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Sekimoto et al.

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[45] **March 6, 1973**

[54] **BUILT-UP SLEEVE ROLL FOR ROLLING AND METHOD OF MAKING THE SAME**

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[52] **U.S. Cl.**.....**29/132,** 29/129.5, 29/148.4 D

[51] **Int. Cl.** **B21b 31/03**

[58] **Field of Search**.....29/129.5, 132, 113 AD, 116 AD, 29 48.4 D

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[57] **ABSTRACT**

In a built-up sleeve for the use of rolling the inner surface of the cylindrical sleeve and the outer surface of the shaft on which the sleeve is mounted are coated with a binder containing hard tough and sharp angled particles of the diameter in average of not less than 0.05 mm (350 mesh in granularity). After being coated with the binder, the cylindrical sleeve and the shaft are fitted together by shrinkage fit or expansion fit. The bending of the shaft and slippage of the sleeve are well prevented by the construction as above.

4 Claims, 6 Drawing Figures

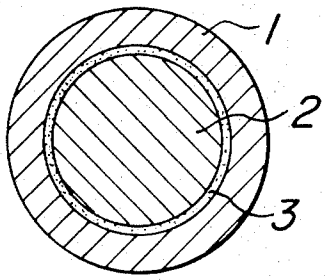


FIG. 1

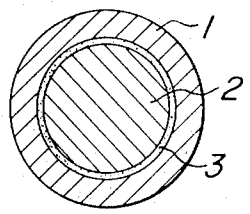


FIG. 5

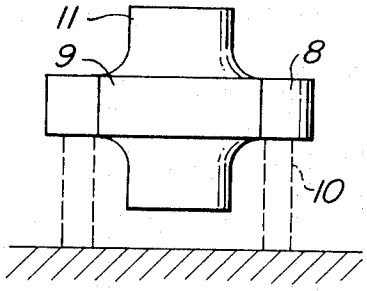


FIG. 2

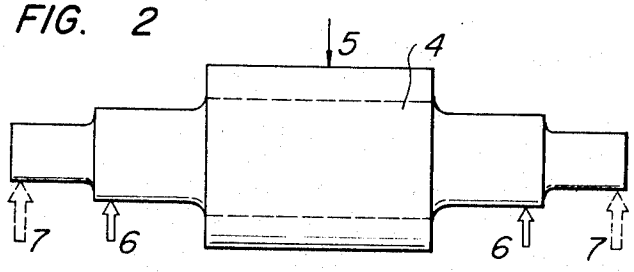
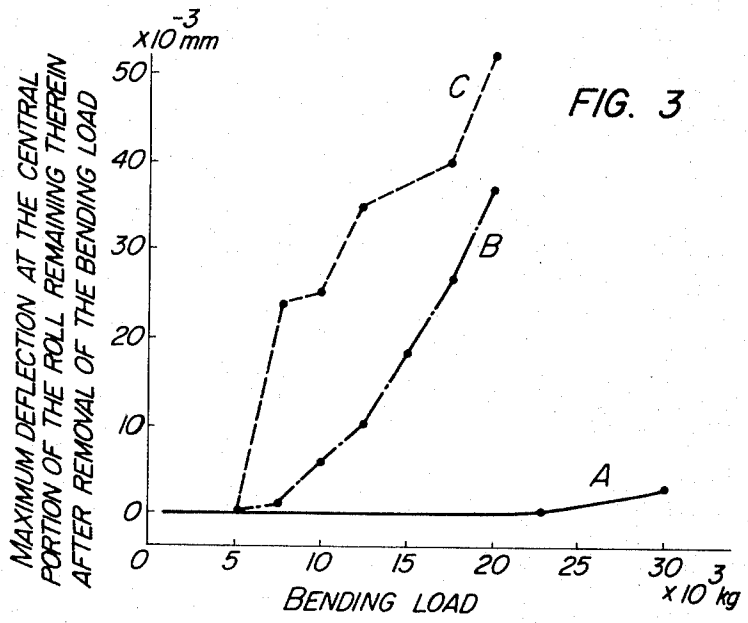


FIG. 3



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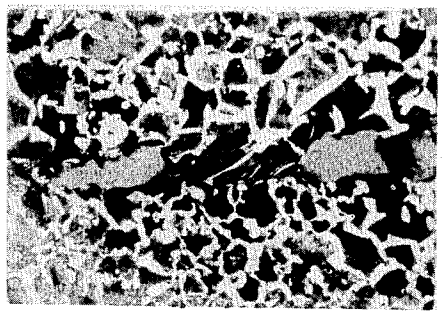
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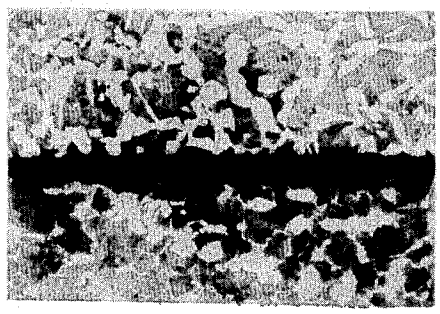
ATTORNEYS

FIG. 4a



x 100

FIG. 4b



x 100

BUILT-UP SLEEVE ROLL FOR ROLLING AND METHOD OF MAKING THE SAME

This invention relates to a built-up sleeve roll for the use of rolling, and more particularly to a built-up backing-up roll for rolling in which the bending of the shaft while used is very small and a working roll for rolling in which the slippage of the sleeve is avoided.

Now the built-up backing-up roll for rolling will be explained in general for example.

In general four-high rolling mill having a pair of working rolls and a pair of backing-up rolls mostly used as the rolling mill for rolling a steel plate, the backing-up roll is required, for the purpose of enduring the large rolling load, (1) to be tough at the neck portions thereof, (2) to have high resistance to spalling and wear on the cylinder sleeve thereof strong enough to endure the repeated rolling contact with the working roll, and (3) to have so large flexural rigidity thereof as not to be deformed.

In the backing-up roll, there are two types at present one of which is of solid type and the other of which is of built-up type in which the sleeve is mounted on the shaft by shrinkage fit. In the latter type, proper material having property suitable for the foregoing neck portion and the cylinder portion is able to be selected as the shaft and the sleeve, respectively. Further, in case that the sleeve is damaged, only the sleeve can be replaced with a new one. Thus, the damaged roll can easily be changed to a new roll at low cost.

In the latter type backing-up roll, however, sometimes the shaft of the roll is bent while rolling. Such bending or the shaft will hardly occur in the solid type roll, but occur only in the built-up type roll having a separate sleeve. The reason why the shaft is bent in the built-up type backing-up roll having a sleeve while the roll is working and its bend remaine after working is that there occurs a slippage between the sleeve and the shaft when the backing-up roll is subject to an excessive bending load while rolling and the slippage is not recovered after removal of the load due to a friction resistance therebetween. Therefore, there are two ways to prevent the residual bending of the shaft. One of which is to prevent the slippage between the sleeve and the shaft even when the roll is subject to an excessive bending load, and the other of which is to make the slippage be recovered easily by reducing the friction resistance between the sleeve and the shaft.

Heretofore, in order to prevent the residual bending of the shaft while rolling in the conventional built-up type backing-up roll, it has been proposed to apply carborundum or adhesive to the surface of the shaft or inject molten metal into the space interposed between the sleeve and the shaft to increase the friction resistance at the shrinkage fit surface. These methods, however, have been limited in the friction resistance and induced lowering of working efficiency. The object of the method of applying carborundum is to increase the friction coefficient at the shrinkage fit surface, so that the friction coefficient is made as large as 0.40 to 0.45, namely, twice as large as that without carborundum in the event carborundum grains of 400 mesh (average diameter 0.04 mm) are applied. The friction resistance on the shrinkage fit surface can be indicated with a shearing stress. In this method, it is difficult in practical sense to make the shearing stress not less than 2 kg/mm² from the viewpoint of gap for shrinkage fit. Further, in this method, the shrinkage fit is slacked due to the temperature rise at the sleeve while used and the friction resistance is reduced. Accordingly, the residual bending of the shaft can not completely avoided in this method.

In the second method in which adhesive is applied to the shrinkage fit surface, it is very difficult to uniformly apply the adhesive to the inner surface of the sleeve and the outer surface of the shaft, and accordingly, even 50 percent of the nominal strength thereof (3 kg/mm² in shearing strength) can not be easily obtained. Further, once the adhered portion is damaged with an excess load while being used, the function of the adhesive is lost and the residual bending can not be prevented.

The third method using injection of molten metal is disadvantageous in that the efficiency of working is extremely low in practical use.

The primary object of the present invention is to provide a built-up sleeve roll for rolling which is stiff and hard to be distorted.

Another object of the present invention is to provide a built-up sleeve roll for rolling in which the sleeve will not slip on the shaft.

In order to accomplish the above described objects of the present invention, hard, tough and sharp angled particles of diameter in average of not less than 0.05 mm (350 mesh in granularity) are applied to the inner surface of the sleeve and/or the outer surface of the shaft, and then the sleeve is mounted to the shaft with shrinkage fit or expansion fit.

Other objects, features and advantages of the present invention will be made apparent from the following description of the preferred embodiment thereof taken in conjunction with the accompanying drawing in which:

FIG. 1 is a cross-sectional view of the built-up sleeve roll in accordance with the present invention,

FIG. 2 is a side view of the sleeve roll showing the method of testing the strength or bending of the sleeve roll,

FIG. 3 is a graphical representation showing in comparison the method of making the sleeve roll in accordance with the present invention and the conventional method,

FIGS. 4*a* and 4*b* are microscopic photographs showing the enlarged cross sections of the shrinkage fit surface of the sleeve roll made in accordance with the present invention and in accordance with the prior art, and

FIG. 5 is an elevational view showing the method of measuring the shearing strength at the shrinkage fit surface.

Now referring to FIG. 1, hard, tough and sharp angled particles of diameter in average of 0.05 mm (350 mesh in granularity) having hardness higher than that of the inner surface of the sleeve 1 and the outer surface of the shaft 2 such as those of finely divided steel grid or ceramics are mixed with a binder and then applied to the surface of the shaft of sleeve. After the application of the binder containing the particles to the surface, the sleeve 1 is mounted to the shaft 2 with shrinkage fit or expansion fit. Alternatively, the particles are sprayed onto the surface of the shaft after ap-

plying a binder thereon, and then the sleeve 1 is fitted to the shaft 2. Thus, the particles 3 are wedged in the surfaces of the shaft 2 and the sleeve, and the resistance against the relative slippage between the sleeve 1 and the shaft 2 is increased up to that corresponding to the solid type roll. Further, since the diameter of the particles 3 is large, the friction resistance is not reduced even when the sleeve 1 is slacked due to the rise of the temperature at the sleeve 1.

The dimension of the particles employed in the present invention is determined by the diameter of the shaft and the gap for shrinkage fit, and should be smaller that the spacing between the shaft and the sleeve at the time of shrinkage fit or expansion fit. For example, in the case where a sleeve having diameter of 1000 mm is fitted to the shaft heated to 200° C with the shrinkage fit ratio of 0.5/1000, shrinkage fit is impossible if the particles are larger than 16 mesh. Moreover, the particles should be larger than 350 mesh (0.05 mm in average diameter) in order that the particles are wedged in the shrinkage fit surface to increase the friction resistance between the sleeve and the shaft. The binder need not have any special property such as heat resistivity since it is used only for the purpose of holding the particles on the surface to be fitted until completion of the shrinkage fit.

As shown in FIG. 2, a comparison experiment was conducted with the conventional method using model rolls 4 having a diameter of 155 mm, a diameter of the shaft 110 mm and a length of 200 mm. Three kinds of model rolls 4 (A, B and C) were made in which a shaft was coated with a binder including steel grid of 100 to 150 mesh (0.15 to 0.20 mm in average diameter) and fitted to a sleeve with shrinkage fit ratio of 0.5/1000 (A), a shaft was coated with carborundum of 100 to 150 mesh and fitted to a sleeve with shrinkage fit ratio of 0.5/1000 (B), and a shaft was fitted to a sleeve with shrinkage fit ratio of 0.5/1000 without coating (C). The sleeve rolls 4 were supported at the points 6,6 spaced apart from each other by 375 mm and subjected to a load at the central point 5 as shown in FIG. 2. Thereafter, the rolls 4 were supported at the points 7,7 spaced apart by 550 mm and the residual bending of the shaft was measured without the load 5 by means of a deflection measuring device. The bending load was increased step by step with the pitch of 2500 kg. The results obtained for the respective rolls A, B and C are shown in FIG. 3 indicated respectively by the same reference characters A, B and C.

As apparent from the graph shown in FIG. 3, the residual bending of the shaft is seen in the roll made in accordance with the conventional method (B and C) with the bending load as small as 5,000 to 7,500 kg. On the other hand, in the roll made in accordance with the present invention A, the residual bending is hardly seen even in case of being subject to the bending load as large as 25,000 kg. Thus, it is apparent that the method of making the sleeve roll is accordance with the present invention is remarkably superior to the conventional method.

FIGS. 4*a* and 4*b* are microscopic views of the section of the model rolls after removal of the bending load, in which the upper half portion shows the section of the sleeve and the lower half portion shows the section of the shaft. FIG. 4*a* shows the section of the model roll A made in accordance with the present invention in which hard and tough particles (steel grid) were used, and FIG. 4*b* shows the section of the model roll B made in accordance with the conventional method in which hard but less solid particles (carborundum) were used. As apparent from the drawing or photographs in FIGS. 4*a* and 4*b*, the particles having high hardness and toughness sufficiently are wedged in the shrinkage surface in the both directions to the sleeve and to the shaft. Further, it will be seen that the particles have wedge like effect and greatly increase the friction resistance when they have sufficient solidness or toughness. If the particles are inferior in solidness and toughness in spite of their hardness and large size, the particles themselves are broken by the shearing stress and do not have the sufficient effect to increase the friction resistance.

In order to clarify the wedge like effect of the particles, a specimen 8 having an outer diameter of 160 mm, a shrinkage fit surface diameter of 100 mm and a length of shrinkage fit of 20 mm was fitted to a shaft 9 with shrinkage fit ratio of 0.5/1,000 as shown in FIG. 5, and the shearing strength was measured. This measurement was conducted for three kinds of sleeve rolls A, B, and C. The specimen 8 was placed on a cylindrical support 10 and a load was placed on the top 11 of the specimen 8, then the value of the load when the shaft 9 of the specimen 8 began to slip downward in the specimen 8 was measured to obtain the shearing strength and the average friction coefficient (shearing strength/shrinkage fit pressure). The results of the measurement are shown in the table below.

Condition on the Surface of Shrinkage Fit	Critical Load (ton)	Critical Shearing Stress (kg/mm^2)	Average Friction Coefficient
Coated with steel grid of 100 to 150 mesh	30—35	4.6—5.2	1.35—1.50
Coated with carborundum of 100 to 150 mesh	11—15	1.7—2.0	0.50—0.65
Shrinkage Fit only	9—11	0.5—1.7	0.30—0.50

As clearly shown in the above results, it was found that the method of making a built-up sleeve roll in accordance with the present invention is remarkably superior to the conventional methods in increasing the friction resistance between the shaft and the sleeve. In general, the friction coefficient is less than 1.0 and it is not conceivable that the friction coefficient becomes over 1.0 as shown in the above result. This means that the particles have the foregoing wedgelike effect. Therefore, it will be understood that the particles coated on the shrinkage fit surface are required to be hard and tough and sharp angled, and coarse.

The hardness of the particles should be determined with respect to the hardness of the material used for the sleeve and the shaft. Since the hardness of the material ordinarily used for the sleeve and the shaft is not less than Hv 170, the hardness of the particles should not be less than Hv 170. The toughness of the particles should be so large as that they endure a shearing stress having a value of not less than 1.0 in the ratio of (shearing

stress per a unit area)/(pressure effecting per a unit area) when the particles are interposed in the shrinkage fit surfaces. This requirement is represented by a formula as $(S \times a \times N)/(P \times A) > 1$, and accordingly, $S > (P \times A)/(a \times N)$ where A is the area of the shrinkage surface, P is the pressure on the shrinkage surface, (a) is the average area in section of a particle interposed between the shrinkage surfaces, N is the number of the particles existing in a unit area, and S is the shearing strength of the particles. For example, in case that the pressure exerted on the shrinkage surface is 5 kg/mm², and the effective area $(a \times N)$ of the particles interposed is 10 percent of the area A of the shrinkage surface, the shearing strength S is represented by $S > 50$ kg/mm², which means that the toughness of the particles required is not less than 50 kg/mm² in shearing strength.

In order to work this invention in a large size roll of 1346 mm in diameter and 1460 mm in length, ten sleeve type backing-up rolls for hot and cold tandem rolling mills were made in accordance with the present invention by the use of steel grid particles of 0.3 mm in average diameter and a binder of silicon coating agent with shrinkage fit with the shrinkage fit interference of 0.5/1000 of the diameter of the shrinkage fit surface. These rolls are still being used now without any trouble. Further, the sleeve rolls made in accordance with the present invention are advantageous in preventing not only the slippage in the axial direction but also the slippage in the tangential direction of the sleeve.

As described above, the built-up sleeve roll in accordance with the present invention employs hard, tough and coarse particles having wedge like effect between the shaft and the sleeve to increase the friction resistance therebetween. The strength of the sleeve roll made in accordance with the present invention is as excellent as that of the integral type sleeve roll. Thus, a compression roll having a strong sleeve can be obtained according to the invention, which well contributes to the industry of this field.

What is claimed is:

1. The method of making a sleeve roll used for rolling comprising applying a binder containing hard, tough and sharp angled particles having diameter of not less than 350 mesh on at least one of the inner surface of the cylindrical sleeve and the outer surface of the shaft on which said sleeve is to be mounted, and fixing said sleeve on the shaft by shrinkage fit or expansion fit by making said particles wedged in the surfaces of the sleeve and the shaft, whereby the residual bending of the shaft and the slippage of the sleeve are prevented.

2. The method of making a built-up sleeve roll used for rolling as defined in claim 1 wherein said particles have hardness not less than Hv 170 and said sleeve is fixed to the shaft with a shearing strength represented by (shearing stress per a unit area)/ (pressure exerted on a unit area) of not less than 1.0.

3. The method of making a built-up sleeve roll as defined in claim 1 wherein said particles are steel grid.

4. A built-up sleeve roll for the use of rolling comprising a shaft, a sleeve fixed to said shaft in coaxial relation therewith by shrinkage fit or expansion fit, and hard, tough and sharp angled particles having diameter of not less than 0.05 mm in average wedged in between the outer surface of the shaft and the inner surface of the sleeve.

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