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(54) METHOD OF FORMING WELDED PIPE AND FORMING STAND THEREFOR

VERFAHREN ZUM HERSTELLEN GESCHWEISSTER RÖHREN UND FORMVORRICHTUNG
DAZU

PROCEDE DE FORMAGE DE TUBES SOUDES ET SUPPORT DE FORMAGE PREVU A CET
EFFET

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(56) References cited:
JP-A- 2 104 419 **JP-A- 4 182 034**
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Description

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0001] The present invention relates to a forming method and forming stand according to the preambles of claims 1 and 8 respectively, for forming welded pipes to accurate dimensions in a welded pipe manufacturing line on which a metallic strip of a predetermined width is continuously formed by rolls and welded by the electric resistance welding method or other welding methods.

2. Related Art

[0002] In general, in a manufacturing process in which welded pipes such as electric resistance welded pipes are manufactured, a metallic strip of a predetermined width is continuously supplied to a group of forming rolls including a plurality of breakdown rolls, side rolls and fin-pass rolls, and then the formed metallic strip is subjected to welding such as high frequency welding in which squeeze rolls are used.

[0003] According to this method, welded pipes are continuously manufactured. Therefore, this method is greatly advantageous in that the manufacturing efficiency is improved and the cost is reduced. Accordingly, this method is widely used when mechanical structure pipes, boiler pipes, oil well pipes and other various pipes are manufactured. Recently, there is a demand for applying this method to the manufacture of thin wall pipes, thick wall pipes and high tensile strength pipes. Further, there is a strong demand for manufacturing pipes of high quality and high accuracy.

[0004] However, when these thin wall pipes, thick wall pipes and high tensile strength pipes are formed by the conventional pipe manufacturing method, the profiles of these pipes are defective. In the initial process of edge forming in which a pair of breakdown rolls composed of upper and lower rolls are used, the edge portions of a work piece are insufficiently bent.

[0005] In order to solve the above problem, a "W-bend method", in which the middle portion of a work piece is bent at a curvature opposite to that of the edge forming process, has come into practical use. The effect of this method is introduced, for example, on page 519 of the proceedings of a plastic working lecture meeting (held in spring of 1985) published by the Plastic Working Society.

[0006] According to the method disclosed in Japanese unexamined Patent Publication (Kokai) No. 1-44217, two rolls are used for the horizontal lower caliber roll applied to the edge forming roll stand, and the inclination angles of the two rolls are capable of being adjusted with respect to the metallic strip advancing direction, so that the edge portions of both thick and thin wall metallic strips are sufficiently bent.

[0007] In the process for manufacturing metallic pipes by means of roll forming and welding, it is desired to provide forming rolls capable of being applied for manufacturing various sizes of pipes for the purpose of reducing the roll cost by reducing the number of rolls, and also for the purpose of improving the operation rate of the manufacturing line by reducing the frequency of roll change. In order to accomplish the above object, a set of rolls is disclosed in Japanese Unexamined Patent Publication (Kokai) No. 62-166027, and these rolls have been put into practical use.

[0008] As described above, in the breakdown roll used for edge forming in the conventional pipe forming method, the problem of defective profile is caused especially when thin wall pipes, thick wall pipes and high tensile strength pipes are formed. In the case where the workpiece is additionally subjected to edge forming by fin-pass rolls disposed in the after-stage so as to solve the problem of defective profile, the thickness of the edge portion is increased as shown by numeral 1 in fig. 1. This increase of thickness 1 is a factor to impair the size accuracy.

[0009] In the case of a breakdown roll of the W-bend system, a sufficiently high bending force can be applied to the edge portions compared with the conventional method. However, in the forming process from the start of contact of a work piece with an upper roll, to a position right below the roll, the upper roll locally comes into contact with the work piece. Therefore, an indentation 2 tends to occur as illustrated in Fig. 2, which is a factor to impair the accuracy of thickness. Even when this method is applied, the problem of defective profile cannot be essentially solved in the case where thick wall and thin wall pipes exceeding the design thickness of the upper roll 3 are formed. Therefore, this method is not sufficient for extending the range of wall thicknesses to which the same forming roll can be applied.

[0010] On the other hand, in the edge forming method disclosed in Japanese Unexamined Patent Publication (Kokai) No. 1-44217 described before, since a workpiece continuously comes into contact with the edge forming roll, the occurrence of indentations can be avoided as compared with the conventional edge forming method. However, the range of wall thickness to which the same edge forming roll can be applied is limited.

[0011] The edge forming rolls disclosed in Japanese Unexamined Patent Publication (Kokai) No. 62-166027 can be applied to a wide range of pipe diameters; however, since the radius of curvature of the roll is continuously changed, the roll locally comes into contact with the metallic strip, so that the problem of defective profile tends to occur, and this

method is not appropriate for forming thick wall pipes.

[0012] JP-A-49-35500, on which the preambles of claims 1 and 8 are based, discloses the bending of the edges of metallic strip between upper and lower forming rolls; the rolls can be skewed relative to the machine direction about a vertical axis, to maintain central positioning of the metallic strip, but each upper roll remains aligned with its co-operating lower roll.

[0013] JP-A-4-182024 discloses the use of upper and lower pairs of rolls for bending metallic strip edges, the rolls being designed to operate with a variety of strip sizes to give a variety of strip edge curvatures, but the upper rolls are not skewed relative to the lower.

[0014] It is an object of the present invention to provide a forming method and forming stand for a welded pipe manufacturing line by which welded pipes of high size accuracy can be formed and especially edge portions of a metallic strip can be accurately bent.

[0015] The present invention provides a method of bending the longitudinal edges of a metallic strip for welded pipe formation by passing the strip longitudinally in contact with a laterally spaced pair of first rotating rolls each cooperating with a second rotating roll to engage and bend a respective strip edge, the rotational axes of said first and second rolls being in respective first and second spaced parallel planes, characterised in that each first roll is skewed relative to the co-operating second roll about an axis perpendicular to said spaced parallel planes.

[0016] The first rotating rolls are preferably skewed so that they converge in the machine direction towards the longitudinal centerline of the metallic strip.

[0017] Each first rotating roll may co-operate with a second rotating roll whose rotational axis is perpendicular to the longitudinal centerline of the metallic strip, i.e. which is aligned in the machine direction.

[0018] The first rotating rolls are preferably skewed so that there is an angle $\alpha_u \leq 45^\circ$ between its rotational axis and the line parallel to said spaced parallel planes and perpendicular to the longitudinal centerline (7) of the metallic strip (5).

[0019] In another embodiment, each first rotating roll co-operates with a respective second rotating roll which is skewed relative to the longitudinal centerline of the metallic strip about an axis perpendicular to said spaced parallel planes in a direction opposite to the skewing of the respective first rotating roll.

[0020] In this case each second rotating roll is preferably skewed to give an angle $\alpha_d \leq 30^\circ$ between its rotational axis and the line parallel to said spaced parallel planes and perpendicular to the longitudinal centerline of the metallic strip.

[0021] The two first rotating rolls are preferably displaced relative to one another in the machine direction.

[0022] The invention also provides a forming stand for bending the longitudinal edges of a metallic strip for welded pipe formation, the stand comprising a laterally spaced pair of first rotating rolls each co-operating with a second rotating roll for engaging and bending a respective edge of a metallic strip passed therethrough in the machine direction, the rotational axes of said first and second rotating rolls being in respective first and second spaced parallel planes, characterised by means for adjusting the lateral spacing between the first rotating rolls and by means for selectively skewing each first rotating roll relative to the co-operating second roll about an axis perpendicular to said spaced parallel planes.

[0023] In one embodiment each first rotating roll co-operates with a respective second rotating roll, the stand including means for adjusting the lateral spacing of the second rotating rolls and means for skewing each second rotating roll relative to the machine direction about an axis perpendicular to said spaced parallel planes.

BRIEF DESCRIPTION OF THE DRAWINGS

[0024]

Fig. 1 is a sectional view of a metallic strip, the edge thickness of which is increased, which impairs the size accuracy.

Fig. 2 is a sectional view of a metallic strip on which a bend indentation is caused, which impairs the size accuracy.

Fig. 3 is a view showing the progress of forming of a metallic strip right below the forming roll.

Figs. 4(a), 4(b), 4(c) and 4(d) are views showing the example of the present invention of a gap formed between the upper and lower rolls in accordance with the forming radius of curvature and the thickness, wherein Fig. 4(a) shows a case of a thin wall, Fig. 4(b) shows a case of low curvature (large diameter), Fig. 4(c) shows a case of a thick wall, and Fig. 4(d) shows a case of high curvature (small diameter).

Figs. 5(a) and 5(b) are schematic illustrations showing orientation, wherein Fig. 5(a) shows the upper rolls converging, and Fig. 5(b) shows the upper rolls diverging, in the machine direction.

Fig. 6 is a schematic illustration showing the direction of thrust in the case of the upper rolls converging in the machine direction.

Fig. 7 is a schematic illustration showing a case in which an upper roll deviates in the case of upper rolls diverging in the machine direction.

Figs. 8(a) and 8(b) are plan views showing an example of rolls to which the present invention is applied, wherein

Fig. 8(a) is a front view and Fig. 8(b) is a plan view.

Fig. 9 is a view showing an example of forming apparatus to which the present invention is applied.

Figs. 10(a) and 10(b) are views showing examples of the distributions in the radius of curvature and wall thicknesses after a metallic strip has passed through a single stand in the case where the present invention is applied and in the case where the present invention is not applied.

Fig. 11 is a view showing an example of the distributions in the radius of curvature and wall thicknesses expressing the properties of sharing a roll in the case where the present invention is applied.

Figs. 12(a) and 12(b) are views showing an example of rolls to which the present invention is applied, wherein Fig. 12(a) is a front view and Fig. 12(b) is a plan view.

Fig. 13 is a view showing an example of forming apparatus to which the present invention is applied.

DESCRIPTION OF THE MOST PREFERRED EMBODIMENT

[0025] According to the present invention, as illustrated in Fig. 8, metallic strips can be accurately formed into pipes with thin or thick walls with two pairs of upper and lower horizontal edge forming rolls disposed on both sides of the metallic strip in a breakdown stand, wherein the edge forming is performed with the upper and lower horizontal rolls crossed or skewed relative to each other about a vertical axis. As illustrated in Fig. 3, a pair of upper and lower horizontal edge forming rolls 3, 4 are crossed, and the upper and lower rolls are continuously contacted with both sides of a metallic strip 5 to be formed right below the upper forming roll. Therefore, in this forming process, localized contact of the forming roll and the metallic strip can be avoided, which is different from the forming process of the prior art. With reference to Figs. 4(a) to 4(c), Fig. 4(a) shows a case of a small wall thickness, Fig. 4(b) shows a case of low curvature (large pipe diameter), and Fig. 4(c) shows a case of large wall thickness. As shown in the drawings, when the orientation of the upper roll 3 is changed, the radius of curvature right below the upper forming roll, which is made by the hysteresis of the upper roll, is changed, so that the hysteresis of the gap between the upper and lower rolls can be provided in accordance with the thickness of the metallic strip to be formed. Therefore, edge forming can be accurately performed over a wall thickness range which includes thin and thick walls.

[0026] Further, with reference to Fig. 4(d) in which a case of high curvature (small pipe diameter) is shown, when the orientation of the lower roll is changed, the radius of curvature formed by the lower roll coming into contact with the outside of the metallic strip is changed, and when two pairs of upper and lower rolls disposed on both sides are moved so as to be adjusted in the width direction of the metallic strip in accordance with the strip width, the edge forming rolls can be shared by metallic strips of different sizes from which pipes of different sizes are formed.

[0027] In general, the orientation of the upper roll is determined by the profile of the upper roll caliber, the outside diameter of the pipe to be formed from the metallic strip, the wall thickness of the metallic strip, and the upper roll diameter. Also, the orientation of the lower roll is determined by the profile of the lower roll caliber, the outside diameter of the pipe to be formed from the metallic strip, and the lower roll diameter. In an embodiment of the present invention, in order to exhibit the effect of the invention at the maximum, the orientations of the upper and lower rolls are limited as follows.

[0028] It is necessary to increase the turning angle (amount of skewing) of the upper roll when the wall thickness of the metallic strip is small; however, when it is increased too much, slippage between the upper roll and the metallic strip is increased. As a result, the strip surface is damaged, the forming rolls seize, and roll life is reduced. For this reason, while consideration is given to the range of metallic strips to be formed, the upper limit of the turning angle is determined to be 45°.

[0029] When the turning angle of the lower roll is increased, the range of metallic strips to be formed is extended. However, when the turning angle is extremely increased, the same problems as those described above are caused, and further the range of metallic strips is limited due to interference of the upper and lower rolls disposed on both sides. Accordingly, with consideration given to the range of the metallic strips to be formed, the upper limit of the turning angle is determined to be 30°. Due to the foregoing, the range of the diameter of the pipe to be formed from the metallic strip can be extended by 1.5 to 2.0 times.

[0030] Further, according to the present invention, each pair of upper and lower rolls may be disposed at different positions with respect to the metallic strip forming direction. Therefore, after the forming of one edge of the metallic strip has been started, the forming of the other edge is started. Due to the foregoing, in the case where small size pipes are formed, interference of the forming rolls on both sides caused when the upper and lower rolls are skewed can be avoided, so that the turning angles of the forming rolls are not restricted. In this case, an interval with respect to the metallic strip forming direction between the pairs of upper and lower rolls disposed on both sides, is determined by the diameters of the upper and lower rolls and the range of the designed turning angle.

[0031] The horizontal upper rolls divided with respect to the metallic strip width direction are disposed on both sides for the purpose of edge forming. The horizontal upper rolls are selectively skewed about a vertical axis. When the metallic strip is formed under the above conditions, pipes of various wall thickness, that is, pipes of thin and thick walls, can

be formed with high accuracy.

[0032] As illustrated in Fig. 3, when the upper horizontal forming roll is skewed on a vertical axis, the upper roll 3 continuously comes into contact with the edge of the metallic strip to be formed right below the roll on both sides, so that both edge portions of the metallic strip are subjected to forming. Therefore, the occurrence of local contact, which tends to occur when the conventional method is applied, can be avoided in the forming process. Also, as illustrated in Figs. 4(a) to 4(c), when the turning angle of the upper roll 3 is changed, the radius of curvature, which is formed by the hysteresis of a portion right below the upper roll, is changed. Accordingly, the hysteresis of a gap can be constructed in accordance with the wall thickness of the metallic strip to be formed. Therefore, pipes with thin or thick walls can be formed with high accuracy.

[0033] The turning angle of the upper roll is determined by the profile of the upper roll caliber, the outside diameter of the pipe to be formed from the metallic strip, the wall thickness of the metallic strip, and the upper roll diameter. In one embodiment of the present invention, in order to exhibit the effect of the invention at the maximum, the turning angle direction of the upper roll is limited as follows.

[0034] It is necessary to increase the turning angle of the upper roll when the wall thickness of the metallic strip is small. However, when the turning angle is increased too much, slippage between the upper roll and the metallic strip is increased. As a result, the strip surface is damaged, the forming rolls seize and roll life is reduced. For this reason, while consideration is given to the range of metallic strips, the upper limit of the turning angle is determined to be 45°.

[0035] Next, the roll direction will be explained as follows. In the case where the upper and lower rolls are divided into two, slippage is caused between the rolls and the metallic strip when the upper and lower rolls are skewed. Therefore, a force is applied to the rolls in the width direction of the metallic strip, and torsion is generated in the rolls. In Fig. 5(a), the upper rolls converge in the machine direction, i.e. they are directed to the edges of the metallic strip on the entry side of the roll stand and to the center of the metallic strip on the delivery side of the roll stand. The lower rolls are positioned in the opposite direction to that of the upper rolls. In the manner described above, the upper and lower rolls are crossed with each other. In this case, since the contact point between the upper roll and the metallic strip is shifted from the edge portion to the center of the metallic strip, the above roll arrangement will be referred to hereinafter as "a converging forming roll arrangement". In this case, as illustrated in Fig. 6, the upper roll is given a thrust directed inwards, and the lower roll is given a thrust directed outwards. Also, a deviation directed outwards in the width direction is caused in the upper roll, and a deviation directed inwards in the width direction is caused in the lower roll. In Fig. 5(b), the upper rolls diverge in the machine direction, i.e. they are directed to the center of the metallic strip on the entry side of the roll stand and to the edge of the metallic strip on the delivery side of the roll stand. The lower rolls are positioned in the opposite direction to that of the upper roll. In the manner described above, the upper and lower rolls are crossed with each other. In this case, since the contact point between the upper roll and the metallic strip is shifted from the center to the edges of the metallic strip, the above roll arrangement will be referred to hereafter as "a diverging forming roll arrangement". As illustrated in Fig. 7, a deviation directed inwards in the width direction is caused in the upper roll, and a deviation directed outwards in the width direction is caused in the lower roll. In the case of "the diverging forming roll arrangement", the following problems are caused:

Since the upper roll is not contacted with an extreme edge portion, the edge portion is not sufficiently bent. In the case where the present invention is applied to the W-bend method, the gap becomes narrow due to the deviation, and the wall thickness is locally reduced.

[0036] On the other hand, in the case of "the converging forming roll arrangement", the above problems are not caused, and further the torsion forces applied to the upper and lower rolls are advantageous for edge forming, and the reduction force of the upper and lower rolls is advantageously reduced. Accordingly, in the case of a roll stand in which torsion tends to occur due to insufficient rigidity, it is preferable to employ "the converging forming roll arrangement".

[0037] The circumstances explained above are essentially the same as those in which only upper rolls are skewed, so that it is preferable to employ "the converging forming roll arrangement" in this latter case.

[0038] With reference to the accompanying drawings, an embodiment of the present invention will be explained as follows.

Example 1

[0039] Fig. 8(a) is a front view of rolls to which the present invention is applied, and Fig. 8(b) is a plan view. In this case, the turning angle α_d of the lower roll 4 is determined in accordance with the forming radius of curvature of the edge portion 13 of the metallic strip 5. In accordance with the width of the metallic strip and the size of the portion of the metallic strip to be bent, the positions of upper and lower rolls on both sides are determined with respect to the width direction. Further, in accordance with the wall thickness of the metallic strip 5, the turning angle α_u of the upper roll 3 is determined.

[0040] In the case where the turning angle is determined in accordance with the wall thickness of the metallic strip and the radius of curvature of the portion to be bent, the hysteresis of the roll gap right below the upper roll is shown in Fig. 4. Also, the deformation of the metallic strip according to the roll gap hysteresis is shown in Fig. 3. In these drawings, numeral 3 is an upper roll, numeral 4 is a lower roll, numeral 5 is the metallic strip, and numeral 7 is the centerline of the metallic strip.

[0041] Fig. 9 is a front view of an example of an edge bending roll stand to which the present invention is applied. The roll support beam members 14, 15 vertically hold the upper and lower roll bearing members 17, 18, and the upper roll support beam member 14 is vertically moved and fixed by the action of the reduction screw shaft 16. The upper and lower roll support stands 19, 20 are moved and fixed in the width direction by the rotation of a screw shaft not shown in the drawing or by the sliding motion of a sliding bracket on a rail not shown in the drawing, wherein the screw shaft or the sliding bracket is disposed in the beam members 14, 15. Further, the upper and lower roll support stands 19, 20 are adjustably skewed on a vertical shaft by means of a gear drive unit not shown in the drawing.

[0042] In this connection, when necessary, bearing members for supporting the middle portions of the upper and lower rolls, or a bearing member for supporting one of them may be fixed to the roll support beam members 14, 15.

[0043] In this embodiment, two pairs of upper and lower horizontal rolls are disposed on both sides of the same stands. However, as shown in the seventh embodiment of the present invention, two pairs of upper and lower rolls are disposed at different positions, and after one pair of rolls have completed edge forming of the edge on one side, the other pair of roll start edge forming of the edge on the other side. In this case, the two pairs of forming rolls may be disposed in different roll stands. Further, it is possible to provide a guide roll at the side where edge forming is not conducted.

[0044] Figs. 10a and 10b show the distributions of radius of curvature and wall thickness after a steel strip of $\varnothing 50.8 \times t2.10$ mm, the yield strength of which was 294 N/mm^2 , was subjected to edge forming, wherein one is a case to which the present invention was applied and the other is a conventional case to which the present invention was not applied. To this example, "the converging forming roll arrangement" was applied. By the conventional method, steel strips of small wall thickness were not sufficiently bent, and indentations were caused on steel strips of large wall thickness. However, in the case where the present invention was applied, excellent profiles were provided.

[0045] Further, Fig. 11 shows the distributions of radius of curvature and wall thickness after a steel strip of $\varnothing 34.0 \times t5$ mm was subjected to edge forming, wherein the same forming rolls as those described above were used and the turning angle was adjusted. The obtained radius of curvature was approximately the same as the radius of curvature which was previously set, and further the provided profile was good. It can be seen that the outer diameter of the forming roll can be shared when the present invention is applied.

[0046] Table 1 shows the results on the radius of curvature and the reduced wall thickness in the case where edge forming was conducted using the same rolls, wherein the turning angles of the upper and lower rolls were changed with respect to various forming diameter and wall thickness. It can be seen that the edge forming properties were improved, the reduction of wall thickness was decreased, and the roll outer diameter was shared, when the present invention was applied. Further, when the turning angle limits described above for the present invention were observed, the effects of the present invention were exhibited to the maximum.

Table 1

No.	Formed size	Forming condition					Remark
		Upper roll turning angle $\alpha_u(^{\circ})$	Lower roll turning angle $\alpha_d(^{\circ})$	Forming roll arrangement	*Radius of curvature	**Ratio of reduced wall thickness	
1	50.8×0.8	0	0	-	0.6	0.025	Conventional method
2	50.8×2.0	0	0	-	0.6	0.025	
3	50.8×5.0	0	0	-	0.75	0.044	
4	50.8×10.0	0	0	-	0.75	0.035	
5	50.8×2.0	14	5	diverging	0.85	0.010	Present Invention
6	50.8×5.0	10	5	diverging	0.9	0.016	
7	50.8×2.0	14	5	converging	1.0	0.010	
8	50.8×5.0	10	5	converging	1.0	0.008	
9	50.8×10.0	5	5	converging	1.0	0.015	
10	34.0×2.0	8	15	converging	1.0	0.010	
11	34.0×5.0	5	15	converging	1.0	0.008	
12	25.4×2.0	5	35	converging	0.9	0.024	
13	50.8×0.8	50	5	converging	0.8	0.022	

*) Average value of the ratio of targeted radius of curvature to obtained radius of curvature in edge forming, wherein the average value is taken in an edge forming region

R_0/R (R_0 : targeted radius of curvature in edge forming, R : obtained radius of curvature in edge forming)

**) Reduction of wall thickness/initial wall thickness

Example 2

[0047] Fig. 12(a) is a front view, and Fig. 12(b) is a plan view, of rolls to which the present invention is applied. The dimensions of the lower roll 4 are determined in accordance with the width of the metallic strip 5 and the size of the portion of the metallic strip 5 to be bent, and the positions of upper and lower roll on both sides with respect to the width direction are also determined in accordance with the width of the metallic strip 5 and the size of the portion of the metallic strip 5 to be bent. Further, in accordance with the wall thickness of the metallic strip 5, the turning angle α_u of the upper roll 3 is determined, and numeral 7 is the centerline of the metallic strip.

[0048] In the case where the turning angle of the forming roll is determined in accordance with the wall thickness and the radius of curvature of edge forming, the hysteresis of the upper roll gap right below the upper roll 3 is shown in Fig. 4, and the hysteresis of the lower roll is the same as that of the conventional case. Circumstances of the metallic strip deformed in accordance with the roll gap hysteresis are shown in Fig. 3, in which numeral 3 is an upper roll, numeral 4 is a lower roll, and numeral 5 is a metallic strip.

[0049] Fig. 13 is a front view of an exemplary edge bend roll stand to which the present invention is applied. The roll support beam member 14 vertically holds the upper roll bearing member 17, and the upper roll support beam member 14 is vertically moved and fixed by the action of the reduction screw shaft 16. The upper roll support stand 19 is moved and fixed in the width direction by the rotation of a screw shaft not shown in the drawing or by the sliding motion of a sliding bracket on a rail not shown in the drawing, wherein the screw shaft or the sliding bracket is disposed in the beam member 14. Further, the upper roll support stand 19 is skewed and fixed on a vertical shaft by means of a gear drive unit not shown in the drawing. The lower rolls 4 can be rotated by the lower roll shaft 20 through the lower roll bearing members 18. The positions of the lower rolls 4 can be changed and fixed in the width direction by means of a screw means or hydraulic means not shown in the drawing.

[0050] In this connection, when necessary, a bearing member for supporting the middle portion of the upper roll may be fixed to the roll support beam member 14.

[0051] According to the results showing the distributions of radius of curvature and wall thickness after a steel strip of

Ø50.8 × t2.10 mm, the yield strength of which was 294 N/mm², was subjected to edge forming though a single stand, wherein one was a case to which the present invention was applied and the other was a case to which the present invention was not applied. In the case where the conventional method was applied, steel strips of small wall thickness were not sufficiently bent, and indentations were caused on steel strips of large wall thickness. However, in the case where the present invention was applied, excellent profiles were provided.

[0052] Table 2 shows the results of radius of curvature and reduced wall thickness in the case where edge forming was conducted using the same rolls, wherein the turning angles of the upper roll was changed with respect to various wall thickness. It can be seen that the edge forming properties were improved and the reduction of wall thickness was decreased when the present invention was applied. Further, when the turning angle limits described above for the the present invention were observed, the effects of the present invention were exhibited at the maximum.

Table 2

No.	Formed size	Forming condition					Remark
		Upper roll turning angle $\alpha_u(^{\circ})$	Lower roll turning angle $\alpha_d(^{\circ})$	Forming roll arrangement	*Radius of curvature	**Ratio of reduced wall thickness	
1	50.8×0.8	0	0	-	0.6	0.025	Conventional method
2	50.8×2.0	0	0	-	0.6	0.025	
3	50.8×5.0	0	0	-	0.75	0.044	
4	50.8×10.0	0	0	-	0.75	0.035	
5	50.8×2.0	14	5	diverging	0.85	0.010	Present Invention
6	50.8×5.0	10	5	diverging	0.9	0.016	
7	50.8×2.0	14	5	converging	1.0	0.010	
8	50.8×5.0	10	5	converging	1.0	0.008	
9	50.8×10.0	5	5	converging	1.0	0.015	
10	50.8×0.8	50	15	converging	0.8	0.022	

*) Average value of the ratio of targeted radius of curvature to obtained radius of curvature in edge forming, wherein the average value is taken in an edge forming region

R_0/R (R_0 : targeted radius of curvature in edge forming, R : obtained radius of curvature in edge forming)

**) Reduction of wall thickness/initial wall thickness

[0053] As described above, according to the present invention, when a metallic strip is continuously formed by rolls and then welded so as to manufacture a welded pipe, the metallic strip is subjected to edge forming by the breakdown roll unit provided in the initial edge forming process without impairing the accuracy of the wall thickness of the metallic strip to be formed. Further, the forming roll can be shared when metallic strips for various pipe diameters are formed.

Reference numerals shown in the drawings

[0054]

- 1 Increase in the wall thickness
- 2 Indentation
- 3 Upper roll
- 4 Lower roll
- 5 Metallic strip
- 6 Fin
- 7 Central portion of the metallic strip
- 8 Thrust
- 9 Hysteresis of the upper roll
- 10 Hysteresis of the lower roll

- 11 Deviation of the roll
- 12 Contact position
- 13 Edge portion of the metallic band
- 14 Upper roll support beam member
- 5 15 Lower roll support beam member
- 16 Reduction screw shaft
- 17 Upper roll bearing member
- 18 Lower roll bearing member
- 19 Upper roll support stand
- 10 20 Lower roll support stand
- 21 Lower roll of the central portion

Claims

- 15 1. A method of bending the longitudinal edges (13) of a metallic strip (5) for welded pipe formation by passing the strip (5) longitudinally in contact with a laterally spaced pair of first rotating rolls (3) each co-operating with a second rotating roll (4) to engage and bend a respective strip edge (13), the rotational axes of said first and second rolls (3,4) being in respective first and second spaced parallel planes, characterised in that each first roll (3) is skewed relative to the co-operating second roll (4) about an axis perpendicular to said spaced parallel planes.
- 20 2. A method according to claim 1 wherein the first rotating rolls (3) are skewed so that they converge in the machine direction towards the longitudinal centerline (7) of the metallic strip (5).
- 25 3. A method according to claim 1 or 2 wherein each first rotating roll (3) is skewed so that there is an angle $\alpha_{\mu} \leq 45^{\circ}$ between its rotational axis and the line parallel to said spaced parallel planes and perpendicular to the longitudinal centerline (7) of the metallic strip (5).
- 30 4. A method according to any preceding claim wherein each first rotating roll (3) co-operates with a second rotating roll (4) whose rotational axis is perpendicular to the longitudinal centerline (7) of the metallic strip (5).
- 35 5. A method according to any of claims 1 to 3 wherein each first rotating roll (3) co-operates with a respective second rotating roll (4) which is skewed relative to the longitudinal centerline (7) of the metallic strip (5) about an axis perpendicular to said spaced parallel planes in a direction opposite to the skewing of the respective first rotating roll (3).
- 40 6. A method according to claim 5 wherein each second rotating roll (4) is skewed to give an angle $\alpha_d \leq 30^{\circ}$ between its rotational axis and the line parallel to said spaced parallel planes and perpendicular to the longitudinal centerline (7) of the metallic strip (5).
- 45 7. A method according to any preceding claim wherein one of the first rotating rolls (3) is displaced relative to the other in the machine direction.
- 50 8. A forming stand for bending the longitudinal edges of a metallic strip (5) for welded pipe formation, the stand comprising a laterally spaced pair of first rotating rolls (3) each co-operating with a second rotating roll (4) for engaging and bending a respective edge (3) of a metallic strip (5) passed therethrough in the machine direction, the rotational axes of said first and second rotating rolls being in respective first and second spaced parallel planes, characterised by means for adjusting the lateral spacing between the first rotating rolls (3) and by means for selectively skewing each first rotating roll (3) relative to the co-operating second roll (4) about an axis perpendicular to said spaced parallel planes.
- 55 9. A forming stand according to claim 8 wherein each first rotating roll (3) co-operates with a respective second rotating roll (4), the stand including means for adjusting the lateral spacing of the second rotating rolls (4) and means for skewing each second rotating roll (4) relative to the machine direction about an axis perpendicular to said spaced parallel planes.
- 10. A forming stand according to claim 8 or 9 wherein one of the first rolls (3) is displaced relative to the other in the machine direction.

Patentansprüche

1. Verfahren zum Biegen der Längskanten (13) eines Metallbandes (5) zum Formen geschweißter Rohre durch Hindurchführen des Bandes (5) in Längsrichtung im Kontakt mit einem seitlich beabstandeten Paar erster Drehwalzen (3) die jeweils mit einer zweiten Drehwalze (4) zusammenwirken, um eine entsprechende Bandkante (13) zu erfassen und zu biegen, wobei die Drehachsen der ersten und zweiten Walzen (3, 4) in entsprechenden ersten und zweiten beabstandeten Parallelebenen liegen, dadurch gekennzeichnet, daß jede erste Walze (3) relativ zur zusammenwirkenden zweiten Walze (4) um eine zu den beabstandeten Parallelebenen senkrecht Achse schräg gestellt ist.
2. Verfahren nach Anspruch 1, wobei die ersten Drehwalzen (3) so schräg gestellt sind, daß sie in Maschinenrichtung zur Längsmittellinie (7) des Metallbandes (5) konvergieren.
3. Verfahren nach Anspruch 1 oder 2, wobei jede erste Drehwalze (3) so schräg gestellt ist, daß ein Winkel $\alpha_{\mu} \leq 45^{\circ}$ zwischen ihrer Drehachse und der Linie parallel zu den beabstandeten Parallelebenen und senkrecht zu der Längsmittellinie (7) des Metallbandes (5) ist.
4. Verfahren nach einem der vorstehenden Ansprüche, wobei jede erste Drehwalze (3) mit einer zweiten Drehwalze (4) zusammenwirkt, deren Drehachse senkrecht zur Längsmittellinie (7) des Metallbandes (5) ist.
5. Verfahren nach einem der Ansprüche 1 bis 3, wobei jede erste Drehwalze (3) mit einer entsprechenden zweiten Drehwalze (4) zusammenwirkt, die relativ zur Längsmittellinie (7) des Metallbandes (5) um eine zu den beabstandeten Parallelebenen senkrechte Achse in einer Richtung entgegengesetzt zur Schrägstellung der entsprechenden ersten Drehwalze (3) schräg gestellt ist.
6. Verfahren nach Anspruch 5, wobei jede zweite Drehwalze (4) schräg gestellt ist um einen Winkel $\alpha_d \leq 30^{\circ}$ zwischen ihrer Drehachse und der Linie parallel zu den beabstandeten Parallelebenen und senkrecht zu der Längsmittellinie (7) des Metallbandes (5).
7. Verfahren nach einem der vorstehenden Ansprüche, wobei eine der ersten Drehwalzen (5) relativ zur anderen in Maschinenrichtung versetzt ist.
8. Formgerüst zum Biegen der Längskanten eines Metallbandes (5) zur Bildung von geschweißten Rohren, wobei das Gerüst aufweist: ein in Querrichtung beabstandetes Paar erster Drehwalzen (3), die jeweils mit einer zweiten Drehwalze (4) zusammenwirken, um eine entsprechende Kante (3) eines Metallbandes (5) zu ergreifen und zu biegen, das in Maschinenrichtung hindurchgeführt wird, wobei die Drehachsen der ersten und zweiten Drehwalzen in entsprechenden ersten und zweiten beabstandeten Parallelebenen liegen, gekennzeichnet durch eine Einrichtung zum Einstellen des Querabstands zwischen den ersten Drehwalzen (3) und durch eine Einrichtung zum wahlweisen Schrägstellen jeder ersten Drehwalze (3) relativ zu der zusammenwirkenden zweiten Walze (4) um eine Achse senkrecht zu den beabstandeten Parallelebenen.
9. Formgerüst nach Anspruch 8, wobei jede erste Drehwalze (3) mit einer entsprechenden zweiten Drehwalze (4) zusammenwirkt und das Gerüst eine Einrichtung zum Einstellen des Querabstands der zweiten Drehwalzen (4) und eine Einrichtung zum Schrägstellen jeder zweiten Drehwalze (4) relativ zur Maschinenrichtung um eine Achse senkrecht zu den beabstandeten Parallelebenen aufweist.
10. Formgerüst nach Anspruch 8 oder 9, wobei eine der ersten Walzen (3) relativ zu der Anderen in Maschinenrichtung versetzt ist.

Revendications

1. Procédé de pliage des bords longitudinaux (13) d'une bande métallique (5) pour la formation de tubes soudés en faisant passer la bande (5) longitudinalement en contact avec une paire latéralement espacée de premiers rouleaux en rotation (3) qui coopèrent chacun avec un deuxième rouleau en rotation (4) afin d'engager et plier un bord de bande respectif (13), les axes de rotation desdits premier et deuxième rouleaux (3, 4) étant dans des premier et deuxième plans parallèles espacés respectifs, caractérisé en ce que chaque premier rouleau (3) est décalé par rapport au deuxième rouleau qui coopère (4) autour d'un axe perpendiculaire aux dits plans parallèles espacés.

2. Procédé selon la revendication 1, dans lequel les premiers rouleaux en rotation (3) sont de préférence décalés de telle sorte qu'ils convergent dans la direction de la machine vers l'axe longitudinal (7) de la bande métallique (5).
3. Procédé selon la revendication 1 ou 2, dans lequel chaque premier rouleau en rotation (3) est décalé de telle sorte qu'il y a un angle $\alpha_{\mu} \leq 45^{\circ}$ entre son axe de rotation et la ligne parallèle aux dits plans parallèles espacés et perpendiculaire à l'axe longitudinal (7) de la bande métallique (5).
4. Procédé selon l'une quelconque des revendications précédentes dans lequel chaque premier rouleau en rotation (3) coopère avec un deuxième rouleau en rotation (4) dont l'axe de rotation est perpendiculaire à l'axe longitudinal (7) de la bande métallique (5).
5. Procédé selon l'une quelconque des revendications 1 à 3, dans lequel chaque premier rouleau en rotation (3) coopère avec un deuxième rouleau en rotation respectif (4) qui est décalé par rapport à l'axe longitudinal (7) de la bande métallique (5) autour d'un axe perpendiculaire aux dits plans parallèles espacés dans une direction opposée au décalage du premier rouleau en rotation respectif (3).
6. Procédé selon la revendication 5, dans lequel chaque deuxième rouleau en rotation (4) est décalé afin de donner un angle $\alpha_d \leq 30^{\circ}$ entre son axe de rotation et la ligne parallèle auxdits plans parallèles espacés et perpendiculaire à l'axe longitudinal (7) de la bande métallique (5).
7. Procédé selon l'une quelconque des revendications précédentes, dans lequel un des premiers rouleaux en rotation (3) est de préférence déplacé par rapport à l'autre dans la direction de la machine.
8. Cage de formage destinée à plier les bords longitudinaux d'une bande métallique (5) pour la formation de tubes soudés, la cage comportant une paire latéralement espacée de premiers rouleaux en rotation (3) qui coopèrent chacun avec un deuxième rouleau en rotation (4) afin d'engager et plier un bord respectif (3) d'une bande métallique (5) qui passe à travers dans la direction de la machine, les axes de rotation desdits premiers et deuxièmes rouleaux en rotation étant dans des premier et deuxième plans parallèles espacés respectifs, caractérisée par des moyens destinés à ajuster l'espacement latéral entre les premiers rouleaux en rotation (3) et par des moyens destinés à décaler de manière sélective chaque premier rouleau en rotation (3) par rapport au deuxième rouleau qui coopère (4) autour d'un axe perpendiculaire aux dits plans parallèles espacés.
9. Cage de formage selon la revendication 8, dans laquelle chaque premier rouleau en rotation (3) coopère avec un deuxième rouleau en rotation respectif (4), la cage comprenant des moyens destinés à ajuster l'espacement latéral des deuxièmes rouleaux en rotation (4) et des moyens destinés à décaler chaque deuxième rouleau en rotation (4) par rapport à la direction de la machine autour d'un axe perpendiculaire aux dits plans parallèles espacés.
10. Cage de formage selon la revendication 8 ou 9, dans laquelle un des premiers rouleaux (3) est déplacé par rapport à l'autre dans la direction de la machine.

Fig.1

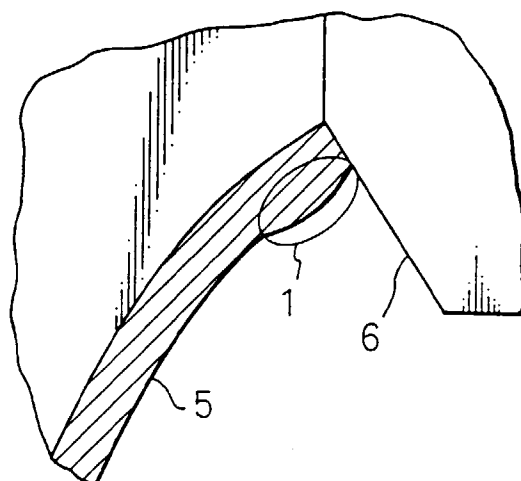


Fig. 2

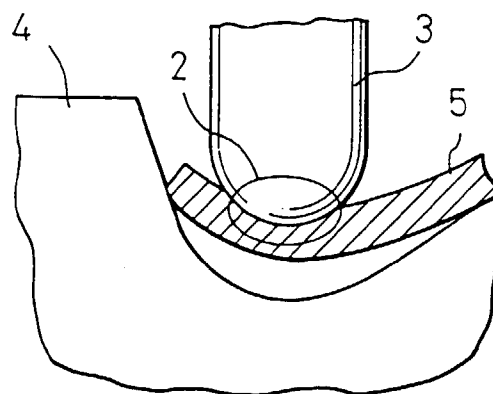


Fig.3

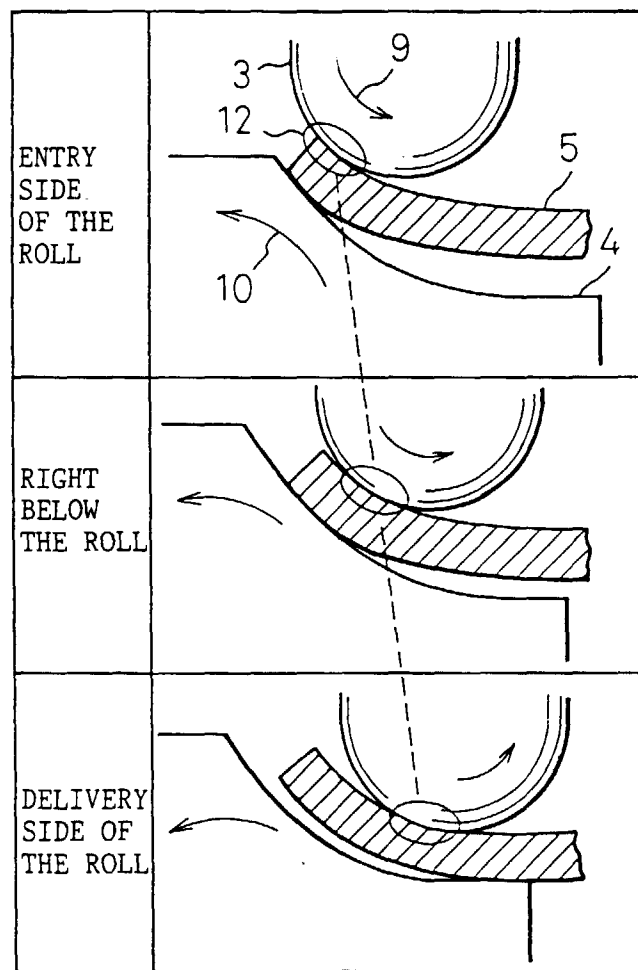


Fig. 4(a)

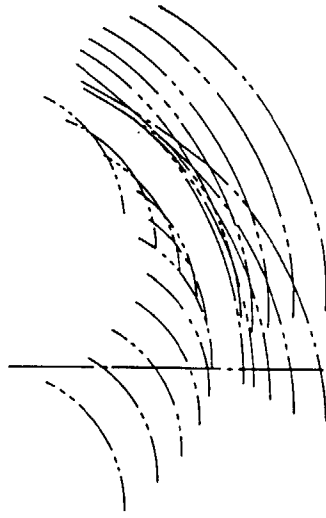


Fig. 4(b)

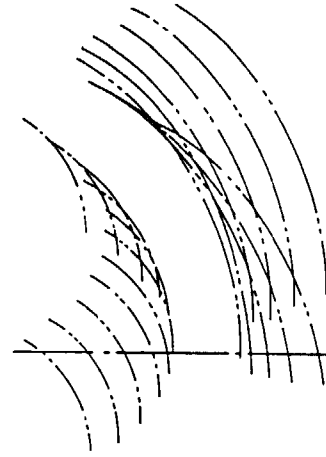


Fig. 4(c)

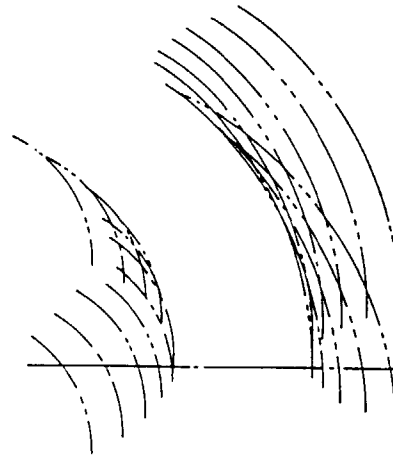


Fig. 4(d)

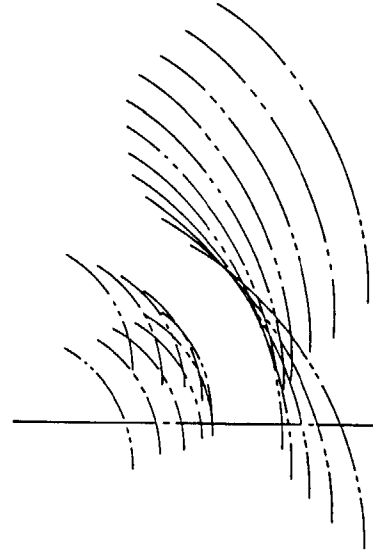


Fig. 5(a)

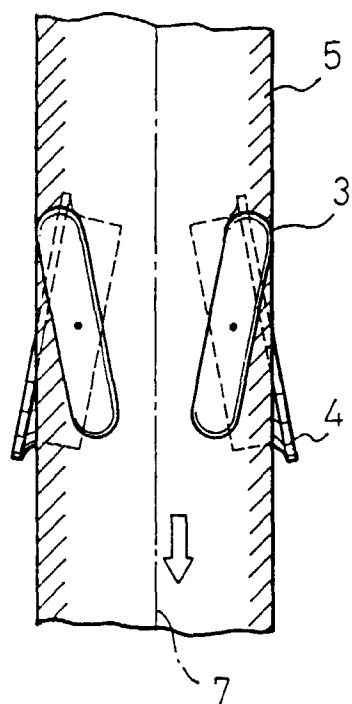


Fig. 5(b)

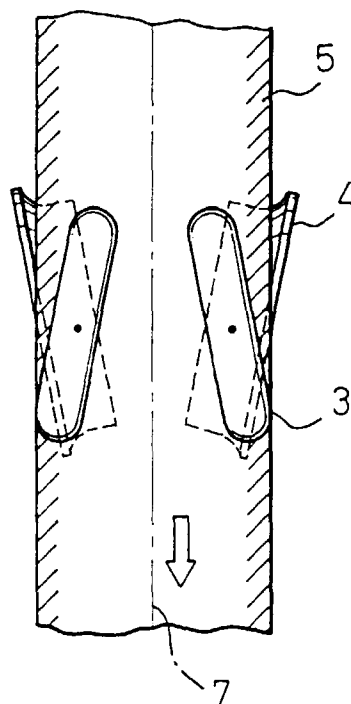


Fig.6

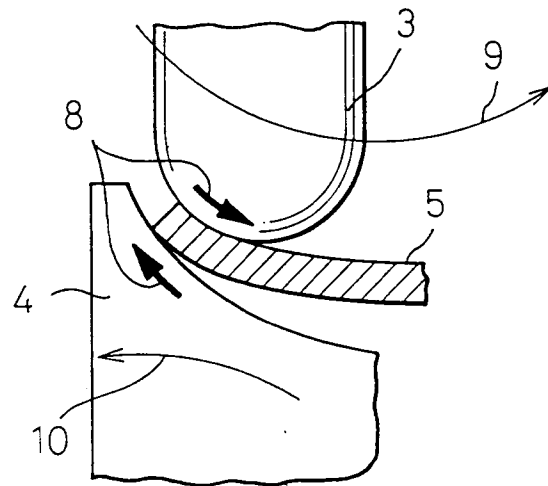


Fig.7

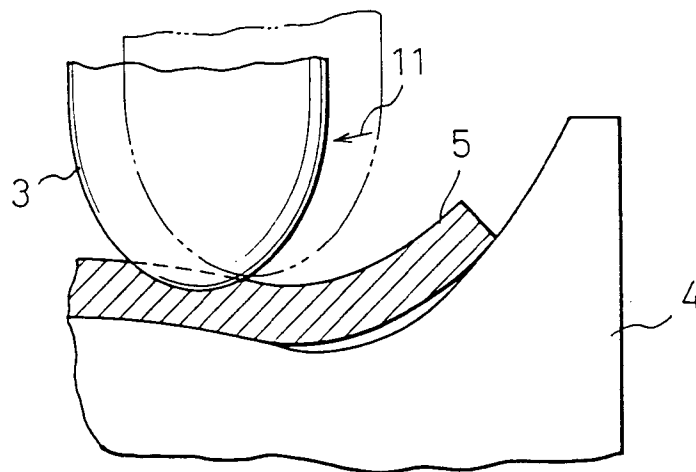


Fig.9

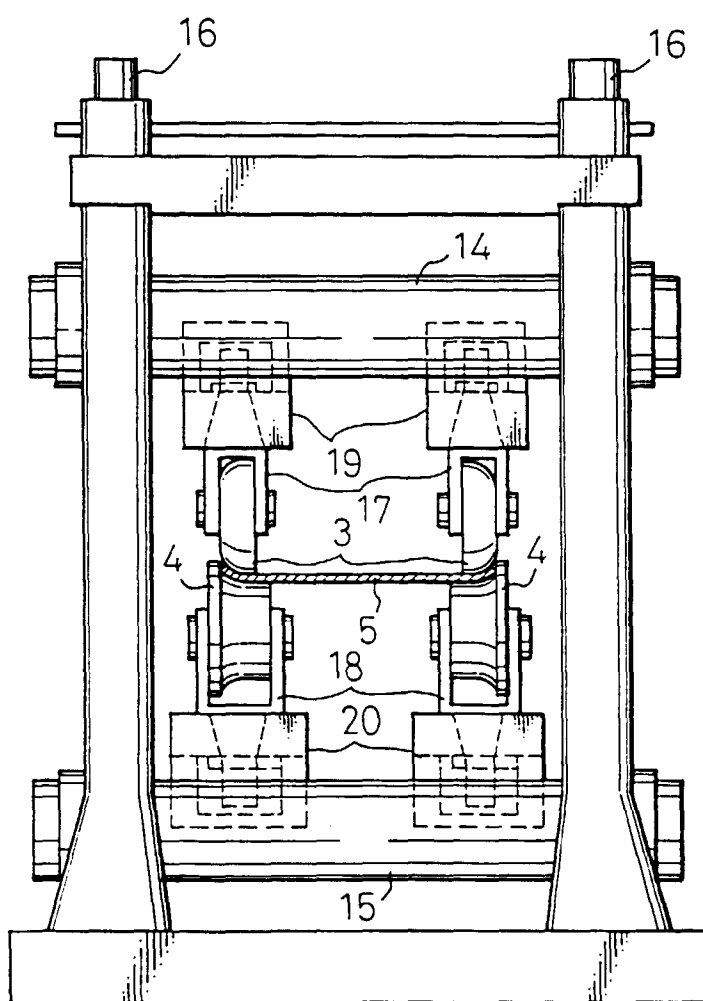


Fig.10(a)

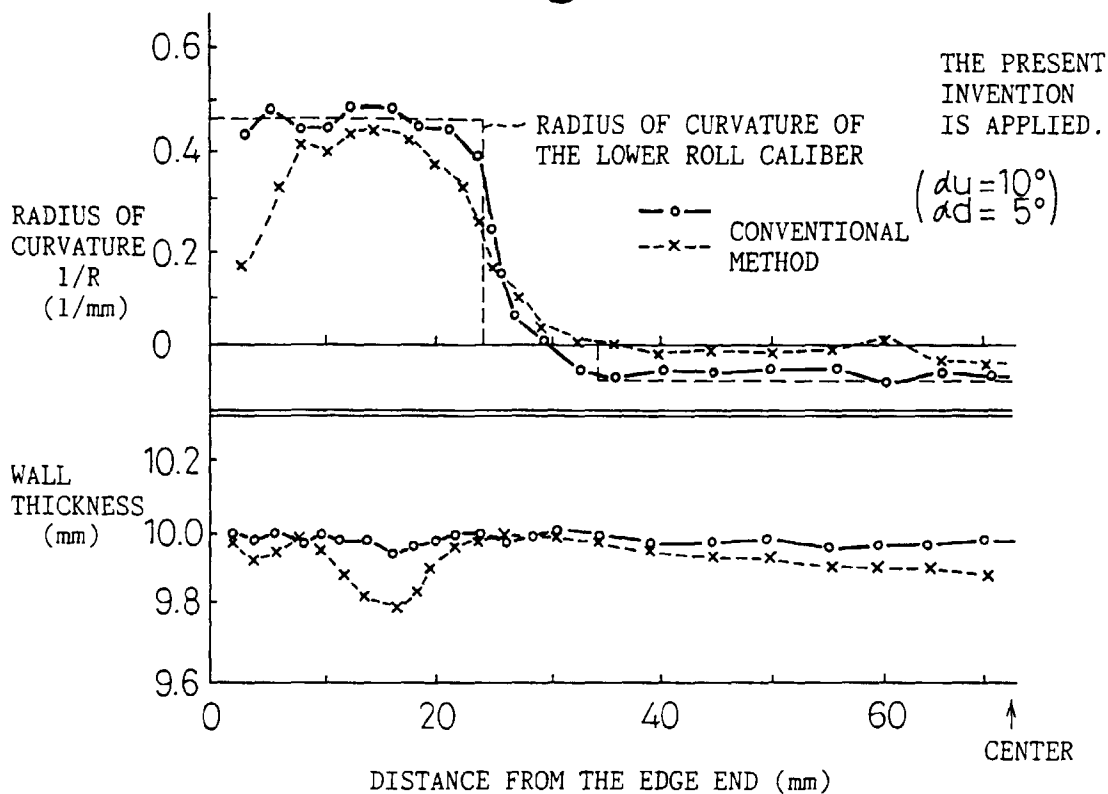


Fig.10(b)

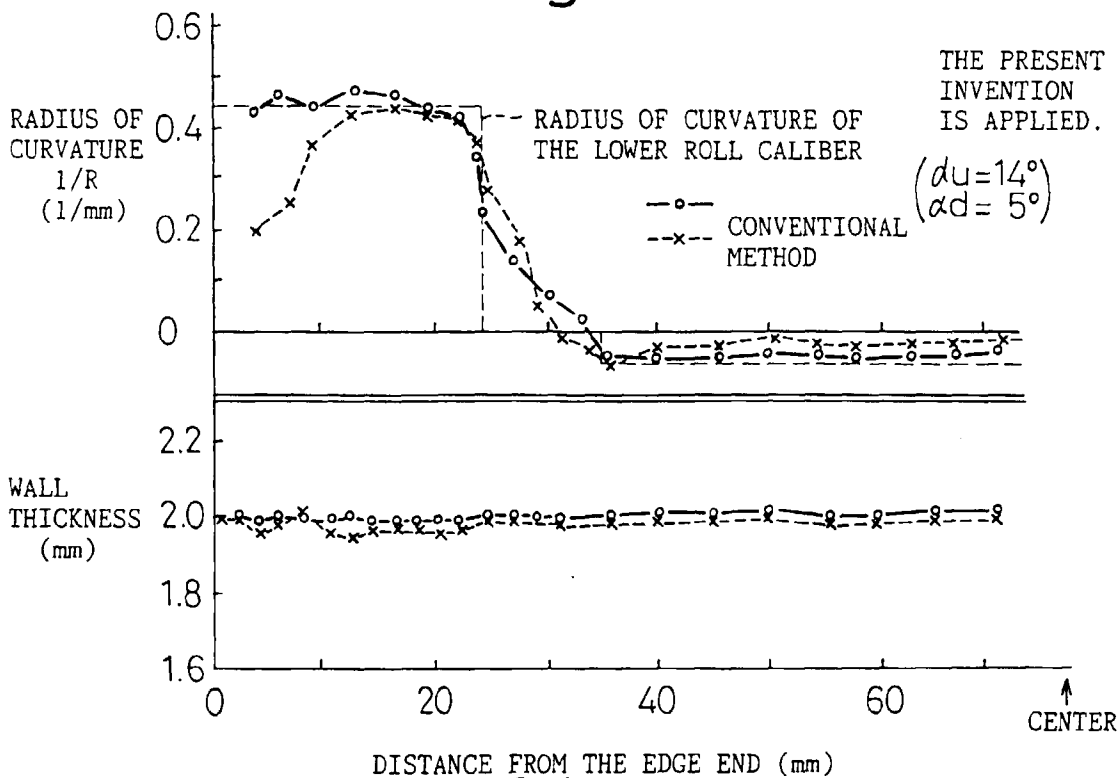


Fig.11

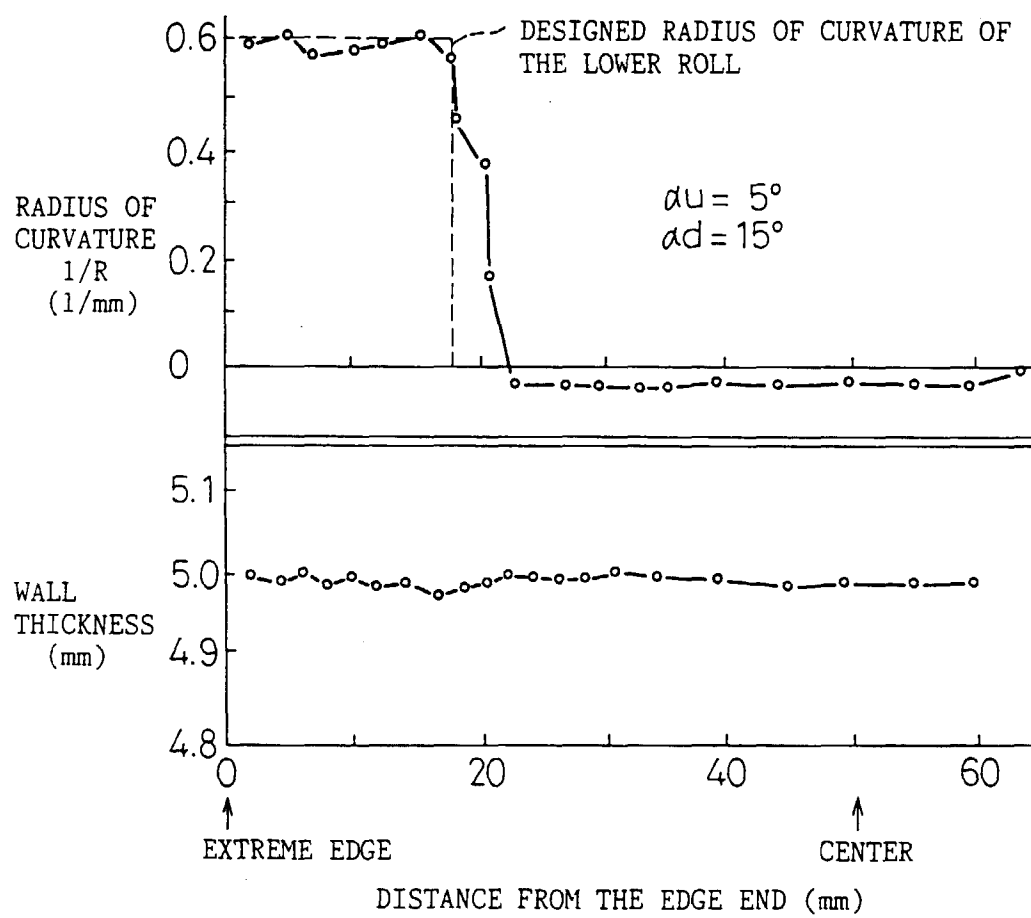


Fig. 12(b)

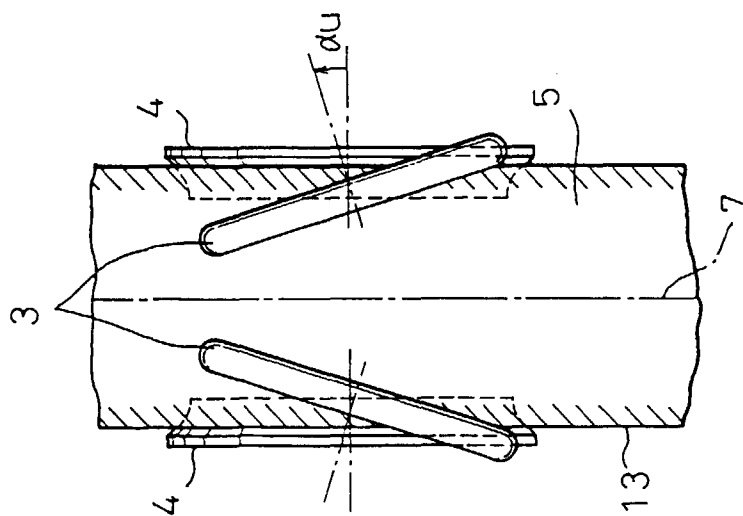


Fig.12(a)

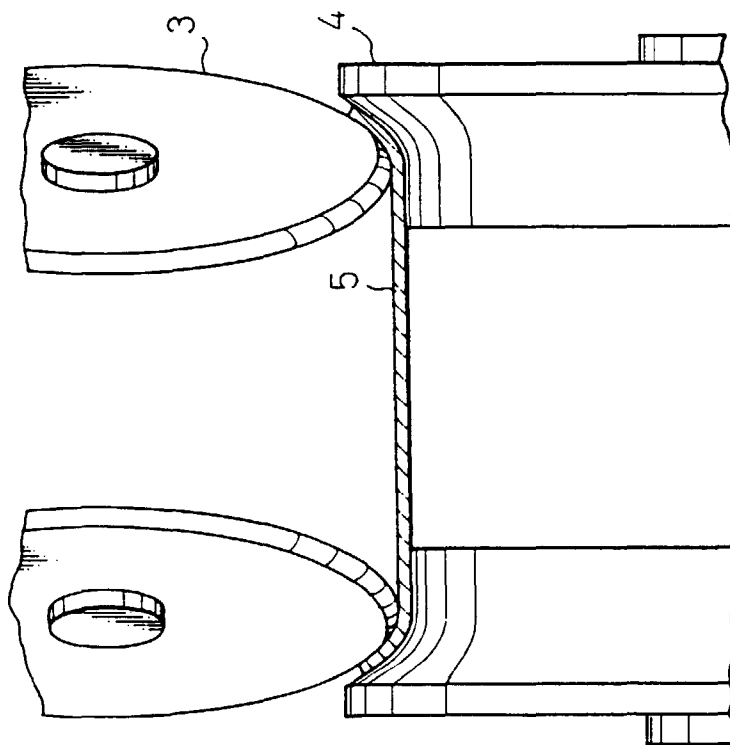


Fig.13

