



(11)

EP 3 686 311 A1

(12)

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

(43) Date of publication:
29.07.2020 Bulletin 2020/31

(51) Int Cl.:
C23C 2/06 (2006.01) **B21D 1/02** (2006.01)
C23C 2/20 (2006.01) **C23C 2/40** (2006.01)
C23C 2/00 (2006.01) **C23C 2/12** (2006.01)
B21D 1/05 (2006.01)

(21) Application number: **17933221.8**

(22) Date of filing: **30.11.2017**

(86) International application number:
PCT/JP2017/043023

(87) International publication number:
WO 2019/106785 (06.06.2019 Gazette 2019/23)

(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:
MA MD

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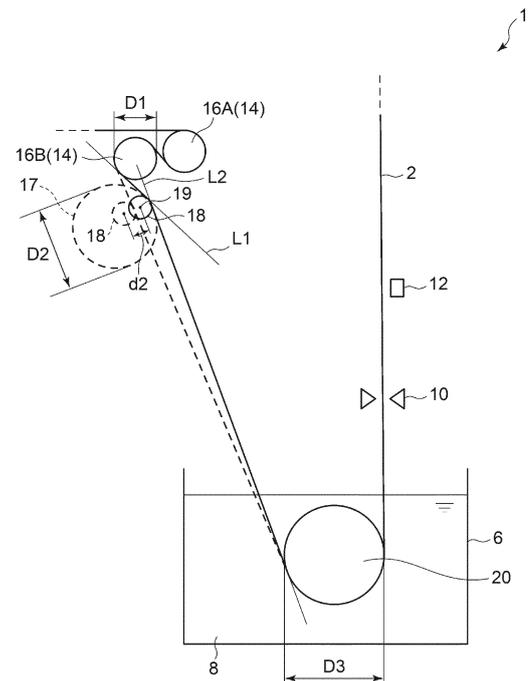
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(54) **PLATE WARP CORRECTION DEVICE FOR METAL PLATES, AND CONTINUOUS PLATING PROCESSING EQUIPMENT FOR METAL PLATES**

(57) A warpage correction apparatus for a metal strip to be used in a continuous plating facility for the metal strip includes a sink roll disposed downstream of a fixed roll, configured to change the conveying direction of the metal strip, with respect to a conveying direction of the metal strip and inside a molten metal pot for plating, and a correction roll disposed between the fixed roll and the sink roll and configured to correct warpage of the metal strip. A ratio $D3/D1$ of a diameter $D3$ of the sink roll to a diameter $D1$ of the fixed roll is not less than 1.5.

FIG. 2



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Description

TECHNICAL FIELD

[0001] The present disclosure relates to a warpage correction apparatus for a metal strip and a continuous plating facility for a metal strip.

BACKGROUND ART

[0002] In a case where a metal plate in strip form is continuously plated with molten metal (hot dip coating), it may be necessary to reduce warpage of the metal strip in the strip width direction at the outlet of a molten metal pot (plating bath) to flatten the metal strip for the sake of, for example, uniformly coating the metal strip with molten metal.

[0003] As an example of a mechanism for reducing warpage of the metal strip in the strip width direction at the outlet of the molten metal pot, Patent Documents 1 and 2 disclose a continuous hot dip coating apparatus provided with a roll disposed upstream of a plating bath for hot dip coating of a steel strip and configured to warp the steel strip in a direction opposite to crossbow warpage after passing through a sink roll in the plating bath.

[0004] Further, Patent Document 2 discloses that the pressing amount of this roll (snubber roll) upstream of the plating bath with respect to the pass line direction of the steel strip is adjustable by translationally moving the axis of the roll, and the pressing amount is adjusted in accordance with the width of the steel strip, for instance.

Citation List

Patent Literature

[0005]

Patent Document 1: JPH2-54746A
Patent Document 2: JPH3-166354A

SUMMARY

Problems to be Solved

[0006] The present inventors have intensively studied and consequently found that, when a correction roll for warping a metal strip in a direction opposite to crossbow warpage of the metal strip after passing through the sink roll is provided upstream of a molten metal pot (plating bath) as in Patent Documents 1 and 2, and in particular, when the metal strip is relatively thick (e.g., in the case of steel strip, the thickness is about 1.5 mm or more), warpage of the metal strip caused upstream of the correction roll may not be effectively corrected even by changing the apparent diameter (pressing amount) of the correction roll between minimum and maximum values.

[0007] In view of the above, an object of at least one

embodiment of the present invention is to provide a warpage correction apparatus for a metal strip and a continuous plating facility for a metal strip whereby it is possible to effectively correct warpage of the metal strip in the strip width direction even when the metal strip is relatively thick.

Solution to the Problems

[0008] A warpage correction apparatus according to at least one embodiment of the present invention for a metal strip to be used in a continuous plating facility for the metal strip comprises: a sink roll disposed downstream of a fixed roll with respect to a conveying direction of the metal strip and inside a molten metal pot for plating, the fixed roll being configured to change the conveying direction of the metal strip; and a correction roll disposed between the fixed roll and the sink roll and configured to correct warpage of the metal strip, and a ratio $D3/D1$ of a diameter $D3$ of the sink roll to a diameter $D1$ of the fixed roll is not less than 1.5.

Advantageous Effects

[0009] According to at least one embodiment of the present invention, there is provided a warpage correction apparatus for a metal strip and a continuous plating facility for a metal strip whereby it is possible to effectively correct warpage of the metal strip in the strip width direction even when the metal strip is relatively thick.

BRIEF DESCRIPTION OF DRAWINGS

[0010]

FIG. 1 is a schematic configuration diagram of a continuous plating facility according to an embodiment. FIG. 2 is a schematic diagram of a warpage correction apparatus according to an embodiment. FIG. 3 is a diagram for describing warpage amount of a metal strip. FIG. 4 is a graph showing an example of a relationship between diameter $D3$ of a sink roll and warpage amount of a metal strip by a warpage correction apparatus according to an embodiment. FIG. 5 is a graph showing an example of a relationship between diameter $D3$ of a sink roll and warpage amount of a metal strip by a warpage correction apparatus according to an embodiment. FIG. 6 is a graph showing an example of a relationship between apparent diameter $D2$ of a correction roll and warpage amount of a metal strip by a warpage correction apparatus according to Example. FIG. 7 is a graph showing an example of a relationship between apparent diameter $D2$ of a correction roll and warpage amount of a metal strip by a warpage correction apparatus according to Comparative Example.

FIG. 8 is a diagram for describing an example of a method of calculating apparent diameter D2.

DETAILED DESCRIPTION

[0011] Embodiments of the present invention will now be described in detail with reference to the accompanying drawings. It is intended, however, that unless particularly identified, dimensions, materials, shapes, relative positions and the like of components described in the embodiments shall be interpreted as illustrative only and not intended to limit the scope of the present invention.

[0012] First, with reference to FIG. 1, an overall configuration of a continuous plating facility according to some embodiments will be described.

[0013] FIG. 1 is a schematic configuration diagram of a continuous plating facility according to an embodiment. As shown in FIG. 1, the continuous plating facility 100 is a facility for continuously plating a metal strip 2 (e.g., steel strip) and includes a furnace 3 for heat treatment of the metal strip 2, a pot 6 (molten metal pot) forming a plating bath 8, and a wiping nozzle 10 for adjusting the amount of a plating solution (molten metal) adhering to the metal strip 2.

[0014] The arrow in FIG. 1 represents the conveying direction (moving direction) of the metal strip 2.

[0015] The furnace 3 is a device for heat treatment of the metal strip 2 passing therethrough. For instance, the furnace 3 may be configured to continuously anneal the metal strip 2.

[0016] The interior of the furnace 3 is provided with a plurality of rolls 14. These rolls 14 serve to apply tension to the metal strip 2 or change the direction of the metal strip 2 to convey the metal strip 2. This enables continuous treatment of the metal strip 2.

[0017] The interior of the furnace 3 may be provided with reducing or non-oxidizing gas.

[0018] An outlet portion 4 of the furnace 3 shown in FIG. 1 is provided with bridle rolls 16A, 16B for adjusting tension applied to the metal strip 2.

[0019] The temperature in the furnace 3 may vary with position. For instance, the outlet portion 4 of the furnace 3 has a relatively low temperature, while a portion on the upstream side of the outlet portion 4 with respect to the conveying direction of the metal strip 2 (hereinafter, also simply referred to as "upstream side"), e.g., a portion in the vicinity of a burner, has a relatively high temperature. Thus, when the furnace has temperature distribution, tension to be applied to the metal strip varies depending on the position in the furnace. Therefore, the bridle rolls 16A, 16B may be configured to apply appropriate tension to the metal strip 2 in accordance with the temperature distribution in the furnace 3, for instance.

[0020] Between the outlet portion 4 of the furnace 3 and the pot 6, a snout 5 is provided which is a tubular member forming a passage for the metal strip 2. An end portion of the snout 5 closer to the pot 6 is immersed in molten metal (plating bath 8) stored in the pot 6 to prevent

leakage of gas from the inside to the outside of the furnace 3 or entrance of gas (e.g., air) from the outside to the inside of the furnace 3.

[0021] The pot 6 stores molten metal as the plating solution and forms a plating bath 8.

[0022] In a case where the metal strip 2 is a steel strip, the molten metal stored in the pot 6 may be, but not limited to, zinc, aluminum, or an alloy containing them.

[0023] The pot 6 contains a sink roll 20. The metal strip 2 introduced from the inside of the furnace 3 to the plating bath 8 through the snout 5 is directed upward by the sink roll 20, so that the metal strip 2 with the molten metal adhering thereto moves to the upper side of the pot 6.

[0024] On the downstream side of the sink roll 20 with respect to the conveying direction of the metal strip 2 (hereinafter, also simply referred to as "downstream side"), the wiping nozzle 10 and a warpage measuring device 12 are provided.

[0025] The wiping nozzle 10 may extend along the strip width direction of the metal strip 2 and include a slit opening to the pass line of the metal strip 2. The wiping nozzle 10 is configured to jet a gas to the traveling metal strip 2, for example through the slit, to wipe and remove the molten metal excessively adhering to the metal strip 2 so as to make the thickness of the molten metal on the surface of the metal strip 2 uniform.

[0026] The warpage measuring device 12 is a device for measuring the warpage amount of the metal strip 2 at the installation position of the warpage measuring device 12. The warpage measuring device 12 may be disposed upstream or downstream of the wiping nozzle 10. The warpage measuring device 12 may include a plurality of position sensors arranged along the strip width direction of the metal strip 2 and each configured to measure a distance from the metal strip 2.

[0027] As described later, the warpage correction apparatus 1 according to some embodiments may be configured to correct warpage of the strip based on a measurement result of the warpage measuring device 12.

[0028] At least some of the plurality of rolls 14 disposed in the furnace 3 are configured to change the conveying direction of the conveyed metal strip 2 during normal operation of the continuous plating facility 100. The roll for changing the conveying direction of the metal strip 2 is generally configured so that the metal strip 2 is wound thereon. For instance, in case of a roll for changing the conveying direction of the metal strip 2 by 90 degrees or more, it can be visually confirmed that the metal strip is wound around the roll. When the metal strip 2 is wound around the roll, generally, the metal strip 2 warps in the strip width direction (C-warp; crossbow).

[0029] Herein, the phrase "the metal strip 2 is wound around the roll 14" means that the bend diameter of the metal strip 2 coincides with the diameter of the roll 14, i.e., the metal strip 2 is in surface contact with the roll 14.

[0030] Further, at least some of the plurality of rolls 14 are fixed rolls whose rotational axes are fixed during normal operation of the continuous plating facility 100.

[0031] Next, with reference to FIGs. 1 to 3, the warpage correction apparatus 1 used in the continuous plating facility 100 will be described.

[0032] FIG. 2 is a schematic diagram of the warpage correction apparatus 1 according to an embodiment. FIG. 3 is a diagram for describing warpage amount w of the metal strip 2, which shows a cross-section of the metal strip 2 taken along a plane perpendicular to the conveying direction at a position of the wiping nozzle 10. FIG. 2 is an enlarged partial view of the continuous plating facility 100 shown in FIG. 1, but the furnace 3 and the snout 5 shown in FIG. 1 are not depicted in FIG. 2 for convenience of description.

[0033] As shown in FIGs. 1 and 2, the warpage correction apparatus 1 according to an embodiment includes a sink roll 20 disposed downstream of the bridle roll 16B, which is a fixed roll for changing the conveying direction of the metal strip 2, and inside the pot 6, and a correction roll 18 disposed between the bridle roll 16B (fixed roll) and the sink roll 20. The correction roll 18 is disposed above the plating bath 8. The correction roll 18 may be disposed inside the snout 5 as shown in FIG. 1.

[0034] The bridle roll 16B is the downstream one of the bridle rolls 16A, 16B disposed at the outlet portion 4 of the furnace 3.

[0035] The correction roll 18 is configured to be able to adjust the pressing amount d_2 (see FIG. 2) toward the metal strip 2 (or toward the pass line of the metal strip 2) by moving the rotational axis 19 of the correction roll 18. As shown in FIGs. 1 and 2, the correction roll 18 is disposed on the opposite side of the metal strip 2 from the bridle roll 16B (fixed roll) and the sink roll 20.

[0036] In FIG. 2, the correction roll 18 and the metal strip 2 when the pressing amount d_2 is 0 are shown by the dotted line. At this time, the metal strip 2 is not pressed to the correction roll 18, and has a linear shape between the bridle roll 16B and the sink roll 20.

[0037] The correction roll 18 has apparent diameter D_2 corresponding to the pressing amount d_2 . The apparent diameter D_2 of the correction roll 18 is a value defined as twice the reciprocal of the curvature of the metal strip 2 around a contact portion between the metal strip 2 and the correction roll 18. The apparent diameter D_2 is affected by both geometrical conditions such as the correction roll, the fixed roll, the thickness and width of the metal strip, and mechanical properties such as Young's modulus, yield stress, and tension of the metal strip 2. By adjusting the pressing amount d_2 , the apparent diameter D_2 can be adjusted from the actual diameter of the correction roll 18 (in a state where the metal strip 2 is wound around the roll 18) to infinity (in a state where the pressing amount d_2 is zero).

[0038] FIG. 8 is a diagram for describing an example of a method of calculating the apparent diameter D_2 .

[0039] For instance, as shown in FIG. 8, in a vertical plane including the extending direction of the metal strip 2, when x -axis and y -axis represent perpendicular directions, with respect to the bending shape of the metal strip

2 in this vertical plane, the apparent diameter D_2 of the correction roll 18 creates an approximate curve of function $y=f(x)$ before and after a contact point P_c (nearly point contact in a side view) between the metal strip 2 and the pressing roll. By second-order differentiating this approximate curve with respect to x in the vicinity of the contact portion between the strip and the roll, a curvature radius is obtained, and twice the curvature radius is defined as the apparent diameter D_2 .

[0040] The curve of the metal strip 2 in the vertical plane can also be obtained based on continuous measurement on the height of the side surface of the metal strip 2 with respect to a certain horizontal line, or based on information processing of an image of the side surface of the metal strip 2.

[0041] However, in the actual operation of the warpage correction apparatus 1, it is not necessary to measure the curvature radius since the apparent radius D_2 in an appropriate range can be obtained by adjusting the pressing amount d_2 of the correction roll 18.

[0042] In the warpage correction apparatus 1 shown in FIGs. 1 and 2, the ratio D_3/D_1 of the diameter D_3 of the sink roll to the diameter D_1 of the bridle roll 16B (fixed roll) is not less than 1.5.

[0043] Further, in the warpage correction apparatus 1 shown in FIGs. 1 and 2, the diameter D_1 of the bridle roll 16B (fixed roll), the apparent diameter D_2 of the correction roll 18, and the diameter D_3 of the sink roll 20 satisfy $D_1 < D_2 < D_3$.

[0044] In the continuous plating facility 100 described above, at the exit sides of the bridle roll 16B (fixed roll), the correction roll 18, and the sink roll 20, the strip may warp in the strip width direction (warp such that the widthwise central portion of the strip protrudes in the strip thickness direction with respect to both widthwise edges, as shown in FIG. 3, i.e., C-warp).

[0045] Herein, the warpage amount w (see FIG. 3) of the metal strip 2 means a distance between both end points in the thickness direction of the metal strip 2 in the strip width direction.

[0046] The deformation direction of warpage in the strip width direction applied to the metal strip 2 by each roll (direction in which the widthwise central portion of the metal strip 2 protrudes) is determined depending on a positional relationship between the roll and the metal strip 2.

[0047] For instance, as shown in FIG. 3, in the warpage correction apparatus 1 shown in FIGs. 1 and 2, when both surfaces of the metal strip 2 are referred to as a first surface 2a and a second surface 2b, warpage in the strip width direction applied to the metal strip 2 by the bridle roll 16B (fixed roll) and the sink roll 20 is warpage in which the central portion of the metal strip 2 protrudes toward the first surface 2a (i.e., in a direction shown in FIG. 3) in the strip thickness direction, while warpage in the strip width direction applied to the metal strip 2 by the correction roll 18 is warpage in which the central portion of the metal strip 2 protrudes toward the second surface 2b

(i.e., opposite to the direction shown in FIG. 3).

[0048] If the metal strip 2 has warpage in the strip width direction as described above at the position of the wiping nozzle 10 downstream of the sink roll 20, the distance between the wiping nozzle 10 and the metal strip 2 in the strip width direction is varied. As a result, the removal amount of the molten metal (plating solution) by the wiping nozzle 10 becomes nonuniform in the strip width direction depending on the distance between the wiping nozzle 10 and the metal strip 2. For instance, as the wiping nozzle 10 is distant from the metal strip 2, the removal amount of the molten metal (plating solution) by the wiping nozzle 10 decreases, so that the plating thickness increases. Conversely, as the wiping nozzle 10 is close to the metal strip 2, the removal amount of the molten metal (plating solution) by the wiping nozzle 10 increases, so that the plating thickness decreases. When the plating thickness is not uniform, the plating thickness increases for ensuring the plating at the thinnest portion, which leads to an increase in cost. Further, the plating thickness variation on the metal strip 2 may lead to uneven weldability (weld strength) at the time of welding the metal strip in a subsequent process, reducing the quality of a product of the metal strip 2.

[0049] In this regard, with the warpage correction apparatus 1 according to the above embodiments, since the ratio $D3/D1$ of the diameter $D3$ of the sink roll 20 to the diameter $D1$ of the bridle roll 16B (fixed roll) is not less than 1.5, it is possible to effectively correct warpage in the strip width direction at the exit side of the sink roll 20, as described later with reference to FIGs. 4 to 7.

[0050] FIGs. 4 and 5 are each a graph showing an example of a relationship between the diameter $D3$ of the sink roll 20 and the warpage amount w of the metal strip 2 at the exit side of the sink roll 20 of the warpage correction apparatus 1 according to an embodiment. The hatched area represents a range of the warpage amount w when the thickness t of the metal strip 2 is 3.2 mm or 2.3 mm respectively, the diameter $D1$ of the bridle roll 16B (fixed roll) is 800 mm, and the apparent diameter $D2$ (or pressing amount $d2$) of the correction roll 18 is changed between 800 mm and 2000 mm. In either figure, the line with the smaller warpage amount w is the case of $D2=800\text{mm}$, and the line with the larger warpage amount w is the case of $D2=2000\text{mm}$.

[0051] As seen from the graphs of FIGs. 4 and 5, regardless of the thickness t , as the diameter $D3$ of the sink roll increases, the range of the warpage amount w that can be adjusted by the apparent diameter $D2$ (or pressing amount $d2$) of the correction roll 18 increases, and the warpage w can be easily adjusted to zero.

[0052] FIGs. 6 and 7 are graphs showing an example of a relationship between the apparent diameter $D2$ of the correction roll 18 and the warpage amount w of the metal strip 2 at the exit side of the sink roll 20 of the warpage correction apparatus 1 according to Example and Comparative Example, respectively. FIG. 6 is a graph when the diameter $D1$ of the bridle roll 16B (fixed

roll) is 800mm, the diameter $D3$ of the sink roll 20 is 2000 mm, $D3/D1$ is 2.5 in the warpage correction apparatus 1 described above. FIG. 7 is a graph when $D1$ is 800mm, $D3$ is 900 mm, $D3/D1$ is 1.1 in the warpage correction apparatus 1 described above. In the graphs, " t " represents the thickness of the metal strip 2.

[0053] As can be seen from the graph of FIG. 7, in the warpage correction apparatus of $D3/D1=1.1$, when the thickness t is relatively thin, i.e., 1 to 2 mm, the warpage amount in the strip width direction at the exit side of the sink roll 20 can be reduced to about zero by adjusting the apparent diameter $D2$ of the correction roll 18 appropriately (i.e., by adjusting the pressing amount $d2$ of the correction roll 18 appropriately). However, when the thickness t is relatively thick, i.e., about 3 to 4 mm, the warpage amount in the strip width direction cannot be reduced to about zero even by adjusting the apparent diameter $D2$ of the correction roll 18.

[0054] In contrast, as can be seen from the graph of FIG. 6, in the warpage correction apparatus of $D3/D1=2.5$, by adjusting the apparent diameter $D2$ of the correction roll 18 appropriately (i.e., by adjusting the pressing amount $d2$ of the correction roll 18 appropriately), the warpage amount in the strip width direction at the exit side of the sink roll 20 can be reduced to about zero in a relatively wide strip thickness range of $1.2\text{ mm} \leq t \leq 4.5\text{ mm}$.

[0055] In other words, the greater the ratio $D3/D1$ of the diameter $D3$ of the sink roll 20 to the diameter $D1$ of the bridle roll 16B (fixed roll), the thicker metal strip 2 can be corrected so that its warpage due to the sink roll 20 is reduced to zero by adjusting the apparent diameter $D2$ (or pressing amount $d2$) of the correction roll 18.

[0056] On the basis of these findings, the warpage correction apparatus 1 according to the above-described embodiments is set so that the ratio $D3/D1$ of the diameter $D3$ of the sink roll 20 to the diameter $D1$ of the bridle roll 16B (fixed roll) is not less than 1.5. Thus, by adjusting the apparent diameter $D2$ (or pressing amount $d2$) of the correction roll 18 appropriately, even when the thickness t of the metal strip 2 is relatively thick, it is possible to effectively reduce the warpage amount w of the metal strip 2 in the strip width direction at the outlet of the pot 6, and it is possible to correct warpage of the metal strip 2.

[0057] Accordingly, it is easy to uniformize the amount of the molten metal adhering to the surface of the metal strip 2, for example, by the wiping nozzle 10 disposed downstream of the pot 6 with respect to the conveying direction of the metal strip.

[0058] Further, in the warpage correction apparatus 1, when the diameter $D1$ of the bridle roll 16B (fixed roll), the apparent diameter $D2$ of the correction roll 18, and the diameter $D3$ of the sink roll 20 satisfy $D1 < D2 < D3$, the plastic deformation amount provided to the metal strip 2 by each of the bridle roll 16B (fixed roll), the correction roll 18, and the sink roll 20 is the greatest in the sink roll 20, followed by the correction roll 18 and the bridle roll 16B (fixed roll). Accordingly, warpage of the metal strip

2 at the exit side of the sink roll 20 can be effectively corrected in an adjustment range of plastic deformation by the correction roll 18.

[0059] In some embodiments, the warpage correction apparatus 1 may further include a controller (not shown) configured to adjust the pressing amount d2 of the correction roll 18 toward the metal strip 2 based on a measurement result of the warpage amount by the warpage measuring device 12.

[0060] For instance, the controller may be configured to adjust the pressing amount d2 of the correction roll 18 toward the metal strip 2 so that the warpage amount w approximates zero by feedback control based on the warpage amount w at the exit side of the sink roll 20 measured by the warpage measuring device 12.

[0061] In a case where the warpage measuring device 12 includes a plurality of position sensors arranged along the strip width direction of the metal strip 2 and each configured to measure a distance from the metal strip 2 as described above, the controller may be configured to calculate the warpage amount w of the metal strip 2 at the exit side of the sink roll 20 based on detection results of the position sensors, and adjust the pressing amount d2 of the correction roll 18 toward the metal strip 2 based on the warpage amount w thus calculated.

[0062] Hereinafter, the outline of the warpage correction apparatus 1 and the continuous plating facility 100 according to some embodiments will be described.

[0063] (1) A warpage correction apparatus according to at least one embodiment of the present invention is a warpage correction apparatus for a metal strip to be used in a continuous plating facility for the metal strip comprising: a sink roll disposed downstream of a fixed roll with respect to a conveying direction of the metal strip and inside a molten metal pot for plating, the fixed roll being configured to change the conveying direction of the metal strip; and a correction roll disposed between the fixed roll and the sink roll and configured to correct warpage of the metal strip, wherein a ratio $D3/D1$ of a diameter $D3$ of the sink roll to a diameter $D1$ of the fixed roll is not less than 1.5.

[0064] When the fixed roll, the correction roll, and the sink roll deform the metal plate in this order, the metal strip may warp in the strip width direction (hereinafter, referred to as "C-warp" or simply "warpage") at the exit side of each roll. According to the findings of the present inventors, as the ratio $D3/D1$ of the diameter $D3$ of the sink roll to the diameter $D1$ of the fixed roll increases, it is possible to expand the adjustable range of warpage amount in the strip width direction at the exit side of the sink roll by adjusting the apparent diameter $D2$ of the correction roll, and it is possible to bring the warpage amount of a thicker metal strip close to zero.

[0065] In this regard, with the above configuration (1), since $D3/D1$ is not less than 1.5, by adjusting the apparent diameter $D2$ of the correction roll appropriately, even when the strip is relatively thick, it is possible to effectively reduce warpage of the metal strip in the strip width direc-

tion at the outlet of the molten metal pot, and it is possible to correct warpage of the metal strip.

[0066] Accordingly, it is easy to uniformize the amount of the molten metal adhering to the surface of the metal strip, for example, by a gas wiping downstream of the molten metal pot with respect to the conveying direction of the metal strip.

[0067] If the correction roll for correcting warpage at the outlet of the molten metal pot is disposed inside the molten metal pot on the downstream side of the sink roll unlike the above (1), the bearing of the correction roll requires a large clearance to prevent biting of foreign matter. In this case, backlash is likely to occur due to the clearance of the bearing, so that it is difficult to accurately correct warpage of the metal strip.

[0068] In this regard, with the above configuration (1), since the correction roll is disposed between the fixed roll and the sink roll (i.e., upstream of the sink roll with respect to the conveying direction of the metal strip), it is unnecessary to dispose the correction roll inside the molten metal pot. Accordingly, a bearing with little backlash can be adopted, and the warpage amount of the metal strip can be accurately adjusted. Further, since the correction roll in the molten metal pot can be eliminated, a sink roll having a larger diameter can be adopted without increasing the size of the existing molten metal pot which assumes that the correction roll is disposed inside the pot.

[0069] The "fixed roll" in the above (1) may be a roll that mainly causes warpage of the metal strip at the exit side of the sink roll. More specifically, the "fixed roll" in the above (1) may be the bridle roll 16B of the warpage correction apparatus 1 or may be another roll 14 fixed in the furnace 3. Moreover, the "fixed roll" in the above (1) may be one disposed on the most downstream side of the fixed rolls for changing the conveying direction of the metal strip.

[0070] (2) In some embodiments, in the above configuration (1), the correction roll is capable of adjusting a pressing amount of the correction roll toward the metal strip.

[0071] With the above configuration (2), by adjusting the pressing amount of the correction roll toward the metal strip (i.e., by adjusting the apparent diameter $D2$ of the correction roll), the plastic deformation amount of the metal strip by the correction roll can be changed. Accordingly, by adjusting the pressing amount appropriately, it is possible to effectively correct warpage of the metal strip in the strip width direction at the outlet of the molten metal pot.

[0072] (3) In some embodiments, in the above configuration (1) or (2), $D1 < D2 < D3$ is satisfied, where $D2$ is an apparent diameter of the correction roll corresponding to a pressing amount of the correction roll toward the metal strip.

[0073] With the above configuration (3), the plastic deformation amount provided to the metal strip by each of the fixed roll, the correction roll, and the sink roll is the

greatest in the sink roll, followed by the correction roll and the fixed roll. Accordingly, warpage of the metal strip at the outlet of the molten metal pot can be effectively corrected in an adjustment range of plastic deformation by the correction roll.

[0074] (4) In some embodiments, in any one of the above configurations (1) to (3), the diameter D3 of the sink roll is not less than 1200 mm.

[0075] Alternatively, in some embodiments, in any one of the above configurations (1) to (3), the diameter D3 of the sink roll is not less than 1300 mm.

[0076] Generally, the diameter of the sink roll disposed inside the molten metal pot is at most about 1000 mm. When a sink roll of larger diameter is adopted, a related facility (e.g., molten metal pot for accommodating the sink roll) other than the sink roll needs to be enlarged, so that the installation cost is increased.

[0077] With the above configuration (4), since the sink roll having a larger diameter than usual, namely 1200 mm, or 1300 mm or more, is adopted regardless of the above circumstances, D3/D1 is easily set to not less than 1.5 when a fixed roll of typical size is used. Thus, by adjusting the apparent diameter D2 of the correction roll appropriately, even when the strip is relatively thick, it is possible to effectively reduce warpage of the metal strip in the strip width direction at the outlet of the molten metal pot.

[0078] (5) In some embodiments, in any one of the above configurations (1) to (4), the fixed roll is disposed inside a furnace for heat treatment of the metal strip.

[0079] With the above configuration (5), when the fixed roll is disposed inside the furnace (e.g., annealing furnace) for heat treatment of the metal strip, as described in the above (1), by adjusting the apparent diameter D2 of the correction roll appropriately, even when the strip is relatively thick, it is possible to effectively reduce warpage of the metal strip in the strip width direction at the outlet of the molten metal pot.

[0080] (6) In some embodiments, in the above configuration (5), the fixed roll is disposed at an outlet portion of the furnace.

[0081] The heating furnace for the metal strip may contain a plurality of rolls for conveying the metal strip with change of direction as appropriate. The roll disposed at the outlet portion of the furnace is the most downstream one of the plurality of rolls. The most downstream roll tends to be a primary cause of warpage in the strip width direction at the entry side of the correction roll.

[0082] In this regard, with the above configuration (6), it is possible to more effectively correct warpage in the strip width direction primarily caused by the fixed roll disposed at the outlet portion of the furnace by means of the correction roll and the sink roll.

[0083] (7) In some embodiments, in any one of the above configurations (1) to (6), the fixed roll is a bridle roll for adjusting a tension applied to the metal strip.

[0084] The bridle roll is generally disposed at the outlet portion of the furnace and thus tends to be a primary

cause of warpage in the strip width direction at the entry side of the correction roll.

[0085] With the above configuration (7), it is possible to more effectively correct warpage in the strip width direction primarily caused by the bridle roll by means of the correction roll and the sink roll.

[0086] (8) In some embodiments, in any one of the above configurations (1) to (7), the correction roll is disposed inside a snout disposed between the molten metal pot and an outlet portion of a furnace for heat treatment of the metal strip.

[0087] (9) In some embodiments, in any one of the above configurations (1) to (8), the warpage correction apparatus further comprises: a warpage measuring device disposed downstream of the sink roll with respect to the conveying direction; and a controller configured to adjust a pressing amount of the correction roll toward the metal strip based on a measurement result of the warpage measuring device.

[0088] With the above configuration (9), since the apparent diameter D2 of the correction roll is adjusted by controlling the pressing amount of the correction roll toward the metal strip by means of the controller based on a measurement result of the warpage measuring device, it is possible to effectively correct warpage of the metal strip in the strip width direction by adjusting the apparent diameter D2 of the correction roll appropriately.

[0089] (10) A continuous plating facility for metal strip according to at least one embodiment of the present invention comprises the warpage correction apparatus described in any one of the above (1) to (9).

[0090] With the above configuration (10), since D3/D1 is not less than 1.5, by adjusting the apparent diameter D2 of the correction roll appropriately, even when the strip is relatively thick, it is possible to effectively reduce warpage of the metal strip in the strip width direction at the outlet of the molten metal pot, and it is possible to correct warpage of the metal strip.

[0091] Accordingly, it is easy to uniformize the amount of the molten metal adhering to the surface of the metal strip, for example, by a gas wiping downstream of the molten metal pot with respect to the conveying direction of the metal strip.

[0092] Embodiments of the present invention were described in detail above, but the present invention is not limited thereto, and various amendments and modifications may be implemented.

[0093] Further, in the present specification, an expression of relative or absolute arrangement such as "in a direction", "along a direction", "parallel", "orthogonal", "centered", "concentric" and "coaxial" shall not be construed as indicating only the arrangement in a strict literal sense, but also includes a state where the arrangement is relatively displaced by a tolerance, or by an angle or a distance whereby it is possible to achieve the same function.

[0094] For instance, an expression of an equal state such as "same" "equal" and "uniform" shall not be con-

strued as indicating only the state in which the feature is strictly equal, but also includes a state in which there is a tolerance or a difference that can still achieve the same function.

[0095] Further, for instance, an expression of a shape such as a rectangular shape or a cylindrical shape shall not be construed as only the geometrically strict shape, but also includes a shape with unevenness or chamfered corners within the range in which the same effect can be achieved.

[0096] On the other hand, an expression such as "comprise", "include", "have" are not intended to be exclusive of other components.

Reference Signs List

[0097]

- 1 Warpage correction apparatus
- 2 Metal strip
- 2a First surface
- 2b Second surface
- 3 Furnace
- 4 Outlet portion
- 5 Snout
- 6 Pot (Molten metal pot)
- 8 Plating bath
- 10 Wiping nozzle
- 12 Warpage measuring device
- 14 Roll
- 16A Bridle roll
- 16B Bridle roll
- 17 virtual roll
- 18 Correction roll
- 19 Rotational axis
- 20 Sink roll
- 100 Continuous plating facility
- d2 Pressing amount
- w Warpage amount

Claims

1. A warpage correction apparatus for a metal strip to be used in a continuous plating facility for the metal strip, the warpage correction apparatus comprising:

 a sink roll disposed downstream of a fixed roll with respect to a conveying direction of the metal strip and inside a molten metal pot for plating, the fixed roll being configured to change the conveying direction of the metal strip; and
 a correction roll disposed between the fixed roll and the sink roll and configured to correct warpage of the metal strip,
 wherein a ratio $D3/D1$ of a diameter $D3$ of the sink roll to a diameter $D1$ of the fixed roll is not less than 1.5.

- 2. The warpage correction apparatus according to claim 1,
 wherein the correction roll is capable of adjusting a pressing amount of the correction roll toward the metal strip.
- 3. The warpage correction apparatus according to claim 1 or 2,
 wherein $D1 < D2 < D3$ is satisfied, where $D2$ is an apparent diameter of the correction roll corresponding to a pressing amount of the correction roll toward the metal strip.
- 4. The warpage correction apparatus according to any one of claims 1 to 3,
 wherein the diameter $D3$ of the sink roll is not less than 1200 mm.
- 5. The warpage correction apparatus according to any one of claims 1 to 4,
 wherein the fixed roll is disposed inside a furnace for heat treatment of the metal strip.
- 6. The warpage correction apparatus according to claim 5,
 wherein the fixed roll is disposed at an outlet portion of the furnace.
- 7. The warpage correction apparatus according to any one of claims 1 to 6,
 wherein the fixed roll is a bridle roll for adjusting a tension applied to the metal strip.
- 8. The warpage correction apparatus according to any one of claims 1 to 7,
 wherein the correction roll is disposed inside a snout disposed between the molten metal pot and an outlet portion of a furnace for heat treatment of the metal strip.
- 9. The warpage correction apparatus according to any one of claims 1 to 8, further comprising:

 a warpage measuring device disposed downstream of the sink roll with respect to the conveying direction; and
 a controller configured to adjust a pressing amount of the correction roll toward the metal strip based on a measurement result of the warpage measuring device.
- 10. A continuous plating facility for a metal strip, comprising:
 the warpage correction apparatus according to any one of claims 1 to 9.

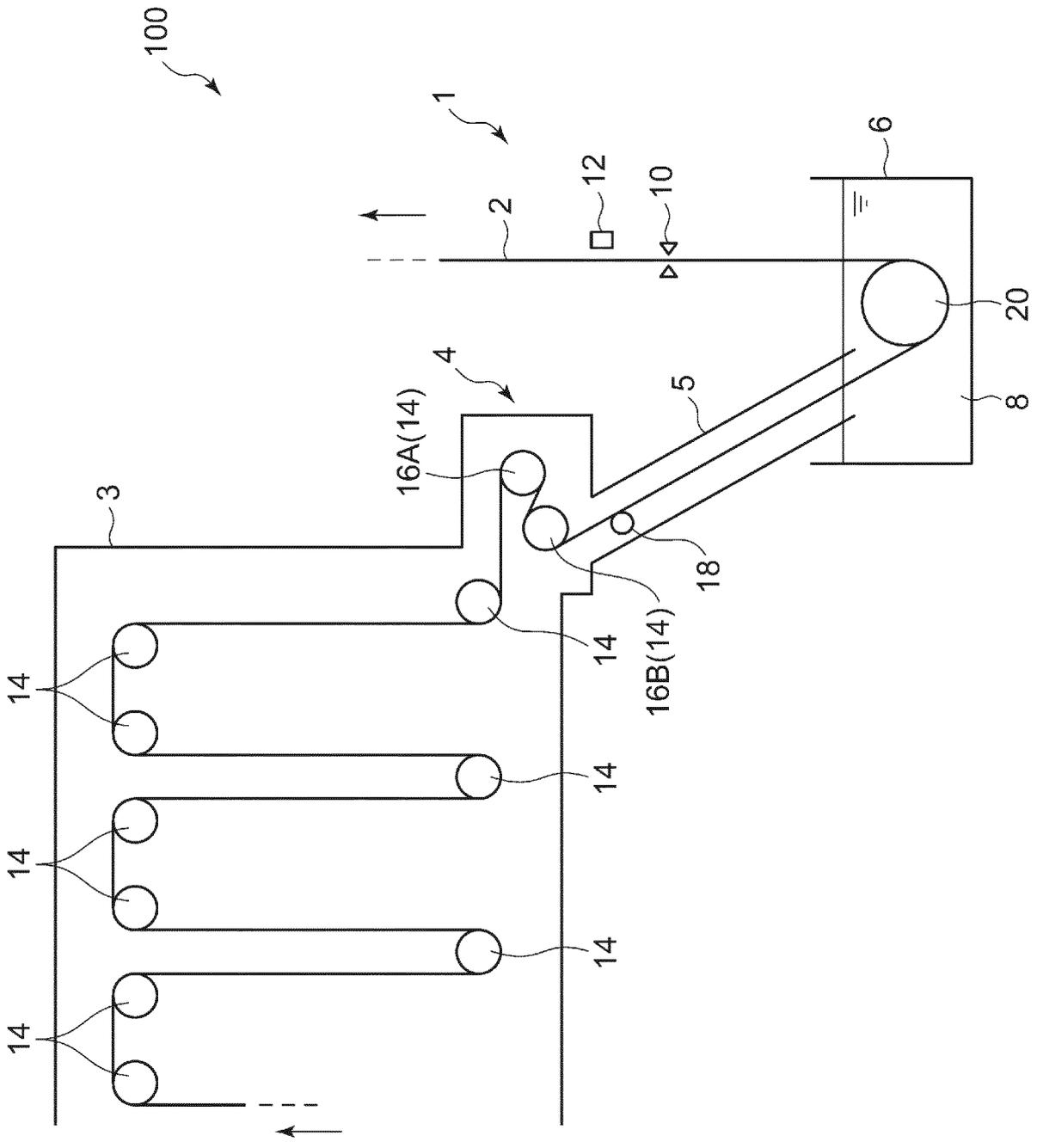


FIG. 1

FIG. 2

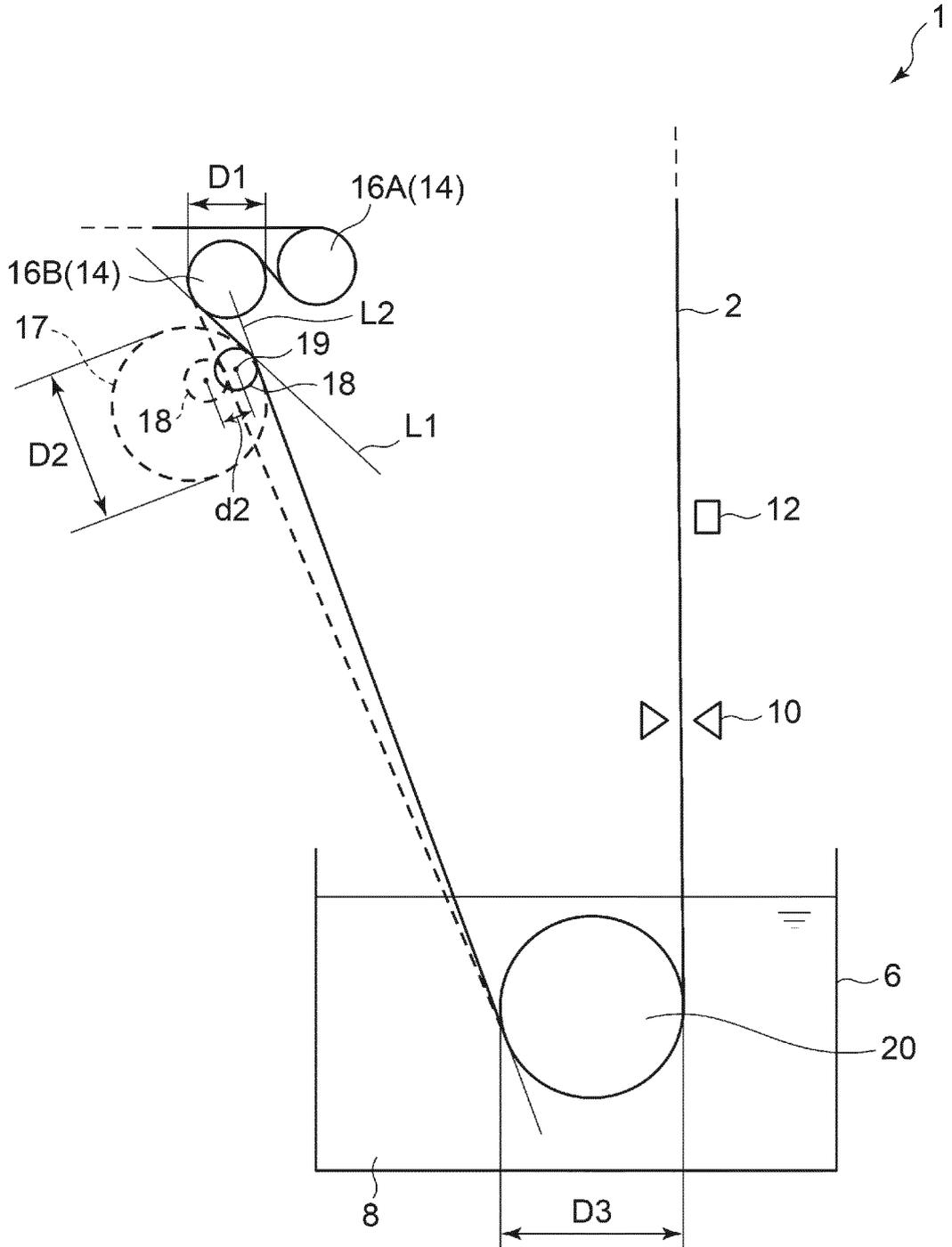


FIG. 3

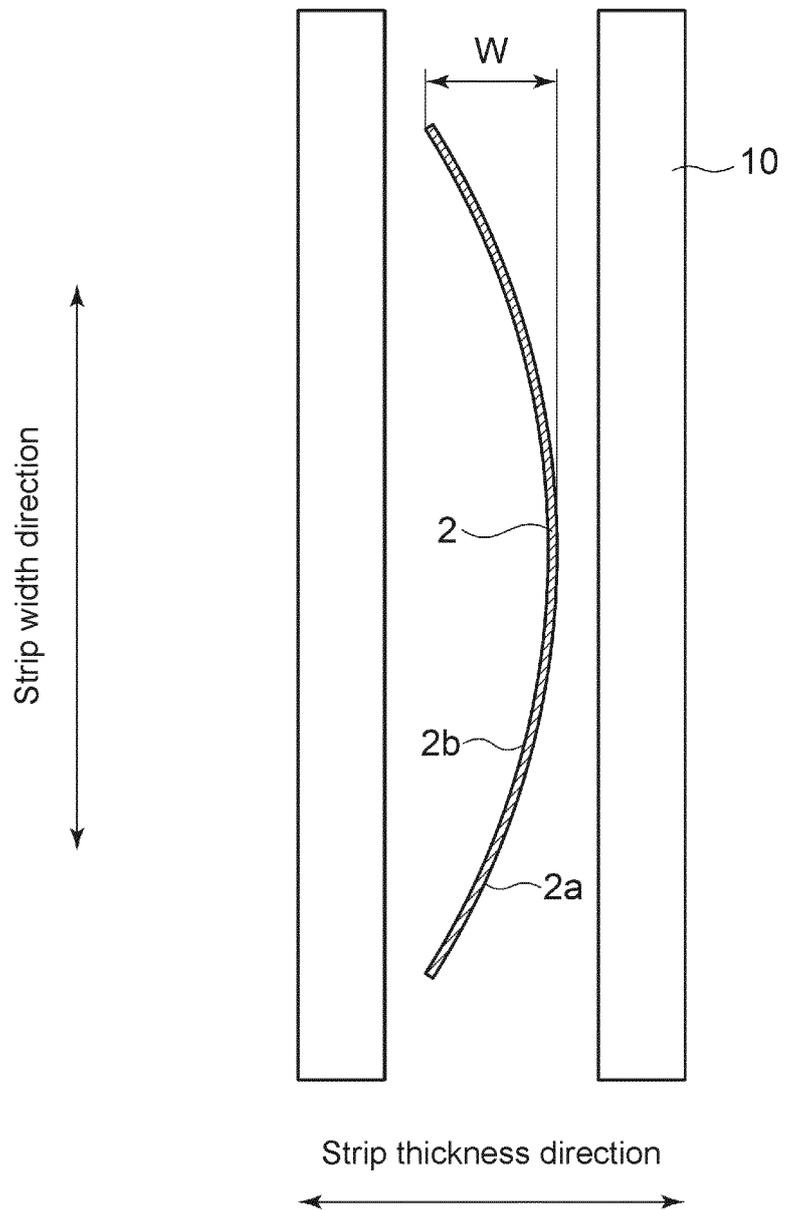


FIG. 4

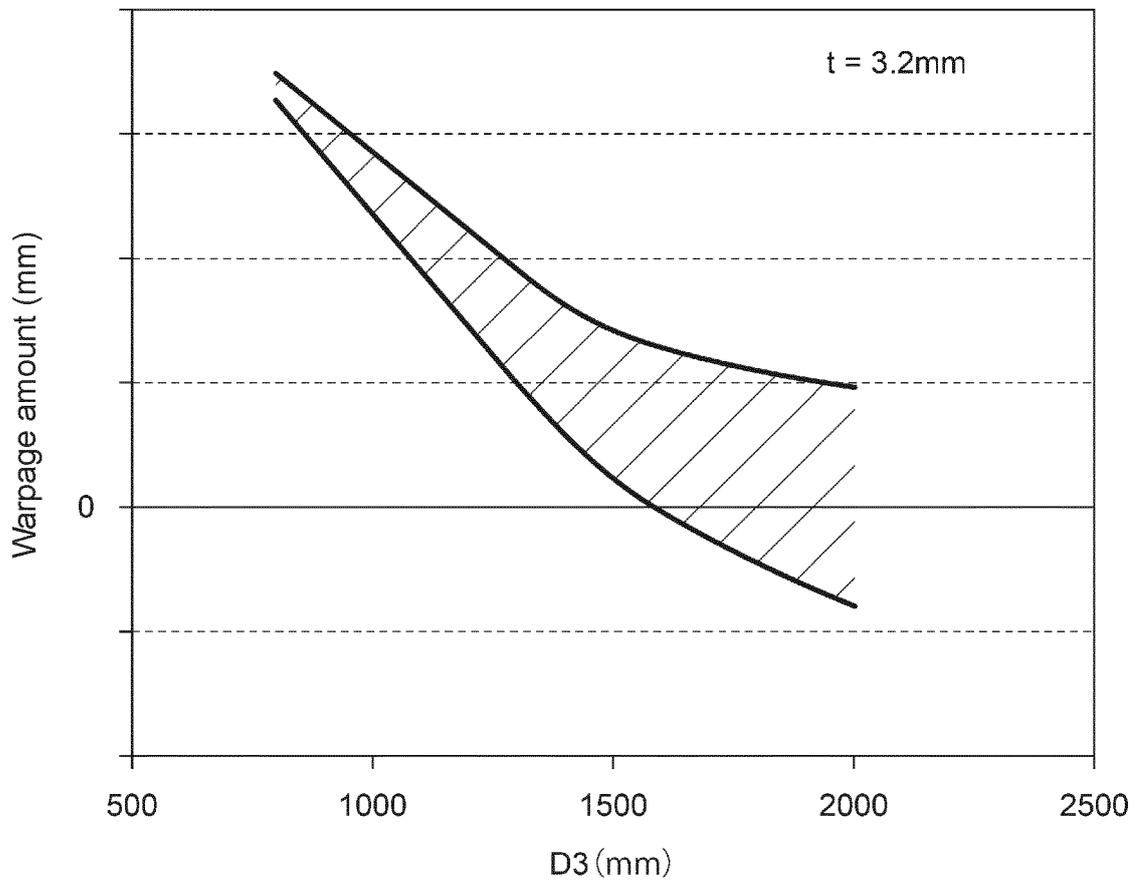


FIG. 5

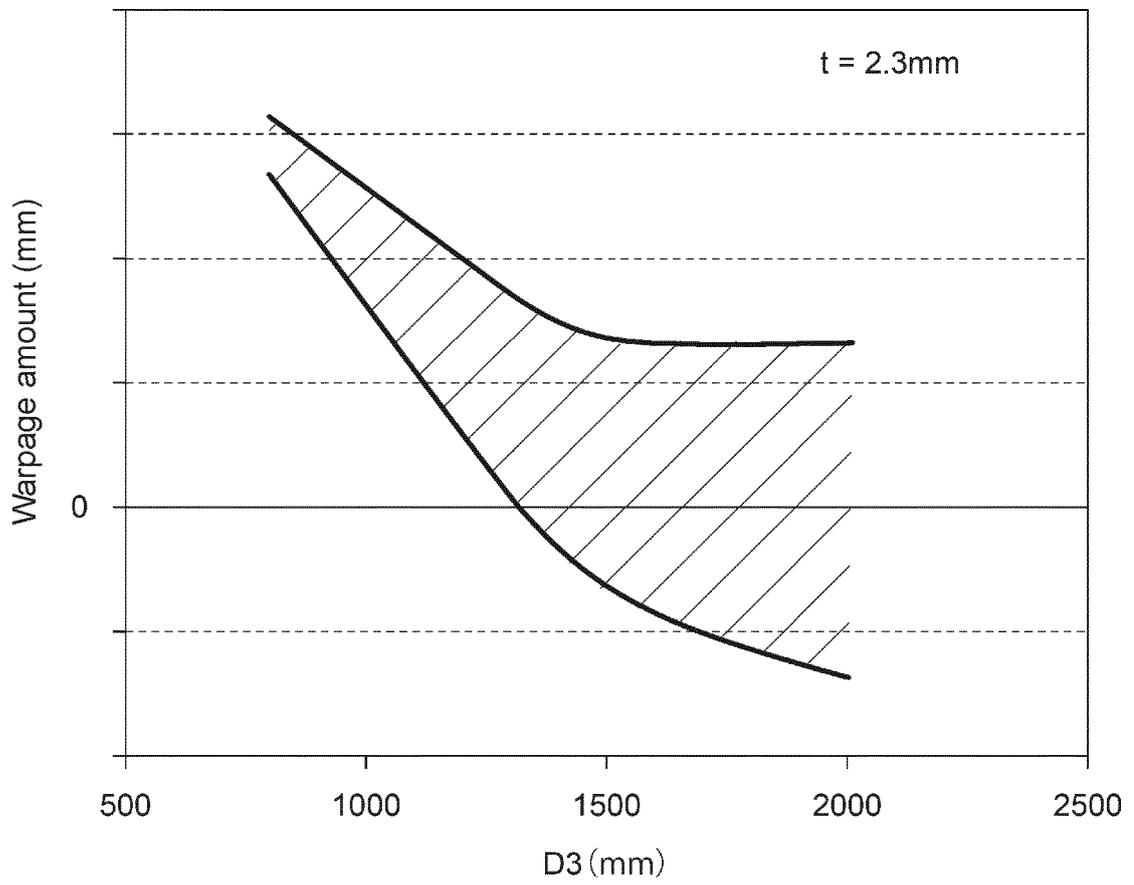


FIG. 6

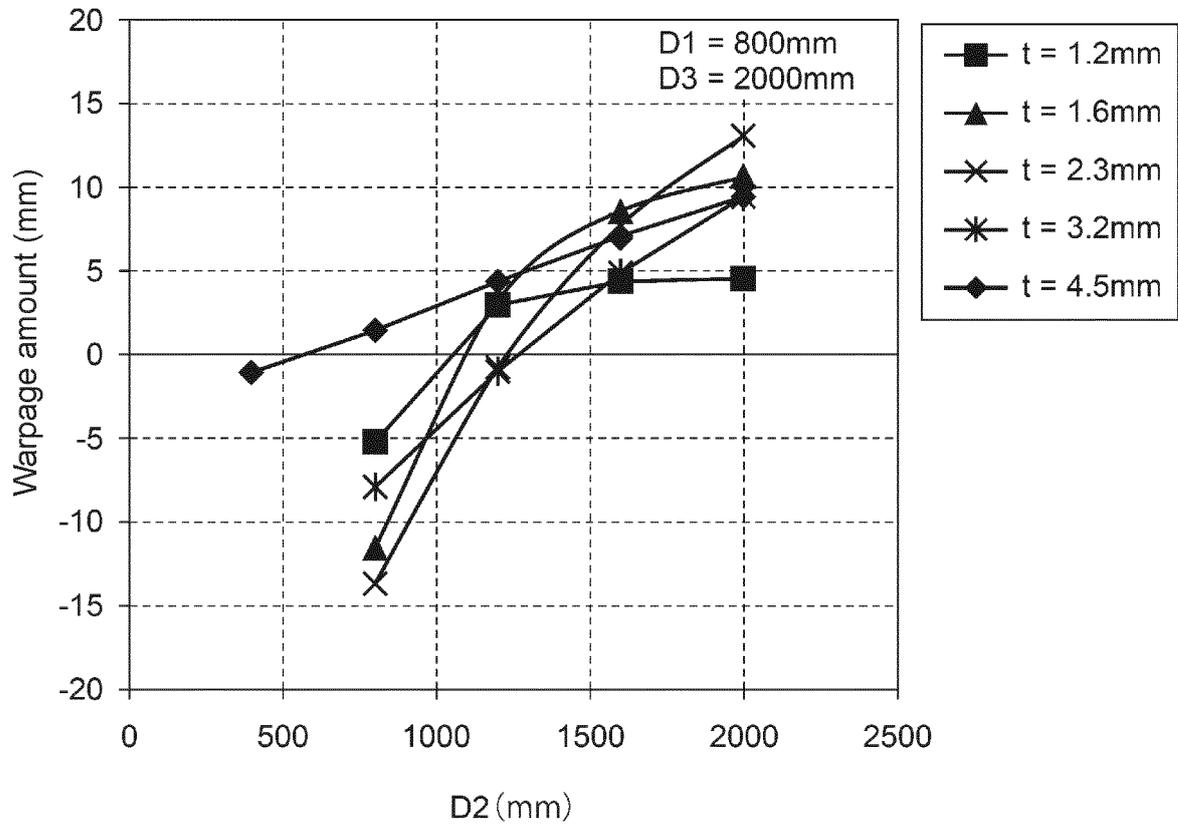


FIG. 7

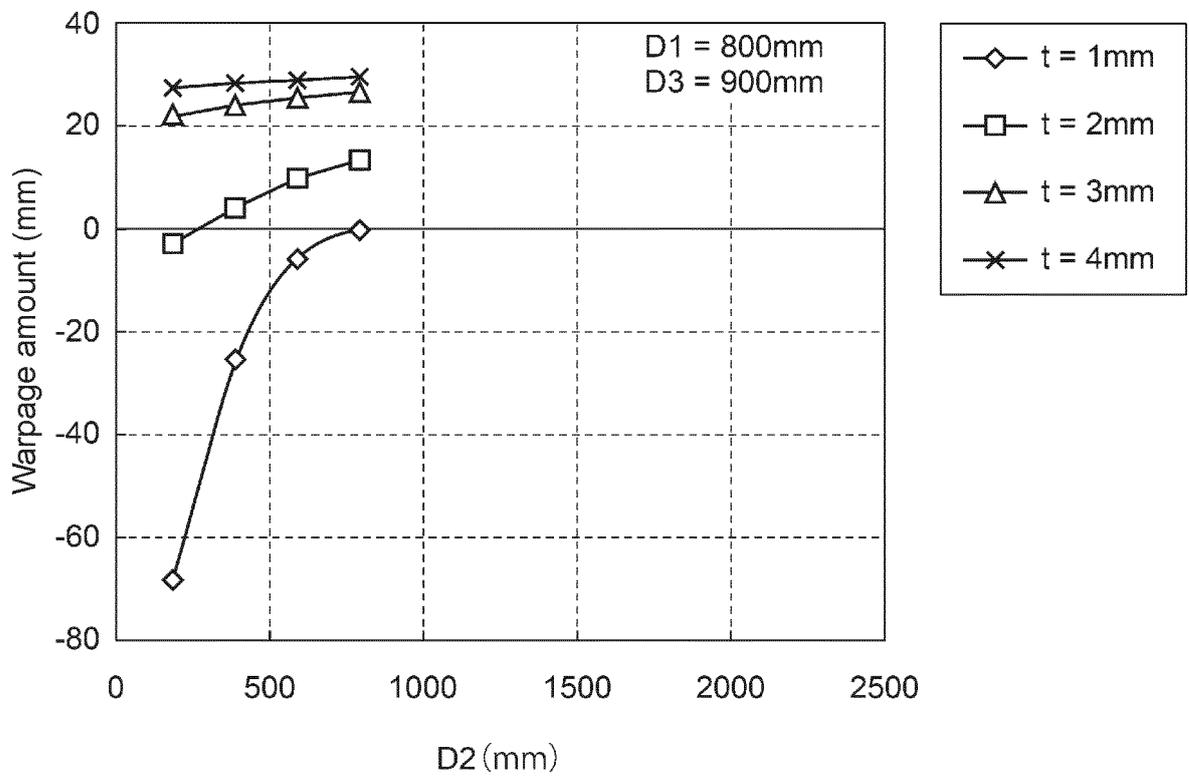
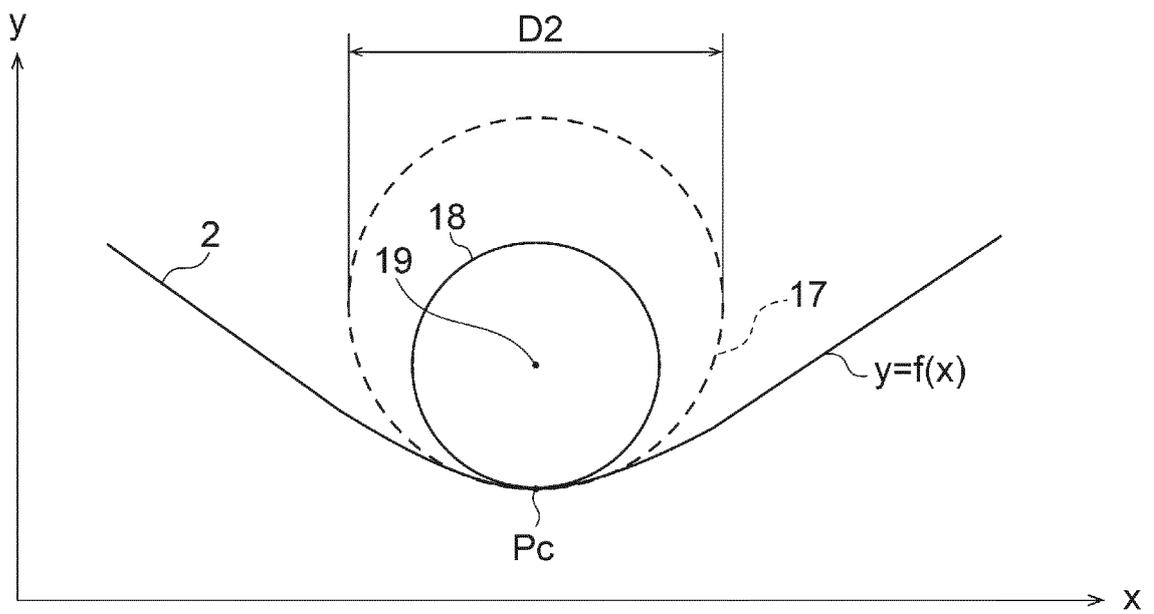


FIG. 8



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2017/043023

5	<p>A. CLASSIFICATION OF SUBJECT MATTER Int. Cl. C23C2/06 (2006.01) i, B21D1/02 (2006.01) i, C23C2/20 (2006.01) i, C23C2/40 (2006.01) i</p> <p>According to International Patent Classification (IPC) or to both national classification and IPC</p>										
10	<p>B. FIELDS SEARCHED Minimum documentation searched (classification system followed by classification symbols) Int. Cl. C23C2/06, B21D1/02, C23C2/20, C23C2/40</p>										
15	<p>Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched</p> <table border="0"> <tr> <td>Published examined utility model applications of Japan</td> <td>1922-1996</td> </tr> <tr> <td>Published unexamined utility model applications of Japan</td> <td>1971-2017</td> </tr> <tr> <td>Registered utility model specifications of Japan</td> <td>1996-2017</td> </tr> <tr> <td>Published registered utility model applications of Japan</td> <td>1994-2017</td> </tr> </table> <p>Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)</p>		Published examined utility model applications of Japan	1922-1996	Published unexamined utility model applications of Japan	1971-2017	Registered utility model specifications of Japan	1996-2017	Published registered utility model applications of Japan	1994-2017	
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20	<p>C. DOCUMENTS CONSIDERED TO BE RELEVANT</p> <table border="1"> <thead> <tr> <th style="width: 10%;">Category*</th> <th style="width: 70%;">Citation of document, with indication, where appropriate, of the relevant passages</th> <th style="width: 20%;">Relevant to claim No.</th> </tr> </thead> <tbody> <tr> <td style="vertical-align: top;">25</td> <td> A JP 2004-107681 A (JFE STEEL CORP.) 08 April 2004, claims, paragraphs [0051]-[0157], fig. 1, 3, 5-8 & US 2005/0115052 A1, claims, paragraphs [0021]-[0140], fig. 2, 4, 6-9 & WO 2004/024974 A1 & EP 1538233 A1 & CA 2479031 A & CN 1650040 A & KR 10-2005-0014809 A & TW 200404915 A </td> <td style="vertical-align: top;">1-10</td> </tr> <tr> <td style="vertical-align: top;">30</td> <td> A JP 2005-97748 A (JFE STEEL CORP.) 14 April 2005, claims, paragraphs [0108]-[0162], fig. 8, 18 & US 2003/0077397 A1, claims, paragraphs [0038]-[0148], fig. 8A, 8B, 11, 21 & WO 2002/077313 A1 & EP 1312692 A1 & CA 2409159 A & TW 575685 B & CN 1501985 A </td> <td style="vertical-align: top;">1-10</td> </tr> </tbody> </table>		Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.	25	A JP 2004-107681 A (JFE STEEL CORP.) 08 April 2004, claims, paragraphs [0051]-[0157], fig. 1, 3, 5-8 & US 2005/0115052 A1, claims, paragraphs [0021]-[0140], fig. 2, 4, 6-9 & WO 2004/024974 A1 & EP 1538233 A1 & CA 2479031 A & CN 1650040 A & KR 10-2005-0014809 A & TW 200404915 A	1-10	30	A JP 2005-97748 A (JFE STEEL CORP.) 14 April 2005, claims, paragraphs [0108]-[0162], fig. 8, 18 & US 2003/0077397 A1, claims, paragraphs [0038]-[0148], fig. 8A, 8B, 11, 21 & WO 2002/077313 A1 & EP 1312692 A1 & CA 2409159 A & TW 575685 B & CN 1501985 A	1-10
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50	Date of the actual completion of the international search 19.12.2017	Date of mailing of the international search report 09.01.2018									
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