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STRIP ROLLING MILL SYSTEM AND PROCESS

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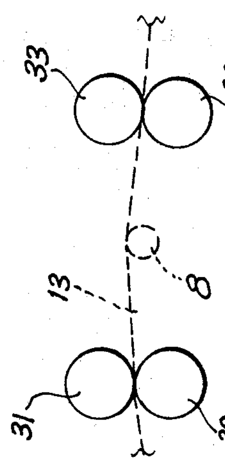

FIG. 3

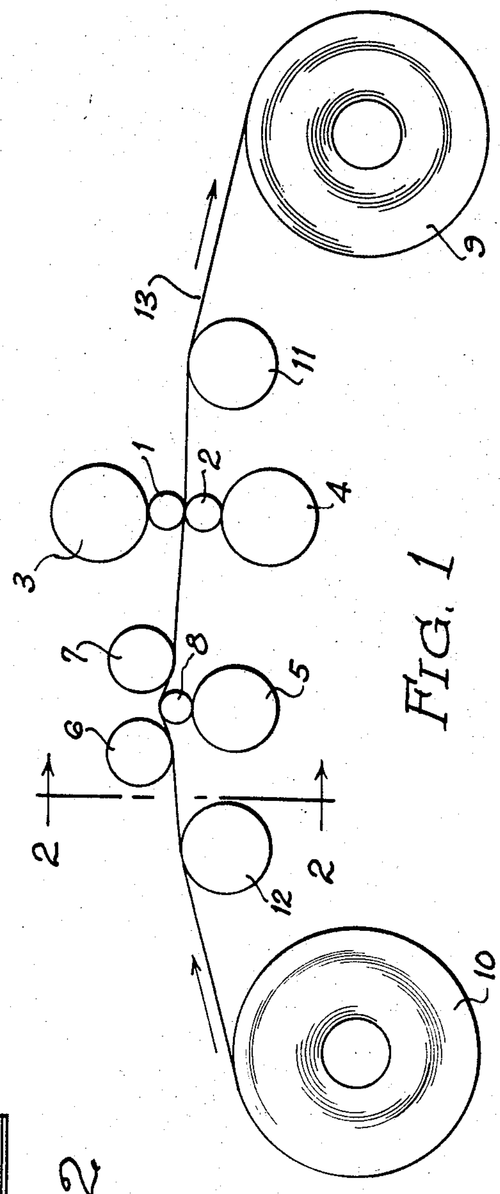

FIG. 1

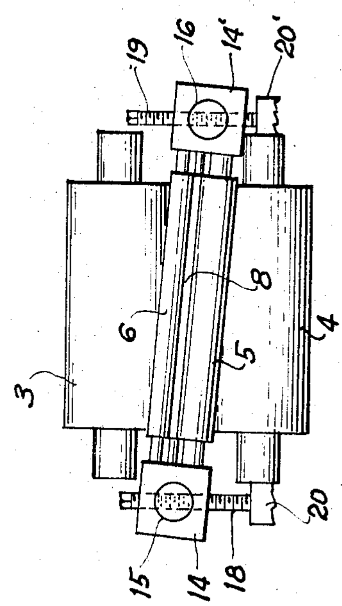

FIG. 2

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1

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ABSTRACT OF THE DISCLOSURE

The invention is addressed to a mill for rolling metal sheets, strips and the like wherein the metal is passed between reducing rolls for decreasing its thickness and in which the improvement is addressed to means adapted to twist the sheet or strip relative to the rolling plane selectively to increase the tension along the lateral edges of the metal for corresponding increase in elongation to offset the over-rolling at the center of the strip by the reducing rolls whereby a more uniform rolled product will result and in which the twisting means comprises the combination of aligned deflector rolls contacted by one surface of the metal and a flexing roll adapted to contact the opposite surface of the metal between the deflector rolls and means for adjustment of the flexing roll relative to the rolling plane of the metal.

This invention relates to an integrated equipment system and processing method for the rolling of metal in strip form. Its purpose is to secure products such as sheet, strip or foil of improved flatness compared with what can be achieved with conventional rolling mills and methods.

It has been recognized that difficulties in obtaining satisfactory flatness in these products originate in the rolling operation itself. Both the distance between the work rolls and their deflections vary in the course of a rolling pass due to slight changes in the incoming strip thickness and hardness, friction between the rolls and work, as well as roll temperature and wear. Each and any of these factors result in variations of roll pressure and, ultimately, of the "shape" and flatness of the strip. Because of the random nature of these variations, the control of flatness in the rolling of metal strip always represented a problem, its severity increasing with decreasing metal thickness.

In many cases, especially on light gauge strip, acceptable flatness of the as-rolled metal cannot be attained at all and it is necessary to employ special corrective devices, such as roller levelers or skin pass mills subsequent to the principal reduction-rolling operation. These devices entail a separate operation but their effectiveness is limited, especially on thin strip. In addition, levelers tend to impair the finish (reflectivity) of bright rolled material while the cost of tempering mills for strip is high. Furthermore, even when an application of these corrective devices is contemplated, their task is rendered easier and more effective when the out-of-flatness of the cold reduced strip is as small as possible.

As an alternative, or a co-measure with the corrective means discussed above, certain camber controlling devices involving bending of the work rolls or the backing rolls are increasingly used to compensate for variable roll deflection, wear, and non-uniform thermal dilatation. Among these devices, those based on bending the work rolls by loading their chocks with the aid of hydraulic cylinders have a small corrective effect because of journal pressure limitation. Those based on direct bending of the backing rolls are very expensive and unsuitable for mounting on existing, conventional rolling mills.

It is an object of this invention to provide a system for the rolling of flat products in continuous lengths (coil stock) which includes means for satisfactory, efficient, and economical control of strip flatness.

2

It is a further object of this invention to provide a flatness control construction and principle which can be incorporated into an existing strip rolling mill irrespective of the design of the rolling stand (or stands) and without making any structural changes thereto.

These and other objects of this invention will appear hereinafter and for purposes of illustration but not of limitation, specific embodiments of this invention are shown in the accompanying drawings in which:

FIGURE 1 is a schematic illustration of a rolling mill system including the operating mechanisms of this invention;

FIGURE 2 is a view of the system of FIGURE 1 taken about the line 2—2; and,

FIGURE 3 is a schematic illustration of a modified form of the invention.

The construction of this invention generally comprises means for twisting the span of the metal strip between the payoff reel and the rolling stand relative to the pass plane while said strip is under tension. The twisting action, which will be described in detail hereinafter, redistributes the total tension by transferring a larger proportion thereof onto the side, or edge portions of the strip while relieving it in the center part. Simultaneously, said strip is flexed by running it over a small diameter roller and it undergoes a plastic extension (stretch), said extension being substantially proportional to the tension per square inch for any fixed flexing roller diameter.

By controlling the amount of twist, a preferential extension of the edge regions is thus obtained, this extension being then used to compensate for the extra extension of the center of the metal strip caused by heat camber on the reducing rolls in the mill stand. The construction of this invention is capable of providing a more uniform rolled product by reason of this compensation of extensions across the strip.

FIGURE 1 illustrates a rolling stand with work rolls **1** and **2** and backing rolls **3** and **4**. It will be understood that the mill for reducing of the metal may be of any conventional type and that the arrangement illustrated is only one typical example.

Located in front of the reducing rolls is a strip flexing assembly including backup roll **5**, deflector rolls **6** and **7** and flexing roll **8**. The general arrangement illustrated is of the same type as the arrangement shown in FIGURE 2 of applicant's copending application Ser. No. 390,167, now Patent No. 3,270,543. In the ordinary use of a structure of this nature, the metal to be flexed is passed in contact with the roll **6**, then over flexing roll **8** and finally in contact with deflector roll **7**. The flexing roll **8** is of a small diameter so that a significant plastic strain in the strip and a substantial angle of flexural contact is achieved. Backup roll **5** supports roll **8** against bending.

The illustrated system also includes takeup reel **9**, payoff reel **10** and idler rollers **11** and **12**. These last mentioned portions of the described system are considered conventional and various other well-known arrangements for handling of the strip **13** are contemplated for use in the system of this invention.

FIGURE 2 illustrates the manner in which the deflector rolls **6** and **7**, flexing roll **8** and backup roll **5** are mounted. It will be noted that common journals **14** and **14'** are provided for the rolls **5**, **6** and **7**. Furthermore, these journals are movable in a vertical direction by reason of their attachment with screws **18** and **19**. Each of the screws is mounted for rotary movement in a base **20**, and means **21** and **22** are provided for rotating the screws.

Threaded pins **15** and **16** are mounted in the journals **14** and **14'**, and the screws **18** and **19** are received in the threaded bores of these pins. Rotation of the screws will provide for vertical movement of the journals so that the angle of the rolls **5**, **6** and **7** can be changed relative to the reducing rolls **3** and **4**.

In the operation of the instant invention, the strip **13** is passed from the payoff reel **10** over the idler **12** and then through the flexing cluster of rolls **5**, **6**, **7** and **8**. With this cluster inclined at an angle as illustrated in the drawings, the strip will be twisted relative to its position as it passes through rolls **1** and **2**.

The strip is normally under tension during its traverse prior to entry between the reducing rolls; however, with the amount of back tension normally used, there will be little perceptible elongation in the strip. When the cluster of rolls **5**, **6**, **7** and **8** is tilted as described herein, tensions are built-up in the edges of the strip, and these tensions are substantially greater than the average tensions in the strip. Accordingly, due to combined action of tension and flexure, the edges of the strip will elongate prior to entering the work rolls' bight, and the amount of this extension can be controlled by varying the tilt. When the strip reaches the work rolls, there is a tendency for greater pressure to be exerted upon its center portions because of the pre-ground camber and the thermal camber so that the center obtains a greater extension.

Such condition of over-rolling the center can also arise in conventional rolling operations when a strip with a full center is reduced between work rolls which do not have a sufficient effective negative camber while in operation. Under these conditions, a center-buckled strip will result. Accordingly, with the cluster **5**, **6**, **7** and **8** in an inclined position, there will be a tendency for the elongation of the strip to equalize since the extra elongation in the center portions will tend to offset the elongation already produced in the peripheral portions of the strip by the described twisting action. It will be appreciated that the degree of twisting can be readily controlled with the arrangement of this invention and, therefore, adjustments can be made to bring the total elongation across the width of the strip to a substantially uniform level.

In a typical use of the instant invention, the combination **5**, **6**, **7** and **8** can be associated with a rolling stand having work rolls **1** and **2** which are ground to produce flat strip when the rolls are cold. As a rolling operation progresses, the rolls **1** and **2** will begin to "swell" at the center and, therefore, there will be a tendency for the strip to elongate preferentially in the center area. By adjusting the tilt of the rolls **5**, **6**, **7** and **8** as the warming of the work rolls progresses, the edges of the strip can be pre-stretched to compensate for the excessive elongation which will take place at the center of the strip as it passes through the work rolls.

Although the aforesaid operation could be performed after the strip passes through the work rolls, it is preferred to provide for pre-stretching since the appearance (brightness) of the sheet will be more uniform when all of the compensating extension is introduced before or during contact with the work rolls. Furthermore, the prestretching takes place in a low tension location since the front tension between the mill and the takeup reel **9** is normally much higher than the back tension. The prestretching, therefore, minimizes any likelihood of tearing of the strip.

By providing an independent adjustment for the backup roll **5**, it is possible to accommodate a wide variety of strip thicknesses. It will be appreciated that various conventional means may be employed for supporting of the backup roll relative to the deflector rolls **6** and **7**.

As shown in FIGURE 1, the twisting action is transmitted to the work rolls **1** and **2** and to reel **10**. This may cause the strip to slightly drift sidewise. To prevent this, it may be advantageous to install two parallel guiding strands, as shown in FIGURE 3, having rolls **31–32** and **33–34**, respectively. These guiding devices are not driven (idlers), and their rolls are spaced apart sufficiently to engage the strip without rolling it. The twisting action is then confined to the metal span between the two guide stands and will not affect the coil or work rolls.

From consideration of FIGURES 1 and 3, it follows that the maximum extension of the edges in a strip of a given width is limited by the maximum tilt of the roll cluster in the pre-stretching device illustrated in FIGURE 2 and the distance (free span) between idler **12** and work rolls **1–2** in the arrangement in FIGURE 1, or between guide stands **31–32** and **33–34** in FIGURE 3. The shorter the free span and the wider the strip, the less tilt is needed to accomplish a specified elongation of the edges. For maximum response per angular unit of tilt, it is thus advantageous to keep this span short. For this reason, an arrangement of the type in FIGURE 3 is preferable to that in FIGURE 1, for the former renders the effectiveness of the system independent from the distance between the mill, idler roller, and reel. It is also seen that presence of the guide stands makes idler roll **12** redundant.

It is also contemplated that the selective increase in tension in the lateral edges of the strip can be accomplished solely due to the twisting action which is achieved. The twisting action will produce sufficient increase in tension to compensate for elongation in the center of the strip during working where such elongation is of a relatively low magnitude.

The small diameter flexing roll is preferably utilized in this invention since this roll will, in itself, produce plastic strain in the strip. Obviously, the smaller the diameter of the roll **8**, the less tension will be needed to differentially stretch the strip. Where relatively great elongation is anticipated at the center of the metal during reduction of the metal by the reducing rolls, a greater compensating extension of the lateral edges can be achieved by the combination of a small diameter flexing roll and the twisting action. A strip twisting action alone can be employed for small corrections, but it is dangerous beyond a certain point since the tension in the edges produced by twisting may reach a level which would cause tearing in the lateral edges. Where the small diameter flexing roll is employed, the diameters preferably extend between about $\frac{3}{16}$ inch and $\frac{3}{4}$ inch for strips from 0.002 to 0.025 inch thick.

The arrangement of this invention can be employed in combination with a reversing mill by providing one twisting means on either side of the mill. The twisting means on the forward side of the mill can be made inoperative by removing the roll **8** or by opening the gap between the rolls by moving backup roll **5** away from rolls **6** and **7**.

The flexing roll **8** is preferably a floating roll with its sole support being provided by the backup roll **5** and without the ends being confined against movement in the rolling direction by a fixed journal housing. However, other strip flexing devices can be used for the same purpose and with the same over-all effect, provided they incorporate the lateral tilting principle described herein.

It will be understood that various changes and modifications may be made in the above described construction which provide the characteristics of this invention without departing from the spirit thereof particularly as defined in the following claims.

That which is claimed is:

1. In a rolling mill operation for rolling of metal sheet, strip and the like wherein the metal is passed between reducing rolls for decreasing its thickness, the improvement comprising means adapted to twist said metal relative to the rolling plane for selectively increasing the tension of the lateral edges of the metal to increase the elongation in said edges and thereby offset the over-rolling of the center of the strip by the reducing rolls whereby a more uniform rolled product will result, in which said twisting means comprise the combination of a pair of aligned deflector rolls adapted to contact one surface of said metal, a flexing roll situated between said deflector rolls and adapted to contact the other surface of said metal whereby said metal is flexed when passing over said rolls, and a backup roll for said flexing roll.

2. A rolling mill in accordance with claim 1 wherein said means for twisting of the metal is located between said reducing rolls and a payoff reel for said metal.

3. A rolling mill in accordance with claim 1 comprising a reversing mill, one of said twisting means being located on either side of said reversing mill for individually handlng said metal depending on the direction of operation of said mill, and means for making one of said twisting means inoperative while the other twisting means handles said metal.

4. A rolling mill in accordance with claim 1 including means for adjusting the degree of twisting action of said twisting means.

5. A rolling mill in accordance with claim 4 wherein said backup roll and said deflector rolls are supported in common mountings and including means associated with said mounting means for adjusting the angle of disposition of said backup and deflector rolls to thereby adjust the twisting effect of said rolls.

6. In a rolling mill operation for the rolling of metal sheet, strip and the like wherein said metal is passed between reducing rolls for decreasing its thickness, the improvement comprising means adapted to twist said metal relative to the rolling plane for selectively increasing the tension in the lateral edges of the metal, and a small diameter flexing roll associated with said twisting means whereby the elongation of said strip in said edges is increased to thereby offset the over-rolling of the center of the strip by the reducing rolls to achieve a more uniform rolled product.

7. A rolling mill in accordance with claim 6 wherein said flexing roll has a diameter between 0.2 and 0.75 inch.

8. In a method for the rolling of metal wherein the metal is to be passed between reducing rolls for decreasing its thickness, the improvement comprising simultaneously passing said metal over a small diameter flexing roll and twisting said metal relative to the rolling plane when passing through said reducing rolls, and whereby tension is introduced in the lateral edges of the metal to offset the stresses introduced at the center of the metal by the reducing rolls to achieve a more uniform rolled product.

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