Typical Products and Manufacturing Processes of Can Materials in JFE Steel†

KOJIMA Katsumi[*1]

Abstract:

JFE Steel has been manufacturing the can materials. Distinctive products and manufacturing processes have been developed to meet the needs of the times. This paper outlines typical products and manufacturing processes in JFE steel.

1. Introduction

Can materials are steel sheets which are used as materials for steel beverage cans and food cans. Surface treated steel sheets such as tin plate (electrolytic tin coated steel) and tin free steel (electrolytic chromium coated steel; TFS) are typical examples.

This paper introduces the features and manufacturing processes of typical can material products produced by JFE Steel.

2. Surface Treated Can Materials

JFE Steel's predecessor companies Kawasaki Steel and NKK each began producing electrolytic tin coated steel at the beginning of the 1960s and tin free steel at the beginning of the 1970s. Subsequently, both companies improved tin plate and TFS and developed new products based on those materials in response to changes in the requirements placed on surface treated can materials accompanying trends in steel cans, and continued to expand their product lines while adding resin film laminated steel sheets to their lineups. **Figure 1** is a schematic illustration of the layer structures of typical surface treated can materials of JFE Steel. The following presents an overview of these respective products.

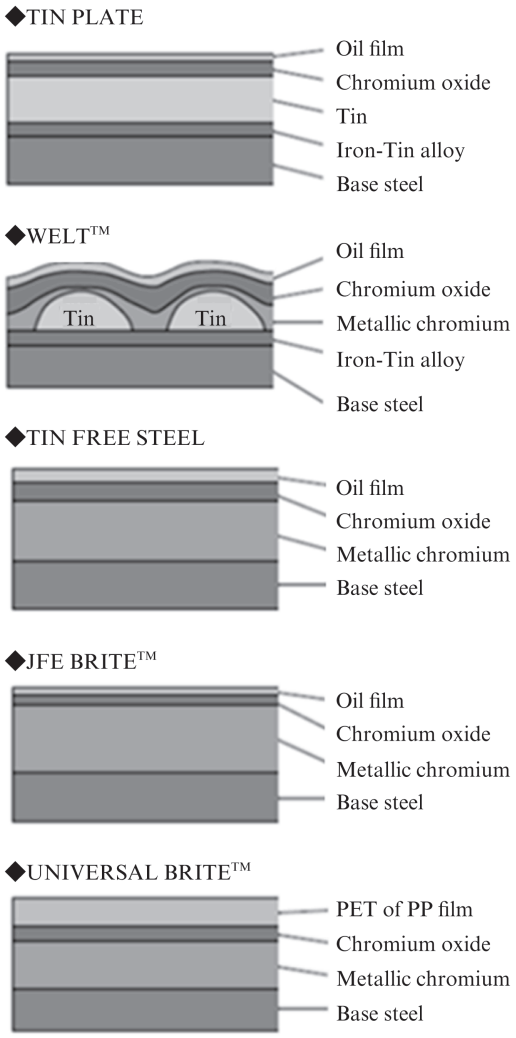

Fig. 1 Schematic layer images of typical can material products in JFE Steel

2.1 Tin Plate

Tin plate has a beautiful surface appearance with a metallic luster, as well as excellent properties such as corrosion resistance, weldability and printability. Its applications extend to all types metal containers, including food cans, beverage cans, 18-liter cans and

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[*1] General Manager,
Can & Laminated Materials Research Dept.,
Steel Res. Lab.,
JFE Steel

general line cans. Because tin plate has excellent solderability due to its tin-plated surface, it is also used widely in fields such as electrical parts, etc.

The typical plating baths for electrolytic tin coating, which is the surface treatment method used with tin plate, are the phenolsulfonic bath, halogen bath and methane sulfonic acid (MSA) bath[1]. JFE Steel produces tin plate by the phenolsulfonic bath process at West Japan Works (Fukuyama) and by the MSA bath process at East Japan Works (Chiba).

Following the start of operation, Chiba had used the halogen bath, which enables operation at a high current density and thus is a high productivity process. However, from the viewpoint of switching to more environment-friendly operation, Chiba studied the MSA bath process, which is a high efficiency process with low chemical oxygen demand (COD), developed additives[2], improved the cell structure, introduced an iron ion removal system, etc[3]. transitioned to operation using the MSA bath in 2005. Because operation with the MSA bath process is both environment-friendly and enables economical production of high quality products, JFE Steel is continuing to improve this technology, envisioning development to other production lines in the future.

2.2 WELT™

Practical application of cans using tin plate began with the method of joining the can body by soldering. From the 1980s, welding was widely adopted as a joining method for tin plate cans, as the can-making speed is fast and productivity is excellent. With conventional soldered joints, a tin coating weight of approximately 5.6 g/m^2 was considered necessary[4], but with welding, joining is possible even when the coating weight is reduced to about 1 g/m^2. For this reason, all companies promoted the development of lightly tin-coated steel sheets from the viewpoint of cost reduction by reducing tin use.

To compensate for the deterioration of corrosion resistance accompanying reduction of the tin coating weight, JFE Steel developed "WELT," which makes it possible to satisfy both weldability and corrosion resistance; in this product, a Ni diffusion layer is formed on the surface of a tin coated steel sheet substrate, and tin with an island-like distribution is coated on this top layer[5]. Formation of the Ni diffusion layer is an original technology of the Chiba No. 4 CAL (Continuous Annealing Line), which is equipped to apply a Ni coating layer at the entry section of the annealing line.

2.3 JFE BRITE™

Against the background of instability in tin supplies in the 1950s, development of a new surface treated can material which did not use tin was demanded, and practical application of tin free steel, which is a electrolytic chromium coated steel sheet, was realized at the beginning of the 1960s[6]. However, due to the high electrical resistance of the chromium hydroxide of the outermost layer, welding was normally impossible without removing the plating layer by grinding, etc. In JFE BRITE, electrical resistance is reduced by uniformly precipitating a thinner top layer of chromium hydroxide than in the conventional TFS. JFE BRITE is a revolutionary original JFE tin free steel product which enables welding without grinding to remove the plating layer.

2.4 UNIVERSAL BRITE™

Accompanying the practical application of beverage cans using resin film laminated steel sheets[7], JFE Steel introduced laminating equipment at the No. 2 TFL (Tin Free steel Line) at Fukuyama and began producing laminated steel sheets.

Focusing on the characteristics of PET (polyethylene terephthalate) films, which do not contain endocrine disrupters, JFE Steel also developed and commercialized UNIVERSAL BRITE Type F considering the potential for development of laminated steel sheets to food can applications[8]. As an advantage of UNIVERSAL BRITE Type F, this material satisfies both easy release of the can contents, which is required in food cans, and high formability, so that film damage and other problems do not occur during drawing. The surface energy of the film was reduced by adding a special surface modifying agent to the PET film, realizing an excellent content release property by avoiding adhesion between the can contents and the film[9]. Formability was also greatly improved by suppressing crystallization of the PET resin, which was achieved by using a combination of a new homo-PET film with a special structure and an original laminating technology.

JFE Steel also developed and commercialized UNIVERSAL BRITE Type E, which is a laminated steel sheet using a newly-developed 2-layer type polypropylene (PP) film, for application to large cans such as 18-liter cans, pail cans, etc., which are used with a diverse range of contents[10]. In this product, both ductility and heat resistance were satisfied by using block PP in the matrix layer, and higher adhesion was achieved in the adhesion layer by addition of the optimum amount of modified PE (polyethylene) to modified PP. As a result, application to various can contents is possible, including surface acting agents, and a design property can be given by printing the outer surface.

UNIVERSAL BRITE Type F and Type E are original JFE Steel products, and have both been recognized

with prestigious awards. UNIVERSAL BRITE Type F received the Surface Finishing Society of Japan Technical Award 2005, and UNIVERSAL BRITE Type E received the Japan Institute of Metals and Materials Technical Development Award 2005.

3. Tin Mill Black Plate

In addition to materials used in its own products, JFE Steel manufactures and supplies tin mill black plate (cold-rolled steel sheets as a substrate for tin plating) to overseas alliances. In order to meet a wide range of requests from customers in Japan and other countries, corresponding to their respective markets, JFE Steel has devoted great effort to the development of tin mill black plate products with special features and manufacturing processes for those products. The following introduces several examples.

3.1 Hard–Temper Can Materials Utilizing Solid Solution Hardening by N

For cost reduction of cans by using thinner-gauge steel sheets, hardening of the can material was required in order to compensate for the resulting reduction of can body strength. Although strengthening by heavy addition of alloying elements is used with automotive steel sheets and other products, application of this strengthening method to can materials was difficult from the viewpoint of deterioration of corrosion resistance. Therefore, as a method that avoids this problem, JFE Steel studied active use of solid solution hardening by N and developed a hard-temper material with addition of approximately 100 ppm of N[11]. In recent years, improvements in N addition technology have expanded the range of material property control, contributing to further gauge reduction in welded can bodies, and the range of applications has expanded to include material for the bottom end of aerosol cans.

3.2 Steel Sheets with Excellent Anti–Aging Property for Can Body Shaping

Although hardening of the steel sheet material is used to compensate for the decrease of can body strength accompanying gauge reduction, improvement of the stiffness of the can body by can body shaping is another method of compensation. Since deterioration of the design property by stretcher-strain in the shaped part is an issue in can body shaping, improvement of the anti-aging property of steel sheets was demanded in order to reduce yield point elongation. While application of batch annealing and other measures for improving the anti-aging property are known, these are not necessary desirable methods from the viewpoint of production efficiency. JFE Steel succeeded in developing a can material with an excellent anti-aging property for can shaping based on low carbon steel by optimizing the composition of additive elements and also optimizing manufacturing conditions, including hot rolling, annealing and other processes[12].

3.3 Nb and B–added Extra Low–carbon Steel for Large Size Welded Cans

Changing the annealing process from batch annealing to continuous annealing has many desirable points from the perspective of higher production efficiency, as various effects can be expected, such as inventory reduction by shortening lead times, improvement of the CAL operation rate, etc. On the other hand, in large size welded can applications such as pail cans, etc., the necessary properties such as the strength of the weld bead could not be obtained with continuous annealed materials. JFE Steel solved this problem by developing Nb and B-added extra low-carbon steel[13]. JFE also overcame process-related problems by investigating the root cause of slab cracks that occurred with the new composition system[14], enabling stable commercial production.

3.4 Cold Rolling Technology for Gauge Reduction

In high speed cold rolling of extra thin gauge steel sheets such as tin mill black plate, it is necessary to secure a high lubricating property. The high speed rolling technology for the cold tandem mill by the hybrid lubrication system developed by JFE Steel, as shown in **Fig. 2**, realized an excellent lubrication property in high speed rolling by actively controlling the behavior by which the oil drops in the high concentration emulsion supplied by the hybrid lubrication system form an oil film on the surface of the steel sheet, based on a circular feeding lubrication system using circulating feeding of a low concentration emulsion of an ester based synthetic lubricating oil. This technology received the Japan Society for the Technology of Plasticity JSTP Medal 2013 and the Iron and Steel Institute of Japan Best Year's Paper Award Tawara Award 2013[15].

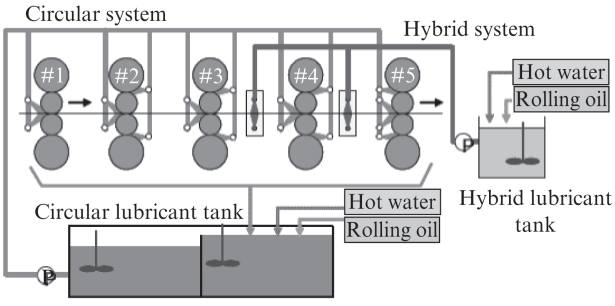

Fig. 2 Schematic image of the hybrid lubrication system[15]

3.5 Continuous Annealing Technology for High Efficiency Production

Chiba No. 4 CAL is a high efficiency production facility that makes it possible to feed extra thin steel strips with a minimum thickness of 0.15 mm at a maximum speed of 1 000 m/min in the furnace section. This plant also leads the world in having a multi-purpose rolling mill that enables DR (Double Reduce) rolling at the delivery section of the annealing line[16]. At Fukuyama No. 5 CAL, which was started up in 2010, a large increase in the average line speed of the furnace section and stabilization of product quality were achieved by introducing a plant optimal control system to control the line speed in the furnace section so as to optimize production efficiency corresponding to various conditions that differ in each coil[17].

4. Conclusion

Steel cans are the most familiar steel products in everyday life. In order to contribute even in a small way to realizing a better life through steel can materials, JFE Steel will strive to achieve further progress in its accumulated technologies for can materials to date, while also continuing active new technology development in the future.

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