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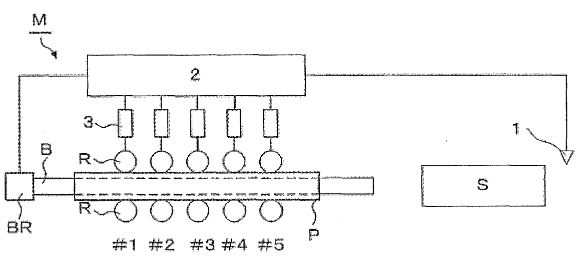
(54) **SEAMLESS PIPE MANUFACTURING METHOD**

(57) There is provided a method for manufacturing a seamless pipe or tube that is capable of making more uniform the wall thickness distribution of a pipe or tube along the longitudinal direction of the pipe or tube than the prior art. The method for manufacturing a seamless pipe or tube according to the present invention comprises a first step of measuring the outside diameter distribution of thg mandrel bar B along the longitudinal direction of the mandrel bar at normal temperature; a second step of measuring the temperature distribution of the mandrel bar along the longitudinal direction of the mandrel bar in the mandrel bar after it being used for a drawing and rolling step in a mandrel mill M; and a third step of measuring the wall thickness distribution of the pipe or tube in the hot state after it being subjected to drawing and rolling with the mandrel bar being inserted thereinto, along the longitudinal direction of the pipe or tube. And the method comprises a fourth step of calculating the outside diameter distribution of the mandrel bar along the longitudinal direction of the mandrel bar at the time of being used for drawing and rolling on the basis of the respective parameters which have been obtained at the first to third steps, and a fifth step of adjusting the setting position of the grooved roll R in the rolling direction on the basis of the outside diameter distribution of the mandrel bar along the longitudinal direction of the mandrel bar when the mandrel bar is inserted into the inside of a pipr or tube at the next timing for being used for drawing and rolling.

Fig. 1



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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 that is capable of making uniform the wall thickness distribution of the pipe or tube along the longitudinal direction of the pipe or tube. Hereinafter, "pipe or tube" is reffered 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 mandrel bar is inserted into the inside of a pipe, and between this mandrel bar and the grooved rolls disposed in a rolling stand, the pipe is subjected to drawing and rolling. Generally, there are prepared a plurality of the mandrel bars, and each mandrel bar is subjected to circulative use. More particularly, each mandrel bar that has been used for the drawing and rolling is extracted from the pipe for which the drawing and rolling has been completed, and then it is again inserted into the inside of another pipe to be subjected to drawing and rolling for use.

[0004] As described above, each mandrel bar is subjected to circulative use, thus tending to be non-uniformly worn in the longitudinal direction thereof. In addition, at the time of being used for drawing and rolling, the mandrel bar makes a non-uniform thermal expansion in the longitudinal direction thereof due to the heat resulting from the thermal conduction from the portions thereof where it is contacted with the pipe, the process heat generation involved in the drawing and rolling, and the like. Thus, there is a problem that the wall thickness distribution of a pipe after it being subjected to drawing and rolling, along the longitudinal direction of the pipe, tends to be non-uniform.

[0005] Conventionally, in order to solve such a problem as described above, methods stated in, for example, JP59-27704A (Patent Document 1), JP61-269909A (Patent Document 2), JP2001-293511A (Patent Document 3) have been proposed.

[0006] However, the method stated in Patent Document 1 is a method which measures the temperature distribution of a mandrel bar along the longitudinal direction of the mandrel bar after completion of the drawing and rolling; from the result of this measurement, calculates the outside diameter distribution of the mandrel bar along the longitudinal direction of the mandrel bar during the drawing and rolling; and on the basis of this calculated outside diameter distribution of the mandrel bar along the longitudinal direction of the mandrel bar, adjusts the setting position of the grooved roll in the rolling direction at the next timing for being used for drawing and rolling. In other words, the method stated in Patent Document 1 gives no consideration about the wear of a mandrel bar and the outside diameter distribution of each mandrel bar along the longitudinal direction of each mandrel bar. Therefore, with the method stated in Patent Document 1, the wall thickness distribution of a pipe along the longitudinal direction in the pipe after completion of the drawing and rolling cannot be made sufficiently uniform.

[0007] The method stated in Patent Document 2 is a method which, on the basis of a typical value of amount of wear of a mandrel bar that is calculated on the basis of the number of pipes subjected to drawing and rolling per mandrel bar, a typical value of amount of thermal expansion of a mandrel bar that is calculated on the basis of the temperature measurement for the mandrel bar after completion of the drawing and rolling, and the like, adjusts the setting position of the grooved roll in the rolling direction when this mandrel bar is used for the subsequent drawing and rolling. In other words, although the method stated in Patent Document 2 adjusts the setting position of the grooved roll in the rolling direction in consideration of the amount of wear and the amount of thermal expansion of a mandrel bar, it gives no consideration about the distribution of the amount of wear and the amount of thermal expansion in the longitudinal direction. Therefore, with the method stated in Patent Document 2, the wall thickness distribution of a pipe along the longitudinal direction of the pipe after completion of the drawing and rolling cannot be made sufficiently uniform.

[0008] The method stated in Patent Document 3 is a method which, on the basis of the measured wall thickness distribution of a pipe along the longitudinal direction of the pipe in the hot state after it being subjected to the drawing and rolling step, the measured outside diameter distribution of a mandrel bar along the longitudinal direction of the mandrel bar before it being used for drawing and rolling, and the like, adjusts the setting position of the grooved roll in the rolling direction when the subsequent pipe is subjected to drawing and rolling. In other words, this method utilizes the measured wall thickness distribution of a pipe along the longitudinal direction of the pipe when a mandrel bar different from the mandrel bar which was used in obtaining the measurement is employed for drawing and rolling the subsequent pipe, thus with this method, the outside diameter distribution in each mandrel bar along the longitudinal direction of each mandrel bar is not sufficiently reflected. Therefore, with the method stated in Patent Document 3, the wall thickness distribution of a pipe along the longitudinal direction of the pipe after completion of the drawing and rolling cannot be made sufficiently uniform.

Disclosure of the Invention

[0009] 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 that is capable of making more uniform the wall thickness distribution of a pipe or tube along the longitudinal direction of the pipe or tube than the prior art.

[0010] In order to achieve the object, the present invention provides a method for manufacturing a seamless pipe or tube including a step of drawing and rolling a pipe or tube, into the inside of which a mandrel bar is inserted, by a mandrel mill provided with a plurality of rolling stands in which a plurality of grooved rolls are disposed respectively, the method being **characterized in that** it comprises: a first step of measuring an outside diameter distribution of the mandrel bar along the longitudinal direction of the mandrel bar at normal temperature; a second step of measuring a temperature distribution of the mandrel bar along the longitudinal direction of the mandrel bar after it being used for the drawing and rolling step; a third step of measuring a wall thickness distribution of a pipe or tube in the hot state after it being subjected to drawing and rolling with the mandrel bar being inserted thereinto, along the longitudinal direction of the pipe or tube; a fourth step of, on the basis of the outside diameter distribution of the mandrel bar along the longitudinal direction of the mandrel bar at normal temperature that has been measured at the first step, and the temperature distribution of the mandrel bar along the longitudinal direction of the mandrel bar that has been measured at the second step, predicting an outside diameter distribution of the mandrel bar along the longitudinal direction of the mandrel bar at the time of being used for drawing and rolling, and correcting the predicted outside diameter distribution of the mandrel bar along the longitudinal direction of the mandrel bar on the basis of the wall thickness distribution of the pipe or tube along the longitudinal direction of the pipe or tube that has been measured at the third step, thereby calculating the outside diameter distribution of the mandrel bar along the longitudinal direction of the mandrel bar at the time of being used for drawing and rolling; and a fifth step of, when inserting the mandrel bar into the inside of a pipe or tube at the next timing for being used for drawing and rolling, adjusting the setting position of the grooved roll in the rolling direction on the basis of the outside diameter distribution of the mandrel bar along the longitudinal direction of the mandrel bar that has been calculated at the fourth step.

[0011] The method according to the present invention measures the outside diameter distribution of the mandrel bar along the longitudinal direction of the mandrel bar at normal temperature at the first step.
Herein, the term "normal temperature" refers to a temperature state before the mandrel bar is first used for drawing and rolling, or a temperature state in which a sufficiently long time period (approx. 30 minutes or longer) has elapsed with the mandrel bar having been kept unused after it being used for drawing and rolling. In this outside diameter distribution of the mandrel bar along the longitudinal direction of the mandrel bar at normal temperature, the amount of wear of the mandrel bar along the longitudinal direction of the mandrel bar are reflected.
In addition, the method according to the present invention measures, at the second step, the temperature distribution of the mandrel bar along the longitudinal direction of the mandrel bar after it being used for the drawing and rolling step (for example, measures just after the mandrel bar being extracted from the pipe for which the drawing and rolling has been completed, or just while the mandrel bar being conveyed for circulative use in the mandrel bar conveyor line). This temperature distribution of the mandrel bar along the longitudinal direction of the mandrel bar is in correlation to the distribution of amount of thermal expansion of the mandrel bar along the longitudinal direction of the mandrel bar. Therefore, if both outside diameter distribution of the mandrel bar along the longitudinal direction of the mandrel bar at normal temperature and temperature distribution of the mandrel bar along the longitudinal direction of the mandrel bar after it being used for the drawing and rolling step are used, the outside diameter distribution of the mandrel bar along the longitudinal direction of the mandrel bar that involves both the amount of wear and the amount of thermal expansion at the time of being used for drawing and rolling (while the mandrel bar being used for drawing and rolling) can be predicted. However, between the temperature distribution of the mandrel bar along the longitudinal direction of the mandrel bar that has been measured at the second step, and the temperature distribution of the mandrel bar along the longitudinal direction of the mandrel bar while it being actually used for drawing and rolling, there is a possibility that a temperature difference may be produced due to the difference in temperature measuring timing. In addition, there is a possibility that the wear of the mandrel bar may have an effect on the temperature measurement. Thus, there is a possibility that the above outside diameter distribution of the mandrel bar along the longitudinal direction of the mandrel bar that has been predicted has an error with respect to the actual outside diameter distribution.

[0012] Then, at the third step, the method according to the present invention measures a wall thickness distribution of the pipe or tube in the hot state after it being subjected to drawing and rolling with the mandrel bar being inserted thereinto, along the longitudinal direction of the pipe or tube. Herein, the term "hot state" refers, needless to say, to the state just after the drawing and rolling has been completed, and also a state in which the pipe or tube is sufficiently red. On the wall thickness distribution of the pipe or tube along the longitudinal direction of the pipe or tube in such hot state, both the distribution of amount of wear of the mandrel bar along the longitudinal direction of the mandrel bar and the distribution of amount of thermal expansion of the mandrel bar along the longitudinal direction of the mandrel bar have an effect.

In other words, the wall thickness distribution of the pipe or tube along the longitudinal direction of the pipe or tube in the hot state includes information about the outside diameter distribution of the mandrel bar along the longitudinal direction of the mandrel bar that involves both the amount of wear and the amount of thermal expansion at the time of being used for drawing and rolling. Therefore, if the above outside diameter distribution of the mandrel bar along the longitudinal direction of the mandrel bar that has been predicted is corrected on the basis of the wall thickness distribution of the pipe or tube along the longitudinal direction of the pipe or tube that has been measured at the third step, the outside diameter distribution of the mandrel bar along the longitudinal direction of the mandrel bar at the time of being used for drawing and rolling can be calculated with high accuracy.

[0013] Thus, at the fourth step, the method according to the present invention, on the basis of the outside diameter distribution of the mandrel bar along the longitudinal direction of the mandrel bar at normal temperature that has been measured at the first step, and the temperature distribution of the mandrel bar along the longitudinal direction of the mandrel bar that has been measured at the second step, predicts the outside diameter distribution of the mandrel bar along the longitudinal direction of the mandrel bar at the time of being used for drawing and rolling, and corrects the predicted outside diameter distribution of the mandrel bar along the longitudinal direction of the mandrel bar on the basis of the wall thickness distribution of the pipe or tube along the longitudinal direction of the pipe or tube that has been measured at the third step, thereby calculates the outside diameter distribution of the mandrel bar along the longitudinal direction of the mandrel bar at the time of being used for drawing and rolling. Therefore, with the method according to the present invention, it is possible to provide setting position adjustment of the grooved roll in the rolling direction in consideration of both the distribution of amount of wear of the mandrel bar along the longitudinal direction of the mandrel bar and the distribution of amount of thermal expansion of the mandrel bar along the longitudinal direction of the mandrel bar.

[0014] And, at the fifth step, the method according to the present invention, when inserting the mandrel bar into the inside of the pipe or tube at the next timing for being used for drawing and rolling, adjusts the setting position of the grooved roll in the rolling direction on the basis of the outside diameter distribution of the mandrel bar along the longitudinal direction of the mandrel bar that has been calculated at the fourth step. In other words, at the timing when the same mandrel bar as that with which the outside diameter distribution of longitudinal direction was calculated is used to perform drawing and rolling of another pipe or tube (a pipe or tube different from the pipe or tube which was subjected to drawing and rolling when the outside diameter distribution of longitudinal direction was calculated), the method according to the present invention adjusts the setting position of the grooved roll in the rolling direction on the basis of the calculated outside diameter distribution of the mandrel bar of the longitudinal direction of the mandrel bar. Therefore, with the method according to the present invention, when a plurality of mandrel bars are used in a circulative manner, it is possible to provide setting position adjustment of the grooved roll in the rolling direction with the outside diameter distribution of each mandrel bar along the longitudinal direction of each mandrel bar being reflected in the adjustment.

[0015] As described above, with the method according to the present invention, it is possible to provide setting position adjustment of the grooved roll in the rolling direction in consideration of both the distribution of amount of wear of the mandrel bar along the longitudinal direction of the mandrel bar and the distribution of amount of thermal expansion of the mandrel bar along the longitudinal direction of the mandrel bar with the outside diameter distribution of each mandrel bar along the longitudinal direction of each mandrel bar being reflected in the adjustment, thus the wall thickness distribution of the pipe or tube along the longitudinal direction of the pipe can be made more uniform than is possible with the conventional method.

Brief Description of the Drawings

[0016]

Figure 1 is a schema schematically illustrating an apparatus configuration of a mandrel mill to which a drawing and rolling step included in the method according to the present invention is applied;

Figures 2 are schemas for explaining the contents of operation to be performed by a control apparatus shown in Figure 1, Figure 2A illustrates an outside diameter distribution of the mandrel bar B along the longitudinal direction of the mandrel bar B, and Figure 2B illustrates a wall thickness distribution of the pipe P along the longitudinal direction of the pipe P; and

Figure 3 gives one example of results of measuring the wall thickness distribution of the pipe along the longitudinal direction of the pipes after completion of drawing and rolling by the method according to the present invention and methods pertaining to comparative examples.

Best Mode for Carrying Out the Invention

[0017] Hereinbelow, one embodiment of the method for manufacturing a seamless pipe according to the present invention will be described with reference to the accompanying drawings as appropriate.

Figure 1 is a schema schematically illustrating an apparatus configuration of a mandrel mill (a retained mandrel mill using a bar retainer) to which a drawing and rolling step included in the method for manufacturing a seamless pipe according to one embodiment of the present invention is applied. Figures 2 are schemas for explaining the contents of operation to be performed by a control apparatus shown in Figure 1, Figure 2A illustrates an outside diameter distribution of the mandrel bar B along the longitudinal direction of the mandrel bar B, and Figure 2B illustrates a wall thickness distribution of the pipe P along the longitudinal direction of the pipe P. With a mandrel mill M shown in Figure 1, a plurality of mandrel bars B (in Figure 1, only one is shown) are used in a circulative manner. In addition, downstream of the mandrel mill M, a sizing mill for performing sizing of a pipe P (such as a sizer, or the like) S is arranged.

[0018] For each mandrel bar B, the outside diameter distribution along the longitudinal direction at normal temperature is previously measured. And, these outside diameter distributions along the longitudinal direction at normal temperature that have been measured are inputted to a control apparatus 2, and are stored by each of mandrel bars B. These outside diameter distributions of the mandrel bars along the longitudinal directions of the mandrel bars at normal temperature are measured using a known optical outside diameter meter, or the like, for example, just before the mandrel bars being conveyed in a mandrel bar conveyor line for circulative use.

[0019] In addition, for each mandrel bar B, the temperature distribution along the longitudinal direction after it being used for the drawing and rolling step is measured. And, these temperature distributions along the longitudinal directions that have been measured are inputted to the control apparatus 2, and are stored by each of mandrel bars B. This temperature distribution of the mandrel bar B along the longitudinal direction of the mandrel bar B is measured, using a radiation thermometer (not shown) arranged, for example, on the inlet side of the mandrel mill M, in the course of the mandrel bar B being extracted from the pipe for which drawing and rolling has been completed. Or, for example, while the mandrel bar B is conveyed on the mandrel bar conveyor line for circulative use, the temperature distribution along the longitudinal direction is measured using a radiation thermometer arranged on this conveyor line.

[0020] As shown in Figure 1, in the present embodiment, an ultrasonic or radioactive wall thickness gauge 1 is arranged on the outlet side of the sizing mill S. And, by this wall thickness gauge 1 and the control apparatus 2, the wall thickness distribution of the pipe P in the hot state which has been passed through the drawing and rolling step in the mandrel mill M, along the longitudinal direction of the pipe P is measured. Specifically, the wall thickness gauge 1 measures the average wall thickness in the circumferential direction of the pipe P, and this measured average wall thickness along the circumferential direction is inputted to the control apparatus 2. As the pipe P is advanced in the longitudinal direction, the average wall thicknesses along the circumferential direction for portions of the pipe P that are in different places along the longitudinal direction are successively inputted to the control apparatus 2, whereby the longitudinal direction distribution of the average wall thicknesses along the circumferential direction is calculated.

In the present embodiment, a configuration in which the wall thickness gauge 1 is arranged on the outlet side of the sizing mill S has been exemplified, however, the present invention is not limited thereto, and the wall thickness gauge 1 may be installed in any other appropriate place, such as on the outlet side of the mandrel mill M.

[0021] On the basis of the outside diameter distribution of the mandrel bar B along the longitudinal direction of the mandrel bar B at normal temperature (the "outside diameter at normal temperature" line shown in Figure 2A) which was used in drawing and rolling the pipe P for which the wall thickness distribution of the longitudinal direction was measured as described above, and the temperature distribution of the mandrel bar B along the longitudinal direction of the mandrel bar B (as described above, these distributions have been inputted to the control apparatus 2 to be stored therein), the control apparatus 2 predicts the outside diameter distribution of the mandrel bar B along the longitudinal direction of the mandrel bar at the time of being used for drawing and rolling (the "outside diameter in the hot state (before correction)" line shown in Figure 2A). In the example given in Figure 2A, the outside diameter distribution of the mandrel bar B along the longitudinal direction of the mandrel bar B at normal temperature is a distribution with which the outside diameter is decreased from the front edge to the rear edge, while the temperature distribution of the mandrel bar B along the longitudinal direction of the mandrel bar B (not shown) is a distribution with which the temperature is increased from the front edge to the rear edge, thus the predicted outside diameter distribution of the mandrel bar B along the longitudinal direction of the mandrel bar B at the time of being used for drawing and rolling is a distribution with which the outside diameter is increased from the front edge to the rear edge.

[0022] Next, the control apparatus 2 corrects the outside diameter distribution of the mandrel bar B along the longitudinal direction of the mandrel bar B that has been predicted as described above on the basis of the wall thickness distribution of the pipe P in the hot state after it being subjected to drawing and rolling with the mandrel bar B being inserted thereinto, along the longitudinal direction of the pipe P (the "wall thickness in hot state" line shown in Figure 2B). In the example shown in Figure 2B, wall thickness distribution of the pipe in the hot state along the longitudinal direction of the pipe is a distribution with which the wall thickness is increased from the front edge to the rear edge, the deviation of the rear edge wall thickness with respect to the front edge wall thickness being expressed as "a". The control apparatus 2 corrects the predicted outside diameter distribution of the mandrel bar B along the longitudinal direction of the mandrel bar B on the basis of, for example, this wall thickness deviation "a". That is to say, if the rear edge wall thickness of the pipe P is larger than the front edge wall thickness thereof by the wall thickness deviation "a", the rear edge outside diameter of the mandrel bar B will be larger than the front edge outside diameter thereof by a dimension equal to double the wall thickness deviation "a". Then, the control apparatus 2 performs a correction for changing the gradient of the predicted outside diameter distribution of the mandrel bar B along the longitudinal direction of the mandrel bar B such that the rear edge outside diameter is decreased with respect to the front edge outside diameter by a dimension equal to double the wall thickness deviation "a", thereby calculating the outside diameter distribution along the longitudinal direction after correction (the "outside diameter in the hot state (after correction)" line shown in Figure 2A) as an outside diameter distribution of the mandrel bar B along the longitudinal direction of the mandrel bar B at the time of being using for drawing and rolling. And, these calculated outside diameter distributions along the longitudinal direction are stored by each of mandrel bars B.

[0023] When the mandrel bar B calculated the outside diameter distribution along the longitudinal direction is inserted into the inside of the pipe P at the next timing for being used for drawing and rolling, and subjected to drawing and rolling , the control apparatus 2 adjusts the setting position of the grooved roll R in the rolling direction on the basis of the outside diameter distribution of the mandrel bar B along the longitudinal direction of mandrel bar B. The grooved roll R for which the setting position in the rolling direction is to be adjusted may be the grooved roll R disposed in each of all the rolling stands (#1 to #5 rolling stands shown in Figure 1) constituting the mandrel mill M, or the grooved roll R disposed in each of a part of the rolling stands (for example, #4 and #5 rolling stands for performing finish rolling, or the like). Specifically, this is explained as follows:

[0024] To the control apparatus 2, positional information on a bar retainer BR which holds the rear edge of the mandrel bar B is inputted. On the basis of the inputted positional information on the bar retainer BR, the control apparatus 2 identifies the longitudinal direction portion of the mandrel bar B that is to be used when the pipe P is subjected to drawing and rolling in the rolling stand (for example, the #5 rolling stand, and hereinafter to be referred to as the "stand to be controlled") where the grooved roll R which is to be adjusted for setting position in the rolling direction is disposed. On the other hand, from the outside diameter distributions of the plurality of mandrel bars B along the longitudinal directions of the mandrel bars B that were calculated and stored as described above, the control apparatus 2 selects the outside diameter distribution of the mandrel bar B along the longitudinal direction of the mandrel bar B which is currently used for drawing and rolling. And, on the basis of the outside diameter distribution of the selected mandrel bar B along the longitudinal direction of the selected mandrel bar B, the control apparatus 2 calculates the outside diameter of the longitudinal direction portion of the mandrel bar B that is to be used in drawing and rolling the pipe P in the stand to be controlled. On the basis of the calculated outside diameter of the mandrel bar B, the control apparatus 2 performs a geometrical calculation to set the roll gap for the grooved roll R disposed in the stand to be controlled, and controls the rolling apparatus 3 in the stand to be controlled such that this roll gap is obtained. The rolling apparatus 3 is composed of a cylinder, and the like, and adjusts the setting position of the grooved roll R in the rolling direction according to the roll gap set.

[0025] With the method for manufacturing the seamless pipe according to the present invention that has been described above, the wall thickness distribution of the pipe P in the hot state after it being subjected to the drawing and rolling step using the mandrel mill M, along the longitudinal direction of the pipe P is measured, and on the basis of this measured wall thickness distribution of the pipe P along the longitudinal direction of the pipe P, the outside diameter distribution of the mandrel bar B along the longitudinal direction of the mandrel bar B at the time of being used for drawing and rolling that is inserted into the inside of the pipe P is corrected, whereby the outside diameter distribution of the mandrel bar B along the longitudinal direction of the mandrel bar B can be calculated with high accuracy, and it is possible to perform setting position adjustment in the rolling direction of the grooved roll R in consideration of both the distribution of amount of wear of the mandrel bar B along the longitudinal direction of the mandrel bar B and the distribution of amount of thermal expansion of the mandrel bar B along the longitudinal direction of the mandrel bar B. In addition, at the timing when the same mandrel bar B as that with which the outside diameter distribution along the longitudinal direction was calculated is used to perform drawing and rolling another pipe P (a pipe P different from the pipe which was subjected to drawing and rolling when the outside diameter distribution along the longitudinal direction was calculated), the setting position of the grooved roll R in the rolling direction is adjusted on the basis of the outside diameter distribution along the longitudinal direction calculated for the mandrel bar B, thus it is possible to provide setting position adjustment of the grooved roll R in the rolling direction with the outside diameter distribution of each mandrel bar B along the longitudinal direction of each mandrel bar B being reflected in the adjustment. Therefore, with the method according to the present invention, the wall thickness distribution of the pipe P along the longitudinal direction of the pipe P can be made more uniform than is possible with the conventional method.

[0026] Figure 3 gives one example of results of measuring wall thickness distributions of the pipes along the longitudinal directions of the pipes after drawing and rolling by the method according to the present invention and methods pertaining to comparative examples. The No. 1 shown in Figure 3 gives results of drawing and rolling a pipe by the same method as that stated in the aforementioned Patent Document 1 using a new mandrel bar (having an outside diameter of 248 mm). In a case where a new mandrel bar is used, the outside diameter distribution along the longitudinal direction at normal temperature (see a graph shown with a solid line in Column A in No. 1 in Figure 3) is uniform (248 mm), thus the outside diameter distribution along the longitudinal direction at the time of being used for drawing and rolling (see a graph shown with a broken line in Column A in No. 1 in Figure 3) exhibits the same tendency as that of the temperature distribution of the mandrel bar along the longitudinal direction of the mandrel bar. Therefore, if the temperature distribution of the mandrel bar along the longitudinal direction of the mandrel bar after completion of the drawing and rolling is measured; from the result of this measurement, the outside diameter distribution of the mandrel bar along the longitudinal direction of the mandrel bar at the time of being used for drawing and rolling is calculated; and on the basis of this calculated outside diameter distribution of the mandrel bar along the longitudinal direction of the mandrel bar, the setting position (roll gap) of a predetermined grooved roll in the rolling direction is adjusted (see Column B in No. 1 in Figure 3), the wall thickness distribution of the pipe along the longitudinal direction of the pipe can be made relatively uniform (see Column C in No. 1 in Figure 3).

[0027] However, in a case where a mandrel bar which is non-uniformly worn in the longitudinal direction is used for drawing and rolling a pipe, the setting position adjustment of the grooved roll in the rolling direction on the basis of the outside diameter distribution of the mandrel bar along the longitudinal direction of the mandrel bar at the time of being used for drawing and rolling that was calculated only from the temperature distribution of the mandrel bar along the longitudinal direction of the mandrel bar that was measured after completion of the drawing and rolling cannot make uniform the longitudinal direction wall thickness distribution in the pipe. The No. 2 shown in Figure 3 gives results of drawing and rolling a pipe by the same method as that stated in the aforementioned Patent Document 1 using a mandrel bar which is non-uniformly worn in the longitudinal direction. In the example given in the No. 2 in Figure 3, with the outside diameter distribution of the mandrel bar along the longitudinal direction of the mandrel bar at normal temperature , the outside diameter is decreased from the front edge to the trear edge due to the wear (see a graph shown with a solid line in Column A in No. 2 in Figure 3), however, at the time of being used for drawing and rolling, a thermal expansion which is non-uniform in the longitudinal direction makes substantially uniform the outside diameter distribution along the longitudinal direction (see a graph shown with a broken line in Column A in No. 2 in Figure 3). However, adjusting the setting position (roll gap) of a predetermined grooved roll in the rolling direction only on the basis of the temperature distribution of the mandrel bar along the longitudinal direction of the mandrel bar that was measured after completion of the drawing and rolling will result in performing the same adjustment as that in No. 1 (see Column B in No. 2 in Figure 3), regardless of the actual outside diameter distribution of the mandrel bar along the longitudinal direction of the mandrel bar at the time of being used for drawing and rolling being uniform, whereby the wall thickness distribution of the pipe along the longitudinal direction of the pipe cannot be made uniform (see Column C in No. 2 in Figure 3).

[0028] The No. 3 shown in Figure 3, which is unlike the case of the No. 2, gives results of having performed drawing and rolling of a pipe (results of having performed drawing and rolling of a pipe using a mandrel bar which is non-uniformly worn in the longitudinal direction) by a method which, in calculating the outside diameter distribution of the mandrel bar along the longitudinal direction of the mandrel bar at the time of being used for drawing and rolling, takes into account not only the temperature distribution of the mandrel bar along the longitudinal direction of the mandrel bar that was measured after completion of the drawing and rolling, but also the outside diameter distribution of the mandrel bar along the longitudinal direction of the mandrel bar that was measured at normal temperature. In the example given in the No. 3 in Figure 3, the outside diameter distribution of the mandrel bar along the longitudinal direction of the mandrel bar that was measured at normal temperature (see a graph shown with a solid line in Column A in No. 3 in Figure 3) is also taken into account, thus as compared to the case of the No. 2, the outside diameter distribution of the mandrel bar along the longitudinal direction of the mandrel bar at the time of being used for drawing and rolling can be calculated with high accuracy. However, between calculated the outside diameter distribution of the mandrel bar along the longitudinal direction of the mandrel bar at the time of being used for drawing and rolling, and the actual outside diameter distribution of the mandrel bar along the longitudinal direction of the mandrel bar at the time of being used for drawing and rolling that is substantially uniform (see a graph shown with a broken line in Column A in No. 3 in Figure 3), there is still an error, thus the adjustment of the setting position (roll gap) of the grooved roll in the rolling direction is not uniform in the longitudinal direction (see Column B in No. 3 in Figure 3), whereby the wall thickness distribution of the pipe along the longitudinal direction of the pipe cannot be made sufficiently uniform (see Column C in No. 3 in Figure 3).

[0029] Contrarily to the methods pertaining to the above comparative examples (see No. 2 and No. 3 in Figure 3), the method according to the present invention (see No. 4 shown in Figure 3) measures the wall thickness distribution of a pipe in the hot state after it being subjected to the drawing and rolling step using the mandrel mill, and on the basis of this measured wall thickness distribution of the pipe along the longitudinal direction of the pipe, corrects the outside diameter distribution of the mandrel bar along the longitudinal direction of the mandrel bar at the time of being used for drawing and rolling that has been predicted for the mandrel bar which is inserted into the inside of the pipe, thus an outside diameter distribution substantially equivalent to the actual outside diameter distribution of the mandrel bar along the longitudinal direction of the mandrel bar which is performing drawing and rolling (see a graph shown with a broken line given in Column A in No. 4 in Figure 3) can be calculated. And, with the method according to the present invention, on the basis of this calculated outside diameter distribution of the mandrel bar along the longitudinal direction of the mandrel bar (i.e., a longitudinal direction outside diameter distribution which is substantially uniform), the setting position (roll gap) of the grooved roll in the rolling direction is adjusted (see Column B in No. 4 in Figure 3), thus the wall thickness distribution of the pipe longitudinal direction along the longitudinal direction of the pipe can be made uniform (see Column C in No. 4 in Figure 3).

Claims

1. A method for manufacturing a seamless pipe or tube including a step of drawing and rolling a pipe or tube, into the inside of which a mandrel bar is inserted, by a mandrel mill provided with a plurality of rolling stands in which a plurality of grooved rolls are disposed respectively, the method being **characterized in that** it comprises:

a first step of measuring an outside diameter distribution of the mandrel bar along the longitudinal direction of the mandrel bar at normal temperature;

a second step of measuring a temperature distribution of the mandrel bar along the longitudinal direction of the mandrel bar after it being used for the drawing and rolling step;

a third step of measuring a wall thickness distribution of a pipe or tube in the hot state after it being subjected to drawing and rolling with the mandrel bar being inserted thereinto, along the longitudinal direction of the pipe or tube;

a fourth step of, on the basis of the outside diameter distribution of the mandrel bar along the longitudinal direction of the mandrel bar at normal temperature that has been measured at the first step, and the temperature distribution of the mandrel bar along the longitudinal direction of the mandrel bar that has been measured at the second step, predicting an outside diameter distribution of the mandrel bar along the longitudinal direction of the mandrel bar at the time of being used for drawing and rolling, and correcting the predicted outside diameter distribution of the mandrel bar along the longitudinal direction of the mandrel bar on the basis of the wall thickness distribution of the pipe or tube along the longitudinal direction of the pipe or tube that has been measured at the third step, thereby calculating the outside diameter distribution of the mandrel bar along the longitudinal direction of the mandrel bar at the time of being used for drawing and rolling; and

a fifth step of, when inserting the mandrel bar into the inside of a pipe or tube at the next timing for being used for drawing and rolling, adjusting the setting position of the grooved roll in the rolling direction on the basis of the outside diameter distribution of the mandrel bar along the longitudinal direction of the mandrel bar that has been calculated at the fourth step.

Fig. 1

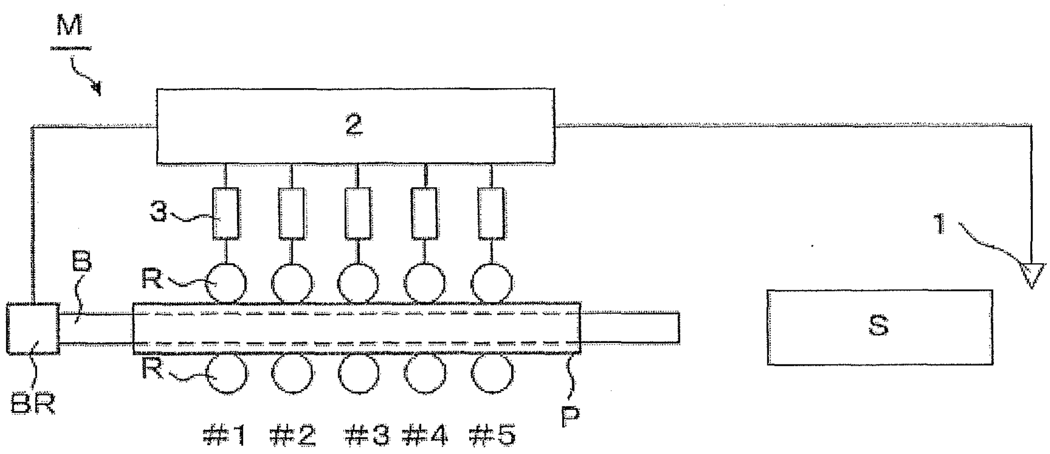


Fig. 2A

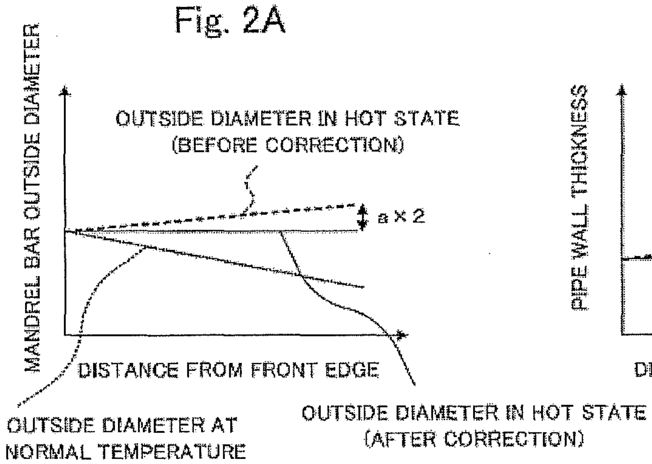


Fig. 2A

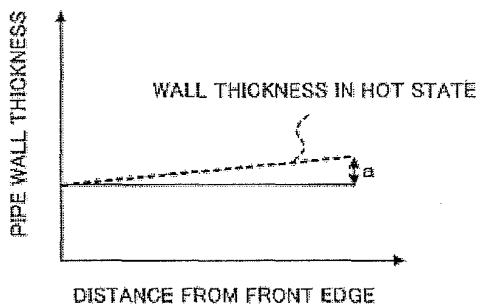
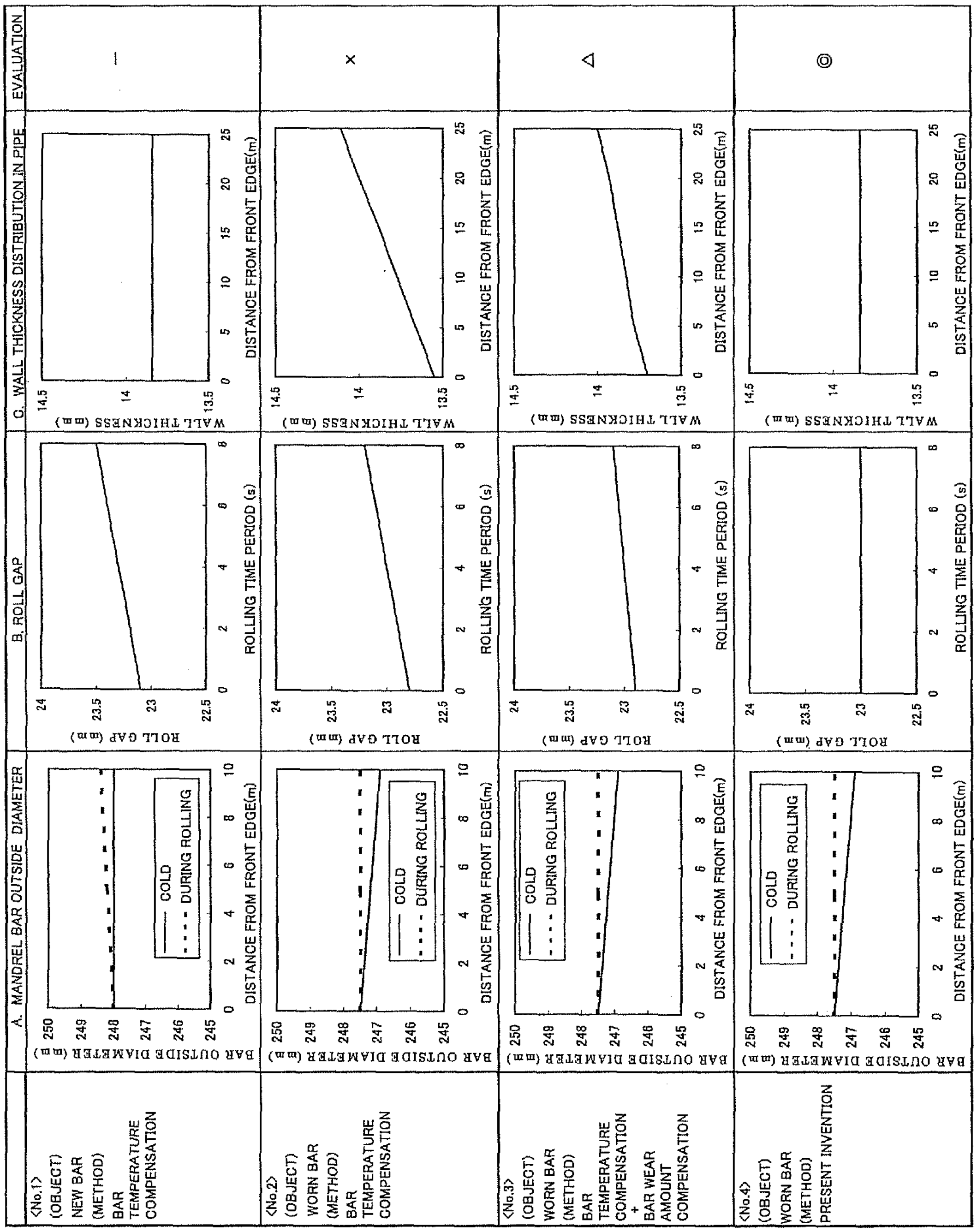


FIG.3


A. MANDREL BAR OUTSIDE DIAMETER
B. ROLL GAP
C. WALL THICKNESS DISTRIBUTION IN PIPE
EVALUATION
<No.1> (OBJECT) NEW BAR (METHOD) BAR TEMPERATURE COMPENSATION
<No.2> (OBJECT) WORN BAR (METHOD) BAR TEMPERATURE COMPENSATION
<No.3> (OBJECT) WORN BAR (METHOD) BAR TEMPERATURE COMPENSATION + BAR WEAR AMOUNT COMPENSATION
<No.4> (OBJECT) WORN BAR (METHOD) PRESENT INVENTION
BAR OUTSIDE DIAMETER (mm)
250
249
248
247
246
245
COLD
DURING ROLLING
0
2
4
6
8
10
DISTANCE FROM FRONT EDGE(m)
ROLL GAP (mm)
24
23.5
23
22.5
ROLLING TIME PERIOD (s)
WALL THICKNESS (mm)
14.5
14
13.5
0
5
10
15
20
25
DISTANCE FROM FRONT EDGE(m)
—
×
△
◎

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2008/055645

A. CLASSIFICATION OF SUBJECT MATTER
B21B37/78(2006.01)i, *B21B17/02*(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)
B21B37/78, B21B17/02

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.
A	JP 59-27704 A (NKK Corp.), 14 February, 1984 (14.02.84), Claims (Family: none)	1
A	JP 61-269909 A (NKK Corp.), 29 November, 1986 (29.11.86), Claims (Family: none)	1
A	JP 2001-293511 A (Sumitomo Metal Industries, Ltd.), 23 October, 2001 (23.10.01), Full text (Family: none)	1

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

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
04 June, 2008 (04.06.08)	17 June, 2008 (17.06.08)

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

Form PCT/ISA/210 (second sheet) (April 2007)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2008/055645

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 11-226623 A (Sumitomo Metal Industries, Ltd.), 24 August, 1999 (24.08.99), Claims (Family: none)	1

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REFERENCES CITED IN THE DESCRIPTION

Patent documents cited in the description

- JP 59027704 A **[0005]**
- JP 61269909 A **[0005]**
- JP 2001293511 A **[0005]**