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(54) **HOT SLAB SHAPE CONTROL EQUIPMENT AND SHAPE CONTROL METHOD**

(57) The conventional techniques cannot minimize increase in yield loss and slab thickness caused by unsteady deformation in top and rear end portions during reduction of the width of a slab, and cannot shape a slab with desired target dimensions at high productivity. With respect to a width pressing machine 2 that reduces the width of a slab, a horizontal rolling mill 1 is arranged at the upstream side of the slab conveying direction, or an entry-side horizontal rolling mill 1 and an exit-side horizontal rolling mill 3 are respectively arranged at the upstream side and downstream side. A slab shape control equipment thus configured is used to simultaneously perform rolling by the horizontal rolling mill 1 or by horizontal rolling mill 1 and horizontal rolling mill 3, and reduce the width of a slab by the width pressing machine 2 on one hot slab 10.

FIG. 1A

(UPSTREAM SIDE)

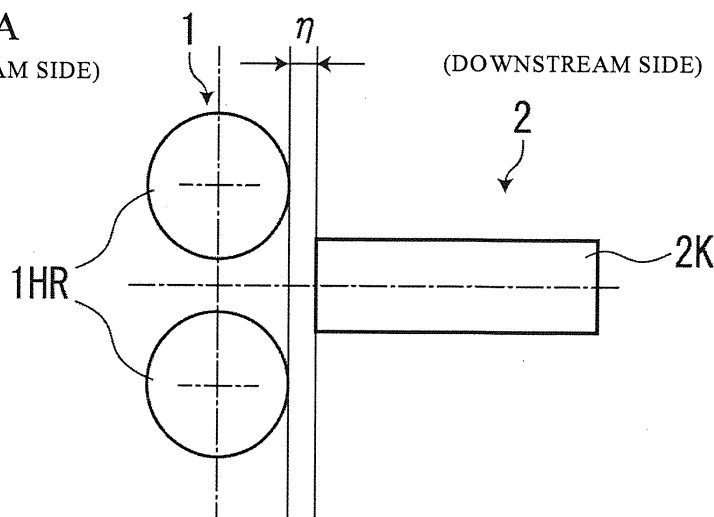
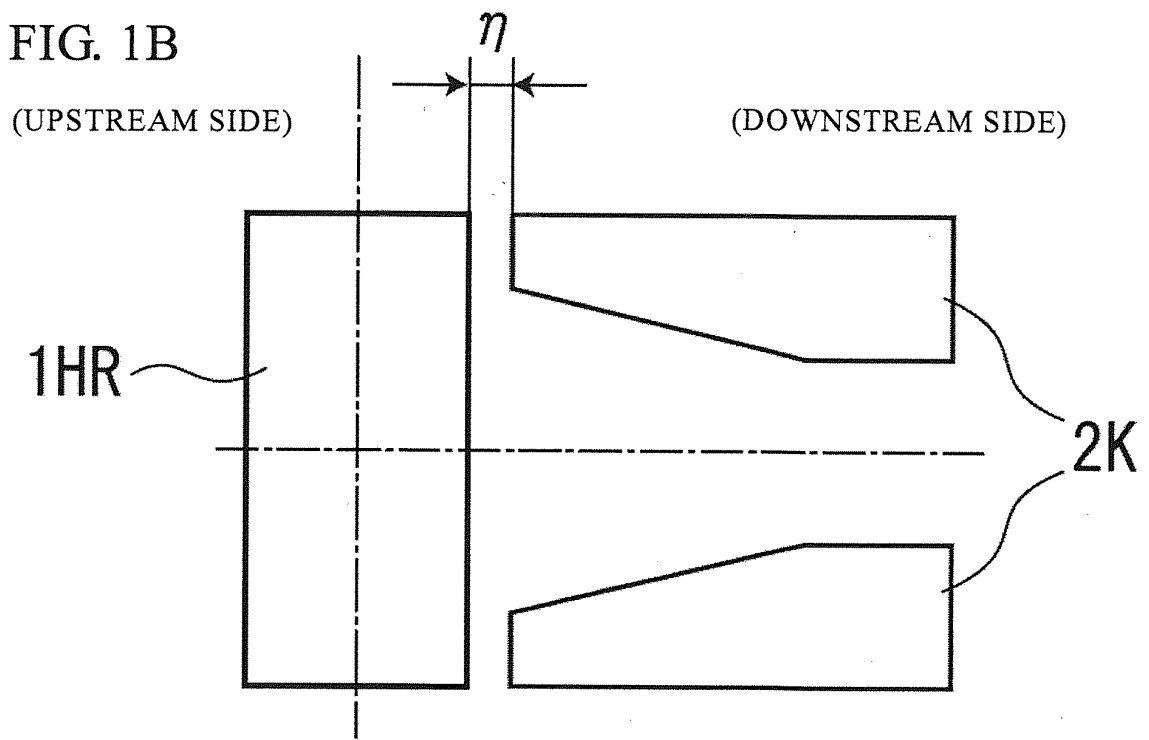


FIG. 1B



$0 < \eta < \text{SLAB LENGTH DURING EXTRACTION FROM HEATING FURNACE}$

Description

TECHNICAL FIELD

[0001] The present invention relates to shape control equipment and a shape control method for a hot slab. Specifically, the present invention relates to a shape control equipment and a shape control method for a hot slab that control a plain view pattern of top and tail ends of slab when a thickness and a width of a slab produced by continuous casting are shaped so as to reduce crop loss and that reduce a local thickness increase at the width center of the top end of the slab so as to solve a problem of reducing pass number of rough rolling and conveying trouble.

BACKGROUND ART

[0002] The casting speed of a slab casted by a continuous casting machine hardly depends on the slab width. Therefore, in order to improve productivity, a method for casting a slab with a large width and reducing the width of the slab to a predetermined slab width corresponding to the product width in a hot-rolling line. As a device that reduces the width of a slab, a sizing mill and a sizing press have been developed and are used. This sizing mill is a device that performs slab-width rolling with rolling rolls mutually opposed on both sides in a slab width direction. However, the contact length of the rolls and the slab is short. Therefore, shear deformation to end portions of the slab width is large. This leads to a concave shape in the top and tail ends of slab that is referred to as fish tail, thus causing yield degradation. Because of this background, in order to increase the contact length with the slab to suppress the fish tail, the sizing press has been developed so as to achieve significant improvement in the yield. In the processing by this sizing press, width reducing load is approximately proportional to the contact length between the slab and the mold. Accordingly, from the aspect of load limitation of the equipment, the width is changed up to about 300 mm. However, the width of a typical hot-rolled steel strip product varies from about 700 mm to 2200 mm. Even in the case where the sizing press device is utilized in the hot-rolling line, it is necessary to cast slabs with widths at a plurality of levels by other chances in the continuous casting process.

[0003] In the case where the reduction amount of the width of a slab is increased by increasing capacity of the sizing press, the following two problems occur in the sizing press processing. One of the problems is a problem A that heavy width reduction increases the slab-top-end width and increases the pass number of rough rolling after the width press, thus reducing production efficiency. Another problem is a problem B that a slab non-constant portion (both end portions in the longitudinal direction) cannot be formed to have a plain view pattern in a rectangular shape and crop loss increases after rough rolling as illustrated in FIG. 14, thus deteriorating yield.

[0004] For the problem A, conventionally, in order to improve biting property after reduction of the width of a slab, a known method A increases a mold inclined angle θ illustrated in FIG. 15 and controls the increased thickness position in the slab thickness direction so as to prevent the thickness increase (see Patent Literature 1). However, in the case where the slab width is narrow or in the case where the reduction amount of the width of a slab is large, the effect is small. For the above-described problem B, conventionally, a known method B illustrated in FIG 16 adjusts a contact length L between the slab and the mold so as to adjust the shapes of the top and tail ends (see Patent Literature 2).

[0005] On the other hand, as a method for expanding the amount of the width change of the continuous-casting slab while reducing the concave shape referred to as a fish tail, which causes deterioration in yield, in the top and tail ends without increasing the load on the equipment, a method that is a combination of the sizing mill and the sizing press has been proposed (see Patent Literature 3). This is a method for changing the width of a constant portion by the sizing mill after preforming the top and tail ends of slab by the sizing press in advance so as to prevent the fish tail. This achieves a large width change of about 650 mm. When preforming by the sizing press significantly changes the width, the thickness of the top end of the slab increases and the slab collides with the roll for conveyance. This makes the conveyance difficult. Accordingly, a device that is devised to mechanically correct the top end of the slab by a lower roll, which is disposed on a conveyor line and can apply upward load, and this device is operated (see Patent Literature 4).

Patent Literature 1: Japanese Unexamined Patent Application Publication No. 2009-6361

Patent Literature 2: Japanese Patent No. 2561251

Patent Literature 3: Japanese Unexamined Patent Application Publication No. 2008-254036

Patent Literature 4: Japanese Unexamined Patent Application Publication No. 2008-254033

DISCLOSURE OF THE INVENTION

PROBLEMS TO BE SOLVED BY THE INVENTION

[0006] However, the above-described conventional techniques have the following problems. The conventional method

A has a small effect on reduction in increase of the slab-top-end width. This does not lead to significant improvement in efficiency. Since the angle of the mold is constant, a sufficient effect cannot be obtained depending on the slab width. Since the mold length in the conventional method B is limited, the effect has a limitation. The reduction effect in thickness increase is not specifically mentioned, and the effect is considered to be poor.

[0007] In Patent Literature 3, the amount of the width change per one pass is small in a vertical rolling mill. In order to increase the width change of the slab, a high rolling pass number is required. Therefore, productivity becomes poor and the slab temperature is reduced. Furthermore, for heavy width reduction in the top end of the slab by the sizing press, a considerable thickness increase occurs in the top end portion. Accordingly, introduction of the correction device as described in Patent Literature 4 becomes a precondition. Thus, there are problems in many points such as installation space, equipment cost, and running cost.

[0008] That is, there is a problem that the conventional techniques cannot minimize yield loss and increase in slab thickness due to unsteady deformation in the top and rear end portions during reduction of the width of a slab and cannot shape the slab to have desired target dimensions at high productivity.

SOLUTIONS TO THE PROBLEMS

[0009] Through long and intensive research carried out by the inventors of the present invention in order to solve the above problems, the present invention according to the following summary of configurations was made.

(1) Shape control equipment for adjusting a width, a top-end plain view pattern, and a thickness profile of a slab. The slab is a hot slab extracted from a heating furnace. The shape control equipment includes a horizontal rolling mill and a width pressing machine. The horizontal rolling mill includes horizontal rolling rolls mutually opposed on both sides in a slab thickness direction. The width pressing machine includes a pair of width press molds mutually opposed on both sides in the slab width direction. The entry-side horizontal rolling mill as the horizontal rolling mill and the width pressing machine are installed in this order at an arrangement interval shorter than a slab length during extraction from heating furnace from an upstream side in a slab conveying direction.

(2) In the shape control equipment for the hot slab according to (1), an exit-side horizontal rolling mill with a pair of horizontal rolling rolls are disposed close to a downstream side of the width pressing machine, the entry-side horizontal rolling mill, the width pressing machine, and the exit-side horizontal rolling mill are installed in this order from the upstream side in the slab conveying direction

(3) A shape control method for a hot slab uses the shape control equipment for the hot slab according to (1) as a method for shape control of a hot slab. The shape control method includes simultaneously performing rolling by the horizontal rolling mill and reduction of a width of a slab by the width pressing machine on one hot slab.

(4) In the shape control method for the hot slab according to (3), the shape control method includes performing a rolling speed control of the horizontal rolling mill during the reduction of the width of the slab by the width pressing machine.

(5) A shape control method for a hot slab uses the shape control equipment according to (2). The shape control method includes applying a compressive force and a tensile force by horizontal rolling using the entry-side and exit-side horizontal rolling mills during reduction of the width of the slab in top and tail ends of slab, and applying a compressive force by the entry-side horizontal rolling mill at a time of rolling start of the exit-side horizontal rolling mill when reducing the width of the hot slab extracted from the heating furnace over an entire length of the slab once or twice or more by the width pressing machine.

EFFECTS OF THE INVENTION

[0010] The present invention keeps a small fish-tail shape in the top and tail ends due to a width change of the slab during sizing press process and prevents conveying trouble, defective biting during horizontal rolling of the slab after the width change by the rough rolling mill in the downstream side, and a local thickness increase in the width center of the top end of the slab causing an increase in pass number. Additionally, the present invention can significantly change the width while maintaining excellent shapes at the top and tail ends. Thus, improvement in yield and improvement in efficiency of the continuous casting machine can be expected.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011]

FIG. 1A and FIG 1B are respectively a side view and a plan view illustrating an outline of shape control equipment for a hot slab according to the present invention described in claim 1.

FIG. 2A and FIG. 2B are respectively a side view and a plan view illustrating an outline of a shape control equipment of a hot slab according to the present invention described in claim 2.

FIG. 3 is an explanatory view illustrating a backward component force during reduction of the width of a slab by a conventional width pressing machine.

FIG. 4 is an explanatory view illustrating a thickness increase in the slab width center in the case where a fish tail portion is formed by conventional reduction of the width of a slab.

FIG. 5 is a chart illustrating a movement example of the neutral point (in flat rolling) when load of a compressive force is applied from the downstream side of the horizontal rolling mill.

FIG. 6 is a chart illustrating an exemplary modification of a plain view pattern of a slab-top-end portion after width press in Working Example 1.

FIG. 7 is a chart illustrating an exemplary modification of a thickness distribution of the slab-top-end portion after width press with respect to a slab width direction in Working Example 1.

FIG. 8 is a chart illustrating an exemplary modification of the thickness distribution of the slab width center after width press with respect to the longitudinal direction in Working Example 1.

FIG. 9 is a chart illustrating an exemplary modification of a plain view pattern of the slab-top-end portion after width press in Working Example 2.

FIG 10A and FIG 10B are charts illustrating an exemplary movement of the neutral point (in flat rolling) when load of compressive forces are applied by entry-side and exit-side rolling mills, respectively.

FIG. 11A and FIG. 11B are charts illustrating plain view patterns of top and tail end portions of slab after width adjustment in an example of the present invention and a comparative example.

FIG. 12A and FIG. 12B are charts illustrating plain view patterns of the top and tail end portions of slab after width adjustment in an example of the present invention and a comparative example.

FIG. 13 is a side view illustrating the outline of a width adjustment method in Working Example 3.

FIG. 14 is a plan view illustrating crop loss of a sheet bar after rough rolling.

FIG. 15 is a plan view illustrating a mold inclined angle θ .

FIG. 16 is a plan view illustrating a contact length L between a slab and a mold.

DESCRIPTION OF PREFERRED EMBODIMENTS

[0012] The following describes embodiments of the present invention with operations and effects. In the following description, "load" and "force" are both amounts per unit area. In reduction of the width of a slab by ordinary sizing press, since the mold stroke is not adequate to increase the amount of the reduction of the width of a slab, the reduction of the width of a slab begins from an inclined portion of a mold 2K. At this time, the amount of fish tail in the top end of the slab increases with increasing mold inclined angle. This locally increases the thickness in the center of the slab-top-end slab width.

[0013] The inventors studied, in detail, a slab-top-end deformation mechanism caused by reducing the width of a slab by the sizing press. As a result, the inventors conceived an advantageous control method for the deformation. In reduction of the width of a slab by the sizing press, a width reducing load P is decomposed into a mold inclined angle θ so as to generate a force $P\sin\theta$ that moves the slab backward as illustrated in FIG. 3. On the other hand, a friction force μP (μ indicates a friction coefficient) acts in the contact area between the mold 2K and a slab 10. The horizontal component force $\mu P\cos\theta$ blocks the backward movement of the slab 10. With these two forces, a large shear force occurs in the slab-top-end portion and a fish tail portion 10FT is formed along with the backward movement of the slab 10. The shear force by this backward component force $P\sin\theta$ increases with increasing mold inclined angle θ .

[0014] In the case where the slab-top-end shape becomes a fish tail, a local increase in thickness of a slab width center 10WC is caused in the slab-top-end portion. FIG. 4 illustrates a mechanism of a thickness increase of the slab width center 10WC after the top end of the slab becomes to have a fish-tail shape and illustrates the appearance of a longitudinal thickness distribution of the slab width center 10WC after the thickness increase. When the fish tail portion 10FT is formed at the top end, a portion without material (a material-missing portion) is formed at the top end of the slab. Accordingly, restriction of the material is released in this portion. This reduces the plastic strain amount of the fish tail portion 10FT without receiving a reactive force from the material. On the other hand, the volume of the material to be deformed by reducing the width of a slab is constant. Accordingly, deformation concentrates on the slab width center 10WC in the slab-top-end portion, thus causing a local thickness increase.

[0015] With the above-described mechanism, the top end fish tail and the local thickness increase of the slab thickness are considered to be effectively reduced by reduction of the backward component force, which is a root cause of these problems. An embodiment of the present invention will be described by referring to FIG. 1A and FIG. 1B. FIG. 1A and FIG. 1B are respectively a side view and a plan view illustrating the outline of the shape control equipment for the hot slab according to the present invention described in the above-described (1). A horizontal rolling mill 1 includes horizontal rolling rolls 1 HR mutually opposed on both sides in the slab thickness direction. A width pressing machine 2 includes

a pair of molds (width press molds) 2K mutually opposed on both sides in the slab width direction. The horizontal rolling mill 1 and the width pressing machine 2 are installed in this order from the upstream side of the slab conveying direction at an arrangement interval η shorter than the slab length during extraction from heating furnace. That is, the slab length during extraction from heating furnace is expressed with L_0 as $0 < \eta < L_0$, preferably, $0 < \eta < 0.3 \times L_0$.

[0016] With this equipment, slab thickness rolling by the horizontal rolling mill 1 and reduction of the width of a slab by the width pressing machine 2 are simultaneously performed on one hot slab. This allows applying a compressive force against the above-described backward component force $P \sin \theta$ to the slab by transfer using the horizontal rolling rolls 1HR of the horizontal rolling mill 1 at the upstream side of the mold 2K during reduction of the width of a slab by the molds 2K of the width pressing machine 2, thus controlling the top-end shape. This method reduces fish tail in the top end portion independently of the slab width or the reduction amount of the width of a slab and allows heavy width reduction while reducing a local thickness increase caused by the fish tail portion in the slab width center.

[0017] Here, the horizontal rolling mill 1 is preferred to perform rolling speed control such that a rolling slip does not occur and the compressive force acts on the slab at the exit side of the horizontal rolling mill. The occurrence condition of a slip during rolling can be determined based on whether or not the neutral point (in flat rolling) exists in a roll bite. FIG. 5 illustrates the result of performing rolling analysis assuming that the horizontal rolling mill applies load of a compressive force. In the analysis condition, the horizontal width of a slab equivalent to have a thickness of 260 mm and a temperature of 1000°C was reduced to have a thickness of 245 mm in a roll with ϕ 1000 mm. From the downstream of the horizontal rolling mill, applying load of a pushing force moves the neutral point (in flat rolling) to the exit side of the roll bite. In this rolling condition, it was found that a pushing force of about 11 MPa or less did not cause a slip. With this pushing force, that is, compressive force, a shape control of the slab-top-end portion was performed.

Working Example 1

[0018] As Working Example 1, the present invention was applied to the case where a slab with a width of 1450 mm and a slab thickness of 260 mm was set as a target and reduction of the width of a slab by 325 mm for each reduction was performed twice so as to reduce 650 mm in the total reduction amount of the width of a slab. The reduction of the width of a slab was started from a mold inclined portion. Only at the time of the first pass, a compressive force of 9 MPa against the backward component force was applied by the horizontal rolling mill. FIG. 6 illustrates a top-end plain view pattern after the reduction of the width of a slab. Ordinary reduction of the width of a slab (with a compressive force of 0 MPa) results in a huge fish-tail shape. However, the condition with application of a compressive force allowed reducing the fish-tail shape, thus cutting 76.2% of the crop loss. FIG. 7 illustrates a thickness profile at the top end of the slab. Application of a compressive force allowed reducing the increase in thickness of the top end portion by about 15%. FIG. 8 illustrates a thickness distribution of the slab width center in the longitudinal direction. Local thickness increase in the slab-topmost-end portion is reduced, and the effect on reducing pass number of rough rolling and solving the problem of conveying trouble of the slab can be expected.

Working Example 2

[0019] As Working Example 2, the present invention was applied to the case where a slab with a width of 1650 mm and a slab thickness of 260 mm was set as a target and the reduction amount of the width of a slab was 250 mm by one reduction of the width of a slab. Under a condition where the reduction amount of the width of a slab is small with respect to the slab width, a problem of a thickness increase does not occur, but fish-tail deformation becomes remarkable. A description will be given of the fish-tail reducing effect by applying a compressive force under this condition. The reduction of the width of a slab was started from a mold inclined portion. Compressive forces of 7 MPa and 9 MPa were applied against a backward component force. FIG. 9 illustrates a top-end plain view pattern after the reduction of the width of the slab. Application of an appropriate compressive force was confirmed to allow controlling the top-end plain view pattern and reducing crop loss by 92%.

[0020] FIG. 2A and FIG. 2B are respectively a side view and a plan view illustrating the outline of the shape control equipment of the hot slab according to the present invention described in the above-described (2). As illustrated in the drawings, the shape control equipment according to the present invention is equipment that adjusts the shape of a hot slab extracted from a heating furnace (not illustrated). This shape control equipment includes a width pressing machine 2, an entry-side rolling mill 1, and an exit-side rolling mill 3. The width pressing machine 2 reduces the width of the slab by a pair of right and left molds. The entry-side rolling mill 1 and the exit-side rolling mill 3 are respectively arranged at an entry side that is the upstream side of a width pressing machine and at an exit side that is the downstream side, close to the width pressing machine 2. The entry-side rolling mill 1 and the exit-side rolling mill 3 each perform horizontal rolling on the slab by a pair of upper and lower rolls. The entry-side rolling mill 1 and exit-side rolling mill 3 have a distance between the respective roll axial centers within a slab length after reduction of the width of the slab.

[0021] In a shape control method according to the present invention, the above-described shape control equipment

was used to reduce the width of the hot slab extracted from the heating furnace once or twice or more by the width pressing machine 2 over the entire length of the slab. At this time, a compressive force and a tensile force were applied during the reduction of the width of a slab at the top and tail ends of slab using horizontal rolling by the entry-side and exit-side rolling mills. Additionally, a compressive force was applied by the entry-side rolling mill at the time of rolling start of the exit-side rolling mill. It is important to apply the compressive force and the tensile force so as to satisfy the condition where the rolling neutral points in flat rolling in the entry-side and exit-side rolling mills are present in a roll bite (the condition not to cause a slip). The range of the compressive force that satisfies this condition can be calculated from rolling theory. For example, FIG. 10A and FIG. 10B are charts illustrating respective results of compressive forces that are allowed to push the slab to the width pressing machine by the respective entry-side and exit-side rolling mills. The calculation conditions are set as initial slab size = 260 mm thickness x 1450 mm width, temperature = 1100°C, roll diameter = 1000 mm ϕ , friction coefficient = 0.3, and exit-side thicknesses of the respective entry-side and exit-side horizontal rolling mills = 245 mm.

[0022] According to FIG. 10A, in the entry-side rolling mill, the neutral point (in flat rolling) moves to the roll bite exit side as a pushing force from the roll bite exit side (a compressive force from the rolling mill to the width pressing machine) increases. However, a slip does not occur insofar as the compressive force is 11.0 MPa or less. According to FIG. 10B, in the exit-side rolling mill, the neutral point (in flat rolling) moves to the roll bite exit side as a pushing force from the roll bite exit side (a compressive force from the rolling mill to a sizing press machine) increases. However, a slip does not occur insofar as the compressive force is 17.2 MPa or less.

Working Example 3

[0023] The shape control equipment with the configuration illustrated in FIG. 2A and FIG. 2B (where the distance between the roll axial centers in the entry-side rolling mill and the exit-side rolling mill $\leq$ the initial slab length) was used to reduce the width of a slab, which has a width of 1450 mm and a thickness of 260 mm as the initial size, over the entire length by 250 mm once using the width pressing machine. At this time, the width adjustment was performed under two conditions. The two conditions includes the case (an example of the present invention) where a compressive force of 7.7 MPa was applied in the slab travelling direction by the entry-side rolling mill during reduction of the width of a slab in the top end portion and a compressive force of 7.7 MPa was applied in the slab travelling direction by the exit-side rolling mill during reduction of the width of a slab in the tail end portion, and also includes the case (a comparative example) where the compressive force was not applied. Then, the respective amounts of crop loss were compared. As a result, as illustrated in FIG. 11A and FIG. 11B, in the example of the present invention (with white circles), the plain view pattern of the top and tail ends of slab after the width adjustment had a shape close to a rectangular shape compared with the comparative example (with black circles). As a result, (a) the top-end crop weight was reduced by 84.3% compared with the comparative example (the calculating formula: $(1 - \frac{\text{the crop loss weight of the example of the present invention}}{\text{the crop loss weight of the comparative example}}) \times 100 (\%)$), and (b) the tail-end crop weight was reduced by 22.3% compared with the comparative example (the calculating formula: $(1 - \frac{\text{the crop loss weight of the example of the present invention}}{\text{the crop loss weight of the comparative example}}) \times 100 (\%)$).

Working Example 4

[0024] The same shape control equipment as used in Working Example 3 was used to reduce the width of a slab, which has a width of 1450 mm and a thickness of 260 mm as the initial size, over the entire length by 325 mm twice for each reduction of the width of a slab, that is, by 650 mm in total using the width pressing machine. At this time, the width adjustment was performed under two conditions. The two conditions includes the case (an example of the present invention) where a compressive force of 7.7 MPa was applied in the slab travelling direction by the entry-side rolling mill during reduction of the width of a slab in the top end portion and a compressive force of 7.7 MPa was applied in the slab travelling direction by the exit-side rolling mill during reduction of the width of a slab in the tail end portion for each reduction of the width of a slab, and also includes the case (a comparative example) where the compressive force was not applied. Then, the respective amounts of crop loss were compared. As a result, as illustrated in FIG. 12A and FIG. 12B, in the example of the present invention (with white circles), the plain view pattern of the top and tail ends of slab after the width adjustment had a shape close to a rectangular shape compared with the comparative example (with black circles). As a result, (a) the top-end crop weight was reduced by 85.0% compared with the comparative example (the calculating formula: $(1 - \frac{\text{the crop loss weight of the example of the present invention}}{\text{the crop loss weight of the comparative example}}) \times 100 (\%)$), and (b) the tail-end crop weight is reduced by 80.5% compared with the comparative example (the calculating formula: $(1 - \frac{\text{the crop loss weight of the example of the present invention}}{\text{the crop loss weight of the comparative example}}) \times 100 (\%)$).

Working Example 5

[0025] The same shape control equipment as used in Working Example 3 was used to reduce the width of a slab, which has a width of 900 mm and a thickness of 260 mm as the initial slab size, over the entire length by 350 mm once using the width pressing machine. Subsequently, the width adjustment was performed under a plurality of conditions. The conditions include the case (an example of the present invention) where various compressive forces (pressing pressures) were applied in the slab travelling direction by the entry-side rolling mill at the start of horizontal rolling (during biting of the top end) at the time of the horizontal rolling by the exit-side rolling mill, and also includes the case (a comparative example) where the compressive force was not applied. Regarding the exit-side rolling mill, an exit-side slab thickness (abbreviated as an exit-side rolling-mill exit-side thickness), a rolling reduction, a biting angle (specifically, the upper limit of the biting angle), and a rolling force were investigated, and the result is shown in Table 1.

[Table 1]

Condition No.	Pressing pressure (MPa)	Exit-side rolling-mill exit-side thickness (mm)	Rolling reduction (%)	Biting angle (degree)	Rolling force (t)	Remarks
1	0.0	316	18	21	394	Comparative example
2	3.0	190	50	36	879	Example of the present invention
3	5.0	150	60	39	1029	Example of the present invention
4	7.0	120	68	42	1221	Example of the present invention
5	10.0	90	77	44	1380	Example of the present invention

[0026] After reduction of the width of a slab (at the entry-side of the exit-side rolling-mill), the slab increased in thickness up to 400 mm in the width center of the slab-top-end portion. According to Table 1, the exit-side rolling-mill exit-side thickness was larger than the initial slab thickness of 260 mm in the comparative example where the pressing pressure was not applied. Additionally, the rolling reduction, the biting angle, the rolling force were all at low level, and reduction in pass number during rough rolling as the subsequent process (and productivity improvement due to this reduction) could not be expected. In contrast, in the example of the present invention where the pressing pressure was applied, the exit-side rolling-mill exit-side thickness considerably decreased as the pressing pressure increased. Thus, the rolling reduction, the biting angle, and the rolling force all increased. A pressing pressure of 10 MPa can reduce the exit-side rolling-mill exit-side thickness to one-third or less of that in the comparative example, and can increase the biting angle twice or more times. This led to reduction in pass number during the rough rolling as the subsequent process and led to productivity improvement due to this reduction. Here, although the rolling force was increased about three times at most compared with the comparative example, this rolling force was within a range of the device capacity. Thus, this did not cause a problem.

DESCRIPTION OF REFERENCE SIGNS

[0027]

- 1 entry-side horizontal rolling mill
- 1HR entry-side horizontal rolling roll
- 2 width pressing machine
- 2K mold (width press mold)
- 3 exit-side rolling mill

3HR	exit-side horizontal rolling roll
10	slab (hot slab)
10WC	slab width center
10FT	fish tail portion
5 η	arrangement interval between horizontal rolling mill and width pressing machine
P	width reducing load
θ	mold inclined angle
μ	friction coefficient

Claims

1. Shape control equipment for adjusting a slab width, a top-end plain view pattern, and a slab thickness profile of a slab, the slab being a hot slab extracted from a heating furnace, the shape control equipment comprising:
 - a horizontal rolling mill that includes horizontal rolling rolls mutually opposed on both sides in a slab thickness direction; and
 - a width pressing machine that includes a pair of width press molds mutually opposed on both sides in the slab width direction, wherein
 - an entry-side horizontal rolling mill as the horizontal rolling mill and the width pressing machine are installed in this order at an arrangement interval shorter than a slab length during extraction from heating furnace from an upstream side in a slab conveying direction.
2. The shape control equipment for the hot slab according to claim 1, further comprising
 - an exit-side horizontal rolling mill as the horizontal rolling mill disposed close to a downstream side of the width pressing machine, the exit-side horizontal rolling mill including a pair of horizontal rolling rolls, wherein the entry-side horizontal rolling mill, the width pressing machine, and the exit-side horizontal rolling mill are installed in this order from the upstream side in the slab conveying direction.
3. A shape control method for a hot slab using the shape control equipment for the hot slab according to claim 1, the shape control method comprising
 - simultaneously performing rolling by the horizontal rolling mill and reduction of a width of a slab by the width pressing machine on one hot slab.
4. The shape control method for the hot slab according to claim 3, further comprising
 - performing a rolling speed control of the horizontal rolling mill during the reduction of the width of the slab by the width pressing machine.
5. A shape control method for a hot slab using the shape control equipment according to claim 2, the shape control method comprising
 - applying a compressive force and a tensile force by horizontal rolling using the entry-side and exit-side horizontal rolling mills during reduction of the width of the slab in top and tail ends of slab, and applying a compressive force by the entry-side horizontal rolling mill at a time of rolling start of the exit-side horizontal rolling mill when reducing the width of the hot slab extracted from the heating furnace over an entire length of the slab once or twice or more by the width pressing machine.

FIG. 1A

(UPSTREAM SIDE)

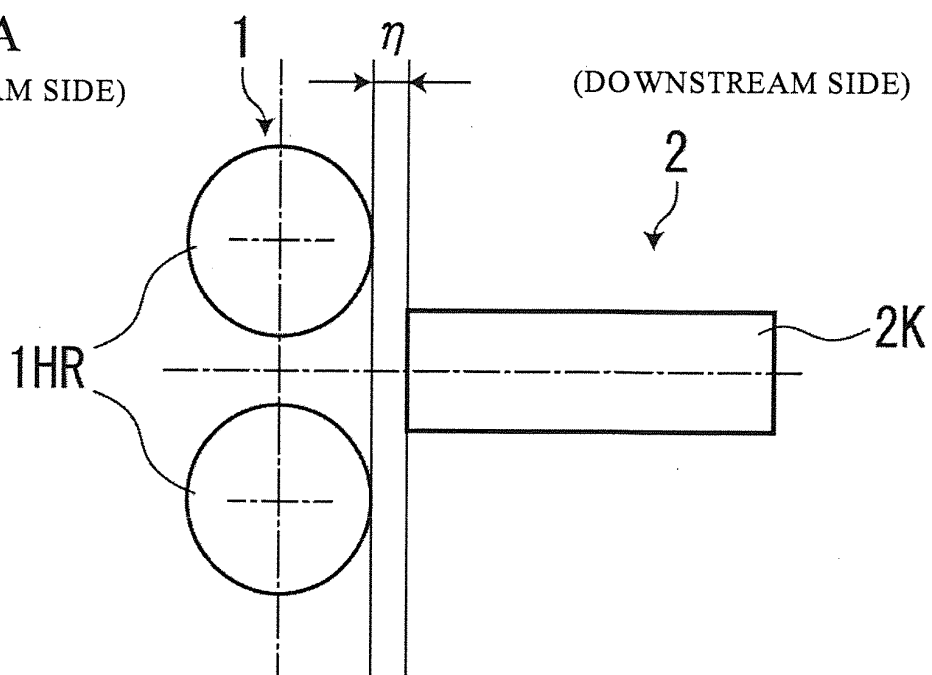
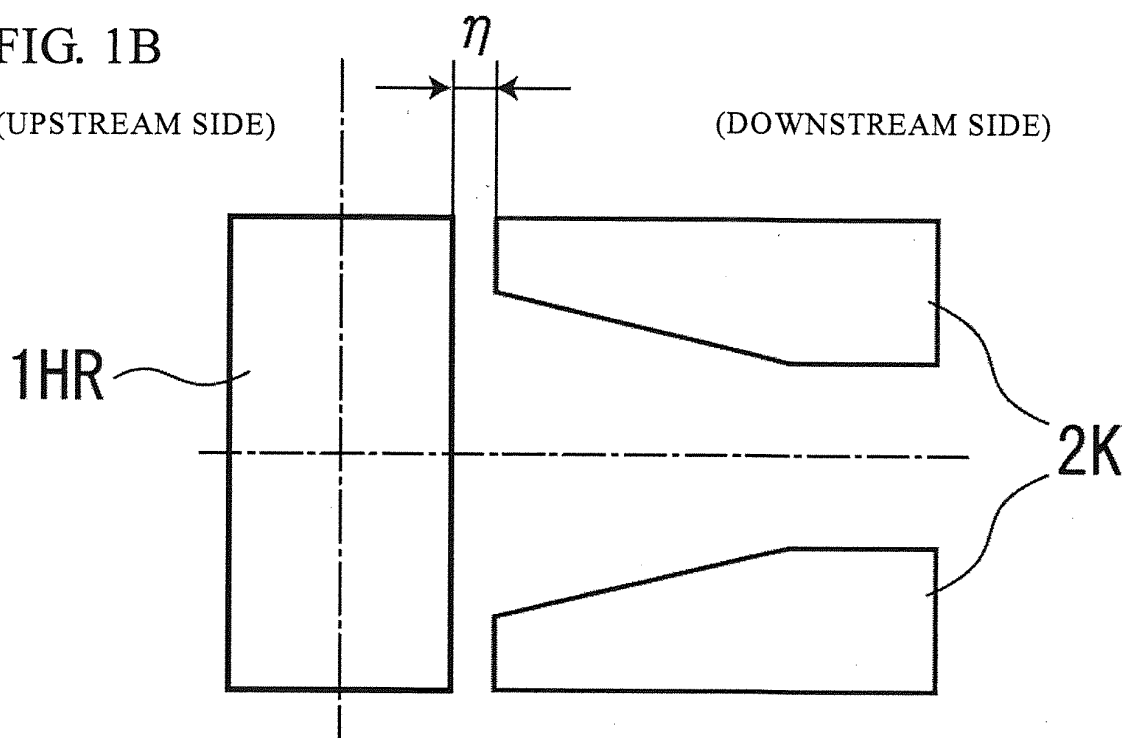


FIG. 1B

(UPSTREAM SIDE)



$0 < \eta < \text{SLAB LENGTH DURING EXTRACTION FROM HEATING FURNACE}$

FIG. 2A

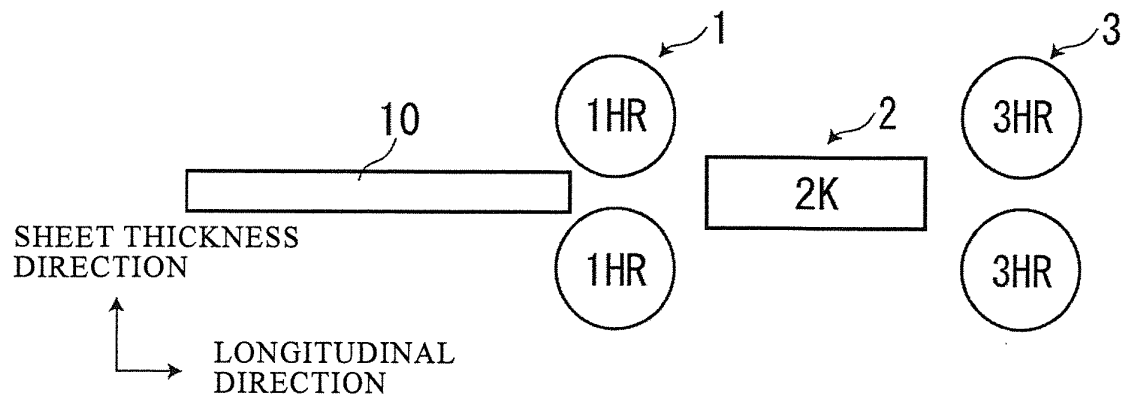


FIG. 2B

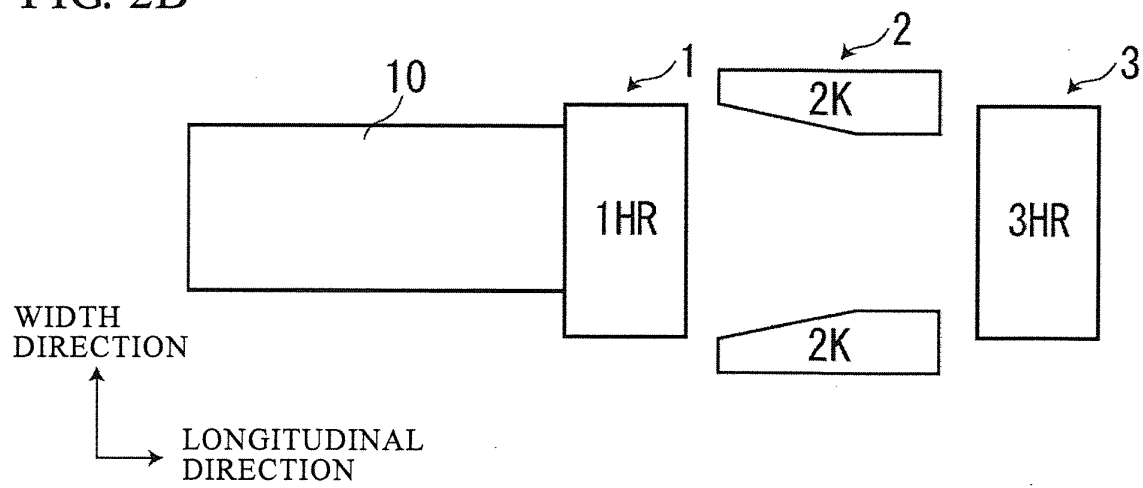


FIG. 3

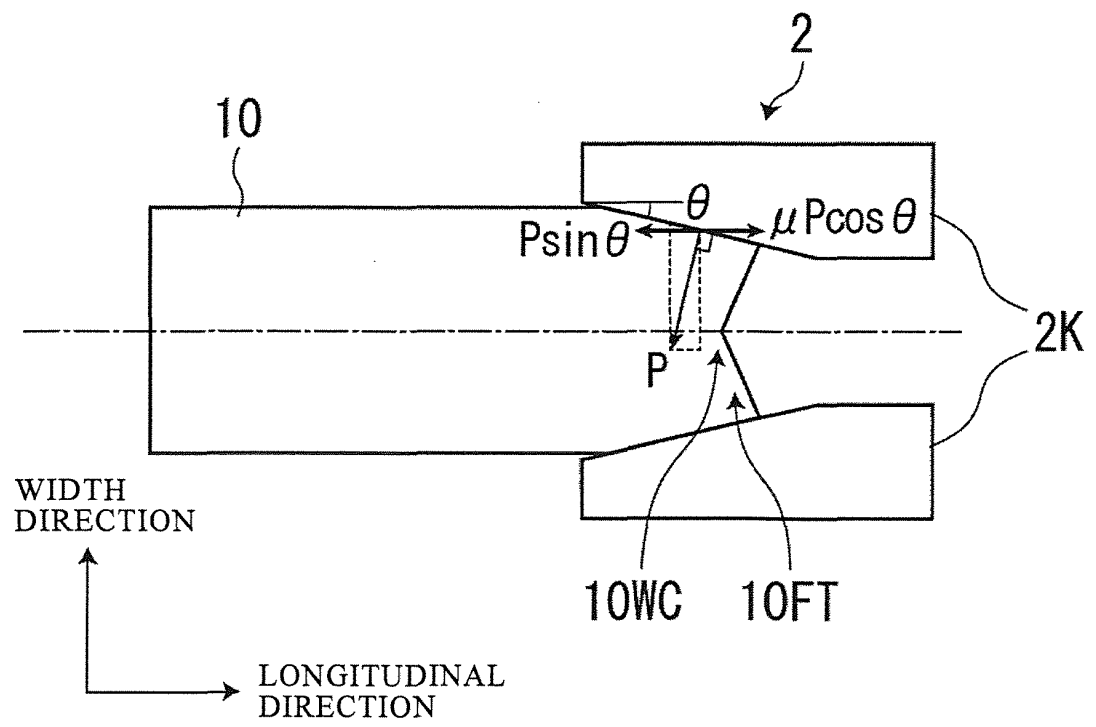


FIG. 4

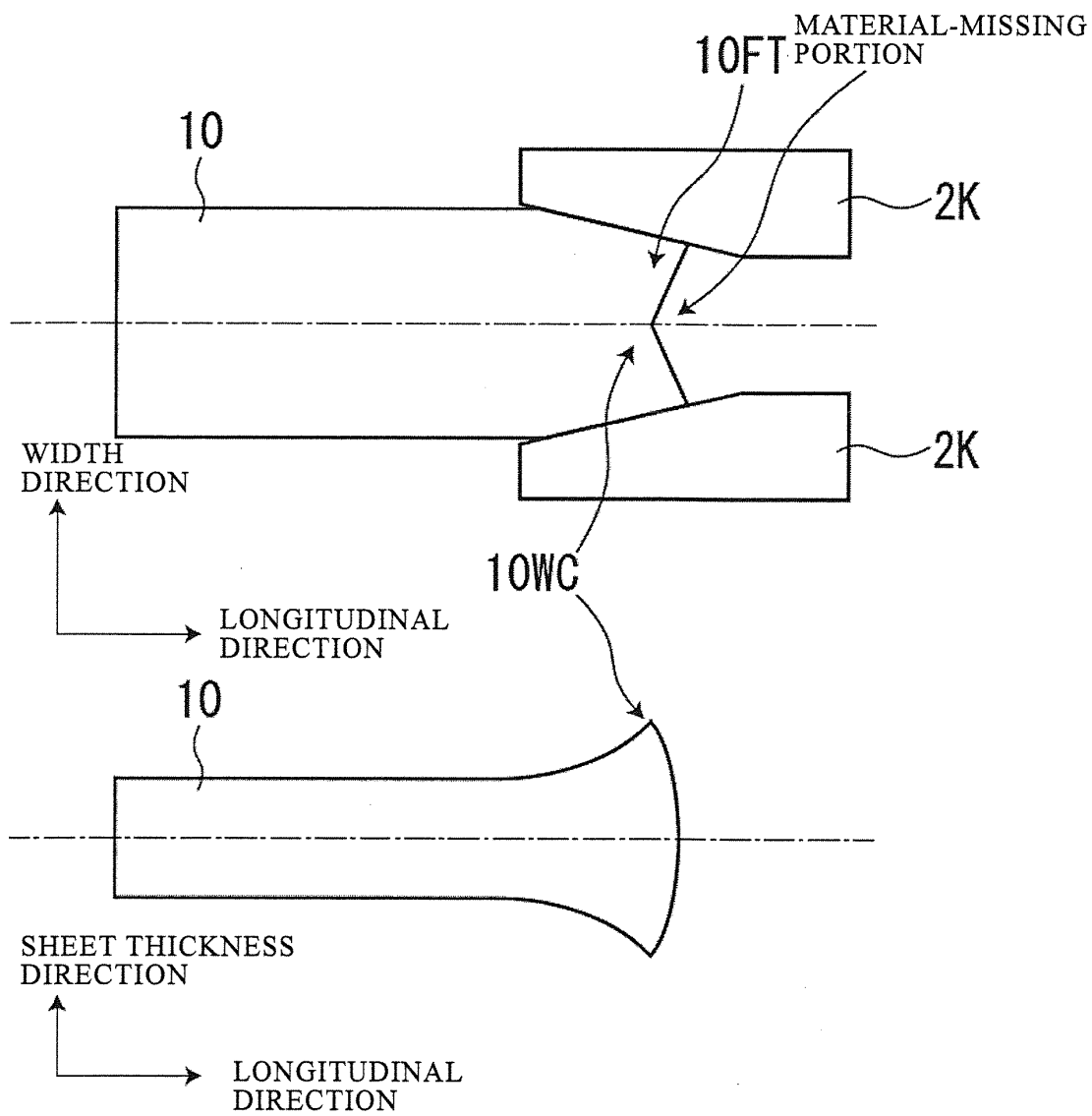


FIG. 5

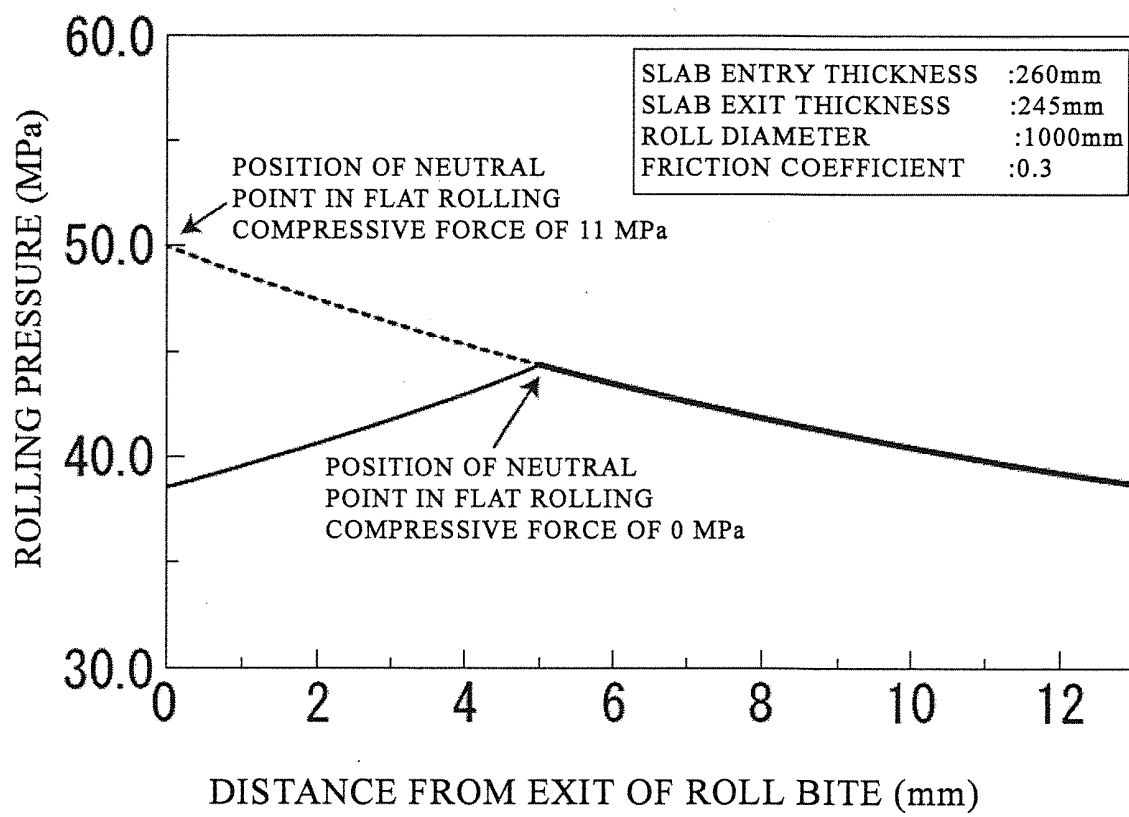


FIG. 6

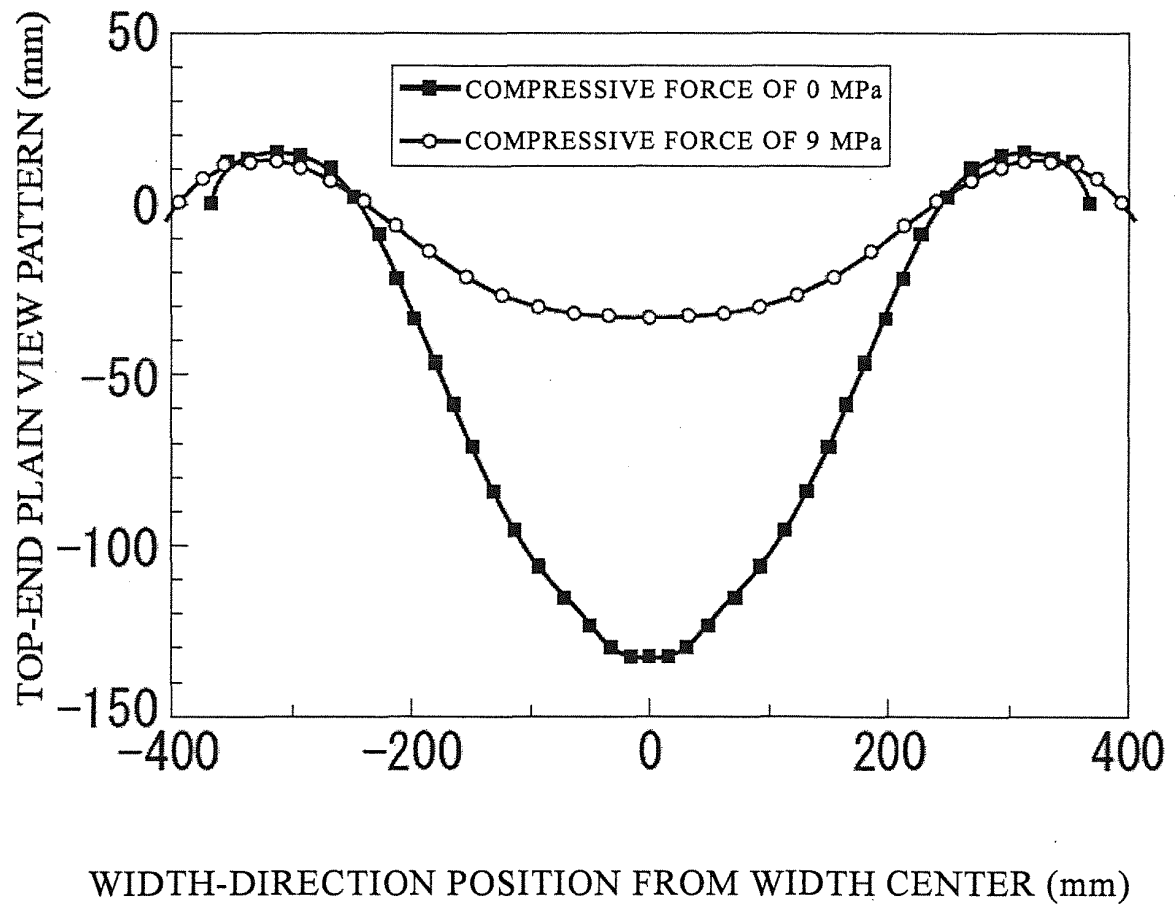


FIG. 7

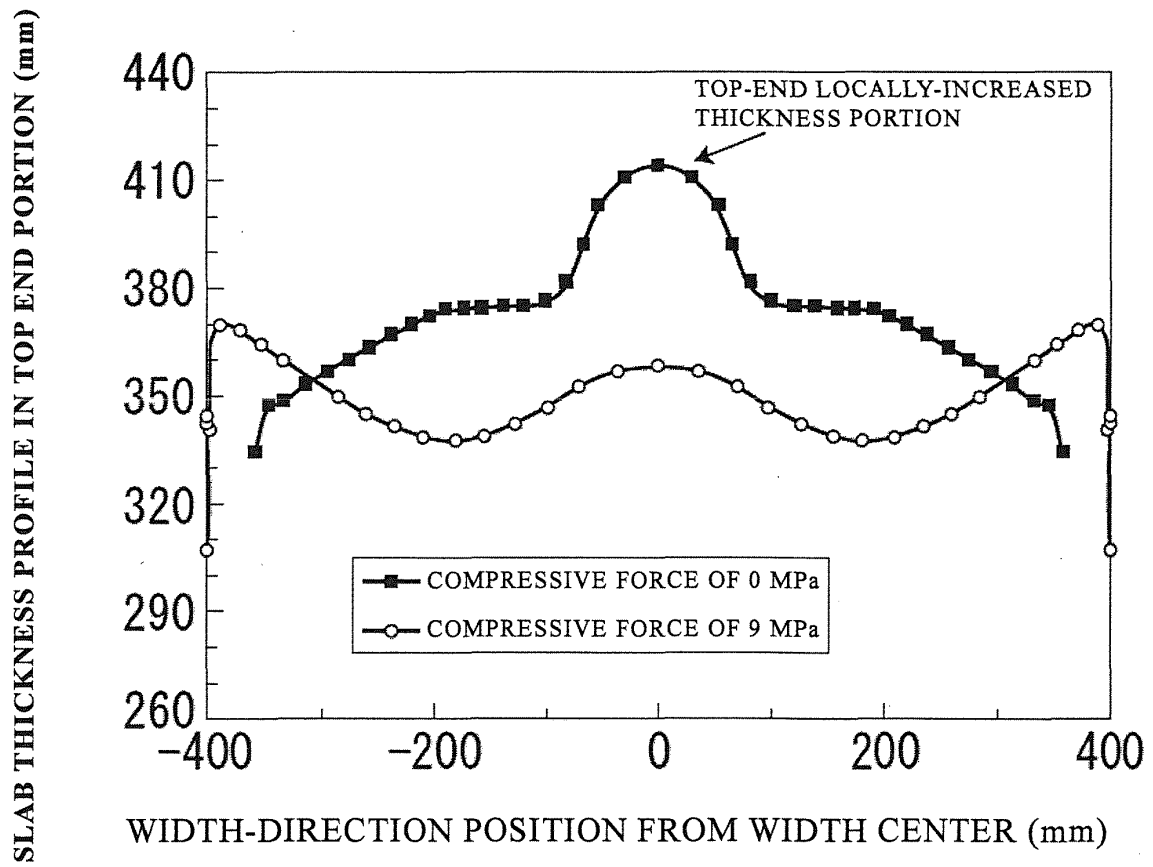


FIG. 8

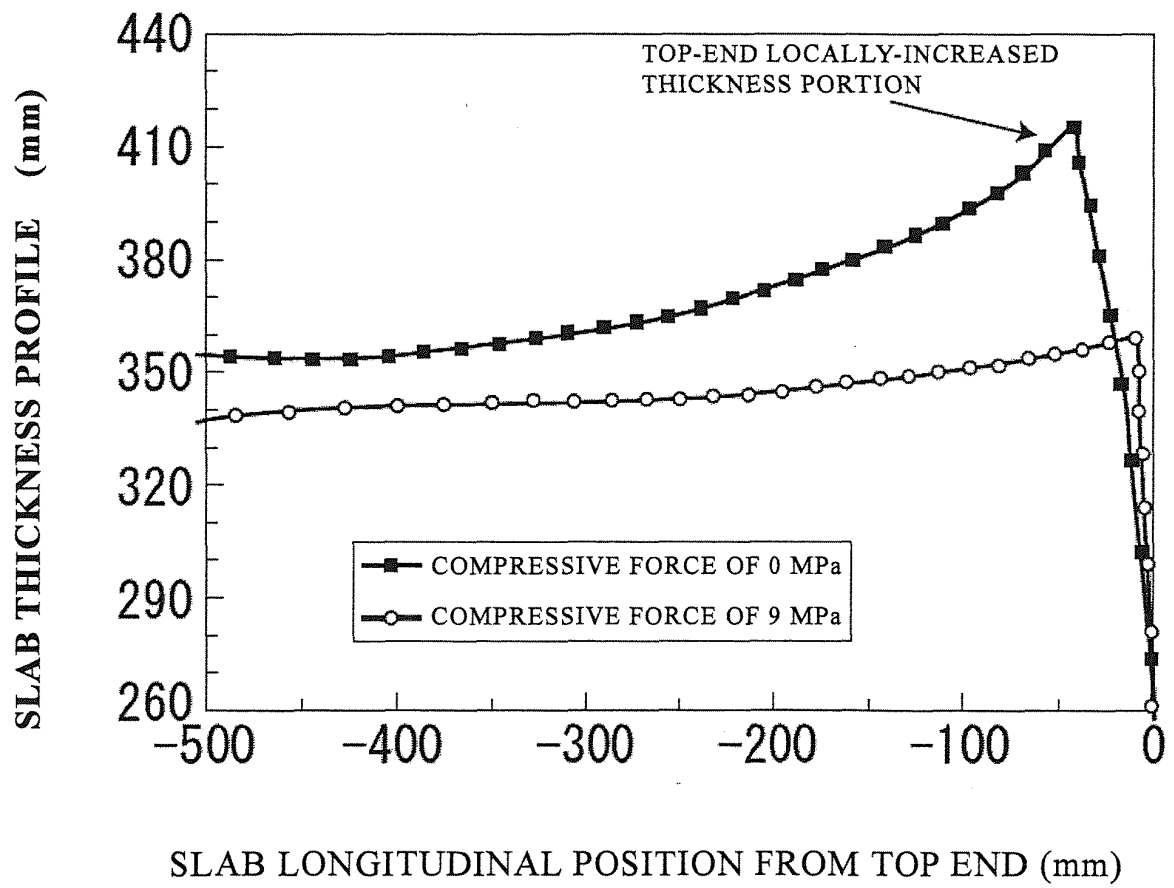


FIG. 9

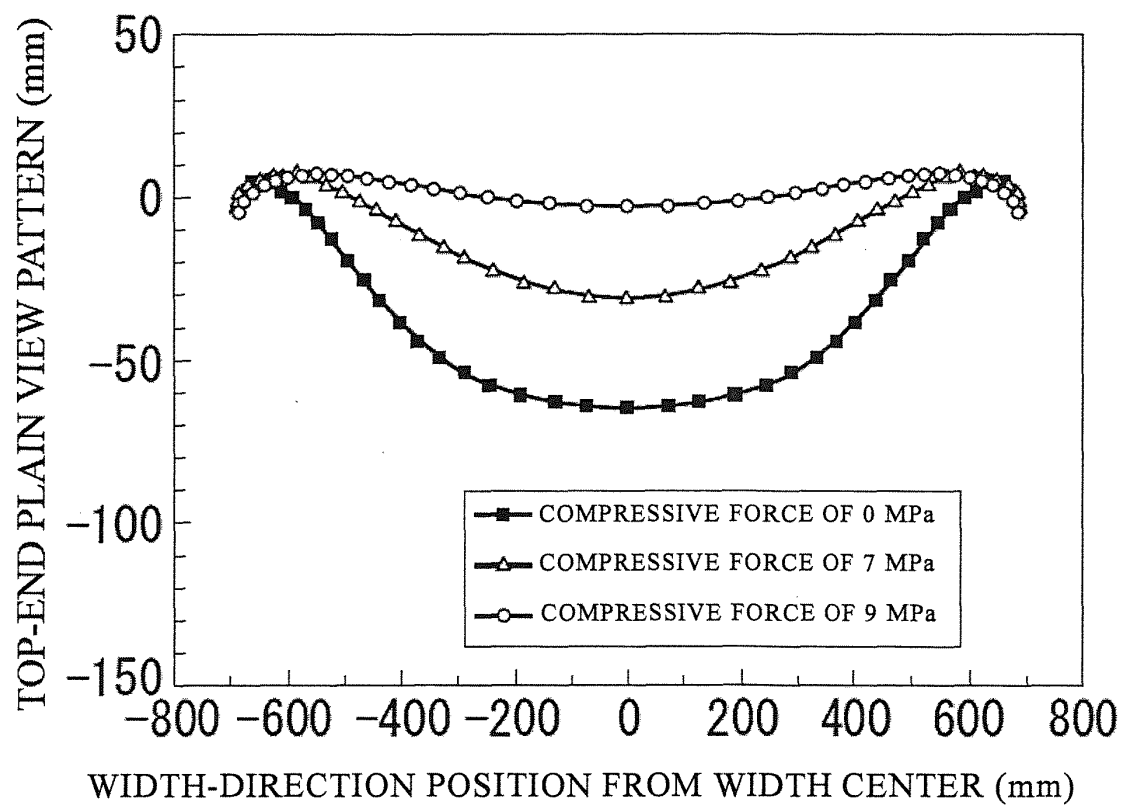


FIG. 10A

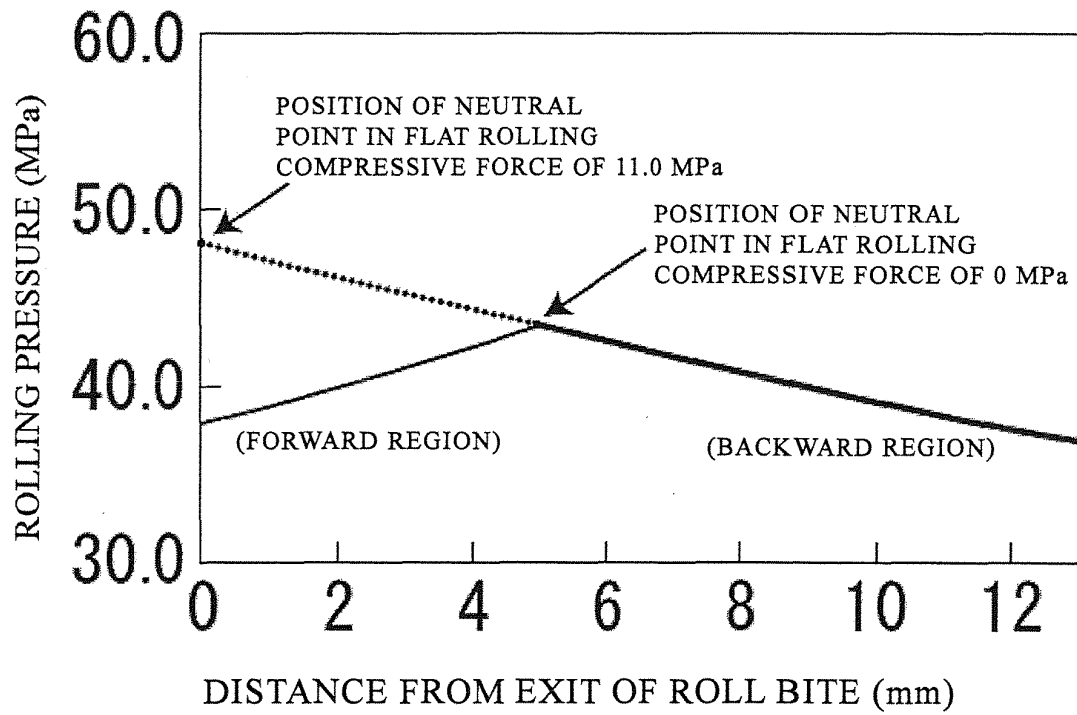


FIG. 10B

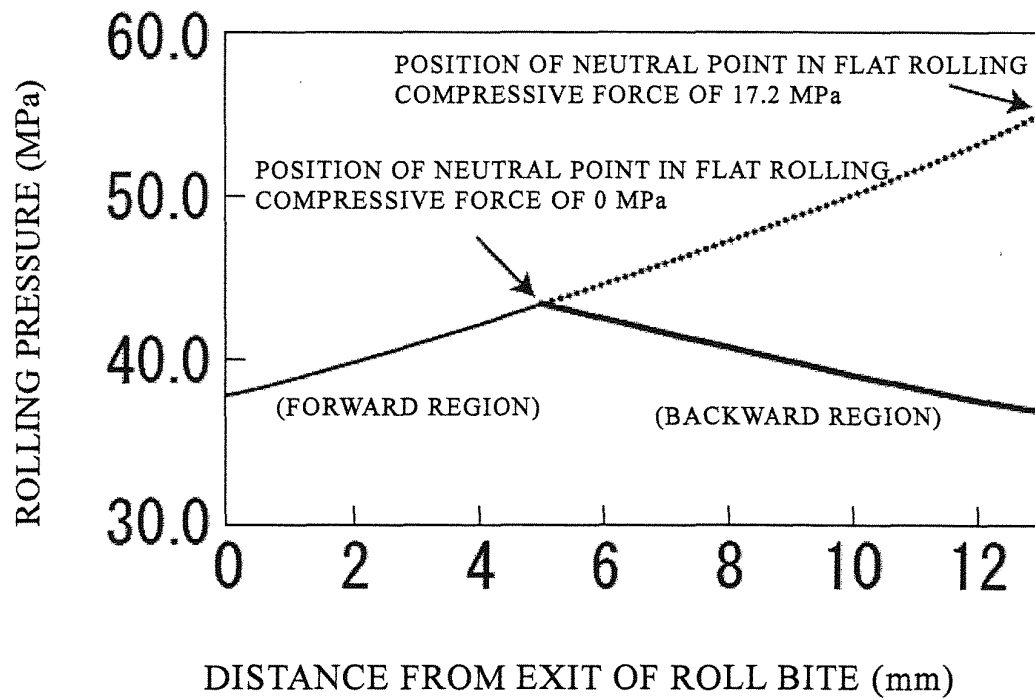


FIG. 11A

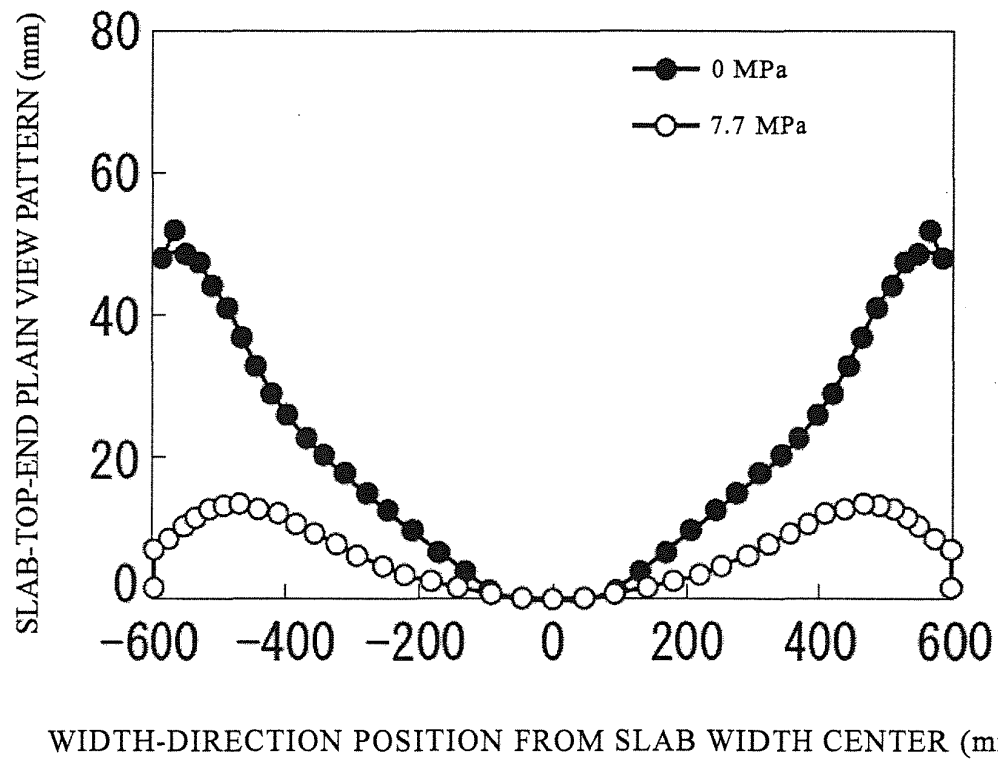


FIG. 11B

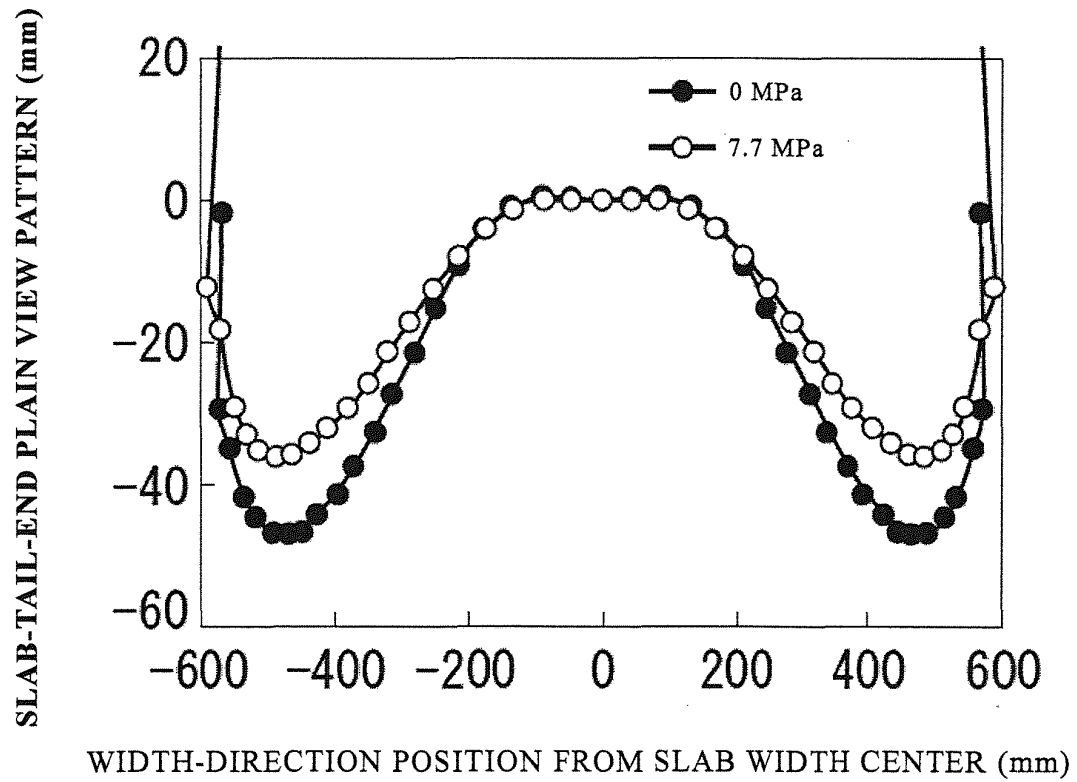


FIG. 12A

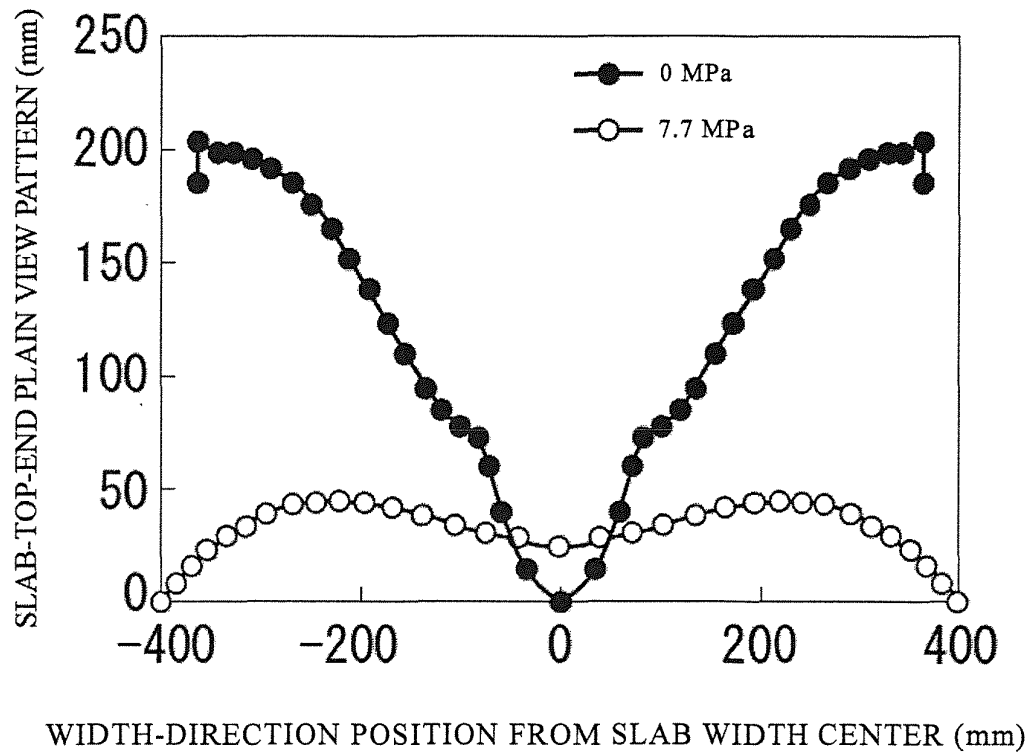


FIG. 12B

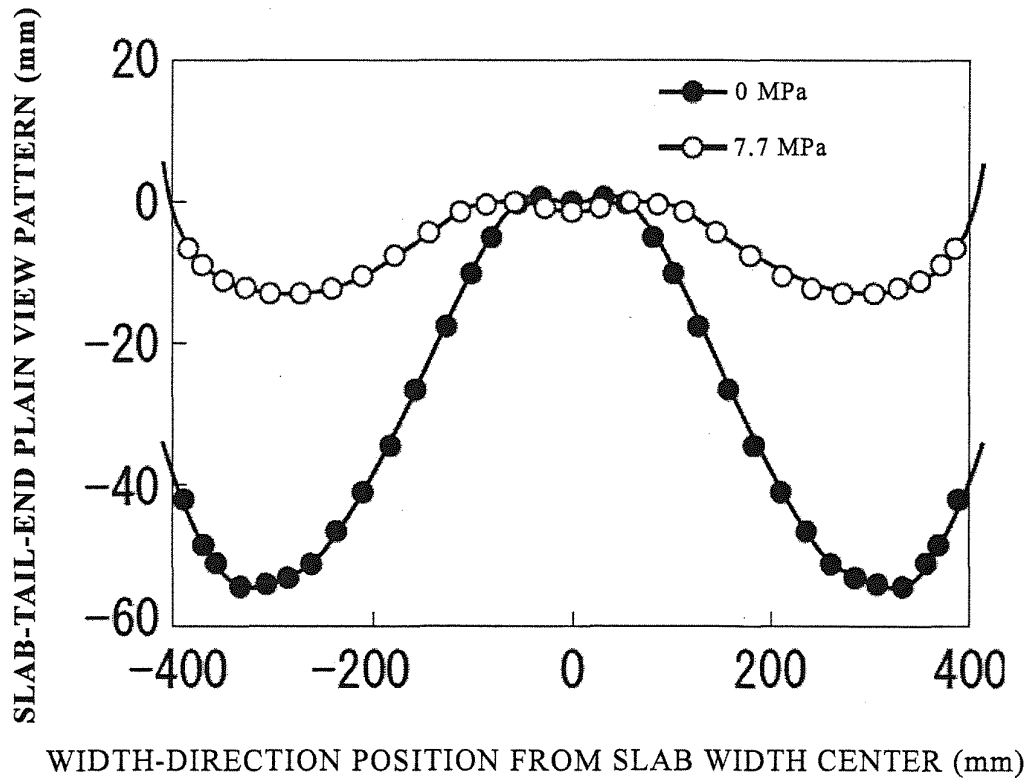


FIG. 13

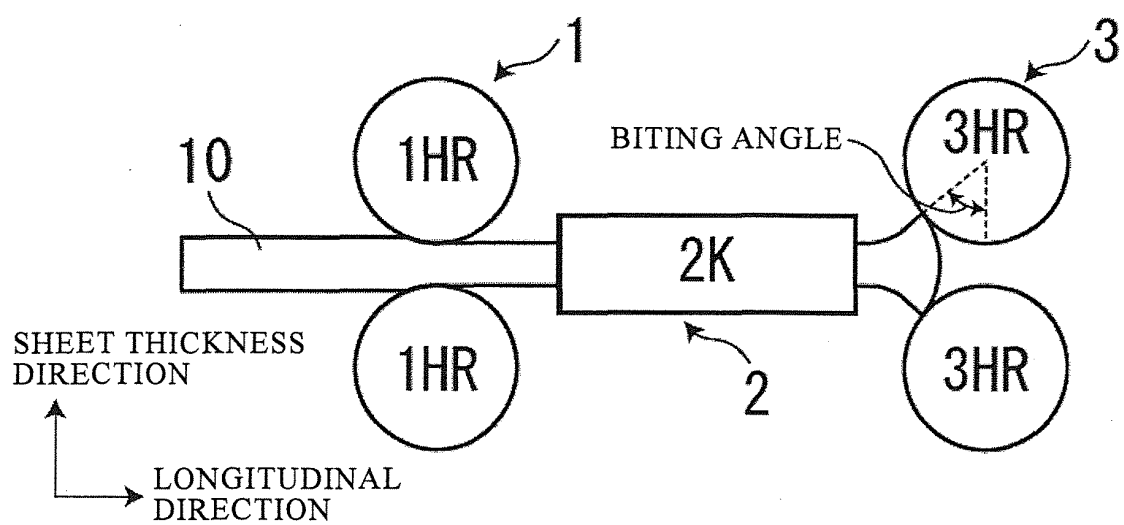


FIG. 14

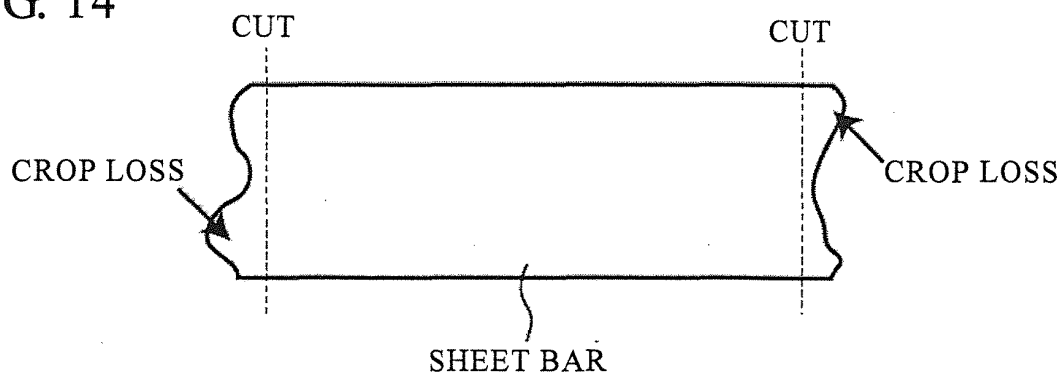
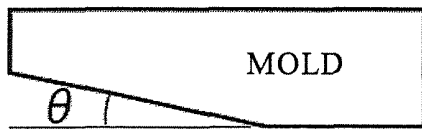


FIG. 15



θ : MOLD INCLINED ANGLE

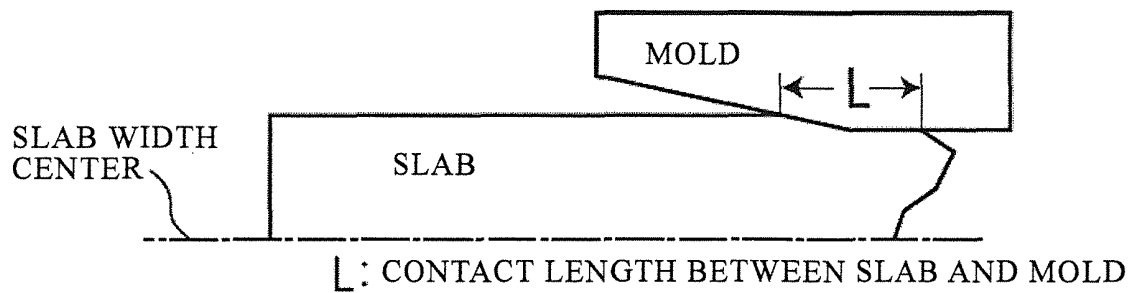
LARGE θ : THICKNESS INCREASE IN SLAB END PORTION

SMALL θ : THICKNESS INCREASE IN SLAB CENTER PORTION

(PROBLEM)

EFFECT IS SMALL IN CASE WHERE SLAB WIDTH IS NARROW OR IN
CASE WHERE REDUCTION AMOUNT OF WIDTH OF SLAB IS LARGE

FIG. 16



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2012/006639

A. CLASSIFICATION OF SUBJECT MATTER

B21B15/00 (2006.01) i, B21B1/02 (2006.01) i, B21J1/04 (2006.01) i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

B21B15/00, B21B1/02, B21J1/04

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Jitsuyo Shinan Koho 1922-1996 Jitsuyo Shinan Toroku Koho 1996-2012

Kokai Jitsuyo Shinan Koho 1971-2012 Toroku Jitsuyo Shinan Koho 1994-2012

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 1-284401 A (Ishikawajima-Harima Heavy Industries Co., Ltd.), 15 November 1989 (15.11.1989), claims; fig. 1 (Family: none)	1-5
X	JP 7-275901 A (Nippon Steel Corp.), 24 October 1995 (24.10.1995), fig. 3 (Family: none)	1-5

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

* Special categories of cited documents:

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

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

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

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

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

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

"&" document member of the same patent family

Date of the actual completion of the international search
13 December, 2012 (13.12.12)Date of mailing of the international search report
25 December, 2012 (25.12.12)Name and mailing address of the ISA/
Japanese Patent Office

Authorized officer

Facsimile No.

Telephone No.

Form PCT/ISA/210 (second sheet) (July 2009)

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2012/006639

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	CD-ROM of the specification and drawings annexed to the request of Japanese Utility Model Application No. 70473/1993 (Laid-open No. 37402/1995) (Toshiba Corp.), 11 July 1995 (11.07.1995), entire text (Family: none)	1-5

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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2009006361 A [0005]
- JP 2561251 B [0005]
- JP 2008254036 A [0005]
- JP 2008254033 A [0005]