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Vydrin et al.

[11] **3,811,307**

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[54] **METHOD OF ROLLING METAL SHEET ARTICLES**

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[51] **Int. Cl.** **B21b 1/00**

[58] **Field of Search** 72/205, 232, 199, 366

[56] **References Cited**

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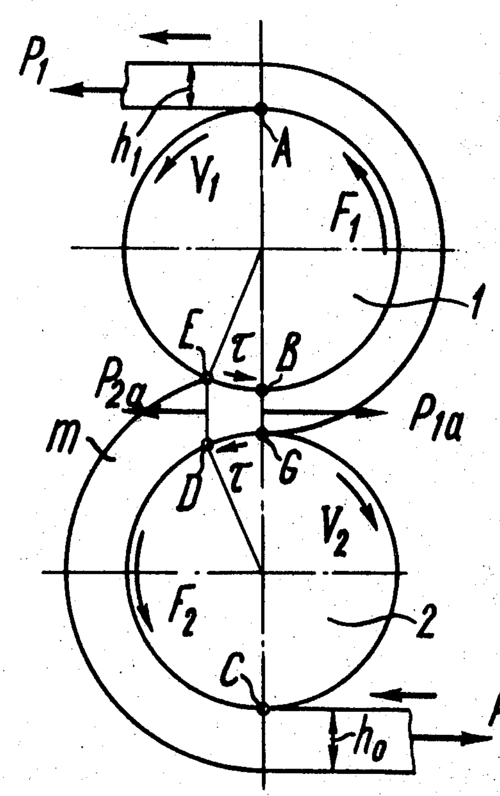
[57] **ABSTRACT**

A method of rolling metal sheet articles in which the rolls in an adjacent pair are rotated in opposite directions at different peripheral speeds under conditions of a rigid mechanical characteristic of the drive of the roll rotating at a higher peripheral speed and such a mechanical characteristic of the drive of the roll rotating at a lower peripheral speed that in the process of rolling the ratio of the peripheral speeds of the rolls is equal to the ratio of the thicknesses of the articles at input and output portions thereof before and after the rolling in the adjacent pair of rolls at a constant thickness of the output portion of the article and at a speed of movement of the output portion of the article equal to the peripheral speed of the roll rotating at a higher peripheral speed.

1 Claim, 2 Drawing Figures



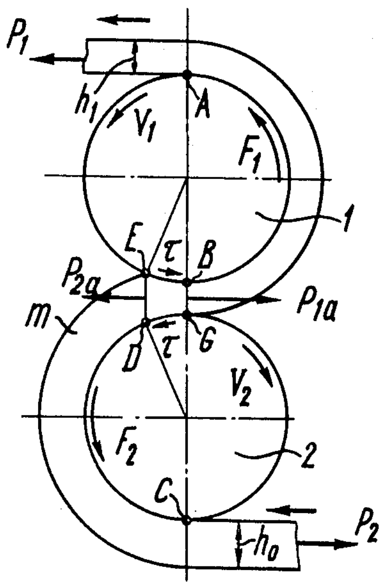

P1
h1
V1
A
F1
1
E
τ
B
P2a
P1a
m
D
τ
G
V2
F2
2
C
P2
h0

FIG. 1

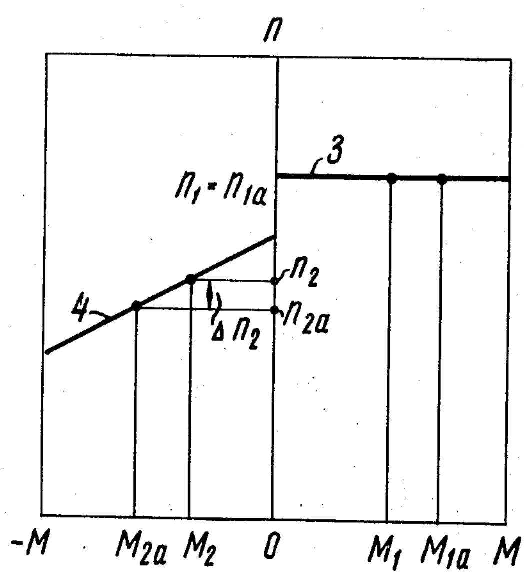

n
3
n1 = n1a
n2
4
Δ n2
n2a
-M
M2a
M2
0
M1
M1a
M

FIG. 2

METHOD OF ROLLING METAL SHEET ARTICLES

The present invention relates to a method of rolling metal sheet members, for example, strips, bands, sheets, foil, preferably for cold rolling of these articles.

Known in the art is a method of rolling metal sheet articles (Application in Britain No. 29255, in the USA No. 836851, now Pat. No. 3,709,017) in which an adjacent pair of rolls are rotated in opposite directions at different peripheral speeds, while tensile forces are applied to the input and output portions of the articles by means of successively enveloping the rolls by the articles with said peripheral speeds of the rolls having a ratio equal to the ratio of the thicknesses of the article before and after the rolling in the adjacent pair of rolls and at the speed movement wherein the output portion of the article is equal to the peripheral speed of the roll rotating at the higher peripheral speed.

As the initial blank always varies in thickness in a longitudinal direction, according to this method, the draw-back is eliminated or reduced by controlling the ratio of the peripheral speeds of the rolls in accordance with the change in the thickness at the input portion of the article to be rolled. This is usually effected by means of an automatic system for controlling the process of rolling, said system being very complicated and expensive.

An object of the invention is to provide a method of rolling metal sheet articles between the driving rolls which would make it possible either to eliminate or to reduce the longitudinal draw-back of the article being rolled without using an automatic system of control the rolling process.

This and other objects are accomplished by a method which proposes to roll the metal sheet articles between the driving rolls of a rolling mill in which the rolls in an adjacent pair are rotated in opposite directions at different peripheral speeds, tensile forces being applied to the input and output portions of the article by successively enveloping the rolls by the article with the ratios of the peripheral speeds of the rolls and being equal to ratios of the thicknesses of the article before and after rolling it in the adjacent pair of rolls with a speed of movement of the output portion of the article being equal to the peripheral speed of the roll rotating at a higher peripheral speed. According to the invention, the mechanical characteristic of the drive of the roll rotating at a higher peripheral speed is absolutely rigid, or close to it while the mechanical characteristic of the drive of the roll rotating at a lower speed is selected so that in the process of rolling the ratio of the peripheral speeds of the rolls would be equal to the ratio of thicknesses of the article at the input and output portions thereof, the output portion of the article having a constant or almost constant thickness.

The present invention provides a method of rolling metal sheet articles between the driving rolls which makes it possible either to eliminate or to reduce the draw-back of the article being rolled by means of a self-controllable process without using any automatic system for controlling the process of rolling.

Other objects and advantages of the invention will be apparent from the following detailed description of one particular embodiment of the invention, reference being made to the accompanying drawings, in which:

FIG. 1 illustrates the method of rolling sheet metal articles between the driving rolls according to the invention;

FIG. 2 illustrates a diagram of mechanical characteristics of the drives of the rolls during the method of rolling metal articles according to the invention.

When effecting the proposed method of rolling metal sheet articles the rolls 1 and 2 (FIG. 1) are rotated by drives (not shown) in opposite directions at different peripheral speeds V_1 and V_2. The roll 1 is rotated at a higher peripheral speed than the roll 2. The ratio of the peripheral speeds of the rolls 1 and 2 is equal to a ratio of the thicknesses of the article m before and after the rolling in the adjacent pair of the rolls 1 and 2, i.e. $V_1/V_2 = h_o/h_1$. The direction of rolling the article is shown by arrows in FIG. 1. To reduce the tension P_1 of the output portion of the article m and the tension P_2 of the input portion of the article the latter is bent about the rolls 1 and 2 utilizing the static friction forces F_1 and F_2 against arcs AB and CD by bending the articles m over the rolls thus providing the necessary forces P_1a and P_2a to accomplish deformation in the region of BEDG. The static friction is a force when the article is moved over the roll without sliding. Inasmuch as the static friction forces F_1 and F_2 on the arcs of the bending rolls 1 and 2 by the wrapping of the article m therearound can be changed within a wide range while using the same tensions P_1 for the output portion of the article and P_2 for the input portion of the article m, the process of rolling will be stable, i.e., without sliding of the article on the arcs AB and CD of bending the rolls 1 and 2.

The diagram in FIG. 1 may be used for evaluation of the action of forces τ within the origin of deformation in the process of deformation: the friction forces τ at the opposite contact surfaces BE and DG of the origin of deformation are equal and oppositely directed so that the pressure acting on the rolled article m side rolls the rols is considerably reduced.

The drive of roll 1 rotated at a higher peripheral speed V_1 operates under active (driving) conditions, i.e., provides for a torque coinciding with the direction of rolling, while the drive of roll 2 rotated at a lower peripheral speed V_2 operates under reactive (braking) conditions, i.e., creates a torque reverse to the direction of rolling.

The initial blank of the article "m" always has different longitudinal draw-back i.e., the thickness h_o of the article before the rolling is different in various places at input. To obtain sheet articles of a high quality it is necessary that the thickness of the article after the rolling is equal in all portions of featuring insignificant deviations from the predetermined constant thickness h_1.

For this purpose, the mechanical characteristic of the drive roll 1 rotated at a higher peripheral speed is made absolutely or almost absolutely rigid, while the mechanical characteristic of the drive of roll 2 rotated at a lower peripheral speed is selected such that in the process of rolling the ratio V_1/V_2 of the peripheral speeds of rolls 1 and 2 is equal to the ratio h_o/h_1 of the thicknesses of the article m at the input and output portions thereof at a constant or near constant thickness h_1 of the output portion of the article m.

FIG. 2 shows a mechanical characteristic 3 of the drive of roll 1 rotated at a higher peripheral speed and a mechanical characteristic 4 of roll 2 rotated at a lower peripheral speed. The drive of the roll 1 has an absolutely rigid mechanical characteristic **3**, i.e., the rotational speed of roll **1** does not change with a change of the load (torque). The drive of the roll **2** has a soft (less rigid) characteristic **4**, i.e., any increase in the load on the roll **2** is associated with a decrease in its rotational speed ensured by its drive.

When rolling the input portion of the article m having a rated thickness h_o the drive of roll **1** is loaded by the torque M_1, while drive of the roll **2** is loaded by the torque M_2. In this case the number of revolutions per minute of the drive of roll **1** is equal to n_1, while the number of revolutions per minute of roll **2** is equal to n_2. If the thickness of the input portion of the article m exceeds the rated thickness h_o, the load on drives of the rolls **1** and **2** increases; the drive of the roll **1** develops a torque M_1a, while the drive of the roll **2** develops a torque M_2a. In this case the number of revolutions of the drive of roll **1** is not changed ($n_1 = n_2$), while the number of revolutions of the drive of roller **2** is reduced ($n_2 > n_2a$).

Therefore, the peripheral speed of roll **1** is unchanged ($V_1 = V_1a$), while the peripheral speed of roll **2** is reduced ($V_2 > V_2a$). Due to this fact the ratio of the peripheral speeds of rolls **1** and **2** increases in accordance with the change in the thickness h_o of the input portion of the article m.

When the thickness h_o of the input portion of the article is increased for a value δh_o while the peripheral speed of roll **2** is decreased for a value ΔV_2, we will get the following equation (on condition that the thickness of the article after rolling is equal to the predetermined value h_1)

$$V_1/V_2 - \Delta V_2 = h_o + \delta h_o/h_1 \quad (1)$$

By converting the equality (1), we will get

$$V_1h_1 = V_2h_o + V_2\,\delta h_o - \Delta V_2h_o - \Delta V_2\delta h_o \quad (2)$$

The product $\Delta V_2\,\delta h_o$ in the equality (2) is a negligible value, therefore it may be taken equal to zero. Taking into account that $h_1/h_o = V_2/V_1$, and converting the equality (2), we get

$$\Delta V_2 = V_2\,\delta h_o/h_o \quad (3)$$

$$\Delta V_2/V_2 = \delta h_o/h_o \quad (4)$$

The equation (4) shows that for producing an article m having a constant thickness h_1, the relative change in the peripheral speed of the roll **2** should be equal to the relative change in the thickness h_o of the input portion of the article.

Thus, the proposed invention may sharply reduce the longitudinal draw-back of the ready sheet article and thus obtain a high-quality product. The absence a complex and expensive system for automatically controlling the process of rolling makes it possible to reduce the cost of the rolling mill and the expenses producing sheet metal articles.

The test rolling of metal bands having a thickness of 2 to 0.05 mm from carbon and alloyed steels according to the proposed method has confirmed the advantages and promises of this method of rolling metal sheet articles.

We claim:

1. A method of rolling metal sheet articles between the driving rolls of a rolling mill in which the rolls in an adjacent pair are rotated in opposite directions at different peripheral speeds while providing for a rigid or close to rigid mechanical characteristic of the drive of the roll rotating at a higher speed, whereby said higher speed is maintained under conditions of varying torque, and such a mechanical characteristic of the drive of the roll rotating at a lower peripheral speed, that its peripheral speed varies inversely with variations in the load thereon due to longitudinal variations in thickness of the input portion of the article, so that, during the rolling, the ratio of the peripheral speeds of the rolls is variable so as to be maintained equal to the ratio of the thicknesses of the article at the input and output portions thereof before and after the rolling in the adjacent pair of rolls at a constant or close to constant thickness of the output portion of the article, and at a speed of movement of the output portion of the article equal to the peripheral speed of the roll rotating at a higher peripheral speed, tensile forces being applied to the input and output portions of the articles by successively enveloping the rolls by the article, first on said roll rotating at said lower peripheral speed, and then on said roll rotating at said higher peripheral speed.

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