The present invention relates to a cold-working plastic bending machine having a tiltably adjustable press-plate located slightly ahead of the main roller of the machine. A plurality of side rollers is provided, one on each side of the main roller. The force of the press-plate acting on the bend-compression side of a work-piece that passes between the main roller, the press-plate and the side rollers is balanced with the force of the side rollers which bend the workpiece so that the bending work is accomplished without twisting or creasing the workpiece.

4 Claims, 5 Drawing Figures
COLD-WORKING PLASTIC BENDING MACHINE

BACKGROUND OF THE INVENTION

The present invention relates to a cold-working plastic bending machine. Structural roll-shaped steel is made lightweight and thin with a profile exhibiting a high flexural rigidity to suit its intended use. When such shaped steel is bent to a required radius of curvature by cold plastic bending under a steadily increased bending moment, transverse buckling occurs at a certain magnitude of this moment. In other words, the steel is twisted at right angles to the stress plane. Twisting and creasing due to this buckling does not develop on the bend-tension side of the steel, but is instead limited to the bend-compression side of the steel. In the conventional plastic bending of shaped steel on three sets of rollers, slipping occurs between the roller and the shaped steel as the radius of curvature becomes smaller thereby rendering it impossible to feed the steel as required. Also, with conventional bending machines no buckle-prevention device is provided. Thus, it is extremely difficult to execute bending work to a small radius of curvature without twisting or creasing the workpiece.

SUMMARY OF THE INVENTION

The present invention is directed to a machine for cold plastic bending of shaped steel to a small radius of curvature. Buckling and slippage of the shaped steel is prevented by providing a tiltably adjustable press-plate ahead of the main roller, and making the force of the press-plate which presses only the compression side of the shaped steel balance the force of a plurality of side rollers.

BRIEF DESCRIPTION OF THE DRAWING

Novel features and advantages of the present invention in addition to those mentioned above will become apparent to those skilled in the art from a reading of the following detailed description in conjunction with the accompanying drawing wherein:

FIG. 1 is a plan view showing the arrangement of rollers of a cold plastic bending machine according to the present invention;

FIG. 2 is a longitudinal cross sectional view taken along lines 2—2 of FIG. 1 showing the relationship between the main roller and the end-bending roller;

FIG. 3 is a side view corresponding to FIG. 2 but slightly modified to bend flat steel;

FIG. 4 is a pictorial view of angle steel bent to a small radius of curvature; and

FIG. 8 shows an operating circuit diagram of oil pressure in various cylinders for a machine according to the present invention.

DETAILED DESCRIPTION OF THE INVENTION

The machine of the present invention shown in FIG. 1 comprises a first side roller 24, an end-bending roller 17, and a second side roller 37 each rotatably arranged close to a main roller 15. The axial distance A between the axis of the main roller 15 and the axis of the side roller 24, and the axial distance B between the axis of the main roller 15 and the axis of the side roller 37, are determined respectively by the profile dimensions of the shaped steel workpiece 23 and the bending radius of curvature. The axial distance A is variable by manual adjustment of the screw 7, as shown best in FIG. 2. Meanwhile the position of the roller 37 is changeable by means of the cylinder 31 and the ram 30. Also, the position of the end-bending roller 17 is changeable by means of the cylinder 20 and the ram 19. The forces of the rollers 17, 24, and 37 acting on the shaped steel workpiece 23 are respectively P2, P3, and P4, thereby the bending is balanced.

FIG. 2 shows the relationship between the main roller 15 and the end-bending roller 17. A hollow shaft 4 is pivoted to the machine body 5 through a combination of radial and thrust bearings. The main roller 15 is keyed to one end of the hollow shaft 4, and a drive gear 6 is keyed to the other end of the shaft. A shaft 2 passes through the hollow of shaft 4 and is pivoted on a spherical bearing 3 fitted at the top of the hollow shaft 4, as shown in FIG. 2. The shaft 2 can be tilted at an angle θ to the axis of the hollow shaft 4. One end of the shaft 2 carries a nut 12 for securing a press-plate 1 to the shaft. The top surface of the press-plate is tapered toward the periphery and the bottom surface forms a flat disk. The other end of the shaft 2 is fixed to the ram 8 by a nut 13 through a thrust bearing. Also, a hydraulic cylinder 7 is fitted to the machine body 5 through a gear cover 14.

When pressurized oil is introduced through the joint hole 10 of the cylinder 7, the pressure P1 causes the ram 8 to withdraw the shaft 2 in the direction of the arrow. The shaped steel workpiece 23 is thereby pressed by the force P1 between the main roller 15 and the press-plate 1. The ram 8 is balanced in the state as illustrated in FIG. 2. Further, when pressurized oil is introduced through the joint hole 21 of the end-bending cylinder 20 as well as through the above-mentioned joint hole 10, the ram 19 is pushed toward the main roller 15 by the force P2. Under the force P2, the shaft 16 and the end-bending roller 17 acting through the yoke 18 press the shaped steel workpiece 23 against the main roller 15. The top surface of the main roller 15 contacting the shaped steel workpiece 23 and the bottom surface of the press-plate 1 are preferably made rough for anti-slippering purposes.

When the gear 6 is driven in the direction of arrow N, as shown in FIG. 1, the shaped steel workpiece 23 rotates in a pressed condition under the force P1 of the main roller 15 and the press-plate 1. The shaped steel workpiece 23 is moved in the direction of arrow M, as shown in FIG. 1, while being bent to a required radius of curvature. The rollers 17, 24, and 37 are balanced with the shaped steel workpiece 23 at the pressures P2, P3, and P4.

The end-bending roller 17, located nearest the main roller 15, mainly serves to bend both ends of the shaped steel workpiece 23. When the press-plate 1 is pressing the bend-compression side of the shaped steel workpiece 23, the end-bending roller 17 applies the pressure P3 to the workpiece to bend it.

When the bending work is finished, the change valve 41 of FIG. 5 is operated to switch the oil from the joint holes 10, 21, 33 of the cylinders 7, 20, 31 to the joint holes 11, 22, 32. The ram 8 then pushes back the press-plate 1 in the direction reverse to the action of the pressure P1, while the end-bending roller 17 and the side roller 37 acting through the yokes 18, 38 are respectively turned back in the direction reverse to the ac-
tions of the pressures $P_1$, $P_2$. The shaped steel workpiece 23 is thereby released from the rollers, and as shown in FIG. 4, a buckle-free product with minimal out-of-roundness is obtained. Reference character E represents the junction between the start and end of bending.

As briefly explained above, FIG. 3 is a side view illustrating the relationship between the main roller 15 and the end-bending roller 17 during the plastic bending of a flat steel workpiece 25 having a simple rectangular cross section. In plastic deformation, the height $H$ scarcely changes, but the thickness increases to $b_2$ on the compression side and decreases to $b_1$ on the tension side. In the process of the thickness being increased to $b_2$ on the compression side, twisting and creasing can easily occur thereby causing buckling. For the purpose of preventing the buckling, on the bend-compression side a tilting angle $\theta$ is formed between the axis of the main roller 15 and the shaft 2 on which the cylinder 7 is mounted. As shown, the compression side thickness $b_2$ between the main roller 15 and the press-plate 1 applying the pressure $P_1$ is plasticly being deformed all the time under the pressure $P_1$ thereby preventing buckling. At the same time the steel workpiece 25 can be reliably fed without slippage by the main roller 15 of FIG. 1 which rotates in the direction of arrow N.

The pressure $P_1$ exerted by the press-plate 1 on the main roller 15, and the respective pressures $P_2$, $P_3$, $P_4$ of the rollers 17, 24, 37, are in a linear proportional relationship. Thus, the proportionality of the pressures $P_1$, $P_2$, $P_3$, $P_4$, to the size and radius of curvature of the shaped steel workpiece 23 or the flat steel workpiece 25 assures an ideal bending work.

As briefly explained above, FIG. 5 is an oil pressure operational circuit diagram for each cylinder. The change valve 41 controls with respectively adequate pressures the supply and exhaust of pressurized oil from the power unit 40 holding the motor M, the pump P, a relief valve and a pressure gauge, to and from the cylinder 7 and the ram 8 for the main roller press-plate, to and from the cylinder 20 and the ram 19 for the end-bending roller, and to and from the cylinder 31 and the ram 30 for the side roller. When pressurized oil is supplied through the change valve 41 to the joint holes 10, 21, 33 of the cylinders, the shaped steel workpiece is pressed and bent. On the other hand, when the oil is supplied to the joint holes 11, 22, 32, the rams 8, 19, 30 are pushed away to release the workpiece. The machine according to the present invention renders it unnecessary to bend both ends of a shaped steel workpiece by a press as in conventional bending work, and prevents both buckling and slipping by mere operation of the change valve 41.

In the prevention of buckling, the point of maximum bending moment (maximum plastic deformation) is at the same time the point most apt to buckle. On the bend-compression side of this point a necessary and sufficient force $P_1$ is exerted by the press-plate 1 to prevent buckling. Also, in the prevention of slipping, use of the main roller 15 equipped with an anti-slip mechanism working the pressure $P_1$, and using the press-plate 1, the shaped steel workpiece 23 or the flat steel workpiece 25 is pressed. Both the main roller 15 and the press-plate 1 are rotated in the direction of arrow N direction to take in and take out the steel reliably without slipping. Thus, a buckle-free product with a required radius of curvature is efficiently obtained.

Using appropriate rollers, the machine according to this invention can ideally bend rectangular steel, angle steel, H-steel, steel tube or any other shaped steel in a similar manner.

What is claimed is:

1. A cold-working plastic bending machine comprising a main roller having a vertical axis of rotation, a plurality of side rollers also having vertical axes of rotation with at least one side roller on each side of the main roller and another side roller directly adjacent the main roller, the rollers defining a path for a workpiece to be bent whereby the workpiece passes between the main roller and each of the side rollers with the main roller engaging the bend-compression side of the workpiece during the bending operation, and a tiltably adjustable press-plate directly above the main roller including means to urge the press-plate toward the main roller during the bending operation of a workpiece therebetween.

2. A cold-working plastic bending machine as in claim 1 including cylinder and ram arrangements connected to the side rollers for changing the positions of these rollers relative to the position of the main roller.

3. A cold-working plastic bending machine as in claim 1 wherein the press-plate includes a shaft portion pivotally mounted at a point along its length and means for urging the shaft portion to pivot about the mounting so as to adjust the tilt of the press-plate relative to the main roller.

4. A cold-working plastic bending machine as in claim 1 wherein portions of the main roller and the press-plate are roughened to prevent slippage between the main roller and the press-plate and workpiece.

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