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A Study on the Characteristics of Work Roll Texturing for Temper Mill

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Abstract : The purpose of this paper is to show the results from the study to improve the formability and appearance which is important in the cold rolled strip, the coated strip and prepainted strip. Furthermore, to give appropriate surface roughness, shape of work roll for temper mill is also important. The strip has a greater peak counts and homogeneous roughness. This makes the prepainted surface smooth and consistent in appearance with good image clarity. 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. This study is classified in order to get an accurate and homogeneous roughness. There are few papers published in this field, because its importance is not known and the proper operation of the machine is not generally well known. This paper investigates the correlation between strip surface roughness and the surface of the work roll. After studying the surface roughness and shape according to the texturing method for roll surfaces at temper rolling, the findings were as follows. Irregular surface roughness can be compensated with several paint coatings, but this also makes the quality deteriorate and manufacturing costs go up.

Key words : Cold rolled strip, peak counts, surface roughness, work roll, temper mill, image clarity

Introduction

Cold rolled steel sheets are widely used in automobiles, home appliances, and construction materials. Even though they are partly replaced by plastic or nonferrous metals for cars, cold steel rolls or coated steel sheets are still widely used. As the material roughness directly affects the surface of painted or coated steel sheet, the cold rolled steel sheets for cars and home appliances should have proper surface roughness, especially when appearance quality matters [1-3].

DOI (Distinctness of Image) and gloss value determining surface quality have a lot to do with the steel sheets Ra (surface roughness) and peak count. These two factors are very important. Recent studies reveal that waviness, pitch and profile of steel rolls have a great effect on steel sheets [4].

The surface roughness of cold rolled steel sheets is decided by the transcription of the pressing rolls roughness; The transcription rate is influenced by sheet material, pressure, tension, roll material, and lubrication. [5-6] After some processing, therefore, pressing rolls are replaced in order to decrease surface roughness deviation. The appearance and surface conditions play an important role when consumers choose home appliance products on painting and coating, even peaks can lead to high DOI. [7-8] In this research, therefore, the properties of roll texturing methods as well as the painting procedure of cold rolled and coated steel sheets were investigated. In particular, emphasis was laid on finding optimum painting conditions by measuring the peak count and roughness of steel surface before and after painting and comparing gloss value, DOI, paint layer, and color difference.

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Experimental Methods

Materials

The steel sheets used in this experiment were SAE 1008 used

Table 1. Chemical compositions of specimens (wt.%)

Material	C	Si	Mn	Al	Cu
SAE 1008	0.05	0.009	0.25	0.010	0.010

Table 2. Mechanical properties of specimens

Material	Tensile strength (N/mm^2)	Yield strength (N/mm^2)	Hardness (HRB)	Elongation (%)
SAE 1008	710.00	640.80	85.90	4.20

Table 3. Surface properties of specimens

Steel sheet		Ra(μm)	Rmax(μm)	Pc(ea/cm)
SBT	CR_1	1.5	8.1	77
	CR_3	1.5	8.0	77
EDT	CR_2	1.4	7.4	92

Table 4. Surface properties of specimens

Steel sheet	Ra (μm)	Rmax (μm)	Pc (ea/cm)	Coated metal (g/m^2)
EGi	1.0	5.0	182	50
Gi	0.4	4.2	140	350
GA	0.4	3.5	163	150

Gi: Galvanized iron, GA: Galvalume sheet, EGi: Electrically galvanized iron.

*SBT: Shot blast texturingEDT: Electro-discharge texturing

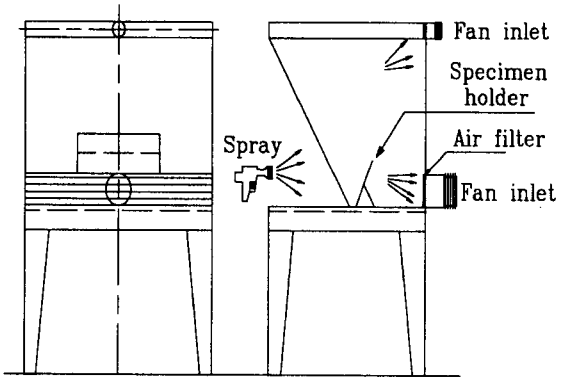


Fig. 1. Schematic diagram of spray booth.

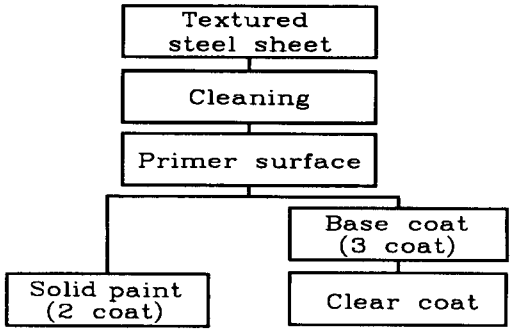


Fig. 2. Schematic diagram of painting procedure.

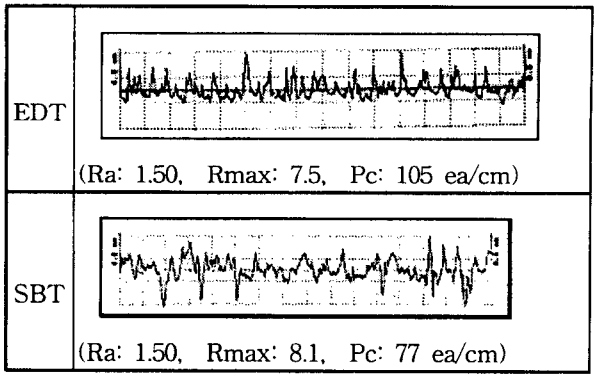
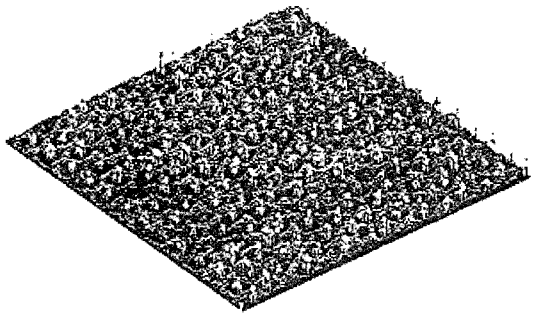
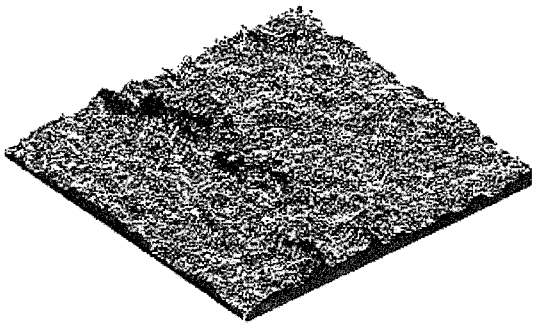


Fig. 3. Shape of surface roughness on the texturing method(x, y: 2.5 mm).



(a) EDT



(b) SBT

Fig. 4. Comparison of the work roll surface roughness.

for automobiles and electric home appliances, Table 1 shows the chemical compositions of specimens and Table 2 their mechanical properties.

Among the specimens were steel sheets with roughness processing, galvanization and zinc coating, Each specimen(10 by 15 cm) was produced.

As Table 3 and Table 4 shows, several kinds of experimental specimens were prepared(3 pieces each) by way of SBT and EDT rolls, coated steel sheets included EGi, Gi and GA.

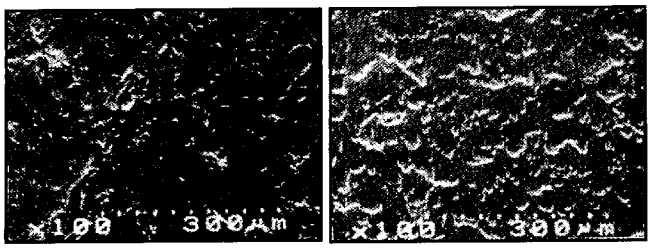
Experimental Equipment

The rolling mill used in this experiment was the irreversible 4-step stand, The rolls surface roughness was processed by the SBT(Type: BICK 4-1, Kuboda Co.) and EDT(Type: ET-60, Waldrich Siegen Co.) devices.

As shown in Fig. 1, the spray booth for painting experiment held the specimen inside and had automatic ventilating fans, The drying device with 3 steps inside had a function of automatically controlling and recording drying temperature and time.

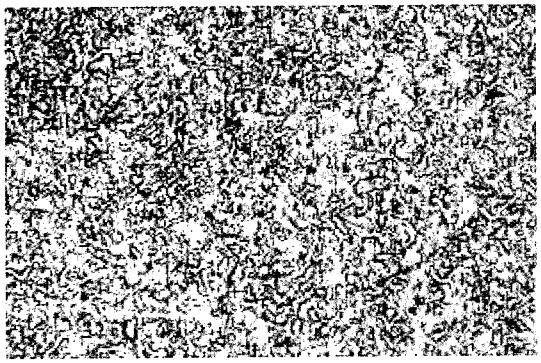
Experimental Methods

Some experimental specimens as given in Table 3 and Table 4 were prepared. The steel sheet specimens, either cold rolled or coated, were measured by the fixed roughness machine(Perthometer S-3P, Mahr Co.). The rolling mills roughness was examined by the portable tester (T-1000, Hommel Co.). Painting was done on the surface of steel sheets after comparing and checking their roughness, peak count and distribution.

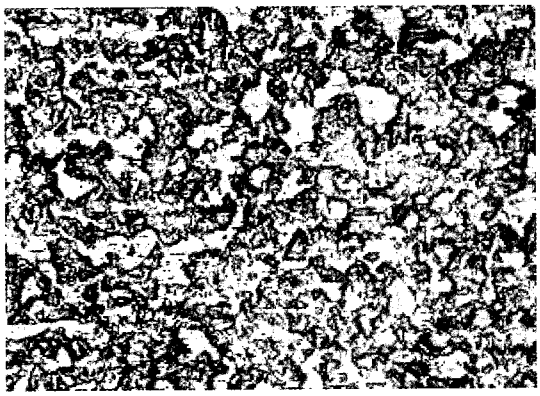


(a) SBT (b) EDT

Fig. 5. Comparison of the steel sheet surface roughness on the texturing method.



(a) Ra 0.5, Pc : 112 ea/cm



(b) Ra 1.5, Pc : 45 ea/cm

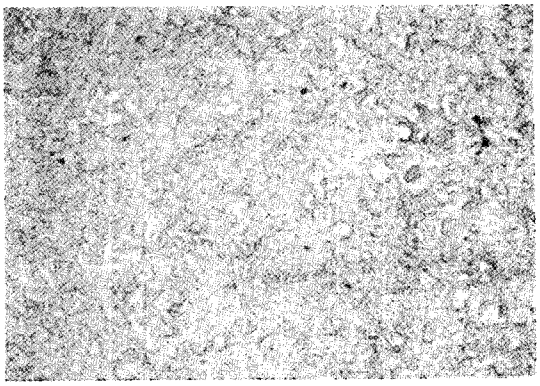
Fig. 6. Comparison of the steel sheet surface roughness (before zinc coating, ×100).

Among the PPG (Paint brand) paints used were solid paint, base-coating metallic paint, and last-touching clear paint. As seen in Fig. 2, the painting procedure of solid and metallic paints was similar to that of cars, When painting was completed, painting layer, gloss value and DOI were measured. After painting, as before painting, surface roughness and peak count were checked again to compare sheet surface roughness, DOI, gloss according to the number of coatings.

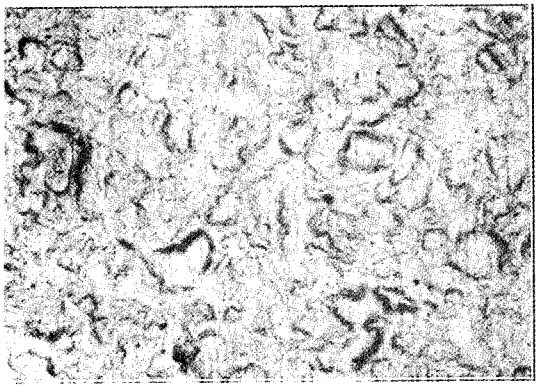
Results and Discussion

Work Roll Texturing and Surface Roughness of Steel Sheet

As presented in Fig. 3, the rolling mills processing used two kinds of texturing methods: EDT and SBT. The former produced uniform and compact peaks, while the latter created irregular peaks.



(a) Ra 0.2, Pc : 67 ea/cm



(b) Ra 0.8, Pc : 35 ea/cm

Fig. 7. Comparison of the steel sheet surface roughness (4 μm zinc coating: ×100).

As depicted in Fig. 4, EDT had very even and dense distribution of peaks, but SBT held partial and uneven processing. Its noteworthy that the former peak counts(105 ea/cm) was 1.5 times higher as the latter(77 ea/cm).

While EDT rolls consistently transcribed roughness on the sheet surface, SBT rolls(as noticed in Fig. 3-b) had abraded peaks in the beginning of texturing.2) Therefore, even starting at the same Ra, SBT rolls brought about rapid abrasion and unequal roughness leading to a short life of rolls. In contrast, EDT rolls maintained rather slow abrasion and equal peak shapes.

In Fig. 5, the two textured steel sheets were compared, revealing different peak types and distribution as transcribed by work rolls. The surface roughness of the work rolls by way of SBT texturing had difficulty in establishing uniform surfaces. The consequently uneven peaks on the transcribed steel sheets contributed to lower gloss value and DOI. [9-10]

But the EDT textured rolls had comparative ease obtaining favorable surfaces even after painting. In that sense, surface roughness texturing of work rolls is vital for the effect of uniform and regular roughness.

Steel Sheet Surface Roughness

Fig. 6 shows the effect of work roll transcription and EDT roughness texturing to manifest different peak count and roughness. [11-13]

Fig. 7 refers to the comparison after zinc coating with 4 μm

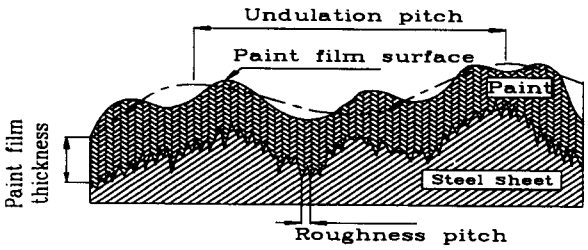


Fig. 8. Schematic diagram of paint layer.

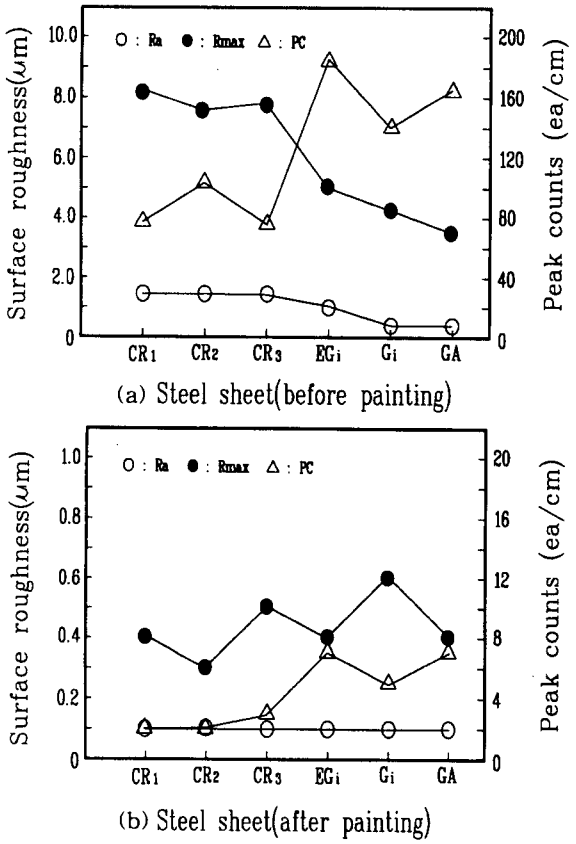


Fig. 9. Variation of surface roughness and peak counts on the painted steel sheet(C_1, C_2: 0.3 μm, LC: 0.8 mm).

thickness. In (a), Ra and peak counts decreased from 0.5 μm to 0.2 μm and 112 ea/cm to 67 ea/cm. In (b), a decrease was also noticed: 1.5 μm to 0.8 μm, 45 ea/cm to 35 ea/cm.

Steel Sheet Surface Roughness and Painting

Fig. 8 is about the influence of paint film thickness on the change of roughness when steel sheets completed surface roughness texturing and painting. [10] As coatings, irregular surface roughness was partly compensated. However, it took more time and required more paint.

Each steel sheets surface roughness and peak count were compared in Fig. 9. At the same roughness level, CR1 with the EDT work rolls had maximum peaks and minimum Rmax, CR1 tended to be plane by decreasing from 1.5 μm to 0.1 μm and from 77 μm to 2 ea/cm. Thus, in comparison with CR1 and CR3 with the SBT work rolls, CR2 produced more

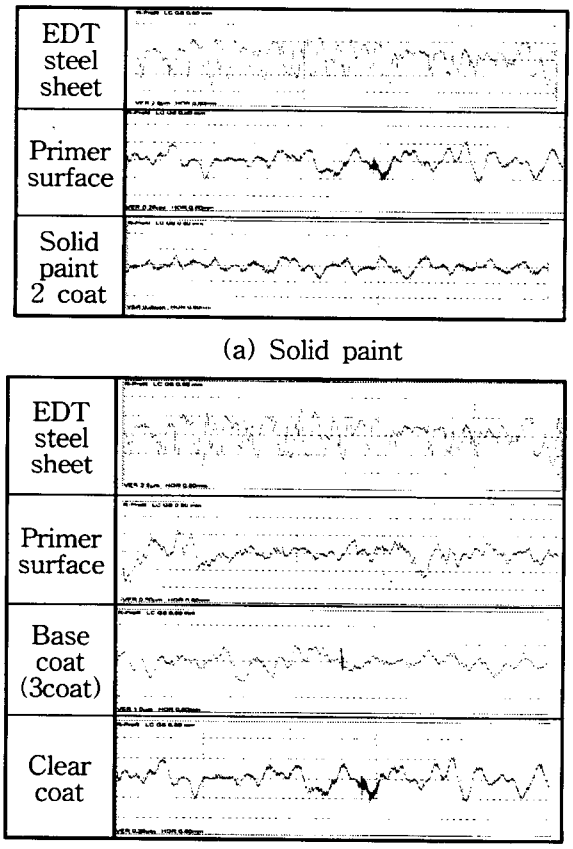


Fig. 10. Variation of painted steel surface for cold rolled steel sheet on the paint.

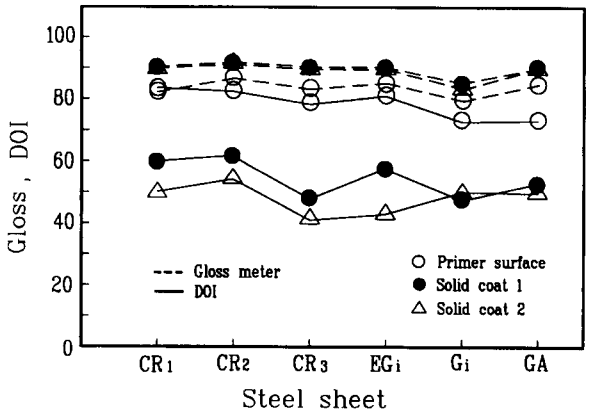


Fig. 11. Relationship between gloss value and DOI on the steel sheet (Gloss meter 20×, Solid paint).

uniform and better coated surfaces.

Fig. 10 portrays the variation of surface roughness and peak count according to the coating increase of solid and metallic paints. One major difference between them is that the latter requires the coating of clear paint. As in (a), primer surface coating in (b) resulted in the decrease of Ra(1.5 μm to 0.3 μm), Rmax(7.7 μm to 2.3 μm) and peaks(2 ea/cm). As a result, similar surface roughness was obtained.

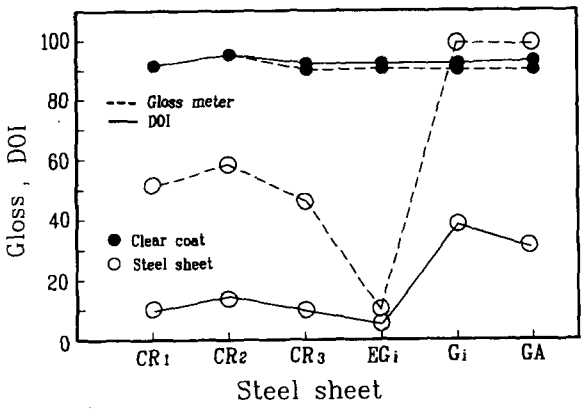


Fig. 12. Relationship between gloss value and DOI on the steel sheet (Gloss meter 20×, Metallic paint).

Comparison of Gloss and DOI

As revealed in Fig. 11, gloss value of solid paint appeared high as 90 and DOI decreased to 40~55(by 35~40 as compared with metallic paint).

Fig. 12 represents the relationship between gloss value and DOI before and after painting. Even though very similar in gloss before coating, EGi sheets appeared low as 10 but Gi sheets had a high gloss value of 97. Therefore, we can see gloss and DOI are related to surface roughness and particle size of paint film. When paint film thickness was greater than 100 μm, gloss and DOI had nothing to do with it.

Conclusion

After comparing the properties of steel sheets and painting according to the steel rolls surface roughness processing and texturing, the following results were attained:

1. EDT processing of work rolls are proper for coating or painting as the amount of current determines the size and space of peaks. Even though Ra is generally equal after painting, peak count of coated steel sheets is greater than that of cold rolled steel sheet. Gloss and DOI have a lot to do with surface roughness and paint particle size and almost none with paint film thickness.
2. When paint film thickness reaches 100 μm or more after coating, Ra is uniform but Rmax is higher in SBT sheets than in EDT sheets, causing poor painting or a risk of rust.
3. EDT steel sheets show superior gloss value and DOI to SBT steel sheets. As gloss and DOI are influenced by Rmax and peak count after painting, careful maintenance is a necessity.

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