United States Patent [19]

Nakajima et al.

[11] **3,901,059**

[45] **Aug. 26, 1975**

[54] **SHAPE-ROLLING MILL FOR WORKING METALLIC SECTION MATERIAL**

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[73] Assignee: **Nippon Steel Corporation,** Tokyo, Japan

[22] Filed: **Oct. 7, 1974**

[21] Appl. No.: **512,407**

[30] **Foreign Application Priority Data**

Oct. 8, 1973 Japan 48-113628

[52] **U.S. Cl.** **72/8;** 72/245; 72/20; 72/16

[51] **Int. Cl.** **B21b 37/02**

[58] **Field of Search** 72/247, 8, 9, 10, 11, 12, 72/16, 20, 245

[56] **References Cited**

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Primary Examiner—Milton S. Mehr

[57] **ABSTRACT**

A shape-rolling mill for working metallic section material, which is capable of correcting mill rigidity in a transverse direction parallel to the axes of work rolls by means of a fluid pressure mechanism. The sectional roll-pass configuration is corrected by adjusting the rigidity in the axial direction of the rolls in relation to the rigidity in the vertical or reducing direction under control of the fluid mechanism. In one preferred form, a second fluid pressure mechanism is provided for correcting the mill rigidity in the reducing direction. The second fluid mechanism controls the vertical rigidity of the mill to allow a greater freedom to the adjustment of the ratio between the longitudinal and transverse rigidities of the mill. The sectional shape of the metallic work is corrected by balancing the vertical and transverse mill rigidities.

4 Claims, 19 Drawing Figures

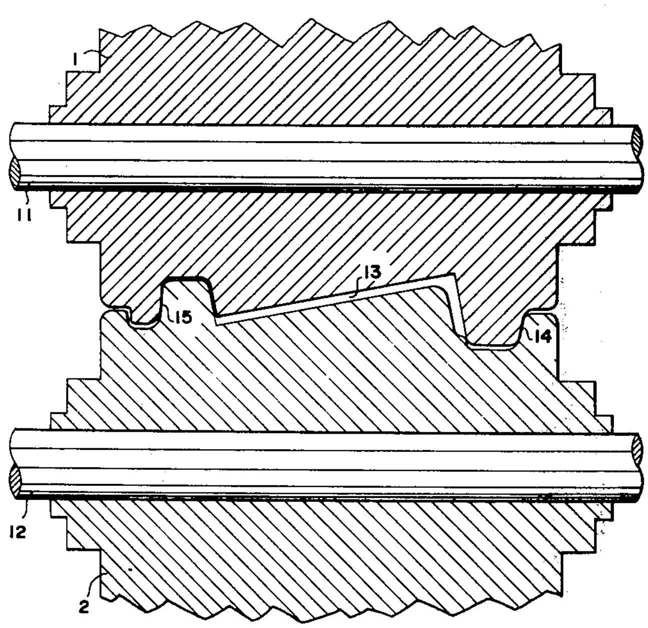
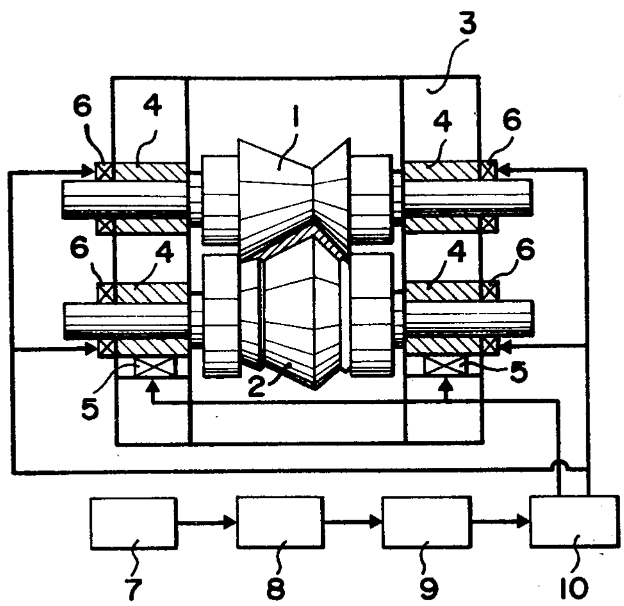


FIG. 1



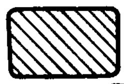


FIG. 2a


FIG. 2b


FIG. 2c


FIG. 2d


FIG. 2e


FIG. 2f


FIG. 2g


FIG. 2h


FIG. 2i


FIG. 2j


FIG. 2k


FIG. 2l

FIG. 3

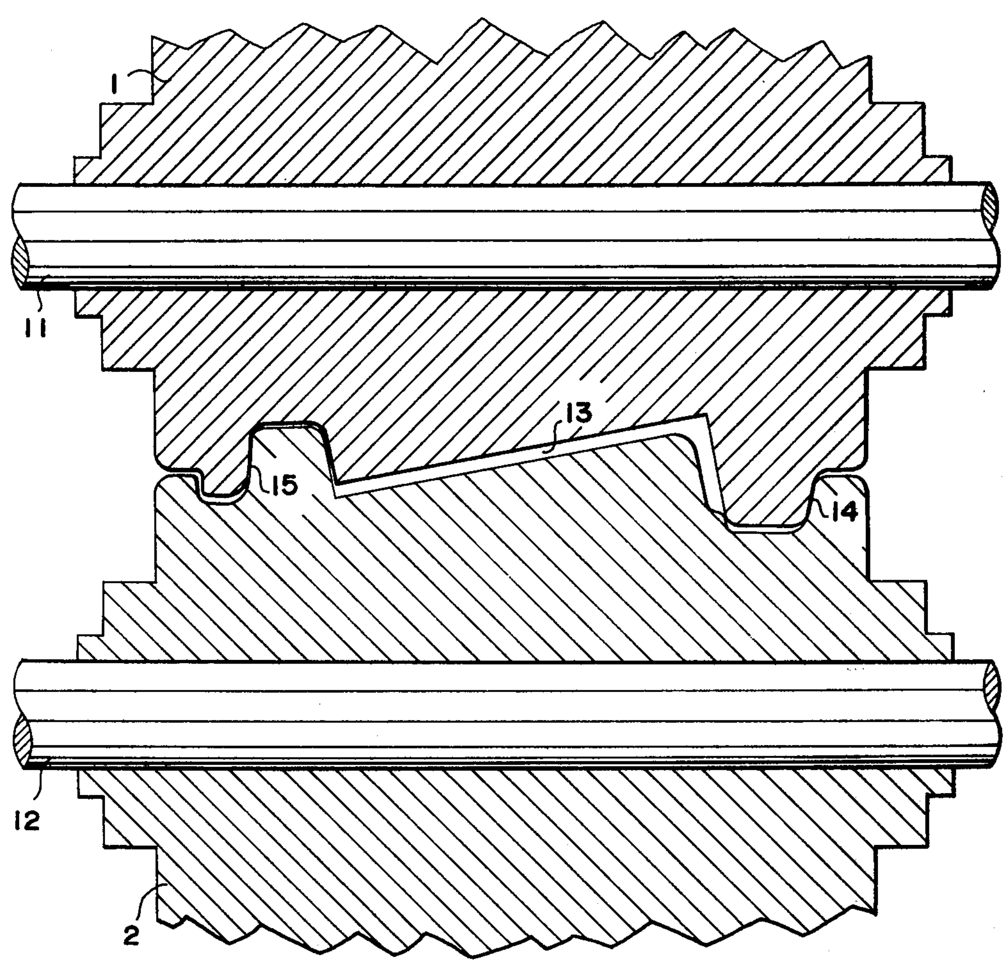


FIG. 4

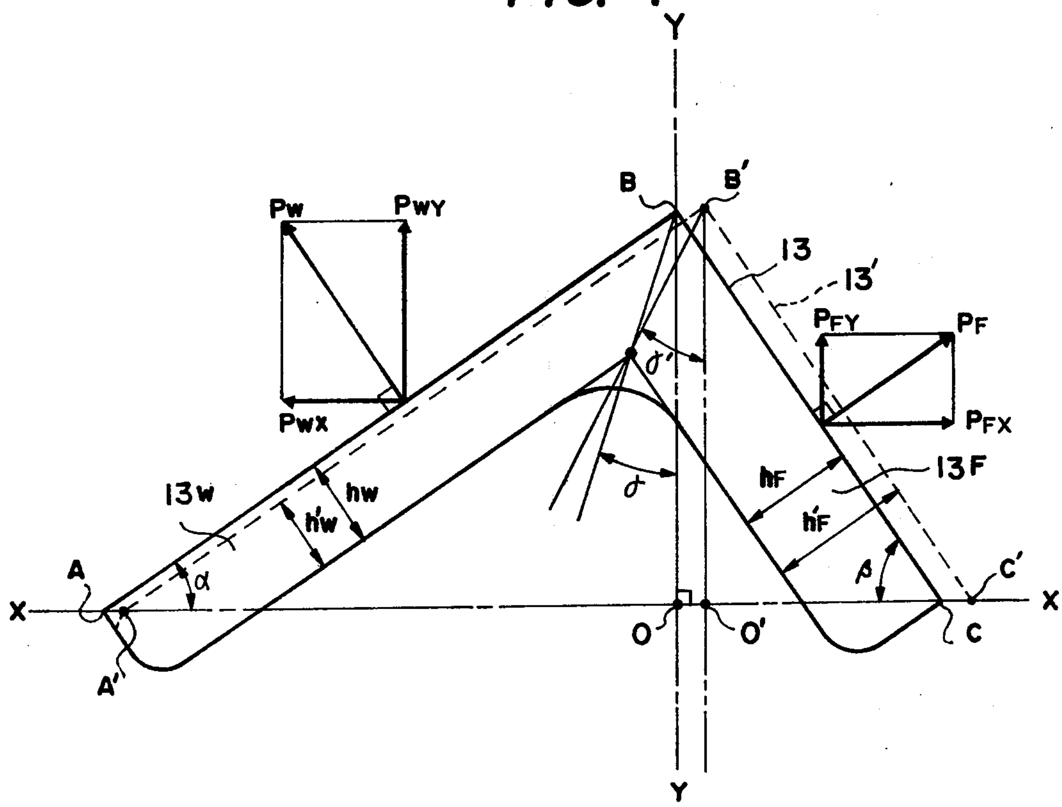

Y
B
B'
Pw
PwY
13
13'
PFY
PF
γ'
PFX
Pwx
hF
13F
13w
hw
γ
h'w
h'F
A
α
β
C'
X
X
O
O'
C
A'
Y

FIG. 5

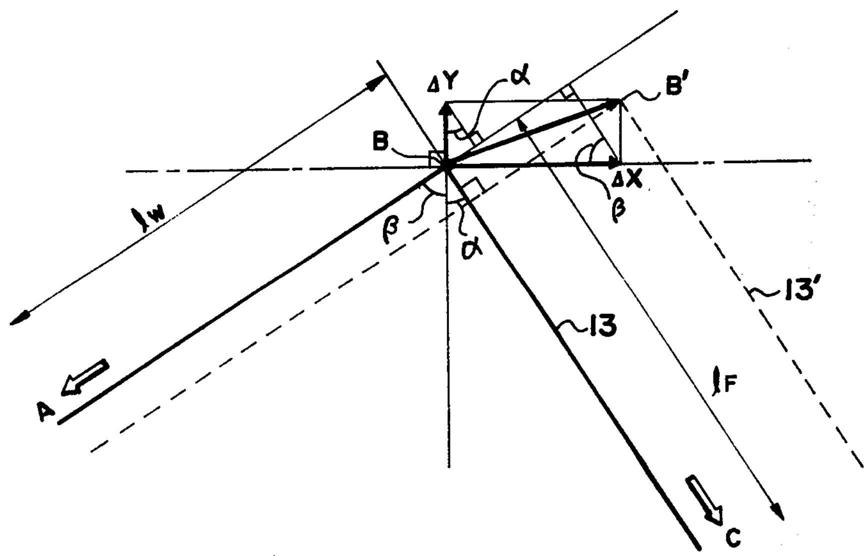


FIG. 6

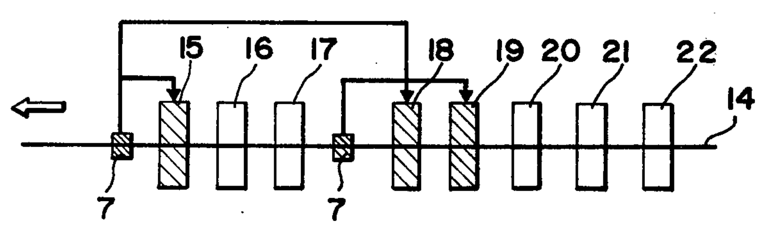


FIG. 7

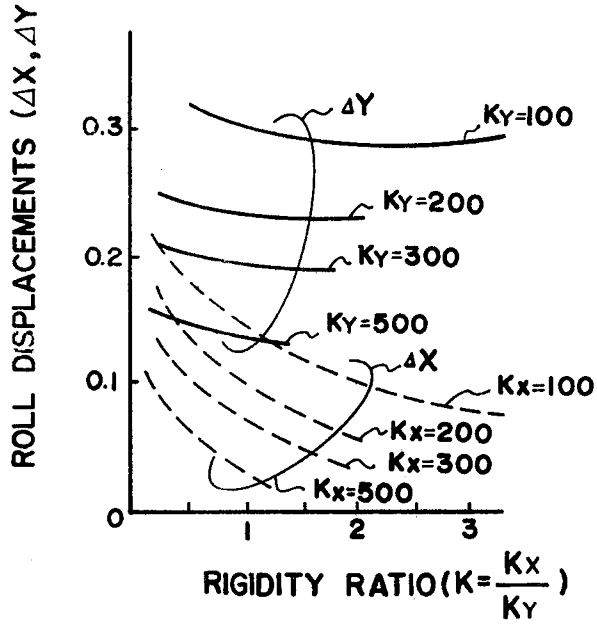
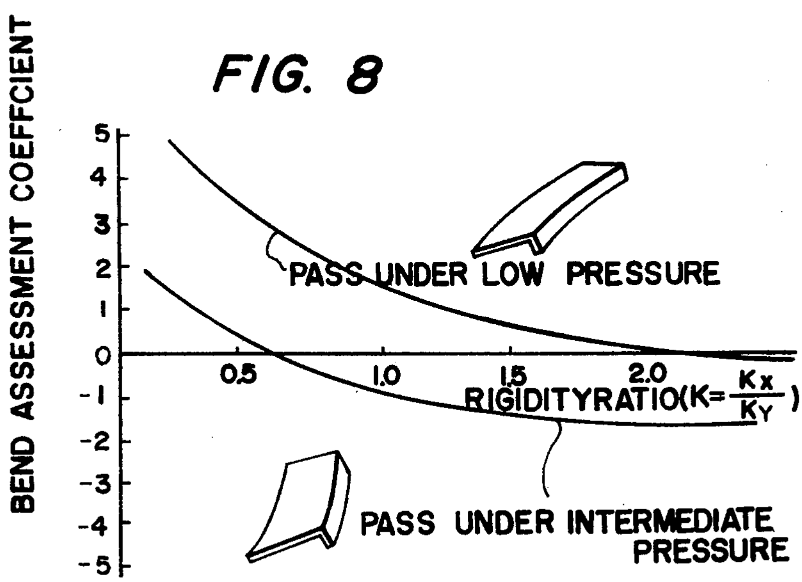

ROLL DISPLACEMENTS (ΔX, ΔY) mm
ΔY
KY=100
KY=200
KY=300
KY=500
ΔX
Kx=100
Kx=200
Kx=300
Kx=500
0.3
0.2
0.1
0
1
2
3
RIGIDITY RATIO(K= Kx/KY)

FIG. 8


BEND ASSESSMENT COEFFCIENT
PASS UNDER LOW PRESSURE
RIGIDITYRATIO(K= Kx/KY)
PASS UNDER INTERMEDIATE PRESSURE
5
4
3
2
1
0
-1
-2
-3
-4
-5
0.5
1.0
1.5
2.0

SHAPE-ROLLING MILL FOR WORKING METALLIC SECTION MATERIAL

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to a rolling mill for shape-rolling elongated structural metal material or section material such as angle steel with web and flange portions different in length and thickness. More particularly, the invention relates to a rolling mill which has means for correcting deformations which occur to the roll-pass contour which is defined by at least two working rolls due to elongation and contraction of the rolling mill per se and the working rolls in diversified directions.

2. Description of the Prior Art

It is a matter of common experience in shape rolling that the roll-pass contour which is defined by two or more than two working rolls is deformed due to elongation and/or contraction of the rolling mill body and the rolls which are mounted on the mill, resulting in products having a sectional area largely deviated from target gauges.

Cross-sectional configurations of metallic section material are not simply rectangular nor of uniform width as with ordinary plates but are diversified in width and thickness. In the shape-rolling operation on the section material with such complicated cross-sectional configurations, the metal material between the working rolls is displaced in the direction of rolling (the direction in which the stock is transferred) as well as in the direction of reduction (the direction perpendicular to the work surface which is in contact with the rolls) and in the transverse direction (the direction parallel to the roll axes).

In general, when rolling metal material into a shape of predetermined cross section, a roll pass contour is defined by a number of rolls. However, in order to obtain exactly an aimed cross section, it is necessary to restrict the displacement of the metal material in the direction of roll axes for balancing the rolling amounts in the respective portions of the contoured roll-pass. However, the displacement of the metal material in the direction of roll axis is varied depending upon the particular shape of the roll pass and the rolling load which is imposed in the vertical direction (the direction of reduction).

If the roll pass contour is maintained in an originally designed shape, it is possible to obtain products of a cross-sectional shape as originally intended. However, in an actual shape-rolling operation, the rolling mill has insufficient rigidity in the direction of reduction (vertical direction) and the opposing rolls are vertically bent away from each other in the middle portions thereof due to rolling loads (rolling reactions), causing variations in the roll clearance width. As a result, the roll clearances in different portions of the roll pass undergo variations in different degrees and contribute to deform the metal work which is passed through the rolls. This is ultimately reflected by dimensional errors or deviations and irregular variations in shape of the final products and sometimes by bending of the rolled metal material.

Heretofore, in rolling metal material into structures of predetermined cross section, the adjustments of the roll clearance and thrust (roll position in the axial direction) for the prevention of the dimensional deviations and shape variations have completely relied on experience. However, it is very difficult and almost impossible even for an experienced person to correct accurately the deformation of the roll pass contour.

SUMMARY OF THE INVENTION

It is therefore an object of the present invention to provide a rolling mill which is capable of rolling metallic section material into predetermined dimension and cross-sectional shape.

It is another object of the present invention to provide a rolling mill which is capable of correcting the rolling cross-sectional shape in a faciliated manner.

It is a further object of the present invention to provide a rolling mill which is capable of correcting bends in the rolling material.

The above-mentioned objects of the present invention can be attained by providing means for adjusting the rolling mill rigidity in the axial direction of the rolls in a shape-rolling mill such as two-roll, three-roll, four-roll universal rolling mill or the like. According to the present invention, the correction of the roll-pass contour, that is to say, the correction of the rolling cross-sectional shape is effected by a rolling mill rigidity adjusting means which is adapted to adjust the mill rigidity in the axial direction of the rolls. The rigidity of the rolling mill in the vertical or reducing direction is normally fixed. However, the deviations in the axial direction of the rolls or the roll pass contours show different behaviors when the rolling mill rigidity in the axial direction of the rolls is changed. Therefore, the roll-pass contours which dictate the cross-sectional shape of the rolling material can be corrected and maintained in optimum shapes by a roll mill rigidity adjusting means which is adapted to balance the rolling mill rigidity in the axial direction with the fixed rigidity in the vertical or reducing direction.

In one preferred form of the invention, the rolling mill further includes a second mill rigidity adjusting means which is adapted to adjust the mill rigidity in the vertical or work reducing direction. In this instance, the rolling mill has a variable rigidity also in the vertical direction, so that the controll of the roll-pass contours affords a greater degree of freedom to ensure exactly the desired cross-sectional rolling shape.

The above and other objects, features and advantages of the present invention will become clear from the following description and appended claims, taken in conjunction with the accompanying drawings which form a part of this specification and which show by way of example preferred embodiments of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

In the accompanying drawings:

FIG. 1 is a diagrammatic view of a rolling mill employing the present invention with mill rigidity control means shown in block diagram;

FIGS. 2*a* to 2*l* are diagrammatic views showing progressive reductions of a metal work which is rolled through a number of passes or roll stands;

FIG. 3 is a diagrammatic sectional view of rolls which are employed in angle steel shape rolling;

FIG. 4 is a diagrammatic view of a roll-pass contour where correct contour is indicated by a solid line while contour deviations are indicated by a broken line;

FIG. 5 is a graphic illustration employed to explain the procedures for calculating the dimensional deviations at the appex B of the roll-pass contour shown in FIG. 4;

FIG. 6 is a block diagram of a shape rolling mill employing a plural number of roll stands;

FIG. 7 is a graphical illustration employed to calculate roll displacements ΔX and ΔY in relation with a rigidity ratio of $K = Kx/KY$; and

FIG. 8 is a graphic illustration showing the value of the bend assessment coefficient Cλ in relation to a rigidity ratio of $K = Kx/KY$.

PARTICULAR DESCRIPTION OF THE INVENTION

Referring to FIG. 1 which shows one preferred form of a shape-rolling mill according to the present invention, the rolling mill is designed to roll angle steel with side walls varying in length and thickness. The upper and lower working rolls 1 and 2 each with a predetermined surface configuration are supported on bearing boxes or chocks 4 within a housing 3. The lower roll 2 is further supported on a fluid pressure mechanism 5 which is adapted to move the lower roll 2 up and down to adjust the rigidity in the vertical or work reducing direction.

A separate fluid pressure mechanism is provided to act on the outer sides of the bearing boxes 4 as shown at 6 for adjusting the rolling mill rigidity in the direction of the roll axes. This fluid pressure mechanism applies a fluid pressure on the upper and lower rolls 1 and 2 in a direction parallel to the roll axes through the respective chocks or bearing boxes 4.

The pressures of the first and second fluid pressure mechanisms 5 and 6 are controlled by a fluid pressure control unit 10 which is supplied with a fluid pressure from a fluid pressure generator 9. The gauges in various portions of the rolling section material which comes out of a roll stand are checked by a detector 7 and the detected signals are supplied to an operating unit 8. The operating unit 8 compares the detected signals with fixed reference signals which indicate a predetermined roll-pass contour (cross-sectional shape and dimension) to produce output signals indicating corrective dimensional deviations. The fluid pressure generator 9 produces a corrective fluid pressure in accordance with the deviation signals from the operating unit 8, the corrective fluid pressure being transmitted to either the first or second fluid pressure mechanism 5 or 6 by the fluid pressure control unit 10 which operates in response to the deviation signals.

In the shape-rolling of angle steel with a web and a flange different in length and thickness, the metal work is gradually transformed while being passed through a number of passes or roll stands, as shown, for example, in FIGS. 2*a* to 2*l*. More particularly, a metal work which has a rectangular cross-section as in FIG. 2*a* is rolled into the shape of FIG. 2*b* by the first pass or roll stand and then into the shape of FIG. 2*c* by the second pass or roll stand. In the similar manner, the metal work is transformed by the succeeding passes or roll stands and finally imparted with the shape of FIG. 2*l* by the last pass or roll stand. The roll-pass contours of the respective passes or roll stands have configurations corresponding to the metal work shapes shown in FIGS. 2*a* to 2*l*. For example, a metal work which has been rolled to the shape of FIG. 2*k* is transformed into the shape of FIG. 2*l* by the final pass or roll stand which has a roll-pass contour as shown particularly in FIG. 3.

As mentioned above, FIG. 3 shows a sectional roll-pass contour of the rolls which transforms the metal work of FIG. 2*k* into the shape of FIG. 2*l*. The metal work is rolled in the clearance or roll-pass 13 between the upper and lower rolls 1 and 2. The upper and lower rolls 1 and 2 are formed integrally with the shafts 11 and 12, respectively, so that, by rotation of the shafts 11 and 12, the metal work is passed through the contoured roll clearance 13 and imparted with the shape of FIG. 2*l*. The surface configurations of the rolls 1 and 2 as well as the positions of the shafts 11 and 12 are determined prior to the rolling operation such that the roll pass 13 has a predetermined cross-sectional shape.

However, upon initiation of the rolling operation and biting the metal work, the roll-pass contour is deformed in various portions depending upon the roll stand rigidity in the vertical and transverse directions. The roll stand is usually set in position in consideration of presumable contour deformations in the roll pass 13 and the metal work is rolled into the intended final shape of FIG. 2*l* in the initial stage of the rolling operation. However, as the rolling operation proceeds, complicated deformations occur in the roll-pass contour 13 due to thermal deformations of the metal work, rolls, stand housing and so forth or due to positional deviations of the upper and roller rolls in vertical and transverse directions which are usually caused by abrasive wear of the work-abutting surfaces or thrust collars 14 and 15 of the upper and lower rollers 1 and 2.

The roll-pass contour 13 which has been deformed by the causes as mentioned above assumes the shape indicated by a broken line 13' in FIG. 4. FIG. 4 shows on an enlarged scale the roll pass 13 which is defined by the upper and lower rolls 1 and 2. The deformation of the roll-pass contour is caused by relative displacement of the upper and lower rolls 1 and 2 in the vertical direction (direction of axis Y — Y) and in the direction parallel to the roll axes (direction of axis X — X). In FIG. 4, the solid line indicates the correct contour of the roll pass 13 and the broken line indicates the deformation which occurs in the course of the rolling operation.

The initial contour of the roll pass 13 has two angularly disposed web and flange portions of h_W and h_F in width, which, however, are widened or narrowed to $h_{W'}$ and $h_{F'}$ in the course of the rolling operation. The appex angle γ is also changed to γ'. In this instance, the positional deviation of the appex B (to the position B') can be expressed as in FIG. 5 where ΔY represents the relative vertical displacement of the upper and lower rolls 1 and 2 (or roll gap displacement) and ΔX represents the relative transverse displacement (in the direction parallel to the roll axes or the direction of axis X — X). If the web and flange portions have angles α and β with respect to the roll axis (axis X — X), the thickness of the web on the lefthand in FIG. 5 is expressed from geometrical relations as

$$\Delta h_W = h_W - h_W' = \Delta X \sin\alpha \qquad (1)$$

On the other hand, the flange on the righthand in FIG. 4 undergoes a variation in thickness which can be expressed as

$$\Delta h_F = h_F - h_F' = Y \sin\beta \quad (2)$$

From equations (1) and (2), the vertical and transverse roll gap deviations ΔX and ΔY are expressed as

$$\Delta X = \frac{\Delta h_W}{\sin\alpha} \quad (3)$$

$$\Delta Y = \frac{\Delta h_F}{\sin\beta} \quad (4)$$

Further, from the geometrical relations shown in FIG. 5, the deviation Δlw of the web length AB due to ΔX and ΔY can be expressed as

$$\Delta lw = \Delta X \sin\beta + \Delta Y \sin\alpha \quad (3')$$

In a similar manner, the deviation ΔlF of the flange length BC can be expressed as

$$\Delta lF = \Delta X \sin\alpha + \Delta Y \sin\beta \quad (4')$$

Thus, the thickness deviations Δhw and ΔhF are obtained by comparing the dimensions h'_W and h'_F as measured on the outlet side of the roll stand with the set reference values h_W and h_F, and then the vertical and transverse roll gap deviations ΔY and ΔX can be obtained from equations (3) and (4). Further, the web and flange length deviations Δl_W and Δl_F are obtained from equations (3') and (4') (these deviations can also be obtained by actual measurements).

In the shape-rolling operation with the rolling mill of the invention as shown for example in FIG. 1, the detector 7 detects the gauges (h_W', h_F') of various portions of the metal work on the downstream side of the rolling stand for comparison with predetermined reference values (h_W, h_F) in the operating unit 8. As a result of this comparison, the vertical and transverse roll gap deviations ΔX and ΔY are computed out. The operating unit 8 produces output signals indicative of the roll gap deviations ΔX and ΔY for transmission to the fluid pressure generator 9 and to the fluid pressure control unit 10 for operating the first fluid pressure mechanism 5 and/or the second fluid pressure mechanism 6 in a manner to zeroize the deviations ΔX and ΔY.

As a matter of fact, it is very diffiuclt to zeroize the deviations ΔX and ΔY completely without imposing prohivitively great burden on the construction design of the rolling mill. As will be seen from equations (1) and (2), the thickness deviations Δh_W and Δh_F corresponding to the gap deviations ΔX and ΔY are equal to ΔX and ΔY as multiplied by the constants sinα and sinβ. Therefore, in order to maintain the dimensional deviations in different portions of the section material uniform, it is not necessary to zeroize the values of ΔX and ΔY but it suffices to maintain a balance between ΔX and ΔY. More particularly, if the dimensional deviations are uniform,

$$\frac{\Delta h_W/h_W}{\Delta h_F/h_F} = \frac{\Delta X \cdot \frac{\sin\alpha}{h_W}}{\Delta Y \cdot \frac{\sin\beta}{h_F}} = 1$$

thus,

$$\frac{\Delta X}{\Delta Y} = \frac{\frac{\sin\beta}{h_F}}{\frac{\sin\alpha}{h_W}} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (5)$$

As both $\sin\beta/h_F$ and $\sin\alpha/h_W$ are constants, the deviations can be maintained uniform by controlling ΔX and ΔY to satisfy the equation (5). This can be easily effected by controlling the pressures of the first and second fluid pressure mechanisms 5 and 6 shown in FIG. 1. If the dimensional deviations in different portions of the section material from a roll stand are balanced in this manner, the succeeding roll stands can control the shape of the section metal work far more easily than not and can impart an accurate cross-sectional shape to the final product.

The foregoing description illustrated the operation of only one roll stand, however, the section material is passed through a number of similar successively located passes or roll stands as mentioned with reference to FIGS. 2*a* to 2*l*. It should be noted that the instant invention may be applied to a roll stand or stands at any stage.

FIG. 6 shows in a block diagram an example of a multi-stand shape-rolling mill employing the present invention in certain roll stands. The rolling mill includes a number of roll stands as indicated at 15 to 22 through which the metal section material is transferred in series. Of a number of roll stands which are installed in series, the hatched stands 15, 18 and 19 are provided with the rigidity adjusting means according to the invention. In FIG. 6, the reference numeral 7 indicates a dimension detector. In the upstream roll stands 20 to 22, the metal work is rolled roughly under relatively great rolling load and does not require accurate control of its cross-sectional shape. In other words, the roll stands according to the invention can be more effectively used on the downstream side of the multi-stand rolling mill. The detector 7 may be located on an outlet side of each roll stand but may be provided at one side of a particular roll stand which is located downstream of a number of similar roll stands as shown in FIG. 6, using the output signals of the detector 7 also for the control of the upstream roll stands. Alternatively, output signals of a single detector may be used for the control of a multiple number of roll stands.

Here, for the convenience of explanation, the force necessary for stretching or contracting the rolling mill by a unit length is expressed by K, the vertical rigidity by K_Y, the transverse rigidity by K_X and the rolling load by P. If, as shown in FIG. 4, the load in the reducing direction is p, the roll gap in the reducing direction is S_Y, the load in the direction parallel to the roll axes (or thrusting direction) is P_X, and the roll gap in the direction parallel to the roll axes is S_X, the thickness h_Y of the rolling material in the reducing direction is expressed as $h_Y = S_Y + (P_Y/K_Y)$. On the other hand, the thickness h_x of the rolling material in the direction parallel to the roll axes is expressed as $h_x = S + (P_X/K_X)$. Therefore, as shown in FIG. 4, if the rolling load of the web AB of the metal work within the roll-pass 13 is P_W and the rolling load of the flange BC is P_F, with vertical components P_{WY} and P_{FY} and transverse components P_{WX} and P_{FX}, respectively,

$$\Delta X = \frac{P_X}{K_X} \quad (6')$$
$$= \frac{P_{WX}+P_{FX}}{K_X} \quad (6)$$
$$\Delta X = \frac{P_Y}{K_Y} \quad (7')$$
$$= \frac{P_{WY}+P_{FY}}{K_Y} \quad (7)$$

where K_X is the mill rigidity in the transverse direction parallel to the roll axes and K_Y is the mill rigidity in the vertical (reducing) direction. Further, if the rolling loads with a roll pass **13** of a correct contour are P_{WO} and P_{FO},

$$P_W = P_{WO} + \frac{\delta P_W}{\delta \Delta X}\cdot \Delta X + \frac{\delta P_W}{\delta \Delta Y}\cdot \Delta Y \quad (8)$$
$$P_F = P_{FO} + \frac{\delta P_F}{\delta \Delta X}\cdot \Delta X + \frac{\delta P_F}{\delta \Delta Y}\cdot \Delta Y \quad (9)$$

where P_W is the sum of vectors P_{WX} and P_{WY} and P_F is the sum of vectors P_{FX} and P_{XY}.

It will be seen from equations (6) to (9) that roll gap deviations ΔX and ΔY and the rolling loads P_W and P_F are correlated with each other. The roll gap deviations ΔX and ΔY are influenced by the rolling loads P_W and P_F and vice versa. As seen from equations X and **1**) and (2), the deviations ΔX and ΔY cause variations in the thickness of the metal work and are determined according to the values of the vertical and transverse rigidities K_X and K_Y. Therefore, if the values of K_X and K_Y are fixed, it is extremely difficult to zeroize ΔX and ΔY. This is because variations in the values ΔX and ΔY give rise to variations also in P_W and P_F and thus in $P_{WX} + P_{FX}$ and $P_{WY} + P_{FY}$. Now, we have to consider parameters which influence the values ΔX and ΔY. As shown in FIG. **4**, the vertical and transverse rolling loads are

$$P_W = P_{WX} + P_{WY}$$
$$P_F = P_{FX} + P_{FY}$$

so that the equations (8) and (9) can be rewritten as follows:

$$P_{WX} = P_{WO} + \frac{\Delta P_{WX}}{\delta \Delta X}\,\Delta X + \frac{\delta P_{WX}}{\delta \Delta Y}\Delta Y \quad (10)$$
$$P_{WY} = P_{WO} + \frac{\delta P_{WY}}{\delta \Delta X}\,\Delta X + \frac{\delta P_{WY}}{\delta \Delta Y}\Delta Y \quad (11)$$
$$P_{FX} = P_{FO} + \frac{\delta P_{FX}}{\delta \Delta X}\,\Delta X + \frac{\delta P_{FX}}{\delta \Delta Y}\Delta Y \quad (12)$$
$$P_{FY} = P_{FO} + \frac{\delta P_{FY}}{\delta \Delta X}\,\Delta X + \frac{\delta P_{FY}}{\delta \Delta Y}66\,Y \cdot \quad (13)$$

and we have already

$$\Delta X = \frac{P_{WX} + P_{FX}}{K_X} \quad (6)$$
$$\Delta Y = \frac{P_{WY} + P_{FY}}{K_Y} \quad (7)$$

In these equations, the values of P_{WXO}, P_{WYO}, P_{XFO} and P_{FYO} are components of a rolling reaction force within a roll pass **13** of a correct contour and are thus known. The terms of $\delta P_{WX}/\delta\Delta X$ to $\delta P_{FY}/\delta\Delta Y$ are obtained as fixed values depending upon the nature of the rolling material. Further, ΔX and ΔY are calculated from equations (3) and (4), based on the dimensions detected after rolling. The six values of K_X, K_Y, P_{WX}, P_{FX} and P_{FY} are left unknown but can be calculated from the six equations given above, which are simultaneous equations with six unknowns. Thus, after detecting the web and flange thicknesses, ΔX and ΔY are calculated from equations (3) and (4) and substituted into the equations (10) to (13) and (6) and (7) above to determine the unknown parameters including the mill rigidities K_X and K_Y. Therefore, the metal work can be rolled into a correct cross-sectional shape by controlling the fluid pressures in the first and second fluid pressure mechanisms **5** and **6** in terms of the values K_X and K_Y. By providing a load detector which is adapted to detect the vertical load P_Y ($=P_{WY} + P_{FY}$) and another detector which is adapted to detect transverse load P_X ($=P_{WX} + P_{FX}$) in the mill of FIG. **1**, the values K_X and K_Y are obtained directly from the equations (6') and (7') since $P_{WY} + P_{FY}$ and $P_{WX} + P_{FY}$ are given by actual measurements. In this instance, therefore, there is no necessity of solving the simultaneous equations (10) to (13). In FIG. **1**, the loads P_Y and P_X are indicated by the output signals of a fluid pressure detector which is operatively connected to the first and second fluid pressure mechanisms **5** and **6**, and the output signals of the fluid pressure detector are fed to the operating unit **8**, which, on the other hand, is supplied from the detector **7** with signals indicative of the amounts of deviations ΔX and ΔY. Based on the received signals, the operating unit **8** calculates and outputs the values of K_X and K_Y for effecting the necessary correction of shape deformation in accordance therewith.

The shape-rolling mill according to the present invention has thus far been discussed in connection with the control of the cross-sectional shape of the rolling section material. However, it can also control bends in the rolling material as will be described hereafter.

The variations in thickness causes differences in elongation percentages between different portions of the cross-sectional area of the metal work. These differences in elongation percentage in turn cause bends to the metal work. If, in the deformed roll pass **13'** of FIG. **4**, the web AB of the metal work undergoes elongation λW while the flange BC undergoes elongation λF, there is established the relation

$$S\lambda = \frac{\lambda W}{\lambda F} + 1 \quad (10)$$

On the other hand, if the web and flange elongations in the roll pass **13** with a correct contour are W_o and F_o, there is established the relation

$$S\lambda_o = \frac{\lambda W_o}{\lambda F_o} + 1 \quad (11)$$

From equations (10) and (11), a bend assessment coefficient Cλ is obtained as

$$C\lambda = \frac{S\lambda - S\lambda_o}{S\lambda_o} \times 100\,(\%) \quad (12)$$

With Cλ = 0, the bend assessment coefficient indicates that the metal work has a bend as designed (normally, the related values are determined to produce no bending). When Cλ has a positively or negatively large value, the metal work is considered to have a bend deviating largely from the initial design. The graph of

FIG. 7 shows the relative roll displacements ΔX and ΔY in the vertical and transverse directions in relation with variations in the vertical rigidity K_Y and the transverse rigidity K_X or variations in the rigidity ratio of $K = K_X/K_Y$. The graph of FIG. 8 shows plots of the bend assessment coefficient Cλ based on the data of FIG. 7.

It will be understood that the shape-rolling mill of the invention as illustrated in FIG. 1 can also be applied for the control of the bends in the metal work. In the rolling mill of FIG. 1, the vertical rolling mill rigidity K_Y is controlled by the first fluid pressure mechanism 5 while the transverse rigidity is controlled by the second fluid pressure mechanism 6, so that bends in the work can be easily corrected by adjusting the rigidity ratio of K_X/K_Y.

What is claimed is:

1. A shape-rolling mill for metallic section material wherein a metal work is rolled into a predetermined cross-sectional shape through a contoured roll pass which is defined between a number of opposingly disposed rolls, said mill comprising a first fluid pressure mechanism for adjusting the mill rigidity in the transverse direction parallel to the roll axes, and pressure control means for controlling the fluid pressure in said first fluid pressure mechanism for maintaining said transverse rigidity in a suitable ratio with respect to the vertical rigidity of the mill.

2. A shape-rolling mill as defined in claim 1, further comprising a second fluid pressure mechanism for adjusting the mill rigidity in the reducing direction and wherein said pressure control means is adapted to control the fluid pressure in both of said first and second fluid pressure mechanisms.

3. A shape-rolling mill as defined in claim 2, wherein said pressure control means comprises a detector located on an outlet side of a roll stand for detecting cross-sectional shape of a rolled metal work, an operating unit adapted to compare the output signals from said detector with predetermined reference signals to produce control signals, a fluid pressure generator, and a fluid pressure control unit.

4. A shape-rolling mill as defined in claim 3, further comprising fluid pressure detectors in association with said first and second fluid pressure mechanisms, said fluid pressure detectors being adapted to produce output signals indicative of the rolling loads in the reducing and transverse directions for transmission to said operating unit.

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