Abstract:

JFE Steel has been providing various types of latest steel sheets for cans. UNIVERSAL BRITE is one of the resin-film laminated steel sheets for food cans, 18 ℓ cans and pail cans and is applicable to conventional uses, in the place of lacquered material sheets, where cans are formed by drawing and seam-welding using lacquered tin free steels (TFS). Because resin film applied does not contain any harmful substances such as organic solvents, its safety for foods has been completely assured. Recently, requirements for diverse can shape designs have been increasing. It is very hard to manufacture so-called fancy cans, like candy- or chocolate-cans, of numerous designs secured through vigorous forming processes and to which, ultra low carbon steel sheets having high formability are applied.

1. Introduction

The principle of manufacturing canned foods was invented by a Frenchman named Nicolas Appert (1750–1841), and tinned beef produced by this method was among the stores of food taken in Admiral Perry's polar expedition in 1824. When one of the same cans was opened 114 years later, the content was still in satisfactory condition,[1] demonstrating that tin cans have excellent long-term food preservation properties. Thereafter, tin cans continued to earn an enviable reputation as safe and reliable food containers.

In more recent years, advanced tinplate manufacturing processes such as continuous cold rolling and electrolytic tinplating, and ultra-thin tinplated steel sheets with excellent seam weldability were developed. With the appearance of tin free steel (TFS) as a tinplate substitute with excellent paint adhesion, TFS gained wide acceptance and is used today in both cemented cans and welded cans in the beverage can and 18 *l* can fields. Accompanying the development of stretched-and-drawn cans (TULC), TFS laminated with thermoplastic resin which is suited to this process was developed and put into mass production.[2]

The development of these steel sheets for can-making, beginning with tinplate, was a result of the pursuit of economy in aspects, including high speed can-making, high speed – eached 0.18 mm, achievin

capacity: 350 g, positive pressure can). On the other hand, with rising social awareness of w

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not affect the flavor of the can content. Thus, these new sheets can be used with a diverse range of contents, corresponding to the needs of the can-making user.

The structure of the PP laminated steel sheet for general applications is shown in **Fig. 6**. As with Type F, the substrate steel is TFS produced by electrolytic precipitation of metallic Cr and Cr hydroxides on cold-rolled steel. However, with Type E, a newly devised 2-layer PP film is laminated on the TFS material by heat sealing.

From the viewpoint of heat resistance, high melting point (160°C) PP is used on the surface layer side of the 2-layer film to prevent film melting due to the heat of the baking process when content markings, etc. are printed on the outside of the can.

By nature, PP resin has a poor adhesive property. Therefore, an adhesion layer is necessary to bond the PP film and TFS substrate. In this adhesion layer, a proper amount of modified PE (polyethylene) is mixed with PP to impart an adhesive property by carboxylic acid modification. Addition of PE increases interfacial adhesion with the TFS sheet because the wettability during heat sealing is improved. Conversely, however, excessive addition increases the difference in the compositions of the PP + PE adhesion layer and the surface PP layer, reducing the bonding force between the 2 resin layers.

Figure 7 shows the influence of the PE ratio in the adhesion layer on (a) cross-cut corrosion resistance and (b) film adhesion (peeling) strength. Cross-cut corrosion resistance was evaluated by immersing a laminated steel sheet on which cross-cutting had been performed in an alkaline solution with a high delamination property for 2 weeks at high temperature, and then measuring the film delamination width. Film adhesion strength was evaluated by pasting together test pieces cut to a 5 mm width with the PP film side as the inner side, then peeling the film by the T peel method and measuring the peeling strength.

As the PE ratio in the adhesion layer increases, the bonding force at the film-TFS interface also increases, preventing penetration by the alkaline solution from the cross-cut edges and thereby reducing interfacial peeling. On the other hand, higher PE ratios also increase the composition difference between the 2 resin layers, reducing the interlayer bonding force and film peeling strength. In particular, insufficient peeling strength has various negative effects, for example, causing susceptibility to peeling at the can lid seam and reducing pressure resisting strength to an inadequate level.

As can be understood from Fig. 7, the PE ratio has a proper region where cross-cut corrosion resistance and film adhesion strength requirements are both satisfied. JFE Steel sets the adhesion] and anR T k cut b

30°C, Humidity : 70–80%, 3d)

the amount of exposed steel is evaluated by precipitating out Fe by substitution with Cu. Smaller precipitation values indicate that the steel is more perfectly covered. The Cr film with JFE BRITE has a value similar to that of conventional TFS, showing that the new product has an excellent covering property. **Photo 5** shows the results of an uncoated corrosion test after Erichsen cup drawing, and indicate that the JFE BRITE film has high uncoated corrosion resistance, equal or superior to that of conventional TFS.

JFE BRITE is not only widely used in manufacturing 18 *l* cans and pail cans as a type of TFS which enables grinding-free welding, but as mentioned in Sec. 3.1, is now also frequently used as an environment-friendly laminated steel sheet (clean material + omission of lacquer coating process) in these markets.

3.2.2 Grinding-free TFS “JFE CLEAN”

The film composition of JFE CLEAN is shown in **Fig. 10**. The film composition of the surface is based on JFE WELT, which has high weldability. Although the material is plated with tin to secure weldability and the sliding property, the tin coating weight is minimized to approximate the appearance and corrosion resistance of TFS as closely as possible, while the Cr coating weight (metallic Cr, Cr hydroxides) is increased to secure lacquer adhesion and resistance to the can contents (resistance to alkaline solutions).

(1) Weldability

An evaluation of film weldability without grinding using a welder for 18 *l* cans confirmed that an adequate available current range (ACR) can be secured (**Fig. 11**).

(2) Sliding Property

Measurements of the dynamic friction coefficient of the steel sheet surface (**Fig. 12**) showed that JFE CLEAN has a satisfactory sliding property, approximately equal to that of tinplate with 2.8 g/m^2 coating weight.

(3) Resistance to Corrosion by Can Contents

Discoloration occurs in some cases when a strong alkaline solution is applied without lacquer. = א tr

4. General Cans (Fancy Cans)

As illustrated in **Photo 6**, fancy cans are products which have the functions of toys or decorative objects as well as the basic function of containers, and are produced in diverse shapes and external finishes. These cans have

Ultra-low carbon continuous annealed steel sheets are used in T1 and T2 temper grade materials, giving *r*-values and elongation higher than those of conventional low carbon batch annealed sheets, and are therefore better suited to difficult forming.

It is possible that new cans with even harder-to-form shapes will appear in the future, but because there are limits to improvement in formability by material properties alone, new approaches from angles will be necessary. In addition to material properties, reduction of frictional resistance is also effective in preventing rupture during drawing. As shown in **Fig. 13**, reducing the friction coefficient by 0.05 has an effect equivalent to reducing the *r*-value by 0.5. Thus, processing which requires higher *r*-values can be performed successfully if frictional resistance is reduced by modifying the roughness or wax specification. For new types of fancy cans, as with other products, JFE Steel applies advanced research technologies to determine the required material properties, for example, using analytical software which enables simulation of the forming process.

In the future, appropriate material design will be performed by developing and applying these technologies to new hard-to-form cans in order to supply materials with minimal breakage or other forming trouble during press-forming. JFE Steel also intends to apply materials which are not included in the conventional category of “steel sheets for can-making” and carry out joint research with press product manufacturers.

5. Conclusions

This report has described representative steel sheets for can-making commercialized by JFE Steel in recent years. In addition to further improvement in the safety and reliability achieved in steel cans to date, innovation in container materials to meet social needs is also necessary. As a conclusion to this paper, this section discusses future development trends in steel sheets for can-making.

Where steel materials are concerned, potential thickness reductions must be realized. Because aluminum and plastic have smaller specific gravities than steel, future containers made from these competitive materials will be lighter in weight than steel. The high strength of steel is essential in supporting high speed can-making and filling, but it is also necessary to develop steel sheets with higher strength to maximize these benefits and achieve further reductions in thickness. Although larg] these pointed out as desirable container functions, but elements which affect the sensory feel of the product, such as warmth when held and a sense of familiarity, also appear to be important. Thus, as an essential element for the future development of steel cans, it must be possible to provide the functions demanded by users in steel containers, while continuing to maintain the outstanding properties of steel cans.

References

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