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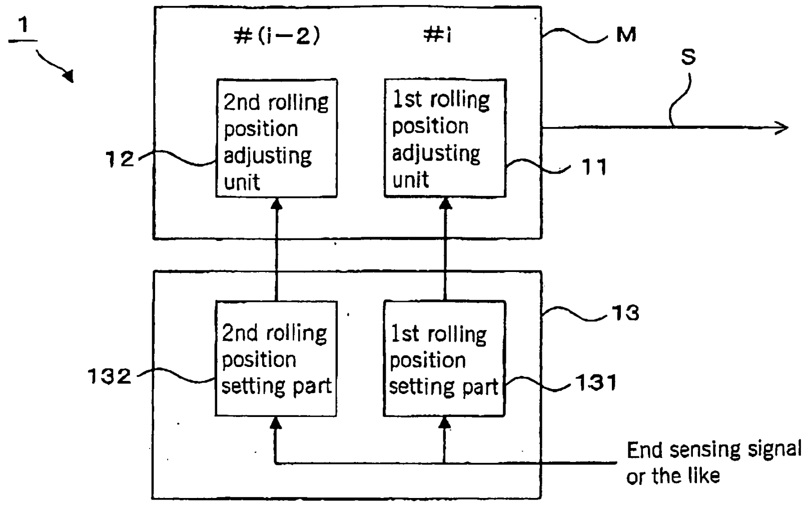
(54) **Rolling control method, rolling control apparatus and control program for a mandrel mill, and a seamless tube or pipe**

(57) In a rolling control method for a mandrel mill M having a plurality of grooved rolls including a finishing stand #i by moving the rolling positions of first grooved rolls installed in the finishing stand outwards when rolling a pierced blank S in the finishing stand #i, when rolling the pierced blank in the closest upstream stand #(i-2) to the finishing stand #i having the same roll-reducing directions, the rolling positions of second grooved rolls installed in the upstream stand #(i-2) are also moved outwards, thereby making it possible to accurately roll a pierced roll for the entire length of a portion such as the end portions to a desired wall thickness when manufacturing a seamless tube using the mandrel mill.

Fig. 1



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Description

Technical Field

[0001] This invention relates to a rolling control method, a rolling control apparatus and a control program for a mandrel mill, which make it possible to accurately roll a pierced blank for the entire length or a portion thereof in the lengthwise directions such as a tube end portion to a desired wall thickness when manufacturing a seamless tube or pipe (hereinafter simply referred to as a seamless tube) using a mandrel mill without deteriorating the surface properties of the resulting rolled blank, as well as a seamless tube manufactured by this rolling control method.

Background Art

[0002] In the manufacture of seamless tubes using the Mannesmann mandrel mill technique, first, a starting material in the form of a round billet or a rectangular billet is heated to 1200 - 1260° C in a rotary hearth heating furnace. The heated round or rectangular billet is then pierced by a piercing mill having a plug and rolls to prepare a hollow pierced blank. Next, the wall thickness of the hollow pierced blank is reduced to a predetermined value by inserting a mandrel bar into the interior of the pierced blank and subjecting the hollow pierced blank to elongation rolling to form a rolled blank using a mandrel mill which usually includes 5 - 8 rolling stands while gripping the outer surface of the pierced blank with grooved rolls in each stand. Then, the mandrel bar is withdrawn from the rolled blank having a decreased wall thickness, and the rolled lank is passed through a reducing mill for sizing into a predetermined outer diameter, thereby producing a desired product in the form of a seamless tube.

[0003] A pair of opposing grooved rolls has conventionally been installed in each rolling stand of a mandrel mill. A 2-roll type mandrel mill in which grooved rolls are alternatingly disposed such that the roll-reducing directions of the rolls changes by 90° between adjoining stands is particularly common. A 4-roll type mandrel mill in which four grooved rolls are provided in each stand with the roll-reducing directions forming angles of 90° is also sometimes used. In addition, a 3-roll type mandrel mill in which three grooved rolls are provided in each stand such that the roll-reducing directions of the rolls form angles of 120° and such that the roll-reducing directions varies by 60° between adjoining stands has also been proposed.

[0004] In general, during sizing of a rolled blank having a particularly large wall thickness using a reducing mill, the wall thinning phenomenon in which the wall thickness of the end portions in the axial directions of the rolled blank becomes thinner than the wall thickness of the central portion is known to occur. In order to prevent this wall thinning phenomenon at the end portions from occurring during sizing, Patent Document 1, for example, discloses a rolling control method in which an elongation rolling step using a mandrel mill, which is a step prior to a sizing step, is controlled so that the wall thickness of the end portions of the resulting rolled blank is increased, specifically by setting the gap between the grooved rolls installed in the finishing stand or stands of the mandrel mill such that the wall thickness of the end portions of the rolled blank after passing through the finishing stand or stands of the mandrel mill cancels out the decrease in the wall thickness of the end portions in the axial directions of the rolled blank which takes place in the sizing step.

[0005] However, when the present inventors carried out a rolling test on a pierced blank in accordance with the method described in Patent Document 1, they found that sometimes the end portions in the axial directions of the rolled blank could not be accurately given a predetermined wall thickness and the surface properties of the rolled blank deteriorated.

[0006] Patent Document 2 describes a method of manufacturing a seamless tube which is accurately rolled to a desired wall thickness by controlling the opening size of the gap between grooved rolls installed in the finishing stand or stands of a mandrel mill in accordance with the actual wall thickness of a rolled blank measured on the exit side of the mandrel mill. Specifically, the wall thickness of a rolled blank on the exit side of a mandrel mill is measured using a thickness gauge installed on the exit side of the mandrel mill, and when the measured value of the wall thickness of the rolled blank on the exit side of the mandrel mill is smaller than a desired wall thickness, the opening size of the gap between the grooved rolls is adjusted so as to increase in accordance with the difference from the desired wall thickness, i.e., the rolling positions (rolling force-acting positions) of grooved rolls are moved outwards with respect to their initial rolling positions, whereby the accuracy of the wall thickness of a seamless tube can be increased.

[0007] However, when the present inventors carried out a rolling test on a pierced blank in accordance with the method described in Patent Document 2, they found that there were cases in which the opening size of the gap between the grooved rolls continue to increase endlessly with continuing outwards movement of the grooved rolls endlessly, and a desired wall thickness could not be obtained.

Patent Document 1: JP 06-190406 A1

Patent Document 2: JP 08-71616 A1

Disclosure of the Invention

Problem Which the Invention is to Solve

[0008] The present invention was made in order to solve the above-described problems of the prior art, and its object is to provide a rolling control method, a rolling control apparatus and control program which make it possible to accurately perform rolling a pierced blank to a desired wall thickness for the entire length or a portion thereof, such as the end portions, when manufacturing a seamless tube using a mandrel mill, and a seamless tube manufactured by the rolling control method,

Means for Solving the Problem

[0009] The present inventors performed diligent research concerning why a pierced blank could not be accurately rolled to a desired wall thickness and concerning the cause of a deterioration in the surface properties of a rolled blank by the method described in Patent Document 1. As a result, they discovered the following phenomenon. Normally, in a finishing stand of a mandrel mill (a stand in which grooved rolls which lastly contact a plurality of portions which have the same circumferential position of a pierced blank are installed), the reduction achieved by the grooved rolls in this stand is set to a small value in order to obtain good surface properties of the resulting rolled blank formed by finish rolling. Under such rolling conditions, when it becomes necessary to increase the opening of the gap between the grooved rolls installed in the finishing stand, namely, when it becomes necessary to move the rolling positions of the grooved rolls outwards, if the rolling positions of the grooved rolls installed in upstream stands located on the upstream side in the directions of transport of the blank being rolled with respect to the finishing stand are not in any way adjusted and the rolling positions initially set based on the pass schedule remain unchanged, the phenomenon known as idle rolling takes place in the bottom portion of grooves in the grooved rolls.

[0010] The idle rolling phenomenon which may occur in the bottom portions of the grooves in grooved rolls is a situation in which the wall thickness of a pierced blank in the position opposing the bottom portions of the grooves of grooved rolls on the entrance side of the finishing stand of a mandrel mill (the wall thickness of a pierced blank in the position opposing the bottom portions of the grooves of grooved rolls on the entrance side of a finishing stand means the wall thickness of the pierced blank in the position opposing the flange portions of grooved rolls in the rolling stand one stand upstream of the finishing stand, where the flange portions mean the portions positioned at 90° with respect to the bottom portions of the grooves of grooved rolls in the case of a 2-roll mandrel mill or the portions midway between the bottom portions of the grooves of adjoining grooved rolls in the case of a 3- or higher mandrel mill) becomes smaller than the gap between the mandrel bar and the grooved rolls in the finishing stand so that rolling does not take place in the finishing stand of the mandrel mill.

[0011] The reason why the idle rolling phenomenon occurs in the bottom portions of the grooves of grooved rolls will be explained. In the case of rolling of a plate-shaped material, the roll-reducing directions are limited to the directions perpendicular to the plate-shaped material, and if the gap between the rolls installed in an upstream stand is set so as to be at least as large as the gap between the rolls installed in a downstream stand, idle rolling does not occur at the time of reduction using the rolls installed in the downstream stand. In contrast, in a mandrel mill for rolling a tube, in the case of any of the above-described 2-roll type, 3-roll type, or 4-roll type, the positions at which rolling force is applied to the tube, i.e., the positions of the bottom portions of the grooves of grooved rolls, differs between adjoining stands in the circumferential directions of a pierced blank to be rolled, and not only the wall thickness of the portions of the pierced blank opposing the bottom portions of the grooves of the grooved rolls but also the wall thickness of the portions of the pierced blank, which oppose the flange portions of the grooved rolls and to which a rolling force is not directly applied, reduces to a certain extent. Since a rolling force is not directly imparted to the portions of a pierced blank which oppose the flange portions of grooved rolls, it is difficult to control the amount of reduction in wall thickness in these portions of the pierced blank, and the wall thickness of these portions after rolling can only be estimated. Therefore, if the reduction in wall thickness of the portions of a pierced blank opposing the flange portions of grooved rolls becomes larger than estimated, even if the gap between the grooved rolls installed in the upstream stand is set to be at least the gap between the grooved rolls installed in the downstream finishing stand, when the portions of a pierced blank which underwent a large reduction in wall thickness which opposed the flange portions of the grooved rolls in the upstream stand are rolled in the bottom portions of the grooves of the grooved rolls of the finishing stand, the wall thickness in these portions of the pierced blank sometimes becomes smaller than the gap between the mandrel bar and the grooved rolls in the finishing stand. As a result, the idle rolling phenomenon occurs in the bottom portions of the grooves of the grooved rolls.

[0012] If such idle rolling phenomenon develops in the bottom portions of the grooves of the grooved rolls in the finishing stand, the pierced blank can no longer be accurately rolled to a desired wall thickness in the finishing stand. In other words, if the wall thicknesses of the portions of the pierced blank opposing the flange portions of the grooved rolls installed in the upstream stand excessively decreases to such an extent that idle rolling occurs in the finishing stand, the wall thickness of the resulting rolled blank on the exit side of the finishing stand ends up becoming smaller than a desired wall thickness. The primary purpose of rolling in the finishing stand of a mandrel mill is to make the inner and outer surfaces of a rolled blank smooth and regular by applying a light rolling force with a small amount of rolling reduction. However, if the idle rolling phenomenon manifests in the bottom portions of the grooves in the finishing stand, there end up being portions which do not undergo rolling, force at all in that stand, and as a result, the surface properties of the resulting seamless tube worsen.

[0013] Thus, the present inventors discovered that the reason why a pierced blank cannot be accurately rolled to a desired wall thickness by elongation rolling and why the surface properties of the resulting rolled blank worsens resides in the idle rolling phenomenon occurring in the bottom portions of the grooves of the grooved rolls in a finishing stand of a mandrel mill. They performed further diligent investigations concerning a method capable of elongation rolling which does not produce the idle rolling phenomenon in the bottom portions of the grooves of grooved rolls. As a result, they found that when moving the rolling positions of grooved rolls installed in a finishing stand outwards at the time of finish rolling, if not only these grooved rolls but also the grooved rolls installed in the closest upstream stand to the finishing stand having the same roll-reducing directions (as the finishing stand) are similarly moved outwards, the occurrence of the idle rolling phenomenon in the bottom portions of the grooves of grooved rolls in the finishing stand can be prevented. This invention was achieved based on this finding.

[0014] Namely, the present invention is a rolling control method for a mandrel mill having a plurality of rolling stands including a finishing stand by moving the rolling positions of first grooved rolls installed in the finishing stand outwards from their initial rolling positions set based on a pass schedule when a pierced blank is rolled in the finishing stand, **characterized in that** when rolling the pierced blank in the closest upstream stand to the finishing stand having the same roll-reducing directions (as the finishing stand), the rolling positions of second grooved rolls installed in the upstream stand are moved outwards from their initial rolling positions set based on the pass schedule in the same manner as for the first grooved rolls.

[0015] According to the present invention, when rolling a pierced blank in the closest upstream stand to the finishing stand having the same roll-reducing directions, i.e., in the upstream stand positioned two stands upstream of the finishing stand, the rolling positions of second grooved rolls installed in this upstream stand are moved outwards in the same manner as for first grooved rolls installed in the finishing stand. Therefore, the rolling reduction achieved in the bottom portions of the grooves during rolling of the pierced blank in the second grooved rolls is decreased. As a result, the wall thickness of the portions of the pierced blank opposing the flange portions of the grooved rolls installed in the upstream stand positioned just one stand upstream of the finishing stand is prevented from being excessively decreased. Accordingly, the idle rolling phenomenon in the bottom portions of the grooves no longer occurs at the time of rolling with the first grooved rolls installed in the finishing stand. As a result, the pierced blank can be accurately rolled to a desired wall thickness, and the surface properties of the rolled blank is not worsened.

[0016] In the present invention, the expression "moved outwards in the same manner as for the first grooved rolls" indicates that when the rolling positions of the first grooved rolls are moved outwards for only a portion such as the end portions of a pierced blank, the rolling positions of the second grooved rolls are also moved outwards only for a corresponding portion such as the end portions of the pierced blank. Similarly, it indicates that when the rolling positions for the first grooved rolls are moved outwards over the entire length of a pierced blank, the rolling positions for the second grooved rolls are also moved outwards over the entire length of the pierced blank. In this specification, the expression "moved outwards in the same manner as for the first grooved rolls" has the same meaning throughout.

[0017] The present invention can be applied to a mandrel mill having a mechanism which can vary the rolling positions of second grooved rolls in accordance with the portion of a pierced blank which is being rolled (leading end portion, central portion, or trailing end portion) in the closest upstream stand to the finishing stand having the same roll-reducing directions. However, some mandrel mills do not have such a mechanism in stands other than the finishing stand. With such mandrel mills, instead of moving the rolling positions in the closest upstream stand in accordance with the portion of the pierced blank being rolled, the rolling positions of the second grooved rolls in that stand can be previously moved outwards prior to rolling the pierced blank.

[0018] Thus, the present invention also provides a rolling control method for a mandrel mill having a plurality of rolling stands including a finishing stand by moving outwards the rolling positions of first grooved rolls installed in the finishing stand when a pierced blank is rolled in the finishing stand, **characterized in that** the rolling positions of second grooved rolls installed in the closest upstream stand to the finishing stand having the same roll-reducing directions are previously moved outwards prior to rolling of the pierced blank.

[0019] In addition, the present invention is a rolling control method for a mandrel mill having a plurality of rolling stands including a finishing stand by moving outwards the rolling positions of first grooved rolls installed in the finishing stand when a pierced blank is rolled in the finishing stand, **characterized in that** a thickness gauge which measures the wall thickness of the resulting rolled blank in the roll-reducing directions at each stand is installed on the exit side of the finishing stand, a previously set target wall thickness of a rolled blank is compared with the actual wall thickness of the rolled blank measured by the thickness gauge at the finishing stand, and if the actual wall thickness is smaller than the target wall thickness, movement of the rolling positions of the first grooved rolls is terminated for the next pierced blank to be rolled.

[0020] According to the present invention, a thickness gauge is installed at the exit of a finishing stand, and in the finishing stand a previously set target wall thickness for a rolled blank is compared with the actual wall thickness of the rolled blank measured by the thickness gauge. When the actual wall thickness is smaller than the target wall thickness, there is the possibility that the idle rolling phenomenon is occurring in the bottom portions of the grooves of first grooved rolls installed in this stand. Accordingly, in this case, it is determined that the idle rolling phenomenon is occurring in the bottom portions of the grooves, and movement of the rolling positions of the first grooved rolls is terminated for the next pierced blank to be rolled. Therefore, for the next pierced blank to be rolled, the outward movement of the first grooved rolls is terminated, and since the rolling reduction by the first grooved rolls is not decreased, the occurrence of the idle rolling phenomenon in the bottom portions of the grooves of the first grooved rolls in the finishing stand can be prevented.

[0021] In the present invention, the expression "movement of the rolling positions of the first grooved rolls is terminated" includes the following two cases (i) and (ii).

(i) Basically, the amount of outwards movement of the first grooved rolls is a value which is previously set regardless of the actual value measured by the thickness gauge. In this case, "movement of the rolling positions is terminated" means (a) when rolling a portion (e.g., an end portion) of a pierced blank, the rolling positions of the first grooved rolls are maintained at the same positions as when rolling the remaining portion (e.g., the central portion) of the pierced blank, or (b) they are kept at the same rolling positions as the rolling positions for the first grooved rolls for the pierced blank which was rolled this time.

(ii) The amount of outward movement of the first grooved rolls is previously set as mentioned in the above, but the set value can be changed in accordance with the actual wall thickness measured by the thickness gauge (for example, when the actual wall thickness is larger than a target wall thickness, the amount of movement is decreased by the difference), and this value is employed for the next pierced blank to be rolled. In this case, "movement of the rolling positions is terminated" means that the set value is not changed in accordance with the actual wall thickness measured by the thickness gauge, and for the next pierced blank to be rolled, the first grooved rolls are moved outwards by the value set for the pierced blank rolled this time.

[0022] In the case of a system in which the set value for the amount of outwards movement of the first grooved rolls is varied in accordance with the actual wall thickness measured by the thickness gauge, when the idle rolling phenomenon occurs in the bottom portions of the grooves of the first grooved rolls and the actual wall thickness becomes smaller than the target wall thickness, there is the possibility of the outwards movement of the grooved rolls endlessly continuing. However, according to the present invention, as described in paragraph (ii), the outward movement of the first grooved rolls is terminated, (changing of the set value in accordance with the actual wall thickness measured by the thickness gauge is terminated), so this problem can be solved.

[0023] This invention determines whether or not the idle rolling phenomenon is occurring in the bottom portions of the grooves by comparing the actual wall thickness with a target wall thickness. Instead, it is also possible to compare the amount of movement of the rolling positions of the first grooved rolls with the amount of change of the actual wall thickness of the rolled blank measured by the thickness gauge in the directions of movement of the first grooved rolls and to determine that the idle rolling phenomenon is occurring in the bottom portions of the grooves when the amount of change of the actual wall thickness is smaller than the amount of movement of the rolling positions of the first grooved rolls, When the amount of change of the actual wall thickness is smaller than the amount of movement of the rolling positions of the first grooved rolls, the bottom portions of the grooves of the first grooved rolls after movement of the rolling positions do not contact the outer peripheral surface of the pierced blank, and there is the possibility that the idle rolling phenomenon is occurring in the bottom portions of the grooves, so it can be determined that the idle rolling phenomenon is occurring in the bottom portions of the grooves.

[0024] The present invention also provides a rolling control method for a mandrel mill having a plurality of rolling stands including a finishing stand by moving outwards the rolling positions of first grooved rolls installed in the finishing stand when a pierced blank is rolled in the finishing stand, **characterized in that** a thickness gauge which measures the wall thickness of the resulting rolled blank is installed on the exit side of the finishing stand, the amount of movement of the rolling positions of the first grooved rolls and the amount of change of the actual wall thickness of the rolled blank measured by the thickness gauge in the directions of movement of the first grooved rolls are compared, and when the amount of change is smaller than the amount of movement of the rolling positions of the first grooved rolls, movement of the rolling positions of the first grooved rolls is terminated for the next pierced blank to be rolled.

[0025] Instead of determining whether the idle rolling phenomenon is occurring in the bottom portions of the grooves by comparing a target wall thickness with the actual wall thickness, it is possible to calculate the difference between the rolling positions after movement of the first grooved rolls for the pierced blank which was rolled this time and the rolling positions after movement of the first grooved rolls for the previously rolled pierced blank, to calculate the difference between the actual wall thickness which was measured by the thickness gauge for the rolled blank which was formed by rolling this time in the directions of movement of the first grooved rolls with the actual wall thickness of the rolled blank which was rolled lastly measured by the thickness gauge in the directions of movement of the first grooved rolls, to compare the calculated difference in the rolling positions and the calculated difference in the actual wall thickness, and to determine that the idle rolling phenomenon is occurring in the bottom portions of the grooves if the calculated difference in the actual wall thickness is smaller than the calculated difference in the rolling positions. In other words, when the calculated difference in the actual wall thickness is smaller than the calculated difference in the rolling positions, for the present rolling, there is the possibility of the occurrence of the idle rolling phenomenon in the bottom portions of the grooves in which the bottom portions of the grooves of the first grooved rolls after movement of the rolling positions do not contact the outer peripheral surface of the pierced blank, so it can be determined that the idle rolling phenomenon is occurring in the bottom portions of the grooves.

[0026] The present invention is a rolling control method for a mandrel mill having a plurality of rolling stands including a finishing stand by moving outwards the rolling positions of first grooved rolls installed in the finishing stand when a pierced blank is rolled in the finishing stand, **characterized in that** a thickness gauge which measures the wall thickness of the resulting rolled blank is installed on the exit side of the finishing stand, the difference between the rolling positions after movement of the first grooved rolls for the pierced blank which was rolled this time and the rolling positions after movement of the first grooved rolls for the pierced blank which was rolled lastly is calculated, the difference between the actual wall thickness measured by the thickness gauge for the rolled blank which was rolled this time in the directions of movement of the first grooved rolls and the actual wall thickness measured by the thickness gauge for the rolled blank which was rolled lastly in the directions of movement of the first grooved rolls is calculated, the calculated difference in the rolling positions and the calculated difference in the actual wall thickness are compared, and movement of the rolling positions of the first grooved rolls is terminated for the next pierced blank to be rolled if the calculated difference in the actual wall thickness is smaller than the calculated difference in the rolling positions.

[0027] The present invention is also a rolling control method for a mandrel mill having a plurality of rolling stands including a finishing stand by moving outwards the rolling positions of fist grooved rolls installed in the finishing stand when a pierced blank is rolled in the finishing stand, **characterized in that** a thickness gauge which measures the wall thickness of the resulting rolled blank in the roll-reducing directions at each stand is installed on the exit side of the finishing stand, a previously set target wall thickness of a rolled blank at the finishing stand is compared with the actual wall thickness of the rolled blank measured by the thickness gauge, and when the actual wall thickness is smaller than the target wall thickness, in the closest upstream stand to the finishing stand having roll-reducing directions which are the same as the directions of wall thickness measurement for which the actual wall thickness is smaller than the target wall thickness, when rolling the next pierced blank to be rolled, the rolling positions of second grooved rolls installed in the upstream stand are moved outwards in the same manner as with the first grooved rolls, or else the rolling positions of the second grooved rolls which are installed in the closest upstream stand to the finishing stand having the same roll-reducing directions as the directions of wall thickness measurement for which the actual wall thickness is smaller than the target wall thickness are previously moved outwards prior to rolling of the next pierced blank to be rolled.

[0028] According to the present invention, a thickness gauge is installed on the exit side of a finishing stand, and a target wall thickness of a rolled blank previously set for the finishing stand is compared to the actual wall thickness of the rolled blank measured by the thickness gauge. As a result, when the actual wall thickness is smaller than the target wall thickness, since there is a possibility that the idle rolling phenomenon is occurring in the bottom portions of the grooves in the directions of wall thickness measurement, it is determine that the idle rolling phenomenon is occurring in the bottom portions of the grooves, and (iii) in the closest upstream stand to the finishing stand having, roll-reducing directions which are the same as the directions of wall thickness measurement for which the actual wall thickness is smaller than the target wall thickness, at the time of rolling the next pierced blank to be rolled, the rolling positions of second grooved rolls installed in the upstream stand are moved outwards, or (iv) the rolling positions of second grooved rolls installed in the closest upstream stand to the finishing stand having roll-reducing directions which are the same as the directions of wall thickness measurement for which the actual wall thickness is smaller than the target wall thickness are previously moved outwards prior to rolling the next pierced blank to be rolled.

[0029] Therefore, in the case of either of the above-described (iii) or (iv), the rolling reduction in an upstream stand having roll-reducing directions which are which is the same as the directions for which it is determined that there is occurrence of the idle rolling phenomenon in the bottom portions of the grooves is decreased for the next pierced blank to be rolled such that the wall thickness of the rolled blank in these roll-reducing directions can be increased, the occurrence of the idle rolling phenomenon in the bottom portions of the grooves when rolling in the finishing stand can be prevented. The method described in (iii) is preferably applied to a mandrel mill having a mechanism which can vary the rolling positions of second grooved rolls in accordance with the portion of a pierced blank (the leading end portion, the middle portion, or the trailing end portion) being rolled in the upstream stand. On the other hand, the method described in (iv) is preferably applied to a mandrel mill which does not have a mechanism for moving the rolling positions of stands other than the finishing stand.

[0030] Thus, the present invention determines whether or not the idle rolling phenomenon is occurring in the bottom portions of the grooves of grooved rolls by comparing a target wall thickness and an actual wall thickness. Alternatively, it is possible to compare the amount of movement of the rolling positions of first grooved rolls and the amount of change of the actual wall thickness of a rolled blank in the directions of movement of the first grooved rolls as measured by a thickness gauge, and to determine that the idle rolling phenomenon is occurring in the bottom portions of the grooves if the amount of change in the actual wall thickness is smaller than the amount of movement of the rolling positions of the first grooved rolls.

[0031] The present invention is a rolling control method for a mandrel mill having a plurality of rolling stands including a finishing stand by moving outwards the rolling positions of fust grooved rolls installed in the finishing stand when a pierced blank is rolled in the finishing stand, characterized by installing a thickness gauge which measures the wall thickness of the resulting rolled blank on the exit side of the finishing stand, comparing the amount of movement of the rolling positions of the first grooved rolls and the amount of change of the actual wall thickness of the rolled blank measured by the thickness gauge in the directions of movement of the first grooved rolls, and when the amount of change of the actual wall thickness is smaller than the amount of movement of the rolling positions of the first grooved rolls, at the time of rolling the next pierced blank to be rolled in the closest upstream stand to the finishing stand having roll-reducing directions which are the same as the directions of wall thickness measurement, moving the rolling positions of second grooved rolls installed in the upstream stand outwards in the same manner as for the first grooved rolls, or previously moving the rolling positions of second grooved rolls installed in the closest upstream stand to the finishing stand having roll-reducing directions which are the same as the directions of wall thickness measurement outwards before rolling the next pierced blank to be rolled.

[0032] Instead of determining whether the idle rolling phenomenon is occurring in the bottom portions of the grooves by comparing a target wall thickness and the actual wall thickness, the difference between the rolling positions after movement of the first grooved rolls for the pierced blank which was rolled this time and the rolling positions after movement of the first grooved rolls for the pierced blank rolled the previous time can be calculated, the difference between the actual wall thickness measured by the thickness gauge in the directions of movement of the first grooved rolls for the pierced blank which was rolled this time and the actual wall thickness measured by the thickness gauge in the directions of movement of the first grooved rolls for the pierced blank rolled the previous time can be calculated, the calculated difference in the rolling positions can be compared with the calculated difference in the actual wall thickness, and it can be determined that the idle rolling phenomenon is occurring in the bottom portions of the grooves of the first grooved rolls when the calculated difference in the actual wall thickness is smaller than the calculated difference in the rolling positions.

[0033] The present invention also provides a rolling control method for a mandrel mill having a plurality of rolling stands including a finishing stand by moving outwards the rolling positions of first grooved rolls installed in the finishing stand when a pierced blank is rolled in the finishing stand, characterized by installing a thickness gauge which measures the wall thickness of the resulting rolled blank on the exit side of the finishing stand, calculating the difference between the rolling positions after movement of the first grooved rolls for the pierced blank which was rolled this time and the rolling positions after movement of the first grooved rolls for the pierced blank which was rolled lastly, calculating the difference between the actual wall thickness measured by the thickness gauge in the directions of movement of the first grooved rolls for the pierced blank which was rolled this time and the actual wall thickness measured by the thickness gauge in the directions of movement of the first grooved-rolls for the pierced blank which was rolled lastly, comparing the calculated difference in rolling positions with the calculated difference in the actual wall thickness, and when the calculated difference in the actual wall thickness is smaller than the calculated difference in rolling positions, in the closest upstream stand to the finishing stand having roll-reducing directions which are the same as the directions of wall thickness measurement, at the time of rolling the next pierced blank to be rolled, moving the rolling positions of second grooved rolls installed in the upstream stand outwards in the same manner as for the first grooved rolls or previously moving the rolling positions of the second grooved rolls installed in the closest upstream stand to the finishing stand having roll-reducing directions which are the same as the directions of wall thickness measurement outwards prior to rolling the next pierced blank to be rolled.

[0034] From another standpoint, the present invention is a rolling control apparatus for a mandrel mill having a plurality of rolling stands including a finishing stand and comprising a first rolling position adjusting unit for adjusting the rolling positions of grooved rolls installed in the finishing stand, a second rolling position adjusting unit for adjusting the rolling positions of grooved rolls installed in the closest upstream stand to the finishing stand having the same roll-reducing directions (as the finishing stand), and an arithmetic and control unit for instructing the first rolling position adjusting unit and the second rolling position adjusting unit as to an amount of adjustment of rolling positions for the grooved rolls, **characterized in that** the arithmetic and control unit carries out a rolling control method according to the present invention as set forth in claim 1 or claim 2 by instructing the first rolling position adjusting unit and the second rolling position adjusting unit as to an amount of adjustment of rolling positions determined based on the current position of the pierced blank (the portion of the pierced blank which is currently being rolled in the stand).

[0035] The present invention is a rolling control apparatus for a mandrel mill having a plurality of rolling stands including a finishing stand and comprising a rolling position adjusting unit for adjusting the rolling positions of grooved rolls installed in the finishing stand and an arithmetic and control unit for instructing the rolling position adjusting unit as to an amount of adjustment of rolling positions for the grooved rolls, **characterized in that** the arithmetic and control unit is connected to a thickness gauge which is installed on the exit side of the finishing stand and which measures the wall thickness of a rolled blank in the roll-reducing directions at each stand, and in that it carries out a rolling control method according to the present invention as set forth in any one of claims 3 - 5 by instructing the rolling position adjusting unit to terminate adjustment of the rolling positions depending on the output of the thickness gauge.

[0036] The present invention is a rolling control apparatus for a mandrel mill having a plurality of rolling stands including a finishing stand and comprising a first rolling position adjusting unit for adjusting the rolling positions of grooved rolls installed in the finishing stand, a second rolling position adjusting unit for adjusting the rolling positions of grooved rolls installed in the closest upstream stand to the finishing stand having the same roll-reducing directions, and an arithmetic and control unit for instructing the first rolling position adjusting unit and the second rolling position adjusting unit as to an amount of adjustment, **characterized in that** the arithmetic and control unit is connected to a thickness gauge which is installed on the exit side of the finishing stand and which measures the wall thickness of a rolled blank in the roll-reducing directions at each stand, and in that it carries out a rolling control method according to the present invention as set forth in any one of claims 6 - 8 by instructing the second rolling position adjusting unit as to an amount of adjustment determined based on the output of the thickness gauge and the current position of a pierced blank.

[0037] From another standpoint, the present invention is a rolling control program for operating an arithmetic and control unit which is connected to a first rolling position adjusting unit for adjusting the rolling positions of grooved rolls installed in a finishing stand among a plurality of rolling stands constituting a mandrel mill, and to a second rolling position adjusting unit for adjusting the rolling positions of grooved rolls installed in the closest upstream stand of the mandrel mill to the finishing stan having the same roll-reducing directions as the finishing stand, and which instructs the first rolling position adjusting unit and the second rolling position adjusting unit as to an amount of adjustment of rolling positions for the grooved rolls in the stands, characterized by operating the arithmetic and control unit so as to carry out a rolling control method according to the present invention as set forth in claim 1 or claim 2 by instructing the first rolling position adjusting unit and the second rolling position adjusting unit as to the amount of adjustment of rolling position determined based on the current position of the pierced blank in the stand

[0038] The present invention is also a control program for operating an arithmetic and control unit which is connected to a rolling position adjusting unit for adjusting the rolling positions of grooved rolls installed in a finishing stand among a plurality of rolling stands constituting a mandrel mill and to a thickness gauge which is installed on the exit side of the finishing stand and which measures the wall thickness of a rolled blank in the roll-reducing directions at each stand, the arithmetic and control unit instructing the rolling position adjusting unit as to an amount of adjustment of rolling positions for the grooved rolls, characterized by operating the arithmetic and control unit so as to carry out a rolling control method according to the present invention as set forth in any one of claims 3 - 5 by instructing the rolling position adjusting unit to terminate adjustment of rolling position depending on the output of the thickness gauge.

[0039] The present invention is also a control program for operating an arithmetic and control unit which is connected to a first rolling position adjusting unit for adjusting the rolling positions of grooved rolls installed in a finishing stand among a plurality of rolling stands constituting a mandrel mill, to a second rolling position adjusting unit for adjusting the rolling positions of grooved rolls installed in the closest upstream stand to the finishing stand having the same roll-reducing directions, and to a thickness gauge which is installed on the exit side of the finishing stand and which measures the wall thickness of a rolled blank in the roll-reducing directions at each stand, the arithmetic and control unit instructing the first rolling position adjusting unit and the second rolling position adjusting unit as to an amount of adjustment, characterized by operating the arithmetic and control unit so as to carry out a rolling control method according to the present invention as set forth in any of claims 6 - 8 by instructing the second rolling position adjusting unit as to the amount of adjustment determined based on the output of the thickness gauge and the current position of a pierced blank in the stand.

[0040] From yet another standpoint, the present invention is a seamless tube characterized by being manufactured using a mandrel mill to which a rolling control method according to the present invention as set forth in any of claims 1 - 8 is applied.

Effects of the Invention

[0041] According to the present invention, when manufacturing a seamless tube using a mandrel mill, it is possible to accurately roll a pierced blank for the eitire length of a portion in the lengthwise directions such as an end portion to a desired wall thickness without worsening the surface conditions or properties of the resulting rolled blank.

[0042] Specifically, according to the present invention, when rolling a pierced blank in the closest upstream stand to the finishing stand having the same roll-reducing directions in a mandrel mill, the rolling positions of second grooved rolls installed in this upstream stand are also moved outwards in the same manner as in the finishing stand, so the rolling reduction achieved in the bottom portions of the grooves when rolling the pierced blank with the second grooved rolls is decreased. As a result, the wall thickness of the portions opposing the flange portions of the grooved rolls installed in the next stand can be prevented from excessively decreasing. Therefore, the occurrence of the idle rolling phenomenon in the bottom portions of the grooves when rolling with the first grooved rolls installed in the finishing stand is eliminated, and the pierced blank can be accurately rolled to a desired wall thickness while the surface properties of the resulting rolled blank can be prevented from worsening.

Brief Description of the Drawings

[0043]

Figure 1 is a block diagram schematically showing the structure of a rolling control apparatus for carrying out a rolling control method for a mandrel mill according to a first embodiment of the present invention.
Figure 2 is a block diagram schematically showing the structure of a rolling control apparatus for carrying out a rolling control method for a mandrel mill according to a second embodiment.
Figure 3 is a block diagram schematically showing the structure of a rolling control apparatus for carrying out a rolling control method for a mandrel mill according to a third embodiment.
Figure 4 is a schematic diagram showing one example of a pattern of movement of the rolling positions of grooved rolls installed in a finishing stand.

Best Mode for Carrying Out the Invention

[0044] The best mode for carrying out the present invention will be explained while referring to the accompanying drawings. The following explanation will be directed to an embodiment, which is given as an example, in which the rolling positions of grooved rolls installed in a finishing stand are moved outwards when rolling the end portions of a pierced blank in a finishing stand of a 2-roll type mandrel mill. However, this is a mere example of the present invention, and the present invention can be similarly applied to an embodiment in which the rolling positions of grooved rolls installed in a finishing stand are moved outwards over the entire length of a pierced blank or an embodiment using a mandrel mill other than a 2-roll type.

First embodiment

[0045] Figure 1 is block diagram schematically showing the structure of a rolling control apparatus for carrying out a rolling control method for a mandril mill according to a first embodiment.

[0046] As shown in Figure 1, a rolling control apparatus 1 according to this embodiment has a first rolling position adjusting unit 11, a second rolling position adjusting unit 12, and an arithmetic and control unit 13.

[0047] The first rolling position adjusting unit 11 is constituted by a cylinder or similar device for adjusting the rolling positions of grooved rolls installed in a finishing stand #i among a plurality of stands constituting a mandrel mill M. The second rolling position adjusting unit 12 is constituted by a cylinder or similar device for adjusting the rolling positions of grooved rolls installed in the closest upstream stand to the finishing stand #i in the mill having the same roll-reducing directions (as the finishing stand), i.e., in stand #(i-2) positioned just two stands upstream of the finishing stand #i. The arithmetic and control unit 13 is connected to the first rolling position adjusting unit 11 and the second rolling position adjusting unit 12 and is constructed so as to instruct the first rolling position adjusting unit 11 and the second rolling position adjusting unit 12 as to an appropriate amount of adjustment of rolling positions based on the current location of the end portions of a pierced blank S being rolled.

[0048] In this embodiment, each of the first rolling position adjusting unit 11 and the second rolling position adjusting unit 12 have a mechanism which can move the rolling positions of the grooved rolls installed in the stand during rolling in accordance with the portion (the leading end portion, the central portion, or the trailing end portion) of a single pierced blank S which is being rolled in that stand.

[0049] The arithmetic and control unit 13 is constituted by a computer equipped with hardware such as a CPU, a memory, an external storage device, and an external input/output interface. By suitably operating this hardware in accordance with a control program stored therein, it functions as a first rolling position setting part 131 and a second rolling position setting part 132.

[0050] An end portion sensing signal which indicates that an end portion of the pierced blank S was detected, for example, by a sensor (not shown) installed on the entrance side of the mandrel mill M is input to the first rolling position setting part 131. In addition, the distance between the sensor and stand #i, the traveling speed of the pierced blank S, the elongation percentage of the pierced blank S in the mandrel mill M and similar parameters are input to this part from an upper level process computer (not shown), for example. Based on the signals and data which were input, the first rolling position setting part 131 calculates the current position of the end portions of the pierced blank S. Specifically, it calculates the timing with which the end portions (leading end portion and trailing end portion) of the pierced blank S reach and leave the finishing stand #i.

[0051] Based on the timing which is calculated in this manner, the first rolling position setting part 131 determines an amount of adjustment of rolling positions for the first grooved rolls installed in the finishing stand #i, and it transmits the amount of adjustment of rolling positions which was determined to the first rolling position adjusting unit 11. Specifically, the rolling positions A of the first grooved rolls at the time of rolling of the end portions of the pierced blank S in the finishing stand #i and the rolling positions B of the first grooved rolls at the time of rolling the central portion of the pierced blank S are stored in the first rolling position setting part 131. the first rolling position setting part 131 sets the difference (A - B) as the amount of adjustment of rolling positions so that the first grooved rolls will move from rolling positions B to rolling positions A by the time that the leading end portion of the pierced blank S reaches the finishing stand #i, and it transmits this value to the first rolling position adjusting unit 11.

[0052] In the same manner, the first rolling position setting part 131 sets the difference (B - A) as the amount of adjustment of rolling positions so that the first grooved rolls will move from rolling positions A to rolling positions B as soon as the leading end portion of the pierced blank S leaves the finishing stand #i, and it transmits this value to the first rolling position adjusting unit 11. Thereafter, it again sets the difference (A - B) as the amount of adjustment of rolling positions when the trailing end portion of the pierced blank S reaches the finishing stand #1 and it transmits this value to the first rolling position adjusting unit 11.

[0053] In addition, it sets the difference (B - A) as the amount of adjustment of rolling positions so that the first grooved rolls will move from rolling positions A to rolling positions B in the period from when the trailing end portion of the pierced blank S leaves the finishing stand #1 until the leading end portion of the next pierced blank S to be rolled reaches the finishing stand #1, and it transmits this value to the first rolling position adjusting unit 11.

[0054] Therefore, in this embodiment, the rolling positions of the first grooved rolls installed in the finishing stand #i can be moved outwards, i.e., to rolling positions A, when the end portions of a pierced blank S are rolled in the finishing stand #i. Rolling positions A and B vary depending on the dimensions, the wall thickness, the material, and the like of the pierced blank S being rolled, so a plurality of combinations of rolling positions A and B corresponding to various dimensions, wall thickness, material, and the like are stored in the first rolling position adjusting unit 11, and appropriate rolling positions A and B are selected in accordance with the dimensions, wall thickness, material, and the like of the pierced blank S which are input from the upper level process computer, for example.

[0055] In the same manner as for the first rolling position setting part 131, end portion sensing signals and the like are input from the outside to the second rolling position setting part 132, and the timing with which the end portions (leading end portion and trailing end portion) of the pierced blank S reach and leave the upstream stand #(i-2) is calculated.

[0056] The second rolling position setting part 132 sets the amount of adjustment of rolling positions for the second grooved rolls installed in the upstream stand #(i-2) based on the calculated timing in the same manner as for the first rolling position setting part 131 and transmits the amount of adjustment of rolling positions which was set to the second rolling position adjusting unit 12. The amount of adjustment of rolling positions which is transmitted to the second rolling position adjusting unit 12, i.e., an amount corresponding to the amount of movement when moving the rolling positions of the second grooved rolls installed in the upstream stand #(i-2) outwards when rolling the end portions of the pierced blank S in the upstream stand #(i-2) need not be set to the same value as the amount of adjustment of rolling positions transmitted to the first rolling position adjusting unit 11. For example, it can be set to a value resulting from multiplying by a predetermined coefficient greater than 0 and smaller than 1 (such as 0.8).

[0057] In a rolling control apparatus 1 according to this embodiment, when rolling the end portions of a pierced blank S not only in the finishing stand #i but also in the upstream stand #(i-2), the rolling positions of the second grooved rolls installed in the upstream stand #(i-2) are moved outwards. Therefore, the rolling reduction in the bottom portions of the grooves when rolling the pierced blank S in the second grooved rolls is decreased, and an excessive decrease in the wall thickness of the portions opposing the flange portions of the grooved rolls installed in the next stand #(i-1) is eliminated. Therefore, the occurrence of the idle rolling phenomenon in the bottom portions of the grooves at the time of rolling with the first grooved rolls installed in the finishing stand #i is prevented. Accordingly, the end portions of a pierced blank S can be accurately rolled to a desired wall thickness, and a deterioration in the surface properties of the resulting rolled blank S can be prevented.

[0058] In this embodiment, an example is given of the case in which a mechanism for moving the rolling positions in the course of rolling of a single pierced blank S is provided in not only the first rolling position adjusting unit 11 but also in the second rolling position adjusting unit 12. However, some mandrel mills M have such a mechanism only in the finishing stand #i. Therefore, in such mandrel mills, instead of moving the rolling positions in accordance with the position of the pierced blank S during rolling, the rolling positions of the grooved rolls of upstream stand #(i-2) can be previously moved outwards prior to rolling the pierced blank S.

[0059] In this embodiment, the second rolling position setting part 132 sets the amount of adjustment of rolling positions, namely, the amount of adjustment necessary to modify the rolling positions to the previously stored outwards positions when the signal indicating that the leading end portion of the pierced blank S has been sensed is input from the exterior, and it transmits the set amount of adjustment of rolling positions to the second rolling position adjusting unit 12. The second rolling position adjusting unit 12 acts to move the rolling positions of the second grooved rolls outwards based on the transmitted amount of adjustment of rolling positions. The modified rolling positions are maintained at the same value throughout rolling of the pierced blank S.

Second embodiment

[0060] Figure 2 is a block diagram schematically showing the structure of a rolling control apparatus for carrying out a rolling control method for a mandrel mill according to a second embodiment, ;

[0061] As shown in Figure 2, a rolling control apparatus 2 according to this embodiment has a rolling position adjusting unit 21 and an arithmetic and control unit 22.

[0062] The rolling position adjusting unit 21 has a mechanism which is constituted by a cylinder or similar device for adjusting the rolling positions of grooved rolls installed in the finishing stand #i among a plurality of rolling stands constituting a mandrel mill M and which can move the rolling positions of the grooved rolls in accordance with the portion being rolled (leading end portion, central portion, or trailing end portion) of a single pierced blank S during rolling.

[0063] The arithmetic and control unit 22 is constituted by a computer having hardware such as a CPU in the same manner as in the first embodiment, but it differs from the first embodiment in that it is connected to a thickness gauge I which measures the wall thickness of the resulting rolled blank S in the roll-reducing directions at each stand (for example, the wall thickness in 4 directions when the mandrel mill M is a 2-roll type) and which is installed on the exit side of the finishing stand #i (in this embodiment, on the exit side of the mandrel mill M).

[0064] The arithmetic and control unit 22 suitably drives hardware in accordance with a control program stored therein, whereby it functions as a rolling position setting part 221 and an idle rolling determining part 222. Depending on the output of the thickness gauge I, it instructs the rolling position adjusting unit 21 to stop adjustment of the rolling positions. In the following paragraphs, it will be explained more concretely.

[0065] In the same manner as with the first rolling position setting part 131 described with respect to the first embodiment, an end portion sensing signal for the pierced blank S and the like are input to the rolling position setting part 221, and it calculates the timing when the end portions (the leading end portion and the trailing end portion) of the pierced blank S reach and leave the finishing stand #i. In addition, in the same manner as in the first embodiment, the rolling position setting part 221 stores the rolling positions of the grooved rolls when rolling the end portions and the central portion of the pierced blank S in the finishing stand #i. The rolling position setting part 221 sets an amount of adjustment of rolling positions for the grooved rolls installed in the finishing stand #i based on the calculated timing and the stored rolling positions of the grooved rolls, and it transmits the set amount of adjustment of rolling positions to the rolling position adjusting unit 21. As a result, when the end portions of the pierced blank S are rolled in the finishing stand #i, the rolling positions of the grooved rolls installed in the finishing stand #i can be moved outwards by an amount corresponding to the amount of adjustment of rolling positions.

[0066] The output of the thickness gauge I (the actual wall thickness of the end portions of the rolled blank S) is input to the idle rolling determining part 222. The target wall thickness of the end portions of the rolled blank S is previously stored in the idle rolling determining part 222. The idle rolling determining part 222 compares the target wall thickness and the actual wall thickness of the rolled blank S, and when the actual wall thickness is smaller than the target wall thickness, namely, when at least one values of the actual wall thickness measured in the roll-reducing directions for the finishing stand #i is smaller than the target wall thickness, it is determined that the idle rolling phenomenon is occurring in the bottom portions of the grooves, and in other cases, it is determined that the phenomenon is not occurring. The target wall thickness of the end portions of the rolled blank S is a value which varies in accordance with the dimensions of the pierced blank S being rolled, the target wall thickness of the central portion, the material of the pierced blank, and the like, so a plurality of target wall thicknesses corresponding to the dimensions, the wall thickness of the central portion, the material, and the like are stored in the first rolling position adjusting unit 11. For example, the target wall thickness is suitably selected in accordance with the dimensions of the pierced blank S, the wall thickness of the central portion, the material, and the like input from an upper level process computer,

[0067] When the idle rolling determining part 222 determines that the idle rolling phenomenon is occurring in the bottom portions of the grooves of the grooved rolls, the rolling position setting part 221 issues an instruction to terminate outwards movement of the rolling positions of the grooved rolls for the next pierced blank S to be rolled. Namely, when the end portions of the pierced blank S are rolled, it transmits an instruction to the rolling position adjusting unit 21 to maintain the rolling positions the same as when rolling the central portion of the pierced blank S. Specifically, it sets the amount of adjustment of rolling positions when rolling the end portions of the pierced blank S to zero, and it transmits this value to the rolling position adjusting unit 21.

[0068] On the other hand, when the idle rolling determining part 222 determines that the idle rolling phenomenon is not occurring in the bottom portions of the grooves, for the next pierced blank S to be rolled as well, amounts of adjustment of rolling positions are set in accordance with the previously stored rolling positions of the grooved rolls when rolling the end portions and the central portion of the pierced blank S, and these values are transmitted to the rolling position adjusting unit 21.

[0069] With a rolling control apparatus 2 according to this embodiment, movement of the grooved rolls outwards can be terminated for the next pierced blank S to be rolled so that the rolling reduction by the grooved rolls is not decreased, and the occurrence of the idle rolling phenomenon in the bottom portions of the grooves in the finishing stand #i can be prevented. As a result, the end portions of the pierces blank S can be accurately rolled to a desired wall thickness, and worsening of the surface properties of the rolled blank S can be prevented.

[0070] In the above explanation, an example is given of a mode in which the amount of outwards movement of the grooved rolls for the next pierced blank S when the idle rolling phenomenon did not occur in the bottom portions of the grooves is made a previously set value regardless of the actual wall thickness of the end portions of the rolled blank S measured by the thickness gauge 1, i.e., a mode in which when the idle rolling determining part 222 determines that the idle rolling phenomenon did not take place in the bottom portions of the grooves, for the next pierced blank S to be rolled, the amount of adjustment of rolling positions in the finishing stand is set in accordance with previously stored rolling positions for the grooved rolls of this stand when rolling the end portions and the central portion of the pierced blank S, and this value is transmitted to the rolling position adjusting unit 21.

[0071] However, the present invention is not limited to this mode. For example, it is also possible to modify the amount of outward movement of the grooved rolls for the next pierced blank S when the idle rolling phenomenon did not occur in the bottom portions of the grooves in accordance with the actual wall thickness of the end portions of the rolled blanks measured by the thickness gauge 1. Specifically, for example, when the actual wall thickness of the end portions is larger than the target wall thickness, the rolling positions of the grooved rolls when rolling the end portions of the pierced blank S can be updated to a new position which is inward by the amount of the difference between the two wall thicknesses, and the new position is stored. For the next pierced blank S to be rolled, the amount of adjustment of rolling positions can be set in accordance with the previously stored rolling positions when rolling the central portion of the pierced blank S and the updated and stored new rolling positions when rolling the end portions of the pierced blank S, and these values can be transmitted to the rolling position adjusting unit 21. In this case, when it is determined that the idle rolling phenomenon is occurring in the bottom portions of the grooves, modification of the set value in accordance with the actual wall thickness measured by the thickness gauge I can be terminated, and the set value for the pierced blank which was rolled this time can also be used for the next pierced blank S to be rolled. As a result, the grooved rolls can be prevented from endlessly moving outwards.

[0072] In this embodiment, an example is given of the case in which the idle rolling determining part 222 compares the target wall thickness and the actual wall thickness of the rolled blank S and determines whether or not the idle rolling phenomenon is occurring in the bottom portions of the grooves based on the magnitude of the difference. However, the method used by the idle rolling determining part 222 to determine whether the idle rolling phenomenon is occurring in the bottom portions of the grooves is not limited to this method. For example, the amount of movement of the rolling positions of the grooved rolls and the amount of change in the actual wall thickness of the rolled blank S measured by the thickness gauge I in the directions of movement of the grooved rolls can be compared, and if the amount of change of the actual wall thickness is smaller than the amount of movement of the rolling positions of the grooved rolls, it can be determined that the idle rolling phenomenon is occurring in the bottom portions of the grooves.

[0073] In this case, the idle rolling determining part 222 first refers to the amount of adjustment of rolling positions set by the rolling position setting part 221, i.e., an amount corresponding to the amount of outward movement of the rolling positions of the grooved rolls when rolling the end portions of the pierced blank S, Then it compares the amount of adjustment of rolling positions which was referred to and the amount of change of the actual wall thickness calculated from the actual wall thickness (the actual wall thickness in the directions of movement of the grooved rolls) at the end portions and the central portion of the rolled blank S (i.e., the difference between the actual wall thickness of the end portions and the actual wall thickness of the central portion) input from the thickness gauge I. If the amount of change in the actual wall thickness is smaller than the amount of adjustment of rolling positions which was referred to, it is determined that the idle rolling phenomenon is occurring in the bottom portions of the grooves. Instead of directly comparing the amount of change and the amount of adjustment of rolling positions which was referred to, it is possible to compare with a weighted value obtained by multiplying the amount of change or the amount of adjustment of rolling positions which was referred to by a predetermined coefficient greater than 0 and smaller than 1 (such as 0.5), and to determine that the idle rolling phenomenon is occurring in the bottom portions of the grooves if the amount of change in the actual wall thickness is smaller even in this case.

[0074] As an example of another method of determining in the idle rolling determining part 222 if the idle rolling phenomenon is occurring in the bottom portions of the grooves, the difference between the rolling positions after movement of the grooved rolls for the rolled blank S which was rolled this time and the rolling positions after movement of the first grooved rolls for the rolled blank which was rolled lastly S is calculated, the difference between the actual wall thickness measured by the thickness gauge I in the directions of movement of the grooved rolls for the rolled blank S which was rolled this time and the actual wall thickness measured by the thickness gauge I in the directions of movement of the grooved rolls for the rolled blank which was rolled lastly is calculated, the difference in the rolling positions and the difference in the actual wall thickness is compared, and it can be determined that the idle rolling phenomenon is occurring in the bottom portions of the grooves if the difference, in the actual wall thickness is smaller than the difference in the rolling positions.

[0075] In this case, the idle rolling determining part 222 refers to the rolling positions after movement of the grooved rolls, i.e., the rolling positions when rolling the end portions of the pierced blank S, which were stored in the rolling position setting part 221 for the rolled blank which was rolled lastly S (including the case in which the rolling positions were modified and stored as described above), and these values are stored. It also refers to the rolling positions after movement of the grooved rolls, i.e., the rolling positions when rolling the end portions of the pierced blank S, which are stored or updated and stored in the rolling position setting part 221 for the pierced blank S which was rolled this time, and by subtracting the former from the latter, it calculates the difference in the rolling positions between the current rolling and the previous rolling. In addition, the idle rolling determining part 222 stores the actual wall thickness of the end portions (the actual wall thickness in the directions of movement of the grooved rolls) which was input from the thickness gauge I for the rolled blank which was rolled lastly S, and by subtracting this thickness from the actual wall thickness of the end portions (the actual wall thickness in the directions of movement of the grooved rolls) which was input from the thickness gauge I for the rolled blank S which was rolled this time, the difference in the actual wall thickness between the present rolling and the previous rolling is calculated. The idle rolling determining part 222 compares the difference in the rolling positions and the difference in the actual wall thickness, and if the difference in the actual wall thickness is smaller than the difference in the rolling positions, it is determined that the idle rolling phenomenon is occurring in the bottom portions of the grooves. Instead of directly comparing the difference in the rolling positions and the difference in the actual wall thickness, it is possible to multiply the difference in the actual wall thickness or the difference in the rolling positions by a predetermined coefficient greater than 0 and less than 1 (such as 0.5) so that a weighted value can be used for comparison, and if the difference in the actual wall thickness is smaller even in this case, it can be determined that the idle rolling phenomenon is occurring in the bottom portions of the grooves.

Third embodiment

[0076] Figure 3 is a block diagram schematically showing the structure of a rolling control apparatus for carrying out a rolling control method for a mandrel mill according to a third embodiment.

[0077] As shown in Figure 3, a rolling control apparatus 3 according to this embodiment has a first rolling position adjusting unit 31, a second rolling position adjusting unit 32, and an arithmetic and control unit 33.

[0078] The first rolling position adjusting unit 31 is constituted by a cylinder or similar device for adjusting the rolling positions of grooved rolls installed in the finishing stand #i among a plurality of rolling stands constituting a 2-roll mandrel mill M. The second rolling position adjusting unit 32 is constituted by a cylinder or similar device for adjusting the rolling positions of grooved rolls installed in the closest upstream stand to the finishing stand having the same roll-reducing directions, i.e., in stand #(i-2) positioned two stands upstream of the finishing stand #i. The arithmetic and control unit 33 is connected to the first rolling position adjusting unit 31 and the second rolling position adjusting unit 32, and it is constituted so as to instruct the first rolling position adjusting unit 31 and the second rolling position adjusting unit 32 as to a predetermined amount of adjustment of rolling positions. The first and second rolling position adjusting units 31. and 32 in this embodiment each have a mechanism which can vary the rolling positions of the grooved rolls in the stand during rolling in accordance with the portion being rolled (the leading end portion, the central portion, or the trailing end portion) of a single pierced blank S which is being rolled.

[0079] The arithmetic and control unit 33 is constituted by a computer having hardware such as a CPU in the same manner as in the first embodiment, but it differs from the first embodiment in that it is connected to a thickness gauge I which is installed on the exit side of the finishing stand #i (in the present embodiment, on the exit side of the mandrel mill M) and which measures the wall thickness of the resulting rolled blank S in the roll-reducing directions at each stand (for example, the wall thickness in four directions in the case of a 2-roll type mandrel mill M). By suitably driving the hardware in accordance with a control program stored therein, the arithmetic and control unit 33 functions as a first rolling position setting part 331 and a second rolling position setting part 332. Depending on the output of the thickness gauge I and the current position of the end portions of the pierced blank S, it can instruct the first rolling position adjusting unit 31 and the second rolling position adjusting unit 32 as to a predetermined amount of adjustment of rolling positions, Below, it will be explained more concretely.

[0080] In the same manner as in the first rolling position setting part 131 described in the first embodiment, end portion sensing signals and the like for the pierced blank S are input to the first rolling position setting part 331, and the part 331 calculates the timing with which the end portions (the leading end portion and the trailing end portion) of the pierced blank S arrive at and exit from the finishing stand #i. In the same manner as in the first embodiment, the rolling positions of the first grooved rolls (the grooved rolls installed in the finishing stand #i) when rolling the end portions and the central portion of the pierced blank S in the finishing stand #i are stored in the first rolling position setting part 331. The first rolling position setting part 331 sets the amount of adjustment of rolling positions for the first grooved rolls installed in the finishing stand #i based on the calculated timing and the stored rolling positions of the first grooved rolls, and it transmits the set amount of adjustment of rolling positions to the first rolling position adjusting unit 31. As a result, when the end portions of the pierced blank S are being rolled in the finishing stand #i, the rolling positions of the first grooved rolls installed in the finishing stand #i can be moved outwards by an amount corresponding to the set amount of adjustment of rolling positions.

[0081] The output of the thickness gauge I is input to the first rolling position setting part 331. In addition, a target wall thickness of the end portions of the pierced blank S is previously stored in the first rolling position setting part 331. The first rolling position setting part 331 compares the target wall thickness and the actual wall thickness of the rolled blank S, and when the actual wall thickness is smaller than the target wall thickness (when at least one actual wall thickness among the actual wall thicknesses in various directions measured in the roll-reducing directions of the finishing stand #i is smaller than the target wall thickness), it is determined that the idle rolling phenomenon is occurring in the bottom portions of the grooves.

[0082] Instead of determining whether the idle rolling phenomenon is occurring in the bottom portions of the grooves of the first grooved rolls by comparing a target wall thickness and the actual wall thickness, as described with respect to the second embodiment, it is possible to employ a different method for determining whether the idle rolling phenomenon is occurring in the bottom portions of the grooves. If the first rolling position setting part 331 determines that the idle rolling phenomenon is occurring in the bottom portions of the grooves of the grooved rolls, then the second rolling position setting part 332 refers to this result, and as described below, for the next pierced blank S to be rolled when it is rolled in the closest upstream stand #(i-2) to the finishing stand #i having roll-reducing directions which are the same as the directions of wall thickness measurement for which the actual wall thickness was smaller than the target wall thickness in the finishing stand, it instructs the second rolling position adjusting unit 32 as to a predetermined amount of adjustment of rolling positions in the upstream stand.

[0083] It is also possible for the first rolling position setting part 331 to vary the amount of outward movement of the first grooved rolls for the next pierced blank S in accordance with the actual wall thickness of the end portions of the rolled blank S measured by the thickness gauge I. Specifically, when, for example, the actual wall thickness is larger than the target wall thickness, the rolling positions of the first grooved rolls when rolling the end portions of a pierced blank S are moved inwards by just the difference in wall thickness and it is stored. Then, for the next pierced blank S to be rolled, the amount of adjustment of rolling positions is set in accordance with the previously stored rolling positions when rolling the central portion of the pierced blank S and in accordance with the updated and stored rolling positions when rolling the end portions of the pierced blank S, and the set amount is transmitted to the rolling position adjusting unit 31.

[0084] In the same manner as for the first rolling position setting part 331, an end portion sensing signal and the like are input from the outside to the second rolling position setting part 332, and it calculates the timing with which the end portions (leading end portion and trailing end portion) of the pierced blank S arrive at and exit from the upstream stand #(i-2).

[0085] The second rolling position setting part 332 refers to the first rolling position setting part 331, and when the first rolling position setting part 331 determines that the idle rolling phenomenon is occurring in the bottom portions of the grooves of the first grooved rolls, based on the calculated timing, the amount of adjustment of rolling positions for the second grooved rolls installed in the upstream stand #(i-2) is set, and the set amount of adjustment of rolling positions is transmitted to the second rolling position adjusting unit 32. Various values can be employed as the amount of adjustment of rolling positions transmitted to the second rolling position adjusting unit 32, i.e., as an amount corresponding to the amount of outwards movement of the rolling positions of the second grooved rolls installed in the upstream stand #(i-2) when rolling the end portions of the pierced blank S in the upstream stand #(i-2). For example, it is conceivable to use a value obtained by multiplying the difference between the target wall thickness and the actual wall thickness calculated in the first rolling position setting apparatus 31 by a coefficient having a value in the range of about 0.8 - 1.2. Alternatively, it is conceivable to use a fixed value (such as 0.2 mm) while the difference between the target wall thickness and the actual wall thickness is not greater than a predetermined value (such as 0.1 mm).

[0086] According to a rolling control apparatus 3 of this embodiment, when it is determined that the idle rolling phenomenon is occurring in the bottom portions of the grooves in the finishing stand based on the output of the thickness gauge I, for the next pierced blank S to be rolled, the rolling positions are moved outwards not only for the finishing stand #i but also for the second grooved rolls installed in the upstream stand #(i-2) having the same roll-reducing directions as the directions in which it is determined that the idle rolling phenomenon is occurring in the bottom portions of the grooves in the finishing stand. Therefore, in the upstream stand #(i-1), the rolling reduction is decreased with increasing the wall thickness of the rolled blank in the roll-reducing directions, and the occurrence of the idle rolling phenomenon in the bottom portions of the grooves can be prevented when rolling in the finishing stand #i. As a result, the end portions of the pierced blank S can be accurately rolled to give a desired wall thickness, and worsening of the surface properties of the rolled blank S can be prevented.

[0087] In this embodiment, an example was given of a case in which not only the first rolling position adjusting unit 31 but also the second rolling position adjusting unlit 32 can move the rolling positions for a single pierced blank S during rolling.

[0088] However, with a mandrel mill which has a mechanism for this purpose only in the finishing stand #i, instead of moving the rolling positions in accordance with the portion of the pierced blank S being rolled, the rolling positions of the second grooved rolls of upstream stand #(i-2) can be previously moved outwards prior to rolling the pierced blank S.

Example 1

[0089] The present invention will be characterized still clearer by the following examples and comparative examples.

[0090] A rolling control method according to the present invention was applied to a 2-roll type mandrel mill having 6 stands (in which the finishing stands were the #5 and #6 stands), and a rolling test was carried out under the following conditions.

(1) Dimensions of the pierced blank at the entrance of the mill: outer diameter of 190 mm, wall thickness of 16 mm, length of 4600 mm

(2) Dimensions of a rolled blank at the exit of the mill: outer diameter of 168 mm, wall thickness of 5 mm, length of 15000 mm

(3) Outer diameter of mandrel bar: 158 mm

(4) Initially set target wall thickness at the exit of each stand (wall thickness at the bottom portions of the grooves of the grooved rolls) based on the pass schedule:

#1 stand:	10mm,
#2 stand:	9 mm,
#3 stand:	6mm,
#4 stand:	5.5 mm,
#5 stand:	5 mm,
#6 stand:	5 mm.

Example 1-1 .

[0091] In the #5 and #6 stands, when rolling the end portions of the pierced blank, the rolling positions of the grooved rolls were moved outwards according to the pattern shown in Figure 4. In the #3 and #4 stands as well, rolling was carried out with the rolling positions of the grooved rolls moved outwards according to the same pattern. In the #1 and #2 stands, rolling was carried out with the initially set rolling positions.

Example 1-2

[0092] In the #5 and #6 stands, rolling was carried out with the rolling positions of the grooved rolls moved outwards according to the pattern shown in Figure 4 in the same manner as in Example 1-1. In the #3 and #4 stands, rolling was carried out with the amount of movement reduced to 0.8 times that of the pattern shown in Figure 4 (namely, to a maximum of 0.4 mm). In the #1 and #2 stands, rolling was carried out with the initially set rolling positions.

Example 1-3

[0093] In the #5 and #6 stands, in the same manner as in Example 1-1, rolling was carried out with the rolling positions of the grooved rolls moved outwards according to the pattern shown in Figure 4. In the #3 and #4 stands, before rolling the pierced blank, the rolling positions of the grooved rolls were moved outwards so that the target wall thicknesses became 6.5 mm (for the #3 stand) and 6 mm (for the #4 stand), and then rolling was carried out. In the #1 1 and #2 stands, rolling was carried out with the initially set rolling positions.

Comparative Example 1

[0094] For only the #5 and #6 stands, when rolling the end portions of the pierced blank, rolling was carried out with the rolling positions of the grooved rolls moved outwards according to the pattern shown in Figure 4. In the #1 - #4 stands, rolling was carried out with the initially set rolling positions.

Evaluation

[0095] The rate of wall thickness defects in the resulting rolled blank was evaluated for Examples 1-1 through 1-3 and Comparative Example 1. When there is a location of measurement at the end portions of the after rolling where the difference between the measured wall thickness and the target value of the wall thickness (for example, in the case of Example 1, the target value of the wall thickness of the end portions is 5.5 mm) exceeds ± 2% of the target value of the wall thickness, it is determined that there is a wall thickness defect. The rate of wall thickness defects is defined by the following equation:

$$\text{Rate of wall thickness defects (\%)} = [(\text{number of tubes having a wall thickness defect}) / (\text{total number of rolled tubes})] \times 100.$$

[0096] The results of evaluation are compiled in Table 1.

Table 1

	Rate of wall thickness defects
Example 1-1	0%
Example 1-2	0%
Example 1-3	0%
Comparative Example 1	10%

[0097] As shown in Table 1, it can be seen that in contrast to Comparative Example 1, the end portions of the pierced blanks for all of Examples 1-1 through 1-3 could be accurately rolled to a desired wall thickness.

Example 2

Example 2-1

[0098] In the #5 and #6 stands, when rolling the end portions of the next pierced blank, the pattern shown in Figure 4 was modified based on the actual wall thickness of the rolled blank which was rolled lastly measured by the thickness gauge, and the rolling positions of the grooved rolls were moved outwards based on the modified pattern. Namely, in order to make the actual wall thickness approach the target wall thickness, the set value (amount of outwards movement of rolling positions) was modified by an amount corresponding to the difference between the measured wall thickness and the target wall thickness. However, when the actual wall thickness was smaller than target wall thickness, it was determined that the idle rolling phenomenon was occurring in the bottom portions of the grooves, modification of the set value in accordance with the actual wall thickness (the above-described modification of the pattern) was terminated, and rolling of the next pierced blank to be rolled was carried out with the currently set values. In the #1 - #4 stands, rolling was carried out with the initially set rolling positions.

Example 2-2

[0099] In the #5 and #6 stands, rolling was carried out in the same manner as in Example 2-1, It was determined whether there was occurrence of the idle rolling phenomenon in the bottom portions of the grooves by comparing the amount of movement of the rolling positions of the grooved rolls and the amount of change of the actual wall thickness measured by the thickness gauge of the rolled blank in the directions of movement of the grooved rolls, and if the amount of change was not greater than 0.5 times the amount of movement, it was determined that the idle rolling phenomenon was occurring in the bottom portions of the grooves.

Example 2-3

[0100] In the #5 and #6 stands, when rolling the end portions of the next pierced blank to be rolled; the pattern shown in Figure 4 was modified based on the actual wall thickness measured by the thickness gauge, and rolling was carried out by moving the rolling positions of the grooved rolls outwards based on the modified pattern. In the #3 and #4 stands as well, rolling was carried out with the rolling positions of the grooved rolls moved outwards using the same pattern as for the #5 and #6 stands. In the #1 and #2 stands, rolling was carried out with the initially set rolling positions.

Example 2-4

[0101] In the #5 and #6 stands, rolling was carried out in the same manner as in Example 2-3. In the #3 and #4 stands, rolling was carried out with the amount of movement decreased to 0.8 times that of the pattern for the #5 and #6 stands. In the #1 and #2 stands, rolling was carried out with the initially set rolling positions.

Example 2-5

[0102] In the #5 and #6 stands, rolling was carried out in the same manner as in Example 2-3. In the #3 and #4 stands, the rolling positions of the grooved rolls were moved outwards prior to rolling the pierced blank so that the target wall thicknesses became 6.5 mm (#3 stand) and 6 mm (#4 stand), and then rolling was carried out. In the # 1 and #2 stands, rolling was carried out with the initially set rolling positions.

Example 2-6

[0103] In the #5 and #6 stands, rolling was carried out in the same manner as in Example 2-3. When the actual wall thickness was smaller than the target wall thickness, it was determined that the idle rolling phenomenon was occurring in the bottom portions of the grooves, and for the closest upstream stands to the finishing stands (#5 and #6 stands) having roll-reducing directions which are the same as the directions of wall thickness measurement for which the actual wall thickness was smaller than the target wall thickness (at least one of the #3 and #4 stands), rolling was carried out with the rolling positions of the grooved rolls moved outwards according to the same pattern as for the #5 and #6 stands. The #1 and #2 stands and one of the #3 and #4 stands, if any, for which the rolling positions of the grooved rolls were not moved, rolling was carried out with the initially set rolling positions.

Example 2-7

[0104] Rolling was carried out in the same manner as in Example 2-6. However, it was determined whether the idle rolling phenomenon was occurring in the bottom portions of the grooves by comparing the amount of movement of the rolling positions of the grooved rolls with the amount of change of the actual wall thickness of the resulting rolled blank measured by the thickness gauge in the directions of movement of the grooved rolls. If the amount of change was at most 0.5 times the amount of movement, it was determined that the idle rolling phenomenon was occurring in the bottom portions of the grooves.

Comparative Example 2

[0105] In the #5 and #6 stands only, when rolling the end portions of the next pierced blank to be rolled, the pattern shown in Figure 4 was modified based on the actual wall thickness measured by the thickness gauge, and the rolling positions of the grooved rolls were moved outwards according to the modified pattern. In the #1 - #4 stands, rolling was carried out using the initially set values.

Evaluation

[0106] For Examples 2-1 through 2-7 and Comparative Example 2, the rate of wall thickness defects in the resulting rolled blanks after rolling was evaluated. The rate of wall thickness defects was calculated using the above-described equation. The frequency with which the rolling positions of the grooved rolls installed in the #5 and #6 stands which are finishing stands were moved outwards by at least 1 mm from the initially set values was also evaluated. This frequency is an evaluation index corresponding to the frequency with which the grooved rolls in the finishing stands move endlessly outwards when the idle rolling phenomenon is occurring in the bottom portions of the grooves and the actual wall thickness has become smaller than the target wall thickness.

[0107] The results of evaluation are shown in Table 2.

Table 2

	Rate of wall thickness defects	Frequency of movement of rolling positions
Example 2-1	4%	4%
Example 2-2	4%	0%
Example 2-3	0%	0%
Example 2-4	0%	0%
Example 2-5	0%	0%
Example 2-6	1%	0%
Example 2-7	1%	0%
Comparative Example 2	5%	0%

[0108] It can be seen from Table 2 that for Examples 2-1 through 2-7, compared to Comparative Example 2, the end portions of a pierced blank could be accurately rolled to a desired wall thickness. In contrast to Comparative Example 2, endless outward movement of the grooved rolls of the finishing stands was prevented.

Industrial Applicability

[0109] When manufacturing a seamless tube using a mandrel mill, a pierced blank can be accurately rolled to a desired wall thickness for the entire length or a portion thereof such as the end portions.

Claims

1. A rolling control method for a mandrel mill having a plurality of rolling stands including a finishing stand by moving the rolling positions of first grooved rolls installed in the finishing stand outwards, **characterized in that** the rolling positions of second grooved rolls installed in the closest upstream stand to the finishing stand having the same roll-reducing directions as the finishing stand are previously moved outwards prior to rolling of the pierced blank.

2. A rolling control method for a mandrel mill having a plurality of rolling stands including a finishing stand by moving the rolling positions of first grooved rolls installed in the finishing stand outwards when rolling a pierced blank in the finishing stand, **characterized in that** a thickness gauge for measuring the wall thickness of the resulting rolled blank in the roll-reducing directions at each stand is installed on the exit side of the finishing stand, a previously set target wall thickness for the rolled blank in the finishing stand is compared with the actual wall thickness of the rolled blank measured by the thickness gauge, and when the actual wall thickness is smaller than the target wall thickness, movement of the rolling positions of the first grooved rolls is terminated for the next pierced blank to be rolled.

3. A rolling control method for a mandrel mill having a plurality of rolling stands including a finishing stand by moving the rolling positions of first grooved rolls installed in the finishing stand outwards, **characterized by** installing a thickness gauge which measures the wall thickness of a rolled blank on the exit side of the finishing stand, comparing the amount of movement of the rolling positions of the first grooved rolls with the amount of change of the actual wall thickness of the rolled blank measured by the thickness gauge in the directions of movement of the first grooved rolls, and terminating movement of the rolling positions of the first grooved rolls for the next pierced blank to be rolled if the amount of change in the actual wall thickness is smaller than the amount of movement of the rolling positions.

4. A rolling control method for a mandrel mill having a plurality of rolling stands including a finishing stand by moving the rolling positions of first grooved rolls installed in the finishing stand outwards, **characterized by** installing a thickness gauge which measures the wall thickness of a rolled blank on the exit side of the finishing stand, calculating the difference between the rolling positions after movement of the first grooved rolls for a pierced blank which was rolled this time and the rolling positions after movement of the first grooved rolls for the previously rolled pierced blank, calculating the difference between the actual wall thickness measured by the thickness gauge for the resulting rolled blank which was rolled this time in the directions of movement of the first grooved rolls and the actual wall thickness measured by the thickness gauge for the rolled blank which was rolled lastly in the directions of movement

of the first grooved rolls, comparing the difference in the rolling positions and the difference in the actual wall thickness, and terminating movement of the rolling positions of the first grooved rolls for the next pierced blank to be rolled if the difference in the actual wall thickness is smaller than the difference in the rolling positions.

5. A rolling control method for a mandrel mill having a plurality of rolling stands including a finishing stand by moving the rolling positions of first grooved rolls installed in the finishing stand outwards, **characterized by** installing a thickness gauge which measures the wall thickness of a rolled blank in the roll-reducing directions at each stand on the exit side of the finishing stand, comparing a target wall thickness for a rolled blank which was previously set for the finishing stand and the actual wall thickness of the resulting rolled blank measured by the thickness gauge, and if the actual wall thickness is smaller than the target wall thickness, when rolling the next pierced blank to be rolled, moving outwards the rolling positions of second grooved rolls installed in the closest upstream stand to the finishing stand having roll-reducing directions which are the same as the directions of wall thickness measurement for which the actual wall thickness was smaller than the target wall thickness in the same manner as for the first grooved rolls, or previously moving outwards the rolling positions of second grooved rolls installed in the closest upstream stand to the finishing stand having roll-reducing directions which are the same as the directions of wall thickness measurement for which the actual wall thickness was smaller than the target wall thickness prior to rolling the next pierced blank to be rolled.

6. A rolling control method for a mandrel mill having a plurality of rolling stands including a finishing stand by moving the rolling positions of first grooved rolls installed in the finishing stand outwards, **characterized by** installing a thickness gauge which measures the wall thickness of a rolled blank on the exit side of the finishing stand, comparing the amount of movement of the rolling positions of the first grooved rolls with the amount of change of the actual wall thickness measured by the thickness gauge of the rolled blank in the directions of movement of the first grooved rolls, and if the amount of change in the actual wall thickness is smaller than the amount of movement of the rolling positions, when rolling the next pierced blank to be rolled, moving outwards the rolling positions of second grooved rolls installed in the closest upstream stand to the finishing stand having roll-reducing directions which are the same as the directions of wall thickness measurement in the same manner as for the first grooved rolls, or previously moving outwards the rolling positions of the second grooved rolls installed in the closest upstream stand to the finishing stand having roll-reducing directions which are the same as the directions of wall thickness measurement prior to rolling the next pierced blank to be rolled.

7. A rolling control method for a mandrel mill having a plurality of rolling stands including a finishing stand by moving the rolling positions of first grooved rolls installed in the finishing stand outwards, **characterized by** installing a thickness gauge for measuring the wall thickness of a pierced blank on the exit side of the finishing stand, calculating the difference between the rolling positions after movement of the first grooved rolls for the pierced blank which was rolled this time and the rolling positions after movement of the first grooved rolls for the rolled blank which was rolled lastly, calculating the difference between the actual wall thickness measured by the thickness gauge for the rolled blank which was rolled this time in the directions of movement of the first grooved rolls and the actual wall thickness measured by the thickness gauge for the rolled blank which was rolled lastly in the directions of movement of the first grooved rolls, comparing the difference in the rolling positions and the difference in the actual wall thicknesses, and if the difference in the actual wall thickness is smaller than the difference in the rolling positions, when rolling the next pierced blank to be rolled, moving outwards the rolling positions of second grooved rolls installed in the closest upstream stand to the finishing stand having roll-reducing directions which are the same as the directions of wall thickness measurement in the same manner as for the first grooved rolls, or previously moving outwards the rolling positions of second grooved rolls installed in the closest upstream stand to the finishing stand having roll-reducing directions which are the same as the directions of wall thickness measurement prior to rolling the next pierced blank to be rolled.

8. A rolling control apparatus for a mandrel mill having a plurality of rolling stands including a finishing stand and comprising a first rolling position adjusting unit for adjusting the rolling positions of grooved rolls installed in the finishing stand, a second rolling position adjusting unit for adjusting the rolling positions of grooved rolls installed in the closest upstream stand to the finishing stand having the same roll-reducing directions as the finishing stand, and an arithmetic and control unit which instructs the first rolling position adjusting unit and the second rolling position adjusting unit as to an amount of adjustment of rolling positions for the grooved rolls in these stands, **characterized in that** the arithmetic and control unit carries out a rolling control method as set forth in claim 1 by instructing the first rolling position adjusting unit and the second rolling position adjusting unit as to an appropriate amount of adjustment of rolling positions depending on the portion of the pierced blank which is currently being rolled.

9. A rolling control apparatus for a mandrel mill having a plurality of rolling stands including a finishing stand and comprising a rolling position adjusting unit for adjusting the rolling positions of grooved rolls installed in the finishing stand and an arithmetic and control unit which instructs the rolling position adjusting unit as to an amount of adjustment of rolling positions for the grooved rolls, **characterized in that** the arithmetic and control unit is connected to a thickness gauge which is installed on the exit side of the finishing stand and which measures the wall thickness of the resulting rolled blank in the roll-reducing directions at each stand, and **in that** it carries out a rolling control method as set forth in any one of claims 2 - 4 by instructing the rolling position adjusting unit to terminate adjustment of rolling position depending on the output of the thickness gauge.

10. A rolling control apparatus for a mandrel mill having a plurality of rolling stands including a finishing stand and comprising a first rolling position adjusting unit for adjusting the rolling positions of grooved rolls installed in the finishing stand, a second rolling position adjusting unit for adjusting the rolling positions of grooved rolls installed in the closest upstream stand to the finishing stand having the same roll-reducing directions as the finishing stand, and an arithmetic and control unit which instructs the first rolling position adjusting unit and the second rolling position adjusting unit as to an appropriate amount of adjustment,
characterized in that the arithmetic and control unit is connected to a thickness gauge which is installed on the exit side of the finishing stand and which measures the wall thickness of the resulting rolled blank in the roll-reducing directions at each stand, and **in that** it carries out a rolling control method as set forth in any one of claims 5 - 7 by instructing the second rolling position adjusting unit as to an appropriate amount of adjustment based on the output of the thickness gauge and the portion of the pierced blank which is currently being rolled.

11. A rolling control program for operating an arithmetic and control unit which is connected to a first rolling position adjusting unit for adjusting the rolling positions of grooved rolls installed in a finishing stand among a plurality of rolling stands constituting a mandrel mill and to second rolling position adjusting unit for adjusting the rolling positions of grooved rolls installed in the closest upstream stand to the finishing stand having the same roll-reducing directions as the finishing stand and which instructs the first rolling position adjusting unit and the second rolling position adjusting unit as to an amount of adjustment of rolling positions for the grooved rolls,
characterized in that the arithmetic and control unit is operated so as to carry out a rolling control method as set forth in claim 1 by instructing the first rolling position adjusting unit and the second rolling position adjusting unit as to an appropriate amount of adjustment of rolling positions depending on the portion of the pierced blank which is currently being rolled.

12. A rolling control program for operating an arithmetic and control unit which is connected to a rolling position adjusting unit for adjusting the rolling positions of grooved rolls installed in a finishing stand among a plurality of rolling stands constituting a mandrel mill and to a thickness gauge installed on the exit side of the finishing stand for measuring the wall thickness of a rolled blank in the roll-reducing directions at each stand and which instructs the rolling position adjusting unit as to an amount of adjustment of rolling positions for the grooved rolls, **characterized in that** the arithmetic and control unit is operated so as to carry out a rolling control method as set forth in any one of claims 2 - 4 by instructing the rolling position adjusting unit to terminate adjustment of rolling position depending on the output of the thickness gauge.

13. A control program for operating an arithmetic and control unit which is connected to a first rolling position adjusting unit for adjusting the rolling positions of grooved rolls installed in a finishing stand among a plurality of rolling stands constituting a mandrel mill and to a second rolling position adjusting unit for adjusting the rolling positions of grooved rolls installed in the closest upstream stand to the finishing stand having the same roll-reducing directions as the finishing stand and to a thickness gauge installed on the exit side of the finishing stand for measuring the wall thickness of a rolled blank in the roll-reducing directions at each stand, and which instructs the first rolling position adjusting unit and the second rolling position adjusting unit as to an amount of adjustment, **characterized in that** the arithmetic and control unit is operated so as to carry out a rolling control method as set forth in any one of claims 5 - 7 by instructing the second rolling position adjusting unit as to an appropriate amount of adjustment depending on the output of the thickness gauge and the portion of the pierced blank which is currently being rolled.

14. A method of manufacturing a seamless tube using a mandrel mill which carries out the rolling control method as set forth in any of claims 1-7.

15. A rolling control method for a mandrel mill having a plurality of rolling stands including a finishing stand by moving the rolling positions of first grooved rolls installed in the finishing stand outwards, **characterized in that** when rolling a pierced blank in the closest upstream stand to the finishing stand having the same roll-reducing directions as the finishing stand, the rolling positions of second grooved rolls installed in the upstream stand are also moved outwards in the same manner as for the first grooved rolls.

Fig. 1

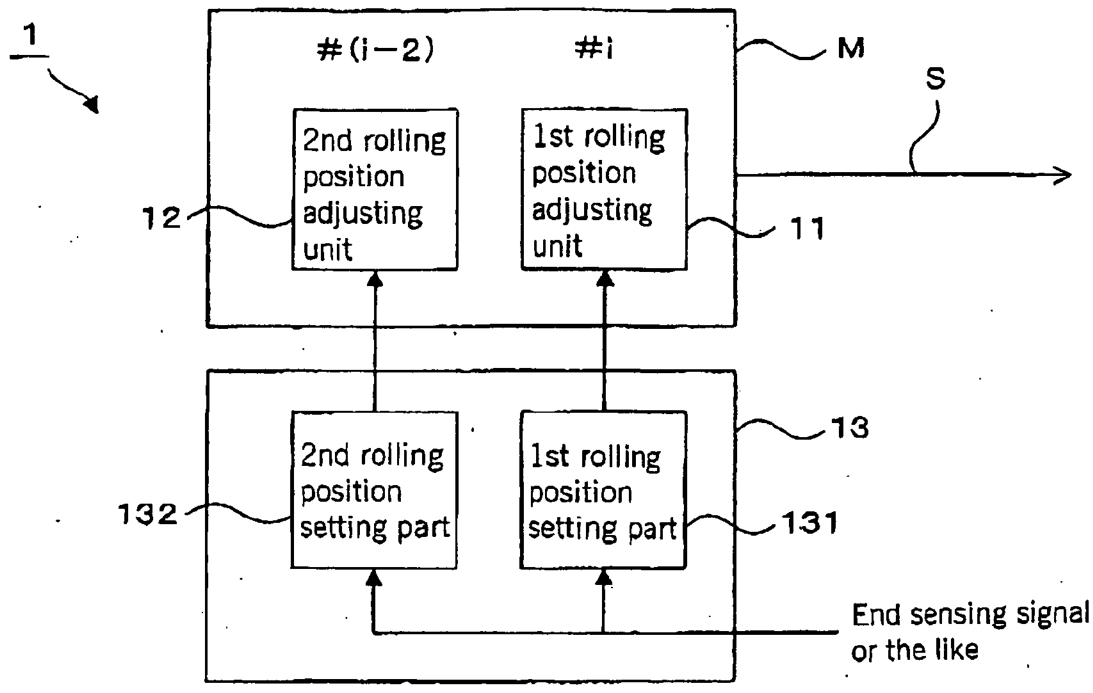

1
#(i−2)
#i
M
S
2nd rolling position adjusting unit
1st rolling position adjusting unit
12
11
13
2nd rolling position setting part
1st rolling position setting part
132
131
End sensing signal or the like

Fig. 2

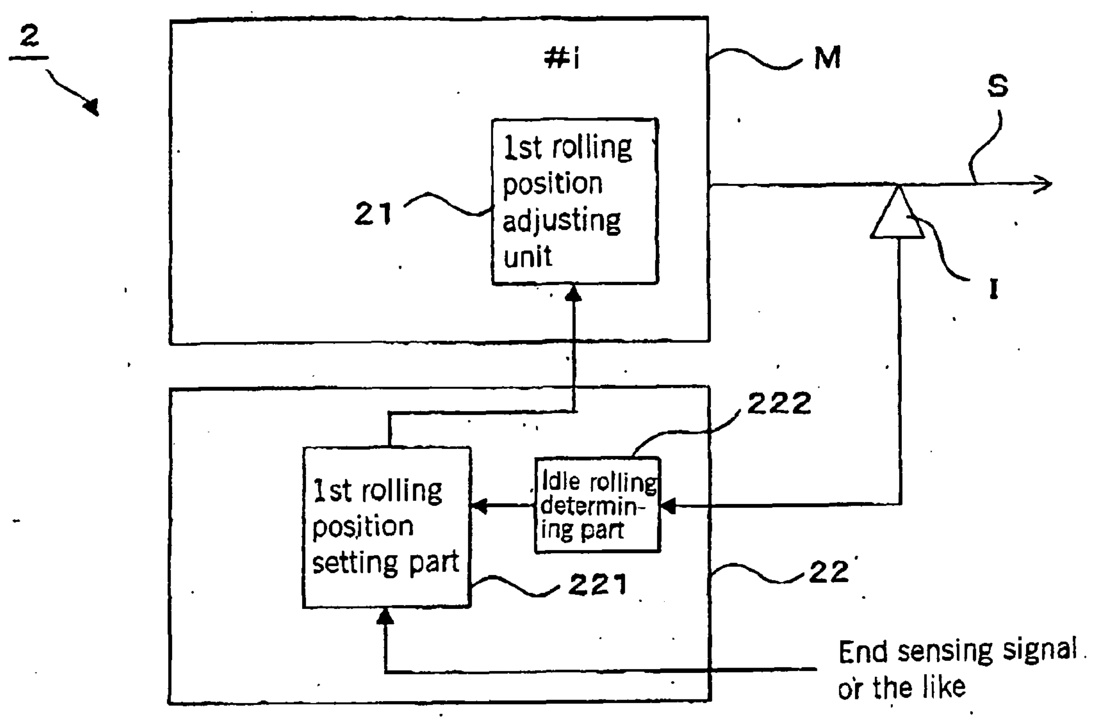

2
#i
M
S
1st rolling position adjusting unit
21
I
222
1st rolling position setting part
Idle rolling determin-ing part
221
22
End sensing signal or the like

Fig. 3

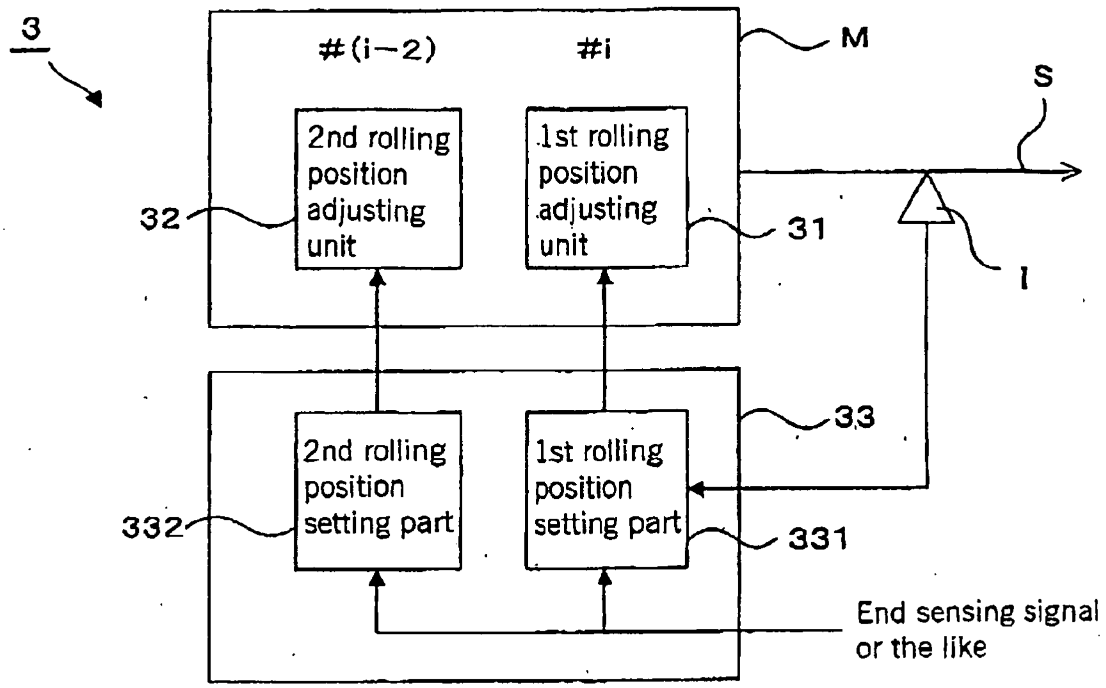
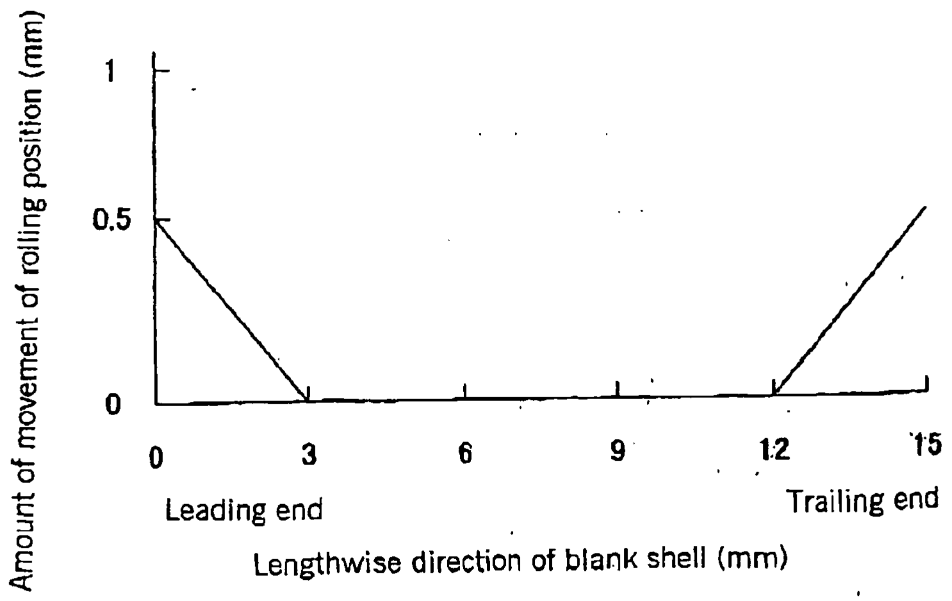

3
#(i−2)
#i
M
S
2nd rolling position adjusting unit
1st rolling position adjusting unit
32
31
I
33
2nd rolling position setting part
1st rolling position setting part
332
331
End sensing signal or the like

Fig. 4


Amount of movement of rolling position (mm)
1
0.5
0
0
3
6
9
12
15
Leading end
Trailing end
Lengthwise direction of blank shell (mm)

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EUROPEAN SEARCH REPORT

Application Number
EP 10 00 2571

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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			B21B

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	23 April 2010	Forciniti, Marco

CATEGORY OF CITED DOCUMENTS

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REFERENCES CITED IN THE DESCRIPTION

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- JP 8071616 A **[0007]**