

Production of Heavy Gauged HY-GALUME in Hyundai HYSKO

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HY-Galume is a brand name of 55%Al-Zn coated steel sheets produced by Hyundai HYSKO. Heavy gauged HY-Galume having thickness around 2 millimeters is used as a steel casing for the electrical distribution panel in the construction market. It requires a strict surface quality because it is used indoors. In this paper, several troubleshooting experiences in producing heavy gauged HY-Galume are proposed.

Keywords : Galvalume, 55%Al-Zn, sink roll, spangle, dross, mottling

1. Introduction

55%Al-Zn coated steel sheets exhibit superior corrosion resistance compared to galvanized steel sheets, and are normally used in the construction and home appliances market.

Conventional process for manufacturing coated steel sheet is CGL(Continuous Galvanizing Line) process. Cold rolled steel strip passes through cleaning section to rinse off lubricating oil and enters annealing furnace to ensure mechanical properties of the strip. Strip then proceeds into coating bath with molten aluminum and zinc. Typical chemical composition of the coating bath is 55 wt.% of Aluminum, 43 wt.% of Zinc, 1.6 wt.% of Silicon, 0.4 wt.% of Iron and other impurity elements. After passing through molten bath, the strip is rapidly cooled to form 'spangle' and Al/Zn rich microstructure on the coating layer. This microstructure is the key factor to guarantee the extended life of the 55%Al-Zn coated sheet.

Heavy gauged 55%Al-Zn steel sheets are normally used as a steel casing for the electrical distribution panel in the Chinese construction market. It requires several quality requirements. First requirement is a uniform spangle on the coating surface. Because it is used indoors, visible surface defects such as dross adhesion and uneven spangle are not tolerated by the customers. Second one is the OT folding property. Edge of the strip is OT folded in actual use, and no coating crack is allowed in the folded surface. In this paper, several troubleshooting experiences in pro-

ducing heavy gauged 55%Al-Zn coated steel sheet with good surface quality.

2. Experimental method

Hot dip simulator (Rhesca HDPS) was used to produce the 55%Al-Zn coated specimen (Fig. 1). It can simulate the CGL process including annealing, hot-dipping and air-cooling to form spangle. Since the cooling rate after hot dipping is sensitive in determining the spangle size, all the specimens were produced with constant cooling rate (Fig. 2)

In this paper, lead and titanium were added respectively as impurity elements to evaluate the influence on the spangle size and on the coating ductility. Chemical compositions of the coating bath are shown in Table 1.

Computational fluid dynamic (CFD) simulation was

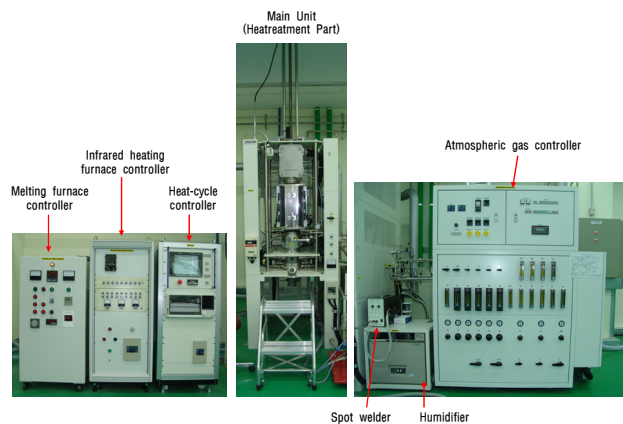


Fig. 1. Hot-Dip Simulator used in this study.

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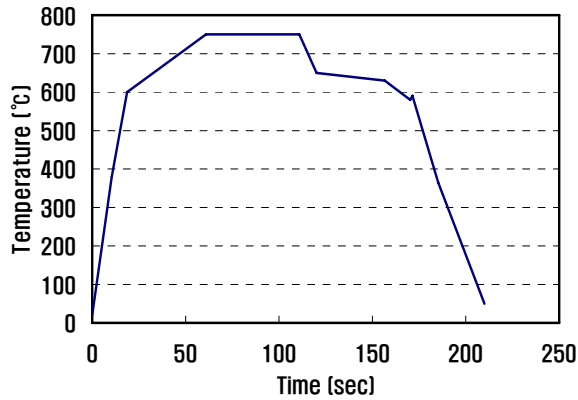


Fig. 2. Heat cycle for hot-dip specimen.

Table 1. Experimental compositions of coating bath

Elements	Composition
Basic Elements	Al 57.2wt.%, Zn 40.6wt.%, Si 1.5wt.%, Fe 0.5wt.%
Pb	20, 50, 70, 90 ppm
Ti	50, 100, 400, 600, 4000 ppm

performed to estimate the movement of dross particles within the coating bath. HYSCO Dangjin Works CGL main pot was modeled, and the total number of elements was more than 1.2 million. After modeling, FLUENT software was used for the simulation. Numerical parameters of 55%Al-Zn molten metal at 600 °C was taken from other papers.¹⁾

3. Results and discussions

3.1 Spangle size and coating ductility due to impurity elements

Hot-dip simulation was performed to evaluate the spangle size and coating ductility according to the impurity elements. First, the influence of lead addition was evaluated. Fig. 3 shows the surface morphology of the specimens. As the lead concentration increased over 70 ppms, the spangle size grew significantly.

As lead is known to be segregated in the spangle boundary during solidification process, we performed bending test of the specimen. Fig. 4 shows the OT-folding test results according to lead concentration. In low concentration of lead, only hair cracks were observed. On the other hand, in high lead concentration, cracks were found along the spangle boundaries. Former studies^{2),4),5)} suggested that lead can be redistributed in the spangle boundaries because the melting point of lead is much lower than other coating materials. So, it seems that lead concentration in the spangle boundaries caused the large intergranular cracks.

EDS analysis was performed in the crack area (Fig. 5). It can be seen the Al-rich dendrite arm and Zn-rich interdendritic region in uncracked area. In the bottom of the crack, Al, Fe, Si was detected, indicating that the interfacial layer between substrate and coating was exposed. We hoped to analyze the track of Pb in the crack area, but, we couldn't find it because maybe Pb concentration was not enough for EDS analysis.

The effect of titanium was estimated also. Titanium is known as an effective spangle refining element. So, we

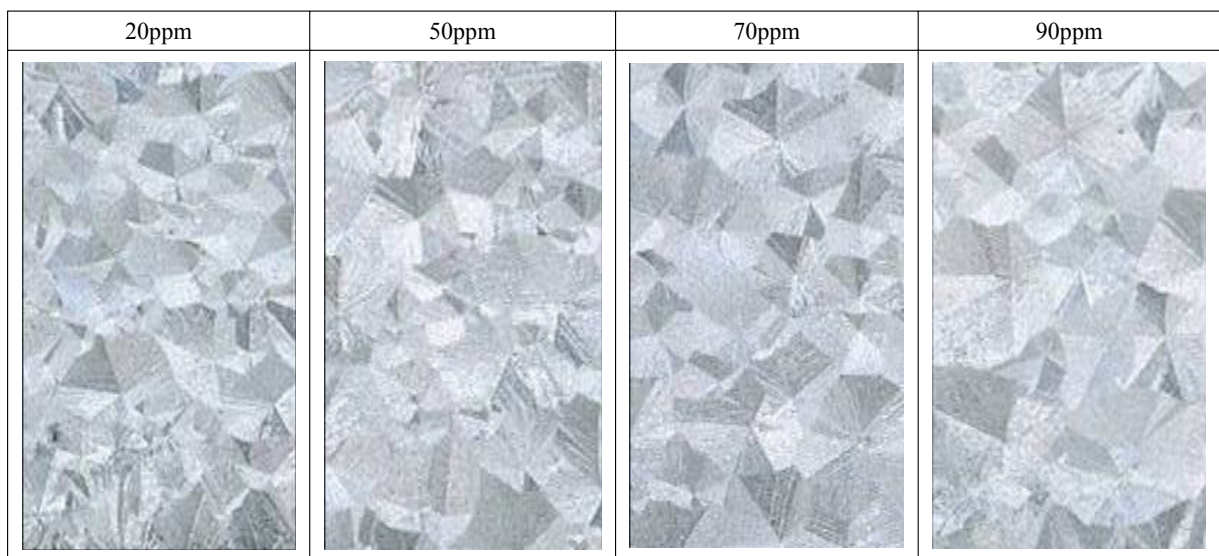


Fig. 3. Spangle size according to Pb concentration.

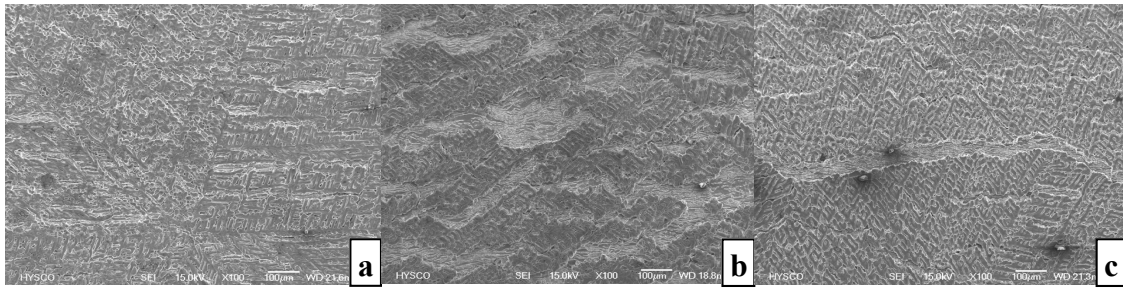


Fig. 4. Result of OT folding test according to Pb concentration (a) 20ppm, (b) 70ppm, (c) 90ppm.

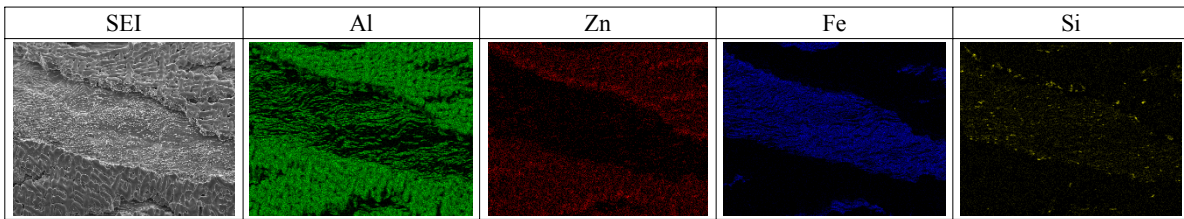


Fig. 5. EDS mapping results of cracked area.

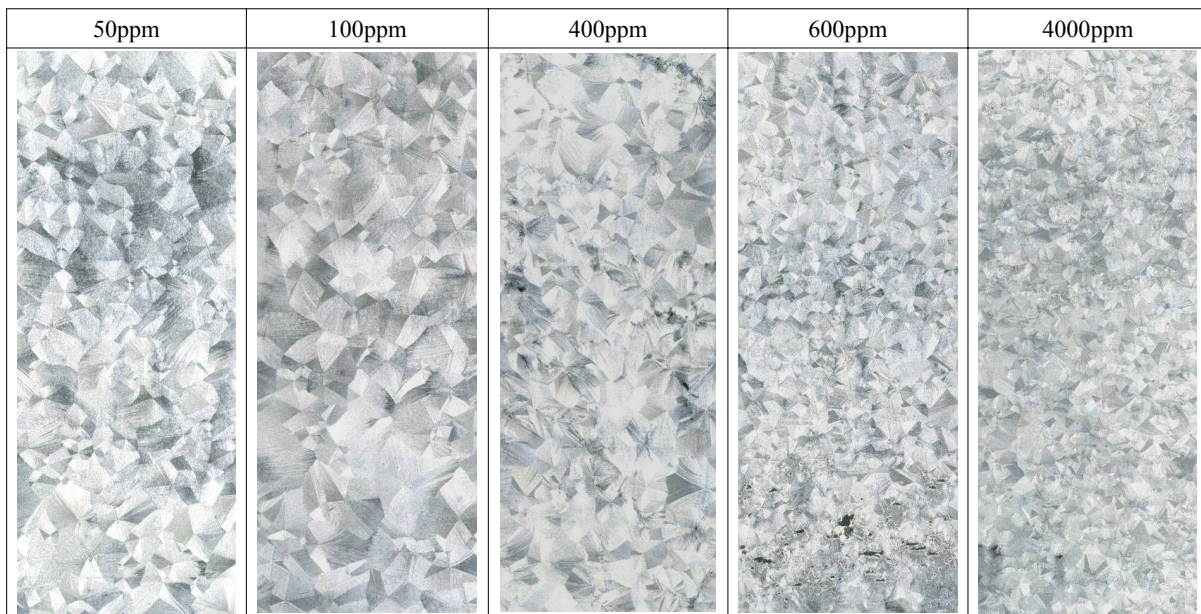


Fig. 6. Spangle size according to Ti concentration.

added Ti from 50 ppm to 0.4%. Specimens having more than 600 ppm of titanium had smaller spangle size compared to others. This is due to the heterogeneous nucleation by titanium particles in the melt. OT-folding test results of titanium added specimens showed only hair cracks in all range of titanium concentration. Therefore, titanium addition did not deteriorate the coating ductility.

3.2 Preventing dross adhesion - effect of line speed

Fig. 7 and 8 show the CFD simulation results at the line speed of 75 and 150 mpm(meters per minute) respectively. Incoming strip goes from upper right to lower left, and the sink roll rotates clockwise direction. Between the incoming strip and the rotating sink roll, we could see the upright arrows indicating the repulsive flow. This repulsive flow prevents the dross particles from adhering

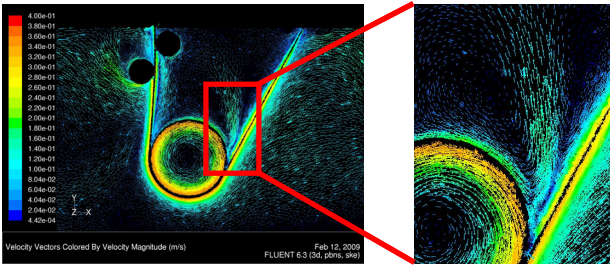


Fig. 7. CFD simulation results at line speed of 75mpm.

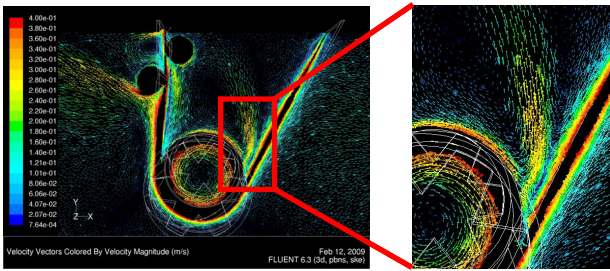
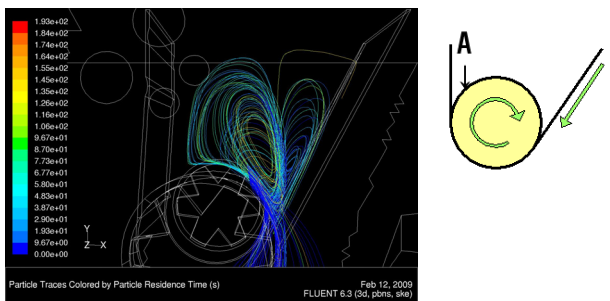
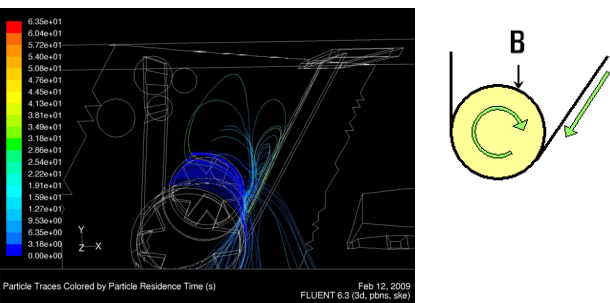


Fig. 8. CFD simulation results at line speed of 150mpm.



(a)



(b)

Fig. 9. CFD simulation of sink roll scraping position (a) far from incoming strip, (b) close to incoming strip.

to the strip. In these results, it can be concluded that the faster line speed promotes more repulsive flow, promoting better coating surface.

3.3 Preventing dross adhesion - effect of sink roll scraping position

Fig. 9 shows the movement of dross particle scraped

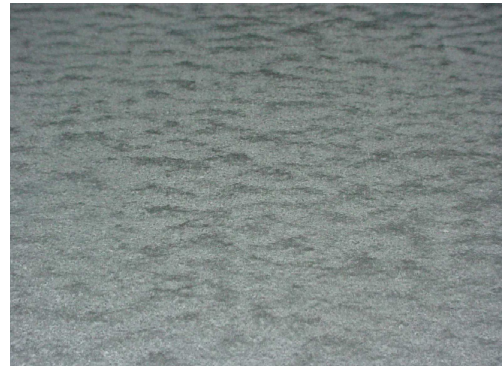


Fig. 10. Surface defects - mottling.

from sink roll surface. We evaluated the dross movement according to the scraping position. Position (a) is located after the centerline, far from the incoming strip, whereas position (b) is located before the centerline, close to the incoming strip. As can be seen in the results, position (a) showed larger dross movement compared with position (b). When dross particles move farther, they can be expelled from sink roll/strip interface, thus preventing dross pickup. In order to minimize dross pickup on the strip, position of the sink roll scraper was decided with these results.

3.4 Other surface defects

In some cases, there existed surface defects that looked like 'Jaguar skin' when seen at certain angle. Former studies clarify these defects as 'mottling'³⁾ and Fig. 10 shows one of these defects. Mottling is often said to be caused by the undissolved silicon or by the excessive silicon content in the coating bath. However, even in normal silicon content, mottling was observed.

EDS analysis was performed on the normal and abnormal surface. On the abnormal surface, large signal of silicon concentration between the interdendritic regions was observed. With these results, it can be concluded that these defects were associated with silicon in the coating bath, in other words, these defects are mottling for sure.

When mottling is generated, some countermeasures such as reducing line speed or reducing coating weight can be applied. These countermeasures help diminishing mottling generation.

4. Conclusion

Various experiences in producing heavy gauged 55%Al-Zn coated steel sheet have been proposed as follows;

- 1) Lead addition into coating bath expands the spangle size. However, it can cause intergranular cracks in OT folding

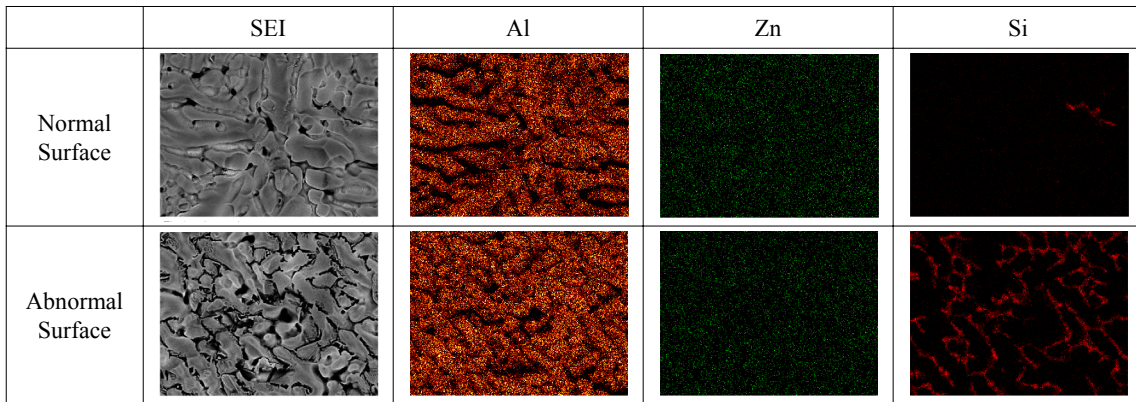


Fig. 11. EDS mapping analysis of surface with mottling defect.

2) Titanium addition helps to minimize the spangle size.

And it doesn't deteriorate the folding property.

3) CFD simulation suggested that higher line speed was effective in preventing dross adhesion on the strip.

4) CFD simulation also suggested that the distance between scrapers and incoming strip should be far enough to prevent scraped dross particles from entering sink roll/strip interface.

5) Mottling generation could be diminished by reducing coating weight and reducing line speed.

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