METHOD AND APPARATUS FOR CONTROLLING THE THICKNESS OF ROLLED STRIP

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This invention relates to an improved method and apparatus for controlling the thickness of rolled metal strip. In the original type of rolling, the thickness of a strip is reduced by an amount which varies with the coefficient of friction between the strip surface and the roll surface. The coefficient of friction in turn varies with the lubricity of a lubricant coating between these surfaces. The greater the lubricity, the less the coefficient of friction, and the thinner the strip, as long as other factors are constant. Different lubricant compositions of course furnish different degrees of lubricity, and when lubricant is applied to strip for cold-rolling, differences in the lubricant temperature also produce differences in its lubricity. For a more extended discussion on this subject as applied to cold-rolling, reference can be made to a printed publication by Whetzel and Rodman "Improved Lubrication in Cold Strip Rolling," which appears in Iron and Steel Engineer, March, 1959, issue, pages 123 to 132. Similar principles apply to hot-rolled strip, except that differences in lubricant temperature are not consequential.

An object of my invention is to provide a method and apparatus for controlling the thickness of rolled strip by regulating the lubricity of the lubricant coating between the strip and roll surfaces.

A further object is to provide a method and apparatus of the foregoing type in which control is effected by applying to one of these surfaces a mixture of two lubricants having different lubricating qualities, and varying the relative proportions of the two in accordance with measured variations in the strip thickness.

A further object is to provide a method and apparatus in which the foregoing operations are accomplished automatically with a combination of simple commercially available devices.

In the drawings:

FIGURE 1 is a diagrammatic perspective view of a control apparatus constructed in accordance with my invention and particularly suited for controlling the thickness of cold-rolled strip;

FIGURE 2 is a schematic diagram of an electric circuit embodied in the apparatus;

FIGURE 3 is a graph showing how the coefficient of friction between the strip and the rolls varies with the temperature of a typical lubricant; and

FIGURE 4 is a view similar to FIGURE 1, but showing a modification particularly suited for controlling the thickness of hot-rolled strip.

FIGURE 1 shows a set of conventional rolls 10 and 12 for cold-rolling a continuous metal strip 5, and a conventional gage 13 located on the exit side of the rolls for measuring the thickness of the rolled strip. The gage develops a voltage which varies in a known relation with variations in the strip thickness. A preferred example is the well-known X-ray type gage whose voltage output increases as the strip becomes thicker. I apply lubricant to the top and bottom surfaces of the strip through conventional spray devices 14 and 15 located on the entry side of the rolls.

The control apparatus of the present invention comprises two tanks 16 and 17 which supply lubricants of different lubricity. In the embodiment of FIGURE 1, the two tanks contain lubricant of the same composition, but maintained at different temperatures. I equip tank 16 with a heater 18 and tank 17 with a refrigeration coil 19, both controlled with thermostats to maintain the lubricant in each tank at a constant temperature. The exact temperatures at which I maintain the two lubricants are not critical, as long as there is a substantial difference between the two. The higher temperature of course must not be so high that the lubricant boils away or decomposes, and the lower temperature must be high enough that the lubricant still flows readily. Examples of suitable temperature ranges are 180 to 210 F. for the hot and 50 to 100 F. for the cold. Preferably the tanks are equipped with agitators 20 to keep the lubricant in a homogeneous physical state. The lubricant can be any of those commonly used in cold-rolling strip, for example palm oil or cottonseed oil or "palm oil substitute" derived mainly from beef tallow blended with emulsifiers and other additives commonly used in the preparation of rolling lubricants.

Pipes 21 and 22 connect these tanks to inlets of a conventional mixing valve 23. A pipe 24 connects the valve outlet to both spray devices 14 and 15. As hereinafter explained, gage 13 is operatively connected with the mixing valve 23 to vary the relative proportions of hot and cold lubricants and thus vary the lubricity of lubricant actually reaching the strip. Excess lubricant drains from the strip into a pan 26 and returns to the tanks through a pipe 27, which contains a suitable pump 28. Pipe 27 has branches 31 and 32 which are connected thereto via a two-way valve 33 and discharge into the hot and cold lubricant tanks 16 and 17 respectively. The two tanks contain floats 34 and 35 mechanically connected to valve 33, whereby the valve directs return lubricant to the tank in which the level is lower.

FIGURE 2 shows schematically a typical circuit for adjusting the mixing valve 23 in accordance with the voltage signal from the thickness gage 13. The voltage illustrated includes a housing 38, a piston 39 slidably mounted in said housing, piston rods 40 and 41 fixed to opposite faces of said piston and extending through the ends of the housing, and cores 42 and 43 of magnetic material fixed to the ends of said piston rods. Compression springs 44 and 45 encircle the piston rod and bear against the respective cores 42 and 43 and oppose ends of the valve housing and thus tend to center the piston with respect to the housing. Pipes 21 and 22, through which hot and cold lubricants enter the valve, are connected to the housing adjacent its opposite ends. The housing has spaced apart outlets 46 and 47 intermediate its length to which pipe 24 is connected. When piston 39 occupies its mid-position, the mixing valve admits approximately equal volumes of hot and cold lubricants to pipe 24. The valve has operating solenoids 50 and 51 which act on cores 42 and 43 respectively for shifting the piston 39. When solenoid 50 is energized, the piston moves to the left to admit a greater proportion of cold lubricant. When solenoid 51 is energized, the piston moves to the right to admit a greater proportion of hot lubricant.

The circuit includes a D-C. voltage source 52, such as
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3. a battery, and a potentiometer 53 whose slide wire is connected thereacross. The voltage signal from the thickness gage is applied to terminals 54 and 55 of the circuit to oppose the voltage from the source 52. That is, in the illustration, the positive line from the thickness gage is connected to terminal 54, which in turn is connected to one end of each solenoid 59 and 51 via conductors 56 and 57. The negative line from the gage is connected to terminal 55, which also is connected to the negative side of the potentiometer 53. The arm of potentiometer 53 is connected to the other end of solenoid 59 via a conductor 58 which contains a rectifier 59 or equivalent, and to the other end of solenoid 51 via a conductor 60, which contains a rectifier 61 or equivalent. If strip S becomes too thin and the signal level falls, a signal appears between conductors 56 and 58, which signal has a value proportional to the departure of the strip from the desired thickness and a polarity to make conductor 58 positive with respect to conductor 56. Thus solenoid 59 is energized, while the rectifier 61 prevents current from flowing through solenoid 51. If strip S becomes too thick, the reverse action takes place and solenoid 51 is energized. In either event the circuit stabilizes with piston 39 in a new position which supplies a proper lubricant mixture to hold the strip at almost the desired thickness. It should be noted that the circuit I have described is of the feedback type which relies on a small error signal to stabilize itself. When either solenoid is energized in response to a deviation in strip thickness, it remains energized to a degree that tends to bring the strip back to desired thickness, but not quite if the gain in system is properly adjusted.

As a specific example, rolls 10 and 12 are installed in a cold reduction mill which has a spring constant of 5000 pounds per thousandths inch of roll gap change and they are set initially to roll strip 19 thousandths inch thick with 93,000 pounds rolling force and with lubricant which provides a coefficient of friction of 0.060. The lubricant is a 5 percent aqueous mixture of "palm oil substitute" derived from beef tallow. I maintain the lubricants in tanks 16 and 17 at temperatures of 200 F and 50 F, respectively. FIGURE 3 shows how the coefficient of friction under these conditions varies with the lubricant temperature. If I apply only the cold lubricant to the strip, the coefficient of friction is 0.071, and the rolls reduce the strip to a thickness of about 0.0215 inch. If I apply only the hot lubricant, the coefficient of friction is about 0.052, and the rolls reduce the strip to a thickness of about 0.017 inch. Thus by properly proportioning my cold and hot lubricants I can vary the coefficient of friction between values of 0.052 and 0.071 and I can effect thickness changes in the range 0.017 to 0.0215 inch. If I commence a rolling operation with equal parts hot and cold lubricants, and the gage detects a deviation in thickness from the intended value, the circuit automatically adjusts the proportions of hot and cold to bring the thickness back nearly to this value, preserving a small error signal, as already explained.

FIGURE 4 shows a modification particularly suited for hot strip mills. The mill comprises upper and lower work rolls 65 and 66 and upper and lower back-up rolls 67 and 68. Tanks 69 and 70 supply lubricants of different chemical compositions. For example, tank 69 may contain one of the same lubricants as used in the embodiment of FIGURE 1 and tank 70 may contain water. The two lubricants flow through a mixing valve 71 and upper and lower spray devices 72 and 73 which direct sprays of lubricant on the work rolls 65 and 66. The mill is equipped with a thickness gage 74 which controls the mixing valve in the same fashion as in the embodiment shown in FIGURE 1.

From the foregoing description, it is seen that my invention furnishes a simple and effective method and apparatus for controlling the thickness of rolled strip. The invention automatically regulates lubricant supplied to the strip or to the work rolls to hold the strip thickness close to the intended value whenever deviations occur which would tend to produce deviations in thickness. The mechanism is formed of conventional components and is readily installed on existing equipment without otherwise altering its structure.

While I have shown and described certain preferred embodiments of my invention, it is apparent that other modifications may arise. Therefore, I do not wish to be limited to the disclosure set forth but only by the scope of appended claims.

I claim: 1. In a metal strip rolling operation, a method of controlling the reduction which takes place in the strip thickness comprising continuously measuring the thickness, applying a lubricant mixture between the strip and roll surfaces, and varying the proportions of lubricants in said mixture in accordance with the measured strip thickness to maintain the thickness at approximately a constant value.

2. In a metal strip rolling operation, a method of controlling the reduction which takes place in the strip thickness comprising continuously measuring the thickness, mixing two lubricants having different lubricating properties, supplying the lubricant mixture between the strip and roll surfaces, and varying the relative proportions of the two lubricants in the mixture in accordance with the measured strip thickness to provide lubricity which maintains the thickness at approximately a constant value.

3. In a metal strip rolling operation, a method of controlling the reduction which takes place in the strip thickness comprising measuring the strip thickness, mixing a first lubricant of relatively high lubricity and a second lubricant of relatively low lubricity, supplying the lubricant mixture between the strip and roll surfaces, and varying the proportions of said lubricants to include more of the first in the mixture when the measurement shows the strip is too thick and more of the second when the measurement shows the strip is too thin.

4. A method as defined in claim 3 in which said lubricants are similar in composition but the first is maintained at a relatively high temperature and the second at a relatively low temperature.

5. A method as defined in claim 3 in which said lubricants are of different chemical composition.

6. In a strip rolling mill which includes a set of rolls, a gage for measuring the thickness of strip as it leaves said rolls, and means for applying lubricant between the strip and roll surfaces, the combination therewith of an apparatus for controlling the thickness, said apparatus comprising means for mixing two lubricants of different lubricity, means operatively connecting said gage with said lubricant mixing means to vary the relative proportions of the two lubricants in accordance with the measured thickness of the strip, and means for delivering lubricant from said lubricant-mixing means to said lubricant-applying means.

7. In a strip rolling mill which includes a set of rolls, a gage for measuring the thickness of strip as it leaves said rolls, and means for applying lubricant between the strip and roll surfaces, the combination therewith of an apparatus for controlling the strip thickness, said apparatus comprising a first source of lubricant of relatively high lubricity, a second source of lubricant of relatively low lubricity, means for mixing the lubricants from said sources, means operatively connecting said gage with said lubricant-mixing means to vary the proportions of the two lubricants in accordance with the measured thickness of the strip, thus including more of the first lubricant in the mixture when the strip tends to become too thick and more of the second when it tends to become too thin, and means for delivering lubricant from said lubricant-mixing means to said lubricant-applying means.
8. A combination as defined in claim 7 in which said sources contain lubricants of similar composition and comprising means for heating the lubricant in said first source and means for cooling the lubricant in said second source.

9. A combination as defined in claim 8 in which said lubricant-applying means includes spray devices for directing lubricant on the strip surfaces ahead of the rolls, and comprising means for recovering excess lubricant and returning it to said sources.

10. A combination as defined in claim 7 in which said sources contain lubricants of different chemical composition and said lubricant-applying means includes spray devices for directing lubricant on the roll surfaces.

References Cited in the file of this patent

UNITED STATES PATENTS

2,310,563 Wilke et al. 2,914,975 Cavanaugh
Feb. 9, 1943 Dec. 1, 1959

FOREIGN PATENTS

806,786 Great Britain Dec. 31, 1958