

Highly Functional Pre-coated Aluminum Sheets, the "KS700" Series

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The KS700 series of newly developed pre-coated aluminum sheets realizes surface functionalization and shortens the manufacturing process. The KS700 series enables the omission of some steps in the manufacturing process, such as degreasing, anodizing and plating, thus saving costs. Products using the KS700 series show good surface qualities and resist fingerprints, scratching and corrosion, among other things. This paper explains the features of the highly functional pre-coated aluminum sheets and introduces several examples of applications.

Introduction

It was in the 1970s that Kobe Steel started the surface treatment of aluminum sheets. The business at that time was limited to the color painting of construction materials and the painting of the coils for beverage cans¹. In the 1980s, a hydrophilic treatment was put into use for air-conditioner fins; and in the 1990s, the development of lubricant pre-coated sheets, the forerunners of the "KS700" series, began². Since the 2000s, the company has strengthened the product line-up of the KS700 series by adding various surface functions, not obtainable by untreated aluminum sheets, while maintaining superior lubricity³.

This paper describes the features, concrete examples of use, and future trends of the highly functional pre-coated aluminum sheets of the KS700 series, whose applications are expanding, particularly in the field of electronics.

1. The advantage of using pre-coated aluminum sheets

Pre-coated aluminum sheets (hereinafter simply referred to as "pre-coated sheet(s)") are aluminum sheets that are coated before factory shipment. The primary purpose of pre-coating aluminum sheets is to provide various functionalities to the surfaces of the aluminum sheets and thus to add high value to the aluminum parts produced by press forming the sheets. The secondary purpose is to decrease the total cost by omitting steps in the process of producing the parts. This section explains the concept of the functional upgrading of aluminum sheets and the steps in the manufacturing process that can be omitted by using the pre-coated sheets.

1.1 The functional upgrading by pre-coating

1) The improvement of formability

Lubrication oil must be applied to the aluminum sheets to be press formed. Providing, in advance, high lubricity to an aluminum sheet surface homogenizes the flow of the aluminum sheet in the mold and prevents cracking and necking. This enables the forming of shapes that had been difficult to form using a conventional aluminum sheet.

2) The improvement of product appearance

Aluminum sheets must be handled with care because, unlike steel sheets, they have surfaces that are soft, can easily be scratched and are susceptible to fingerprints. The pre-coating protects the aluminum sheet surfaces and decreases the number of scratches caused by sliding against press forming molds⁴. Pre-coating also makes fingerprints much less noticeable during the manual handling of the press-formed parts, improving the product yield.

3) The improvement of corrosion resistance

When an aluminum sheet is left with salt and/or fingerprints on its surface for a long period of time, white rust forms at the places where the salt and/or fingerprints have adhered. In a normal environment, the white rust does not erode the internal portion of the aluminum sheet; however, it deteriorates the esthetic appearance. White rust can be prevented by applying an anticorrosion pre-coating.

Because the pre-coated sheets are presumed to be press formed, the corrosion resistance of, not only the flat sheet, but also the formed parts, is being considered⁵.

4) The selection of electric non-conductance/ conductance

Aluminum is an electrically conductive material; however, when an application calls for electric insulation, a non-conductive film can be pre-coated on the aluminum surface. Conversely, the pre-coated film can be provided with an electrical conductivity suitable for securing the grounding required for electronics products.

1.2 The omission of process steps, thanks to pre-coated sheets, and environmental considerations

1) The omission of the cleaning step

Fig. 1 shows an example of the processes for

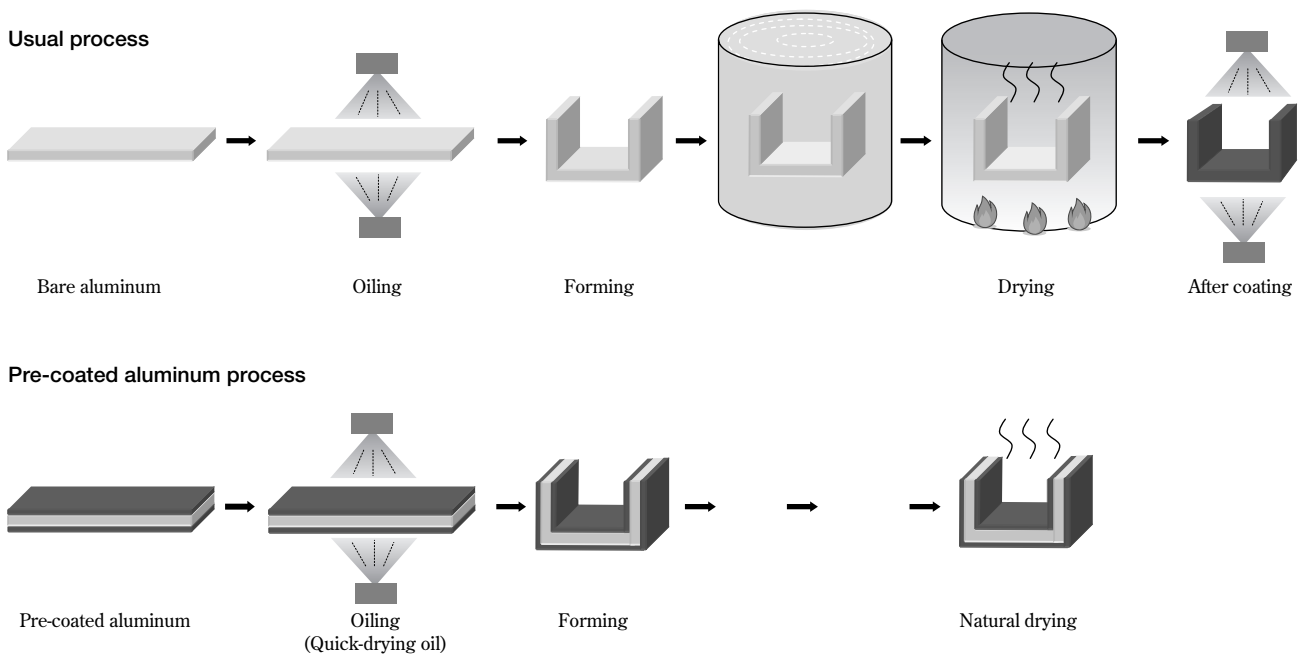


Fig. 1 Production process omission

producing parts from aluminum sheets. In general, when an aluminum sheet is press-formed, lubrication oil is applied to the surface to facilitate the flow of the sheet in the mold, and the lubrication oil is removed by a cleaning step after the forming. Providing the aluminum sheet surface in advance with a lubricity sufficient to permit the flow of the material into the mold enables the use of a quick-drying oil that requires no cleaning after the forming, thus making the step of removing the lubrication oil unnecessary.

2) The omission of surface treatment

The functional upgrading of the surfaces of the aluminum parts can be achieved by surface treatments after forming. Treating the surfaces of the parts one by one in a batch process, however, may have the drawback of low productivity and high cost. In the case of pre-coated sheets, on the other hand, functional films can be continuously applied to the surfaces in advance, so as to omit steps such as the surface treatment after forming.

Therefore, the cost increase caused by pre-coating can be offset sufficiently by the omission of process steps such as cleaning and surface treatment.

3) Environmental considerations

The hydrocarbon detergents and chloride detergents used for cleaning, as well as the process liquid used for anodization and plating, are not environmentally friendly. The use of pre-coated sheets makes process steps such as cleaning, anodization and plating unnecessary and thus decreases the use of noxious liquids.

2. The development of the "KS700" series

2.1 The basic concept

The basic concept for the KS700 series is to provide lubricity sufficient to allow continuous forming using a quick-drying lubrication oil and thus to render unnecessary the cleaning steps in the customers' processes, decreasing their total production cost. There are 9 types of products in the KS700 series (Table 1), each having varied functionality, in addition to lubricity; they were developed in response to the various needs of customers. The following describes the features of these types of products and gives concrete examples of their uses.

2.2 Highly formable pre-coated sheet "KS705"

Products such as beverage cans and the casings for chip capacitors are deep-drawn / ironed and are usually painted, or are used with film laminates, after forming. The film laminates are materials consisting of thermoplastic films, such as nylon films and PET films, adhered together. Unlike the thermosetting resins generally used for the pre-coated sheets, the thermoplastic resins used for the film laminates have molecules that are not three-dimensionally cross-linked and are more flexible than the thermosetting resins. These thermoplastic resins, on the other hand, have lower heat resistance because of their thermoplasticity, are difficult to make into thin films and are more costly.

Table 1 Features of KS700 series

	KS705	KS725K	KS730	KS744	KS750	KS752	KS760	KS776	KS780	No coating
Lubricity	Good	Good	Good	Normal	Good	Good	Good	Normal	Good	Poor
Corrosion resistance	Good	Good	Good	Good	Good	Good	Good	Good	Good	Poor
Fingerprint resistance	Good	Good	Good	Good	Good	Good	Good	Good	Good	Poor
Scratch resistance	Good	Excellent~ Good	Good	Excellent	Good	Good	Good	Good	Good	Poor
Electrical conductivity	Poor	Excellent	Poor	Poor	Good	Poor	Poor	Poor	Poor	Excellent
Hygienic	—	—	Excellent	—	—	—	—	—	Excellent	—
Heat release	Normal~ Excellent	—	—	—	Excellent	Excellent	—	—	—	Poor
Peel-off adhesive tape	Poor	Poor	Poor	Poor	Poor	Poor	Excellent	Excellent	Poor	Poor
Scratch protection for optical disc	Poor	Poor	Poor	Poor	Poor	Poor	Poor	Excellent	Poor	Poor
Antibacterial	—	—	—	—	—	—	—	—	Excellent	—

The KS705 is an aluminum sheet with a pre-coat that is as flexible as the film laminates and can be deep drawn, unlike the conventional pre-coated sheets. Fig. 2 shows the examples of $\phi 10 \times 20$ mm hollow cylinders that are deep drawn. The film can be colored so as to realize heat radiation with an emissivity 15 to 20 times higher than that of the conventional aluminum sheet. The KS705 is expected to be used, for example, for the heat sinks of LEDs. These heat sinks have complicated shapes and are required to have high heat radiation. Our internal evaluation has confirmed that heat sinks made of the KS705 have a cooling performance that is comparable with that of the commercially available die-cast heat sinks⁶⁾.

2.3 Conductive lubricant pre-coated sheet "KS725K"

Many electronics parts are required to be grounded on their surfaces to prevent malfunctioning due to electromagnetic noise and static electricity. Conventional pre-coated sheets, which have insulated surfaces, are difficult to use for such applications. Kobe Steel launched aluminum sheets such as KS720 and KS724, pre-coated with conductive lubricant, as groundable pre-coated sheets⁷⁾; however, with further advances in the performance of electronic devices, there has come to be a need for pre-coated sheets with increased conductivity. The KS725K has an extremely high conductivity, which is comparable with that of the untreated aluminum sheet, a level of conductivity unprecedented in any existing products such as KS724, and has anti-scratch and anti-fingerprint properties that cannot be achieved by untreated aluminum sheets (Fig. 3, Fig. 4). This product can improve the product yield because it

	KS705 white	KS705 black	KS705 silver	No coating
Emissivity	>0.75	>0.80	>0.60	0.04
Formed cup appearance				—

Fig. 2 Emissivity and formed cup appearance of KS705

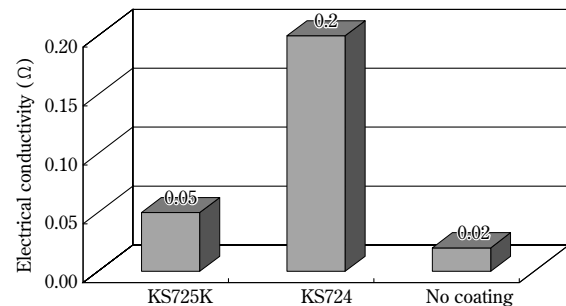


Fig. 3 Electrical conductivity of KS725K

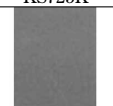
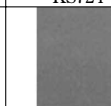
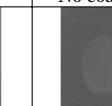

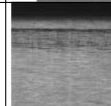
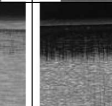
	KS725K	KS724	No coating
Fingerprint resistance			
Scratch resistance			

Fig. 4 Fingerprint resistance and scratch resistance of KS725K

decreases the number of scratches due to sliding against the molds during press forming, as well as the scratches due to friction with the packaging materials during transportation. These characteristics of the KS725K have expanded its applications, including that of covers for optical disk drives.

2.4 Corrosion resistant, lubricant pre-coated sheet "KS730"

Parts for refrigerators and rice cookers may come in direct contact with food. Therefore, it is a prerequisite for the materials used in these parts that they be harmless to the human body.

The KS730 uses a raw material film that has been approved as safe by the Food and Drug Administration (FDA). The KS730 also passed testing according to the standards set by the Ministry of Welfare (back then) and has been safely used for food-related applications.⁸⁾ The product has excellent corrosion resistance, an important feature for food-related applications, and prevents the corrosion of the aluminum sheet by hot water and hot steam (Fig. 5).

Exploiting these features, the pre-coated sheet is applied to refrigerator trays, rice cooker parts, and the like.

2.5 Hard pre-coated sheet "KS744"

Untreated aluminum sheets and the conventional pre-coated sheets have soft surfaces and are easily scratched. Therefore, they are usually provided with hard anodized films or with post-process painting when they are used for sliding parts or for parts affecting the appearance.

The film of the KS744 has a high degree of hardness and no scratches are left when its surface is scrubbed with steel wool (Fig. 6). In addition, the film is not only hard, but also well-formable (Fig. 7). Therefore, the pre-coated sheet can replace the anodized products used for the exterior parts and sliding parts of electronic equipment.

2.6 Heat releasing pre-coated sheet, "KS750" and "KS752"

The heat generated by electronic equipment may cause the equipment to malfunction, so it must be released outside. Modern electronic devices, with their high performance, downsizing and emphasis on design, have complicated internal structures that call for more efficient heat radiation.

The film used for the KS750 (KOBELCO aluminum) has an emissivity, an indicator of its infrared radiation characteristic, of 0.86, which is approximately 20 times higher than the emissivity of the untreated aluminum, which is 0.04⁹⁾. A heat radiation test conducted internally on this KS750, with its superior heat releasing performance, demonstrated that the temperature inside a box simulating an electronic device is 5°C lower than

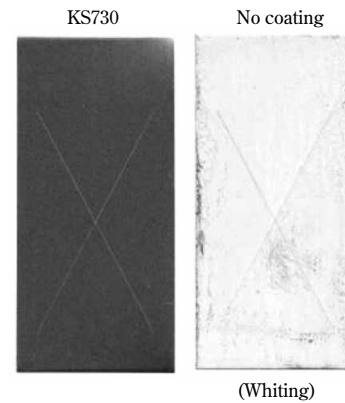


Fig. 5 Corrosion resistance of KS730 (JIS Z2371 SST500h)

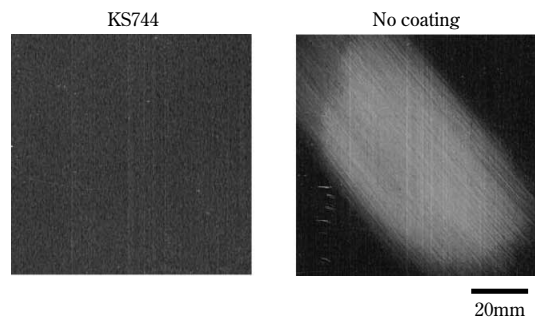


Fig. 6 Scratch resistance of KS744 (Rubbed with steel wool)

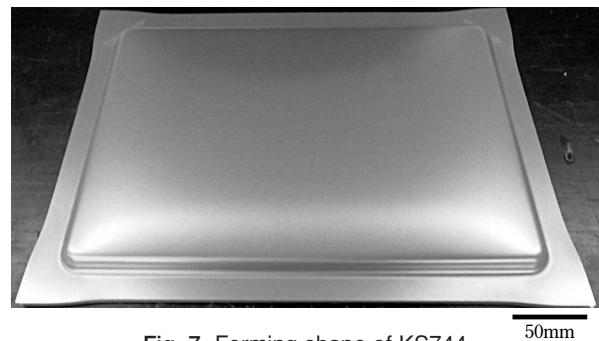


Fig. 7 Forming shape of KS744

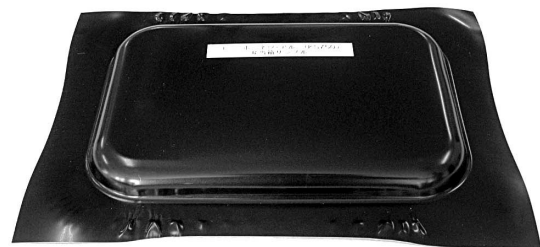


Fig. 8 Forming shape of KS750

that inside a box made of an untreated aluminum sheet.

Fig. 8 is an example of drawn-formed KS750. In addition to the conventional black conductive type, KS750 (KOBELCO aluminum), a black insulation type, "KS752BK", and white insulation type, "KS752WT", have recently been commercialized,

allowing customers to choose the conductivity and color of their applications.

2.7 Non-adhesive pre-coated sheet, "KS760"

Personal computers with built-in optical drives have prevailed these days, enabling people to easily produce CDs and DVDs (hereinafter, optical disks) of their own at home. The trouble is that the labels affixed to user-made optical disks may adhere inside audio-visual apparatuses, making the disks difficult to unload. We have developed a non-adhesive pre-coated sheet, KS760, to prevent such troubles¹⁰.

The KS760 has a film featuring a surface which does not readily permit adhesive materials such as labels to adhere to it. Fig. 9 shows the test results confirming the non-adhesive nature of the KS760. The adhesive material on the KS760 was peeled off using one-fifteenth of the force required to peel it off the conventional coating. The surface is less likely to become smeared--with oil-based ink, for example--and such smearing can readily be removed. The KS760 has won a fine reputation as a material for use in the internal parts of on-board auto-changers.

2.8 Anti-scratch pre-coated sheet "KS776" for optical disks

Repeated loading and unloading of an optical disk may scratch the disk at the points where it comes in contact with the optical disk apparatus, rendering the media no longer usable.

The KS776 adopts a film that is softer than the optical disks. With a decreased number of contact points between the disk and film, the number of scratches on the disk has been decreased significantly (Fig.10).

These characteristics have been highly rated, leading to the use of KS776 in the housings of the slot-in drives built into personal computers.

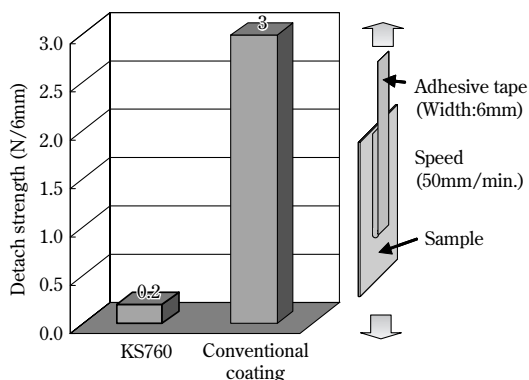


Fig. 9 Peel off strength of adhesion label of KS760

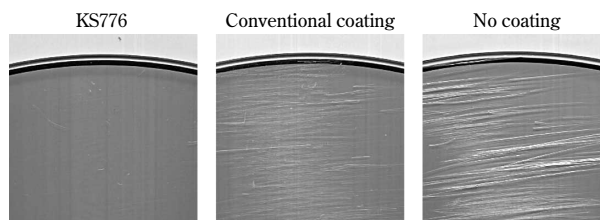


Fig.10 Scratch protection for optical disc of KS776

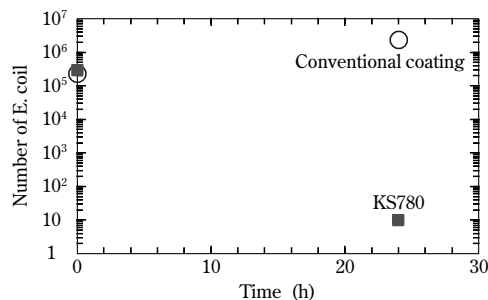


Fig.11 Anti-bacterial test result of S780

2.9 Antibacterial pre-coated sheet, "KS780"

Modern airtight buildings tend to have increased humidity and unventilated air, causing bacteria and mold to easily breed in the interior living environment. There has been an increasing interest in antibacterial and sterilizing measures.

The KS780 is a pre-coated sheet that exploits the antibacterial action of silver ion to prevent the breeding of Escherichia coli, Staphylococcus aureus, and the like. Fig.11 shows an evaluation result for the sheet's antibacterial feature. The KS780 exhibits a number of E. coli a ten-thousandth of that counted on a conventional pre-coated sheet. The newly developed film retains its antibacterial feature after immersion in boiling water or retort sterilization. It also satisfies the standard of the Ministry of Welfare (at the time) and can be used safely in the fields of food, kitchens and cosmetics.

3. Future efforts

In order to make the pre-coated aluminum sheets stand out from steel and stainless sheets, the intrinsic features of aluminum, the base material, must be exploited, e.g., in applications that require weight reduction, thermal and electrical conductivity and/or corrosion resistance. Among other areas of interest, electronics will continue to be a major target, because, for example, notebook PCs and tablet devices are required to be smaller, lighter and more mobile, and advanced digital home electronics and LED lamps are required to have improved heat radiation.

In order to cultivate demand in the field of electronics, where the price competition is fierce, it

is necessary to develop new products that are conventionally unthinkable. Examples include: ① pre-coated sheet that achieves overwhelmingly low costs, ② pre-coated sheet that achieves major weight reduction, for example, by replacing die cast parts, ③ pre-coated sheet with superior designability, and ④ pre-coated sheet that can be used in an unexpectedly severe environment. The users' requirements are becoming more and more stringent every year. In response to such user needs, we will continue to develop new products that are attractive enough to offset the cost of the pre-coated sheets, which is slightly higher than that of untreated aluminum sheets.

Conclusions

The features and examples of the use of the pre-coated aluminum sheet "KS700" series, manufactured by Kobe Steel, have been summarized. The KS700 series is being employed, and its applications are expanding, in the field in which steel sheets, stainless steel sheets and untreated aluminum sheets have hitherto been used. With the lack of increase in the domestic demand for aluminum, as in the case of beverage cans, developing new applications of

aluminum is a challenge not only for Kobe Steel, but also for the whole industry. Adding value by pre-coating is expected to be a useful approach for dealing with such a challenge. We will strive to develop technologies and products to cultivate new applications.

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