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(54) IMPROVEMENTS IN AND RELATING TO PLATE ROLLING

(71) I, KENNETH MICHAEL HUME, an Australian citizen, of 8 Lister Street, East Kew, 3102, in the States of Victoria, Commonwealth of Australia, do hereby declare the invention, for which I pray that a patent may be granted to me, and the method by which it is to be performed, to be particularly described in and by the following statement:—

10 This invention relates to improvements in and relating to plate rolling and is concerned more particularly with a new method of rolling steel plate into cylindrical form, for the manufacture of pipes, although it is not necessarily restricted thereto.

15 In the past, methods of bending steel plate into cylindrical or partly cylindrical form have been essentially processes employing simple bending. Thus plate has been rolled between the rollers of a triple roller arrangement, or plate has been engaged between opposed dies wherein the curvature of the plate is achieved by simple bending, and usually a multi-stage bending is necessary before the final cylindrical form is achieved. Even where many stages are employed it is frequently difficult or impossible to achieve a true cylindrical formation.

20 It is an object of the invention to provide for the rolling of plate in a simple and effective manner, and with good approximation to truly cylindrical form, and with this object in view the invention resides in a method of rolling plate to form a cylindrical article.

35 According to the invention, a method of rolling plate to form a cylindrical article comprises engaging a leading edge of a length of plate between a mandrel and gripping means on the mandrel so that the plate is tangential to the mandrel from the said edge, rotation the mandrel while engaging the remainder of the plate against the mandrel by pressing means so that the plate is gripped between the gripping means and the mandrel and a forward part of the plate is curved about the mandrel into a semi-cylindrical shape, subsequently advancing the plate relative to the mandrel until the rearward part of the plate and its trailing edge pass beyond contact with the mandrel, and

then engaging the said trailing edge between the mandrel and the gripping means and turning the mandrel again while engaging the remainder of the plate against the mandrel by pressing means whereby the rearward part of the plate is curved about the mandrel into a semicylindrical shape so that said forward and rearward parts together complete the formation of a cylinder.

Conveniently the gripping step includes gripping the leading edge of the plate with a rib which projects radially outwardly from the mandrel and extends axially therealong and includes a circumferentially extending flange. Engagement of the trailing edge may be effected by reversing the direction of motion of the plate and wherein the mandrel is rotated in the reverse direction to that used in the initial curving of the plate while curving the said rearward portion of the plate, and wherein said rib has two flanges which extend one in one circumferential direction and one in the other, the leading edge being engaged with one circumferentially extending flange and the trailing edge being thereafter engaged with the other.

Apparatus for carrying out the method as set out in the immediately two preceding paragraphs comprises a mandrel having a periphery defining a cylinder and having a rib extending radially outwardly from the periphery of the mandrel and extending in an axial direction for gripping the edge of a plate with the mandrel with the plate extending tangentially to the mandrel from the said edge, and pressing means for exerting pressure against the surface of the plate to urge the plate against the mandrel, said rib having two circumferentially directed flanges, one extending to each side, each flange defining a recess into which an edge of the plate can be placed to be gripped, and including means for driving the mandrel about its axis in both directions.

Other objects and features will be apparent from the following description of particular forms of the invention.

In the description reference is made to the accompanying drawings in which:—

Figure 1 is an elevational view of the ap- 100

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paratus according to one form of the invention locking endwise in relation to the mandrel.

5 Figures 2 to 10 inclusive are schematic views looking in the same direction as Figure 1 and showing, on a smaller scale, stages in the operation of the apparatus to produce a pipe.

10 Figure 11 is an elevational view of the apparatus of Figure 1 looking in a direction at right angles to Figure 1.

Figure 12 is a detailed fragmentary view in the direction of the arrows 12-12 of Figure 11.

15 Figure 13 is a fragmentary view of a modified construction of mandrel, and

20 Figures 14, 15 and 16 are schematic views illustrating a modified method of rolling plate into cylindrical form according to the invention.

Referring firstly to Figures 1 and 11 there is shown therein plate rolling apparatus comprising a horizontal framework 11 embodying supporting rollers 12 or other like supporting means upon which steel or other plate 13 may be advanced horizontally at a convenient height. The framework 11 has a well 14 through which a massive supporting I-beam 15 extends in a direction at right-angles to the direction of advancement of the plate 13 with its flanges horizontal. The upper flange 16 supports two horizontal rollers 17 and 18 the axes of which extend in the longitudinal direction of the I-beam 15 at an appropriate height for the upper surface of the rollers 17 and 18 to be at the same height as the upper surfaces of the rollers 12. The flat plate advanced along the rollers 12 also contacts and runs upon the rollers 17 and 18. The lengths of the rollers 17 and 18 are sufficiently great to engage the full width of the plate 13. The rollers 17 and 18 are shown supported by end brackets 19 fixed on the flange 16 and it is to be understood that as many intermediate supporting brackets may be provided along the rollers 17 and 18 are deemed necessary to prevent significant flexing.

25 The flange 16 is provided with means for supporting a mandrel 20 with its axis above the web of the I-beam 15 centrally spaced between the rollers 17 and 18 but above them. As shown by Figure 11 the supporting means comprises two hydraulic cylinders 21 and 22. One cylinder 21 is fixed in position with a shaft bearing 23 mounted on the upper end of its position rod 24. The other cylinder 22 also has a piston rod 25 with a shaft bearing 26 mounted on its end, but instead of being fixed to the flange 16 it is connected by a pivot pin 27 to a bracket 28 fixed on the flange 16. The cylinder 22 is pivotally connected to the piston rod 29 of a further hydraulic cylinder 30 pivoted to the web of the I-beam 15 so that by retraction

of the piston rod 29 into the cylinder 30 the cylinder 22 together with its piston rod 25 and bearing 26 can be swung downwardly from the full line position shown in Figure 11 into the position shown in dotted lines in which it is entirely below the path of movement of the plate 13.

70 With the cylinder 22 in its erect position shown in full lines in Figure 11, its bearing 26 and the bearing 23 provide support for a shaft 31 of the mandrel. Mandrels of different diameters can be used with appropriate raising or lowering of the piston rods 24 and 25. Suitable driving means is provided for the shaft 31 comprising a motor 32 and reduction and reversing gear box 33, both mounted on the I-beam 15 with a double universal drive connection 34 extending from the gear box 33 to the shaft 31.

80 The mandrel 20 may be in the form of a cylindrical drum as shown in Figures 1 and 11, in which case for the sake of rigidity it is desirably provided with internal discs or other suitable supporting means, not shown. However, it is not essential for the mandrel to have an enclosing peripheral surface which is a complete cylinder. Thus Figure 13 shows a suitable arrangement in which the mandrel is made of a plurality of discs 35 of the same diameter mounted on the shaft 31. Provided that the discs 35 are placed close enough to each other to achieve even bending of the sheet over its width it is not necessary to use an outer skin on the mandrel, although it is desirable to have a partial peripheral surface as indicated by 35a extending over the full length of the mandrel and for a short distance in the circumferential direction.

85 An essential aspect of the mandrel however is the provision thereon of plate gripping means 36 which consists of a continuous rib extending in an axial direction at the peripheral region of the mandrel. The rib 36 projects radially away from the mandrel for a short distance and has two flanges 37 which extend in the circumferential direction, one at each side. The flanges 37 provide between themselves and the periphery or the partial peripheral surface of the mandrel a recess which is slightly greater in width than the thickness of the plate with which the mandrel is to be used.

90 The apparatus further includes a welding head 38 disposed vertically above the axis of the mandrel, and means to facilitate removal of a completed pipe from the mandrel. The latter means comprises a roller 39 mounted for rotation in a bracket 40 mounted on the I-beam 15 near the bracket 28, the axis of the roller being horizontal and parallel to the direction of movement of the plate 13. It further comprises a second roller 41 mounted in the mandrel 20 diametrically opposite from the rib 36 and projecting slightly proud of the peripheral sur-

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face to co-operate with the roller 39 as shown in Figure 12 and explained further below.

In use the plate 13 of appropriate width to suit the length of pipe required and of appropriate length to suit the circumference of the pipe is advanced forwardly, i.e. to the right as seen in Figure 1 over the rollers 12 and the roller 17. At this stage the mandrel is disposed with the rib 36 in the bottom dead centre position and at a suitable height for the leading edge of the plate to enter into the recess provided by the flange 37 at the appropriate side of the rib. Figure 2 shows the approach to this position.

The mandrel is then turned in the anti-clockwise direction by the operation of the motor 32. This action causes the plate to be gripped by the flange 37 and to be drawn in an arc around the periphery of the mandrel. Figure 3 shows an early stage in this step. Normally it will not be found necessary to give the plate 13 a positive forward drive to ensure that it moves with the mandrel. The engagement of the leading edge by the rib 36 is sufficient to move it and the mandrel does not run away from the plate.

At an appropriate stage, indicated by Figure 4, when the mandrel has turned a predetermined extent slightly beyond 180° the turning is discontinued and the mandrel is raised slightly by means of the cylinders 21 and 22. At the same time the drive is disengaged. Since the deformation which has occurred is partially elastic some springing back occurs and the curved part of the plate thus assumes a part-cylindrical formation with a radius slightly greater than the mandrel as shown in Figure 5.

A ready method of determining the extent to which the turning should proceed beyond the top dead centre position of the rib 36 to produce a semi-cylindrical shape can be achieved by initially measuring the appropriate length of plate to suit the half circumferential length for the pipe diameter, and determining when the trailing edge of the plate has proceeded this distance. In fact, controlling means operated by a time switch or by optical or other interference means may be employed to stop the rotation at the desired position.

Having achieved this stage in the operation the plate is advanced bodily until the trailing end is clear of the mandrel whereupon the latter is turned until the rib 36 is again at the bottom dead centre position. This stage is illustrated by Figure 6. Thereafter the plate is moved in the reverse direction so that the former trailing edge enters the recess provided by the flange 37 at the appropriate side of the rib 36 and the mandrel is then turned in the reverse direction to curve the remaining half of the plate. Figure 7 shows an early stage in this pro-

cedure and Figure 8 shows the end of it. In this case also the mandrel is turned a little beyond the 180° to allow for the springing back which occurs when the load is relieved. In this case the appropriate position is determined when the initial leading edge of the plate reaches an appropriate point above the mandrel, due allowance being provided for any welding gap which may be required.

Preferably in the final stage of the rolling a slipper 42 is employed, the said slipper comprising a tapered plate having an appropriate concave face which can be engaged over the roller 18 to transfer the load between that roller and the previously curved part of the plate 13, Figure 8 shows this arrangement and Figure 9 shows the position on raising the mandrel again.

Having completed the formation of the cylindrical pipe and also the welding if required at this stage, it is then necessary to remove the pipe from the mandrel. In this process the cylinder 22 is operated to lower the mandrel at its end until the pipe rests on the roller 39 and the mandrel is supported in the pipe by the roller 41. The cylinder 30 is then operated to withdraw the cylinder 22, piston rod 25, and bearing 26 out of the way for removal of the pipe. Figure 10 shows the arrangement at this stage. Using suitable gripping means such as a power winch the pipe can then be withdrawn whereupon the bearing 26 can be re-engaged with the shaft 31 and the mandrel levelled for production of the next pipe.

The process of welding may be carried out while the pipe is mounted on the mandrel, in the operation of withdrawing it, or at some subsequent stage.

According to another particular form of the invention the pressing means against which the plate is engaged while the mandrel turns may comprise the floor or a flat machine bed. In this arrangement which is illustrated diagrammatically in Figures 14, 15 and 16 provision is made for moving the mandrel bodily in the longitudinal direction parallel to the floor or bed simultaneously with its turning, so that the unbent portion of the plate remains stationary upon the floor or bed.

With this arrangement it is again possible to achieve the formation of a pipe by first forming one half of the pipe by engaging one end of the plate, and thereafter forming the remaining half by engaging the opposite edge of the plate. The mandrel is similar in construction to that previously described, and again the turning of the mandrel to form the half cylinder extends through slightly more than half a turn to allow for the spring back of the curved portion when the mandrel is raised and disengaged from the driving means. Again it is possible to control the extent of the turning of the man-

drel by the amount of linear motion although in this case it is the mandrel which moves in a linear fashion, rather than the plate.

As the leading or trailing edge of the plate enters the recess beneath a flange 37 and is held therein a moment is applied to the edge of the plate rather than a force and this enables curving of the plate to occur right to the edge.

Further, the forces which make up the couple at the plate edge have lines of action almost opposite and the forces are therefore very high relative to the force exerted by the pressure rollers which by comparison has a long moment arm.

These very high opposing forces constitute a clamp and are the reason why the plate does not release (once the gripping action has taken place) until the plate edge is rotated relative to the rib 36 in the direction which will remove the opposing forces and allow the plate to become loose in the recess beneath a flange 37.

WHAT I CLAIM IS:—

1. A method of rolling plate to form a cylindrical article which comprises engaging a leading edge of a length of plate between a mandrel and gripping means on the mandrel so that the plate is tangential to the mandrel from the said edge, rotating the mandrel while engaging the remainder of the plate against the mandrel by pressing means so that the plate is gripped between the gripping means and the mandrel and a forward part of the plate is curved about the mandrel into a semi-cylindrical shape, subsequently advancing the plate relative to the mandrel until the rearward part of the plate and its trailing edge pass beyond contact with the mandrel, and then engaging the said trailing edge between the mandrel and the gripping means and turning the mandrel again while engaging the remainder of the plate against the mandrel by pressing means whereby the rearward part of the plate is curved about the mandrel into a semi-cylindrical shape so that said forward and rearward parts together complete the formation of a cylinder.

2. A method according to Claim 1 which includes forming each semi-cylindrical shape by turning the mandrel beyond 180° and thereafter releasing the mandrel and allowing the curved part of the plate to spring back to a semi-cylindrical shape.

3. A method according to Claim 1 in which the engagement of the said trailing edge is effected by reversing the direction of motion of the plate, and wherein the mandrel is then rotated in the reverse direction to that used in the initial curving of the plate.

4. A method according to Claim 1, wherein the gripping step includes gripping the leading edge of the plate with a rib

which projects radially outwardly from the mandrel and extends axially therealong and includes a circumferentially extending flange.

5. A method according to Claim 4, in which the engagement of said trailing edge is effected by reversing the direction of motion of the plate and wherein the mandrel is rotated in the reverse direction to that used in the initial curving of the plate while curving the said rearward portion of the plate, and wherein said rib has two flanges which extend one in one circumferential direction and one in the other, the leading edge being engaged with one circumferentially extending flange and the trailing edge being thereafter engaged with the other.

6. An apparatus for rolling plate to form a cylindrical article by the method as claimed in Claim 5, the apparatus comprising a mandrel having a periphery defining a cylinder and having a rib extending radially outwardly from the periphery of the mandrel and extending in an axial direction for gripping the edge of a plate with the mandrel with the plate extending tangentially to the mandrel from the said edge, and pressing means for exerting pressure against the surface of the plate to urge the plate against the mandrel, said rib having two circumferentially directed flanges, one extending to each side, each flange defining a recess into which an edge of the plate can be placed to be gripped, and including means for driving the mandrel about its axis in both directions.

7. Apparatus according to Claim 6 wherein the mandrel is provided at each end with bearing means capable of being raised and lowered and wherein the bearing means at one end can be disengaged to enable a formed cylindrical article to be removed from the mandrel.

8. Apparatus for rolling plate substantially as hereinbefore described with reference to Figures 1, 11 and 12 of the accompanying drawings.

9. Apparatus according to Claim 8 modified substantially as hereinbefore described with reference to Figure 13 of the accompanying drawings.

10. A method of rolling plate substantially as hereinbefore described with reference to Figures 1 to 12 of the accompanying drawings.

11. A method of rolling plate substantially as hereinbefore described with reference to Figures 14 to 16 of the accompanying drawings.

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(14) (15)

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5 As the leading or trailing edge of the plate enters the recess beneath a flange 37 and is held therein a moment is applied to the edge of the plate rather than a force and this enables curving of the plate to occur right to the edge.

10 Further, the forces which make up the couple at the plate edge have lines of action almost opposite and the forces are therefore very high relative to the force exerted by the pressure rollers which by comparison has a long moment arm.

15 These very high opposing forces constitute a clamp and are the reason why the plate does not release (once the gripping action has taken place) until the plate edge is rotated relative to the rib 36 in the direction which will remove the opposing forces and allow the plate to become loose in the recess beneath a flange 37.

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50 2. A method according to Claim 1 which includes forming each semi-cylindrical shape by turning the mandrel beyond 180° and thereafter releasing the mandrel and allowing the curved part of the plate to spring back to a semi-cylindrical shape.

55 3. A method according to Claim 1 in which the engagement of the said trailing edge is effected by reversing the direction of motion of the plate, and wherein the mandrel is then rotated in the reverse direction to that used in the initial curving of the plate.

60 4. A method according to Claim 1, wherein the gripping step includes gripping the leading edge of the plate with a rib

which projects radially outwardly from the mandrel and extends axially therealong and includes a circumferentially extending flange.

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6. An apparatus for rolling plate to form a cylindrical article by the method as claimed in Claim 5, the apparatus comprising a mandrel having a periphery defining a cylinder and having a rib extending radially outwardly from the periphery of the mandrel and extending in an axial direction for gripping the edge of a plate with the mandrel with the plate extending tangentially to the mandrel from the said edge, and pressing means for exerting pressure against the surface of the plate to urge the plate against the mandrel, said rib having two circumferentially directed flanges, one extending to each side, each flange defining a recess into which an edge of the plate can be placed to be gripped, and including means for driving the mandrel about its axis in both directions.

7. Apparatus according to Claim 6 wherein the mandrel is provided at each end with bearing means capable of being raised and lowered and wherein the bearing means at one end can be disengaged to enable a formed cylindrical article to be removed from the mandrel.

8. Apparatus for rolling plate substantially as hereinbefore described with reference to Figures 1, 11 and 12 of the accompanying drawings.

9. Apparatus according to Claim 8 modified substantially as hereinbefore described with reference to Figure 13 of the accompanying drawings.

10. A method of rolling plate substantially as hereinbefore described with reference to Figures 1 to 12 of the accompanying drawings.

11. A method of rolling plate substantially as hereinbefore described with reference to Figures 14 to 16 of the accompanying drawings.

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