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REGENERATION OF REFUSED ROLLS

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ABSTRACT OF THE DISCLOSURE

Process for salvaging a defective malleable roll so that it is useful as a forged roll, which involves heating the defective roll to a forging temperature of about 1,000° C.; subjecting the thus heat-treated roll to a forging treatment and thereafter subjecting the forged roll to the same heat treatment as that of a freshly forged roll.

This invention relates to the production of forged rolls for hot-rolling by regenerating refused malleable rolls.

In a normal process of manufacturing rolls for use in hot-rolling rolls are manufactured by casting or forging steel materials and then subjecting the materials to the heat treatment in an electric furnace or gas-heating furnace and thereafter to a machining treatment to obtain the desired dimensions, and usually the rolls are so designed that they may be used so long as they are worn off about 10% of the maximum diameter of thereof. This allowable range of use is a result of the difficulty in the rolling operation and the fault in the quality of the section of the roll deeper than this range. Rolls worn off over this range have been usually scrapped as refused rolls.

The idea of the present invention is to salvage the refused rolls to be scrapped.

An object of this invention is, therefore, to regenerate reusable rolls from thus refused hot-rolling rolls, that is, the object of this invention is to provide a process of regenerating rolls having excellent wear resistance and other mechanical properties from the above-mentioned refused rolls.

Another object of this invention is to provide a process for making rolls having almost the same or even better qualities than those of fresh rolls from refused malleable rolls by subjecting them to improved forging and heat treatments.

Still another object of this invention is to reduce remarkably the manufacturing cost of rolls.

Other objects of this invention and the complete understanding of the invention will become clear from the following description and the claims.

According to the present invention, a refused malleable roll, that is, refused cast roll or forged roll, which has no defects in the inside thereof as will exert deleterious effects on the subsequent treatments, is used as a material.

At first the refused roll is thinly chipped at its surface to remove small scratches or other defects on the surface which would disturb the subsequent forging treatment.

After the roll has been thinly chipped, it is subjected to a heat treatment prior to a forging treatment. In the heating treatment, the roll may be treated as in a conventional method of producing normal fresh forged rolls. That is, it may be heated up to 800° C. at a heating rate of 20° C. per hour and held at this temperature for 24 hours at the first stage and thereafter heated up to the forging temperature of about 1,000° C. at heating rate of 40° C. per hour and held at this temperature for 8 hours at the second stage. But, in the present invention the heat treatment may also be conducted much more quickly than in the conventional method. That is, it may be heated to 600° C. at a heating rate of 100° C. per hour and held at this temperature for 10 hours at the first stage, then further heated to 900° C. at a heating rate of 100° C. per hour and held at this temperature for 5 hours at the second stage and at last up to a forging temperature at a heating rate of 90° C. per hour and held at this temperature for 4 hours. In other words, the heating treatment of the present invention may be conducted for a period of time less than half of the time required for the conventional method.

The thus heat-treated roll is subjected to a forging treatment, but the method of the present invention is characterized in that a light forging treatment is sufficient. That is, a reduction ratio of section area, expressed by the ratio section area before forging: section area after forging may be 1.1 to 1.4.

As a result of the above mentioned shorter heating period and light forging operation the defects in the inside of the roll material such as small cavities and coarsened portions are removed, as the structure of the roll is consolidated and fined.

By subjecting the thus forged roll to subsequent post-heat treatment and working as explained in the following examples, a roll having almost the same or even better qualities than those of fresh rolls can be obtained from refused rolls. That is, the hardness suitable for the rolling conditions can be easily obtained and at the same time the various properties required in a fresh roll, such as, wear resistance, anti face-coarsening properties, thermal cracking resistance, and toughness can be obtained.

Therefore, since by the above-mentioned process, refused malleable rolls can be easily regenerated into good forged rolls, the economical advantage of the process is very great. For example, the manufacturing cost of the thus generated roll by the process of this invention as described in the below-stated examples can be reduced about 35% as compared with that of a fresh roll.

The invention will now be explained by the following examples:

Example 1

(1) The dimensions of a refused roll:

Name of roll	2HW
Diameter mm	645
Length mm	2,057

(2) Chemical composition of the refused roll:

C	1.49
Si	0.42
Mn	0.92
Cr	0.94
Ni	0.19
Mo	0.29
Hardness (Hs)	42

(3) Surface chipping: The practicability of the roll as a material to be forged was previously checked and then the surface of the roll was chipped about 10 mm. in diameter.

(4) Heating: The roll was heated by increasing the heating temperature gradually at a rate of 100° C./hr. to 600° C., maintained at the temperature for 10 hours. The temperature was then increased to 900° C. at a rate of 100° C./hr. and the roll was maintained at the temperature for 5 hours. Thereafter, the roll was heated to 1,130° C. by increasing the temperature at a rate of 90° C./hr. and maintained at the temperature for 4 hours.

(5) Forging: (a) The roll heat-treated as in heating (4) was forged at 1,050–900° C. (b) The forging was

conducted by using a 1,200 ton press. The forging number of the roll was 5 with a forging amount of 20–30 mm. in diameter for one forging. The reduction ratio of area was 1.4.

(6) Heat treatment after forging: First of all, for a homogenizing treatment, the thus forged roll was maintained for 5 hours at 350° C., heated to 600° C. by increasing the temperature at a rate of 30° C./hr., maintained at the temperature for 3 hours, heated further to 880° C. by increasing the temperature at a rate of 50° C./hr., maintained at the temperature for 30 hours and then forcibly cooled by air to 500° C.

Then, for a spheroidizing treatment, the roll was heated to 730° C. by increasing the temperature at a rate of 50° C./hr., maintained at the temperature for 10 hours, cooled in furnace to 680° C., and then after maintaining at the temperature for 15 hours, cooled in furnace to 200° C.

After the heat treatment, the roll was chipped roughly and then subjected to the following refining treatment, that is, after maintaining at 900° C. for 5 hours, the roll was spray-quenched down to 500° C., the temperature was increased to 550° C. and the roll was maintained at the temperature for 20 hours and then cooled in furnace to conduct tempering.

Thereafter, the roll was subjected to finish working to provide a final product.

Example 2

In this example, the process of this invention was applied to a refused cast steel roll of a high carbon containing alloyed steel (Mn—Cr—Ni—Mo).

(1) Dimensions of the refused roll:

Name of roll		ISH–60
Diameter	mm	640
Length	mm	3,810

(2) Chemical composition of the roll:

C	1.47
Si	0.49
Mn	0.80
Cr	1.09
Ni	0.32
Mo	0.60
Hardness (Hs)	43–44

(3) Surface chipping: The surface of the roll was chipped about 2.5 mm. in depth and hence the diameter of the roll was reduced from 640 mm. to 635 mm.

(4) Inside crack detection test (ultrasonic reflectoscope). Result: When detected from the lower end of the roll by an ultrasonic wave of 0.4 megacycle, an F echo (casting cavity) was found at a place of 1,280 mm. therefrom. When detected from the upper end, reflective wave was undetectable. And, when detected diagonally by an ultrasonic wave of 1 megacycle, no opening was observed.

(5) Heating: The above-treated roll was heated to 800° C. in an electric furnace by increasing the temperature at a rate of 20° C./hr., maintained at the temperature for 24 hours and then sent to a forging step wherein the roll was heated to a forging temperature.

(6) Forging: (a) The roll heated to 800° C. in a heating furnace of the forging step as above-mentioned was further heated to 1,050° C. by increasing the temperature at a rate of 40° C./hr. and maintained at the temperature for 8 hours followed by forging. (b) The forging was conducted using a 4,100 ton press. The roll (diameter 635 mm. at hot-state) was forged 3 times at a temperature of 1,000–1,040° C. while changing the deformation extents of the roll between top side (T.S.) and bottom side (B.S.), which became 560 mm. and 595 mm. in diameter respectively. The maximum forging amount was 20 mm. for one forging. The reduction ratio of area was 1.3 and 1.1.

(7) Heat treatment after forging: The roll was then subjected to a spheroidizing treatment as follows using a heavy oil furnace:

The roll was maintained for 20 hours at 500° C., for 30 hours at 880° C., for 15 hours at 450° C., for 30 hours at 810° C., cooled to 600° C. at a rate of 10° C./hr., and then cooled in furnace.

Thereafter, a quality refining treatment was conducted as follows:

The roll was preheated by increasing the temperature to 460° C. at a rate of 20° C./hr. and maintaining at the temperature for 24 hours, heated to 900° C. by increasing the temperature at a rate of 20° C./hr., maintained at the temperature for 15 hours and then forcibly cooled by air. Further, the roll was heated to 600° C. by increasing the temperature at a rate of 20° C./hr., maintained at the temperature for 15 hours and cooled in furnace to conduct tempering.

The results of the above examples are as follows:

That is, although the forging of light degree was performed as mentioned above, the forging effect reached the inside or central portion of the roll, whereby the shrinkage cavity in the inside of the refused roll before forging was completely removed and the mechanical properties thereof were improved to the almost original ones.

The properties of thus treated rolls are as follows:

(i) Hardness:

Example 1

The surface and intermediate section of the roll

Hs	48–51

Example 2

T.S. section, Hs	46–48
B.S. section, Hs	45

(ii) Structures of the roll (Examples 1 and 2):

As the results of comparing the macro structure of the forged portion and the non-forged portion, it was confirmed that the micro shrinkage cavity specific to cast steel roll was completely removed by the above-mentioned light forging. Further, on comparing the micro structures of each portion, the structures are almost the same pearlite structure containing eutectics, but while some directional properties were observed in the proeutectoid carbide at the non-forged portion, there were almost no directional properties at the forged portion.

(iii) Tensile strength test:

The tensile strength of the roll which had been processed in Example 1 was as follows:

	Kg./sq. mm.
Surface of roll	92.1
Intermediate portion	64.4
Central portion	57.5

Since the tensile strength of the surface of the cast steel roll before the forging is generally about 55 kg./sq. mm., the above result shows that the tensile strength of the forged portion is very high.

Example 2

	1 (kg./sq. mm.)	2 (kg./sq. mm.)	3 (kg./sq. mm.)	4 (kg./sq. mm.)
T.S. section	65, 68, 66	63, 66	52, 67	52, 56
B.S. section	63, 66	63, 55, 57	59, 53, 62	

In the above table, the numeral 1 stands for the surface portion, 2 stands for a section of ¼ inner towards the center from the surface, 3 stands for a section intermediate between the center and the surface, and 4 stands for the surface of the non-forged portion. The results indicated in the table show good values as compared with a general cast steel roll.

The invention was explained above with some specific examples but it should be understood that they are only illustrative and various modifications and changes in each step of the aforementioned processes may be done within the scope and the spirit of the invention as claimed below.

What I claim is:

1. A process of regenerating a refused malleable roll to a forged roll which comprises heating the refused roll to a forging temperature of about 1,000° C., then subjecting said heat-treated roll to a forging treatment and thereafter subjecting the forged roll to the same heat treatment as that of a fresh forged roll.

2. A process of regenerating a refused malleable roll claimed in claim 1, wherein the diameter of said roll is reduced at a reduction ratio of 1.1 to 1.4.

3. A process of regenerating a refused malleable roll to a forged roll which comprises chipping slightly the surface of the refused roll, heating said roll to 800° C. at a heating rate of 20° C. per hour and holding it at this temperature for 24 hours; further heating the roll to 1,000° C. at a heating rate of 40° C. per hour and holding it at this temperature for 8 hours; thereafter subjecting the heat-treated roll to a forging treatment to reduce the diameter of the roll at the reduction ratio of 1.1 to 1.4 and finally subjecting said roll to the same heat treatment as that of a freshly forged roll.

4. A process of regenerating a refused malleable roll to a forged roll, which comprises chipping slightly the surface of the refused roll, heating said roll to 600° C. at a heating rate of 100° C. per hour and holding it at this temperature for 10 hours; further heating the roll to 900° C. at a heating rate of 100° C. per hour and holding it at this temperature for 5 hours; further heating the roll to nearly the forging temperature at a heating rate of 90° C. per hour and holding it at this temperature for 4 hours, thereafter subjecting the roll to a forging to reduce the diameter of the roll at the reduction ratio of 1.1 to 1.4 and finally subjecting the roll to the same heat treatment as that of a freshly forged roll.

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