Fig. 1

Fig. 2

Fig. 3

Prior Art

Fig. 4

Prior Art

Fig. 5

INVENTOR
Natalis H. Polakowski
by McDougall, Herle, Scott
and Allys
ABSTRACT OF THE DISCLOSURE

A rolling mill for reducing strip thickness comprising work rolls, backup rolls and support rolls. The support rolls comprise rows of narrow disc-like rolls biased individually by fluid pressure means, whereby the work rolls deflect in conformity with the strip profile to produce a uniform transverse reduction in the thickness thereof. This action avoids buckles which result along initially thickened portions of strip reduced in mills having rigid roll support means.

This invention relates to a mill for rolling strip or sheet and it relates more particularly to a rolling mill for metal strip or sheet.

To the present, rolling mills for strip or sheet have been designed to achieve maximum stiffness or rigidity in the mill stand or frames and of the work roll supporting elements thereby to minimize their elastic extensions and deflections under rolling load. The intent is to minimize longitudinal and transverse gauge variation on the assumption that a rigid, nondeformable housing and rigid, nondeformable rolls would produce strip or sheet of the same thickness in all directions, regardless of the variations in thickness of the incoming material. While such extreme conditions have not been attained, the intent has been to approach the ideal as closely as possible.

When a sheet having a central portion that is thicker than the remainder is fed into a rigid mill of the type described, the central portion becomes reduced by an amount greater than the remainder with the result that the central portion will be rolled out to a greater length than the adjacent portions of the sheet. The resulting sheet will have a pronounced buckle along its midsection, with the result that it may become totally unacceptable for its intended usage notwithstanding the improved geometrical uniformity in thickness in its cross-section. Similarly, when a sheet or strip fed into the stiff rolls has a central portion of lesser thickness than the edge portions, the greater deformation, which will take place at the edges will result in greater elongation at the edge portions whereby the product will have wavy edges and it too may be unsuitable for use.

The concept of this invention is addressed to the proposition that flatness in a rolled sheet or strip is often more desirable than extreme gauge uniformity, especially for such applications as paneling for building and in automotive products and trucks; sheets for appliance doors and walls; and container stock. Thus it is an object of this invention to produce and to provide a mill for producing sheet and strip having a high degree of flatness.

More specifically, it is an object of this invention to produce a machine and method for rolling strip or sheet in a manner to take a substantially uniform percentage reduction throughout the cross-section of the sheet or strip independent of the variations in thickness through said cross-section of the sheet or strip, which produces a sheet or strip having a high degree of flatness; which flexibly engages the sheet or strip across the width of the sheet or strip to conform generally to the contour of the sheet or strip for substantially uniform application of pressure for rolling; and it is a related object to produce a machine of the type described which is simple in construction and easy in operation, which can be sturdily built for continuous operation to roll endless lengths of sheet or strip of steel, aluminum, copper, or other metals, or even sheets or strips of plastic and the like materials.

These and other objects and advantages of this invention will hereinafter appear and for purposes of illustration, but not of limitation, an embodiment of the invention is shown in the accompanying drawings, in which—

FIG. 1 is a schematic sectional elevational view of a reduction in strip performed in accordance with the features of this invention with the variations in thickness exaggerated for purposes of illustration; FIG. 2 is a plan view of the strip after the rolling reduction in accordance with FIG. 1; FIG. 3 is a schematic sectional elevational view of a reduction in strip in accordance with the concepts of present practice with the original strip having an edge portion of greater thickness than the center; FIG. 4 is a plan view of the strip after the rolling reduction illustrated in FIG. 3; FIG. 5 is a schematic sectional elevational view showing the arrangement of rolls in a roll mill embodying the features of this invention; FIG. 6 is a top plan view of a portion of the roll mill shown in FIG. 5; and FIG. 7 is a schematic diagram of the fluid pressure system which may be employed in the practice of this invention.

It is believed that the inability of a rolling mill to adjust its roll-gap profile to the variation and profile of the sheet or strip processed thereon stems from the high flexural rigidity of the rolls, including the backup rolls and supports in present design. The direct consequence of such rigidity in the roll assembly is to increase contact pressure where portions of greater thickness are engaged between the rolls while the contact pressure falls to considerably lower levels where the portions passing between the rolls are thinner in cross-section. Under such circumstances, the portions of greater thickness become reduced by a much greater amount percentage-wise than the remainder of the cross-section with the result that elongation occurs to a greater extent along the portions of greater thickness by comparison with the remainder. Such differential causes the sheet or strip to buckle.

Attempts to overcome such defects in the rolled sheet or strip have been made by grinding a chamfer in the rolled surface in the attempt to accommodate the differences in cross-section of the sheet material. However, the chamfer designed for one sheet does not necessarily conform to the profile of the rest while the rigidity of the rolls remains the same thereby oftentimes to aggravate the situation rather than to relieve it.

Reference is made to FIGS. 1-4 for illustration of the theory underlying the concepts of this invention. In order to achieve flatness, it is believed necessary for percentage reduction in the cross-section of the sheet or strip to be substantially uniform throughout the width of the sheet or strip, independent of the variation in the cross-section of the sheet or strip. As indicated in FIG. 1, the numeral 100 represents the amount of reduction that has been taken and the portion 101 indicates the cross-section of the resulting sheet. Exaggeration is made of the differences in the cross-section of the sheet with the portion of greater thickness at the ends. It will be seen that the amount of reduction that is taken, in accordance with the practice of this invention, is somewhat the same percentage-wise with the result that a flat sheet is produced
3,478,559

Figure 3

with little, if any, buckle. For all practical purposes, it may be said that the amount of reduction is substantially
and uniformly distributed across the entire section of the sheet independent of any variation in profile or thickness.

FIGS. 3 and 4 are representative of rolling with a stiff roll whereby a greater percentage of reduction is taken at the end sections with 104 representing the reduction that was taken and 105 the cross-section of the rolled strip while some of the material which would have been seen that the strip 105 is wrinkled at the ends while the strip 101 remains relatively flat.

The concepts of this invention are addressed to a rolling mill which makes use of a "soft" or flexible roll that automatically readjusts to conform to the changing profile of the sheet or strip responsive to pressure engagement thereat with the operation of the mill thereby to yield a product of improved flatness while still taking the desired rolling reduction across the width of the sheet or strip. Ready deflection of the work roll to accommodate cross-sections of variable thickness enables the work roll to effect reductions by uniform amounts across the width of the sheet or strip as distinguished from reductions in much greater amounts at the thinner sections and much lesser amounts at the thicker sections.

Referring now to FIGS. 5-7 of the drawings which diagrammatically illustrate the roll assembly embodying the features of this invention, the sheet roll 14 is processed advanced linearly between the work rolls 12 and 14. The lower work roll 14 can be conventionally supported against deflection by a large diameter backup roll 16 rotatably supported at its ends in conventional bearing blocks mounted in the side walls of the rigid frame 18.

The upper work roll 12 is supported in the nip over a pair of relatively flexible backup rolls 20 and 22 which are in turn backed up by three rolls 24, 26 and 28 of larger diameter disc bearing rolls 30, each of which is mounted on a separate axle 32. The backup roll 20 is located in the nip between the rolls 24 and 26 to be engaged throughout its length by the disc bearings 30 aligned in the rolls 24 and 26 while the backup roll 22 is in the nip between the rolls 26 and 28 whereby the separate disc bearings 30 in said rows engage the backup roll 22 throughout its length. The separate axles 32 for each disc bearing roll 30 are carried by shoes 34 in the form of semicircular supports which are fixed on the ends of separate rods 36.

In the preferred arrangement, the rods 36 carrying the shoes 34 in engagement with the axles 32 of the upper center row 26 of disc bearing members are fixed at their outer ends to the frame 18 thereby to rigidly support the disc bearing members. Under such conditions, the disc bearing members may be joined into a single roll extending crosswise of the mill with the roll supports at the ends. Instead, the separate disc bearing members in row 26 may be resiliently supported as will hereinafter be described with reference to the assemblies forming the side rows 24 and 28.

In the rows 24 and 28, which engage the backup rolls 20 and 22, respectively, from opposite sides, the rods 36 are in the form of piston rods extending outwardly from pistons reciprocally in fluid operated pressure cylinders 38 seated into separate openings or cavities otherwise fixed to the side walls of frame 18 with the rods 36 extending laterally from the frame walls 18 preferably with a slight downward incline of from 2-20° to impart an inward force on the axles with a slight downward pressure.

While, as previously pointed out, the rods 36 supporting the shoes 34 for the row 26 of disc bearing members could be similarly supported by downwardly extending piston rod and cylinder assemblies, such arrangement is not essential since the breakdown of the force acting on the backup rolls 20 and 22 will provide a component acting vertically against the upper support bearings which is small by comparison with the force vectors acting laterally against the side rows 24 and 28 of the disc bearings.

Thus the deflection in roll 12 will be controlled principally by the deflections permitted in the backup rolls 20 and 22. If rods 36 were all immovably fixed to the heavy frame 18 or to massive horizontal members which link the frames on opposite sides of the mill, the backup rolls 20 and 22 would be held against deflection thereby to reduce the rolls or stiff rolls resulting in a rigid mill of the types presently employed. The support of the disc bearings engaging the backup rolls separately across their lengths coupled with the resiliency in the support to enable relative endwise displacement of the axle 32 in each row will enable the backup rolls freely to deflect in sections across the lengths of the rows to permit corresponding deflection in the engaged work roll 12.

In the preferred practice of this invention, each of the individual cylinders 38 are connected by pressure fluid lines 40 to a header line 42 fitted with a main shutoff valve 44. A bypass line 46 fitted with a pressure regulated bypass valve 48 communicates the header 44 with the source 50 of pressure fluid. Fluid under pressure is delivered to the header 42 through line 52 fitted with a high pressure pump 54 or communicates with an accumulator for delivery of fluid under pressure from the supply source 50 to the cylinders 38.

When in open position, the pump 54 operates to deliver fluid under pressure to each of the cylinders 38 for uniform application of pressure to each disc bearing for application of force to the corresponding engaged sections of the backup rolls 20 and 22 and from the backup rolls to the work roll 12 to effect the desired reduction. The operation pressure remains constant, as determined by the pressure setting of the bypass valve 48. The relatively low inherent rigidity of the backup rolls 20 and 22 and the greater flexibility in the supporting axles 32 enable the work roll 12 freely to deflect automatically to adapt itself to the instantaneous profile of the sheet or strip tending thereto to effect the desired uniformity in percentage reduction throughout the cross-section of the sheet.

It is possible to operate the described mill not only as a constant separating force device, as described, but also as a relatively rigid device with self-correcting features for adjustment in profile of the work roll 15 to accommodate differences in profile of the sheet material as it is being passed between the work rolls. For this purpose, the fluid is pumped up to the desired pressure after which the hydraulic or fluid system is sealed by closing the main shutoff valve 44. The hydraulic cylinders are interconnected through the lines 40 and the header 42 to enable the fluid under high pressure to flow freely between the cylinders in response to variations in pressure emanating from differences in sheet profile thereby to preserve the freedom of the roll 12 and the backup rolls 20 and 22 to deflect.

Under such conditions, mill pressure will increase overall with increased thickness of sheet stock and vice versa, but the unit load across the rolls will remain approximately constant by reason of the interconnection of the pressure fluid lines.

By way of still further modification, certain portions of the work roll 12 can be operated as a stiff roll while other portions continue to operate as a flexible roll. As illustrated in FIG. 7, selected lines for feeding pressure fluid to the cylinders can be provided with shutoff valves 56 to isolate certain of the cylinders from the fluid system whereby such isolated cylinders operate completely independently of the remainder and at the pressure required in the fluid in the sealed cylinders. Thus the pistons are rendered immobile while the pistons in the other sections remain free for movement in response to force to permit the desired flexibility in conformance with the profile of the sheet.

By way of still further modification, the rigid support for the work roll 14 can be replaced by a similar arrangement of flexible supports thereby to increase the response...
in the profile of the space between the work rolls to correspond to the profile of the sheet passing therebetween. The work rolls and the support rolls are also supported conditionally at their ends in suitable bearing blocks rigid with or built into the side walls of the rigid frame. Rolls having the desired flexibility for use as work rolls and as backup rolls, in accordance with the practice of this invention, are generally independent of the lengths of the rolls but will depend upon the diameter of the rolls. Hardened steel rolls having a diameter of from 1 to 6 inches are suitable for use as the work rolls 12 and corresponding metal rolls having a diameter within the range of from 2 to 10 inches are suitable for use as the backup rolls. The stiffness of a roll is proportional to the cube of its diameter. Thus, in a conventional four-high roll mill of 42 inch face width, use is made of a work roll of about 12 inches in diameter backed up with a support roll of about 40 to 45 inches in diameter. By comparison, a 6 inch work roll will have ten times the flexibility of a 12 inch work roll and a 10 inch backup roll will have forty to fifty times the flexibility of a 40 inch backup roll. The diameters of the rolls are given by way of illustration of the preferred range which may be used in the practice of this invention for roll widths of from 12 to 80 inches. It will be understood that rolls of slightly greater diameter or even lesser diameter may be used depending somewhat upon the structural material.

It will be apparent from the foregoing that the work roll 12 and the backup rolls 20 and 22 are selected of materials and of a diameter which will permit deflection thereby to constitute flexible or soft rolls from a comparative standpoint since such rolls will still be constructed of conventional hard steel or other metal used in roll construction.

Instead of making use of separate axles 32 for rotatably supporting the bearing disc members 24 and 28, use can be made of a single axle on which the bearing disc members in each row are mounted provided that the axle members 32 are of sufficiently small diameter to enable flexure for displacement of the bearing disc members in response to flexure of the corresponding portion of the backup roll while maintaining substantially constant pressure.

It will be understood that changes may be made in the details of construction, arrangement and operation without departing from the spirit of the invention, especially as defined in the following claims.

1. A roll mill for the reduction of strip passing therethrough comprising a pair of work rolls mounted for rotational movement, at least one of said work rolls being sufficiently slender for relative flexibility across the length thereof, a pair of rotatably mounted backup rolls forming a cluster for the flexible work roll with the backup rolls being relatively flexible throughout their length, each backup roll being supported against rolling pressure by a cluster of rotatably mounted support rolls arranged in rows, at least one row of which comprises an assembly of separate resilient pressure means mounted with freedom of movement radially in the direction towards and away from the bearing disc rolls and in pressure engagement with said bearing disc rolls continuously to urge said bearing disc rolls individually against the backup roll to enable deflection of the backup roll across its length during rotational movement in response to corresponding deflection of the work roll in accordance with the strip profile.

2. A roll mill as claimed in claim 1 in which the pair of backup rolls are supported by three rows of support rolls with the middle row common to the pair of backup rolls.

3. A roll mill as claimed in claim 2 in which the outer of the rows of the support rolls are each formed of a plurality of spaced apart bearing disc rolls arranged in laterally spaced apart relation across the length of the backup roll with each disc roll being separately mounted for rotational movement and for movement in the direction toward and away from the backup roll and in which the pressure means continuously urged the backup rolls in the direction towards the backup roll comprises fluid operated piston and cylinder assemblies having one portion communicating with the disc roll and the other portion fixed to a lateral portion of the frame and fluid transmitting members communicating the cylinders with a pressure fluid supply source.

4. A roll mill as claimed in claim 3 in which the piston and cylinder assembly resiliently interconnecting the bearing disc rolls with the frame extend laterally from the frame with a slight downward incline in the direction towards the backup roll.

5. A roll mill as claimed in claim 3 in which the fluid transmitting members are interconnected one with the other for the transmission of uniform fluid pressure to the communicating cylinders.

6. A roll mill as claimed in claim 5 which includes a shutoff valve between the cylinders and the pressure fluid supply source for cutting off the flow of fluid theretbetween at predetermined pressure.

7. A roll mill as claimed in claim 5 which includes a bypass valve between the pressure cylinders and source of fluid supply for bypassing fluid from the cylinders to maintain a substantially constant roll separating force in the mill.

8. A roll mill as claimed in claim 1 in which both of the work rolls are flexible rolls.

9. A roll mill as claimed in claim 3 which includes shutoff valves for at least one of the fluid transmitting members to enable the corresponding cylinders to be isolated from the pressure fluid system to reduce the corresponding portions of the backup rolls to a stiff roll portion.

10. A roll mill as claimed in claim 1 in which the bearing disc rolls in one row are mounted on a flexible axle common to all of the bearing disc rolls.

11. In the method for achieving a substantially uniform percentage rolling reduction in continuous strip independent of the variation in profile of the strip to produce a flat rolled strip, the steps of advancing the strip between a pair of work rolls in which at least one of the work rolls is flexible across its length, backing up the flexible work roll with a cluster of relatively flexible backup rolls, supporting the flexible backup rolls resiliently mounted bearing disc rolls arranged across the length of the flexible backup roll, and resiliently urging selected ones of the bearing disc rolls in the direction towards the backup roll for the transmission of uniform rolling force to the work roll while permitting flexure of the work and backup rolls to correspond to the profile of the strip.

References Cited

UNITED STATES PATENTS

1,614,423 1/1927 Coe ________________ 72—242
2,194,212 3/1940 Sendzimir ________________ 72—242
2,430,410 11/1947 Pauls ________________ 72—245
2,828,654 4/1958 Ungerer ________________ 72—242
3,049,949 8/1962 Volkhausen et al. ________________ 72—243

FOREIGN PATENTS

387,205 9/1953 Japan.

MILTON S. MEHR, Primary Examiner

U.S. Cl. X.R.

72—245