainless steel has a ferritic or martensitic phase fraction of less than 1 %.

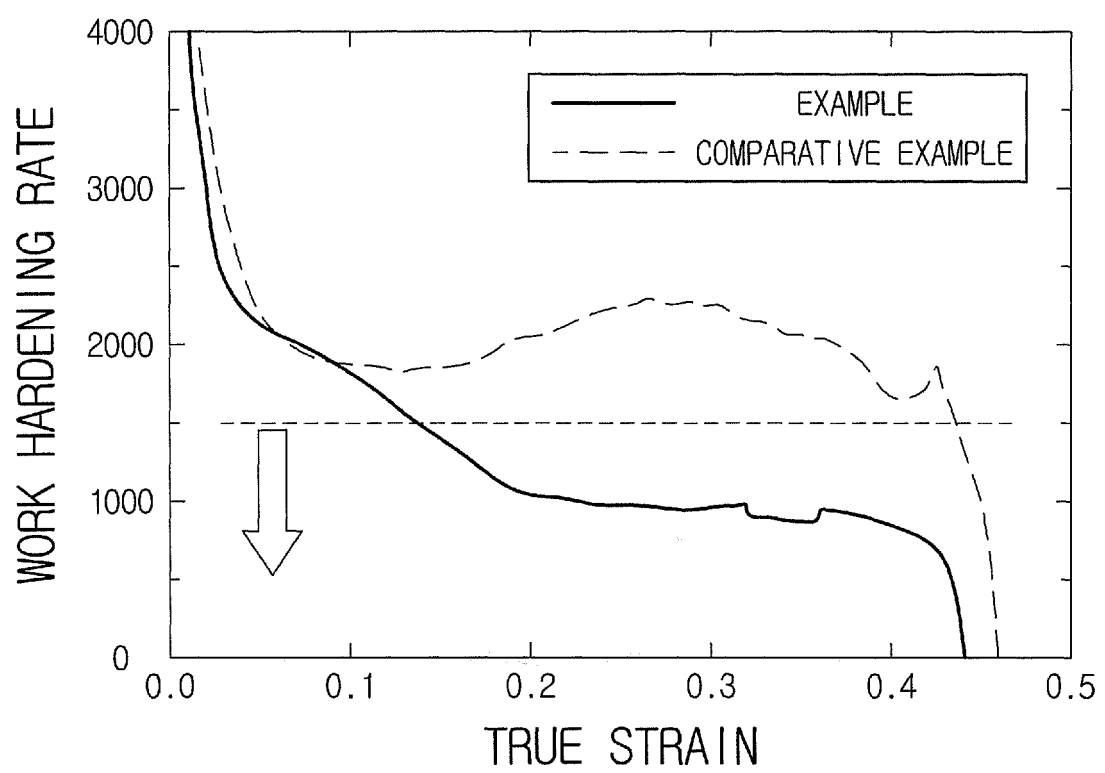
【FIG. 1】



【FIG. 2】



【FIG. 3】



INTERNATIONAL SEARCH REPORT

International application No.

PCT/KR2016/015024

A. CLASSIFICATION OF SUBJECT MATTER

C22C 38/58(2006.01)i, C22C 38/42(2006.01)i, C22C 38/00(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 38/58; C21D 9/46; C21D 8/02; C22C 38/00; C22C 38/60; C22C 38/42

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: austenite, stainless steel, workability, true strain, nickel, copper and grain size

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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A	JP 2004-238700 A (NISSHIN STEEL CO., LTD.) 26 August 2004 See paragraphs [0004]-[0030] and figure 1.	1-5
A	KR 10-2010-0097741 A (NIPPON STEEL & SUMIKIN STAINLESS STEEL CORPORATION) 03 September 2010 See paragraphs [0016]-[0026]; claims 1-6; and figures 1-5.	1-5
A	US 2013-0174948 A1 (PEULTIER, Jerome et al.) 11 July 2013 See paragraphs [0006]-[0106] and claims 1-14.	1-5
A	CN 103380224 A (NIPPON STEEL & SUMIKIN STAINLESS STEEL CORPORATION) 30 October 2013 See paragraphs [0021]-[0095] and figures 1-3.	1-5

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

* Special categories of cited documents:

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Date of the actual completion of the international search

08 MARCH 2017 (08.03.2017)

Date of mailing of the international search report

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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

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