

Coated Sheet Products with Highly Functional Surface for Building and Can Applications

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Abstract:

This paper describes the coated steel sheets for building and can materials. In the field of building materials, Zn based coated steel sheets produced by hot dip galvanizing with high corrosion resistance have been commercialized for longer life of steel structures. In addition, environment-friendly chemical conversion treatments and color paintings were developed, and they provide the multi-function to the surface. For the container, functional coated products have been developed from the viewpoints of can performance, can manufacturing, and environmental compatibility. Material development utilizing the advantages of steel is important considering the competition with aluminum and plastic. In the future, not only the performance of coatings themselves but also the development of coated products that are more environmentally friendly and contribute to a sustainable society are required.

1. Introduction

Coated steel sheets are used in a wide range of industrial sectors, and play an important role in the quality of steel products and structures. Galvannealed steel sheet (GA) is mainly used for automotive parts in the domestic market. On the other hand, various types of hot-dip galvanized steel (GI, GF, GL, etc.) and electrogalvanized steel (EG) are used in the building and electrical appliance sectors. Since various performances in addition to rust prevention are required in these sectors, high functional quality is achieved by chemical conversion coatings or color pre-paint as well as metallic coatings. Coated steels for beverage cans, food cans and industrial cans include tinplate, tin free steel (TFS; electrolytic chromium coated steel), and laminated steel with a thin plastic film on the surface of TFS. This paper presents an overview of coated steel products

and technology development at JFE Steel, focusing on the building materials and container fields.

2. Coated Steel Sheet for Building Field

2.1 Technical Trends in Coated Steel Sheets for Building Applications

In the building materials field, many coated steel sheets are used in housing and factories, roofing materials for infrastructure facilities and housing equipment, exterior wall materials, structural components and exterior and interior materials, etc.^{1,2)} Recently, application to structures related to renewable energy, such as photovoltaic (PV) power equipment, etc., has also expanded. Hot-dip galvanized steel sheets have a long history of use in building applications, and have now become the second largest field after automobiles, as shown in **Fig. 1**³⁾. In recent years, there have been growing needs for higher corrosion resistance as a measure for extending the service life of housing and addressing the aging and maintenance of infrastructure. In addition,

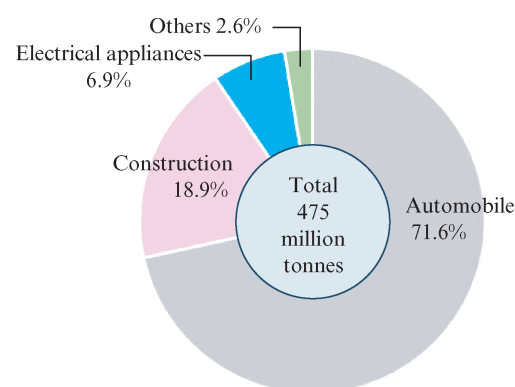


Fig. 1 Order booked of hot dip galvanized steel by application (Data 2023 from The Japan Iron and Steel Federation)

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tion to Japan's "Housing Performance Labeling System," which indicates the durability performance of housing in classes of three levels (the longest being 90 years), corresponding to the anti-rust specification of the steel materials used in the structural frame, the "Act for Promotion of Long-Life Quality Housing" was enacted in 2009, establishing a certification system for long-life quality housing based on a durability standard of 100 years or longer⁴⁾. Against the background of Japan's declining domestic population and transformation to a sustainable consumer society, there is a need to improve the durability of buildings and structures, and the corrosion resistance of coated steel sheets is expected to play a major role.

Higher corrosion resistance in coated steel sheets has been achieved by increasing the thickness of the coating and by applying Al or Zn-Al alloy coatings^{5,6)}. Representative coatings include hot-dip Al, Zn-5% Al and 55% Al-Zn coatings. Various types of hot-dip Zn-Al-Mg coatings have also been developed in recent years, and their applications are currently expanding. These steel sheets are generally processed for use as structural components in buildings. Therefore, formability of the coating and corrosion resistance of the processed parts and cut edges are required. In addition, triggered by the standardization of chromate-free steel sheets in the electrical appliance field for environmental conservation and RoHS Directive, the transition to chromate-free conversion coatings and color pre-paints are also being promoted in the building field. In the future, high requirements are expected to be placed on coated steel sheet products as sustainable materials that contribute to long life and reduced life cycle cost while continuing to reduce environmental impacts.

2.2 Coated Sheet Products and Technology Development for Building Applications

The coated sheet products for building applications supplied by the JFE Group include hot-dip Zn coated steel: GI (JIS G 3302), hot-dip 55% Al-Zn coated steel: GL (JIS G 3321) and GALFLEXTM, which improves the formability of GL, and ECOGALTM and ECOGAL-NeoTM (JIS G 3317), in which a small amount of Mg is added to hot-dip Zn-5%Al: GF⁷⁾.

Since hot-dip galvanized steels demonstrate excellent corrosion resistance under atmospheric environments, they have been used as building materials from an early date. Subsequently, application of Zn-Al based coated steel sheets with higher corrosion resistance progressed. In particular, GL characterized by its unique spangle pattern, has seen an increase in production for both unpainted and pre-painted applications, primarily for exterior use. However, since GL has a hard coating, it was difficult to apply in parts requiring severe form-

ing due to concerns about deterioration of external appearance and corrosion would occur at coating cracks in formed parts. To overcome this problem, JFE Steel developed GALFLEX, which has achieved excellent formability by a unique coating structure control technology. GALFLEX-COLOR which has both ductility and paint adhesion was also developed as a pre-painted product⁸⁾. While maintaining high corrosion resistance, these products reduce cracks in formed parts and suppress rust and paint delamination. This has enabled their application in complex-shaped components where the use of GL was previously challenging due to severe forming requirements. On the other hand, ECOGAL-Neo, in which small amounts of Mg and Ni are added to a Zn-5% Al coating, has a beautiful appearance and satisfies both excellent corrosion resistance and formability. Since the coating layer is softer than GL and similar products, it can be formed in the same manner as GI. Moreover, due to the effects of trace addition of Mg and Ni, it not only has high corrosion resistance of coating in flat surfaces, but also excellent red rust resistance in formed parts and cut edge surfaces, which can be an issue with GL.

In order to suppress the discoloration such as white rust and blackening caused by corrosion of the coating, a chromate-free coating is applied to the metallic coating surface. Prior to the introduction of a JIS standard for chromate-free coated steels, JFE Steel achieved completely chromate-free hot-dip Zn coated products in 2020. Inorganic or organic chromate-free coatings are selectively utilized depending on specific customer requirements. In addition, color pre-painted steel sheets with various functions were also commercialized by applying a primer or painting, providing performance not only in terms of an excellent design property, but also durability and environmental performance⁹⁾.

In the future, in addition to needs for improved durability in buildings and structures, there will be increasing momentum for preservation of the global environment and response to the growing severity of natural disasters accompanying climate change. Through its existing products and the development of coated sheet products in the future, JFE Steel will respond to the needs of customers for long life and cost reduction in the installation and maintenance of buildings and infrastructure facilities, and will contribute to the realization of a sustainable society, including measures to solve labor shortages due to the low birth rate in Japan and achieve resource recycling.

3. Container Field

3.1 Technical Trends in Coated Sheet Products for Containers

Coated steel sheet products are also used as cans in the container sector. Since the widespread adoption of food canning following the development of tinplate, base material steel sheets and coating technologies have been developed. Steel sheets for cans are now used in beverage cans, food cans, industrial cans, art cans, etc.¹⁰⁾. Although the current market scale in Japan is estimated to be 500,000 to 600,000 tons per year, that scale is now showing a shrinking tendency due to the adoption of aluminum and plastic containers as well as Japan's declining population.

However, against the backdrop of rising environmental awareness in recent years, moves to reevaluate the inherent properties of steel materials can be seen. One important advantage of steel cans is their high recyclability. Due to its magnetic properties, steel can be easily sorted and its impurities can be removed more easily than other materials, thereby enabling closed-loop recycling¹¹⁾. Closed-loop recycling means the steel can be recycled again as the same type of product by using the scrap of used products and that is an extremely important element for achieving a recycling society. From the viewpoint of the SDGs, etc., some moves to return to steel cans as an alternative material from the plastics can be seen with global attention focused on the problem of microplastics. Taking another advantage of high strength and formability, differentiation of steel from other competing materials is expected to expand the use of steel cans, for example, by developing cans with a high design property in cooperation with can manufacturers. In this manner, it is thought that materials will be selected considering their design property and contribution to a circular economy in addition to the basic performance and their cost.

Coated steels for containers have been developed and evolved, beginning with tinplate, and now include tin-free steel (TFS), in which layers of metallic chromium and a hydrated chromium oxide layer are formed by electrolytic chromic acid treatment without using tin, and laminated sheets, in which an additional plastic film is applied by thermocompression bonding¹²⁾. In particular, practical application of laminated steel sheets accelerated rapidly after it was pointed out that BPA (bisphenol A), which is the main raw material for the internal coatings of beverage and food cans, is an endocrine disrupter (so-called “environmental hormone”). Furthermore, in the European Union, the REACH regulation has decided to restrict the use of

hexavalent chromium (Cr(VI)) in production processes. Although products such as tinplate, TFS and laminated steel do not contain Cr(VI), treatment solutions containing Cr(VI) will be prohibited in the production process¹³⁾. Therefore, it is necessary to develop REACH-compliant coated sheets for containers. The safety of food containers is secured not only by sterilization and sealing, but particularly by the quality of the inner surface. Coated steel sheets must be designed to meet the strict standards for suppressing the elution of metal or coating components during long-term storage, thereby preventing any degradation of the contents.

3.2 Coated Sheet Products for Containers and Cans and Technology Development

JFE Steel began manufacturing tinplate (electrolytic tin plating) in the 1960s, and now has a lineup of coated sheet products for containers and cans, as shown in **Fig. 2**. Tinplate, which features a beautiful appearance with a metallic luster, has excellent corrosion resistance, weldability, printability and other properties, and is used in a wide range of containers including food cans, beverage cans, 18-liter cans and art cans. With the diffusion of can-making technologies using welding, JFE developed WELTTM, in which the tin plating is distributed in an island-like form on a substrate of cold-rolled steel with a Ni-diffused layer on its surface to improve high-speed weldability and corrosion resistance after painting. JFE has also commer-

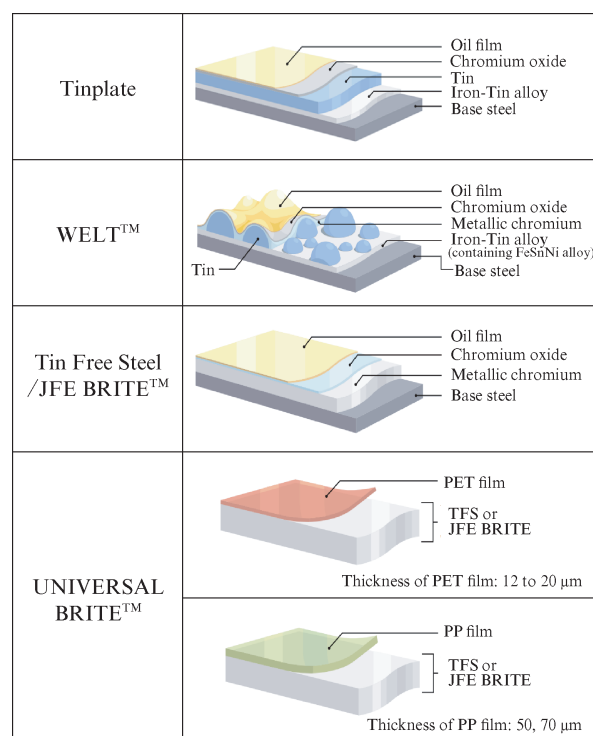


Fig. 2 JFE's products of coated steel sheet for containers

cialized JFE BRITE™, a TFS with excellent weldability. In comparison with conventional TFS, the formation of a thin and uniform hydrated chromium oxide layer enables electric resistance welding without the need for mechanical removal of the surface insulating layer. Furthermore, this process contributes to a clean can-making process by eliminating the generation of grinding dust¹⁴⁾. Following the application of plastic laminated steel sheets to beverage cans, JFE developed low-cost laminated steel sheets of UNIVERSAL BRITE™ Type F for food cans for the first time in the world by focusing on the properties of PET (polyethylene terephthalate) as a plastic which does not contain environmental hormones. Both excellent content release property and formability have been achieved by reducing the surface free energy of the PET film through the addition of specialized surface-modifying additives, and by suppressing crystallization of the PET through a combination of a special-structured homo-PET film and a proprietary laminating technology¹⁵⁾. On the other hand, UNIVERSAL BRITE Type E, the laminated steel sheet using a 2-layer polypropylene (PP) film was also developed for the application of large containers such as 18-liter cans and pail cans. Both flexibility and heat resistance were satisfied by the main layer of block PP, while high adhesion was secured by an adhesive sub-layer, in which modified polyethylene (PE) is added to modified PP. These containers can be filled with a wide range of contents, from acids to alkalis, also including surfactants, and make it possible to give the container a design property by exterior printing¹⁶⁾.

With the diversification of beverage containers and increase in retort pouches, production of steel cans has shown a decreasing tendency in Japan in recent years. Globally, however, the metal can market is expanding, and interest in metal cans is growing with increasing environmental awareness. Three types of JFE Steel coated sheet products for containers have received “SuMPO EPD” certification from the Sustainable Management Promotion Organization (SuMPO). In the future, we intend to improve transparency to enable an objective quantitative evaluation of the environmental impacts of products in the total life cycle. In research and development, while continuing to develop Cr(VI)-free coating technologies for tinplate and TFS applications that anticipate REACH regulations, we will also promote the development of high-performance laminated steel sheets that realize the full potential of the properties of steel cans, which feature excellent recyclability and strength, through a skillful

combination of the film composition, structure, thermocompression conditions, etc.

4. Conclusion

Japan’s domestic market for coated steel sheet products for building and container applications is mature, and continuing competition with imports and other materials is also anticipated in the future. In addition to durability and the other property requirements of each field of application, steel products produced through coating technologies must contribute to realizing a sustainable society. In technology development, it is necessary to develop competitive value-added products, not only based on the accumulated knowledge and technologies, but through progress in surrounding technologies, utilization of digital technologies and collaboration with other industries. JFE Steel is committed to promoting the development of world-leading technologies by using steel to create the future we ourselves, our customers and society desire.

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