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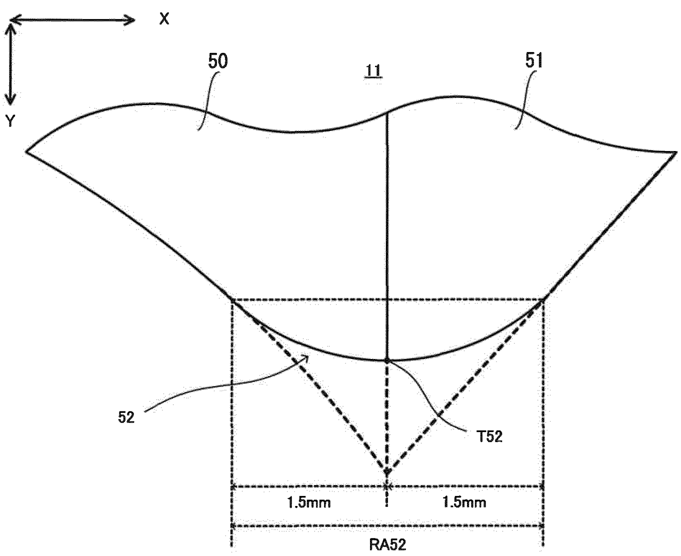
(54) METHOD FOR MANUFACTURING ROLL FOR REDUCING, AND ROLL FOR REDUCING

(57) There is provided a method for manufacturing a roll for reducing rolling capable of suppressing the occurrence of fin flaws and edge flaws. A roll for reducing rolling that is used on a three-roll type reducing-rolling mill is prepared. Next, a ridge part (52) formed in the adjacent portion between a caliber part and a flange part is rounded by cutting the ridge part (52) while rotating the roll for reducing rolling around the roll axis. In the step of rounding the ridge part, in a ridge part region (RA52) within the range of 3.0 mm in a roll axis direction with the top of the ridge part (52) being the center, the average of radiuses of curvature measured at a 0.5 mm pitch is made in the range of 2.5 to 3.0 mm, and the difference between the maximum value and the minimum value of the radiuses of curvature is made at most 1.0 mm.

FIG. 8



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Description

Technical Field

[0001] The present invention relates to a method for manufacturing a roll for reducing rolling, and a roll for reducing rolling. More particularly, it relates to a method for manufacturing a roll for reducing rolling, and the roll for reducing rolling, which roll is used on a three-roll type reducing-rolling mill for reducing-rolling steel pipes.

Background Art

[0002] A reducing-rolling mill, which is represented by a sizer or a stretch reducer, reducing-rolls a steel pipe to a predetermined outside diameter dimension. As the reducing-rolling mill, a three-roll type reducing-rolling mill has been known mainly. The three-roll type reducing-rolling mills are described, for example, in WO 2005/070574 and WO 2005/092531.

[0003] The reducing-rolling mill is usually provided with a plurality of stands arranged along the pass line. Each of the stands includes a plurality of rolls for reducing rolling each having a groove for forming a pass (caliber). For the three-roll type reducing-rolling mill, at each stand, three rolls are arranged at equal intervals around the pass line, and also are arranged so as to be shifted by 60 degrees around the pass line with respect to the three rolls included in the previous-stage stand.

[0004] Generally, the roll included in each stand of the reducing-rolling mill has a groove of an elliptical arc shape in the transverse cross section (the cross section in the direction perpendicular to the pass line, that is, the cross section including the roll axis). By using such a roll, the draft per one stand can be increased to some extent.

[0005] In the conventional art, however, a near-surface portion of a steel pipe being rolled squeezes out of the roll groove, and a so-called fin flaw occurs in some cases. Further, if the load applied to a steel pipe portion, which is in contact with the vicinity of groove edge, of the reducing-rolled steel pipe increases, an edge flaw occurs easily in that steel pipe portion. Specifically, a linear flaw occurs easily in the longitudinal direction of steel pipe.

[0006] Techniques for preventing such a fin flaw or edge flaw have been proposed in JP11-197714A and JP11-57816A.

[0007] These Publications describe that, on the caliber roll used in the reducing-rolling mill, a ridge part, which is a boundary between the caliber and a flange, is rounded, whereby finning on the flange side of the steel pipe being reducing-rolled is reduced.

Disclosure of the Invention

[0008] Unfortunately, the occurrence of fin flaws or edge flaws cannot be suppressed merely by rounding the ridge part of roll as described in these Publications.

[0009] An objective of the present invention is to provide a method for manufacturing a roll for reducing rolling capable of suppressing the occurrence of fin flaws or edge flaws.

[0010] The method for manufacturing a roll for reducing rolling in accordance with an embodiment of the present invention is a method for manufacturing a roll for reducing rolling, which roll is used on a three-roll type reducing-rolling mill for reducing-rolling steel pipes, and includes a caliber part having a groove of an arched shape in transverse cross section and flange parts adjacent to the caliber part. The method for manufacturing a roll for reducing rolling includes a step of preparing a roll for reducing rolling, and a step of rounding a ridge part formed in the adjacent portion between the caliber part and the flange part by cutting the ridge part while rotating the roll for reducing rolling around the roll axis. In the step of rounding the ridge part, in a ridge part region within the range of 3.0 mm in a roll axis direction with the top of the ridge part being the center, the average of radiuses of curvature measured at a 0.5 mm pitch is made in the range of 2.5 to 3.0 mm, and the difference between the maximum value and the minimum value of the radiuses of curvature is made at most 1.0 mm.

[0011] With the method for manufacturing a roll for reducing rolling in accordance with this embodiment, a roll for reducing rolling capable of suppressing the occurrence of fin flaws or edge flaws can be manufactured.

[0012] The roll for reducing rolling in accordance with this embodiment is used on a three-roll type reducing-rolling mill for reducing-rolling steel pipes. The roll for reducing rolling includes a caliber part having a groove of an arched shape in transverse cross section, and flange parts adjacent to the caliber part. Within the range of 3.0 mm in a roll axis direction with the top of a ridge part, which is formed in the adjacent portion between the caliber part and the flange part, being the center, the average of radiuses of curvature measured at a 0.5 mm pitch is in the range of 2.5 to 3.0 mm, and the difference between the maximum value and the minimum value of the radiuses of curvature is at most 1.0 mm.

[0013] The roll for reducing rolling in accordance with this embodiment can suppress the occurrence of fin flaws or edge flaws.

Brief Description of Drawings

[0014]

[Figure 1] Figure 1 is a side view of a three-roll type reducing-rolling mill.
[Figure 2] Figure 2 is a front view of a stand in Figure 1.
[Figure 3] Figure 3 is a front view of a stand at the previous stage of the stand shown in Figure 2.
[Figure 4] Figure 4 is a schematic view of a reducing rolling operation of a steel pipe performed by using the three-roll type reducing-rolling mill shown in Figure 1.
[Figure 5] Figure 5 is a front view of a roll for reducing rolling in Figure 1.
[Figure 6] Figure 6 is an enlarged view of the vicinity of a ridge part of the roll for reducing rolling shown in Figure 5.
[Figure 7] Figure 7 is a schematic view of a turning machine used for manufacturing the roll for reducing rolling shown in Figure 5.
[Figure 8] Figure 8 is an enlarged view of the vicinity of a ridge part of the roll for reducing rolling cut by the turning machine shown in Figure 7.
[Figure 9] Figure 9 is a schematic view for explaining a method for measuring the radius of curvature of the ridge part shown in Figure 8.
[Figure 10] Figure 10 is a view showing one example of a method for measuring the radius of curvature of the ridge part shown in Figure 8.
[Figure 11] Figure 11 is a sectional view of a cold-setting resin in Figure 10.
[Figure 12] Figure 12 a chart showing measurement results of the shapes and the radiuses of curvature of the rolls used in Examples.

Description of Embodiments

[0015] An embodiment of the present invention will now be described in detail with reference to the accompanying drawings. The same symbols are applied to the same or equivalent elements in the drawings, and the explanation thereof is omitted.

[Configuration of reducing-rolling mill]

[0016] Figure 1 is a side view of a reducing-rolling mill 1 in accordance with the embodiment of the present invention. This reducing-rolling mill 1 is of a three-roll type. Referring to Figure 1, the reducing-rolling mill 1 is provided with a plurality of stands ST1 to STm (m is a natural number) arranged along a pass line RA. The reducing-rolling mill 1 is, for example, a stretch reducer, and the number m of stands is about 20 to 30.
[0017] Figure 2 is a front view of a stand STi (i is a natural number not larger than m) of the reducing-rolling mill 1 shown in Figure 1, and Figure 3 is a front view of a stand STi-1.
[0018] Referring to Figure 2, each stand STi includes three rolls for reducing rolling (hereinafter, referred simply to as rolls) 11. The three rolls 11 are arranged at equal angular intervals around the pass line RA. Therefore, the three rolls 11 are arranged at angular intervals of 120 degrees around the pass line RA. Each of the rolls 11 has a groove 20 whose transverse cross section (cross section in the roll axis direction) takes an arched shape. The groove 20 of each of the three rolls 11 forms a caliber PA.
[0019] As shown in Figures 2 and 3, the three rolls 11 included in the stand STi are arranged so as to be shifted by 60 degrees around the pass line RA with respect to the three rolls 11 included in the previous-stage stand STi-1.
[0020] The three rolls of each stand STi are connected to each other by a bevel gear, not shown. By the rotation of one of the three rolls 11 made by a motor, not shown, all of the rolls 11 are rotated.
[0021] The cross-sectional area of the caliber PA formed by the three rolls 11 of each stand STi decreases in the subsequent stand. Therefore, the caliber PA formed at the stand ST1 has the largest cross-sectional area, and the caliber PA formed at the rearmost stand STm has the smallest cross-sectional area. As shown in Figure 4, a steel pipe is reducing-rolled by passing through from the stand ST1 to the stand STm along the pass line RA, and by the reducing rolling, a steel pipe having a predetermined outside diameter and wall thickness is produced.
[0022] The roll 11 included in the stand STi has the shape shown in Figure 5. Referring to Figure 5, the roll 11 includes a caliber part 50 and a pair of flange parts 51. The caliber part 50 is of a columnar shape, and has a groove 20 having an arched transverse cross section on the surface thereof. The flange part 51 is of a disc shape, and is arranged coaxially with the caliber part 50. The flange part 51 has a frusto-conical shape in which the width decreases toward the direction of separating from the caliber part 50. The caliber part 50 and the flange parts 51 are formed as a single unit.
[0023] As described above, the transverse shape of the groove 20, that is, the shape of the groove 20 in the cross section in the roll axis direction X of the roll 11 is an arched one. In this embodiment, the groove 20 is of a circular arc

shape having a radius Ra1. The line segment DB connecting a groove bottom (the center in the roll axis direction of the groove 20) GB of the groove 20 to the pass line RA is shorter than the radius Ra1. Therefore, the transverse shape of the groove 20 is of an elliptical arc shape in which the line segment DB is a semiminor axis. Since the transverse shape of the groove 20 is an elliptical arc, the draft per one stand can be increased to some extent.

[0024] In the adjacent portion between the caliber part 50 and the flange part 51, a ridge part 52 is formed. Figure 6 is an enlarged view of the vicinity of the ridge part 52 shown in Figure 5. Referring to Figure 6, the ridge part 52 extends in the circumferential direction of the roll 11. Also, the ridge part 52 is rounded.

[0025] The above-described reducing-rolling mill 1 produces a thin-wall steel pipe by means of reducing rolling. The thin-wall steel pipe has a wall thickness of, for example, 2.0 to 3.0 mm, and an outside diameter of, for example, 30.0 to 100.0 mm. When such a thin-wall steel pipe is produced, a fin flaw or an edge flaw occurs easily. The edge flaw described herein means a linear flaw formed along the longitudinal direction on the surface of a steel pipe by the hollowing of the near-surface portion of steel pipe caused by the ridge part of roll. The reason why the fin flaw or the edge flaw occurs easily on the thin-wall steel pipe is presumed to be that since the wall thickness is small, a portion of the steel pipe being rolled which portion comes into contact with the edge vicinity portion of the groove 20 (hereinafter, referred to as a metal portion) flows easily to the roll axis direction X.

[0026] By manufacturing the roll 11 based on the manufacturing method described below, especially when a thin-wall steel pipe is produced, the occurrence of fin flaws or edge flaws is suppressed. In the following, the method for manufacturing the roll 11 is described in detail.

[Manufacturing method]

[0027] The roll 11 is manufactured by the well-known method. Specifically, a prepared roll 11 is set on a well-known turning machine. Figure 7 is a schematic view of a turning machine 60. Referring to Figure 7, the turning machine 60 includes a bed 601, a headstock 602, a carriage 603, a tailstock 604, and a control unit 605.

[0028] The headstock 602 and the tailstock 604 each include a chuck, not shown. By the chucks on the headstock 602 and the tailstock 604, the roll 11 is rotatably set on the turning machine 60.

[0029] The headstock 602 is further provided with a motor, not shown. By the motor, the roll 11 is rotated around the roll axis.

[0030] The carriage 603 is movably disposed on the bed 601. The carriage 603 can be moved in the roll axis direction by a motor, not shown. The carriage 603 is provided with a cutting tool 606. The cutting tool 606 can be moved in the direction perpendicular to the roll axis (the radial direction of the roll 11) by a servomotor, not shown.

[0031] The control unit 605 controls the rotating speed of the roll 11. The control unit 605 further controls the movement in the roll axis direction of the carriage 603 and the movement in the roll radial direction of the cutting tool 606. The control unit 605 may be provided with a storage device for storing the shape data of the groove 20 and the ridge part 52. In this case, the control unit 605 controls the movement of the carriage 603 and the cutting tool 606 based on the shape data.

[0032] After the roll 11 has been set on the turning machine 60, the groove 20 is formed by turning.

[0033] Next, the ridge part 52 is cut. Specifically, the cutting tool 606 is exchanged, that is, an R cutting tool 607 having a concave-shaped tool tip having a predetermined curvature is set onto the carriage 603. The R cutting tool 607 is brought into contact with the ridge part 52 while the roll 11 is rotated to R-chamfer the ridge part 52. At this time, the ridge part 52 is cut so that the radius of curvature of the ridge part 52 satisfies the conditions described below.

[0034] Figure 8 is an enlarged view of the ridge part 52. Referring to Figure 8, the ridge part 52 has a convex shape in the roll radial direction Y and also has a rounded shape.

[0035] The highest point in the Y direction of the ridge part 52 is defined as a top T52. A region RA52 within the range of 3.0 mm in the X direction with the top T52 being the center is identified. Hereinafter, this region is defined as the ridge part region RA52. The ridge part region RA52 includes a range of 1.5 mm on the left-hand side (the caliber part 50 side) in the figure from the top T52 and a range of 1.5 mm on the right-hand side (the flange part 51 side) from the top T52.

[0036] In the identified ridge part region RA52, the radius of curvature is determined at a 0.5 mm pitch in the roll axis direction X. Specifically, as shown in Figure 9, points P1 to Pn (n is a natural number) on the surface of the ridge part region RA52 are identified at a 0.5 mm pitch in the roll axis direction X.

[0037] A radius of curvature Rt at point Pt (t is a natural number smaller than n) is determined as described below. Two points (point Pt-1 and point Pt+1) adjacent to point Pt are identified. Next, a circle CRt drawn through the identified three points (point Pt-1, point Pt, and point Pt+1) is determined. The radius of the determined circle CRt is defined as the radius of curvature Rt.

[0038] In the ridge part region RA52, the radiuses of curvature R1 to Rn (mm) at points P1 to Pn satisfy Formulas (1) and (2).

$$2.5 \le (R1 + R2 + . . . + Rn)/n \le 3.0 \qquad ... (1)$$

$$Rmax - Rmin \le 1.0 \qquad ... (2)$$

in which, Rmax is the maximum value of measured radiuses of curvature, and Rmin is the minimum value of measured radiuses of curvature.

[0039] In effect, the average of radiuses of curvature measured at a 0.5 mm pitch in the roll axis direction X in the ridge part region RA52 is in the range of 2.5 to 3.0 mm, and the difference between the maximum value and the minimum value of the measured radiuses of curvature is at most 1.0 mm.

[0040] By satisfying Formulas (1) and (2), especially when a thin-wall steel pipe having an outside diameter of 30.0 to 100.0 mm and a wall thickness of 2.0 to 3.0 mm is rolled, the occurrence of fin flaws or edge flaws can be suppressed. The reason for this is indefinite, but the reason described below is presumed.

[0041] In the case where F1 = (R1 + R2 + ... + Rn)/n is defined, if the F1 value exceeds 3.0 mm, the metal portion is not restrained by the ridge part 52, and flows easily in the roll axis direction. Therefore, a fin flaw occurs easily.

[0042] On the other hand, if the F1 value is smaller than 2.5 mm, the metal portion that is in contact with the vicinity of edge of the groove 20 is restrained excessively by the ridge part 52. For this reason, the metal portion is hollowed by the ridge part 52, and an edge flaw occurs easily.

[0043] In the case where F2 = Rmax - Rmin is defined, if the F2 value exceeds 1.0 mm, a fin flaw and an edge flaw occur. The reason for this is indefinite, but the reason described below is presumed. When a thin-wall steel pipe is reducing-rolled, the flow of the metal portion that is in contact with the vicinity of edge of the groove 20 is great. If the F2 value exceeds 1.0 mm, irregularities, though being minute, exist on the surface of the ridge part 52. Therefore, as compared with the case where the F2 value is smaller than 1.0 mm, the metal portion is made liable to flow unevenly by the irregularities. It is presumed that, by the uneven flow, the metal portion of steel pipe is deformed unevenly, and as the result, a fin flaw or an edge flaw occurs easily.

[0044] The radiuses of curvature at the above-described points P1 to Pn are measured, for example, as described below. After the ridge part 52 has been cut by using the turning machine 60, as shown in Figure 10, a cold-setting resin 70 is brought into contact with an optional location of the ridge part 52, and is cured to make a model of the shape of the ridge part 52. Next, by using a three-dimensional shape measuring machine, the surface shape of the cured cold-setting resin 70 is measured. Specifically, referring to Figure 11, the cross-sectional shape of the cold-setting resin 70 at the time when the cold-setting resin 70 is cut by a plane that includes the roll axis and extends in the roll radial direction is measured. Of the cross section shown in Figure 11, a region RA72 in which the model of the ridge part 52 has been made has the same shape as that of the ridge part 52. Therefore, by measuring the shape of the region RA72, the shape of the ridge part 52 can be determined. Based on the determined shape of the ridge part 52, the radius of curvature Rn can be determined at a 0.5 mm pitch in the roll axis direction X. The shape may be measured by a measuring method other than the method using three-dimensional shape measuring machine.

[0045] After the ridge part 52 has been cut by using the turning machine 60, the radius of curvature Rn is determined by the above-described method. Based on the determined radius of curvature Rn, it is judged whether or not the ridge part 52 satisfies Formulas (1) and (2). If the ridge part 52 does not satisfy Formula (1) or (2), the R cutting tool is adjusted, and the ridge part 52 is cut again by using the adjusted R cutting tool.

[0046] By repeating the above-described process as necessary, a roll 11 satisfying Formulas (1) and (2) is manufactured.

[0047] The roll 11 manufactured by the above-described manufacturing method is set on the reducing-rolling mill 11, and reducing rolling is performed. In this case, the occurrence of fin flaws or edge flaws especially on a thin-wall steel pipe is suppressed.

[0048] Preferably, the roll 11 manufactured by the above-described manufacturing method is set on the stand STi at which the outside diameter working ratio is 5.7 to 6.3%. The outside diameter working ratio described herein is defined by Formula (3).

$$\text{Outside diameter working ratio (\%)} = [\{(\text{cross-sectional area of caliber of stand } STi-1) - (\text{cross-sectional area of caliber of stand } STi)\}/(\text{cross-sectional area of caliber of stand } STi)] \times 100 \quad \ldots (3)$$

[0049] In this case, the occurrence of fin flaws and edge flaws is suppressed effectively.

[0050] The roll 11 for reducing rolling in accordance with this embodiment is especially suitable to the case where a thin-wall steel pipe having an outside diameter of 30.0 mm to 100.0 mm and a wall thickness of 2.0 to 3.0 mm is produced. However, the roll 11 can suppress the occurrence of fin flaws and edge flaws to some extent even in the case where a steel pipe having an outside diameter and a wall thickness other than those described above.

[0051] If the roll 11 is applied to at least one stand STi of the plurality of stands ST1 to STm, the above-described effect can be achieved to some extent. If the roll 11 is applied to the stand STi at which the outside diameter working ratio defined by Formula (3) is in the above-described range, a remarkable effect can be achieved.

[0052] In the above-described embodiment, the transverse shape of the groove 20 is a circular arc having the radius Ra1. However, the shape of the groove 20 is not limited to this one. For example, the transverse shape of the groove 20 may be such that the groove bottom portion thereof is of a circular arc shape having the radius Ra1, and the groove edge portion thereof is of an arched shape having a radius Ra2 (Ra2 > Ra1). Also, the groove edge portion may be of a straight line shape. An arched transverse shape of the groove 20 suffices.

[0053] In the above-described embodiment, the ridge part 52 is cut by using the turning machine 60 and the R cutting tool 607. However, the ridge part 52 may be cut by any other well-known method.

[0054] Also, in the above-described embodiment, the groove 20 and the ridge part 52 may be cut continuously by using the control unit 605 of the turning machine 60.

[0055] Further, the ridge part 52 may be cut following the adjustment of the setting position of the R cutting tool 607 made by the worker without the use of the control unit 605.

Examples

[0056] A plurality of rolls having differently shaped ridge parts were prepared. The occurrence ratio of fin flaws and edge flaws at the time when reducing rolling was performed by using each roll was examined.

[Examination method]

[0057] A stretch reducer (three-roll type) provided with twenty-six stands was used. Also, rolls of Set A to Set C shown in Figure 12 were prepared.

[0058] For each roll of each set (Set A to Set C), the shape of ridge part was measured. Each set included three rolls 11. For each set, a model of the shape of one optional location of the ridge part 52 of the roll 11 was made by using a cold-setting resin (Technovit). By using the cold-setting resin by which the model has been made, the radius of curvature of the ridge part region RA52 was determined at a 0.5 mm pitch by using the above-described method.

[0059] Figure 12 shows the shape and the radius of curvature of the ridge part 52 of each set, which were obtained by the model made as described above. Referring to Figure 12, in the "R shape" column in the chart, the shapes of the ridge parts of Set A to Set C are shown by graphs. The ordinate (Y-coordinate) of each graph represents the distance in the roll radial direction. The abscissa (X-coordinate) of the graph represents the distance in the roll axis direction X. The dotted line in the graph represents the shape of ridge part in the case where the radius of curvature is 2.5 mm. The solid line in the graph represents the actual shape of the roll 11 of each set.

[0060] In the "Radius of curvature" column, the radiuses of curvature of the ridge part shapes shown in the "R shape" column, which were determined at a 0.5 mm pitch in the roll axis direction X, are shown by graphs. The ordinate of each graph represents the radius of curvature (mm). The abscissa (X-coordinate) represents the coordinate in the roll axis direction X. Specifically, "T52" on the abscissa represents the position of the top T52 of the ridge part 52. "T52-1.5 mm" represents a position 1.5 mm distant from the top T52 to the left-hand side (the caliber part side) in the figure, and "T52+1.5 mm" represents a position 1.5 mm distant from the top T52 to the right-hand side (the flange part side) in the figure. In effect, the range between "T52-1.5 mm" and "T52+1.5 mm" represents the ridge part region RA52.

[0061] For each set, based on the measured radius of curvature, the F1 value and the F2 value were determined. The determined results are given in Table 1.

[0062] [Table 1]

TABLE1

	F1 value (mm)	F2 value (mm)	Number of rolled pipes	Number of pipes on which a flaw occurs	Flaw occurrence ratio (%)
Set A	4.01	2.93	20	4	20.0%
Set B	2.88	0.97	20	0	0.0%
Set C	4.18	2.95	20	6	30.0%

[0063] Referring to Table 1, Set B satisfied Formulas (1) and (2). On the other hand, the F1 value of Set A exceeded 3.0 mm, and the F2 value thereof exceeded 1.0 mm. That is, Set A did not satisfy Formulas (1) and (2). For Set C, the F1 value exceeded 3.0 mm, and the F2 value exceeded 1.0 mm. Therefore, Set C also did not satisfy Formulas (1) and (2).

[0064] The rolls of Set A were set onto No. 3 stand. By using the stretch reducer on which the rolls of Set A were had been set, twenty steel pipes having a material quality corresponding to XSTC of JIS Standard were reducing-rolled at a hot processing to produce thin-wall steel pipes each having an outside diameter of 31.8 mm and a wall thickness of 2.5 mm. At this time, the outside diameter working ratio in reducing rolling as a whole was 71%.

[0065] The outside diameter working ratio in reducing rolling as a whole described herein was determined by Formula (4).

$$\text{Outside diameter working ratio in reducing rolling as a whole (\%)} = [\{(\text{outside diameter of steel pipe before reducing rolling}) - (\text{outside diameter of steel pipe after reducing rolling})\} / (\text{outside diameter of steel pipe before reducing rolling})] \times 100 \quad \ldots (4)$$

[0066] During the rolling, the hot steel pipe coming out of the No. 3 stand was observed visually, and it was judged whether a fin flaw or an edge flaw occurred on the steel pipe. Then, the flaw occurrence ratio (%) was determined based on Formula (5).

$$\text{Flaw occurrence ratio (\%)} = (\text{number of steel pipes on which fin flaw or edge flaw was found} / \text{total number of reducing-rolled steel pipes}) \times 100 \quad \ldots (5)$$

[0067] After the reducing rolling of Set A had been finished, the rolls of No. 3 stand were exchanged from Set A to Set B. The rolls of other stands were not exchanged. After the rolls of Set B had been set onto the No. 3 stand, as in the case of Set A, twenty steel pipes were reducing-rolled. At this time, the material quality of steel pipe and the outside diameter working ratio in reducing rolling as a whole were the same as those in the case of Set A.

[0068] As in the case of Set A, the hot steel pipe coming out of the No. 3 stand was observed visually, and it was judged whether a fin flaw or an edge flaw occurred on the steel pipe. Then, the flaw occurrence ratio (%) was determined based on Formula (5).

[0069] After the reducing rolling of Set B had been finished, the rolls of No. 3 stand were exchanged from Set B to Set C. The rolling was performed under the same conditions as those of Set A and Set B, and the flaw occurrence ratio was determined based on Formula (5).

[Examination results]

[0070] Table 1 gives the examination results. Referring to Table 1, the F1 value of the roll of Set B satisfied Formula

(1), and the F2 value thereof satisfied Formula (2). Therefore, in the reducing rolling operation using the rolls of Set B, the flaw occurrence ratio was 0%.

[0071] On the other hand, the roll of Set C did not satisfy Formulas (1) and (2). Therefore, the flaw occurrence ratio was high, being 30.0%. Also, the roll of Set A did not satisfy Formulas (1) and (2). Therefore, the flaw occurrence ratio was 20.0%.

[0072] The above is an explanation of the embodiment of the present invention. The above-described embodiment is merely an illustration for carrying out the present invention. Therefore, the present invention is not limited to the above-described embodiment, and the above-described embodiment can be carried out by being changed as appropriate without departing from the spirit and scope of the present invention.

Claims

1. A method for manufacturing a roll for reducing rolling, which roll is used on a three-roll type reducing-rolling mill for reducing-rolling steel pipes, and comprises a caliber part having a groove of an arched shape in transverse cross section and flange parts adjacent to the caliber part, comprising the steps of:

preparing the roll for reducing rolling; and
rounding a ridge part formed in the adjacent portion between the caliber part and the flange part by cutting the ridge part while rotating the roll for reducing rolling around the roll axis, wherein
in the step of rounding the ridge part,
in a ridge part region within the range of 3.0 mm in a roll axis direction with the top of the ridge part being the center, the average of radiuses of curvature measured at a 0.5 mm pitch is made in the range of 2.5 to 3.0 mm, and the difference between the maximum value and the minimum value of the radiuses of curvature is made at most 1.0 mm.

2. A roll for reducing rolling which is used on a three-roll type reducing-rolling mill for reducing-rolling steel pipes, comprising:

a caliber part having a groove of an arched shape in transverse cross section; and
flange parts adjacent to the caliber part, wherein
within the range of 3.0 mm in a roll axis direction with the top of a ridge part, which is formed in the adjacent portion between the caliber part and the flange part, being the center, the average of radiuses of curvature measured at a 0.5 mm pitch is in the range of 2.5 to 3.0 mm, and the difference between the maximum value and the minimum value of the radiuses of curvature is at most 1.0 mm.

FIG. 1

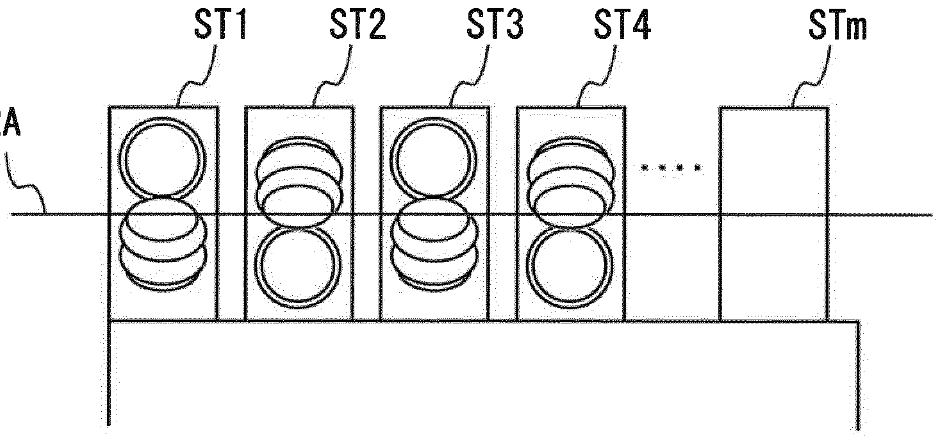


FIG. 2

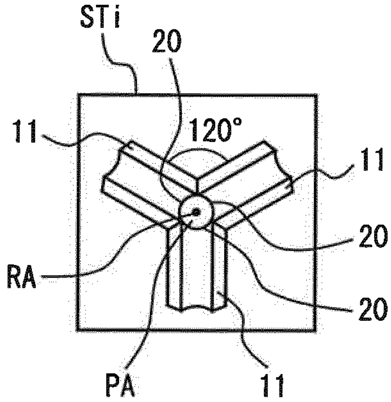


FIG. 3

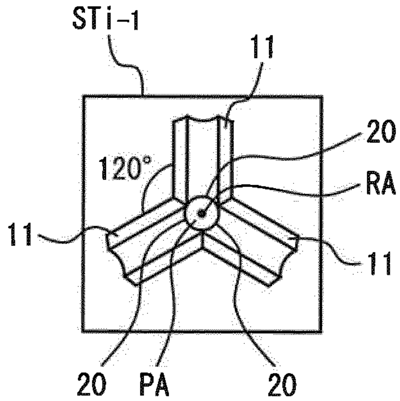


FIG. 4

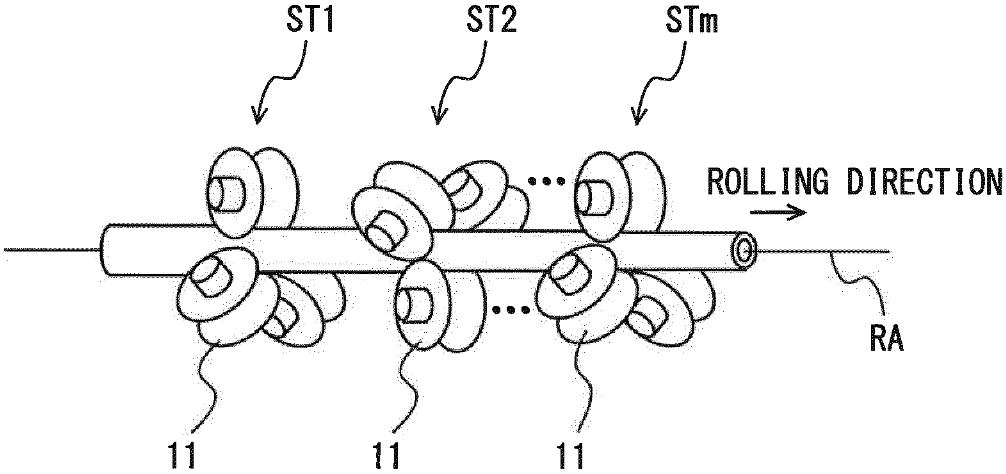


FIG. 5

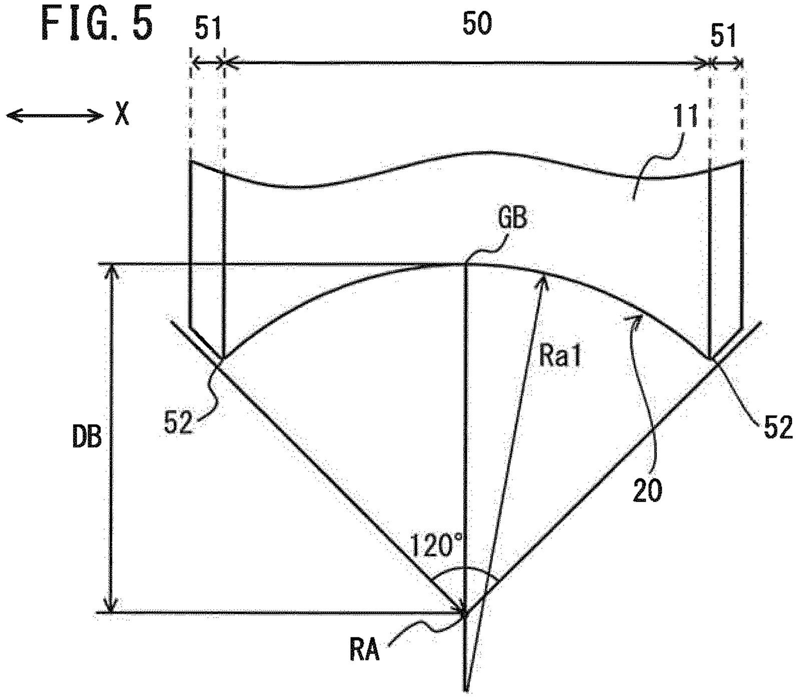


FIG. 6

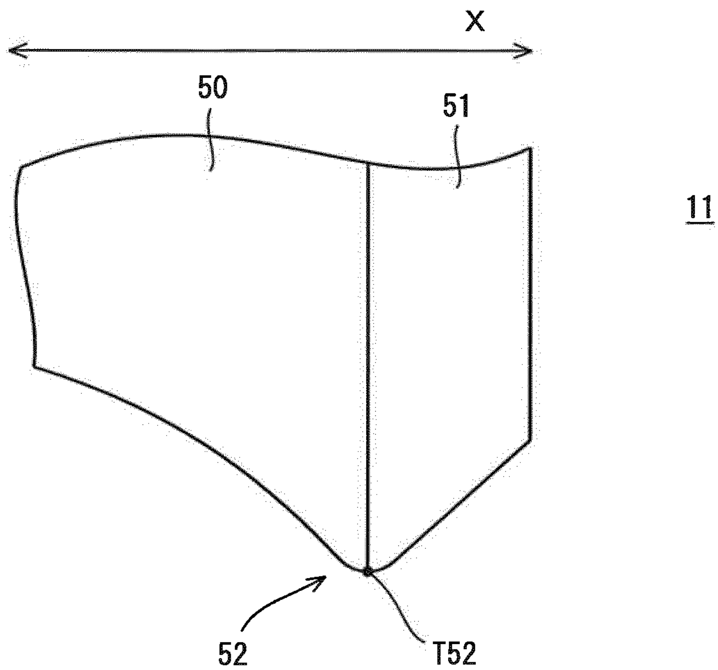


FIG. 7

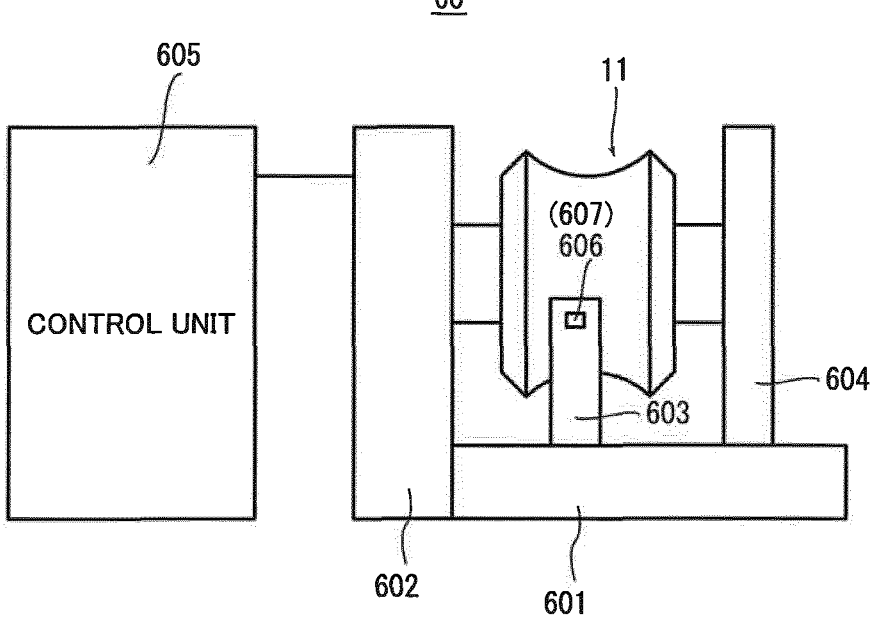


FIG. 8

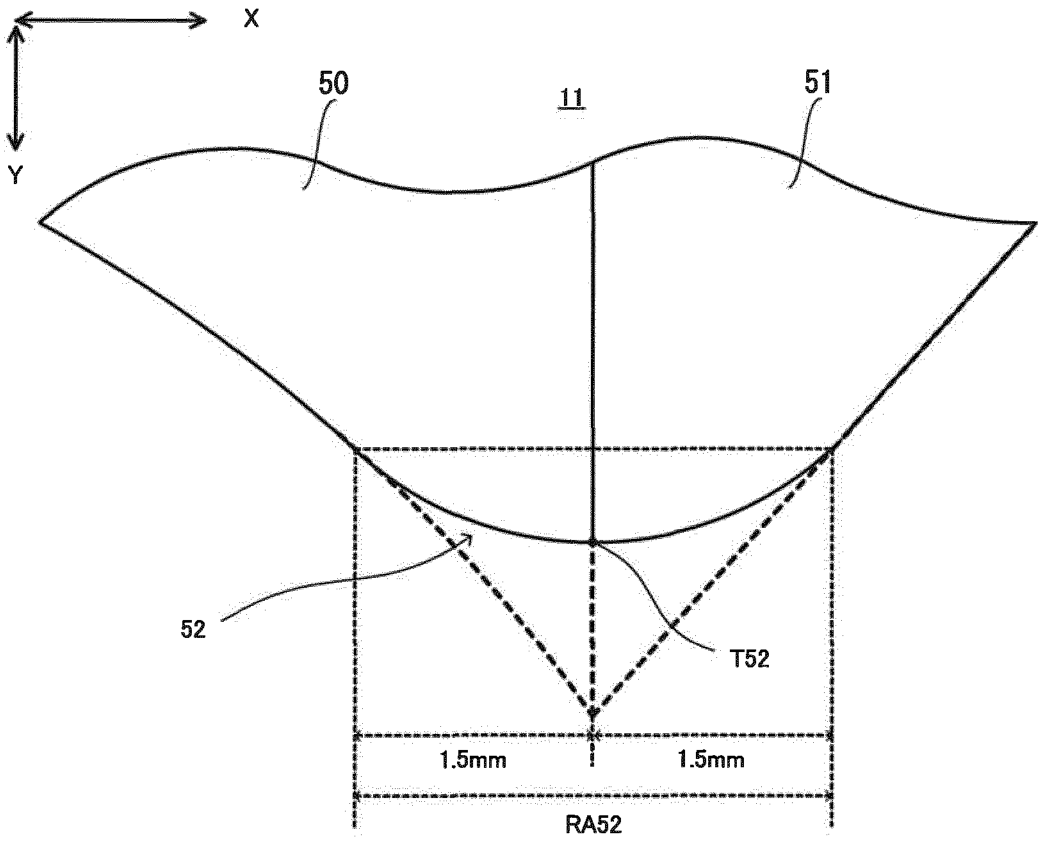


FIG. 9

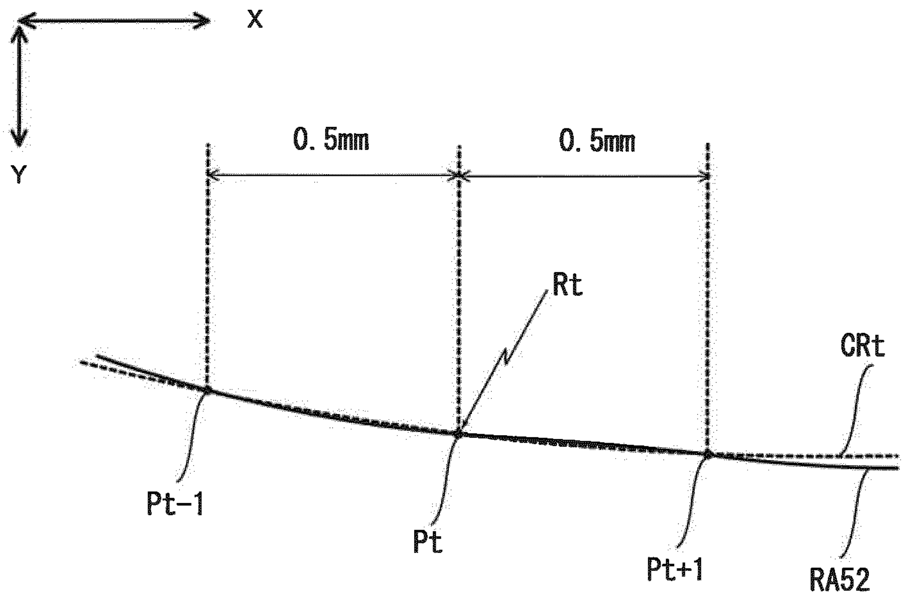


FIG. 10

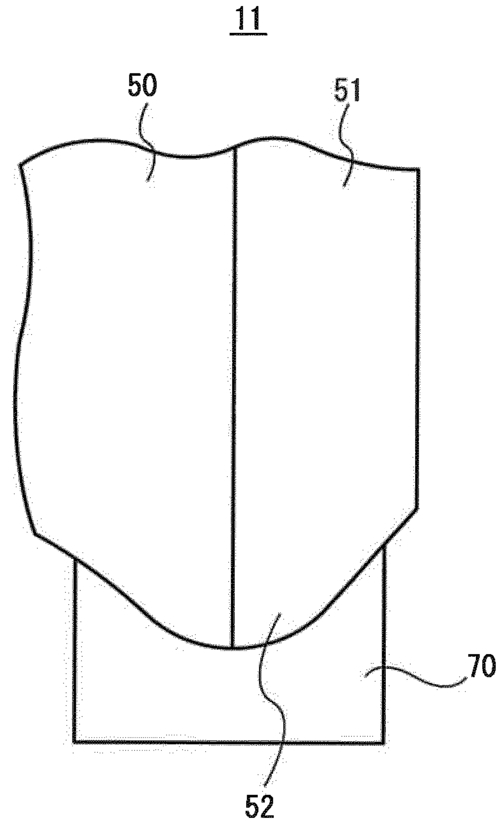


FIG. 11

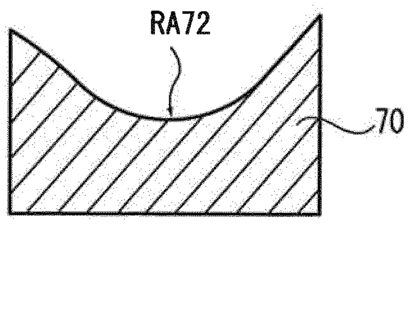
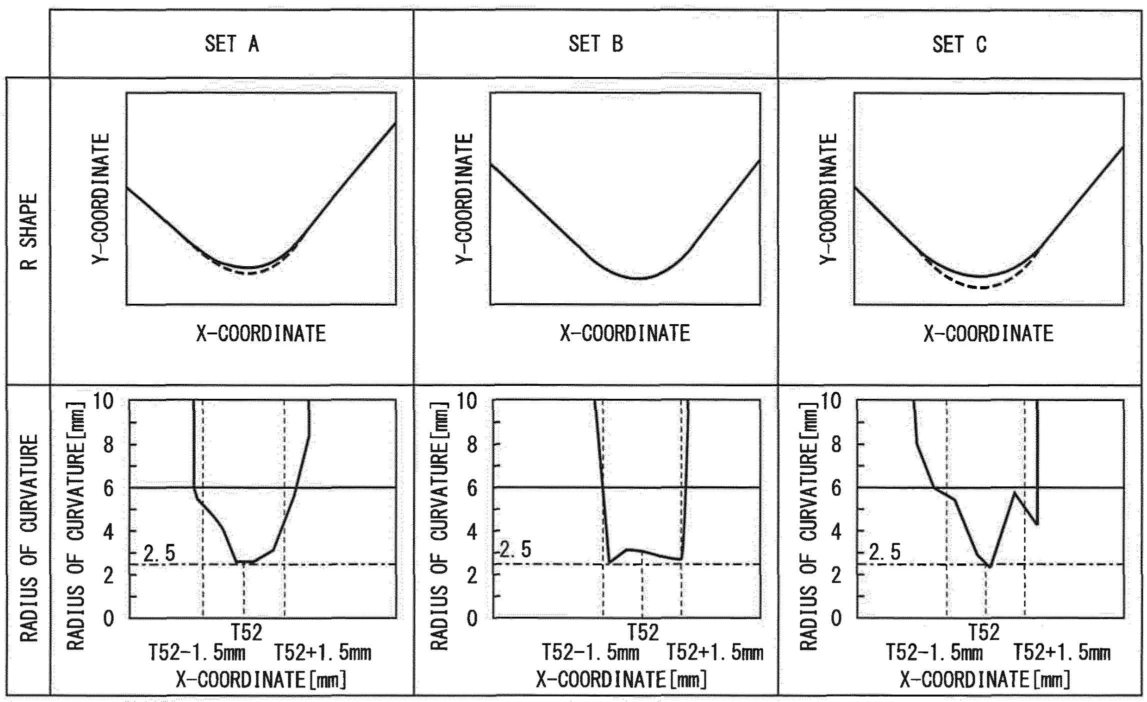


FIG. 12


SET A
SET B
SET C
R SHAPE
Y-COORDINATE
X-COORDINATE
RADIUS OF CURVATURE
RADIUS OF CURVATURE[mm]
10
8
6
4
2
0
2.5
T52
T52-1.5mm
T52+1.5mm
X-COORDINATE[mm]

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2012/058058

A. CLASSIFICATION OF SUBJECT MATTER
B21B27/02(2006.01)i, *B21B17/14*(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)
B21B27/02, B21B17/14

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.
A	WO 2005/92531 A1 (Sumitomo Metal Industries, Ltd.), 06 October 2005 (06.10.2005), fig. 7 & JP 4650747 B & EP 1731234 A1 & CN 1905958 A	1,2
A	WO 2005/70574 A1 (Sumitomo Metal Industries, Ltd.), 04 August 2005 (04.08.2005), fig. 12 & JP 4647501 B & US 2008/0289391 A1 & EP 1707281 A1 & DE 602005019537 D & CN 1909985 A	1,2

[X] Further documents are listed in the continuation of Box C. [ ] See patent family annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
18 April, 2012 (18.04.12)	01 May, 2012 (01.05.12)

Name and mailing address of the ISA/	Authorized officer
Japanese Patent Office	
Facsimile No.	Telephone No.

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2012/058058

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 11-57816 A (Kawasaki Steel Corp.), 02 March 1999 (02.03.1999), claim 5 (Family: none)	1,2
A	JP 61-88905 A (Nippon Steel Corp.), 07 May 1986 (07.05.1986), fig. 10 to 12 (Family: none)	1,2

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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- WO 2005070574 A **[0002]**
- WO 2005092531 A **[0002]**
- JP 11197714 A **[0006]**
- JP 11057816 A **[0006]**