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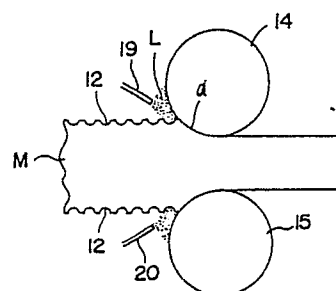
(54) Rolling method and rolling machine.

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(57) A workpiece to be rolled is formed in its surface with a large number of recesses for retaining a lubricating fluid therein, and then the workpiece is rolled while the lubricating fluid is confined in the recesses. A rolling machine comprising a rolling mill further includes a recess impressing unit for forming a large number of recesses in the surface of the workpiece, which is provided on the inlet side of the rolling mill. The recess impressing unit includes a pair of pinch rolls formed with a large number of projections. The rolling machine further includes a nozzle for spraying the lubricating fluid which is

provided on the inlet side of work rolls for rolling.

Fig. 2



Rolling Method And Rolling Machine

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to a method and a machine for rolling metal plate, shape steel, bar steel, etc. made of steel, aluminum and the like with a reduced coefficient of friction.

2. Description of the Prior Art

In rolling a band plate made of steel, aluminum and the like, nowadays, a hot strip mill is used in case of hot rolling, or a tandem cold mill is used in case of cold rolling, for example. In such mills, the band plate is rolled thin by putting it between a pair of upper and lower rotating work rolls. To reduce the friction arising between the work roll and the band plate when the rolling takes place, hitherto, fluid such as a rolling lubricating agent was supplied to the surface of the work roll to decrease a load devoted to causing plastic deformation. In this regard, the lubricating agent is effective in preventing the generation of abrasion of the work roll and of flaws in the surface of a workpiece to be rolled.

In case of hot rolling, however, the temperature of the band plate reaches about 900°C to 1200°C, and the rolling lubricating agent supplied to the work roll loses its lubricating power because it generally burns at temperatures above 200°C. Consequently, the rolling lubricating agent adhering to part of the work roll exerts only a poor lubrication effect, thereby increasing the abrasion of the roll. With an increase in abrasion of the roll, the coefficient of friction between the band plate and the roll increases; hence, a large rolling load must be imposed to keep the reduction ratio of the band plate.

According to the conventional hot rolling process, there is no fluid, but air present between the work roll and the band plate, and the air cannot contribute as a boundary film because of its compressibility, thus, it is deemed that every surface region of the band plate is brought into a boundary friction state wherein metal-to-metal contact prevails. Therefore, the coefficient of friction between the work roll and the band plate becomes 0.2 or more ($\mu \geq 0.2$); consequently, the rolling load increases, the surface of the roll becomes rough, the roll wears, and so on.

As a result, the rolled band plate has surface irregularity in the widthwise direction, such as local projection or high spot, defective shape, and zigzag pattern.

In case of cold rolling, to increase the reduction ratio, the pressure within the contacting arc region between the band plate and the work roll for rolling the former is made very high; thus, the rolling lubricating agent cannot get enough into the contacting arc region of the roll to thereby exert only a poor lubrication effect.

SUMMARY OF THE INVENTION

In view of the foregoing circumstances, it is the object of the present invention to provide band plate rolling method and rolling machine capable of reducing the abrasion of rolls of a rolling mill, decreasing the rolling load, keeping the reduction ratio identical with the prior art, and making the rolling machine compact.

To achieve the foregoing object, a rolling method according to the present invention is characterized by the steps of forming a large number of recesses in the surface of a workpiece to be rolled and rolling the workpiece while confining a lubricating fluid in the recesses, and a rolling machine according to the present invention is characterized by a recess impressing unit provided on the inlet side of a rolling mill for rolling a workpiece to be rolled, for forming a large number of recesses adapted to retain a lubricating fluid therein in the surface of the workpiece.

In operation, a large number of recesses are formed in the surface of a workpiece to be rolled by the recess impressing unit provided on the inlet side of the rolling mill, then, at the time of rolling the workpiece by the rolling mill, a lubricating fluid is retained and confined in the recesses, and when the workpiece is pressed, the lubricating fluid thus confined is expanded thin to form a boundary film. It should be noted that the recesses disappear as the rolling of the workpiece progresses, and the surface of the workpiece after the rolling becomes smooth.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a schematic view of an embodiment of a rolling machine according to the present invention;

Fig. 2 is an enlarged view of an important portion of the embodiment;

Fig. 3 is a perspective view of a pinch roll with projections of the embodiment;

Fig. 4 is a perspective view of a band plate formed with recesses; and

Fig. 5 is a graph showing the relationship between the rolling load and the reduction ratio.

DESCRIPTION OF THE PREFERRED EMBODIMENT

The present invention will now be described in greater detail.

Fig. 1 is a schematic view of a rolling machine according to the present invention, and Fig. 2 is an enlarged view of an important portion of the rolling machine. As shown in these drawings, the rolling machine 10 comprises a rolling mill 11 for rolling a band plate M, and a recess impressing unit 13 for forming recesses 12 in both sides of the band plate M on the inlet side of the rolling mill 11.

The rolling mill 11 includes upper and lower work rolls 14 and 15 for rolling the band plate M, and backup rolls 16 and 17 rotatable in contact with the upper and lower work rolls 14 and 15 to bear the reaction thereof, these individual rolls being rotatably supported by a housing 18.

Nozzles 19 and 20 are provided on the inlet side of the band plate M in relation to the work rolls 14 and 15 to spray a lubricating fluid L to individual contacting portions of the band plate M with the work rolls 14 and 15.

The recess impressing unit 13 provided on the upstream side of the rolling mill 11 includes a pair of projection-provided pinch rolls 22 and 23 having a large number of projections 21 as shown in Fig. 3, these pinch rolls being rotatably supported by a housing 24 so as to pinch the band plate M being fed.

It should be noted that the curvature of the recess 12 formed by the projection 21 is made larger than that of the work roll 14, but the shape of the recess 12 may take any form if it can be pressed completely flat at the time of rolling.

Further, the pinch rolls 22 and 23 pinch the band plate M at a pressure enough for the recess 12 to be formed by the corresponding projection 21 by virtue of the plastic deformation of the band plate M being fed.

Accordingly, when the band plate M is fed rightward in Fig. 1, at first, a large number of recesses 12 are formed in both sides of the band plate M by the recess impressing unit 13 as shown in Fig. 4. Then, when the band plate M formed with the recesses 12 is fed to the rolling mill 11, the fluid L sprayed to the contacting portions between the work rolls 14 and 15 and the band plate M is retained in the recesses 12 before being caught in the contacting arc regions α of the work rolls 14

and 15. Thereafter, at the time of the band plate M being rolled, the lubricating fluid L in the recesses 12 is temporarily confined in the recesses 12 because the surfaces of the work rolls 14 and 15 contact with the opening margins of the recesses 12. On the other hand, the fluid adhering to the surfaces of the work rolls 14 and 15 is introduced into the recesses 12 as the work rolls 14 and 15 rotate. Then, when the rolling progresses, the fluid L confined in the recesses 12 forms a boundary film over the contacting portions between the work rolls 14 and 15 and the band plate M because the recesses 12 are gradually expanded thin and flat within the contacting arc region. Since due to the formation of the boundary film the fluid L largely remains in the contacting arc region at the time of the band plate M being rolled in contrast with the prior art, the abrasion of the roll is reduced.

Further, since a large number of recesses 12 are formed in the band plate M, the amount of the fluid L being sprayed is sufficient if it is confined in the recesses 12 to remain therein enough, thus, the consumption of the fluid L can be decreased remarkably compared with the prior art.

Although the foregoing embodiment uses the projection-provided pinch rolls 22 and 23 to form the recesses 12 wherein the plastic working is attained through rolling, the recesses 12 may be formed through pressing or cutting.

Here, considering the reduction of the coefficient of friction between the work roll and the band plate according to the present invention, a general expression of the frictional shearing stress τ will be given below.

$$\tau = a\tau_b + (1 - a)\tau_f$$

where $\tau_b (= \mu P)$ boundary friction zone,

$$\tau_f (= \eta \frac{\partial u}{\partial h})$$

is a fluid friction zone, μ is the coefficient of boundary friction, P is the bearing pressure of the roll, η is the viscosity of the fluid, u is the speed of the fluid, h is the thickness of the fluid, and a is the area ratio of the boundary friction zone.

Generally, $\mu = 0.2$ to 0.5 , and $\tau_b \gg \tau_f$. Therefore, the frictional shearing stress τ can be decreased if the area ratio a is decreased.

That is, according to the present invention, to decrease the area ratio a , a large number of recesses 12 are formed in the surface of the band plate M before rolling, and the rolling is performed while confining the fluid L in the recesses 12. Therefore, the value of the area ratio a can be arbitrarily controlled by confining the fluid L in the recesses 12 formed in the band plate M.

Further, compared with the prior art, the fluid lubrication effect can be enhanced only by confining a small amount of fluid L in the recesses 12.

As the lubricating fluid used in the present invention, there are lubricating oil (such as mineral oil used hitherto), water, a mixture of water and lubricating oil, etc. Especially, in case of hot rolling, those may be used such as molten salt and glass which change to a liquid state depending on the temperature condition of the band plate (at high temperatures).

As described above, the present invention can really reduce the coefficient of friction in both cases of hot rolling and cold rolling of the band plate M.

Specifically, in case of hot rolling, due to the adiabatic effect of the confined fluid, the quantity of heat conducted from the band plate to the work roll can be reduced, preventing the band plate from being cooled by the work roll, this feature being advantageous to the problem of heat resistance of the roll and the like.

Test performed will be described below to show the effectiveness of the present invention.

In the test, the band plate was an Al plate of 10mm thick, which was rolled at room temperature using a rolling mill having work rolls of 200mm diameter.

The lubricating agent was water, and the Al plate was machined to have recesses of 3mm diameter arranged at a pitch of 3mm.

A reference workpiece was an Al plate having no recess, which was similarly subjected to testing.

Fig. 5 shows the result of the test. As shown in Fig. 5, the rolling load was reduced in accordance with the present invention by about 20% to 40% compared with the reference workpiece having no recess, this exhibiting the effectiveness of the present invention.

Therefore, according to the present invention, the rolling load can be significantly reduced compared with the prior art; consequently, the individual components of the rolling mill, such as the backup rolls and housing for supporting the work rolls, can be made compact, allowing the rolling mill to be manufactured at low costs.

As described in detail with reference to the embodiment and the test, the present invention can reduce the coefficient of friction of the workpiece at the time of rolling and provide a large reduction ratio even if the rolling load is kept very small. Further, the surface roughness and abrasion of the rolling roll are reduced, the fluid serves effectively as an adiabatic agent, and the heat resistance of the roll is enhanced. In addition, with the rolling load reduced, the rolling mill can be made compact.

Claims

1. A rolling method characterized by the steps of forming a large number of recesses in the surface of a workpiece to be rolled, and rolling the workpiece while confining a lubricating fluid in the recesses.

2. A rolling machine characterized by a recess impressing unit provided on the inlet side of a rolling mill for rolling a workpiece to be rolled, for forming in the surface of the workpiece a large number of recesses adapted for the retaining of a lubricating fluid therein.

3. A rolling machine according to claim 2, wherein said recess impressing unit includes a pair of pinch rolls formed with a large number of projections.

4. A rolling machine according to claim 2, further including a nozzle for spraying the lubricating fluid which is provided on the inlet side of work rolls for rolling.

Fig. 1

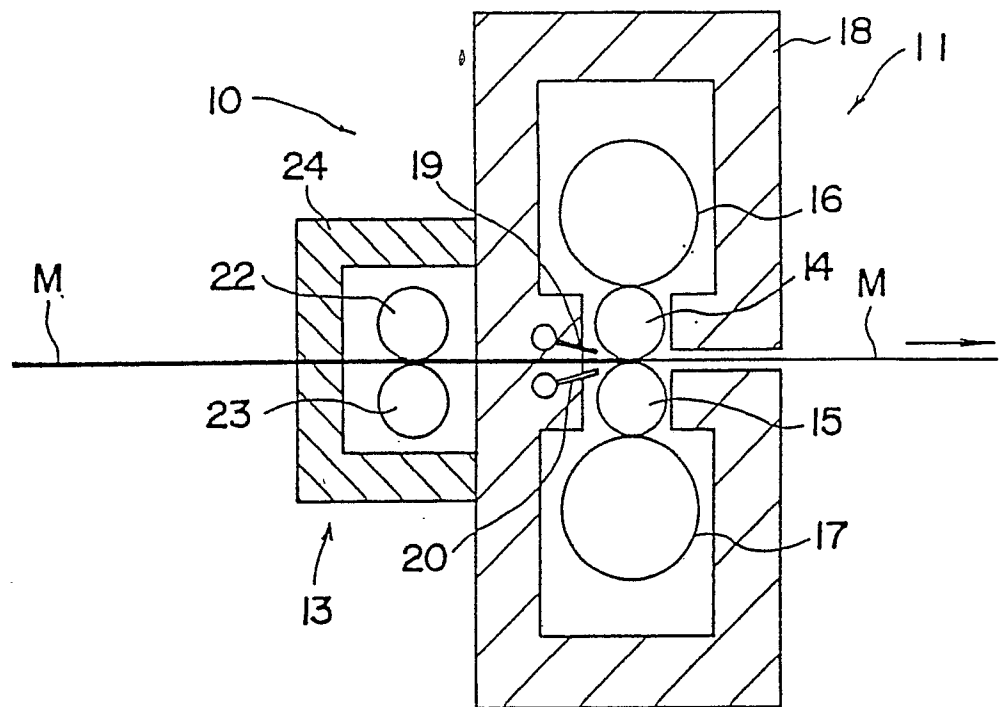


Fig. 2

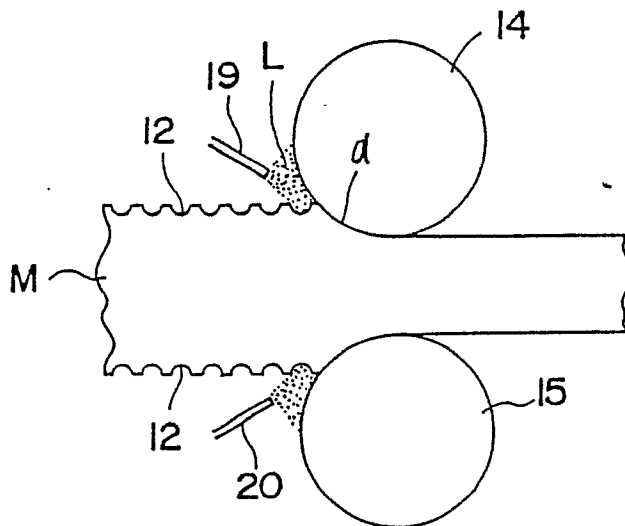


Fig. 3

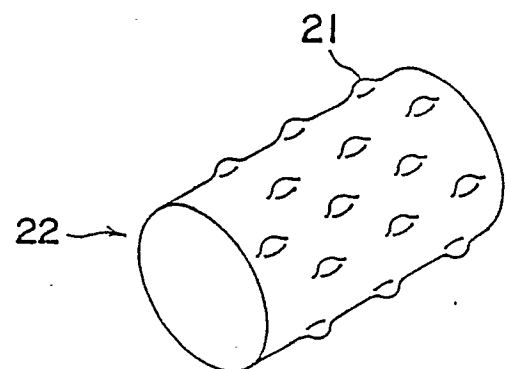


Fig. 4

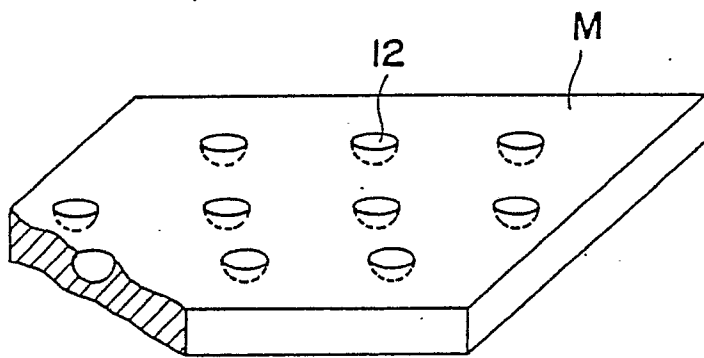
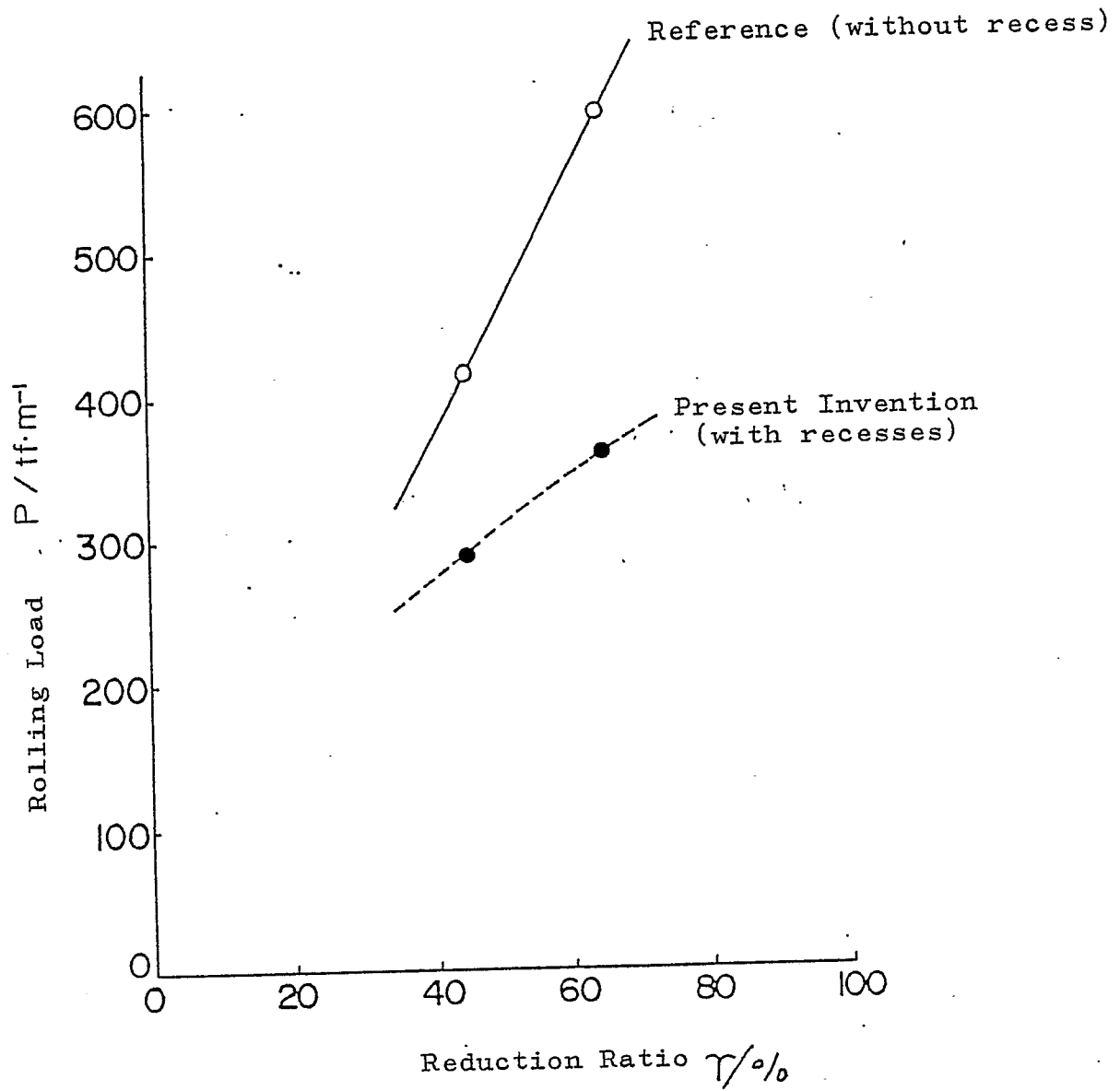


Fig. 5





DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.4)
X	WO-A-8 203 575 (BADGER) * Claim 1 * ---	1	B 21 B 45/02 B 21 B 15/00
Y	DE-C- 635 220 (C.T. PETZOLD) * Page 1, lines 1-4,49-56; claim * ---	1	B 21 B 27/00 B 21 H 8/00 B 21 H 7/00
Y	FR-A-2 290 623 (SOCIETE LORRAINE DE LAMINAGE CONTINU) * Page 1 * ---	1	
A	US-A-1 960 958 (SARGENT) * Page 3, lines 17-20 * ---		
A	US-A-2 361 039 (LANGEL) * Figure 5; page 2, lines 11-20 * ---	1-3	
A	US-A-1 490 944 (SIMPSON) * Figures 4,7 * -----	1-3	
			TECHNICAL FIELDS SEARCHED (Int. Cl.4)
			B 21 B B 21 H
The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 30-08-1989	Examiner ASHLEY G.W.
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	