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Synopsis :
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Chromate Electrogalvanized steel sheet "RIVER ZINC F" with Anti-fingerprint Property and High Corrosion Resistance*1

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A new product **RIVER ZINC F**, *an electrogalvanized steel sheet with special resin and chromate coating, has been developed for its anti-fingerprint property and high corrosion resistance. Kawasaki Steel has succeeded in commercial production of this material on KM-RCEL (Kawatetsu Multipurpose Radial Cell Electroplating Line) at Chiba Works. Under the hydrogen quantitative feeding method, deviation of Cr coating weight and color tone of chromate coating is very slight. This product is coated with special resin on chromate coating by the roll coater on KM-RCEL. Corrosion resistance of the resin coated product was evaluated by the salt spray test for more than 500 h, and the anti-fingerprint property was found excellent. This product has other beneficial properties such as paintability, weldability, etc., and will be suitable for both painting and non-painting uses.*

1 Introduction

Electrogalvanized sheets for acoustic appratuses and electric appliances are increasingly required to possess antifingerprint property and a uniform and excellent apperance in addition to other conventional properties such as corrosion resistance, formability, and paintability.

To meet these customers' demands, Kawasaki Steel has recently developed a new electrogalvanized steel sheet named **RIVER ZINC F (RZ-F)** using KM-RCEL (Kawasaki Steel Multipurpose Radial Cell Electroplating Line)[1] at the Chiba Works. RZ-F is chromate-treated and coated with a special resin to import a unique antifingerprint property and a high-corrosion resistance.

This report describes the manufacturing method and characteristics of RZ-F.

2 Manufacturing Method of RZ-F

The product quality and appearance vary with the coating weight of the chromate film, and three types of product: RZ-FA, RZ-FB, RZ-FC are produced on KM-RCEL as shown in **Table 1**.

Table 1 Variations of RZ-F

Variation	Cr coating weight (mg/m²)	Color tone
RZ-FA	10	white
RZ-FB	50	gray
RZ-FC	100	pale yellow

2.1 Manufacturing Process

RZ-F has a dual-layer of a special resin film and a chromate film on the electrogalvanized sheets as shown in **Fig. 1**.

Figure 2 shows the main manufacturing process on KM-RCEL. The chromate treatment on the electrogalvanized sheets[2] is of the conversion type and the special resin is coated by the roll coater in the line.

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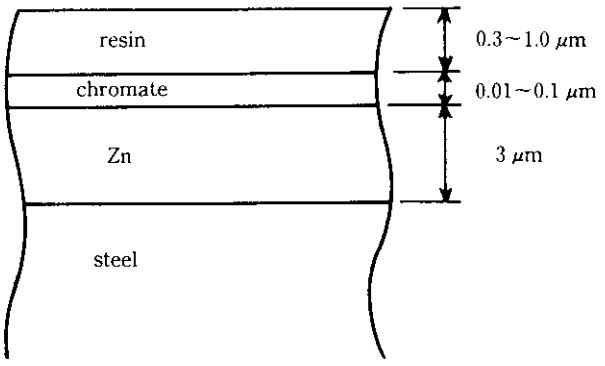


Fig. 1 Structure of RZ-F

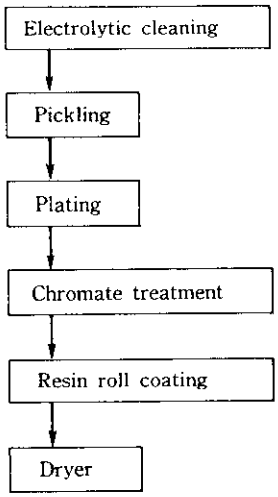


Fig. 2 Manufacturing process of RZ-F in KM-RCEL

2.2 Hydrogen Quantitative Feeding Method for Chromate Treatment[3)]

It is necessary to stabilize the coating weight of chromate in order to obtain an excellent and uniform appearance. In the case of the conversion type, however, the coating weight is apt to fluctuate, because it is difficult to regulate the conditions of the chromate solution during operation. In KM-RCEL, the adjustment of the coating weight is carried out using a hydrogen quantitative feeding method which has been newly developed, and as a result, a stable coating weight of chromate and a uniform and attractive appearance has been obtained. **Figure 3** is a diagram of the hydrogen quantitative feeding method in which the amount of H^+ supplied to the solution is controlled according to the consumption of H^+ which can be calculated from the target coating weight of chromate. The mechanism for the formation of chromate film is generally understood to be as follows[4)].

The generation of H_2 gas and the accompanying dissolution of Zn cause the pH to rise near the coating surface in the solution, which results in the formation of a chromate film consisting mainly of chromium hydroxide. A mass balance of this reaction is given by Eq. (1).

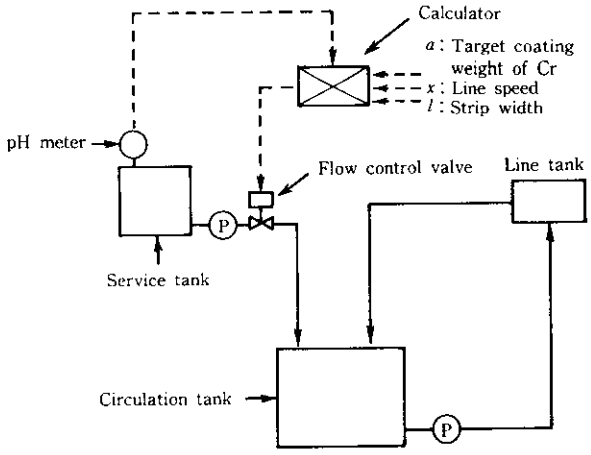


Fig. 3 Schematic diagram of hydrogen quantitative feeding method for chromate treatment

$$4Zn + 18H^+ + Cr_2O_7^{2-} + 2CrO_4^{2-} = 4Zn^{2+} + Cr(OH)_3 \cdot Cr(OH) \cdot CrO_4 + Cr^{3+} + 7H_2O \quad \cdots\cdots (1)$$

So, the quantity of H^+ needed can be calculated by Eq. (2)

$$y = \frac{3}{13} axl \quad \cdots\cdots (2)$$

Therefore, the flow rate of solution supply is given by Eq. (3).

$$f = \frac{3}{13} axl \times 10^p \quad \cdots\cdots (3)$$

where, y: quantity of H^+ needed (mg/min)
a: target coating weight of Cr (mg/m^2)
x: line speed (m/min)
l: width of strip (m)
f: flow rate of solution supply (mg/min)
p: pH of supply liquid

As shown in **Fig. 4**, by comparison with the conventional method, the fluctuation of Cr coating weight among coils has been decreased under this method. This is due to the mechanism that pH changes when the actual coating weight of Cr is not equal to the target and remains the same when it is equal, as shown in **Table 2**.

2.3 Special Resin Coating

The special resin is of the alkyd resin type which contains colloidal silica, and it is coated using a roll coater with 3 rolls. **Table 3** shows the specifications and **Fig. 5** shows a diagram of the resin coating section.

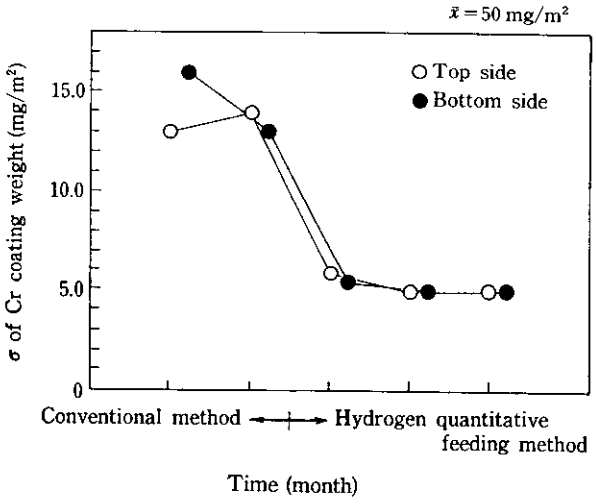


Fig. 4 Monthly fluctuation of Cr coating weight

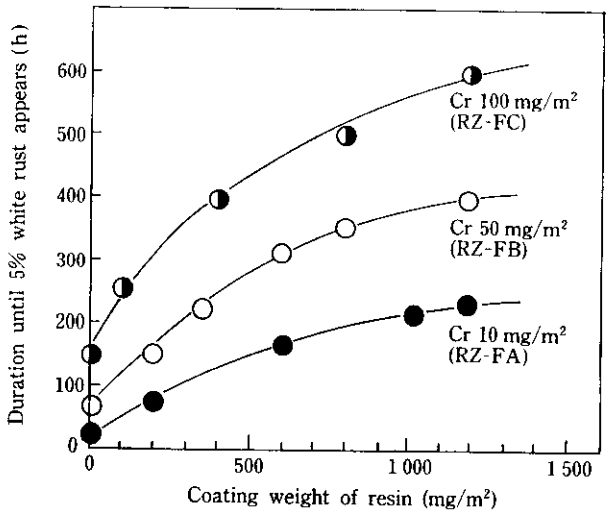


Fig. 6 Effect of coating weight of resin and chromate on corrosion resistance by salt spray test

Table 2 pH self control function by hydrogen quantitative feeding method

Actual coating weight of Cr	H^+ balance	pH change	Change of Cr coating weight
more	spend > supply	↗	↘
equal	spend = supply	→	→
less	spend < supply	↘	↗

Table 3 Specifications of roll coater

Type	3 rolls type
Roll dia.	200 mmϕ for pick-up roll 250 mmϕ for doctor roll 300 mmϕ for coating roll
Line speed	120 m/min max.
Dryer	60°C max. of strip temp.

The coating weight of the resin can be easily adjusted by altering the roll gap and the concentration of the solution. The resin coating is dried at a strip temperature of under 60°C.

3 Product quality

In the use of electric appliances, a high level product quality is demanded. The product qualities of RZ-F are mentioned below.

3.1 Corrosion Resistance

Figure 6 shows the corrosion resistance of the flat portion by salt spray test. Corrosion resistance increases with the coating weight of Cr in the chromate film as well as that of the special resin. In the case of RZ-FC, white rust does not occurred until 500 h when the coating weight of resin is more than 1000 mg/m². This shows that RZ-FC has a good corrosion resistance.

Corrosion resistance of a portion formed by Erichsen testing apparatus and a bending machine is given in **Table 4**. Although this is not as good as that of the flat portion, RZ-FC can pass more than 200 h of salt spray test.

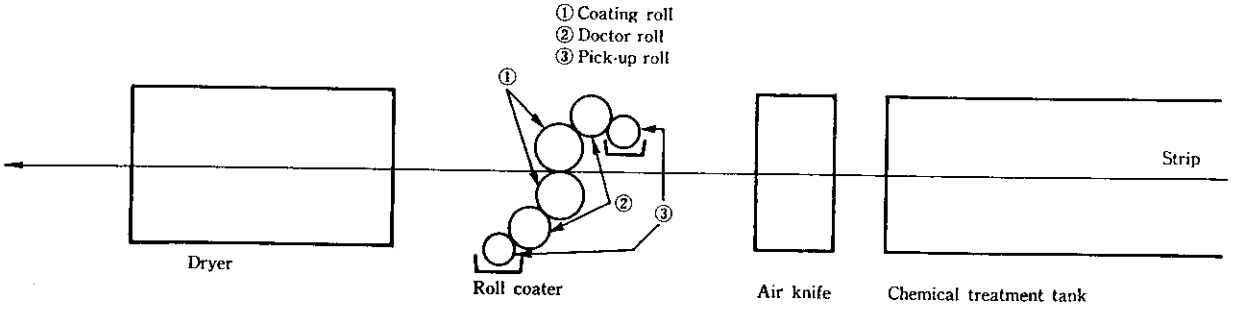


Fig. 5 Schematic diagram of resin coating section in KM-RCEL

Table 4 Corrosion resistance of formed portion—SST time (h) until 5% white rust appears

Type	Erichsen 5 mm	Erichsen 7 mm	0t bend	Flat
RZ-FA	100	72	72	200
RZ-FB	200	200	120	350
RZ-FC	300	250	250	500

Coating weight of resin is 800 mg/m²

3.2 Antifingerprint Property

Since handling of the product results in finger prints, an excellent antifingerprint property is imperative.

As shown in **Table 5**, the antifingerprint property improves gradually as the coating weight of the resin increases, and an excellent property is obtained by more than 300 mg/m² of the coating weight, which is evaluated by visual inspection using a synthetic sweat.

Table 5 Effect of resin coating weight on antifingerprint property

Resin coating weight (mg/m²)	RZ-FA	RZ-FB	RZ-FC
—	×	×	×
100	△	△	△
300	○	○	○
500	◎	◎	◎
1 000	◎	◎	◎

Evaluation: ◎ excellent, ○ good, △ fair, × bad

3.3 Resistance to Organic Solvent

Table 6 gives the resistance to some organic solvents which are used for washing or removing press oil at the customers. In the resistance test, the surface of the product is rubbed 10 times using a cotton which contains an organic solvent and is evaluated visually.

Good resistance to any organic solvent is obtained in RZ-FA and RZ-FB, but slightly poorer resistance to acetone and trichloroethylene in RZ-FC.

3.4 Wear Resistance

As shown in **Table 7**, good wear resistance is obtained when evaluated using the apparatus for wear resistance testing (JIS H 8682). It has been confirmed that there is no damage to the product when a tension pad is used at a slit line.

Table 6 Resistance to organic solvent

Type	Resin coating weight (mg/m²)	Acetone	Xylene	Trichloroethlene	Dichloromethone
RZ-FA	300	○	○	○	○
	500	○	○	○	○
	1 000	○	◎	○	◎
RZ-FB	300	○	○	○	○
	500	○	○	○	○
	1 000	○	◎	○	◎
RZ-FC	300	△	○	△	○
	500	△	○	△	○
	1 000	△	○	△	○

Evaluation: ◎ excellent, ○ good, △ fair, × bad

Table 7 Wear resistance

Resin coating weight (mg/m²)	RZ-FA	RZ-FB	RZ-FC
300	◎	○	○
500	◎	○	○
1 000	○	○	○

Evaluation: ◎ excellent, ○ good, △ fair, × bad

3.5 Paintability

Test panels of RZ-FB are painted with 30 μm of amino-alkyed and are examined for corrosion resistance and paint adhesion.

3.5.1 Corrosion resistance after painting

Corrosion resistance after painting is measured from the values of creep width at the scribed portion of the test panels after 200 h of salt spray test. As given in **Table 8**, the values of creep width are as good as under 2 mm, and corrosion resistance after painting is known to increase over a range of 300 to 1000 mg/m² of the resin coating weight.

Table 8 Corrosion resistance of RZ-FB after painting

Resin coating weight (mg/m²)	Maximum peeling width after 200 h of SST (mm)
300	1.7 , 1.6
500	1.5 , 1.3
1 000	0.8 , 0.5

Table 9 Paint adhesion of RZ-FB by tape peeling test

Resin coating weight (mg/m²)	Primary adhesion		Wet adhesion*1)	
	Erichsen 5 mm*2)	Du Pont impact*3)	Erichsen 5 mm*2)	Du Pont impact*3)
300	○	○	○	△
500	◎	○	○	○
1 000	◎	○	○	○

Evaluation: ◎ excellent, ○ good, △ fair, × bad

*1) After 1 h of hot water immersion

*2) With grid scratches

*3) 1/2 inch × 500 g × 50 cm

3.5.2 Paint adhesion

Paint adhesion is evaluated by the tape peeling test after Du Pont impact or 5 mm of Erichsen with grid scratches. As given in **Table 9**, both primary adhesion and wet adhesion after 1 h of immersion in hot water are good. These improve as the coating weight of the resin increases.

3.6 Resistance to Alkaline Solution

An alkaline treatment is often used prior to painting. For applications where no painting is used, the alkaline treatment is sometimes used to remove press oil. Therefore, high quality is demanded even after alkaline treatment.

Table 10 shows resistance to an alkaline solution which consists mostly of sodium phosphate (FC-4349, Nihon Perkerizing Co., Ltd.). Corrosion resistance and paintability do not deteriorate after the alkaline treatment; therefore, it proves that resistance to alkaline solution is excellent.

Table 10 Effect of alkaline treatment on corrosion resistance and paintability of RZ-FB*1)

Item	Before alkaline treatment	After alkaline treatment*6)
Corrosion resistance*2)		
Flat	350 h	350 h
Erichsen 7 mm	200 h	200 h
0t bend	120 h	120 h
Corrosion resistance after painting*3)	1.2 , 1.0 mm	1.3 , 1.0 mm
Paint adhesion*4)		
Erichsen 5 mm	◎	○
Du Pont impact	○	○
Wet adhesion*5)		
Erichsen 5 mm	○	○
Du Pont impact	○	○

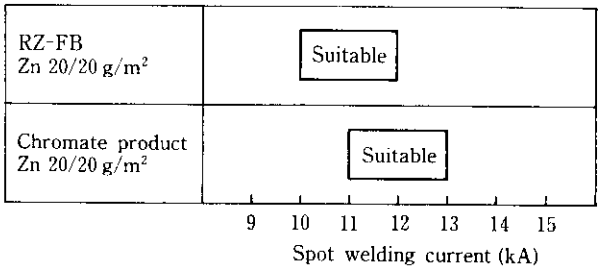
*1) With 800 mg/m² of resin

*2) Same as Table 4

*3) Same as Table 8

*4,5) Same as Table 9

*6) pH 10, 60°C, 2 min



Electrode radius : 6 mm φ (Cu-Cr)
Welding force : 200 kgf
Resistance welding time: 10~

Fig. 7 Current range of single spot welding for RZ-FB and chromate product

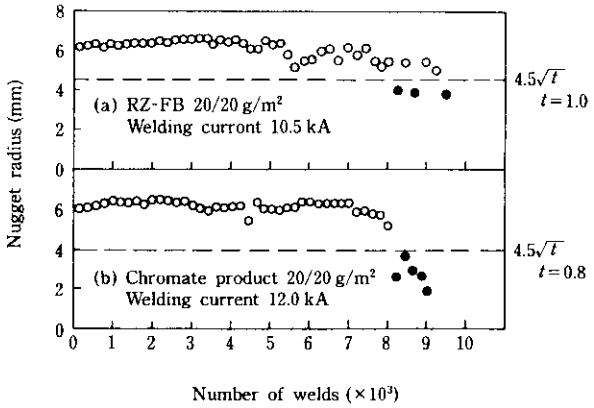


Fig. 8 Change of nugget radius in relation to the number of spot welds

3.7 Weldability

Figure 7 shows the suitable current range for spot welding, and **Fig. 8** shows the electrode life for RZ-FB with 1000 mg/m² of the resin coating weight. The suit-

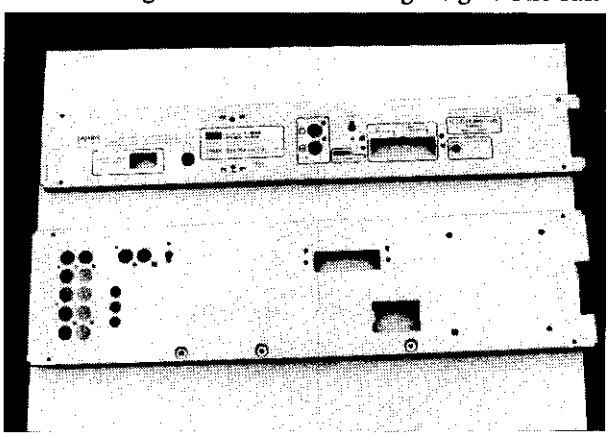


Photo 1 Electric appliance use of RZ-F

able current range for spot welding of the product is lower than that for the conventional chromate product. The number of continuous welds is 8000, which is almost the same as that for the conventional one. Therefore, RZ-FB is believed to possess excellent weldability.

According to the above-mentioned results, it is expected that RZ-F offers excellent characteristics whether painting is carried out or not. Large amounts of RZ-F have been used for such an appliance material as shown in **Photo 1**.

4 Summary

A new RZ-F product, which is coated with a special resin on chromate electrogalvanized sheets, has been developed and produced commercially on KM-RCEL in Chiba Works.

(1) A stable coating weight of chromate film can be obtained in attractive appearance by using the hydrogen quantitative feeding method.

(2) The special resin, which is of the alkyd type containing a coloidal silica, is coated on chromate electrogalvanized sheets using a roll coater in KM-RCEL.

(3) RZ-FC, with chromium coating of 100 mg/m^2 and more than 800 mg/m^2 of the resin coating weight, passed more than 500 h of salt spray test.

(4) A high-level antifingerprint property is obtained by more than 300 mg/m^2 of the resin coating weight.

(5) RZ-F is excellent in other chracteristics such as paintability, resistance to organic solvent, wear resistance, resistance to alkaline solution and weldability.

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