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A Study on the EDT Characteristics of TM Work Roll and Variation of Strip Surface Roughness

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Abstract : This paper investigates the correlation between strip surface roughness and the surface of the work roll. As the actual temper mill(TM) is used, this data will be adopted to another actual temper mill for the application and operation of this experiment. Conclusions are as follows: Electro-discharge texturing(EDT) roll has homogeneous roughness distribution and shape, and also a sinuous peak surface and the life is 2 times longer than that of shot blast texturing(SBT) method. And the higher surface roughness of work roll, the more time is necessary at the EDT method. In the SBT method without the correlation of roughness, but impeller rotation speed with an uncontrollable peak count. The roughness of SBT roll is irregularity compared to that of EDT roll because the work roll roughness is transferred to the strip which was temper rolled, and produces a more desirable image and greater clarity to the color painted steel sheet.

Key words : Electro-discharge texturing, shot blast texturing, peak counts, surface roughness, temper rolling.

1. Introduction

According to the results of the study to improve the formability and appearance which is most important to the cold rolled strip, coated strip and prepainted products. To give appropriate surface roughness, shape of work roll for TM is most important.[1-4] The strip has a greater peak counts and homogeneous roughness. This makes the prepainted surface smooth and excellent in appearance with good image clarity. The surface of the strip with high peak counts prevents sticking during high temperature annealing.[5] Therefore, the surface roughness of the work roll is very important. The reason that surface roughness of the work roll is transferred to the strip surface is the rolling force and tension at the temper rolling or cold rolling.

Generally conventional texturing of the work roll for cold rolling or temper rolling is made by small and rigid grit shot blast at high velocity from the texturing machine. The resultant surface is irregularity with small peaks & craters. The SBT method is very difficult to obtain optimum conditions due to hardness, speed, size and shooting angle of grit, and on the work roll, Therefore, reproducibility is difficult to achieve using this process. However, irregularity of surface roughness can be compensated with several paint coatings, but this also makes the quality deteriorate and manufacturing costs go up. This study is to resolve these problems, Our research involved the use of EDT and laser beam texturing methods to get good quality steel. Many developed countries are adopting this process increasingly.

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This study is classified to under study and to get accurate and homogeneous roughness. There are few papers published because its importance is not known and the proper operation of the machine is not generally well known.[6]

This paper investigates the correlation between strip surface roughness and the surface of the work roll. After studing the surface roughness and shape according to the texturing method used of the work roll surface at temper rolling, the findings were as follows.[7]

As the actual rolling mill is used, this data will be adopted to another actual rolling mill for the application and operation of this experiment.

Experimental Apparatus and Method

Apparatus

The actual work rolls textured by two types of texturing machine were used in this experiment and the results were compared. As shown in Fig.1 the SBT machine itself and principle is very simple. This machine consists of dust collector equipment to remove the steel powder and small grit outside from sieve selecting the proper size grit and the impeller which sprays grit on the work roll surface and rail car which is moving and rotating the rolls with constant speed. The proper surface roughness of the work roll can be obtained, by rotating the speed of the impeller.

The EDT machine, consists of the head stock of the machine main body, the tail stock, the neck rest hydraulic system for the hydraulic cylinder and a filter for removing impurities in the dielectric oil. In the case of EDT, if the work piece is placed on the nest, distance between head stock and tail stock is set and controlled automatically and the hydraulic

Table 1. Chemical compsitions of work roll (wt.%)

C	Si	Mn	P	S	Cr
0.95	1.00	0.60	0.02	0.02	3.00

Table 2. Mechanical properties of sample at temper rolled

Material	Tensile Strength (N/mm^2)	Hardness (H_RB)	Elongation (%)
SCP-1	314.58	42.7	44.40

Table 3. Chemical compositions of sample at temper rolled (wt.%)

Material	C	Si	Mn	P	S
SHP-1	0.05	0.009	0.25	0.010	0.010

cylinder of the tail stock secures the end of the work piece. The servo-cylinder controls the distance between electrode and work piece to meet the diameter and length of the work piece by the input data to the computer it is then EDT begins.

The gap between electrode and work roll is controlled by 0.02~0.2 mm, there are 2 of 5 modes used largely to control peak counts under the same roughness volitionally. Determination of peak counts is controlled by varying the voltage and by changing the polarity of the generator and voltage is generally controlled within the 30~50 V range, roughness is determined by the frequency of the current and interval of the pulse.

Experimental material

The hardness of the work roll used for this experiment is Hs 95 and the normal work roll involving a wt. of 3% Cr as shown in Table 1 is used.

Mechanical properties of annealed strip to determine the transference of surface roughness from the roll to the work is as shown in Table 2 and the chemical compositions are shown in Table 3.

The thickness and width of sample used here is 1.0 mm and 1219 mm respectively and it is most representative of the standard in cold rolled strip processing.

Experimental method

The same roll was used here to examine the exact roughness, shape and change according to the texturing method used. To compare the transference shape and type under the same conditions, the roll for TM was textured with SBT and EDT was used under the same temper rolling condition. Temper rolling used 1 pass to make the experiment as shown in Fig. 1.

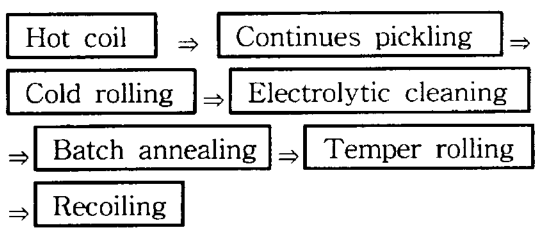


Fig. 1. Flow chart of cold rolling processing.

Work roll taken out of the temper rolling was atmospherically cooled and a full fatigue layer of 0.025mm was ground at roll grinder. The work roll surface roughness and peak counts were measured on all surfaces of the roll before placing in the TM and after working. And surface condition of the strip were examined by SEM to observe in more detail, the surface roughness by "Hommel tester-1000" of portable roughness test equipment.

The surface roughness and peak counts of work roll and strip is of average value, which is measured 3 points along the direction of roll body and direction of strip width respectively. The strip surface roughness cannot be measured at TM, so it was measured during recoiling process after temper rolling, work roll surface roughness was measured with vibration free condition before and after rolling.

Results and Discussion

Roughness shape

Roughness shape of work roll is very different by the texturing method as shown in Fig. 2 and EDT method has homogeneous peak height and a large peak counts, but SBT method has a heterogeneous peak height and smaller peak counts. A

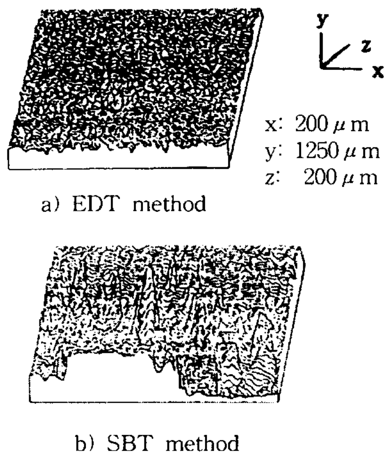
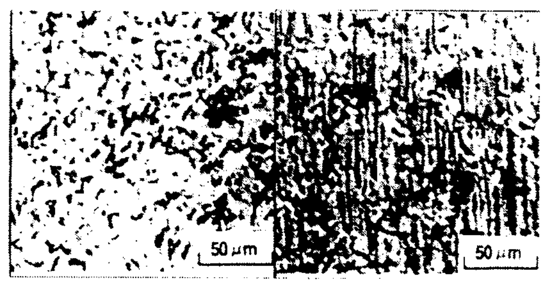


Fig. 2. Shape of surface roughness according to texturing method.



EDT method. (Ra.:1.1 μm, Pc:95 ea/cm) SBT method. (Ra.:1.20 μm, Pc : 65 ea/cm)

Fig. 3. Photograph of work roll surface roughness on the texturing method.

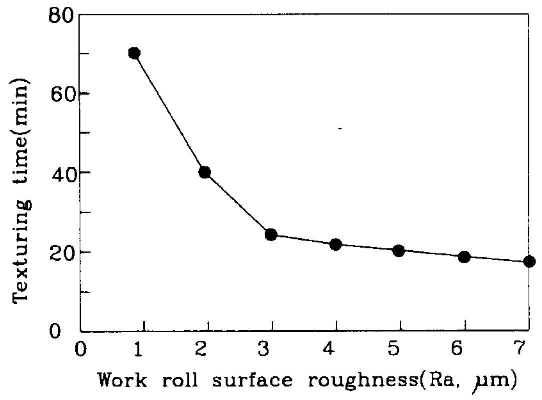


Fig. 4. Relationship between work roll surface roughness and texturing time on the EDT method.

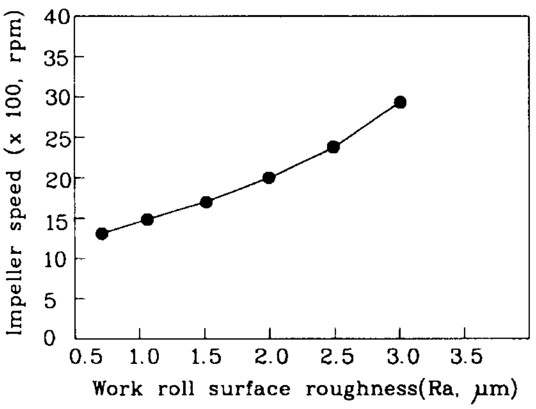


Fig. 5. Relationship between work roll surface roughness and impeller speed on the SBT method.

partially untextured area can also be observed as shown in Fig. 3, if the roll surface is magnified 175 X. The reason is that grit size which is sprayed by the impeller is not uniform in size and the grit is sprayed onto the surface of the roll irregularly. But in the case of the EDT method, there is no untextured area due to the uniformity of the electric discharge, Peak shape and height is therefore uniform.

The EDT work roll has almost regularity peak shape and peak counts after use, but in case of SBT work roll has irregularity texturing and rapid wearing because it has several changing factors such as grit size, hardness and rotation speed of the impeller.

Fig. 4 shows the relationship between the work roll surface roughness and texturing time on the EDT, if the roughness is low, texturing time is long and the higher the roughness the shorter the texturing time. The reason is when there are low peaks there is a large arc, at this time, the gap between the electrode and the roll becomes bigger. If the roughness is higher, the gap is smaller. SBT time does not change according to the roughness, the roughness determined by the impeller speed only. So, it takes 20 minutes for the texturing 1 roll which is equivalent to the rail car speed. The impeller speed is controlled according to the required roughness, the correlation between the roughness and impeller speed is shown in Fig. 5.

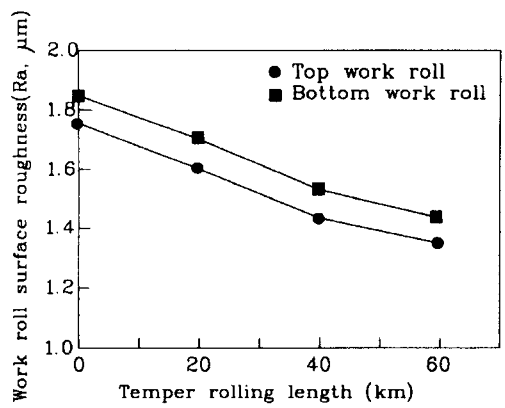


Fig. 6. Relationship between work roll surface roughness and temper rolling length on the EDT method.

The work roll surface roughness obtained from EDT method is similar to a very homogeneous cratering shape and there is a trace formed by the roll grinding stone. If the work roll surface was textured by the SBT method is magnified the irregularity surface can be readily observed. So, the surface roughness of the work roll which is worked by EDT method is more regularity and homogeneous to the peak shape and peak counts than that of SBT method.

The surface roughness of the strip affecting paintability and formability for cold rolled products must be controlled properly because the surface roughness is determined by the roughness of TM work roll.

The variation of roughness and peak count on the work roll surface

Figure 6 shows the relationship between work roll surface roughness and temper rolling length on EDT, correlation between the work roll surface roughness and temper rolling length on the SBT method is shown in Fig. 8. Work roll surface roughness by EDT is almost stable gradient to the both rolls of top and bottom work roll and has a linear trend, roll surface roughness by SBT method deteriorates rapidly and becomes glassified quickly during temper rolling. Wearing of work roll surface and deteriorating of work roll surface roughness creates the Fe powder, which is attached on the work roll surface and leaves a trace on the strip surface, eventually the roll becomes disfunctional.

As shown in Fig. 6, in the case of EDT, work roll surface roughness is 1.4 when temper rolled length is 60 km. But in the case of SBT, temper rolled surface roughness deteriorates after 20 km of rolling length as shown Fig. 7. After temper rolling this characteristic was transferred to the strip produces inferior formability and paintability.

This is related to the roll life therefore it is very important. The roughness by EDT is not triangular but sinuous,[8] Experimental results by actual TM shows 2 times more life. This phenomenon can be seen in Fig. 8. Rmax is large in the case of SBT method, and is divided into two parts of untextured and textured areas. Stress is accumulated to the textured parts large and sharp, so peaks are worn rapidly by the

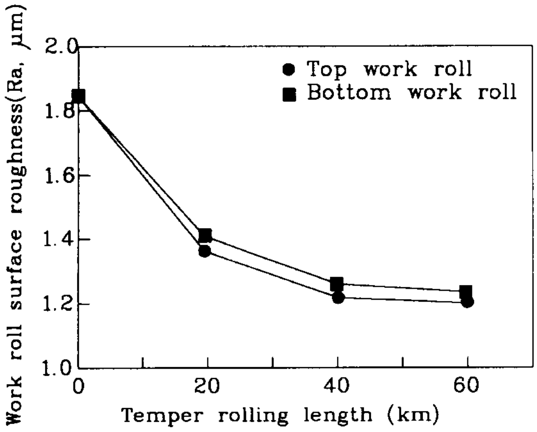


Fig. 7. Relationship between work roll surface roughness and temper rolling length on the SBT method.

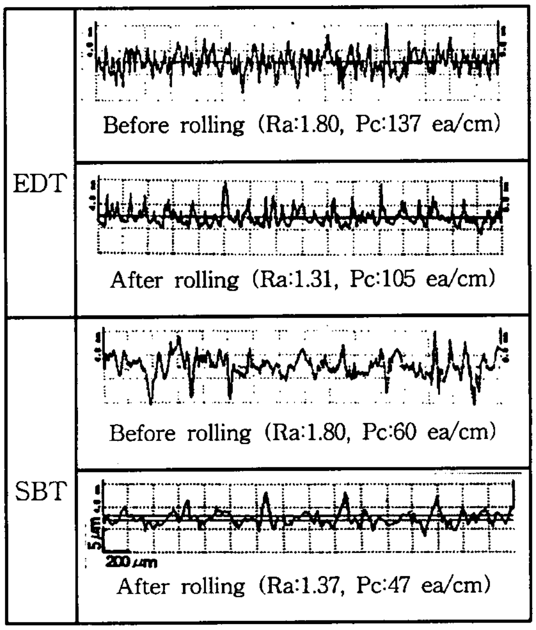


Fig. 8. Variation of work roll surface roughness and peak counts on the texturing method.

friction, in the case of EDT Rmax is low and little height difference exists so wearing is slow and constant. peak counts of work roll surface in the case of EDT method decreases with a constant gradient, in case the of SBT method peak counts of the work roll decreases rapidly at the beginning step and no change is observed after rolling approximately 1/3 the length of the EDT method process. As shown in Fig. 8 sharp and salient peaks are wearing quickly in the early stages of rolling, This is the reason that peak counts value does not changed at this time because it is similar to that of the roll grinding surface. At the same time, wearing of work roll is minimal.

The variation of roughness and peak count of strip surface

Surface roughness of cold rolled strip is transferred and determined during the temper rolling and peak counts and roughness are also the same. But surface roughness of strip is

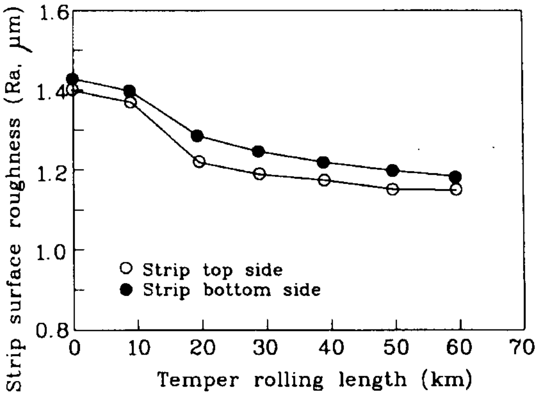


Fig. 9. Relationship between strip surface roughness and temper rolling length on the EDT method.

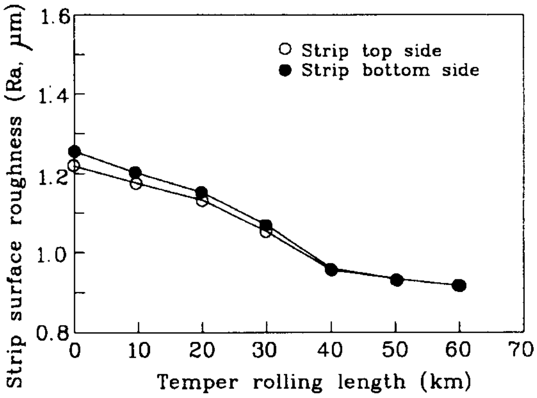


Fig. 10. Relationship between strip surface roughness and temper rolling length on the SBT method.

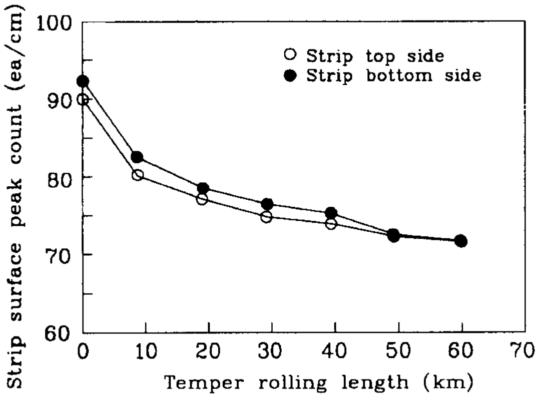


Fig. 11. Relationship between strip surface peak counts and temper rolling length on the EDT method.

different due to the elongation from the temper rolling. So it was rolled 1.0% of the base criterion. Fig. 9 shows the results, of the EDT roll, Fig. 11 shows the results of the SBT roll. There is no change until 60 km of strip length in the case of EDT roll, there is no roughness after 30 km of strip length in the case of SBT roll as shown in Fig. 10. peak counts of strip surface is determined by the roll surface roughness but the higher total reduction ratio the more peak counts.

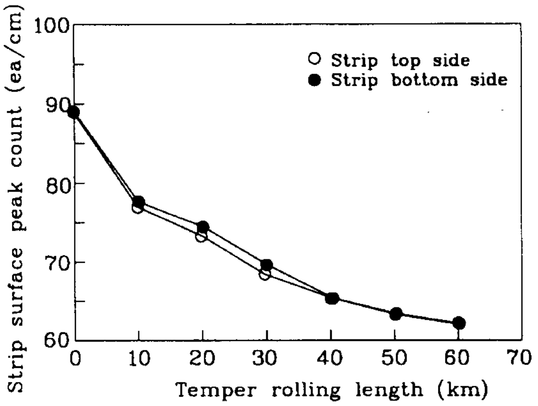
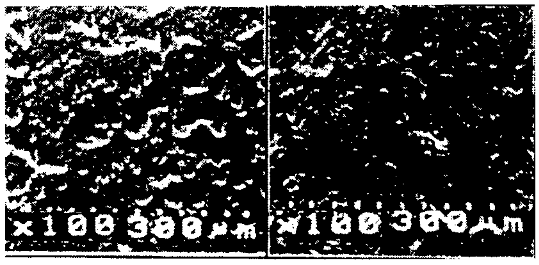


Fig. 12. Relationship between strip surface peak counts and temper rolling length on the SBT method.



a) EDT method. (Ra.: 0.92 μm, Pc: 105 ea/cm) b) SBT method. (Ra.:1.04 μm, Pc:67 ea/cm)

Fig. 13. Photograph of strip surface on the texturing method.

As shown in Fig. 11 the peak counts goes down rapidly in the first 10 km and then it has stable values, after 30 km. Bottom surface of strip has more peak counts than top surface of the strip, which is not touched by the neutral point of the roll bite and top and bottom roll are different from each other. This is the reason that there is length difference from the contact length of work roll and strip between the top and bottom work roll by the cross brake roll which is installed to prevent edge breakage of the strip.

The strip surface roughness is transferred by the SBT work roll as shown in Fig. 12, it is not as clear and slower than the EDT work roll. This can not be expressed because the exact trend of wear of the roll surface is irregular. So, EDT can control the proper roughness and peak counts to meet the customer's needs. But SBT can not control peak counts and producers irregular surface quality. It can be seen with a magnified SEM image of the strip surface as shown Fig. 13. The strip surface which used EDT roll has a more homogeneous and smooth roughness, the strip which used the SBT roll has unclear and heterogeneous roughness, with surface morphologies of the rolling direction. This produces a bad image clarity, and inferior clarity and formability in the case of painting.

Conclusion

This paper has investigated the characteristics of two of the texturing methods of the TM work roll and the results from the actual TM process were obtained as follows:

1) EDT roll has homogeneous roughness distribution and shape, and also a sinuous peak surface and the life is 2 times longer than that of SBT method.

2) The higher roughness the more rolling time to the EDT, peak counts decreases, texturing time is constant. In the SBT method without the correlation of roughness, but impeller rotation speed with an uncontrollable peak counts.

3) The roughness of SBT roll is irregularity compared to that of electro -discharge textured roll because the work roll roughness is transferred to the strip which was temper rolled.

4) The roughness and peak counts of strip surface which used a EDT roll is more homogeneous than that of SBT and it produces a more desirable image clarity and greater clarity to the color painted steel sheet.

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