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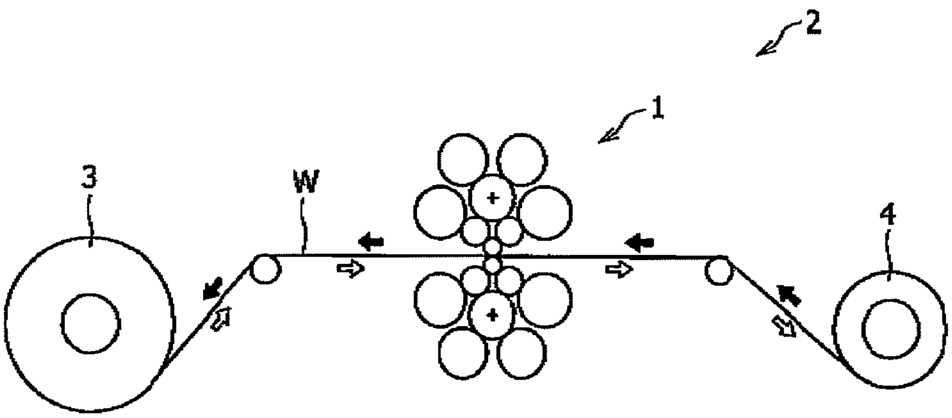
(54) Multi-high rolling mill

(57) In the multi-high rolling mill (1) according to the present invention, a pair of upper and lower work rolls (5) for rolling material (W) is disposed; two upper first intermediate rolls (7) and two lower first intermediate rolls (7) are disposed outside the upper and lower work rolls (5) respectively so as to contact with the work rolls (5); three upper rolls (6,8) and three lower rolls (6,8) are disposed outside the upper and lower first intermediate rolls (7) respectively to contact with the first intermediate rolls (7). A second intermediate roll (6) that is a center roll of the three rolls (6,8) is functioned as a drive roll, and two rolls (8) of the three rolls at both sides are functioned as first back-up rolls for supporting the first intermediate rolls (7). At least one upper second back-up roll (8) and at least one lower second back-up roll (8) are disposed outside the upper and lower second intermediate rolls (6,8) respectively to support the second intermediate rolls (6,8). According to such a structure, both productivity and satisfactory shape controllability can be attained in the multi-high rolling mill (1).

FIG. 1



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Description

BACKGROUND OF THE INVENTION

Field of the Invention:

[0001] The present invention relates to a multi-high rolling mill used for rolling of strip metal or the like.

Description of the Related Art:

[0002] As is well known, multi-high rolling mills are used in cold rolling of materials such as stainless, titanium, special steel and copper. As such multi-high rolling mills, generally, a "cluster type multi-high rolling mill" provided with a roll group for supporting a work roll, the roll group having a roll arrangement spreading out in a fan-like shape as a cluster of grape, is used.

[0003] The roll group for supporting a work roll includes back-up rolls and intermediate rolls, and it is known that the cluster type multi-high rolling mill is classified to types such as 12-high, 14-high and 20-high structures depending on the number of rolls used. The reason that the cluster type multi-high rolling mill is classified to such types is as follows.

[0004] The cluster type multi-high rolling mill is generally provided with a pair of upper and lower work rolls disposed on both surface sides of a material to roll the material. Roll groups for supporting the work rolls are disposed respectively on the upper side and lower side of the work rolls. When focusing attention on only the upper roll group, for example, since outer rolls are installed to prevent distortion of inner rolls in the roll group, it is common to gradually dispose more rolls according as it is more away from the work roll, such that, for example, two rolls are disposed just on the outside (upper side) of the upper work roll, and three on the further outside (upper side), and to set the diameter of the outer rolls to be larger than that of the inner rolls.

[0005] When three back-up rolls 108 are disposed on the upper side of an intermediate roll 106 as a drive roll, which is disposed just on the upper side of a work roll 105, as shown in Fig. 4(a), a multi-high rolling mill of 12-high structure is constituted. Further, when four back-up rolls 108 are disposed on the upper side of the intermediate roll (drive roll) 106, as shown in Fig. 4(b), a multi-high rolling mill of 14-high structure is constituted. On the other hand, when three second intermediate rolls are disposed on the upper side of two first intermediate rolls disposed just outside a work roll, two rolls of the three second intermediate rolls at both sides are functioned as drive rolls, and four back-up rolls are disposed on the upper side of the three second Intermediate rolls, a multi-high rolling mill of 20-high structure as shown in Fig. 4 (d) is constituted.

[0006] As the multi-high rolling mills of 12-high structure as described above, KT mill described in "R&D KOBE STEEL ENGINEERING REPORTS Vol. 58, No. 2, Aug. 2008 (refer to KT mill (12-high rolling mill) and KST mill (20-high rolling mill))" is known. As the multi-high rolling mill of 14-high structure, the one described in Japanese Patent Application Laid-Open No. 2004-136328 is known. And as the multi-high rolling mill of 20-high structure, KST mill described in the above-mentioned literature is known.

[0007] Recently, the demand for accuracy of rolled shape of strip metal products produced by multi-high rolling mills becomes stricter every year, and there is growing emphasis on the shape control performance of the multi-high rolling mills. Configuration and performance of a shape control actuator in a multi-high rolling mill is disclosed in pages 14 to 15 of the above-mentioned literature.

[0008] When the back-up rolls are particularly used as the shape control actuator, the shape of material is controlled via the intermediate rolls and the work roll.

[0009] To enhance the shape controllability, the lesser effect of roll flatness due to contact between rolls disposed intermediately is more preferred. Therefore, compared with the control of the shape of material from the back-up rolls via the second intermediate rolls, the first intermediate rolls and the work roll as in the 20-high rolling mill, the control of the shape of material from the back-up rolls via the intermediate rolls and the work roll as in the 12-high rolling mill or 14-high rolling mill is less affected by the roll flatness and high in the effect of shape control due to the smaller number of stages of intermediate rolls disposed intermediately

[0010] However, with respect to wide-width rolling of hard material which requires a high rolling torque, the 20-high rolling mill can more advantageously secure high productivity than the 12-high rolling mill or 14-high rolling mill, since higher torque can be transmitted due to the relation of space between drive rolls.

[0011] Comparing a 20-high rolling mill with a 12-high or 14-high rolling mill using work rolls with the same roll diameter as the 20-high rolling mill, the distance between drive rolls in the 12-high or 14-high rolling mill in which the intermediate rolls disposed just outside the work roll are functioned as drive rolls is small with respect to both vertical direction and lateral direction, compared with the 20-high rolling mill in which the second intermediate rolls at both sides are functioned as drive rolls (refer to Fig. 4 of the present specification).

[0012] As a result, in the 12-high or 14-high rolling mill smaller in the distance between drive rolls, limitation of a space for installing a drive system of the drive rolls makes it difficult to transmit a drive torque equivalent to that in the 20-high rolling mill.

[0013] Although universal spindles of further large size can be adopted also in the 12-high or 14-high rolling mill to increase the transmittable drive torque, for example, by varying the positions in width direction (transverse direction of Fig. 5 in the present specification) of cross parts of universal spindles for transmitting the drive torque, the transmittable drive torque falls short of that in the 20-high rolling mill even by using this technique.

[0014] Therefore, when hard wide-width material, for example, hard stainless material with wide-width as large as 1300-1600 mm and relatively large thickness of 4-5 mm is rolled at a high rolling reduction rate of about 25% or more per pass, the 20-high rolling mill is used at the expense of shape controllability.

SUMMARY OF THE INVENTION

[0015] The present invention has been achieved to solve the above-mentioned problem. An object of the present invention is to provide a multi-high rolling mill which has satisfactory shape controlling capability equal to those of the 12-high and 14-high rolling mills, and also has a drive torque equal to or higher than that in the 20-high rolling mill.

[0016] In order to attain the above object, the multi-high rolling mill according to the present invention takes the following technical means.

[0017] The multi-high rolling mill according to the present invention includes: a pair of upper and lower work rolls for rolling material; two upper first intermediate rolls and two lower first intermediate rolls, disposed outside the upper and lower work rolls respectively so as to contact with the work rolls; three upper rolls and three lower rolls, disposed outside the upper and lower first intermediate rolls respectively to contact with the first intermediate rolls, a center roll of the three rolls being a second intermediate roll as a drive roll, and two rolls of the three rolls at both sides being first back-up rolls for supporting the first intermediate rolls; and one or more upper second back-up rolls and one or more lower second back-up rolls, disposed outside the upper and lower second intermediate rolls respectively to support the second intermediate rolls.

[0018] The present inventors thought that not the two rolls disposed outside the work roll but any one of the three rolls disposed further outside the two rolls could be driven as drive roll. As a result, the present inventors found that both productivity and shape controlling performance can be attained by driving the center roll of the three rolls and providing back-up rolls for the roll to be driven, and completed the present invention.

[0019] Namely, instead of four first intermediate rolls used as drive rolls in conventional 12-high and 14-high rolling mills, two second intermediate rolls are functioned as the drive rolls, whereby the distance between the drive rolls is extended, in the vertical direction. Further since two upper drive rolls and two lower drive rolls in the lateral direction that were used before are reduced to one upper drive roll and one lower drive roll, a sufficient space can be secured also in the lateral direction. Therefore, universal spindles with large swing diameter can be adopted and, consequently, a drive torque equal to or higher than that in the 20-high rolling mill can be applied.

[0020] A drive torque equal to that in the multi-high rolling mill as described above may be able to be obtained if the central back-up roll of the 12-high rolling mill is driven. In this case, however, the central back-up roll of the 12-high, rolling mill must be composed of not a width-directionally divided roll including a plurality of bearings and saddles but an integrated roll similarly to the intermediate roll of the 12-high rolling mill for drive.

[0021] When the central back-up roll is thus constituted, work roll distortion is increased since the center back-up roll is not supported in a housing With a plurality of saddles in the width direction, and it becomes difficult to secure a satisfactory plate shape. It is disclosed, for example, in pages 60 to 61 of "R&D KOBE STEEL ENGINEERING REPORTS Vo. 59, No. 2, Aug. 2009" that reduced work roll distortion of multi-high rolling mill is attributable to a structure such that the back-up roll is composed of a divided roll, and saddles provided on the divided roll are supported in the housing in the width direction.

[0022] Further, since a crown control device that is an actuator for shape control can be installed also in the multi-high rolling mill of the present invention by applying the same structure as the back-up rolls of the conventional 12-high or 14-high rolling mill to first back-up rolls that are two of the three rolls at both sides, three rolls being just outside the first intermediate rolls, the multi-high rolling mill of the present invention can maintain satisfactory shape controllability of the 12-high and 14-high rolling mills.

[0023] In the multi-high rolling mill as described above, since the second intermediate roll is constituted as the integrated roll to be used as the drive roll, the work roll distortion must be minimized by installing a width-directionally divided second back-up roll including a plurality of bearings and saddles on the outside of the second intermediate roll.

[0024] The multi-high rolling mill can be constituted as a 16-high structure by providing two of the upper second back-up rolls and two of the lower second back-up rolls outside the upper and lower second intermediate rolls respectively.

[0025] The multi-high rolling mill can be constituted as a 14-high structure by providing one of the upper second back-up roll and one of the lower second back-up roll outside the upper and lower second intermediate rolls respectively.

[0026] By using the multi-high rolling mill of the present invention, even the above-mentioned hard wide-width material can be rolled at a high rolling reduction rate with a drive torque equal to or higher than that in the 20-high rolling mill while maintaining the shape controllability of the conventional 12-high and 14-high rolling mills.

BRIEF DESCRIPTION OF THE DRAWINGS

[0027]

Fig. 1 is a front view schematically showing a rolling device provided with a multi-high rolling mill according to the present invention;

Fig. 2 is a view showing a roll arrangement of a multi-high rolling mill according to one preferred embodiment;

Fig. 3 is a view showing a roll arrangement of a multi-high rolling mill according to another preferred embodiment;

Figs. 4 are views comparatively showing roll arrangement examples of conventional multi-high rolling mills and an arrangement example of a first embodiment of the present invention, using the same work roll diameter, wherein (a) shows a 12-high structure, (b) a 14-high structure, (c) a 16-high structure related to the arrangement example of the first embodiment of the present invention, and (d) a 20-high structure; and

Fig. 5 is a view showing an example of a drive system for driving intermediate rolls in conventional multi-high rolling mills (12-high and 14-high).

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0028] A preferred embodiment of a multi-high rolling mill 1 according to the present invention will be described in reference to the drawings.

[0029] Firstly, a rolling device 2 provided with the multi-high rolling mill 1 will be exemplified to describe the multi-high rolling mill 1 of the present invention in detail.

[0030] As shown in Fig. 1, the rolling device 2 includes a feed part 3 for unwinding a material W to be rolled; a take-up part 4 for rewinding the rolled material W; and the multi-high rolling mill 1 for rolling the material W, which is provided between the feed part 3 and the take-up part 4. The rolling device 2 is configured so that reverse rolling can be performed to the material W while normally and reversely switching plate passing direction (while reversing the plate passing direction between the blackened arrow and the blanked arrow in Fig. 1).

[0031] The multi-high rolling mill 1 of the present invention, which is constituted, as shown in Fig. 2, by combining a plurality of work rolls 5, second intermediate rolls (drive rolls) 6, first intermediate rolls 7 and back-up rolls 8, is called a cluster type multi-high, rolling mill since a combination form of the plurality of rolls looks like just a cluster of grape, and is used to roll a sheet-like material W of stainless, titanium, special steel, cupper or the like.

[0032] The vertical direction on the paper surface of Fig. 2 corresponds to vertical direction in description for the multi-high rolling mill 1. The lateral direction on the paper surface of Fig. 2 corresponds to lateral direction in description for the multi-high rolling mill 1. These directions match the directions when the multi-high rolling mill 1 is viewed from a drive side. In the following description, the same reference number is assigned to the same component. Such same components have the same name and the same function. Therefore, detailed description for these components is not repeated.

[0033] Each roll constituting the multi-high rolling mill 1 will be described.

[0034] The multi-high rolling mill 1 includes a plurality of rolls (hereinafter, the plurality of rolls is referred to as a roll group 9), which is arranged, on the basis of a material W to be horizontally transferred at the center in vertical direction, each on the upper side and lower side of the material W so as to be a mirror image (symmetric). In the following description, the roll group 9 on the upper side is taken as a typical example to illustrate each roll constituting the roll group.

[0035] The roll group 9 on the upper side is composed of one work roll 5, two first intermediate rolls 7, one second intermediate roll (drive roll) 6, and four back-up rolls 8, and the multi-high rolling mill 1 of this embodiment has a 16-high structure.

[0036] As shown in Fig. 2, the work roll 5 is a roll smaller in diameter than other rolls, which is formed in a diameter of about 20 to 100 mmφ, for example, for a facility for cold-rolling stainless material W. The work roll 5 is constituted as a pair of upper and lower rolls, so that rolling load can be applied to the material W while holding it between both the rolls.

[0037] First intermediate rolls 7L and 7R are rolls to be disposed adjacently to the left upper side and right upper side (the outside) of the work roll 5 respectively, and the two rolls are arranged with a space from each other. The first intermediate rolls 7L are 7R are larger in diameter than the work roll 5, and disposed so that the respective outer circumferential surfaces contact with the outer circumferential surface of the work roll 5. The second intermediate roll (drive roll) 6 is disposed on the upper side of the first intermediate rolls 7L and 7R, so that a drive force of the second intermediate roll (drive roll) 6 can be transmitted to the work roll 5 through the first intermediate rolls 7L and 7R.

[0038] The second intermediate roll (drive roll) 6 is disposed on the right upper side as viewed from the left intermediate roll 7L and on the left upper side as viewed from the right intermediate roll 7R so as to contact with the left and right mat intermediate rolls 7L and 7R, and provided singly for each roll group 9. The second intermediate roll (drive roll) 6 is a roll further larger in diameter than the first intermediate rolls 7L and 7R, and is provided to be rotatable around a shaft center. The second intermediate roll (drive roll) 6 is configured to be rotatably driven by a drive force generated in a motor by connecting a universal spindle not shown to a shaft end portion thereof.

[0039] • The back-up rolls 8 are disposed on the further outside of the second intermediate roll (drive roll) 6 and the first intermediate rolls 7L and 7R on the basis of the above-mentioned work roll 5 to support these rolls. The back-up rolls 8 include first back-up rolls 10L and 10R for supporting the first intermediate rolls 7 and second back-up rolls 11L and 11R for supporting the second intermediate roll (drive roll) 6.

[0040] The first back-up rolls 10L and 10R are rolls to be disposed respectively on the left upper side as viewed from the left intermediate roll 7L and on the right upper side as viewed from the right first intermediate roll 7R, and each of these rolls is formed to be larger in diameter than the first intermediate rolls 7L and 7R. The first back-up rolls 10L and 10R are disposed respectively with a space from the second intermediate roll (drive roll) 6, and the gap formed between the left first back-up roll 10L and the second intermediate roll (drive roll) 6 is set to be substantially equal to the gap formed between the right first back-up roll 10R and the second intermediate roll (drive roll) 6. The left first back-up roll 10L and the right first back-up roll 10R are in contact with the left first intermediate roll 7L and the right first intermediate roll 7R respectively, so that the first intermediate rolls 7L and 7R can be supported with pressure from above.

[0041] The second back-up rolls 11L and 11R are disposed respectively on the left upper side and the right upper side as viewed from the second intermediate roll (drive roll) 6. Each of the second back-up rolls 11L and 11R is in contact with the upper side of the second intermediate roll (drive roll) 6 to support the second intermediate roll (drive roll) 6 with pressure from above.

[0042] The function effects of the multi-high rolling mill of the present invention will be described while comparing with conventional multi-high rolling mills 101 shown in Figs. 4 to 5. The function effects which will be described below are based on comparison between multi-high rolling mills having work rolls with the same diameter, and each of the multi-high rolling mills of 12-high, 14-high and 20-high structures shown in Fig. 4 is provided with work rolls having the same diameter as those in the multi-high rolling mill 1 of the present invention.

[0043] In the multi-high rolling mill 101 of 12-high structure shown in Fig. 4(a), for example, two intermediate rolls 106 are disposed just outside a work roll 105, and three back-up rolls 108 are disposed outside the two intermediate rolls 106. In the multi-high rolling mill 101 of 14-high structure shown in Fig. 4(b), also, two intermediate rolls 106 are provided just outside the work roll 105 although the number of back-up rolls 108 is four, and both the rolling mills are the same in the point that the intermediate rolls 106 just outside the work roll 105 are driven as drive rolls.

[0044] In such a structure that the intermediate rolls 106 just outside the work rolls 105 are driven as drive rolls, also the distance between drive rolls is naturally apt to be small both in the vertical direction and in the lateral direction. To cite the vertical distances between drive rolls, for example, the distances in these mills are extremely small as shown by L2 and L3. Since universal spindles are provided at shaft end portions of these intermediate rolls 106 to be driven as drive rolls to transmit drive forces to the intermediate rolls 106, mutual interference of respective cross parts of the universal spindles can prevent the rotation of the universal spindles if the universal spindles are mutually rotated within such a narrow distance L2, L3 as described above. Therefor, in the multi-high rolling mill 101 of 12-high or 14-high structure, the axial positions of the cross parts of the universal spindles are often mutually shifted (arranged in a so-called zigzag form) as shown in Fig. 5, so that the universal spindles can be mutually rotated without vertical or lateral interference.

[0045] On the other hand, when the second intermediate roll 6 is functioned as the drive roll as in the multi-high rolling mill 1 of the present invention shown in Fig. 4(c), the distance L1 between the second intermediate rolls (drive rolls) 6, 6 is wider (L1>L2, L3), and the lateral interference between universal joints is also eliminated. Therefore, universal spindles with large swing diameter can be adopted to give a large drive torque to the second intermediate roll (drive roll) 6. Consequently, material which is difficult to roll with the multi-high rolling mill 101 of 12-high or 14-high structure, for example, a stainless steel plate with wide width of 1800-1600 mm and large thickness of 4-5 mm, can be rolled at a high rolling reduction rate of about 25% or more per pass by giving the large drive torque to the second intermediate rolls (drive roll) 6.

[0046] Compared with the conventional rolling mill of 12-high or 14-high structure using the four first intermediate rolls 106 as drive rolls, the multi-high rolling mill 1 of the present invention uses two second intermediate rolls 6 (one each for upper side and lower side) as the drive rolls. According to this, the distance between the second intermediate rolls (drive rolls) 6 can be extended in the vertical direction. Further, since two upper drive rolls and two lower drive rolls in the lateral direction that were used in the conventional 12-high rolling mill or 14-high rolling mill are reduced to one upper drive roll and one lower drive roll in the multi-high rolling mill 1 of the present invention, a sufficient space can be secured also in the lateral direction. Therefore, universal spindles with large swing diameter can be adopted and, consequently, a drive torque equal to or higher than that in the 20-high rolling mill can be applied.

[0047] Since the center roll which functioned as the back-up roll 108 in the multi-high rolling mill 101 of 12-high structure is used as the drive roll in the multi-high rolling mill 1 of the present invention as descried above, 6 in Fig. 2 is composed of an integrated roll. Therefore, a width-directionally divided second back-up roll including a plurality of bearings and saddles must be installed, as shown in Fig. 2 or Fig. 3, on the outside of this roll to minimize the work roll distortion.

[0048] In the multi-high rolling mill 101 of 20-high structure shown in Fig. 4(d), two intermediate rolls 107 are disposed just outside the work roll 105, three rolls are disposed outside the two intermediate rolls 107, and intermediate rolls 106 that are two of three rolls at both sides are functioned as two drive rolls. Namely, since the vertical distance L4 between the intermediate rolls (drive rolls) 106 in the multi-high rolling mill 101 of 20-high structure is larger than that in the multi-high rolling mill 101 of 12-high or 14-high structure (L1≥L4>L2, L3), and the lateral space is also larger than that in the 12-high or 14-

high structure, a universal spindle with large swing diameter can be directly connected to the intermediate roll (drive roll) 106 without adoption of zigzag arrangement or the like, and a larger drive torque can be applied to the intermediate roll (drive roll) 106 than that in the multi-high rolling mill 101 of 12-high or 14-high structure.

[0049] However, in the multi-high rolling mill 101 of 20-high structure, three rolls are disposed outside the intermediate rolls 107, two of the three rolls at both sides are functioned as intermediate rolls (drive rolls) 106, and four back-up rolls 108 are arranged further outside these intermediate rolls (drive rolls) 106. Therefore, when shape control (crown control) is performed by the back-up rolls, the number of contact points between rolls which exist in the path from the back-up roll 108 on the upper outer side to the work roll 105 (shown by black dots in Figs. 4 (a), (b) and (d)) are three each on left side and right side in the multi-high rolling mill 101 of 20-high structure, in contrast to two each on left side and right side in the multi-high rolling mill 101 of 12-high or 14-high structure. In this way, the multi-high rolling mill 101 of 20-high structure is highly susceptible to the influence of elastic deformation in the contact points between rolls, and inferior in shape controllability. In the present invention, the shape control (crown control) is performed by the first back-up rolls 10L and 10R. Therefore, in the multi-high rolling mill of the present invention, the number of contact points between rolls in the path from the first back-up roll 10L, 10R to the work roll 5 is reduced to two as shown in Fig. 4(c), and excellent shape controllability can be secured, compared with the multi-high rolling mill 101 of 20-high structure.

[0050] In the multi-high rolling mill 101 of 20-high structure, the diameter of the first intermediate roll 107 is small because of the size balance between respective rolls, compared with the intermediate rolls of the multi-high rolling mill 101 of 12-high or 14-high structure and the multi-high rolling mill 1 of the present invention, and the resulting narrowed space restricts the size of thrust bearing or the like. Therefore, in shape control by the intermediate rolls (lateral adjusting device) by shifting the intermediate rolls in the axial direction, the lateral moving speed in the multi-high rolling mill 101 of 20-high structure is restricted more strictly than in the multi-high rolling mill of 12-high or 14-high structure and the multi-high rolling mill of the present invention to prevent rapid shape control, since the drive force of the first intermediate rolls 107 is limited in the multi-high rolling mill 101 of 20-high structure.

[0051] As just described, in the shape control (crown control) by the back-up rolls, the 20-high rolling mill is inferior in shape controllability due to the larger number of contact points between rolls than in the 12-high or 14-high rolling mill and the multi-high rolling mill of the present invention. In the shape control by the intermediate rolls which contact the work roll (lateral adjustment), also, the 20-high rolling mill 101 with the smaller intermediate roll diameter is inferior in controlling capability of rolled shape to the 12-high or 14-high rolling mill and the multi-high rolling mill of the present invention.

[0052] On the other hand, in the multi-high rolling mill 1 of the present invention, the material W can be rolled in a satisfactory condition while surely controlling the rolled shape.

EXAMPLES

[0053] The function effects of the present invention will be described in more detail by comparing Example using a multi-high rolling mill 1 of 16-high structure with Comparative Example 1 and Comparative Example 2 using multi-high rolling mills 101 of 12-high and 20-high structures respectively, while taking the fatigue strength of a universal spindle which can use a drive torque transmittable to each multi-high rolling mill 1 for the comparison, for example.

[0054] In Example, Comparative Example 1 and Comparative Example 2 to be described below, the multi-high rolling mills were compared with respect to drive torque on the same basis using work rolls with the same diameter (30 mmφ).

[0055] Although the universal spindle is cited, for example, as the means for transmitting drive torque, other drive torque transmitting means such as a gear spindle may be used.

[Comparative Example 1]

[0056] The multi-high rolling mill 101 of Comparative Example 1 as shown in Fig. 4(a) is a multi-high rolling mill of 12-high structure in which two intermediate rolls (drive rolls) 106 are provided just outside a work roll 105 with 30 mmφ. In this case, since the distance between the intermediate rolls (drive rolls) 106 is extremely small both in the vertical direction and in the lateral direction, four universal joints must be disposed within an extremely small space. Therefore, only a spindle with maximum 100 mm spindle diameter can be used as the universal spindle even when the zigzag arrangement of spindles is adopted.

[0057] Since the fatigue torque in twisting direction of this spindle with 100 mm swing diameter is 160 Kgm/piece, the drive torque transmitted, to the multi-high rolling mill 101 is only 640 Kgm at a maximum even if the four spindles evenly transmit the drive torque.

[Comparative Example 2]

[0058] The multi-high rolling mill 101 of Comparative Example 2 as shown in Fig. 4(d) is a multi-high rolling mill of 20-high structure in which two intermediate rolls 106 as drive rolls are provided just outside a work roll 105 with 30 mmφ through intermediate rolls 107. In this case, since the distance between the intermediate rolls 106 as drive rolls is extended both in the vertical direction and in the lateral direction, a spindle with maximum 125 mm swing diameter can be used as the universal spindle.

[0059] Since the fatigue torque in twisting direction of this spindle with 125 mm swing diameter is 280 Kgm/piece, the drive torque transmitted to the multi-high rolling mill 101 is 1120 Kgm if the four spindles evenly transmit the torque, and a drive torque a little under twice that in Comparative Example 1 can be generated.

[Example]

[0060] In contrast to Comparative Example 1 and Comparative Example 2 described above, the multi-high rolling mill of Example 1 is a multi-high rolling mill of 16-high structure in which two first intermediate rolls 7 are provided between a work roll 5 and a second intermediate roll 6 as a drive roll, and only the central one of three rolls located just outside the two first intermediate rolls 7 is functioned as the second intermediate roll 6 as the drive roll as shown in Fig. 4(c). In this case, since a wide distance can be secured in the vertical direction between the second intermediate rolls (drive rolls) 6, and only one drive roll is present in the lateral direction, no dimensional restriction is present.

[0061] Therefore, a spindle with 180 mm swing diameter which was difficult to use in Comparative Example 1 and Comparative Example 2 can be adopted.

[0062] Since the fatigue torque in twisting direction of this spindle with 180 mm swing diameter is 1500 Kgm/piece, the drive torque transmitted to the multi-high rolling mill 1 is 3000 Kgm in spite of only two spindles. Namely, a drive torque about 4.6 times that of Comparative Example 1 and about three times that of Comparative Example 2 can be transmitted.

[0063] Although the multi-high rolling mill (20-high) of Comparative Example 2 has the same effect that a wide distance can be secured between the drive rolls in the vertical direction, the intermediate rolls (drive rolls) 106 are juxtaposed in the lateral direction in Comparative Example 2, and the intermediate roll 107 or a spindle support member must be provided between the intermediate rolls (drive rolls) 106. In the multi-high rolling mill of Comparative Example 2, it is thus difficult to sufficiently secure a space for installing the universal spindles in the lateral direction. Consequently, a spindle with swing diameter as large as 180 mm as in Example cannot be attached, and the transmittable drive torque is not as large as in the multi-high rolling mill 1 of Example.

[0064] In both Comparative Example 1 and Comparative Example 2, the number of spindles used in the multi-high rolling mill 101 is four, and particularly in Comparative Example 1, two types of spindles are needed for the zigzag arrangement of spindles. Therefore, the multi-high rolling mills of Comparative Examples are inferior in the point of spare retention and maintenance, compared with the multi-high rolling mill 1 of Example using only two spindles of the same type.

[0065] The embodiment disclosed herein should be considered to be only exemplary but not restrictive in every point. The scope of the present invention is shown not by the above-mentioned description but by the appended claims, and all changes that fall within the meaning and bounds that are equivalent to the claims are therefore intended to be embraced by the claims.

[0066] The number of second back-up rolls 11 may be one although two second back-up rolls 11 are provided per second intermediate roll (drive roll) 6 in the above-mentioned embodiment. In this case, as shown in Fig. 3, the second back-up roll 11 can be disposed so that the rotation axis of the second back-up roll 11 is located on a line connecting the rotation axis of the work roll 5 to the rotation axis of the second intermediate roll (drive roll) 6.

[0067] In the multi-high rolling mill according to the present invention, a pair of upper and lower work rolls for rolling material W is disposed; two upper first intermediate rolls and two lower first intermediate rolls are disposed outside the upper and lower work rolls respectively so as to contact with the work rolls; three upper rolls and three lower rolls are disposed outside the upper and lower first intermediate rolls respectively to contact with the first intermediate rolls. A second intermediate roll that is a center roll of the three rolls is functioned as a drive roll, and two rolls of the three rolls at both sides are functioned as first back-up rolls for supporting the first intermediate rolls. At least one upper second back-up roll and at least one lower second back-up roll are disposed outside the upper and lower second intermediate rolls respectively to support the second intermediate rolls. According to such a structure, both productivity and satisfactory shape controllability can be attained in the multi-high rolling mill.

Claims

1. A multi-high rolling mill, comprising:

a pair of upper and lower work rolls for rolling material;
two upper first intermediate rolls and two lower first intermediate rolls, disposed outside said upper and lower work rolls respectively so as to contact with said work rolls;
three upper rolls and three lower rolls, disposed outside said upper and lower first intermediate rolls respectively to contact with said first intermediate rolls, a center roll of said three rolls being a second intermediate roll as a drive roll, and two rolls of said three rolls at both sides being first back-up rolls for supporting said first intermediate rolls; and
one or more upper second back-up rolls and one or more lower second back-up rolls, disposed outside said upper and lower second intermediate rolls respectively to support said second intermediate rolls.

2. The multi-high rolling mill according to claim 1, constituted as a 16-high structure by providing two of said upper second back-up rolls and two of said lower second back-up rolls outside said upper and lower second intermediate rolls respectively.

3. The multi-high rolling mill according to claim 1, constituted as a 14-high structure by providing one of said upper second back-up roll and one of said lower second back-up roll outside said upper and lower second intermediate rolls respectively.

4. The multi-high rolling mill according to claim 1, constituted to perform shape control of crown control with said first back-up rolls.

5. The multi-high rolling mill according to claim 1, wherein said first intermediate rolls are larger in diameter than said work rolls, and said second intermediate rolls and said first back-up rolls are larger in diameter than said first intermediate rolls.

FIG. 1

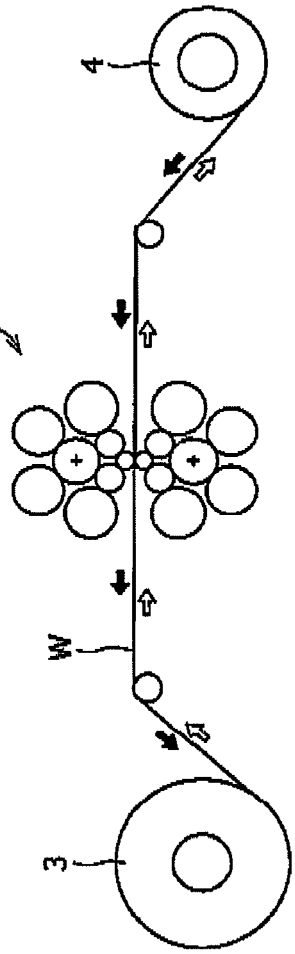


FIG. 2

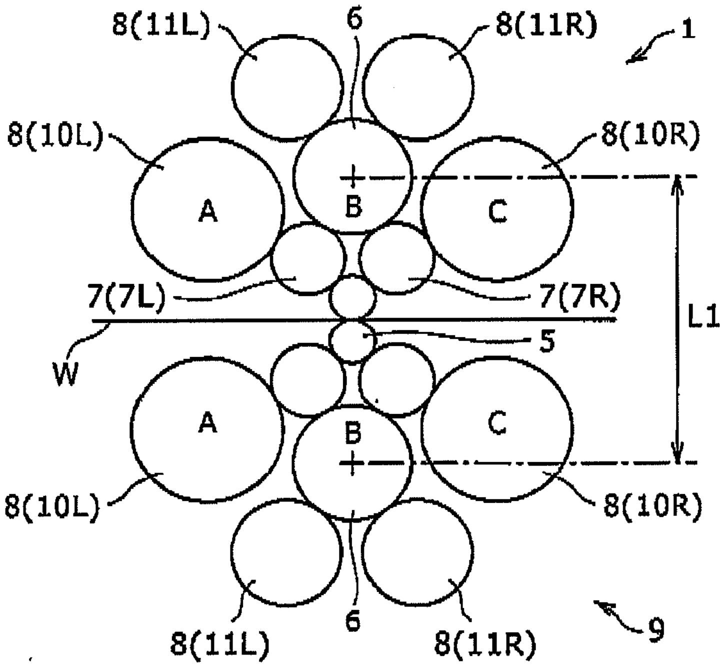
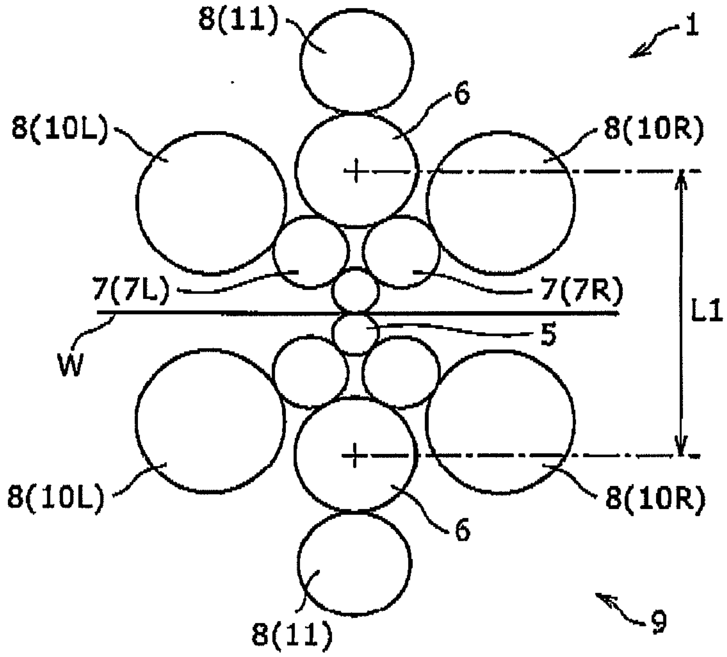

8(11L)
6
8(11R)
1
8(10L)
8(10R)
A
B
C
7(7L)
7(7R)
L1
W
5
A
B
C
8(10L)
8(10R)
8(11L)
6
8(11R)
9

FIG. 3



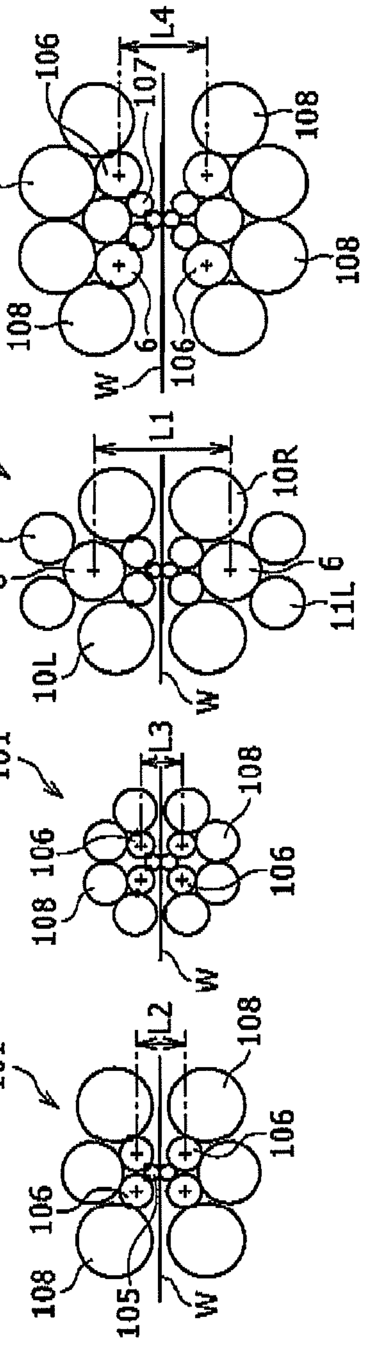


FIG.4A FIG.4B FIG.4C FIG.4D

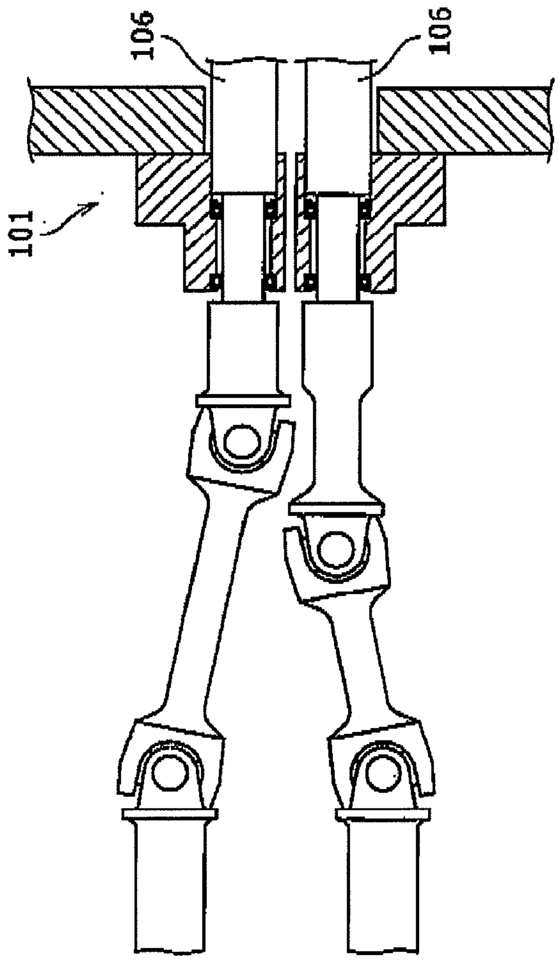


FIG. 5

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EUROPEAN SEARCH REPORT

Application Number
EP 11 15 4782

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

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	21 July 2011	Jeggy, Thierry

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