Hot-Dip Galvanized Sheet Steel with Excellent Press Formability and Surface Quality for the Automotive Panels*



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Synopsis:

A new type of a hot-dip galvanized steel sheet (GI steel sheet), excellent in press formability, weldability and surface appearance, for automotive bodies has been developed. As for press formability, through the optimization of surface roughness effected by texture control with skin-pass rolling and by the use of a high-lubricating oil, sliding characteristics has been improved. Concerning an advantage in weldability, with the suitable selection of coating and substrate chemistry, the life of welding electrode has been extended. Improved surface quality for the better exterior appearance was achieved through the introduction of such measures as the prevention of bath wrinkle patterns by adjusting a wiping condition, the avoidance of dross adherence with the use of bath exclusive for GI use, and the substantial reduction of spangles by using cooling rate control after galvanizing. The hot-dip galvanized steel sheet demonstrates distinguished characteristics as a material sheet for automotive outer panels. The newly developed GI sheets are put into commercial production,

remained to be solved with GI, including relatively poor surface quality and inadequate performance in the properties which are necessary for manufacturing and assembling auto bodies, such as press formability and spot weldability, and improvements were needed.

This report describes the quality criteria of a GI sheet steel which solves the previously-mentioned problems and has been applied successfully to automotive outer panels, together with a stable production technology for this GI product.

2 Properties of Hot-Dip Galvanized Steel Sheets (GI)

2.1 Corrosion Resistance

Figure 1 shows the results of a corrosion test of various types of Zn coated steel sheets.[2)] In this test, which was conducted at seashore test site in Okinawa (approximately 10 m from the coastline), various types of coated steel sheets with different Zn coating weights were exposed for four years in the as-galvanized condition. Corrosion resistance was improved as the coating weight increased. Because a heavy zinc coating can easily be realized at low cost with GI sheets, high rust resistance can be obtained. In particular, GI demonstrates a rust-resistance effect in the hem and flange parts of the auto body, where paint coating cannot be expected to guarantee rust prevention.

Figure 2 shows the results of an evaluation of the corrosion resistance of the various types of sheet steels with and without painting in cyclical corrosion test (CCT). Zn-Ni alloy coated sheets showed relatively high perforation corrosion resistance without painting, and GA sheets tended to exhibit excellent corrosion resistance when painted. It was found that GI sheets have excellent corrosion resistance after painting, even against perforation corrosion.

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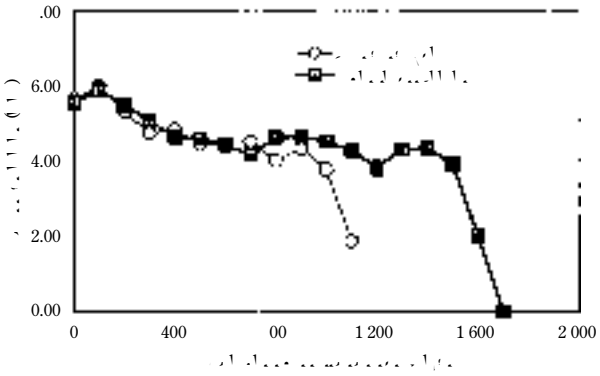

Fig. 7 Comparison between electrode life of GI before and after improvement

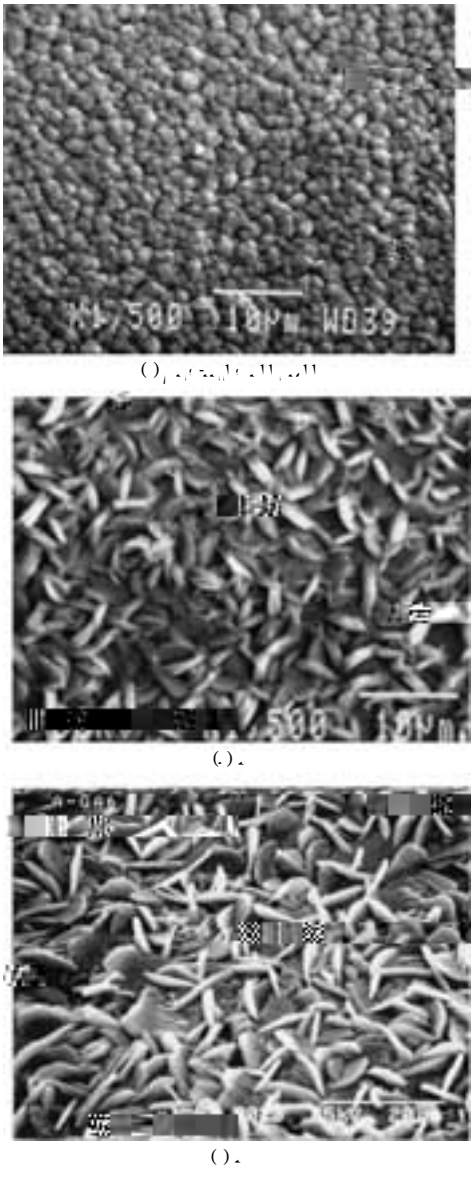

Photo 1 Scanning electron micrographs of phosphate coating formed on (a) CR (b) GI and (c) GA

cold rolled sheets, grains having a phosphophyllite crystals were seen, and there were no significant differences between the two types of sheet in either the size or shape of the crystals.

With GA steel sheets, it has been reported that a paint coating defect called "crater" tends to occur in electro deposition coating.[3,4] Therefore, Fe-P coating is performed as a top layer in order to prevent craters. In comparison with GA sheets, craters do not occur with GI sheets, which show satisfactory electro deposition coating performance.[2]

3 Production Technology for Hot-Dip Galvanized Steel Sheets (GI)

3.1 Improvement of Surface Quality (Appearance)

3.1.1 Wrinkle pattern

When steel sheets are coated in a Zn bath, the Zn coating weight is controlled by an air or nitrogen wiping gas jet above the Zn pot. In this process, however, the wiping gas jet causes the steel strip to vibrate, and the flow of molten Zn in the coating layer is irregular. As a result, a wave-shaped flow pattern called a "wrinkle" pattern frequently occurs, as illustrated in **Photo 2**. In particular, this wrinkle pattern must be prevented in materials which are to be applied to the outer panels of automobiles because it is detrimental to the surface properties of the paint film, and especially to smoothness, when the Zn-coated surface is the substrate surface for painting.

For this reason, a wrinkle pattern prevention technology was established at the continuous hot-dip galvanizing line (CGL) at Mizushima Works by the control of wiping conditions (wiping pressure, gap between nozzle and steel strip, height of nozzle above Zn bath surface). **Photo 3** shows the surface property of a GI sheet after establishment of this technology.

3.1.2 Countermeasures against spangle

When the zinc coating on a steel sheet solidifies, dendrite-type crystals form and grow around a core of solidified Zn. In some cases, this results in a flower-shaped pattern called "spangle" on the surface of the

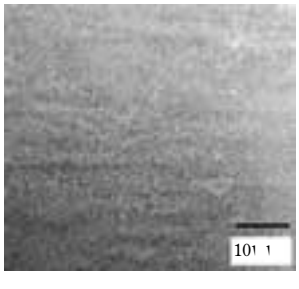

Photo 2 Wrinkle pattern of GI surface

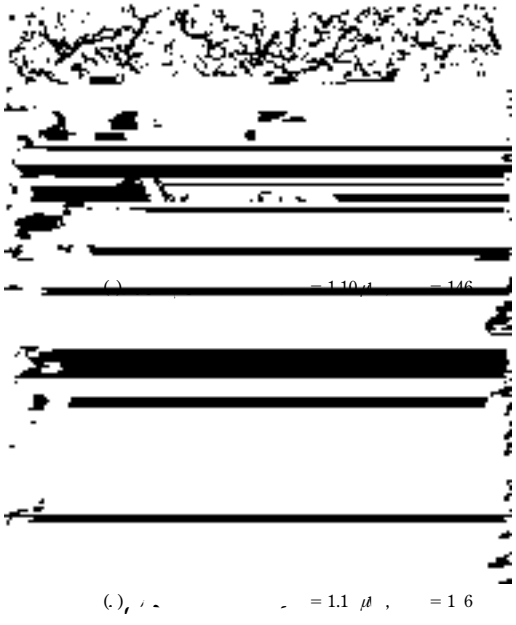

Fig. 10 Influence of skin-pass roll texturing on texture and roughness for GI sheet

texturing equipment, cold strip mill at Mizushima Works introduced an electro discharge texturing (EDT) device in December 1999, in addition to the existing shot blast and laser roll texturing devices.