



(19) United States

(12) Patent Application Publication

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(10) Pub. No.: US 2003/0177807 A1

(43) Pub. Date: Sep. 25, 2003

(54) METHOD TO CONTROL THE AXIAL FORCES GENERATED BETWEEN THE ROLLING ROLLS

Publication Classification

(51) Int. Cl.⁷ B21B 31/07
(52) U.S. Cl. 72/247

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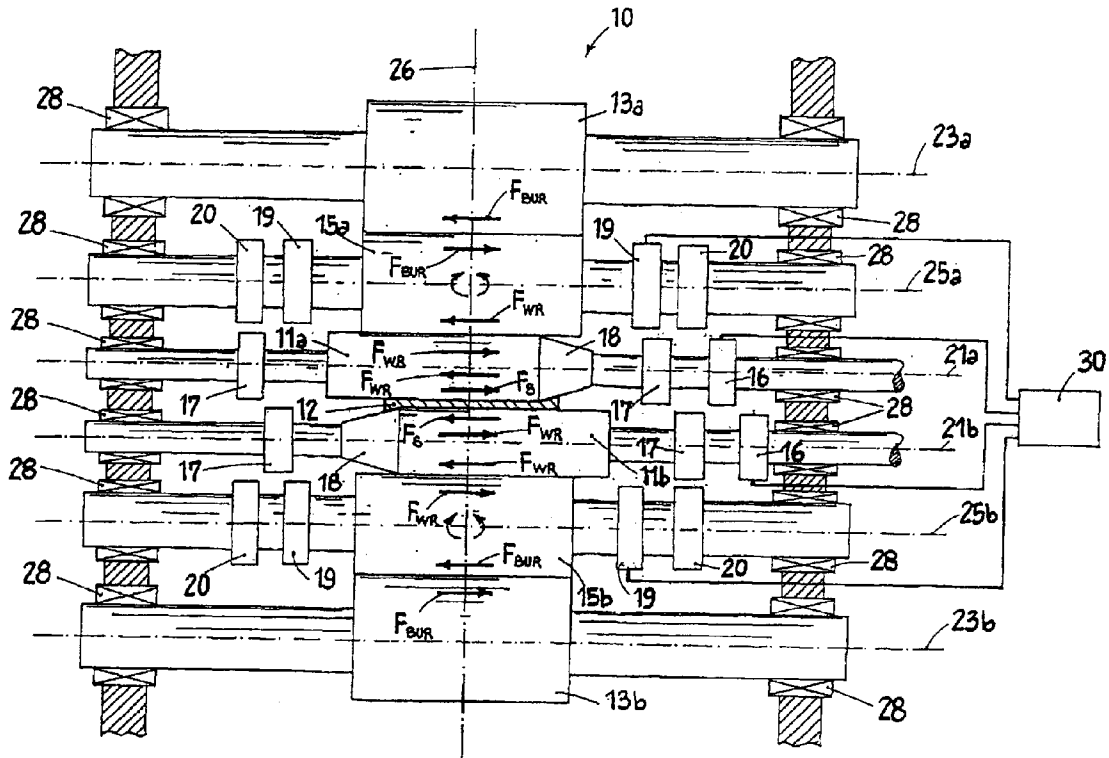
(21) Appl. No.: 10/381,098
(22) PCT Filed: Sep. 24, 2001
(86) PCT No.: PCT/IB01/01740

(30) Foreign Application Priority Data

Sep. 25, 2000 (IT) UD2000 A 000176

(57) ABSTRACT

Method to control the axial forces generated between the rolls in a rolling stand (10) for plane products (12) having at least a pair of working rolls (11a, 11b), a corresponding pair of back-up rolls (13a, 13b) and at least an intermediate roll (15a) located between one of the working rolls (11a) and a corresponding back-up roll (13b), axial translation means (16) associated with the working rolls (11a) to translate them axially (WR shifting), crossing means (19) associated with the intermediate roll (15a) to arrange it with its longitudinal axis (25a) inclined (IR crossing), that is, rotated on a horizontal plane by a set angle (α) with respect to the longitudinal axes (21a, 21b, 23a, 23b) of the working rolls (11a, 11b) and of the back-up rolls (13a, 13b); according to this method the WR shifting and the IR crossing are controlled by control means (30) so as to reduce to a minimum the axial forces generated in the working rolls (11a, 11b), and consequently the axial load on the corresponding thrust bearings (28).



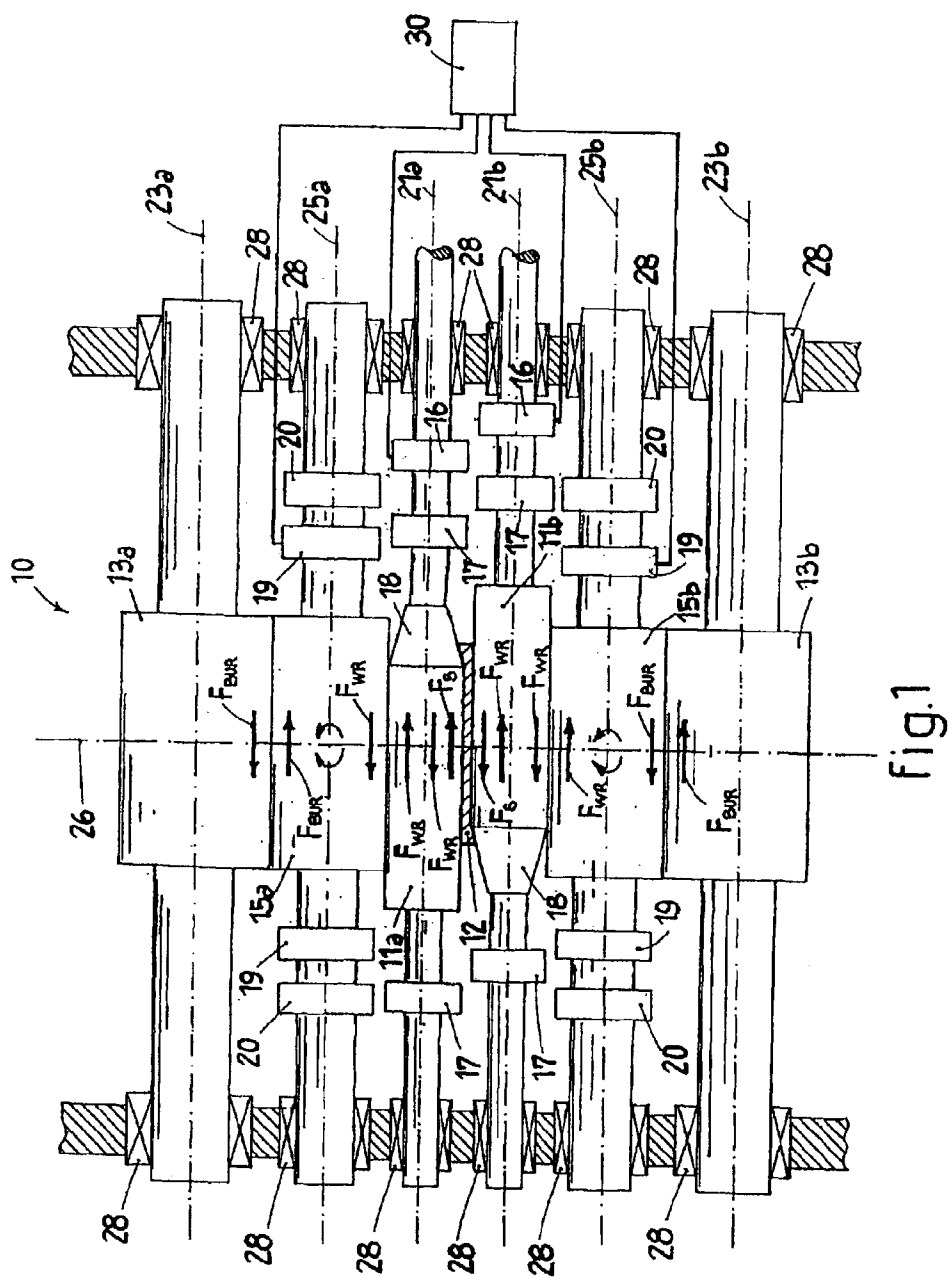


fig.1

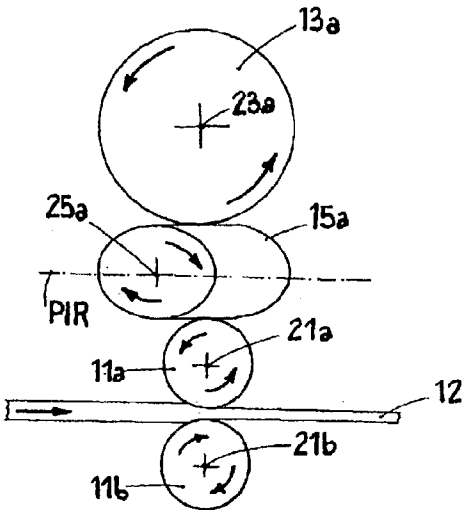


fig.2

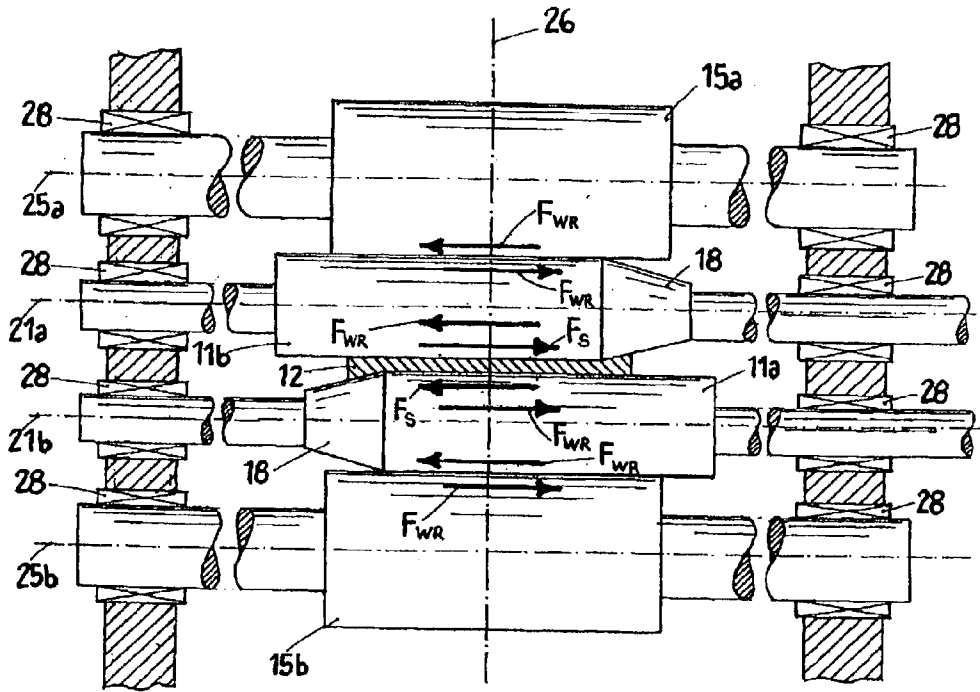


fig.3

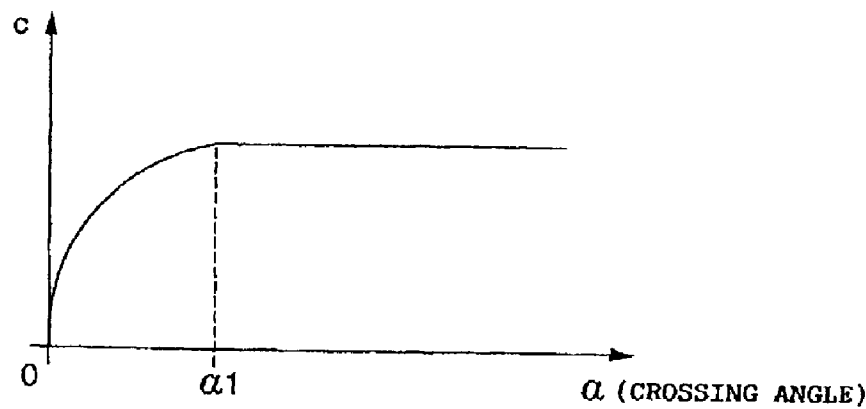


fig.4

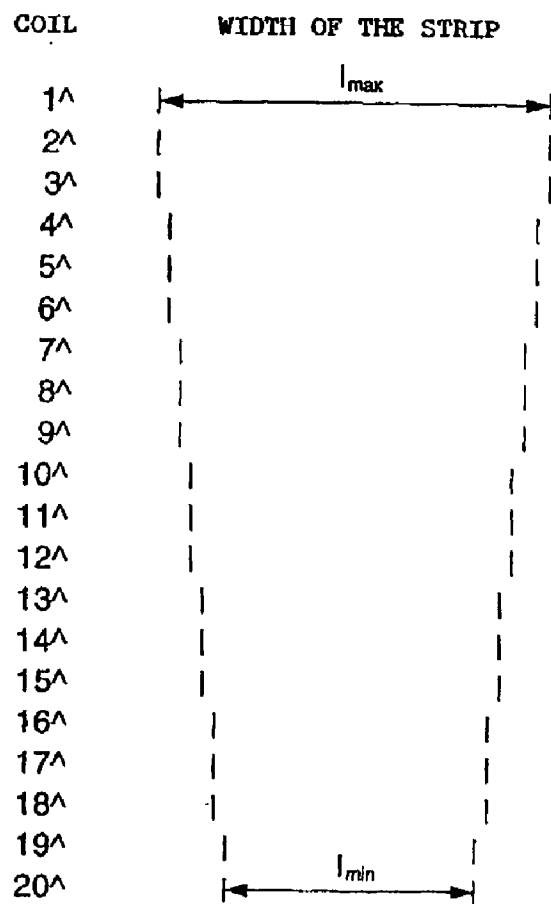


fig.5

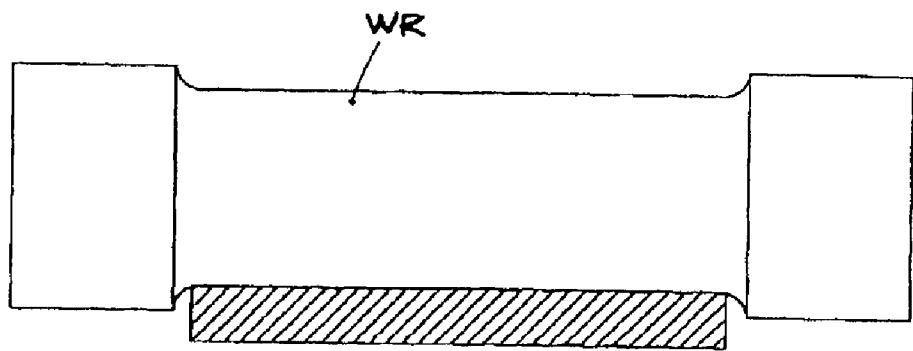


fig.6a

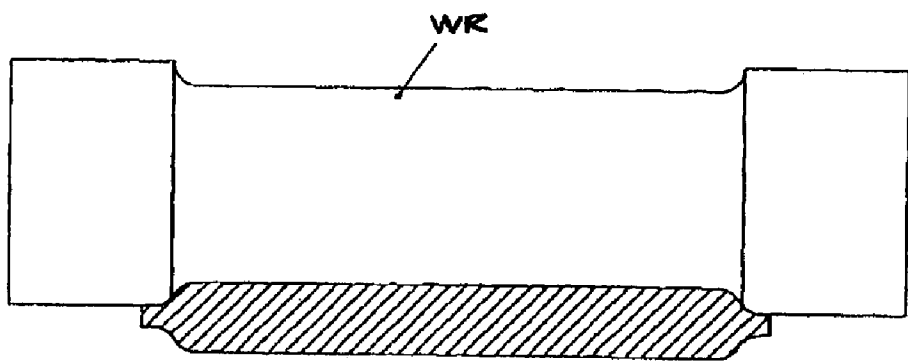


fig.6b

METHOD TO CONTROL THE AXIAL FORCES GENERATED BETWEEN THE ROLLING ROLLS

FIELD OF THE INVENTION

[0001] The invention refers to a method to reduce the axial forces generated between the rolling rolls in a five-high or six-high stand, having a pair of working rolls (WR) associated with a shifting mechanism, a corresponding pair of back-up rolls (BUR), and at least one intermediate roll (IR) associated at least with a crossing mechanism. The intermediate roll is generally crossed. The “sign” of the angle of crossing is determined by the direction of shifting during rolling.

[0002] The method according to the invention provides that WR shifting and IR crossing are suitably controlled so as to reduce the axial forces between the intermediate roll and the working roll, during the shifting of the working rolls, in the rolling step.

BACKGROUND OF THE INVENTION

[0003] In the state of the art, to control the planarity of plane products rolled in five-high or six-high rolling stands, the working rolls are associated both with a bending system, positive and negative, and also with a shifting system, and the intermediate roll is associated with a crossing system.

[0004] The state of the art also includes a method to control the planarity of plane rolled products wherein the intermediate roll is also associated with a positive or negative bending system.

[0005] Crossing each intermediate roll with respect to the working rolls and back-up rolls inevitably generates thrusts or axial forces both on the intermediate roll, on the corresponding working roll and also on the corresponding back-up roll.

[0006] Moreover, considering that the working rolls can also be provided with bevels, hollows and/or tapers at their edges, in order to solve the problem of edge-drop of the rolled products, inevitably the tapers, due to the pressure of contact between the rolls, also generate further axial components which are added to those generated by the shifting of the working roll and the crossing of the intermediate roll.

[0007] To overcome the shortcomings of the state of the art, the present Applicant has devised, planned and perfected the method according to the invention to reduce the axial forces generated between the rolling rolls during the operation to modify the axial position or to shift the working rolls during the rolling operation.

SUMMARY OF THE INVENTION

[0008] The method to control the axial forces generated between the rolls of a rolling stand according to the invention is set forth and characterized in the main claim, while the dependent claims describe other innovative characteristics of the invention.

[0009] Before describing the invention, it is appropriate to make the following premises.

[0010] The crossing of the intermediate roll generates axial thrusts both on the intermediate roll itself, on the working roll and also on the back-up roll.

[0011] The forces F_{BUR} and F_{WR} (FIG. 1) generated are the function of various parameters, particularly the rolling force, the coefficient of friction between the rolls and hence of the lubrication and surface condition of the rolls, and finally the angle of crossing.

[0012] Given the same rolling force, the multiplicative coefficient “c” which causes the axial thrust develops as shown in FIG. 4. When the threshold α_1 (limit crossing angle)

[0013] In continuous rolling mills, that is, where the strip is rolled continuously and the operation to divide it into coils is made downstream of the rolling mill, it is necessary to reposition the working rolls following the sequence of the variations in width between one coil and the next. Since the coils entering the rolling mill are welded together in succession, that is, with the trailing end of one coil against the leading end of the other, this repositioning is carried out without stopping the rolling process.

[0014] On a cold rolling mill, the production program is normally made following a procedure of progressive reduction, starting at the beginning of the rolling session from a greater initial width l_{max} which, coil after coil, is subsequently and gradually reduced until it reaches the final width l_{min} , as shown schematically in FIG. 5. This procedure is made to prevent the modification to the profile of the working rolls, generated by the wear caused by rolling the previous strips (FIGS. 6a and 6b), from damaging the strip being rolled now.

[0015] The movement of the working rolls, for the reasons stated above, is carried out in the axial direction during rolling. This movement is done in correspondence with the change in width from one coil to the next.

[0016] The shifting movement in the axial direction, made during rolling, generates a force of friction between the strip and each working roll, so that each working roll is subject to a force F_s in the opposite direction to that of the axial movement.

[0017] Therefore, each working roll, during shifting, is subject to the axial forces F_{WR} and F_s .

[0018] According to one characteristic of the invention, once the direction of shifting of the working rolls has been established, the intermediate rolls are crossed so that the two forces F_{WR} and F_s have opposite directions, so as to avoid, during the shifting operations during rolling, further loading the thrust bearings of the working rolls, and consequently extend the duration thereof.

[0019] Therefore, the shifting action is correlated to the crossing action, according to the model given in FIG. 3.

[0020] As a secondary effect we also have the advantage that it is not necessary to increase the force which each shifting device has to apply, and therefore the size thereof, with respect to the “stationary” force F_{WR} , that is, the working rolls axially stationary.

[0021] One purpose of the invention is therefore to achieve a method to reduce to a minimum the axial forces generated between the rolls of a rolling stand, particularly but not exclusively during the operation to axially position the working rolls when there is a change in the strip width,

and which therefore allows to increase the working life of the members associated with the rolling rolls, like the axial thrust bearings.

[0022] In accordance with this purpose, the method to control the axial forces generated between the rolls of a rolling stand, comprising at least a pair of working rolls, a corresponding pair of back-up rolls and at least an intermediate roll located between one of the working rolls and a corresponding back-up roll, axial translation means associated with at least one of the working rolls to translate it axially, provides crossing means associated with said intermediate roll to arrange it with its longitudinal axis inclined (IR crossing), that is to say, rotated on a horizontal plane, with respect to the longitudinal axes of the working rolls and the back-up rolls. The method provides that both WR shifting and IR crossing are controlled by control means which act on the axial translation means of the working rolls, during rolling, so that the axial force generated between the intermediate roll and the corresponding working roll due to the shifting of the latter is in the opposite direction to the axial force generated by the crossing of the intermediate roll.

BRIEF DESCRIPTION OF THE DRAWINGS

[0023] These and other characteristics of the invention will become clear from the following description of a preferred form of embodiment, given as a non-restrictive example with the aid of the attached drawings wherein:

[0024] FIG. 1 is a schematic front view of a six-high rolling stand able to adopt the method according to the invention;

[0025] FIG. 2 is a schematic and partial side view of the rolling stand shown in FIG. 1;

[0026] FIG. 3 is an enlargement of the rolling stand in FIG. 1;

[0027] FIG. 4 is a graph of the development of the coefficient of friction between a working roll and an intermediate roll according to the crossing angle α of the latter;

[0028] FIG. 5 is a schematic representation of the variation in the width of the plane product rolled in a particular rolling session;

[0029] FIG. 6a is a schematic representation of the profile of a working roll WR after "n" strips with a constant width;

[0030] FIG. 6b is a schematic representation of the effect which would be obtained on rolling a wider strip if the same rolling roll WR were used as in FIG. 6a.

DETAILED DESCRIPTION OF A PREFERRED FORM OF EMBODIMENT

[0031] With reference to the attached Figures, a rolling stand 10 able to adopt a method according to the invention comprises a pair of working rolls 11a, 11b between which the plane product 12 to be rolled, consisting for example of a steel strip, is able to pass.

[0032] Associated with the two working rolls 11a, 11b there are two corresponding back-up rolls 13a, 13b, able to contrast the vertical thrusts due to the rolling of the product 12 and to reduce the flexion of the working and intermediate rolls.

[0033] The rolling stand 10 is of the so-called six-high type, and comprises a pair of intermediate rolls 15a, 15b positioned between the working rolls 11a, 11b and the back-up rolls 13a, 13b.

[0034] According to a simplified variant not shown in the drawings, the rolling stand 10 can comprise only one intermediate roll, for example the upper 15a, and thus become a five-high stand.

[0035] Associated with at least one working roll 11a or 11b, but advantageously both, there is a shifting mechanism 16, of a conventional type and not shown in detail in the drawings, which is able to move the corresponding working roll 11a, 11b along the horizontal plane on which its longitudinal axis 21a, 21b lies, thus achieving the axial translation of one working roll 11a with respect to the other 11b.

[0036] Moreover, associated with at least one working roll 11a or 11b, but advantageously both, there is also a bending mechanism 17, of a conventional type and not shown in detail in the drawings, which is able to bend the corresponding working roll 11a, 11b in one direction and the other with respect to the horizontal plane on which their longitudinal axis 21a, 21b lies at rest, and thus obtain a controlled bending thereof, both positive and negative.

[0037] The working rolls 11a and 11b are also provided, at at least one end, with bevels 18 suitably configured to control the profile at the edges of the rolled product 12.

[0038] The intermediate rolls 15a, 15b are associated with a crossing mechanism 19, of a conventional type and not shown in detail in the drawings, which is able to incline them around a vertical axis 26 by a desired angle α both in one direction and the other with respect to the working rolls 11a, 11b and the back-up rolls 13a, 13b, maintaining their longitudinal axes 23a, 23b on the same horizontal plane PIR parallel to the rolling plane on which the rolled product 12 lies.

[0039] Each intermediate roll 15a, 15b is also associated with a bending mechanism 20, of a conventional type and not shown in detail in the drawings, which is able to bend the corresponding intermediate roll in one direction and the other with respect to the horizontal plane PIR on which their longitudinal axis 25a, 25b lies at rest, and thus obtain a controlled bending, both positive and negative.

[0040] No device to control and/or modify their position or profile is associated with the back-up rolls 13a, 13b, so their longitudinal axes 23a, 23b normally remain in their nominal position.

[0041] Each rolling roll 11a, 11b, 13a, 13b, 15a and 15b is subjected to axial forces generated during the rolling of the product 12, mainly due to the WR shifting and IR crossing, and also due to the bevels 18 and the shape that the rolled product assumes at the edges.

[0042] To be more exact, as we have seen, the working rolls 11a and 11b are subjected both to axial forces F_{WR} , due to the crossing of the intermediate rolls 15a and 15b, and also to the axial forces F_S , due to the shifting of the working rolls 11a and 11b.

[0043] The axial thrust caused by said crossing changes direction according to the sign of the angle of crossing.

[0044] To contrast the axial forces, axial thrust bearings **28**, of a conventional type, are associated with every rolling roll.

[0045] According to a characteristic of the invention, a control unit **30** is connected at least to the WR shifting mechanisms **16** and to the IR crossing mechanisms **19**, in order to control said mechanisms **16** and **19** and act thereon in a suitable fashion, to reduce at least the axial forces which act on the working rolls **11a** and **11b** during the axial repositioning of the latter.

[0046] In order to do this, the shifting of the working rolls **11a** and **11b**, in the axial direction, is performed by the mechanisms **16** during rolling so that the two forces F_{WR} and F_S have opposite directions, so as to avoid further loading the thrust bearings **28** and thus prolong their working life.

[0047] To be more exact, once the direction of shifting of the working rolls **11a** and **11b** has been established, according to the position of the bevels **18** of said rolls to compensate edge-drop of the strip and according to the rolling session chosen, that is, with a width of the strip **12** preferably decreasing from l_{max} to l_{min} (FIG. 5), the crossing of the intermediate rolls **15a** and **15b** is actuated, inclining them clockwise or anti-clockwise, so that the two forces F_{WR} and F_S have opposite directions, so as to avoid further loading the thrust bearings **28** of the working rolls **11a** and **11b**, and consequently prolong their working life.

[0048] It is obvious that modifications or additions can be made to the method to control the axial forces generated between the rolls of a rolling stand and to the rolling stand **10** as described heretofore, without departing from the spirit and scope of this invention.

[0049] It is also obvious that, although the invention has been described with reference to specific examples, a skilled person shall certainly be able to achieve many other equivalent variants thereof, all of which shall come within the field and scope of this invention.

1- Method to control the axial forces generated between the rolls in a rolling stand (**10**) for plane products (**12**) having at least a pair of working rolls (**11a**, **11b**), a corresponding pair of back-up rolls (**13a**, **13b**) and at least an intermediate roll (**15a**) located between one of said working rolls (**11a**) and a corresponding back-up roll (**13b**), axial translation means (**16**) associated with said working rolls (**11a**) to axially translate said working rolls (WR shifting), crossing means (**19**) associated with said intermediate roll (**15a**) to dispose said intermediate roll (**15a**) with its longitudinal axis (**25a**) inclined, that is, rotated on a horizontal plane by a set angle (α) with respect to the longitudinal axes (**21a**, **21b**, **23a**, **23b**) of said working rolls (**11a**, **11b**) and of said back-up rolls (**13a**, **13b**) (IR crossing), the method being characterized in that said WR shifting and said IR crossing are controlled by control means (**30**) so as to reduce to a minimum the axial forces generated in said working rolls (**11a**, **11b**), and consequently the axial load on the corresponding thrust bearings (**28**).

2- Method as in claim 1, characterized in that said shifting of the working rolls (**11a**, **11b**) is made during rolling and that said control means (**30**) control said axial translation means (**16**) so that the axial force (F_S) generated between the product (**12**) being rolled and the corresponding working roll (**11a**) due to the shifting of the latter is in the opposite direction to the axial force (F_{WR}) generated by the crossing of the intermediate roll (**15a**) with respect to the corresponding working roll (**11a**).

3- Method as in claim 1, characterized in that, once the direction of shifting of said working rolls (**11a** and **11b**) has been established, according to the rolling session chosen, that is, with the width of the product (**12**) being rolled preferably decreasing from a maximum width (l_{max}) to a minimum width (l_{min}), the crossing of said intermediate roll (**15a**) is actuated, inclining it clockwise or anti-clockwise, so that the two corresponding axial forces generated (F_{WR} and F_S) have opposite directions.

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