METHOD AND APPARATUS FOR REMOVING EDGE CAMBER FROM STRIPS

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ABSTRACT OF THE DISCLOSURE

A method for removing lateral curvature from a metal strip including running the strip longitudinally and passing the strip between alternately angularly disposed pairs of rollers.

This invention relates to an improved method and apparatus for automatically straightening metal strips and, more particularly, for removing lateral curvature known as "edge camber" from the strips.

During the rolling of sheet metal in rolling mills non-uniform internal stresses are produced in the sheet. When the sheet is cut into strips during the slitting operation these latent non-uniform internal stresses are translated into a deformation of the strip itself. One such physical deformation of the strip is a lateral curvature known as "edge camber."

Various types of apparatus known to the prior art have been developed to correct this problem but they are generally cumbersome and complicated in operation. One such apparatus is a stretcher which grasps each end of the strip and exerts a longitudinal stress upon it so as to overcome its elastic limit and thereby straighten it. Such a stretcher is necessarily very large and expensive to operate, rendering its use prohibitive except in special instances. Furthermore, it is very wasteful of the strip in that substantial portions at the lead end and at the trailing end of the strip cannot be worked since they are deformed during the clamping operation. Another known apparatus is a rolling mill in which small edge rollers are mounted for pinching and sinusoidally deflecting the shorter edge of the strip for removing the camber. This apparatus is an expensive and complicated structure and also has the distinct disadvantage of deforming the strip and changing its dimensions. Furthermore, the strip must be periodically examined prior to its introduction to this apparatus for determining the degree of lateral curvature in the strip so that the position of the edge rollers, which create the edge distortion, can be adjusted for producing a final product which is longitudinally straight.

Accordingly, it is the primary object of my invention to provide a simple and economical method and apparatus for automatically removing edge camber from a strip regardless of the degree or direction of the lateral curvature.

Another object is to provide such a method and apparatus which does not stretch, deform or otherwise impair the dimensional stability of the strip.

A further object is to provide an improved method and apparatus for removing edge camber from a strip by directing the non-longitudinal strip in one pass through a plurality of roller pairs for producing a product which is longitudinally straight.

The objects of this invention are achieved in a general sense by running the strip in a single pass in a longitudinally directed and progressively passing it between a plurality of alternately angularly disposed roller pairs.

Other objects and further details of that which I believe to be novel and my invention will be clear from the following description and claims taken with the accompanying drawings wherein:

FIG. 1 is a top plan view of an improved edge camber removing apparatus constructed in accordance with my invention;
FIG. 2 is an enlarged side elevational view taken substantially along line 2—2 of FIG. 1;
FIG. 3 is a sectional view taken substantially along line 3—3 of FIG. 2;
FIG. 4 is a partial top plan view taken substantially along line 4—4 of FIG. 3 showing the details of one of the roller pairs;
FIG. 5 is an enlarged perspective view of a cam structure employed to raise the top rollers of the roller pairs;
FIG. 6 is a schematic top plan view of the apparatus shown carrying out the improved method of my invention;
FIG. 7 is a partial schematic side elevational view of the anti-buckling rollers; and
FIG. 8 is a schematic representation of the path of the strip centerline shown as it passes through the apparatus of my invention.

With particular reference to the drawings, there is illustrated in FIG. 1 a frame 1 having mounted thereon a plurality of roller pair subassemblies 10 each of which is pivotally mounted about its center upon a pivot pin 86 (FIG. 3). A swivel adjustment subassembly 12 is also mounted upon the frame for rotating each roller subassembly and for indicating the angular orientation of each roller subassembly. Between adjacent roller subassemblies 10 there are positioned anti-buckling guide rollers 14 whose function will become apparent.

It should be understood that the roller subassemblies 10 are identical and therefore only one will be described as representative. As best seen in FIGS. 2–4, the roller subassembly comprises a base 16 including a positioning lever 18 at one end thereof, a central aperture 20 and an elongated slot 22 at the end opposite the lever 18. Mounted upon and secured to the base 16 are spaced upright members 24 having aligned apertures 26 in which are located bushings 28. The upright members 24 further include a pair of opposed channels 30 for receiving slides 32 which are maintained within the channel by means of opposed cheeks 34. The slides are also provided with apertures 36 in which are located bushings 38. A top plate 40 is secured to the upright supports 24 by means of a pair of screws 42 in each end. The top plate 40 is provided with a pair of spaced openings 44, one at either end of the plate, through which are passed tubular spacers 46 for maintaining the slides 32 separated from a yoke 48. The yoke 48 is secured to and carries the slides 32 by means of a pair of elongated slide supporting screws 50 which pass through the tubular spacers 46 and are threadedly anchored in tapped openings 52 formed in the slides 32.

A bolt 54, threaded at both its ends, is threadedly anchored in the top plate 40 with its Shank passing through an elongated slot 56 in a release bar 58, an elongated slot 60 in a cam plate 62 and an opening 64 formed in the yoke 48. A knurled nut 66 is threadedly secured to the upper end of the bolt 54 for maintaining a compression spring 68 in compression for downwardly biasing the yoke 48 and the slides 32.

The roller subassembly 10 further includes a lower roller 70, fixedly mounted for rotation within the bushings 28 and an upper roller 72 mounted for vertical reciprocation with the slides 32 and for rotation within the bushings 38 located in the slides. In order for the upper roller 72 to be moved away from the lower roller 70 for introduction of a strip S between the rollers when setting up the machine for operation, it is apparent that the slides 32 must be moved upwardly by movement of the yoke.
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48 in that direction. This movement is accomplished by means of the cam plate 62 (FIG. 5) secured to the release bar 58 by means of a plurality of screws 74. The release bar 62 is longitudinally of the frame, being supported upon the top plates 40 of the roller subassemblies 10, and having the cam plates 62 mounted thereon at each subassembly as shown in FIG. 5. Each cam plate 62 includes a pair of raceways 76, comprising a straight run portion and a ramp portion on which a pair of steel balls 78 are carried in a suitable manner in the lower surface of the yoke 48, such as in a spherical depression, and are free to rotate therein upon the raceways 76. It is apparent that, as the release bar 58 is moved towards the left (as viewed in FIG. 1), the captured balls 78 are caused to roll upon the ramp portions of the raceways 76 thus moving the yoke 48 and the upper roller 72 upwardly. It should be understood that this is only one means which may be employed to perform this elevating operation.

The release bar 58 may be moved longitudinally by means of a release lever 80 which is swung about a fixed pivot located upon a bracket 82 secured to the rear upright member 24 of the last roller subassembly 10 (as viewed in FIG. 1). The release lever 80 is provided with an elongated slot for receiving a pin 84 which is fixedly secured upon the release bar 58. In this manner the swinging motion of the release lever 80 about its pivot is translated into the longitudinal motion of the release bar 58 for elevating the upper rollers 72 of each of the roller subassemblies 10.

As mentioned above, each roller subassembly 10 is mounted for rotation about its center upon a central pivot pin 86. The pivot pin 86 has a head 88 seated in a counterbore formed in the base 16 and a threaded end 90 to which is secured the nut 92 spaced from the frame F by a washer. Once the roller subassembly has been rotated to the desired angular position the nut 92 may be tightened for firmly urging the base 16 to the frame F and for securing it in that position. In order to insure that the roller subassembly 10 is firmly secured to the frame in its angular position a second locking means is provided including a locking screw 94 which passes through the elongated aperture 22 in the base plate 16 and is threadedly engaged in a tapped hole formed in the frame.

For accurate location of the roller subassembly 10 in its angular position there is provided a swivel adjustment subassembly 12 comprising: an indicator block 96 mounted upon the frame F and secured in place by suitable screws, a bracket 98 also mounted upon the frame F by means of suitable screws, the positioning lever 18, a compression spring 100, the other end of which is seated connecting a suitable driving means to the rollers 70 and within a similar seat 114 formed in the positioning lever 18. A headed pin 116 is secured in the wall of the positioning lever opposite the positioning screw 102 for preventing a backward movement of which the tip of the positioning screw 102 may bear.

Starting or centering rollers 14 are mounted upon the frame F on the entrance side of the first roller subassembly and anti-buckling rollers 14 are mounted between adjacent roller subassemblies. The guide rollers 14 are provided to grind the roller and constrain it in a substantially level or horizontal plane for countering the natural tendency of the strip to buckle between the roller subassemblies. The guide rollers 14, having undercut circumferential strip receiving grooves 118, are mounted upon suitable standards for maintaining the rollers 14 at the required height above the frame F. As illustrated in FIG. 2 each standard comprises a bolt 120 having a smaller diameter threaded end which is passed through an opening 123 in the frame F and is secured thereto by means of a locking nut 122, the other end also being of reduced diameter and passing through the guide roller 14 which is secured upon the standard by means of another locking nut 124. It should be noted that the openings in the frame 123 through which the lower ends of the bolts pass are elongated for allowing transverse adjustment of the guide rollers 14 to accommodate flat metal strips of various widths.

Operation

In order to utilize the above described apparatus for removing lateral curvature or "edge camber" it is necessary to set up the apparatus by swiveling the individual roller subassemblies 10—that is, angularly displacing each subassembly 10 to a predetermined position. The first roller subassembly (the furthest left in FIGS. 1 and 2) is swiveled upon its pivot pin 86 an angular amount equal to approximately one degree in either a clockwise or a counterclockwise direction from its central position, i.e., that position normal to the longitudinal direction of strip travel. The second roller subassembly is then swiveled half that amount, or one-half degree, from its central position, in the opposite direction. The third roller subassembly is swiveled oppositely from the second roller subassembly by one-half the preceding amount, or one-quarter of a degree, from its central position. This is repeated as well for the subsequent roller subassemblies. It has been empirically determined that at least five subassemblies are required for satisfactory camber removal and that the addition of more subassemblies to the frame F results in a straighter strip.

Once the roller subassemblies have been properly oriented and locked in their angular positions, the upper rollers 72 and the lower rollers 70 are separated for introduction of the strip S by swinging the release lever 80 clockwise, as described above. When the strip S is properly in place between each of the pairs of rollers, the control lever 80 is swung counterclockwise for clamping the strip between the rollers. The amount of clamping force exerted by each upper roller 72 upon the strip is merely sufficient to maintain the roller 72 in contact with the strip and the "floating" mounting of this roller is required to compensate for the usual tolerances or variances in the thickness of the strip. The slight force required is maintained by the compression spring 68 whose deflection is controlled by the position of the knurled nut 66, the force being very slight and of a magnitude which will not deform the strip. For example, it has been found that a force of approximately twenty-five to thirty pounds is all that is required for this purpose. Any larger force is undesirable for straightening a steel strip one inch wide and .025±.002 inch thick.

The metal strip S may be driven through this apparatus in any suitable manner such as by positive driving means located either fore or aft of the apparatus or by connecting a suitable driving means to the rollers 70 and
72—but the driving means forms no part of my present invention. It should be understood that this apparatus may be used in conjunction with and attached to various other machinery such as power presses, slitting machines or progressive die stamping machines for insuring that straight stock is fed to them. These machines are usually powered for pulling the strip therethrough and in such use, the drive of the auxiliary equipment may, of course, be utilized to pull the strip through my novel straightening apparatus.

As the strip S passes between the first swiveled rollers 70 and 72 there is a tendency for the strip to be "steered" and take the path of least resistance in the direction of their axis and to bend in one direction, thereby imposing a lateral curvature or "edge camber" upon the strip in that direction (see FIG. 6). However, as the strip emerges from the first pair of rollers 72 it is not allowed to follow this "steered" direction but is forced to pass between the second pair of rollers wherein it has been clamped, causing the strip to be bent laterally in a direction opposite to the imposed lateral curvature. This is repeated as the strip emerges from the second pair of rollers which are swiveled in the opposite direction and again as the strip emerges from the third, fourth and fifth roller sub-assemblies, each "steering" the strip S to a lesser degree. Thus the apparatus of my invention operates to impose a lateral curvature upon the strip, by the one pair of rollers but constrains the strip between the subsequent pair of rollers, in a generally longitudinal direction thereby causing the strip to be laterally bent against the imposed lateral curvature. Repeating this process with plural roller sub-assemblies each angularly displaced by an amount somewhat less than the preceding pair results in substantially straightening the strip S.

It can be seen in FIGS. 6 and 8 that when observed in plan view the centerline of the strip S will be forced to follow a sinusoidal path of decreasing amplitude as it passes through the pairs of rollers 70, 72. Therefore, between the roller pairs, one edge of the strip will always have to follow a shorter path than the other edge and it will have a tendency to buckle. The anti-buckling rollers 14 (see FIG. 7) have been provided between the roller sub-assemblies to prevent this buckling and to maintain the strip in a substantially horizontal plane.

It should be readily understood that it is immaterial whether the strip S is perfectly straight or has an "edge camber" in either direction when presented to my apparatus. Since my apparatus, in effect, imposes a lateral curvature upon the strip and subsequently removes all lateral curvature (that imposed plus that latent in the metal strip), the original condition of the strip need not be determined. This automatic operation is a distinct advantage, avoiding time consuming and costly periodic checking of the strip and resetting of the apparatus as now required by the known apparatus.

Furthermore, it is important to note that only a slight roller pressure is used, so that the strip is neither deformed nor re-rolled and there is no change in the thickness of the material. The only observable change in the strip is the removal of "edge camber" resulting in a substantially straight strip. I have found that such automatic straightening of the strip may be accomplished by guiding the strip through five roller sub-assemblies. Of course, it will be understood that the addition of more roller sub-assemblies will result in further straightening. This apparatus has been tested on steel, brass and zinc strip up to one and one-half inches and thicknesses from .020 to .080 inch and the results are always the same, viz., the removal of substantially all "edge camber."

The apparatus described above is automatic in operation due to the fact that the roller sub-assemblies 10 are set in a predetermined manner. However, the principle of my invention has been satisfactorily employed manually for short run operations by utilizing only one roller assembly which may be manually selec-


tively swiveled by the operator of the apparatus. Straightening is accomplished by periodically checking the strip as it is introduced to the roller subassembly and by correcting for (by counteracting) the amount of edge camber in the strip by manually resetting the angular orientation of the roller subassembly. This will cause the strip to emerge from the roller subassembly normal to the lateral center line thereof for effecting camber removal.

Having described my invention of an automatic swivel assembly for strip straightening it will be readily appreciated by those skilled in this art that such an apparatus is both simple in design, low in cost and efficient in operation. Reliability of operation was of primary concern although ease of assembly and minimum cost of manufacture were also important considerations that were achieved by this invention. The apparatus of this invention will find numerous uses wherever absolutely true strip stock is necessary, as for example in progressive die stamping operations.

It is understood that the present disclosure has been made only by way of example and that numerous changes in details of construction and the combination and arrangement of parts may be resorted to without departing from the true spirit and the scope of the invention as hereinafter claimed.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. A method of automatically removing lateral curvature from a flat metal strip in a single pass, comprising the steps of: running the strip in a substantially longitudinal direction; and progressively passing the strip between a plurality of alternately angularly disposed roller pairs.

2. The method of automatically removing lateral curvature from a flat metal strip as defined in claim 1 including: passing the strip between a first roller pair which is slightly angularly displaced from its central position normal to the longitudinal direction of strip travel; passing the strip to and between a second roller pair as it emerges from the first roller pair, the second roller pair being slightly angularly displaced in the opposite direction of rotation from its central position, relative to the first roller pair, the angle of displacement of said second roller pair being approximately one-half that of the angle of displacement of the first roller pair; and passing the strip to and between subsequent roller pairs, each roller pair being displaced from its central position oppositely relative to the preceding pair by approximately one-half the angle of displacement of the preceding pair.

3. The method of automatically removing lateral curvature from a flat metal strip as defined in claim 1 including: passing the strip between guide rollers located between adjacent roller pairs for preventing buckling of the strip as it passes from one roller pair to the next.

4. The method of automatically removing lateral curvature from a flat metal strip as defined in claim 1 including: passing the strip between a first roller pair which is slightly angularly displaced from its central position normal to the longitudinal direction of strip travel; passing the strip between a second roller pair as it emerges from the first roller pair; passing the strip to and between a second roller pair as it emerges from the guide rollers, the second roller pair being slightly angularly displaced in the opposite direction of rotation from its central position and the angle of displacement being approximately one-sixth the angle of displacement of the first roller pair; and passing the strip to and between subsequent anti-buckling guide rollers and roller pairs, each roller pair being angularly displaced from its central position in a direction opposite from the preceding roller pair and by an amount approximately one-half that of the preceding pair.

5. A method of removing lateral curvature from a flat metal strip in a single pass, comprising the steps of: running the strip in a substantially longitudinal direction;
periodically determining the amount of lateral curvature in the strip; passing the strip through a pair of rollers which may be swiveled about a central pivot; and angularly displacing the roller pair relative to a central position which is normal to the longitudinal direction of strip travel an amount sufficient to overcome or remove the lateral curvature.

6. Apparatus for removing lateral curvature from a flat metal strip comprising a roller subassembly including: a frame; a pair of rollers; means for supporting said pair of rollers with their axes parallel to one another including means for maintaining one of said rollers in a fixed position and means for maintaining the other of said rollers in a vertically movable position; and pivotal means for mounting said supporting means upon said frame for angularly displacing said pair of rollers from its central position normal to the longitudinal direction of strip travel.

7. Apparatus for automatically removing lateral curvature from a flat metal strip including a plurality of aligned roller subassemblies, as defined in claim 6, mounted upon said frame.

8. Apparatus for automatically removing lateral curvature from a metal strip as defined in claim 7 further including means for moving said movable rollers vertically from a clamping position to a non-clamping position for insertion of the metal strip between the pairs of rollers and for returning said movable rollers to the clamping position when the strip is in place.

9. Apparatus for automatically removing lateral curvature from a flat metal strip as defined in claim 7 including means for rotating said roller subassemblies about said pivotal means; and means for accurately positioning said roller subassemblies in the rotated position.

10. Apparatus for automatically removing lateral curvature from a flat metal strip as defined in claim 7 including means for preventing buckling of the metal strip, said means being mounted upon said frame between successive roller subassemblies.

11. Apparatus for automatically removing lateral curvature from a flat metal strip comprising: a frame; and a plurality of aligned roller subassemblies carried by said frame, each of said roller subassemblies including a pair of rollers, means for supporting said pair of rollers with their axes parallel to one another including means for maintaining one of said rollers in a fixed position and means for maintaining the other of said rollers in a vertically movable position, wherein said roller subassemblies are positioned upon said frame so that a first one is slightly angularly displaced from the normal to the longitudinal direction of strip travel, a second one is slightly angularly displaced in the opposite direction from the normal to the longitudinal direction of strip travel, relative to said first one, the angle of displacement from the normal of said second one being less than that of said first, and the subsequent ones being angularly displaced from the normal, oppositely from the preceding one, by less than the angle of displacement of said preceding one.

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