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

(11) EP 4 170 054 A1

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

(43) Date of publication:
26.04.2023 Bulletin 2023/17

(21) Application number: **21824759.1**

(22) Date of filing: **01.06.2021**

(51) International Patent Classification (IPC):
C22C 38/00 *(2006.01)* ***C22C 38/12*** *(2006.01)*
B22D 11/00 *(2006.01)* ***B22D 11/04*** *(2006.01)*
B22D 11/124 *(2006.01)*

(52) Cooperative Patent Classification (CPC):
B22D 11/00; B22D 11/04; B22D 11/124; C22C 38/00; C22C 38/12

(86) International application number:
PCT/JP2021/020838

(87) International publication number:
WO 2021/256243 (23.12.2021 Gazette 2021/51)

(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: **18.06.2020 JP 2020105178**

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

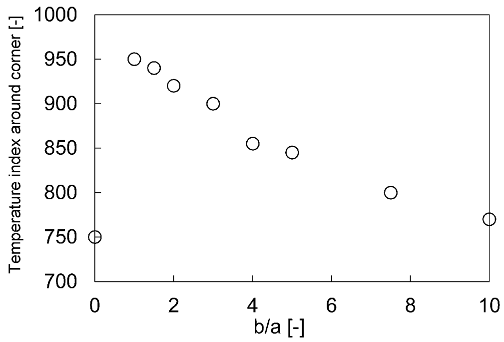
(72) Inventors:
- **ODAGAKI, Tomoya**
  Tokyo 100-0011 (JP)
- **ARAMAKI, Norichika**
  Tokyo 100-0011 (JP)
- **SHIGETOSHI, Yasuhiro**
  Tokyo 100-0011 (JP)
- **OBA, Yoshiharu**
  Tokyo 100-0011 (JP)
- **MARUKO, Takashi**
  Tokyo 100-0011 (JP)

(74) Representative: **Haseltine Lake Kempner LLP**
Bürkleinstrasse 10
80538 München (DE)

(54) **CONTINUOUS CASTING METHOD**

(57) A continuous casting method that manufactures a slab that is of high quality, particularly free of corner cracks, by reliably mitigating surface cracks of a cast slab is proposed. In this continuous casting method for steel, a mold having a chamfered shape meeting $0.09 \leq C/L \leq 0.20$ (where C is an amount (mm) of chamfering at a corner, and L is a length (mm) of a short side of a cast slab) at each corner portion of the mold is used, and an average flow rate of secondary cooling water sprayed onto corner portions of the cast slab in a section from immediately below the mold to lower straightening part is set to 20 to 60 L/(min·m^2). In particular, it is preferable that the steel has an element composition including, in mass%, C: 0.05 to 0.25% and Mn: 1.0 to 4.0%, and further optionally one or more elements selected from Nb: 0.01 to 0.1%, V: 0.01 to 0.1%, and Mo: 0.01 to 0.1%.

FIG. 2



EP 4 170 054 A1

Description

Technical Field

[0001] The present invention relates to a continuous casting method for steel that mitigates occurrence of surface cracks of a cast slab in continuous casting.

Background Art

[0002] Recently, as specifications required for high-tensile-strength steel have become more stringent, the amounts of alloy elements, such as Cu, Ni, Nb, V, and Ti, contained in sheet steel have been increased for the purpose of enhancing its mechanical properties. When casting such alloy steel using, for example, a vertical bending continuous caster, four corners of a cast slab in rectangular cross-section orthogonal to the casting direction (hereinafter referred to also as corner portions of a cast slab) are subjected to stress in a cast slab straightening part or bending part, which is likely to result in surface cracks, especially cracks at the corner portions of the cast slab. Being a frequent cause of a surface defect of a thick steel sheet, such corner cracks cause a decrease in the yield of steel sheet products.

[0003] Specifically, a cast slab of alloy steel undergoes a significant decrease in hot ductility at temperatures near an Ar_3 transformation point at which its solidification structure transforms from the austenite phase to the ferrite phase.

[0004] Therefore, to prevent the aforementioned corner cracks, common practice in a continuous casting process is to control the surface temperature of the cast slab by secondary cooling and straighten it at a temperature equal to or higher than the transformation point, or to control the solidification structure of the cast slab to be a structure resistant to cracking.

[0005] Common practice for keeping the surface temperature of the cast slab at a higher temperature is to reduce a spray width that involves closing spray pipes near the corner portions of the cast slab so as not to perform cooling.

[0006] As a method of controlling the solidification structure, for example, Patent Literature 1 discloses a technique that starts secondary cooling of a cast slab immediately after the cast slab is withdrawn from a rectangular mold to temporarily cool the cast slab until the surface temperature becomes lower than the Ar_3 transformation point; then heats the cast slab to recover a temperature exceeding the Ar_3 transformation point; and, when straightening the cast slab thereafter, controls the time of holding the surface temperature of the cast slab at a temperature lower than the Ar_3 transformation point and the lowest temperature that the surface temperature of the cast slab reaches within respective appropriate ranges. Thus, the solidification structure of the cast slab to a depth of at least 2 mm from the surface is made into a mixed structure of ferrite and perlite with an unclear austenite grain boundary.

Citation List

Patent Literature

[0007] Patent Literature 1: JP2002-307149A

Summary of Invention

Technical Problem

[0008] However, the above-described related art has the following problems.

[0009] The technique of spray width reduction stops spraying from sprays near the corner portions of a cast slab to prevent a decrease in the corner temperature. However, cast slabs come in many different widths to meet the diverse needs of recent years. Thus, one problem is that appropriately reducing the spray width at the corners for cast slabs of all sizes requires enormous facility investment. In addition, when the casting speed slows, the corner portions of the cast slab, which are cooled from two sides, the sides of a long side and a short side of the slab, tend to be overcooled. Another problem is that, as the residence time inside the continuous caster increases, even when cooling sprays are not activated, the corner temperature decreases due to radiation cooling.

[0010] Further, the technique described in Patent Literature 1 raises a concern about the influence of dripping water that flows over the cast slab after being sprayed from the secondary cooling spray onto the cast slab. In particular, when the casting speed slows, the dripping water affects the cooling of the surface of the cast slab, which may make it difficult to quantitatively control the surface temperature of the cast slab by, for example, heat transfer calculation.

[0011] Having been contrived in view of these circumstances, the present invention aims to propose a continuous casting method that manufactures a slab that is of high quality, particularly free of corner cracks, by reliably mitigating surface cracks of a cast slab that have been hitherto not sufficiently eliminated solely by temperature control of the cast slab through secondary cooling.

Solution to Problem

[0012] The present inventors found that surface cracks of a cast slab could be mitigated by mitigating a temperature decrease of the corner portions of the cast slab during secondary cooling while using a mold having a casting space of an appropriate shape, which led us to conceive of the present invention.

[0013] A continuous casting method of the present invention that advantageously solves the above problems is a continuous casting method for steel, characterized in that a mold having a chamfered shape meeting a following Formula (1) at each corner portion of the mold is used, and in that an average flow rate of secondary cooling water sprayed onto corner portions of a cast slab in a section from immediately below the mold to lower straightening part is set to 20 to 60 L/(min·m^2):

$$0.09 \le \mathrm{C/L} \le 0.20 \cdots (1)$$

where C is an amount (mm) of chamfering of a corner, and L is a length (mm) of a short side of the cast slab.

[0014] The continuous casting method according to the present invention could be a more preferable solution when the steel has an element composition including, in mass%, C: 0.05 to 0.25% and Mn: 1.0 to 4.0%, and further optionally one or more elements selected from Nb: 0.01 to 0.1%, V: 0.01 to 0.1%, and Mo: 0.01 to 0.1%.

Advantageous Effects of Invention

[0015] The present invention controls the temperature of the corner portions of the cast slab through secondary cooling while using a mold in which a casting space of an appropriate shape is defined, and can thereby prevent corner cracks of the cast slab in continuous casting and provide a high-quality slab.

Brief Description of Drawings

[0016]

[Figure 1] Figure 1 is a schematic top view showing a mold according to one embodiment of the present invention.
[Figure 2] Figure 2 is a graph showing an influence of a chamfered shape on a temperature of corner portions of a cast slab.

Description of Embodiment

[0017] A continuous casting method for steel (steel slab manufacturing method) according to one embodiment of the present invention has casting process in which a cast slab having been withdrawn from a continuous casting mold is supported by a plurality of pairs of rolls facing each other. First, molten steel is subjected to primary cooling in the mold. Thereafter, the cast slab is withdrawn from the mold at a predetermined withdrawal speed, and this cast slab is subjected to secondary cooling while being supported by a plurality of pairs of rolls arrayed in a casting direction to obtain a steel slab. For example, in the case of a curved continuous caster, there is one pair or a plurality of pairs of rolls that straightens a curved cast slab near an exit side, and the cast slab is withdrawn in a horizontal direction after its bend is straightened by these rolls. In this process, to prevent surface cracks from being induced at the corner portions of the cast slab during straightening, it is important to use a mold in which a casting space of an appropriate shape is defined and to go through an appropriate cooling pattern in a cooling zone from immediately below the mold to an unbending straightening point (lower straightening part). The continuous caster used in this embodiment is not particularly limited as long as it includes bending or unbending straightening in a section from immediately below the mold to a location of carrying out of the cast slab.

[0018] Here, the present inventors observed surface cracks in a cast slab cast by a curved continuous caster. Surface cracks in the cast slab was frequently occurred at its upper surface corners and around these corners. This is because tensile stress occurs during unbending straightening. The upper surface side of the cast slab refers to the inner side of a bend in a curved zone of the curved continuous caster, i.e., the side of the long-side surface that constitutes the upper surface in a horizontal zone.

[0019] When we etched a cracked part, the cracks had propagated along the former austenite grain boundary. Therefore, we presumed that cracks had occurred in a temperature range in which transformation from austenite to ferrite started (generally called a embrittlement temperature), and conducted an experiment in which secondary cooling conditions were changed in various ways.

[0020] Specifically, we conducted an experiment using a heat transfer analysis under various secondary cooling conditions, and learned that cracks at the corner portions of a cast slab were reduced when the average flow rate of a spray of secondary cooling water sprayed onto areas around the corner portions of the cast slab was controlled to be lower than 20 L/(min·m^2) in a section from immediately below the mold to the entry to the lower (unbending) straightening part and the surface temperature was controlled so as not to decrease to or below the Ar_3 point before the cast slab undergoes unbending straightening.

[0021] However, since the temperature of the corner portions of the cast slab tends to decrease compared with the surrounding area as described above, it was necessary to considerably reduce the amount of the cooling spray, which led to insufficient cooling of the surface of the cast slab other than the corner portions. The resulting lack of solidified shell thickness caused cast slab bulging (a phenomenon of a cast slab bulging between support rolls due to the static pressure of molten steel), which in turn caused cracks inside the solidified shell.

[0022] Therefore, the present inventors focused attention on the shape of the cast slab. As the cross section of the conventional cast slab is rectangular and its corner portions are cooled from two sides, the corner portions of the cast slab tend to be overcooled. We considered that changing the shape of the cast slab might change the cooling mechanism and thereby mitigate overcooling, and studied a more appropriate shape of a cast slab by a thermal stress analysis.

[0023] As a result of conducting a study based on a thermal stress analysis, we found that overcooling and, further, stress loading at the corner portions of the cast slab could be reduced by forming the cast slab into a chamfered shape with edges at the four corners in a rectangular cross-section orthogonal to the casting direction cut away. To form a chamfered shape at four corners of the cast slab, it is important to cast it using a mold in which (right-angled portions of) the four corners of the casting space that is rectangular as with a mold with a rectangular cross-section are cut away into a right-angled triangular shape so as to form a chamfered shape. Hereinafter, a mold having such a casting space of a chamfered shape will also be referred to as a chamfered mold.

[0024] As a result of our intensive studies aimed at finding out a chamfered shape of a mold that suits the object of the present invention, the following shape specification turned out to be necessary. A chamfered portion 4 in a chamfered mold is shown in Figure 1 that is a top view of the chamfered mold. When chamfering the right-angled portion at each corner of a rectangular casting space into a right-angled triangular shape, we specified this right-angled triangular shape by a ratio b/a that is a ratio of a length b on the side of a mold short side 3 to a length a on the side of a mold long side 2, and performed a thermal analysis on the influence of this ratio b/a on overcooling of the corner portion. Figure 2 shows the calculation result, with the temperature in a rectangular mold before chamfering (b = a = 0 in Figure 1) being standardized as 750 °C. Here, the examination was conducted with a set to be within a range of 2 to 20 mm and b fixed at 20 mm. As the temperature of the corner portion of the cast slab in the chamfered mold, the lowest one among temperatures at two corners resulting from chamfering and at a point therebetween was used. As shown in Figure 2, first, it can be seen that when the chamfered mold is used, the temperature of the corner portion of the cast slab becomes higher compared with that in the rectangular mold. In particular, the temperature of the corner portion of the cast slab is highest at a ratio b/a = 1. In this embodiment, an amount of chamfering C (= a = b) was defined under the most effective condition b/a = 1, and a continuous casting mold 1 was designed accordingly.

[0025] As described above, this embodiment is suitably applied to steel that has high embrittlement sensitivity in transformation from austenite to ferrite. For example, this embodiment can be suitably applied when the element composition of the steel includes, in mass%, C: 0.05 to 0.25% and Mn: 1.0 to 4.0%, and further optionally one or more elements selected from Nb: 0.01 to 0.1%, V: 0.01 to 0.1%, and Mo: 0.01 to 0.1%. Hereinafter, unless otherwise noted, "mass%" in an element composition will be simply written as "%."

C: 0.05 to 0.25%

[0026] When the content of C is 0.05 to 0.25%, austenite grains are especially likely to coarsen. Therefore, it is preferable that this embodiment is applied when the steel has a composition with a content of C of 0.05 to 0.25% and thus has high embrittlement sensitivity.

Mn: 1.0 to 4.0%

[0027] When the content of Mn is lower than 1.0%, MnS that is an embrittlement factor is less likely to form and therefore no problems arise. When the content is 1.0% or higher, the embrittlement sensitivity becomes high, and when it exceeds 4.0%, the strength of the product becomes too high, which is not desirable. Therefore, it is preferable that this embodiment is applied when the steel has a composition with a content of Mn of 1.0 to 4.0% and thus has high embrittlement sensitivity.

One or more elements selected from Nb: 0.01 to 0.1%, V: 0.01 to 0.1%, and Mo: 0.01 to 0.1%

[0028] Nb, V, and Mo are elements that contribute to enhancing the strength of steel. When the content of each of these elements is lower than 0.01%, carbonitride that is an embrittlement factor is less likely to form and therefore no problems arise. On the other hand, when the content exceeds 0.1%, the price of the alloy becomes high and the cost increases, as well as the performance becomes excessively higher than necessary. Therefore, adding these elements at a ratio higher than 0.1% is not desirable.

Examples

(Example 1)

[0029] Using a curved continuous caster, steel having a predetermined element composition including, in mass%, C: 0.18%, Si: 1.4%, Mn: 2.8%, P: 0.020% or less, S: 0.003% or less, and Ti: 0.020% was cast. The Ar_3 transformation point of this steel is 805°C. As for casting conditions, the cast thickness was 220 mm, the cast width was 1000 to 1600 mm, and the casting speed was within a range of 1.20 to 1.80 m/min. The temperature of the cast slab at the time of passing an unbending part (lower straightening part) was checked by measuring it using a thermocouple or a radiation thermometer. To facilitate observation of surface cracks in the cast slab, oxides on the surface of the cast slab having been cast were removed by shot blasting, and then a color check (a dye penetrant test) was performed to examine the corner portions of the cast slab for cracks. An occurrence rate of corner cracks was evaluated by: the number of cast slabs having corner cracks / the number of cast slabs examined × 100%. For the examination of internal cracks, cross-section samples perpendicular to the casting direction of the cast slabs were cut out, and after finish milling, macro-etching was conducted using warm hydrochloric acid. Whether internal cracks were present or absent was examined in pictures of macro-etching.

[0030] First, an examination was conducted to determine the magnitude of the chamfer size (the amount of chamfering) C [mm] for exhibiting an effect. Here, the average flow rate of secondary cooling water sprayed onto the corner portions of the cast slab in a section from immediately below the mold to lower straightening part was fixed at 60 L/(min·m^2). The result is shown in Table 1. When the length of the short side of the cast slab is L [mm], in the case of Tests No. 1 and 2 in which C/L is lower than 0.09, the distances from the long side and the short side differ little from those in a rectangular corner, so that hardly any mitigating effect on overcooling is produced. On the other hand, in the case of Tests No. 8 and 9 in which C/L is higher than 0.20, a connection area between the chamfered portion and the short side or between the chamfered portion and the long side was subjected to cooling from two sides, which lowered the temperature of the corner portion of the cast slab. Thus, it was learned that the amount of chamfering of the chamfered mold needed to be within a range of $0.09 \le C/L \le 0.20$.

[Table 1]

No.	Thickness L	Chamfer C	C/L	Secondary cooling water flow rate	Corner temperature	Occurrence rate of corner cracks	Presence or absence of internal cracks	Remarks
	[mm]	[mm]	[-]	[L/(mim·m^2)]	[°C]	[%]		
1	220	15	0.068	60	780	0.7	Absent	Comparative Example
2	220	18	0.082	60	800	0.4	Absent	Comparative Example
3	220	20	0.091	60	825	0	Absent	Inventive Example
4	220	25	0.114	60	880	0	Absent	Inventive Example
5	220	30	0.136	60	850	0	Absent	Inventive Example
6	220	40	0.182	60	820	0	Absent	Inventive Example
7	220	42	0.191	60	810	0	Absent	Inventive Example
8	220	45	0.205	60	765	1.5	Absent	Comparative Example
9	220	50	0.227	60	763	1.6	Absent	Comparative Example

(Example 2)

[0031] Next, tests were conducted using the same type of steel and the same continuous casting conditions as in Example 1 to determine a relationship between the average flow rate of secondary cooling water sprayed onto the corner portions of the cast slab before the cast slab passes the unbending part (lower straightening part) and corner and internal cracks. The result is shown in Table 2.

[0032] It can be seen that in the case of a rectangular mold (Tests No. 10 to 16), setting the average flow rate of secondary cooling water to be lower than 20 L/(min·m^2) (Tests No. 10 and 11) raises the corner temperature to or above Ar_3 and reduces corner cracks. However, as it is impossible to slowly cool only the corners, the solidified shell thickness around the corners became insufficient and internal cracks due to bulging occurred. This demonstrates that an ordinary rectangular mold cannot mitigate both corner cracks and internal cracks at the same time. Also when a chamfered mold that does not comply with this embodiment is used (Tests No. 17 to 23), hardly any mitigating effect on corner overcooling is produced as has been shown in Example 1. Thus, as with the rectangular mold, unless the average flow rate of secondary cooling water was reduced to below 20 L/(min·m^2), corner cracks could not be mitigated and internal cracks due to bulging could not be avoided. Similarly, when the chamfered mold of this embodiment is used (Tests No. 24 to 31), internal cracks occur at a flow rate below 20 L/(min·m^2) (Tests No. 24 and 25). On the other hand, owing to the effect of changing the shape of the cast slab, overcooling of the corner portions of the cast slab was mitigated and corner cracks could be prevented when the average flow rate of secondary cooling water was within a range equal to or lower than 60 L/(min·m^2) (Tests No. 24 to 30). Thus, setting the average flow rate of secondary cooling water sprayed onto the corner portions in a section from immediately below the mold to lower straightening part to be within a range of 20 to 60 L/(min·m^2) (Tests No. 26 to 30) allowed the cast slab to be manufactured with both corner cracks and internal cracks mitigated at the same time.

[Table 2]

No.	Thickness L	Chamfer C	C/L	Secondary cooling water flow rate	Corner temperature	Occurrence rate of corner cracks	Presence or absence of internal cracks	Remarks
	[mm]	[mm]	[-]	[L/(min·m^2)]	[°C]	[%]		
10	220	0	0	10	820	0	Present	Comparative Example
11	220	0	0	15	805	0.2	Present	Comparative Example
12	220	0	0	20	800	0.4	Absent	Comparative Example
13	220	0	0	30	790	0.9	Absent	Comparative Example
14	220	0	0	40	780	1.2	Absent	Comparative Example
15	220	0	0	50	770	1.1	Absent	Comparative Example
16	220	0	0	60	740	1.8	Absent	Comparative Example
17	220	18	0.082	10	830	0	Present	Comparative Example
18	220	18	0.082	15	810	0.1	Present	Comparative Example
19	220	18	0.082	20	805	0.3	Absent	Comparative Example
20	220	18	0.082	30	795	0.8	Absent	Comparative Example
21	220	18	0.082	40	790	1	Absent	Comparative Example
22	220	18	0.082	50	785	1.3	Absent	Comparative Example
23	220	18	0.082	60	780	1.2	Absent	Comparative Example

(continued)

No.	Thickness L	Chamfer C	C/L	Secondary cooling water flow rate	Corner temperature	Occurrence rate of corner cracks	Presence or absence of internal cracks	Remarks
	[mm]	[mm]	[-]	[L/(min·m^2)]	[°C]	[%]		
24	220	20	0.091	10	980	0	Present	Comparative Example
25	220	20	0.091	15	940	0	Present	Comparative Example
26	220	20	0.091	20	920	0	Absent	Inventive Example
27	220	20	0.091	30	900	0	Absent	Inventive Example
28	220	20	0.091	40	870	0	Absent	Inventive Example
29	220	20	0.091	50	840	0	Absent	Inventive Example
30	220	20	0.091	60	810	0	Absent	Inventive Example
31	220	20	0.091	65	800	0.5	Absent	Comparative Example

Reference Signs List

[0033]

1 Continuous casting mold
2 Long side
3 Short side
4 Chamfered portion

Claims

1. A continuous casting method for steel, **characterized in that** a mold having a chamfered shape meeting a following Formula (1) at each corner portion of the mold is used, and **in that** an average flow rate of secondary cooling water sprayed onto corner portions of a cast slab in a section from immediately below the mold to lower straightening part is set to 20 to 60 L/(min·m^2):

$$0.09 \leq C/L \leq 0.20 \cdots (1)$$

where C is an amount (mm) of chamfering of a corner, and L is a length (mm) of a short side of the cast slab.

2. The continuous casting method according to claim 1, wherein the steel has an element composition including, in mass%, C: 0.05 to 0.25% and Mn: 1.0 to 4.0%, and further optionally one or more elements selected from Nb: 0.01 to 0.1%, V: 0.01 to 0.1%, and Mo: 0.01 to 0.1%.

FIG. 1

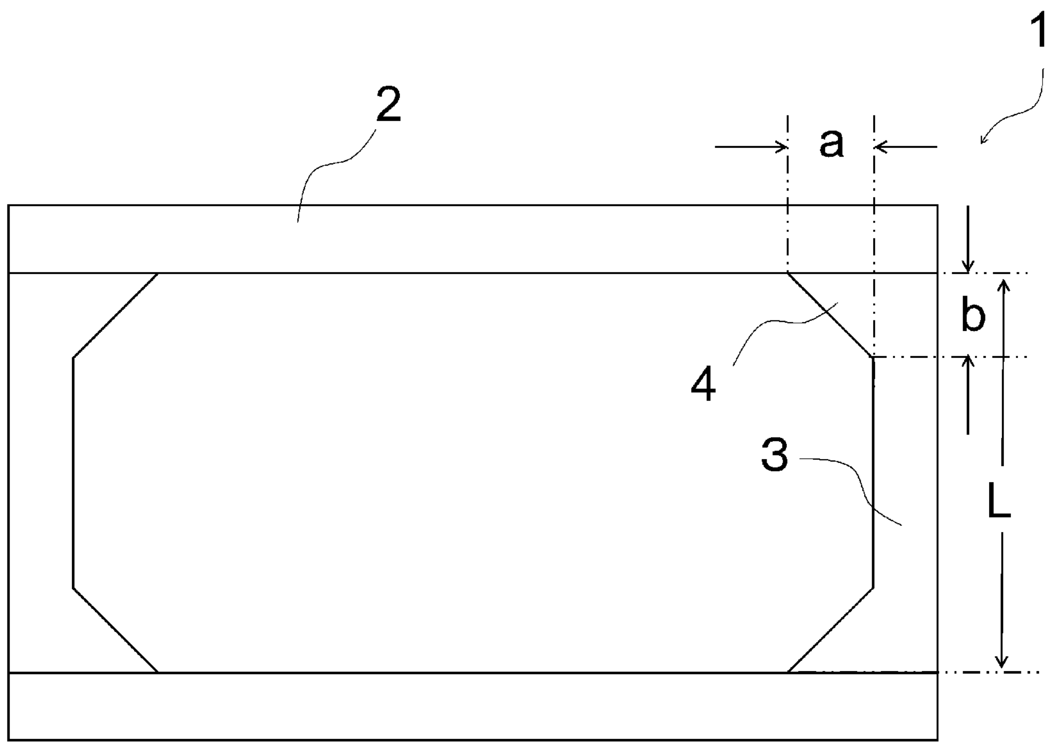
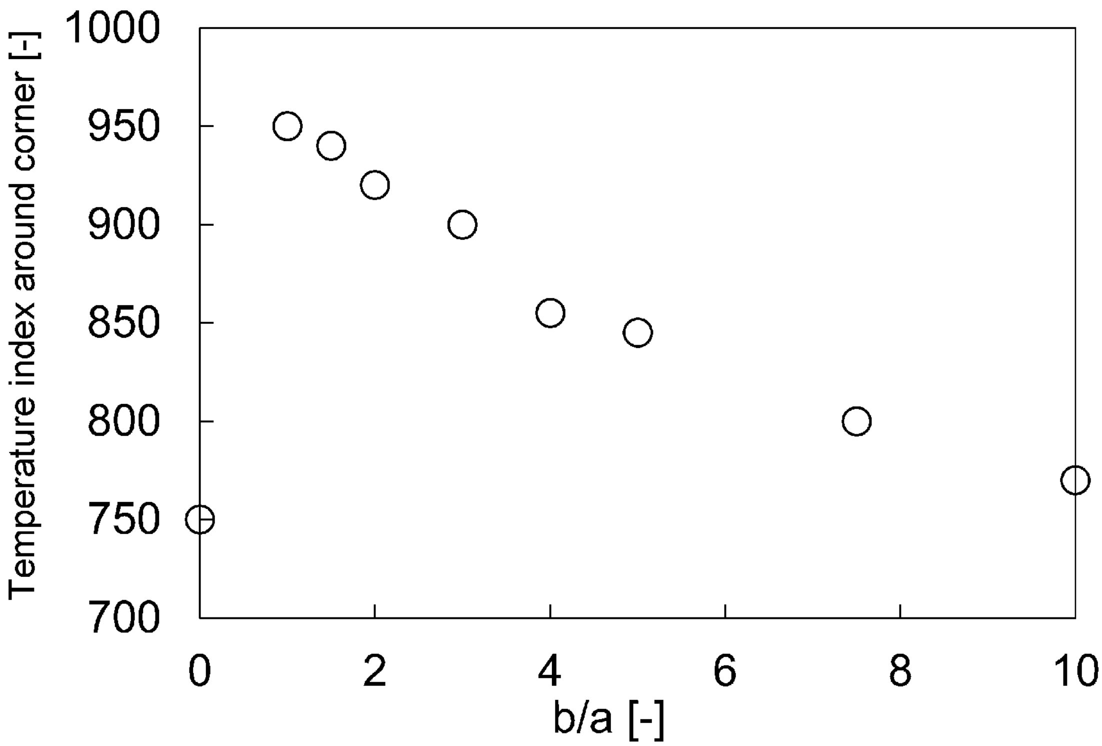

1
2
a
b
4
3
L

FIG. 2


Temperature index around corner [-]
1000
950
900
850
800
750
700
0
2
4
6
8
10
b/a [-]

INTERNATIONAL SEARCH REPORT

International application No. PCT/JP2021/020838

A. CLASSIFICATION OF SUBJECT MATTER

Int.Cl. C22C38/00(2006.01)i, C22C38/12(2006.01)i, B22D11/00(2006.01)i, B22D11/04(2006.01)i, B22D11/124(2006.01)i

FI: B22D11/124N, B22D11/04311F, B22D11/00A, B22D11/00G, C22C38/00301Z, C22C38/12

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. C22C38/00, C22C38/12, B22D11/00, B22D11/04, B22D11/124

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.
A	JP 2015-128776 A (MISHIMA KOSAN CO., LTD.) 16 July 2015 (2015-07-16), entire text	1, 2
A	JP 2020-66018 A (NIPPON STEEL CORP.) 30 April 2020 (2020-04-30), entire text	1, 2
A	JP 2007-331000 A (KOBE STEEL, LTD.) 27 December 2007 (2007-12-27), entire text	1, 2
A	JP 2015-503450 A (POSCO) 02 February 2015 (2015-02-02), entire text	1, 2

☐ 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
08 July 2021	20 July 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
Information on patent family members

International application No.
PCT/JP2021/020838

JP 2015-128776 A	16 July 2015	(Family: none)
JP 2020-66018 A	30 April 2020	(Family: none)
JP 2007-331000 A	27 December 2007	(Family: none)
JP 2015-503450 A	02 February 2015	EP 2799162 A1 whole document WO 2013/100499 A1 KR 10-2013-0074898 A CN 104023874 A

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

REFERENCES CITED IN THE DESCRIPTION

Patent documents cited in the description

- JP 2002307149 A **[0007]**