

# Technical Outlook for Steel Sheet for Containers

Akihiro OTA\*

## Abstract

*I describe the current market status of domestic beverage and overseas food cans, and the technical policy of Nippon Steel Corporation.*

## 1. Introduction (Overview of Domestic and Overseas Markets)

Canned foods were developed for long-term storage and portability in the 19th century and have since then grown in various ways according to the food culture of each country. Globally, canned foods such as fish, meat, vegetables and soup are still consumed as daily ingredients. Tinplate is produced and consumed as can materials at the rate of about 16 million tons per year worldwide. The growing global population is expected to increase tinplate production at an annual rate of about 2%. As tinplate mill expansions started in about 2010, mainly in China, the world's tinplate production capacity now surpasses 27 million tons. In reality, high-quality tinplate that can be used for food cans forms part of this volume. In developed countries that have manufactured high-quality tinplate up to now, the elimination and consolidation of aging tinplate mills are progressing, but chronic overcapacity remains an issue.

Before the war in Japan, canned fish and meat were produced in large quantities as major export items. After the high-growth period, a can market peculiar to Japan was formed centering on strongly preferred beverages, such as coffee, soft drinks and alcoholic drinks. This is partly because Japanese people prefer fresh ingredients. Nippon Steel Corporation has conducted a lot of research and development in collaboration with can manufacturers, with the domestic beverage can market as the main target. As a result of being tried and tested in the domestic beverage can market with extremely strict quality requirements, we undoubtedly have the world's top capabilities to develop and manufacture container steel sheets. Due to intensifying competition with other materials and with a dwindling canned coffee market where steel is a predominant can material, the domestic tinplate demand shrunk from well over 1 million tons by the 2000s to about 600,000 tons recently. **Figure 1** shows changes in the can production in Japan.

The global food and beverage can markets continue to expand. Steel sheets are expected to play new social roles as materials to counter food losses and as materials with low CO<sub>2</sub> emissions. In the following section, the direction in which we should proceed while making use of the achievements of our predecessors is considered

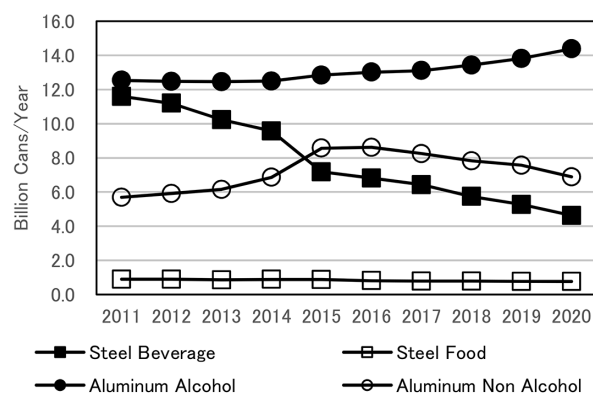


Fig. 1 Domestic can production

from technology viewpoints while recalling past circumstances.

## 2. Domestic Beverage Container Markets

### 2.1 Current status and issues

#### 2.1.1 Alcoholic beverages

Aluminum drawn and ironed (DI) cans were developed in the United States in the 1960s. They then rapidly spread to the beverage can markets that had been monopolized by steel. Emerging metal cans with enormously rational shapes as beverage cans with ultra-thin DI bodies and scored easy open ends (EOEs) became standard beverage cans thereafter. In the 1970s, Daiwa Can Company succeeded in developing and commercializing the world's first DI steel cans. There was a time when DI steel cans were predominantly beverage cans, especially in Europe. At present, however, most of the DI cans manufactured in Japan and the world are made of aluminum. Especially for low-alcohol beverages such as beer, DI aluminum cans have predominant shares of the containers, including glass and PET bottles.

The automatic vending machine markets, chiefly for coffee and soft drinks, struggled as people were restrained from going out amid the COVID-19 pandemic. The domestic beverage can markets,

\* General Manager, Head of Dept., Tin Mill Products Technology Dept., Tin Mill Products & Electrical Steel Sheet Div., Flat Products Unit 2-6-1 Marunouchi, Chiyoda-ku, Tokyo 100-8071

however, has weathered the pandemic with stay-at-home drinking demand for beer beverages and low-alcohol beverages such as ready-to-drink (RTD) shochu and soda beverages. DI aluminum cans have some advantage over DI steel cans in terms of flavor, but there is no decisive superiority or inferiority in terms of functionality. The cost of materials periodically depends on the market conditions. The ease of tracking the aluminum prices on the London Metal Exchange (LME) and the procurability of aluminum are theorized to favor aluminum. Some schools and regional kids' clubs earned money by collecting and selling empty aluminum cans. This trend hampered the use of DI steel cans. As a result, DI aluminum cans came to dominate the low-alcohol beverage container markets. In the past, many lines produced both DI steel and aluminum cans. In recent years, however, the full production of DI aluminum cans has continued and has left no opportunity for DI steel cans to enter the market.

### 2.1.2 Soft drinks

DI steel or aluminum cans were often used as soft drink containers. The use of small PET bottles was voluntarily restricted to control plastic waste until the latter half of the 1990s. Upon the then removal of this voluntary restriction, small PET bottles instantaneously gained an overwhelming share of the soft drink beverage market, not only because they are easily portable, but also because they do not require huge capital investment nor advanced expertise to make them. To compete with PET bottles, we developed and commercialized resealable bottle cans, including resealable steel cans. But the momentum of PET bottles has not abated and PET bottles have continued to expand into the fields of soda beverages and coffee where metal cans are traditionally strong. In recent years, however, plastic waste has become a social problem not only in Japan, but also internationally as initially feared. New movements are starting to appear in this respect. An example is that a major mass merchandizer chain has switched their private brand beverage containers from PET bottles to bottle cans.

### 2.1.3 Coffee-based beverages

Since 2015, DI aluminum cans and then PET bottles have started to expand into the canned coffee field that was the last stronghold of steel cans. Conventionally, tapping inspection (the method whereby pulse waves are applied to the bottom of a can and the resulting echoes are examined to detect the change in the internal pressure and to check the content of the can for spoilage) was feasible only for steel cans that can be internally held under negative pressure and that are flat bottomed. It was difficult to use materials other than steel for coffee containing corrosive milk. The change in the way the beverage industries think about quality assurance has removed the barrier to the entry of aluminum cans and PET bottles. Consequently, steel cans have lost their share for coffee-based beverages like for alcoholic and soft drink beverages. With the changing coffee consumption structure as represented by coffee sold at coffee chain stores and convenience stores, the canned coffee market itself is shrinking.

In the domestic beverage container markets, the structure whereby different materials (steel, aluminum and PET) were used for different contents has collapsed not only due to technical and economic factors, but also due to social factors. Steel has continued to compete fiercely with other materials. Unfortunately, unfavorable situations continue for steel cans. Hitherto different social factors, such as the reduction of CO<sub>2</sub> emissions, reduction of plastic waste and as-

surance of food safety, have triggered new competition among materials. We must develop market and technology strategies to take advantage of the strengths of steel cans.

### 2.2 Technological outlooks for steel sheets for domestic beverage cans

We think that domestic beverage cans have high-performance fields where cans are provided with resealability and designability, and general-purpose fields where cans are specialized in container functions such as DI cans. High-performance fields include irregular-shaped cans that are expanded and work hardened to have both rigidity and designability, and resealable bottle cans.

Irregular-shaped cans have high body strength and can make use of the unique properties of steel, such as embossability. They have been used to disseminate the brand image of beverage manufacturers. Several bottle cans made of steel were put on the market before, but now there are no conspicuous bottle cans other than the resealable wide-mouthed cans made by Daiwa Can. Resealable wide-mouthed cans are characteristic in that they can be produced on conventional three-piece beverage can filling lines. This characteristic applies only to steel and allows steel to maintain a certain market share among the fierce competition. CANWEL™ (Ni-coated steel sheet) with excellent weldability and film adhesion is adopted as the body material. Resealable wide-mouthed cans were born from the fusion of excellent material properties and can-making technology. Bottle-type beverage containers are a stronghold of PET, but we must continue to develop highly functional cans with performance that can only be achieved with steel in collaboration with can manufacturers.

In the general-purpose fields, we will pursue integrated can cost reduction for both two-piece and three-piece cans without being affected by the raw material market fluctuations. Thickness reduction and weight reduction are principal measures. The theoretical unit price per can strength is highest for steel in comparison with other materials. We will develop can-making technology and concomitant materials in cooperation with can manufacturers. We must also promote the development of a thin-gauge steel sheet manufacturing process for manufacturing thin materials without reducing productivity.

## 3. Overseas Food Can Markets

### 3.1 Current status and issues

Recently, canned mackerel and canned tomatoes have come to be recognized not as preserved foods but as general foods, even in Japan. In many foreign countries, canned foods have traditionally been used as daily ingredients. Many tinplate products are consumed for canned foods rooted in the food culture unique to each country. Steel is still used as the main material for such reasons as content resistance and can strength. In Japan, many easy open ends (EOEs) are made of aluminum. Overseas, steel ends are commonly used for steel can bodies because of concern about corrosion current between dissimilar metals. Steel is advantageous in competition with other materials in the overseas canned food markets. Consumers are strongly cost conscious about the canned foods they consume daily. There is not much room for the consumers to allow additional costs for functionality, design and appearance. Nippon Steel has differentiated itself from emerging mills by thinning the can material that has a direct impact on the cost of cans. Especially for three-piece can body materials that have a possible flange cracking problem and EOEs that require riveting, high-elongation double-rolled

(DR) tinplate with the strength-ductility balance improved by finely tuning the mechanical properties per specification has been introduced into the overseas food can markets. The adoption rate of DR tinplate has increased dramatically in the last 10 years.

At the beginning of the 2010s, European mills and can manufacturers jointly developed three-piece cans using 0.10 mm steel sheets and actively promoted them. We have not yet heard anything about their mass production, however. The thickness of the thinnest steel sheets for containers mass-produced in the world, including those made by Nippon Steel, is about 0.13 mm. A further thickness reduction has hurdles that must be overcome, such as flange formability and end seamability.

Procurability is an important factor for overseas can manufacturers that procure materials from all over the world. They do not like to purchase from a single source and tend to avoid the adoption of special materials. Nippon Steel's CANWEL™ (Ni-coated steel sheet) and CANLITE™ (Fe-Ni-Sn alloy coated steel sheet) are principal materials used for beverage cans in Japan. These high-performance tin-coated steel sheets are adopted by few overseas manufacturers because their advantages cannot be enjoyed except by can manufacturers with advanced can-making technology. The overseas food can markets attach importance to the productivity and yield of can manufacturers, that is, shape, material quality, coating characteristics and appearance quality. They were markets where it was difficult for us to introduce high added value tinplate products. In recent years, however, the overseas food can markets have come to demand low CO<sub>2</sub> emissions and food safety as new social issues as in Japan. Using as weapons the technologies we have cultivated in the domestic markets, we must present Nippon Steel's answers to the new global demands.

## 3.2 Technological outlooks of steel sheets for overseas food cans

### 3.2.1 Film lamination

In the domestic beverage can markets, studies on film lamination began around the 1980s. In the early 1990s, Toyo Seikan Co., Ltd. and Daiwa Can respectively commercialized stretched and drawn two-piece cans and gravure-printed film-laminated three-piece cans. At present, most of the domestic steel beverage cans are film laminated, regardless of whether they are two-piece or three-piece cans. This is an event peculiar to the Japanese beverage can market. The study of the film laminations was promoted by the improvement of productivity by elimination of lacquering and the functional enhancement of plastic films such as flavor. The film lamination then rapidly spread to meet new social requirements such as environmental protection and food hygiene. Particularly, the problem of endocrine disruptors (so-called environmental hormones) began to be pointed out in the latter half of the 1990s, mainly in Europe and the United States. In 1998, the Ministry of the Environment listed "chemicals suspected of having endocrine disrupting effects". Concerns began to be directed to the inside lacquering of beverage cans as well as to polystyrene containers for instant cup noodles. Bisphenol A (BPA) is used as the main raw material for the inside lacquering (epoxy resin lacquer) and has an endocrine disrupting effect. We have promoted film-laminated cans while reducing the BPA content.

In the overseas beverage can markets, major European tinplate mills started the development of film-laminated steel sheets at about the same time. In the 1990s when endocrine disruptors began to attract attention as mentioned above, the application of film-laminated steel sheets to food cans started at some can manufacturers. In the 2010s, Europe and the United States started the legal regulations of

the use of BPA in food containers one after another. The application of film-laminated steel sheets to food cans as done by Nippon Steel in Japan accelerated mainly in the North American markets. The development of lacquers that do not use BPA is also advancing. The BPA-free feature alone does not work as a trump card for the film lamination. Some of the BPA-free lacquers still have problems such as content resistance and lacquering cost increase. Particularly, can manufacturers that have aging lacquering equipment and capacity problems are increasingly choosing film-laminated steel sheets. There is a possibility that new regulations will be imposed on the elution of BPA and other chemical substances. The demand for steel sheets laminated with high polymer films is expected to continue in the long term.

The film lamination of steel sheets for cans is accompanied by a structural change in the supply chain. As overseas food can manufacturers do not own their own film laminating lines, this means that the resin lacquering of the steel sheet surface performed by can manufacturers must be entrusted to steel sheet manufacturers. Manufacturers of film-laminated steel sheets for food cans, including Nippon Steel, have started to compete with major lacquer manufacturers in Europe and the United States as well. We must improve our capabilities to develop food container laminating films and to evaluate the food safety of such films.

### 3.2.2 Chromate-free tinplate

For steel sheets other than tinplate, efforts were made from early on to free them of hexavalent chromium. Tinplate steel sheets have been chemical conversion coated using hexavalent chromium (dichromic acid or chromic acid anhydride) throughout the world. Hexavalent chromium does not remain in the chromate coating of the product. There was little need to make the chromate coating free of hexavalent chromium. Nippon Steel manufactures phosphate-coated tinplate products for limited applications. This was not intended to make the product chromate-free. In the meantime, Europe decided to prohibit the use of hexavalent chromium in the tinplate manufacturing process under the REACH regulation (scheduled to come into effect in April 2024). To comply with such strict environmental regulations and meet the request from the customers for the supply of chromate-free tinplate, Nippon Steel developed and commercialized chromate-free tinplate EZP™. In the EZP™ manufacturing process, zirconium treatment is used instead of the current chromate treatment to form a zirconium oxide coating equivalent in performance to the conventional tinplate chromate coating. For commercialization, we have EZP™ officially approved by the FDA and other organizations as a "food contact substance" for a food container material. EZP™ is now pending approval by the South American Common Market (MERCOSUR).

The components in the tinplate steel used for food containers and the impurity components in the coating layer have been specified by standards and the like. The metals that can be used as coatings and the elution of the food contact substances into cans are also regulated by the laws and regulations of each country. Interest in food safety is growing worldwide. When we develop new surface treatments and coatings, we are required to exercise subtlety and care.

## 4. Initiatives Toward Recycling Society

The environmental impact of products is beginning to be regarded as one of the indicators of competitiveness along with quality, cost and procurability. Food containers are familiar to everyone. We

handle them at least once a day and discard them after use. To appeal to consumers how much of the discarded container materials are used as resources, container material manufacturers are working to improve the recycling rate of their materials. However, the definition and meaning of the recycling rate vary with container materials. We must build a mechanism whereby consumers can correctly understand the recycling rate. The tinplate products sold by Nippon Steel have received the EcoLeaf environmental label certification from the general incorporated association “Sustainable Management Promotion Organization (SuMPO)” in compliance with the international standard ISO 14025. EcoLeaf is one of the Environmental Product Declaration (EPD) certification systems that quantitatively disclose environmental information in consideration of the entire life cycle of products from resource extraction through manufacture to discard or recycle using the life cycle analysis (LCA) method. Using the LCA method, can and food manufacturers can objectively evaluate the environmental impact of the products they use. According to ISO 20915:2018, we can now present quantitative values of environmental impact reductions such as CO<sub>2</sub> emission reductions in the “manufacture” stage and the “recycle after use” stage in the life cycle of steel materials (steel products). Standards that calculate

environmental contributions, including the benefits of recycling after use, are not available for other materials.

Steel cans can be easily sorted out magnetically. For many years, almost all of the steel cans have been collected and reused as scrap. During steel regeneration, most impurities can be removed by oxidizing refinement. Steel cans can be recycled into many things many times, forming a closed loop. According to the Japan Steel Can Recycling Association, the steel can recycling rate in fiscal 2020 was 94.0% and remained stable at a high level. Conversely, we can say that there is little room for improvement regarding steel can recycling. As another principal environmental impact reduction measure, we are tackling the weight reduction of can materials. In the past, our main purpose was to reduce the cost of materials and can manufacture. In the future, our endeavors must take into consideration the reduction of environmental impact as an index. The Can Manufacturers Institute of Japan established the Committee for the Weight-Reduction of Steel Cans where the weight reduction of steel cans is now studied. Most recently, steel cans recorded higher reduction rate than aluminum cans. In other words, it means that there is still room for the weight reduction of steel cans. We will continue to reduce the weight of steel cans to meet the new needs of society.



Akihiro OTA  
General Manager, Head of Dept.  
Tin Mill Products Technology Dept.  
Tin Mill Products & Electrical Steel Sheet Div.  
Flat Products Unit  
2-6-1 Marunouchi, Chiyoda-ku, Tokyo 100-8071