(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 4 151 755 A1

(12) **EUROPEAN PATENT APPLICATION**
published in accordance with Art. 153(4) EPC

(43) Date of publication:
22.03.2023 Bulletin 2023/12

(21) Application number: **21837995.6**

(22) Date of filing: **05.07.2021**

(51) International Patent Classification (IPC):
C21C 7/068 *(2006.01)* ***C22C 38/00*** *(2006.01)*
C22C 38/04 *(2006.01)* ***B22D 11/00*** *(2006.01)*
B21B 1/02 *(2006.01)*

(52) Cooperative Patent Classification (CPC):
B21B 1/02; B22D 11/00; C21C 7/068; C22C 38/00; C22C 38/04

(86) International application number:
PCT/JP2021/025374

(87) International publication number:
WO 2022/009849 (13.01.2022 Gazette 2022/02)

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
KH MA MD TN

(30) Priority: **08.07.2020 JP 2020117921**

(71) Applicant: **JFE Steel Corporation**
Tokyo 100-0011 (JP)

(72) Inventors:
- **SANO, Keisuke**
  Tokyo 100-0011 (JP)
- **ISHIWARI, Masatoshi**
  Tokyo 100-0011 (JP)
- **MIYAKE, Masaru**
  Tokyo 100-0011 (JP)
- **TSUZUMI, Kenji**
  Tokyo 100-0011 (JP)

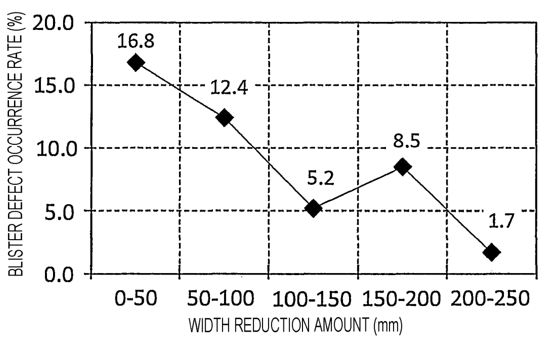
(74) Representative: **Grünecker Patent- und Rechtsanwälte**
PartG mbB
Leopoldstraße 4
80802 München (DE)

(54) METHOD FOR MANUFACTURING ULTRA-LOW CARBON STEEL PRODUCT

(57) Provided is a method for producing an ultra-low carbon steel product in which, even if bubbles are captured in a solidified shell, occurrence of blister defects can be suppressed in a hot rolling step and subsequent steps.

A method for producing an ultra-low carbon steel product having a carbon concentration of 0.005% by mass or less includes, at least, a step of adjusting a carbon concentration of molten iron to obtain molten steel, a step of casting the molten steel into a slab, and a step of hot rolling the slab to obtain a hot-rolled steel sheet, in which the method further includes a width reduction step of performing width reduction on the slab with a reduction amount which is predetermined in accordance with the slab width in a direction orthogonal to the rolling direction of the slab.

FIG. 1



EP 4 151 755 A1

Description

Technical Field

[0001] The present invention relates to a method for producing an ultra-low carbon steel product having a small number of blister defects.

Background Art

[0002] In recent years, regarding cold-rolled steel sheets or surface-treated steel sheets obtained by subjecting cold-rolled steel sheets to coating treatment for automobile use and for can use, requirements for surface quality have become much stricter. In particular, surface defects referred to as "blisters" occurring on the surface of steel sheets are opened by working and cause cracking and deterioration in corrosion resistance. Therefore, occurrence of such defects may in some cases stop shipment of product, resulting in a decrease in yield.

[0003] Blister defects in cold-rolled steel sheets are, as disclosed in Non Patent Literature 1, blister-like surface defects which occur when hydrogen that has entered a steel sheet during pickling after hot rolling is retained in bubbles in the steel sheet, the volume thereof expands with heating during annealing after cold rolling, and the pressure raised by this deforms the surface of the steel sheet that has been softened by heating.

[0004] As a technique for suppressing occurrence of such blisters, Patent Literature 1 discloses a method in which, by a continuous casting machine including a mold having upper magnetic poles and lower magnetic poles and a nozzle having exit ports of molten steel positioned between the magnetic field peak position of the upper magnetic poles and the magnetic field peak position of the lower magnetic poles, a slab is cast while the flow of molten steel being controlled, so that bubbles are suppressed from being captured in a solidified shell, and thus, occurrence of blisters can be suppressed.

Citation List

Patent Literature

[0005] PTL 1: Japanese Unexamined Patent Application Publication No. 2011-206846

Non Patent Literature

[0006] NPL 1: Masamichi Kowaka, "Metal Corrosion Damage and Corrosion Protection Technology", Agune Inc., 1983, p.207

Summary of Invention

Technical Problem

[0007] However, the technique disclosed in Patent Literature 1 is a technique in which bubbles which may cause blister defects are suppressed from being captured in the solidified shell mainly at the casting stage. In the casting step, in order to prevent non-metallic inclusions, such as alumina, from adhering to the inner wall surface of an immersion nozzle, inert gas is introduced into the immersion nozzle. Accordingly, it is difficult to completely prevent bubbles from being captured in a solidified shell. There has been a demand for a method in which, even if bubbles are captured in a solidified shell, occurrence of blister defects can be suppressed in a following hot rolling step and subsequent steps. The present invention has been made in consideration of the problem of the existing technique, and it is an object of the invention to provide a method for producing an ultra-low carbon steel product in which, even if bubbles are captured in a solidified shell, occurrence of blister defects can be suppressed in a hot rolling step and subsequent steps.

Solution to Problem

[0008] The gist of the present invention which solves the problem is as follows:

(1) A method for producing an ultra-low carbon steel product having a carbon concentration of 0.005% by mass or less, the method including, at least, a refining step of adjusting a carbon concentration of molten iron to obtain molten steel, a casting step of casting the molten steel into a slab, and a hot rolling step of hot rolling the slab to obtain a hot-rolled steel sheet, in which the method further includes a width reduction step of performing width reduction on

the slab to be subjected to the hot rolling step with a reduction amount which is predetermined in accordance with the slab width in a direction orthogonal to the rolling direction of the slab.

(2) A method for producing an ultra-low carbon steel product having a carbon concentration of 0.005% by mass or less, the method including, at least, a refining step of adjusting a carbon concentration of molten iron to obtain molten steel, a casting step of casting the molten steel into a slab, a hot rolling step of hot rolling the slab to obtain a hot-rolled steel sheet, and a cold rolling step of cold rolling the hot-rolled steel sheet to obtain a cold-rolled steel sheet, in which in the cold rolling step, cold rolling is performed at a rolling reduction ratio which is predetermined in accordance with the thickness of the hot-rolled steel sheet.

(3) The method for producing an ultra-low carbon steel product according to (2), further including a width reduction step of performing width reduction on the slab to be subjected to the hot rolling step with a reduction amount which is predetermined in accordance with the slab width in a direction orthogonal to the rolling direction of the slab.

Advantageous Effects of Invention

[0009] By carrying out the method for producing an ultra-low carbon steel product according to the present invention, it is possible to suppress occurrence of blister defects in an ultra-low carbon steel product produced from an ultra-low carbon steel slab containing bubbles. By suppressing the occurrence of blister defects, improvement in the yield of a production line for ultra-low carbon steel products can be achieved.

Brief Description of Drawings

[0010]

[Fig. 1] Fig. 1 is a graph showing the relationship between the width reduction amount and the blister defect occurrence rate.

[Fig. 2] Fig. 2 is a graph showing the relationship between the rolling reduction ratio of cold rolling and the blister defect occurrence rate.

Description of Embodiments

[0011] As described above, blister defects occur when hydrogen that has entered a steel sheet during pickling after hot rolling is retained in bubbles and the like in the steel sheet, the volume thereof expands with heating during annealing after cold rolling, and the pressure raised by this deforms the surface of the steel sheet that has been softened by heating. The present inventors have found that by performing width reduction on a slab to be subjected to hot rolling with a reduction amount which is predetermined in accordance with the slab width (size) in a direction orthogonal to the rolling direction of the slab so as to deform bubbles contained in the slab, occurrence of blister defects can be suppressed, and thus the present invention has been made. The present invention will be described below by way of an embodiment.

[0012] A method for producing an ultra-low carbon steel product according to the embodiment includes, at least, a refining step of adjusting a carbon concentration of molten iron to obtain molten steel, a casting step of casting the molten steel into a slab, a width reduction step of performing width reduction on the slab, and a hot rolling step of hot rolling the slab subjected to width reduction. Furthermore, in some cases, the method may include, after the hot rolling step, a cold rolling step of cold rolling the hot-rolled steel sheet. Molten steel of ultra-low carbon steel is obtained by steelmaking in such a manner that molten steel which has been subjected to a primary refining process in a refining apparatus, such as a converter, in advance is further subjected to a degassing and decarburization process using an RH type degassing apparatus or the like. The step including these processes is an example of the refining step of adjusting a carbon concentration of molten iron to obtain molten steel. In the refining step according to the embodiment, molten steel of ultra-low carbon steel having a carbon concentration of 0.005% by mass or less is obtained.

[0013] The molten steel of ultra-low carbon steel is continuously cast into a slab using a continuous casting machine equipped with a tundish, a mold, foot rolls, guide rolls, pinch rolls, a secondary cooling device, and the like. The step of continuously casting molten steel into a slab using the continuous casting machine is an example of the casting step of casting the molten steel into a slab.

[0014] Subsequently, the slab is subjected to hot rolling to obtain a hot-rolled steel sheet, and by pickling the hot-rolled steel sheet, a hot-rolled steel sheet is produced. Furthermore, the hot-rolled steel sheet may be further subjected to cold rolling, annealing, and other processes to obtain a cold-rolled steel sheet. Moreover, the cold-rolled steel sheet may be subjected to hot-dip galvannealing treatment to obtain a hot-dip galvannealed steel sheet. The step of subjecting the slab to hot rolling including the pickling process to obtain a hot-rolled steel sheet is an example of the step of hot rolling the slab, and the step of subjecting the hot-rolled steel sheet to cold rolling, annealing, and other processes to obtain a cold-rolled steel sheet is an example of the cold rolling step of cold rolling the hot-rolled slab.

[0015] In the casting step, molten steel in a tundish is poured into a mold through an immersion nozzle. The ultra-low carbon steel having a carbon concentration of 0.005% by mass or less contains alumina generated during the degassing and decarburization process using an RH-degassing apparatus. In order to prevent non-metallic inclusions, such as alumina, from adhering and accumulating to the inner wall surface of the immersion nozzle and blocking the immersion nozzle, inert gas, such as Ar gas, is blown into the nozzle through the inner wall surface of the immersion nozzle which is used for pouring molten steel from the tundish into the mold. Bubbles of the inert gas are discharged, together with the molten steel, from molten steel exit ports of the immersion nozzle into the mold.

[0016] When bubbles of the inert gas discharged into the mold are captured in a solidified shell, a slab containing bubbles is cast. When the slab containing bubbles is formed into a hot-rolled steel sheet and when the hot-rolled steel sheet is subjected to pickling, hydrogen is retained in bubbles, the volume thereof expands with heating during annealing after cold rolling, and the pressure raised by this deforms the surface of the steel sheet that has been softened by heating, resulting in the occurrence of blister defects.

[0017] Concerning such blister defects, the method for producing an ultra-low carbon steel product according to the embodiment further includes a width reduction step of performing width reduction on the slab to be subjected to hot rolling with a reduction amount which is predetermined in accordance with the slab width in a direction orthogonal to the rolling direction of the slab. Specifically, using a sizing press, width reduction is performed on the slab to be subjected to hot rolling. In this way, occurrence of blister defects during annealing after cold rolling can be suppressed.

[0018] Next, a mechanism by which occurrence of blister defects is suppressed will be described. When a bubble contained in a slab is considered as a beam, the expansion amount (δ) of the bubble is expressed by formula (1) below, using the beam calculation formula in which both ends of the beam are supported.

$$\delta = WL^2/384EI \quad \cdots \ (1)$$

[0019] In the above formula (1), δ is the expansion amount (m), W is the stress (N), L is the bubble width (m), E is the Young's modulus (MPa), and I is the moment of inertia of area (m^4).

[0020] By performing width reduction on the slab with a sizing press, the bubble width is narrowed, and L in the formula (1) decreases. When L decreases, the expansion amount (δ) at the center of the beam also decreases. Because of this effect, expansion of bubbles is suppressed, and thus it is considered that occurrence of blister defects is suppressed.

[0021] Next, the relationship between the width reduction amount of the slab and the blister defect occurrence rate will be described. Slabs having a width of 1,100 to 2,100 mm were subjected to width reduction by a sizing press with different reduction amounts, each with a weight of 500 t or more. Each of the slabs subjected to width reduction was hot rolled to obtain a hot-rolled steel sheet (thickness: 2.6 to 4.0 mm), followed by pickling with hydrochloric acid, and then cold rolling was performed at a certain rolling reduction ratio (0.72 to 0.76) to obtain a cold-rolled steel sheet. The resulting cold-rolled steel sheet was subjected to hot-dip galvannealing treatment, and surface defects of the resulting hot-dip galvannealed steel sheet were continuously measured with an on-line surface defect meter. By appearance inspection, SEM analysis, ICP analysis, or the like, it was visually confirmed whether or not the surface defects were blister defects. A value obtained by dividing the mass coils in which blister defects occurred by the total coil mass was multiplied by 100 to calculate the blister defect occurrence rate. Furthermore, the rolling reduction ratio of cold rolling was calculated in accordance with formula (2) below.

Rolling reduction ratio = (steel sheet thickness at entry of cold rolling - steel sheet thickness at exit of cold rolling)/steel sheet thickness at entry of cold rolling ··· (2)

[0022] The blister defect occurrence rate was confirmed using an ultra-low carbon steel 1 whose standard component concentrations were C concentration: 0.0000 to 0.0020, Si concentration: 0.00 to 0.03% by mass, Mn concentration: 0.10 to 0.25% by mass, P concentration: 0.010 to 0.020% by mass, S concentration: 0.003 to 0.010% by mass, and N concentration: 0.0000 to 0.0035% by mass, and an ultra-low carbon steel 2 whose standard component concentrations were C concentration: 0.0000 to 0.0015, Si concentration: 0.00 to 0.03% by mass, Mn concentration: 0.05 to 0.18% by mass, P concentration: 0.000 to 0.010% by mass, S concentration: 0.003 to 0.009% by mass, and N concentration: 0.0000 to 0.0030% by mass.

[0023] Fig. 1 is a graph showing the relationship between the width reduction amount by the sizing press and the blister defect occurrence rate. In Fig. 1, the horizontal axis represents the slab width reduction amount (mm), and the vertical axis represents the blister defect occurrence rate (%). As shown in Fig. 1, although the blister defect occurrence rate slightly increases when the width reduction amount is increased from 100 to 150 mm to 150 to 200 mm, as a whole, the blister defect occurrence rate tends to decrease as the slab width reduction amount is increased. This result shows that by performing width reduction on the slab to be subjected to hot rolling with a reduction amount which is predetermined in accordance with the slab width in a direction orthogonal to the rolling direction of the slab, occurrence of blister defects can be suppressed.

[0024] Here, the proper width reduction amount in accordance with the slab width can be predetermined by grasping the relationship between the width reduction amount and the blister defect occurrence rate shown in Fig. 1 by an experiment or the like. That is, in the example shown in Fig. 1, it is clear that by subjecting a slab with a width of 1,100 to 2,100 mm to width reduction by a sizing press, with a reduction amount of 200 to 250 mm or more, the blister defect occurrence rate can be greatly decreased.

[0025] As described above, by carrying out the method for producing an ultra-low carbon steel product according to the embodiment, it is possible to suppress occurrence of blister defects in an ultra-low carbon steel product produced from an ultra-low carbon steel slab containing bubbles. By suppressing the occurrence of blister defects, improvement in the yield of a production line for ultra-low carbon steel products can be achieved.

[0026] Furthermore, instead of width reduction of the slab, or together with width reduction of the slab, cold rolling may be performed at a rolling reduction ratio which is predetermined in accordance with the thickness of the hot-rolled steel sheet. By performing cold rolling at a predetermined rolling reduction ratio, the dislocation density in the steel microstructure increases, and the size of recrystallized grains decreases during annealing, thereby increasing the strength of the steel sheet. The occurrence of blister defects is suppressed by the increase in the strength.

[0027] Next, the relationship between the rolling reduction ratio of cold rolling and the blister defect occurrence rate will be described. Slabs subjected to width reduction by a sizing press with a certain width reduction amount (0 to 100 mm) were hot rolled to obtain hot-rolled steel sheets (thickness: 2.6 to 4.0 mm), followed by pickling with hydrochloric acid, and then cold rolling was performed at various rolling reduction ratios to obtain cold-rolled steel sheets with different rolling reduction ratios, each with a weight of 200 t or more. Each of the resulting cold-rolled steel sheets was subjected to hot-dip galvannealing treatment, and surface defects of the resulting hot-dip galvannealed steel sheet were continuously measured with an on-line surface defect meter. By appearance inspection, SEM analysis, ICP analysis, or the like, it was confirmed whether or not the surface defects were blister defects, and the blister defect occurrence rate was calculated.

[0028] Fig. 2 is a graph showing the relationship between the rolling reduction ratio of cold rolling and the blister defect occurrence rate. In Fig. 2, the horizontal axis represents cold rolling reduction ratio (-), and the vertical axis represents the blister defect occurrence rate (%). As shown in Fig. 2, the rolling reduction ratio of cold rolling also correlates with the blister defect occurrence rate, and the blister defect occurrence rate tends to decrease as the rolling reduction ratio of cold rolling is increased. This result shows that instead of width reduction of the slab, or together with width reduction of the slab, cold rolling may be performed at a rolling reduction ratio which is predetermined in accordance with the thickness of the hot-rolled steel sheet, and thereby, occurrence of blister defects can be suppressed.

[0029] Furthermore, the proper rolling reduction ratio in accordance with the thickness of the hot-rolled steel sheet can be predetermined by grasping the relationship between the rolling reduction ratio of cold rolling and the blister defect occurrence rate shown in Fig. 2 by an experiment or the like. That is, in the example shown in Fig. 2, it is clear that by performing cold rolling at a rolling reduction ratio of 0.76 or more on a hot-rolled steel sheet with a thickness of 2.6 to 4.0 mm, the blister occurrence rate can be greatly decreased.

[0030] Furthermore, as described above, since the mechanism of suppression of occurrence of blister defects by slab width reduction is different from the mechanism of suppression of occurrence of blister defects by cold rolling, it is clear that by using these techniques together, the occurrence of blister defects can be further suppressed. In the case where slab width reduction and cold rolling are used together, slabs subjected to width reduction with different reduction amounts are prepared, and regarding hot-rolled steel sheets produced from the slabs prepared, the relationship between the cold rolling reduction ratio and the blister defect occurrence rate is grasped in advance by an experiment or the like. In this way, the width reduction amount in accordance with the slab width and the rolling reduction ratio in accordance with the thickness of the hot-rolled steel sheet can be predetermined.

[0031] In the case where the occurrence of blister defects is suppressed by width reduction, an ultra-low carbon steel product produced by the method for producing an ultra-low carbon steel product according to the embodiment is a hot-rolled steel sheet obtained by subjecting an ultra-low carbon steel slab with 0.005% by mass or less to width reduction with a predetermined width reduction amount, followed by hot rolling and pickling. Furthermore, in the case where the occurrence of blister defects is suppressed by rolling reduction of cold rolling, an ultra-low carbon steel product produced by the method for producing an ultra-low carbon steel product according to the embodiment may be a cold-rolled steel sheet obtained by subjecting an ultra-low carbon steel slab with 0.005% by mass or less to hot rolling, followed by pickling and cold rolling, or may be a hot-dip galvannealed steel sheet obtained by subjecting the cold-rolled steel sheet to hot-dip galvannealing treatment.

[0032] Furthermore, the method for producing an ultra-low carbon steel according to the embodiment can be applied not only to the ultra-low carbon steels 1 and 2 described above, but also to an ultra-low carbon steel 3 whose standard component concentrations are C concentration: 0.0000 to 0.0030, Si concentration: 0.00 to 0.03% by mass, Mn concentration: 0.10 to 0.25% by mass, P concentration: 0.015 to 0.030% by mass, S concentration: 0.005 to 0.012% by mass, and N concentration: 0.0000 to 0.0035% by mass, and an ultra-low carbon steel 4 whose standard component concentrations are C concentration: 0.0000 to 0.0020, Si concentration: 0.00 to 0.04% by mass, Mn concentration: 0.10 to 0.25% by mass, P concentration: 0.000 to 0.010% by mass, S concentration: 0.004 to 0.012% by mass, and N concentration: 0.0000 to 0.0030% by mass.

Claims

1. A method for producing an ultra-low carbon steel product having a carbon concentration of 0.005% by mass or less, the method comprising, at least, a refining step of adjusting a carbon concentration of molten iron to obtain molten steel, a casting step of casting the molten steel into a slab, and a hot rolling step of hot rolling the slab to obtain a hot-rolled steel sheet,
   wherein the method further comprises a width reduction step of performing width reduction on the slab to be subjected to the hot rolling step with a reduction amount which is predetermined in accordance with the slab width in a direction orthogonal to the rolling direction of the slab.

2. A method for producing an ultra-low carbon steel product having a carbon concentration of 0.005% by mass or less, the method comprising, at least, a refining step of adjusting a carbon concentration of molten iron to obtain molten steel, a casting step of casting the molten steel into a slab, a hot rolling step of hot rolling the slab to obtain a hot-rolled steel sheet, and a cold rolling step of cold rolling the hot-rolled steel sheet to obtain a cold-rolled steel sheet, wherein in the cold rolling step, cold rolling is performed at a rolling reduction ratio which is predetermined in accordance with the thickness of the hot-rolled steel sheet.

3. The method for producing an ultra-low carbon steel product according to Claim 2, further comprising a width reduction step of performing width reduction on the slab to be subjected to the hot rolling step with a reduction amount which is predetermined in accordance with the slab width in a direction orthogonal to the rolling direction of the slab.

FIG. 1

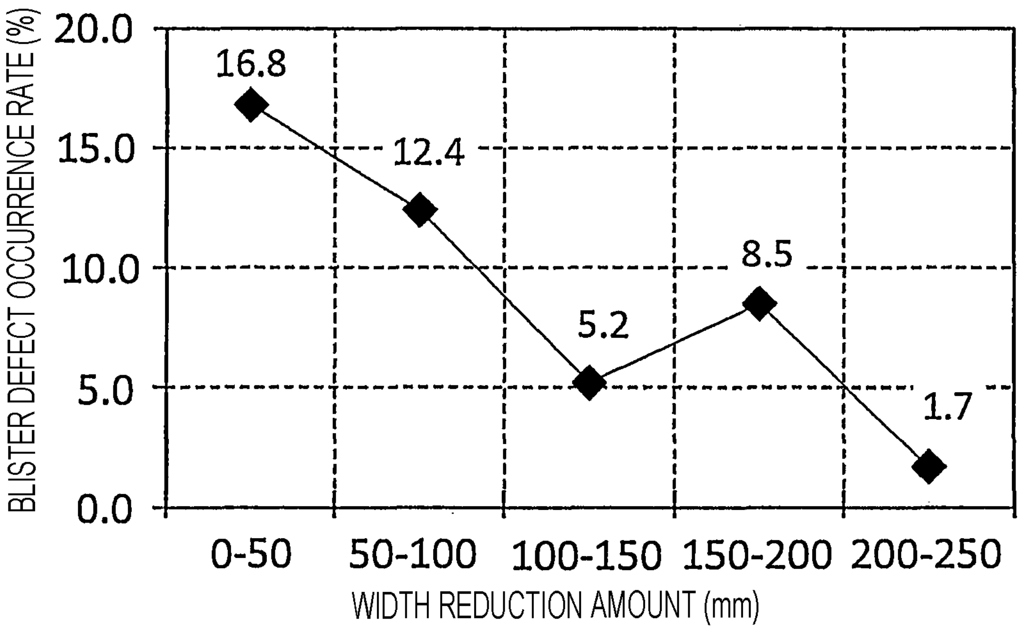
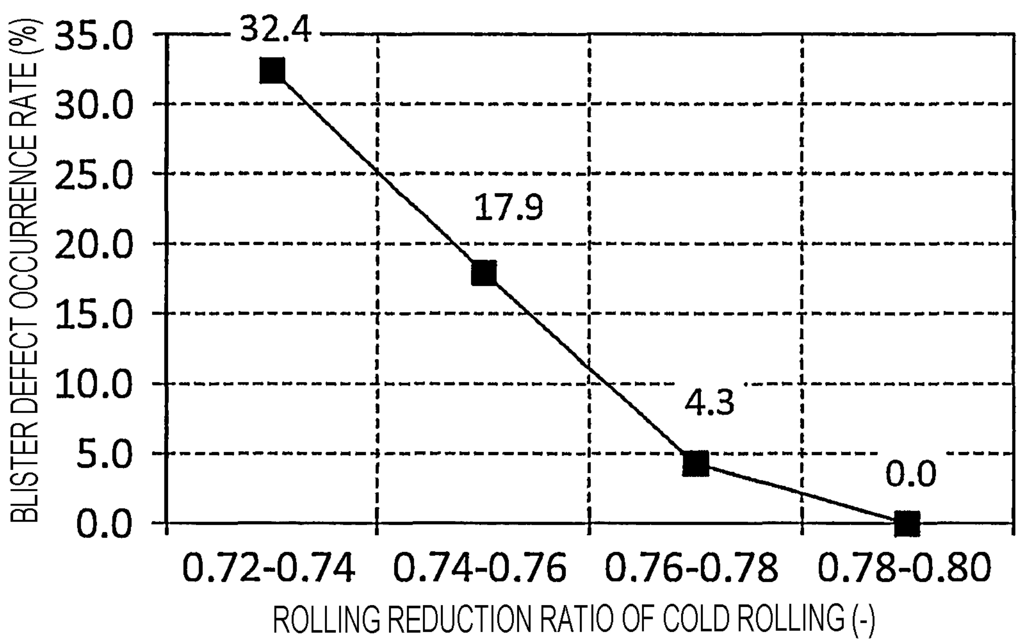

BLISTER DEFECT OCCURRENCE RATE (%)
20.0
15.0
10.0
5.0
0.0
16.8
12.4
5.2
8.5
1.7
0-50
50-100
100-150
150-200
200-250
WIDTH REDUCTION AMOUNT (mm)

FIG. 2


BLISTER DEFECT OCCURRENCE RATE (%)
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
32.4
17.9
4.3
0.0
0.72-0.74
0.74-0.76
0.76-0.78
0.78-0.80
ROLLING REDUCTION RATIO OF COLD ROLLING (-)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2021/025374

A. CLASSIFICATION OF SUBJECT MATTER
Int. Cl. C21C7/068(2006.01)i, C22C38/00(2006.01)i, C22C38/04(2006.01)i, B22D11/00(2006.01)i, B21B1/02(2006.01)i
FI: B21B1/02 E, B22D11/00 A, C21C7/068, C22C38/00 301R, C22C38/04
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)
Int. Cl. C21C7/068, C22C38/00, C22C38/04, B22D11/00, B21B1/02

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Published examined utility model applications of Japan 1922-1996
Published unexamined utility model applications of Japan 1971-2021
Registered utility model specifications of Japan 1996-2021
Published registered utility model applications of Japan 1994-2021

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	JP 2001-137905 A (NIPPON STEEL CORP.) 22 May 2001 (2001-05-22) paragraphs [0002], [0005]-[0007], [0009], [0011],	1
Y	paragraphs [0002], [0005]-[0007], [0009], [0011]	2-3
Y	JP 56-003413 B2 (NIPPON STEEL CORP.) 24 January 1981 (1981-01-24), claims	2-3
Y	JP 63-002504 A (FURUKAWA ALUMINIUM CO., LTD.) 07 January 1988 (1988-01-07), p. 2, lower left column, lines 9, 10	2-3

☐ 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
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"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
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
31.08.2021	14.09.2021

Name and mailing address of the ISA/	Authorized officer
Japan Patent Office 3-4-3, Kasumigaseki, Chiyoda-ku, Tokyo 100-8915, Japan	Telephone No.

Form PCT/ISA/210 (second sheet) (January 2015)

INTERNATIONAL SEARCH REPORT

International application No.

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

(See extra sheet.)

1. ☒ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☒ No protest accompanied the payment of additional search fees.

Form PCT/ISA/210 (continuation of first sheet (2)) (January 2015)

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/JP2021/025374

Patent Documents referred to in the Report	Publication Date	Patent Family	Publication Date
JP 2001-137905 A	22.05.2001	(Family: none)	
JP 56-003413 B2	24.01.1981	(Family: none)	
JP 63-002504 A	07.01.1988	(Family: none)	

Form PCT/ISA/210 (patent family annex) (January 2015)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2021/025374

(Continuation of Box No. III)

Document 1: JP 2001-137905 A (NIPPON STEEL CORP.) 22 May 2001 (2001-05-22), paragraphs [0002], [0005]-[0007], [0009], [0011] (Family: none)

The claims are classified into the following two inventions.

(Invention 1) Claim 1 of the present application

Document 1 (paragraphs [0002], [0005]-[0007], [0009], and [0011]) discloses the configuration of the invention in claim 1 of the present application, as stated below:

performing a prescribed component adjustment at a secondary refining facility by degassing, powder blowing, and stirring on molten steel that has been refined in a steelmaking furnace such as a converter or an electric furnace (corresponding to the "refining step for adjusting at least the carbon concentration of the molten iron to make molten steel" in the present application): paragraph [0006]

casting, at a continuous casting facility, the molten steel that was produced to have the prescribed components (corresponding to the "casting step for casting the molten steel into a slab" in the present application): paragraph [0007]

producing a thin plate, subsequent to the production of the slab by continuous casting, through a hot rolling step, and optionally thereafter through a cold rolling step (corresponding to the "hot rolling step for hot-rolling the slab to make a hot-rolled steel plate" in the present application): paragraph [0005]

using the casting method of the present invention when producing Ti-bearing ultra-low carbon steel for automobile use or thick plate steel for general structures in the converter-RH-continuous casting step: paragraph [0009]

ultra-low carbon steel having 0.004% or less C (corresponding to the "method of producing an ultra-low carbon steel product having a carbon concentration of 0.005 mass% or less" in the present application): paragraph [0002]

either without change or heating to 1100-1300°C, width-rolling to the width dimension of a finished plate (corresponding to an "edging step for

Form PCT/ISA/210 (extra sheet) (January 2015)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2021/025374

edging the slab to be subjected to the hot rolling step, with an amount of pressing established in advance in accordance with a slab width of a direction orthogonal to the direction of rolling of the slab" in the present application): paragraph [0005].

Claim 1 of the present application is deprived of novelty by document 1 and therefore does not have a special technical feature.

As such, the invention in claim 1 of the present application is classified as invention 1.

(Invention 2) Claims 2-3 of the present application

Claims 2-3 of the present application cannot be said to have a feature identical to or corresponding to that of claim 1 of the present application classified as invention 1.

Furthermore, claims 2-3 of the present application are not substantially identical to or similarly closely related to any of the claims classified as invention 1.

As such, claims 2-3 of the present application cannot be classified as invention 1.

Claims 2-3 in the present application has a special technical feature of "comprising ... and a cold rolling step for cold-rolling the hot-rolled steel plate to make a cold-rolled steel plate, the cold rolling step involving cold rolling at a rolling reduction ratio that is established in advance in accordance with the plate thickness of the hot-rolled steel plate."

As such, the invention in claims 2-3 of the present application is classified as invention 2.

REFERENCES CITED IN THE DESCRIPTION

Patent documents cited in the description

- JP 2011206846 A **[0005]**

Non-patent literature cited in the description

- **MASAMICHI KOWAKA.** Metal Corrosion Damage and Corrosion Protection Technology. Agune Inc, 1983, 207 **[0006]**