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(72) Inventor: **SENDAI, Yusuke**
Osaka-shi
Osaka 541-0041 (JP)

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(74) Representative: **Dallmeyer, Georg**
Patentanwälte
von Kreisler Selting Werner
Deichmannhaus am Dom
Bahnhofsvorplatz 1
50667 Köln (DE)

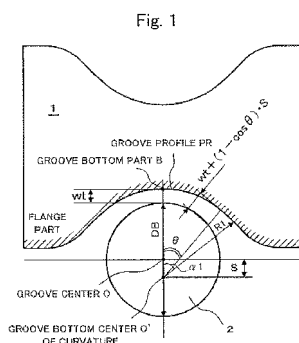
(71) Applicant: **Sumitomo Metal Industries, Ltd.**
Osaka 541-0041 (JP)

(54) **METHOD FOR PRODUCING SEAMLESS PIPE AND HOLE TYPE ROLL**

(57) There is provided a method for manufacturing a seamless pipe or tube and a grooved roll with which, even when the target wall thickness of pipe or tube is different, a mandrel bar having the same outside diameter can be used, and the wall thickness eccentricity along the circumferential direction of the pipe or tube can be effectively suppressed. A method for manufacturing a seamless pipe or tube according to the present invention includes a step of drawing and rolling a pipe or tube wherein the step of drawing and rolling comprises, in a case where there exist a plurality of target wall thicknesses of pipe or tube after drawing and rolling, preliminary replacing only the grooved rolls disposed in the finishing stand among the plurality of rolling stands with grooved rolls each of which meets the requirement given by the following expression (1) and each of which has a groove bottom radius of curvature differently depending on a target wall thickness of pipe or tube after drawing and rolling, and drawing and rolling a pipe or tube by using the replaced grooved rolls,

$$-0.1 \text{ mm} \leq (1 - \cos \theta) \cdot S \leq 0.1 \text{ mm} \dots\dots (1)$$

where θ is an angle expressed by $\theta = 90/i$ degrees if the number of grooved rolls disposed in each rolling stand is i ($i = 2$ to 4), and S is the offset amount (mm) for the grooved roll.



Description

Technical Field

[0001] The present invention relates to a method for manufacturing a seamless pipe or tube, and particularly relates to a method for manufacturing a seamless pipe or tube and a grooved roll with which, even when the target wall thickness of pipe or tube after drawing and rolling is different, a mandrel bar having the same outside diameter can be used, and the wall thickness eccentricity along the circumferential direction of pipe or tube can be effectively suppressed. Hereinafter, "pipe or tube" is referred to as pipe when deemed appropriate.

Background Art

[0002] As a mandrel mill, there have been conventionally used a 2-roll type mandrel mill in which two grooved rolls opposed are disposed in each rolling stand, and between adjacent rolling stands, the rolling directions of the grooved rolls differ by 90°, and a 3-roll type mandrel mill in which three grooved rolls are disposed in each rolling stand such that the angle formed by the rolling directions is 120°, and between adjacent rolling stands, the rolling directions of the grooved roll differ by 60°. In addition, a 4-roll type mandrel mill in which four grooved rolls are disposed in each rolling stand such that the angle formed by the rolling directions is 90° has also been applied.

[0003] In these mandrel mills, a pipe into the inside of which a mandrel bar is inserted is passed between the grooved rolls disposed in each rolling stand, thereby the pipe being subjected to drawing and rolling.

In this drawing and rolling step, the pipe is rolled in the gap between the grooved roll and the mandrel bar, the wall thickness being finished to a predetermined dimension according to the dimension of the aforementioned gap. Thus, when the target wall thickness of pipe after drawing and rolling is different, it is necessary to change the dimension of the gap across the grooved roll and the mandrel bar in accordance with such difference.

[0004] In order to change this gap dimension, a plurality of mandrel bars having different outside diameters are generally prepared, and the mandrel bar to be used is replaced according to the target wall thickness of pipe. However, if the setting pitch for the target wall thickness is fine, there arises the need for a number of mandrel bars having different outside diameters in accordance therewith. In addition, when the target wall thickness of pipe is of one type, the mandrel bar is extracted from the pipe after being used for the drawing and rolling, cooled, and coated with a lubricant on the surface, then it is generally again inserted into the inside of another pipe to be subjected to drawing and rolling for use (circulative use). Thus, there arises also the need for having a number of mandrel bars with the same outside diameter. Therefore, in a case where the target wall thickness of pipe is different, if it is assumed that the drawing and rolling of pipe is to be accommodated only by replacing the mandrel bar, a tremendous number of mandrel bars would be required to be possessed, with the material cost needed for the mandrel bars and the installation cost for handling them being excessively increased.

[0005] Thus, in addition to the method for replacing the mandrel bar, a method for changing the rolling position of the grooved roll (roll gap) according to the target wall thickness of pipe has been used in conjunction. However, when the roll gap for the grooved roll has been changed, a wall thickness eccentricity (a fluctuation in wall thickness) tends to be produced along the circumferential direction of the pipe. Especially when the roll gap for the grooved roll disposed in the finishing stand (i.e., a rolling stand in which a grooved roll is disposed which is to be lastly contacted with a portion of the pipe that is identical in circumferential location), among a plurality of rolling stands provided for the mandrel mill, has been changed, a wall thickness eccentricity along the circumferential direction of pipe tends to be produced. For example, in the case of a 2-roll type mandrel mill, a quaternary wall thickness eccentricity along the circumferential direction (a wall thickness eccentricity with which the measure of the wall thickness is periodically fluctuated four times while the pipe is rounded) tends to be produced. In the case of a 3-roll type mandrel mill, a senary wall thickness eccentricity along the circumferential direction tends to be produced, while in the case of a 4-roll type mandrel mill, a wall thickness eccentricity along the circumferential direction tends to be produced.

[0006] Conventionally, as a drawing and rolling method with a mandrel mill aiming at suppressing such a wall thickness eccentricity along the circumferential direction of the pipe, methods stated in, for example, JP61-86020A (Patent Document 1), JP5-237514A (Patent Document 2), JP6-179003A (Patent Document 3), and JP8-71610A (Patent Document 4) have been proposed.

[0007] The method stated in Patent Document 1 is a method which, in a 2-roll type mandrel mill, adjusts the rolling position of the grooved roll asymmetrically in a vertical or horizontal direction. However, the method stated in Patent Document 1 introduces occurrence of a senary or octonary wall thickness eccentricity along the circumferential direction, instead of being capable of suppressing the quaternary wall thickness eccentricity along the circumferential direction.

[0008] The method stated in Patent Document 2 is a method which, in a 2-roll type mandrel mill, arranges the respective roll axes of a pair of grooved rolls, inclining them towards the directions reverse to each other with respect to the direction of advance of the pipe, for drawing and rolling. However, with the method stated in Patent Document 2, there is a

possibility that the edge part of the grooved roll which is inclination-arranged may be contacted with the outer surface of the pipe, resulting in an outer surface flaw being produced.

[0009] The method stated in Patent Document 3 is a method which uses a mandrel bar the diameter of which is reduced in a tapered manner toward the outlet side of the mandrel mill, and controls the position of this mandrel bar relative to that of the pipe in the longitudinal direction for drawing and rolling. However, with the method stated in Patent Document 3, it is difficult to convey the tapered mandrel bar, and in addition, it is necessary to control the relative position between the mandrel bar and the pipe with extremely high accuracy, thus this method is practically difficult to be applied.

[0010] The method stated in Patent Document 4 is a method which performs drawing and rolling of the pipe by means of a mandrel mill in which four grooved rolls are disposed in the rolling stands at the most proximal and distal stages, while two grooved rolls are disposed in the other rolling stands. However, with the method stated in Patent Document 4, there is a possibility that the portion of the pipe opposed to the flange part of the grooved roll disposed in the rolling stand located one stage before the most distal stage (a rolling stand in which two grooved rolls are disposed) may interfere with the flange part of the grooved roll disposed in the rolling stand at the most distal stage (a rolling stand in which four grooved rolls are disposed), resulting in an outer surface flaw being produced in the pipe.

Disclosure of the Invention

[0011] The present invention has been made in view of such prior art, and it is a subject thereof to provide a method for manufacturing a seamless pipe or tube and a grooved roll with which, even when the target wall thickness of pipe or tube after drawing and rolling is different, a mandrel bar having the same outside diameter can be used, and the wall thickness eccentricity along the circumferential direction of the pipe or tube (in the case of using a 2-roll type mandrel mill, a quaternary wall thickness eccentricity along the circumferential direction) can be effectively suppressed.

[0012] The present inventors have made a keen study to solve the aforementioned subject and have found the facts described in the following (1) and (2).

(1) The peak location of a wall thickness eccentricity along the circumferential direction of the pipe or tube on the finishing stand outlet side (the location where the wall thickness is at maximum or minimum) tends to occur in a location which is angularly displaced from the location opposed to the groove bottom part of the grooved roll by $\theta = 90/i$ degrees (i denotes the number of grooved rolls disposed in each rolling stand) along the circumferential direction around the groove bottom center of curvature of the grooved roll (see Figure 1).

(2) On the geometrical calculation, the wall thickness of the pipe or tube in the aforementioned location, which is displaced by θ degrees, is increased by $(1 - \cos \theta) \cdot S$ (S denotes the offset amount for the grooved roll) with respect to the wall thickness of the pipe or tube in the location opposed to the groove bottom part on the finishing stand outlet side (see Figure 1). Therefore, in a case where there exist a plurality of target wall thicknesses of pipe or tube, by replacing the grooved rolls disposed in the finishing stand with grooved rolls each of which has a groove bottom radius of curvature differently depending on a target wall thickness of pipe or tube (for example, when a pipe or tube of a smaller target wall thickness is to be subjected to drawing and rolling, the grooved roll is replaced with a grooved roll having a smaller groove bottom radius of curvature), and holding the absolute value of $(1 - \cos \theta) \cdot S$ for the replaced grooved roll to within a predetermined range, a mandrel bar having the same outside diameter can be used when a pipe or tube of each target wall thickness is subjected to drawing and rolling, and the wall thickness eccentricity along the circumferential direction of the pipe or tube can be effectively suppressed.

[0013] The present inventors have completed the present invention on the basis of the above findings. The present invention provides a method for manufacturing a seamless pipe or tube including a step of drawing and rolling a pipe or tube by a mandrel mill provided with a plurality of rolling stands in which a plurality of grooved rolls are disposed respectively, wherein the step of drawing and rolling comprises, in a case where there exist a plurality of target wall thicknesses of pipe or tube after drawing and rolling, preliminary replacing only the grooved rolls disposed in the finishing stand among the plurality of rolling stands with grooved rolls each of which meets the requirement given by the following expression (1) and each of which has a groove bottom radius of curvature differently depending on a target wall thickness of pipe or tube after drawing and rolling, and drawing and rolling a pipe or tube by using the replaced grooved rolls,

$$-0.1 \text{ mm} \leq (1 - \cos \theta) \cdot S \leq 0.1 \text{ mm} \dots\dots (1)$$

where θ is an angle expressed by $\theta = 90/i$ degrees if the number of grooved rolls disposed in each rolling stand is i ($i = 2$ to 4), and S is the offset amount (mm) for the grooved roll.

[0014] The term "finishing stand" used in the present invention means a rolling stand in which the grooved roll which

is to be lastly contacted with a portion of the pipe or tube that is identical in circumferential location is disposed. The terms "groove bottom radius of curvature" and "offset amount" used in the present invention will be described later with reference to the drawing.

[0015] In order to achieve the object, the present invention also provides a grooved roll which is disposed in the finishing stand in the mandrel mill used with the manufacturing method, wherein the grooved roll meets the requirement given by the following expression (1):

$$-0.1 \text{ mm} \leq (1 - \cos \theta) \cdot S \leq 0.1 \text{ mm} \dots\dots (1)$$

where θ is an angle expressed by $\theta = 90/i$ degrees if the number of grooved rolls disposed in each rolling stand is i ($i = 2$ to 4), and S is the offset amount (mm) for the grooved roll.

[0016] According to the method for manufacturing a seamless pipe or tube and the grooved roll in the present invention, even when the target wall thickness of pipe or tube after drawing and rolling is different, a mandrel bar having the same outside diameter can be used, and the wall thickness eccentricity along the circumferential direction of the pipe or tube can be effectively suppressed.

Brief Description of the Drawings

[0017]

Figure 1 is a drawing for explaining the meanings of groove bottom radius of curvature and offset amount in the method according to the present invention, giving a longitudinal sectional view schematically expressing a grooved roll disposed in a 2-roll type mandrel mill and a mandrel bar;

Figure 2A and Figure 2B give examples of grooved rolls to be disposed in each rolling stand in a mandrel mill when a pipe is subjected to drawing and rolling by the method according to the present invention and the conventional method. Figure 2A gives examples of grooved rolls to be disposed when there exist two different target wall thicknesses of 10 mm and 9 mm for a target outside diameter of pipe after drawing and rolling of 276 mm. Figure 2B gives examples of grooved rolls to be disposed when there exist two different target wall thicknesses of 17.5 mm and 16.5 mm for a target outside diameter of pipe after drawing and rolling of 382 mm; and

Figure 3A and Figure 3B give graphs showing the component of a quaternary wall thickness eccentricity along the circumferential direction of the pipe after drawing and rolling when the grooved rolls given in Figure 2B are used. Figure 3A shows the component of a quaternary wall thickness eccentricity along the circumferential direction when the method according to the present invention is used for drawing and rolling, while Figure 3B shows the component of a quaternary wall thickness eccentricity along the circumferential direction when the method pertaining to the comparative example is used for drawing and rolling.

Best Mode for Carrying Out the Invention

[0018] Hereinbelow, one embodiment of a method for manufacturing a seamless pipe according to the present invention will be described with reference to the accompanying drawings as appropriate. As mentioned above, the method for manufacturing a seamless pipe according to the present invention includes a step of drawing and rolling a pipe by a mandrel mill provided with a plurality of rolling stands in which a plurality of grooved rolls are disposed respectively. And, the step of drawing and rolling comprises, in a case where there exist a plurality of target wall thicknesses of pipe after drawing and rolling, preliminary replacing only the grooved rolls disposed in the finishing stand among the plurality of rolling stands with grooved rolls each of which meets the requirement given by the following expression (1) and each of which has a groove bottom radius of curvature differently depending on a target wall thickness of pipe after drawing and rolling, and drawing and rolling a pipe by using the replaced grooved rolls,

$$-0.1 \text{ mm} \leq (1 - \cos \theta) \cdot S \leq 0.1 \text{ mm} \dots\dots (1)$$

where θ is an angle expressed by $\theta = 90/i$ degrees if the number of grooved rolls disposed in each rolling stand is i ($i = 2$ to 4), and S is the offset amount (mm) for the grooved roll.

[0019] Hereinbelow, referring to Figure 1, the terms "groove bottom radius of curvature" and "offset amount" used in the present invention will be described. Figure 1 is a drawing for explaining the meanings of groove bottom radius of

curvature and offset amount, giving a longitudinal sectional view schematically expressing a grooved roll disposed in a 2-roll type mandrel mill and a mandrel bar. Figure 1 gives an example of a groove profile PR of a grooved roll 1 that is designed by combining a plurality of circular arcs. This groove profile PR is drawn in a two curves being symmetrical to a straight line connecting between a groove bottom part B and a groove center (pass line center) O. Each curve has a geometry which is formed by continuously combining a circular arc of a radius R1 having a central angle $\alpha 1$ (hereinafter, to be referred to as a circular arc R1) with another circular arc.

<Groove bottom radius of curvature>

[0020] The groove bottom radius of curvature is expressed by the distance between the groove bottom part B and the center O' of the circular arc R1 (the groove bottom center of curvature), i.e., the radius R1 of the circular arc R1.

<Offset amount>

[0021] The offset amount S is expressed by the distance between the groove bottom center O' of curvature and the groove center O. In other words, if the outside diameter of a mandrel bar 2 is DB, and the target wall thickness of pipe after drawing and rolling is wt, the offset amount S is expressed by the following expression (2):

$$S = R1 \cdot DB/2 - wt \dots\dots (2)$$

The offset amount S is of a positive value when the groove bottom center O' of curvature is located outside of the groove center O (in the direction further away from the groove bottom part B of the grooved roll 1), i.e., when the grooved roll 1 is moved closer to the mandrel bar 2 from the reference position (the position where the groove bottom center O' of curvature coincides with the groove center O).

[0022] Hereinabove, the terms "groove bottom radius of curvature" and "offset amount" have been explained with the 2-roll type mandrel mill being used as an example, however, for the 3-roll type and 4-roll type mandrel mills, the meanings of those terms are the same.

[0023] Figure 2A and Figure 2B give examples of grooved rolls to be disposed in each rolling stand in a mandrel mill when a pipe is subjected to drawing and rolling by the method according to the present invention and the conventional method. Figure 2A and Figure 2B exemplify cases where a 2-roll type mandrel mill is provided with five rolling stands, the fourth rolling stand (#4 rolling stand) and the fifth rolling stand (#5 rolling stand) counted from the inlet side of this mandrel mill being used as the finishing stands. The "QP" given in Figure 2A and Figure 2B denotes the value of $QP = (1 - \cos \theta) \cdot S$. Figure 2A gives examples of grooved rolls to be disposed when there exist two different target wall thicknesses of 10 mm and 9 mm for a target outside diameter of pipe after drawing and rolling of 276 mm. Figure 2B gives examples of grooved rolls to be disposed when there exist two different target wall thicknesses of 17.5 mm and 16.5 mm for a target outside diameter of pipe after drawing and rolling of 382 mm.

[0024] As can be seen from Figure 2A, with the conventional method, the groove bottom radius R1 of curvature of the grooved rolls disposed in the finishing stands (the #4 and #5 rolling stands) is set (at $R1 = 138$ mm) (in No. 1 given in Figure 2A) with the case where a pipe of a target wall thickness after drawing and rolling of 10 mm is to be manufactured being used as the reference (such that the offset amount S expressed by the aforementioned expression (2) is 0 mm). And, also in a case where a pipe of a target wall thickness of 9 mm is to be manufactured, the grooved rolls disposed in these finishing stands are not replaced. Specifically, also in a case where a pipe of a target wall thickness of 9 mm is to be manufactured, if a mandrel bar having the same outside diameter (an outside diameter of 256 mm) as that of the mandrel bar used for manufacturing a pipe of a target wall thickness of 10 mm is used, the roll gap for the grooved rolls disposed in the finishing stands is reduced as compared to that for the target wall thickness of 10 mm for carrying out the drawing and rolling (in No. 2 given in Figure 2A). This results in $QP = 0.3$ mm, with a pipe after drawing and rolling having a quaternary wall thickness eccentricity along the circumferential direction. On the other hand, in a case where a pipe of a target wall thickness of 9 mm is to be manufactured, if a mandrel bar having an outside diameter larger than that of the mandrel bar used for manufacturing a pipe of a target wall thickness of 10 mm is used, a mandrel bar having an outside diameter of 258 mm can be used to realize $QP = 0$ mm with no need for changing the roll gap for the grooved roll disposed in the finishing stands. However, for the aforementioned reasons, it is practically difficult to always reserve a mandrel bar having such a favorable outside diameter. Figure 2A exemplifies a case where, as a mandrel bar having a larger outside diameter next to an outside diameter of 256 mm, only a mandrel bar with an outside diameter of 262 mm is possessed, and if this mandrel bar having an outside diameter of 262 mm is used, it is necessary to carry out the drawing and rolling with the roll gap for the grooved rolls disposed in the finishing stands being increased to over that for a target wall thickness of 10 mm (in No. 3 given in Figure 2A). This results in $QP = -0.6$ mm, with a pipe after drawing

and rolling having a quaternary wall thickness eccentricity along the circumferential direction.

[0025] Also with the method according to the present invention, in a case where a pipe of a target wall thickness after drawing and rolling of 10 mm is to be manufactured, grooved rolls (with a groove bottom radius of curvature of $R1 = 138$ mm) which are identical to those used with the conventional method are disposed in the finishing stands (in No. 4 given in Figure 2A). However, with the method according to the present invention, in a case where a pipe of a target wall thickness of 9 mm is to be manufactured, the grooved rolls disposed in the finishing stands are replaced with those having a different groove bottom radius $R1$ of curvature (in an example of No. 5 given in Figure 2A, $R1 = 137$ mm). In this case, with the outside diameter of the mandrel bar used being taken into account, the grooved rolls disposed in the finishing stands are replaced with those having a groove bottom radius $R1$ of curvature which provides a QP meeting the expression of $-0.1 \text{ mm} \leq QP \leq 0.1 \text{ mm}$. Thereby, even if a mandrel bar having the same outside diameter (an outside diameter of 256 mm) as that of the mandrel bar used for manufacturing a pipe of a target wall thickness of 10 mm is used, the expression of $-0.1 \text{ mm} \leq QP \leq 0.1 \text{ mm}$ can be met (in an example of No. 5 given in Figure 2A, $QP = 0.0 \text{ mm}$), whereby the quaternary wall thickness eccentricity along the circumferential direction of pipe after drawing and rolling can be significantly reduced. In addition, in a case where, using the method according to the present invention, a pipe of a target wall thickness of 9 mm is to be manufactured, a mandrel bar having a large outside diameter (an outside diameter of 262 mm) as compared to that for the mandrel bar used for manufacturing a pipe of a target wall thickness of 10 mm can also be used, as is the case with the conventional method (in No. 6 given in Figure 2A). Also in this case, with the outside diameter (262 mm) of the mandrel bar used being taken into account, the grooved rolls disposed in the finishing stands are replaced with those having a groove bottom radius $R1$ of curvature (in an example of No. 6 given in Figure 2A, $R1 = 140$ mm), which provides a QP meeting the expression of $-0.1 \text{ mm} \leq QP \leq 0.1 \text{ mm}$ (in an example of No. 6 given in Figure 2A, $QP = 0.0 \text{ mm}$). Thereby, even if a mandrel bar having the same outside diameter (an outside diameter of 256 mm) as that of the mandrel bar used for manufacturing a pipe of a target wall thickness of 10 mm is used, the expression of $-0.1 \text{ mm} \leq QP \leq 0.1 \text{ mm}$ can be met (in an example of No. 6 given in Figure 2A, $QP = 0.0 \text{ mm}$), whereby the quaternary wall thickness eccentricity along the circumferential direction of pipe after drawing and rolling can be significantly reduced.

[0026] The example given in Figure 2B is similar, that is to say, with the conventional method, the groove bottom radius $R1$ of curvature of the grooved rolls disposed in the finishing stands is set (at $R1 = 191$ mm) (in No. 7 given in Figure 2B) with the case where a pipe of a target wall thickness after drawing and rolling of 17.5 mm is to be manufactured being used as the reference and, also in a case where a pipe of a target wall thickness of 16.5 mm is to be manufactured, the grooved rolls disposed in these finishing stands are not replaced. Thus, also in a case where a pipe of a target wall thickness of 16.5 mm is to be manufactured, if a mandrel bar having the same outside diameter (an outside diameter of 347 mm) as that of the mandrel bar used for manufacturing a pipe of a target wall thickness of 17.5 mm is used (in No. 8 given in Figure 2B), the roll gap for the grooved rolls disposed in the finishing stands is required to be reduced as compared to that for the target wall thickness of 17.5 mm for carrying out the drawing and rolling, which resulted in $QP = 0.3 \text{ mm}$. As a result of this, as shown in Figure 3B, a pipe after drawing and rolling has a large quaternary wall thickness eccentricity along the circumferential direction.

[0027] Contrarily to this, with the method according to the present invention, in a case where a pipe of a target wall thickness of 16.5 mm is to be manufactured, the grooved rolls disposed in the finishing stands are replaced with those having a different groove bottom radius $R1$ of curvature (in an example of No. 10 given in Figure 2B, $R1 = 190$ mm). In this case, with the outside diameter of the mandrel bar used being taken into account, the grooved rolls disposed in the finishing stands are replaced with those having a groove bottom radius $R1$ of curvature which provides a QP meeting the expression of $-0.1 \text{ mm} \leq QP \leq 0.1 \text{ mm}$. Thereby, even if a mandrel bar having the same outside diameter (an outside diameter of 347 mm) as that of the mandrel bar used for manufacturing a pipe of a target wall thickness of 16.5 mm is used, the expression of $-0.1 \text{ mm} \leq QP \leq 0.1 \text{ mm}$ can be met (in an example of No. 10 given in Figure 2B, $QP = 0.0 \text{ mm}$). As a result of this, the quaternary wall thickness eccentricity along the circumferential direction of pipe after drawing and rolling can be significantly reduced as shown in Figure 3A.

Claims

1. A method for manufacturing a seamless pipe or tube including a step of drawing and rolling a pipe or tube by a mandrel mill provided with a plurality of rolling stands in which a plurality of grooved rolls are disposed respectively, wherein the step of drawing and rolling comprises, in a case where there exist a plurality of target wall thicknesses of pipe or tube after drawing and rolling, preliminarily replacing only the grooved rolls disposed in the finishing stand among the plurality of rolling stands with grooved rolls each of which meets the requirement given by the following expression (1) and each of which has a groove bottom radius of curvature differently depending on a target wall thickness of pipe or tube after drawing and rolling, and drawing and rolling a pipe or tube by using the replaced grooved rolls,

$$-0.1 \text{ mm} \leq (1 - \cos \theta) \cdot S \leq 0.1 \text{ mm} \dots\dots (1)$$

5 where θ is an angle expressed by $\theta = 90/i$ degrees if the number of grooved rolls disposed in each rolling stand is i ($i = 2$ to 4), and S is the offset amount (mm) for the grooved roll.

2. A grooved roll which is disposed in the finishing stand in the mandrel mill used with the manufacturing method of claim 1, wherein the grooved roll meets the requirement given by the following expression (1):

$$-0.1 \text{ mm} \leq (1 - \cos \theta) \cdot S \leq 0.1 \text{ mm} \dots\dots (1)$$

15 where θ is an angle expressed by $\theta = 90/i$ degrees if the number of grooved rolls disposed in each rolling stand is i ($i = 2$ to 4), and S is the offset amount (mm) for the grooved roll.

Fig. 1

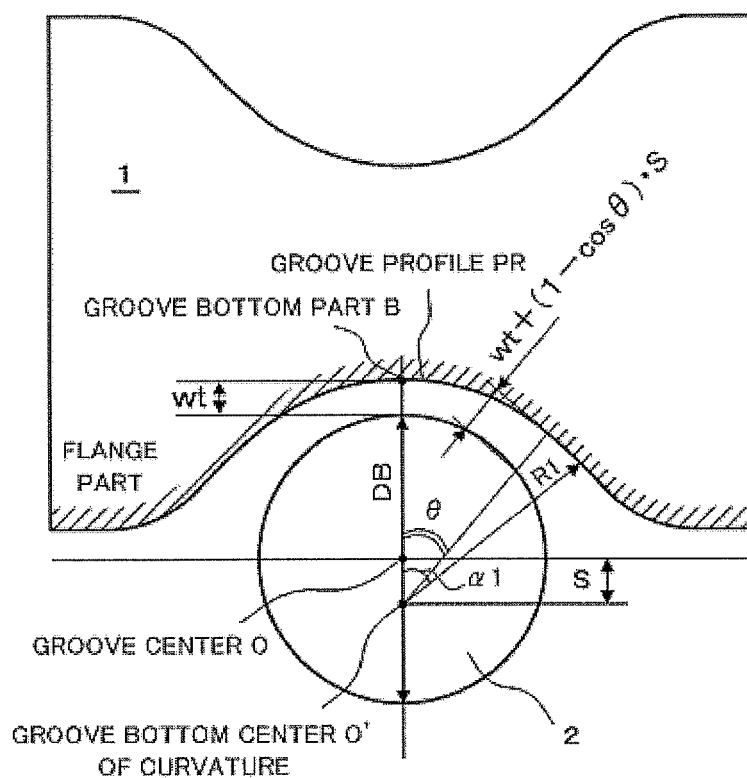


Fig.2A

	REMARK	TARGET OUTSIDE DIAMETER	TARGET WALL THICKNESS	MANDREL BAR OUTSIDE DIAMETER	#1 TO #3	#4	#5	QP
PRIOR ART	No. 1	276mm	10mm	256mm	—	R1=138mm	R1=138mm	0. 0mm
	No. 2		9mm	256mm				0. 3mm
	No. 3			262mm				—0. 6mm
PRESENT INVENTION	No. 4	276mm	10mm	256mm	DITTO	R1=138mm	R1=138mm	0. 0mm
	No. 5		9mm	256mm		R1=137mm	R1=137mm	0. 0mm
	No. 6			262mm		R1=140mm	R1=140mm	0. 0mm

Fig.2B

	REMARK	TARGET OUTSIDE DIAMETER	TARGET WALL THICKNESS	MANDREL BAR OUTSIDE DIAMETER	#1 TO #3	#4	#5	QP
PRIOR ART	No. 7	382mm	17. 5mm	347mm	—	R1=191mm	R1=191mm	0. 0mm
	No. 8		16. 5mm					0. 3mm
PRESENT INVENTION	No. 9	382mm	17. 5mm	347mm	DITTO	R1=191mm	R1=191mm	0. 0mm
	No. 10		16. 5mm			R1=190mm	R1=190mm	0. 0mm

Fig. 3A

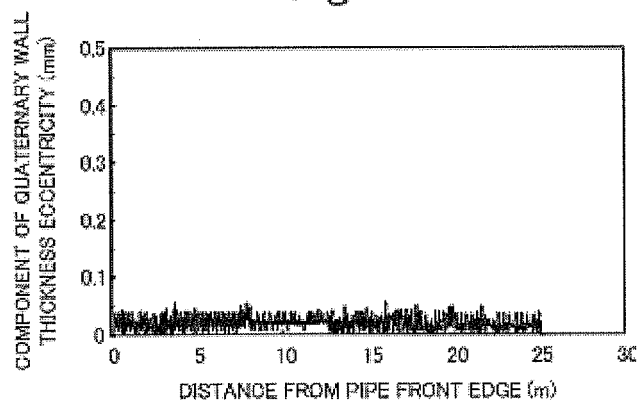
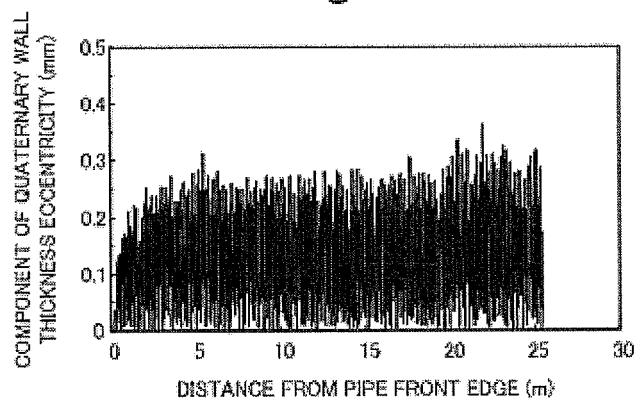


Fig. 3B



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2008/055207

A. CLASSIFICATION OF SUBJECT MATTER

B21B17/02 (2006.01) i, B21B27/02 (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)

B21B17/02, B21B27/02

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	1996-2008
Kokai Jitsuyo Shinan Koho	1971-2008	Toroku Jitsuyo Shinan Koho	1994-2008

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.
Y	JP 11-123409 A (Sumitomo Metal Industries, Ltd.), 11 May, 1999 (11.05.99), Par. Nos. [0003], [0004] (Family: none)	1, 2
Y	WO 2004/085086 A1 (Sumitomo Metal Industries, Ltd.), 07 October, 2004 (07.10.04), Example 1 & EP 1607148 A1 & US 2006/0059969 A & BR 2004/08939 A & MX 2005/010257 A & CN 1764509 A	1, 2

☐ 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
30 May, 2008 (30.05.08)Date of mailing of the international search report
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