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Black Chromate-free Coated Steel Sheet "ECO-BLACK™" with Excellent Press Formability†

1. Introduction

Pre-coated steel sheets are frequently used in the back covers of large-size flat-panel televisions. As these back covers have complex shapes, the material must provide not only a high design property, but also excellent press formability, making it possible to maintain a beautiful black appearance after press forming. In response to the rapid decrease in the price of flat-panel televisions in the market, there is also an increasing need for development of products with cost advantage for use in television back covers.

JFE Steel developed and has begun commercial production of a black electrogalvanized steel sheet "ECO-BLACK™" for use in back covers of thin-panel televisions as a new lineup in the JFE "Eco Frontier™" series of chromate-free electrogalvanized steel sheets.

2. Features of "ECO-BLACK™"

Figure 1 shows the cross-sectional structure of "ECO-BLACK™." In this coating structure, a black-colored special organic/inorganic composite coating is applied to the surface of a Zn-plated electrogalvanized steel sheet. "ECO-BLACK™" displays a beautiful black appearance, even though the thickness of thin coating film is only about 1/3 of that in the pre-coated steel sheet (JFE Excel Coat™) used conventionally in the back covers of thin-panel televisions. As an additional feature, damage of the black coating layer during press forming is extremely slight.

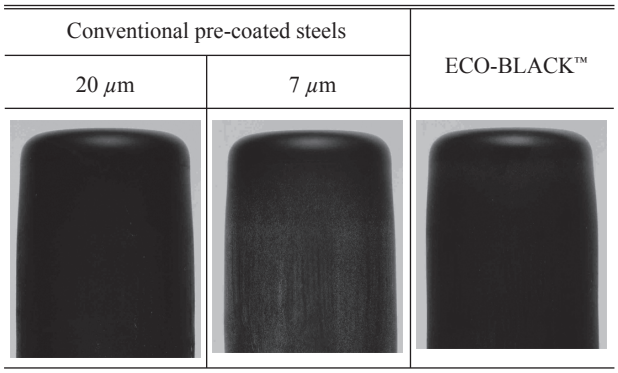

Photo 1 Appearances of ECO-BLACK™ and conventional coatings after deep draw forming

Photo 1 shows the appearance of a conventional pre-coated steel sheet and the same material when the coating thickness was simply reduced to 1/3 of the ordinary level after cylindrical deep draw forming. When the coating thickness of the pre-coated steel sheet was simply reduced to a thin film, an adequate black appearance could not be obtained after forming due to deterioration of the covering property for the underlying steel sheet. With the "ECO-BLACK™" coating, a beautiful black appearance was successfully obtained after forming while using a thin film because extremely fine black particles are used in the coating.

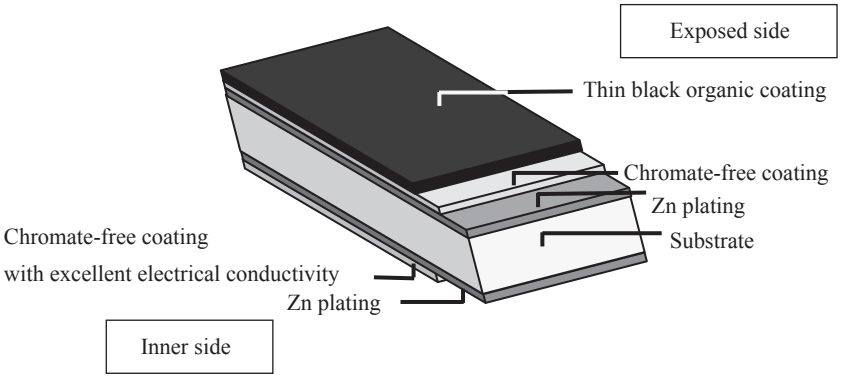

Fig. 1 The coating structure of ECO-BLACK™

†Originally published in *JFE GIHO* No. 30 (Aug. 2012), p. 57–58

Photo 2 Appearance of ECO-BLACK™ after press forming

	ECO-BLACK™	Pre-coated steel
Appearances after 3-cycle combined cyclic corrosion test (CCT)		
	No white rust	No white rust

Photo 3 Corrosion resistance of ECO-BLACK™

3. Quality Properties

3.1 High Formability

Photo 2 shows the appearance of "ECO-BLACK™" after press forming with a model die for use with a thin panel television back cover. If the thickness of an ordinary coating film is reduced, scratches easily occur due to contact with the die during forming. In contrast, because a newly-developed special resin which satisfies both elongation and strength at a high order is used in the "ECO-BLACK™" coating, the coating is capable of following the deformation of the steel sheet during press forming, and also displays satisfactory resistance to scratches due to contact with the die.

3.2 Corrosion Resistance

Photo 3 shows the appearance of specimens after a corrosion resistance test (3-cycle test; one cycle = spray with 5% solution of NaCl at liquid temperature of 308 K for 8 h → discontinuing for 16 h). No occurrence of white rust was observed with "ECO-BLACK™" and satisfactory corrosion resistance was displayed, on the same level as the conventional pre-coated steel sheet.

3.3 Alkali Resistance

Because a distinctive feature of "ECO-BLACK™" is the beautiful black appearance of the product, it must show no peeling or discoloration of the black coating film as a result of degreasing treatment in the case of the application of fast-drying oil during press forming followed by degreasing after the forming. Therefore, a test was performed using a 20 g/*l* concentration of FC4386 (manufactured by Nihon Parkerizing Co., Ltd.) as a general weak alkali degreasing solution. Spray treatment was performed for 2 min at a liquid temperature of 333 K, followed by rinsing and drying. The specimens were then inspected for changes in external appearance, and the luminosity difference ΔL before and after degreasing treatment was measured.

After the treatment described above, no peeling of the film was observed, the difference in luminosity ΔL before and after degreasing treatment showed a value of 0.5 or less, and no changes in appearance were found, confirming that "ECO-BLACK™" has excellent resistance to degreasing.

In addition to the above, "ECO-BLACK™" possesses a combination of excellent properties that include an anti-fingerprinting property, weathering resistance, and chemical resistance.

3.4 Back Surface Conductivity

In order to prevent leakage of electromagnetic waves, thin-panel televisions use conduction at points of contact with the cover, and to isolate electromagnetic waves generated by internal electronic equipment, a chemical conversion treatment agent with excellent conductivity is coated on the inner side of the black coating surface of the television. The surface resistance value (measured by the four-terminal method in accordance with JIS K 7194 (JIS: Japanese Industrial Standard)) of the back surface coating film of "ECO-BLACK™" shows a low value on the $10^{-4}\ \Omega$ level and thus displays excellent conductivity in comparison with the back surface coating film of pre-coated steel sheets. Based on this, "ECO-BLACK™" provides a stable electromagnetic wave shielding property.

4. Conclusion

The coating film design and quality properties of "ECO-BLACK™" were described. By using a proprietary high ductility and high strength resin, and high dispersibility coloring particles in "ECO-BLACK™," it was possible to satisfy both high design property and press formability while using a thin-film coating. Because "ECO-BLACK™" is capable of responding to increasingly high needs for back covers of flat-panel televisions, an expanded range of applications is expected in the future.