Development of Thermal Products Using the EB Method

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ABSTRACT In the brazing of aluminum, flux or vacuum brazing have been widely used in the past. But we have developed exudation brazing (EB) method, a new brazing process which has no flux in the air. This method is limited to the lap joint, using a special five-layer brazing sheet, and it is expected to provide brazed bonding with higher quality, lower cost, higher joint strength and higher corrosion resistance. We introduce some examples of thermal products such as heat sinks and laminated molds using this method.

1. INTRODUCTION

Brazing of aluminum is widely utilized in the production of radiators and coolers for automobiles using a brazing sheet. In brazing there are currently two methods: the NB method of non-corrosive flux brazing in an atmosphere of nitrogen and the VB method of vacuum brazing without flux. We have developed the EB method a new brazing process which has no flux in the air [1], and are putting this method to practical use. In this paper we introduce some examples other than those for heat exchangers for automobiles.

2. EXUDATION BRAZING (EB) METHOD

2.1 EB Sheet

The EB method uses an EB sheet, a special brazing sheet, which is composed of five layers and adds external skin layers to both surfaces of the present three-layer brazing sheet. The comparison of these compositions is shown in Figure 1. The external skin layer material is pure aluminum, the brazing alloys are 4004 and 4104 alloys, and the core alloys are 3003, 6061 and 6951 alloys.

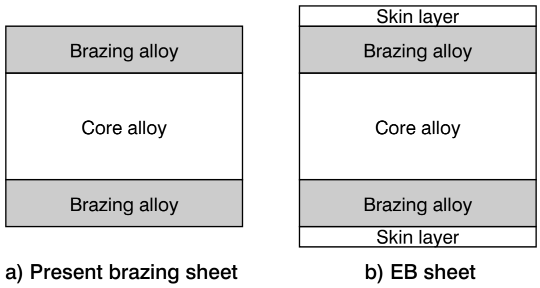

Figure 1 Composition of EB sheet.

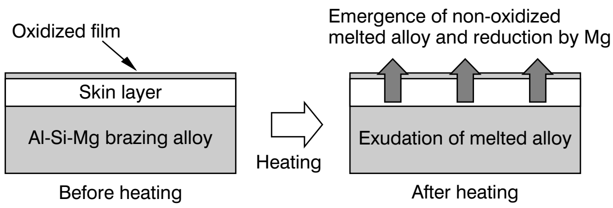

Figure 2 Concept of the exudation of brazing alloy.

2.2 Concept of the EB Method

The concept of the EB method, which does not use flux in the air, is as follows. Generally in brazing, it is necessary for wetting of the melted brazing alloy to occur. Oxidation of the alloy during heating must be prevented, and the oxidized film must be destroyed. Accordingly current brazing methods such as the NB method or the VB method are carried out under conditions where flux or vacuum are used. In the EB method, by contrast, the brazing alloy is not exposed to the air and thus undergoes no oxidation. In melting, the brazing alloy exudes through the external skin layer and at the moment of exudation, nonoxidized brazing alloy appears. Thus, wetting can be achieved without flux or vacuum. Figure 2 is a conceptual representation of exudation in the EB method.

Figure 3 is a schematic showing the change in thickness of the oxidized film on the EB sheet during heating in air. A close-contact lap joint is required in this method, so its use in the air is limited to brazed bonding. Figure 4 shows a schematic of the lap joint.

2.3 Features of EB Method

1. High quality brazed bonding: These joints are based on the exuding of non-oxidized molten metal over the joint surface. Photo 1 shows the microstructure of a brazed section.
2. Low cost brazing: Although the material cost is higher, total cost is lower because there is no need for a high cost furnace with atmosphere control, and no flux is required.

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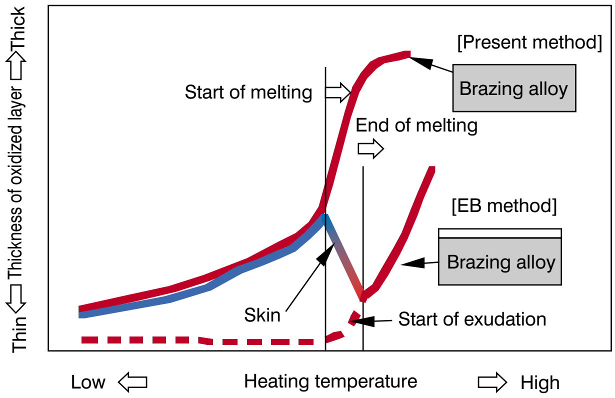


Figure 3 Schematic showing behavior of oxidation under heating in air.

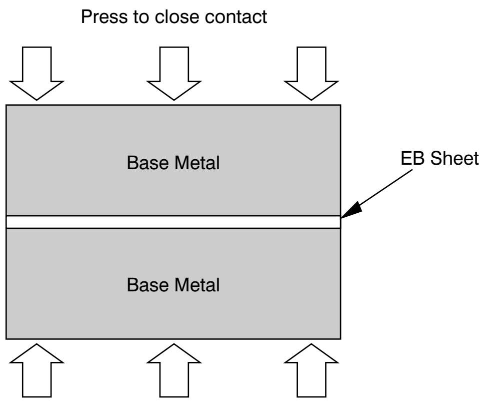


Figure 4 Schematic of lap joint.

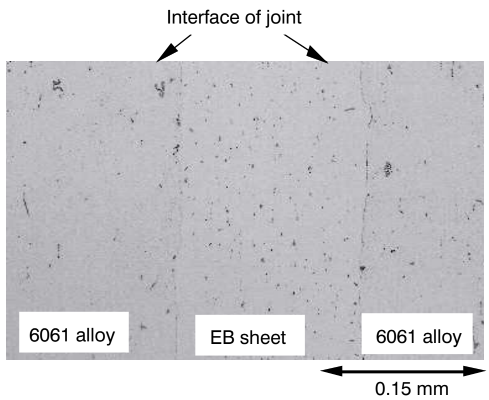


Photo 1 Microstructure of brazed section.

3. High corrosion resistance: Because the brazed products are heated to a high temperature (about 600°C) in the air, the oxidized film is extremely thick.
4. High tensile strength of the joint: Because this method is performed with no flux in the air, it enables residual Mg to enter the brazed alloy, greatly increasing joint strength. In the methods previously used this residue could not occur. Figure 5 shows the tensile strength of the brazed joint using selected base metals. Tensile strength was good for 6061 but not for 5052 and 5083. This is attributed to the effect of Mg oxide on the Al-Mg alloys of the surface.

† LEB-sink is a registered trademark of Sky Alumi Products Co., Ltd.

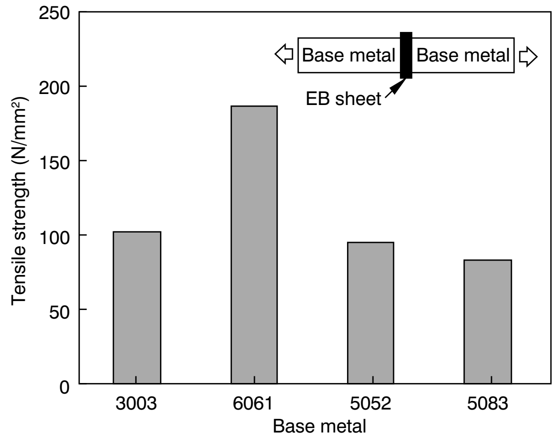


Figure 5 Tensile strength of EB butt joint.

3. TYPICAL APPLICATIONS OF EB METHOD

3.1 LEB-sink† Heatsinks

3.1.1 Structure

The comb-type LEB-sink heatsink is made by laminating fins and EB sheets alternatively. Figure 6 shows a schematic figure, and Photo 2 shows the appearance of typical LEB-sinks.

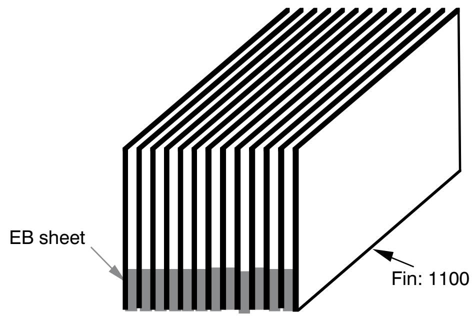
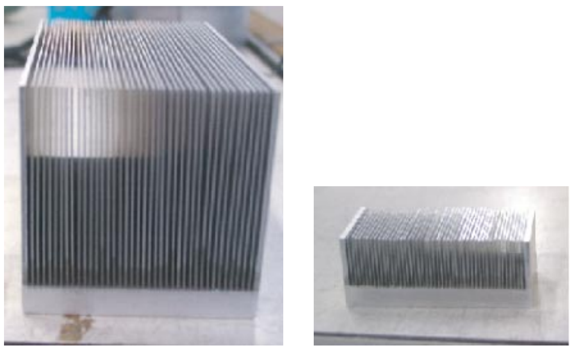


Figure 6 Schematic of LEB-sink.



(a) Fin height: 60 mm **(b) Fin height: 20 mm**

Photo 2 Appearance of middle-size LEB-sink. (base width: 60mm, fin pitch: 1.5mm)

3.1.2 Features of LEB-sink

1. The LEB-sink has high-quality heat releasing characteristics. The fin pitch can be reduced, even below 0.5 mm, the narrowest in the world, so that fin area can be increased. Figure 7 shows the heat releasing characteristics of LEB-sinks [2], and Figure 8 shows a range of products according to fin pitch. Base widths

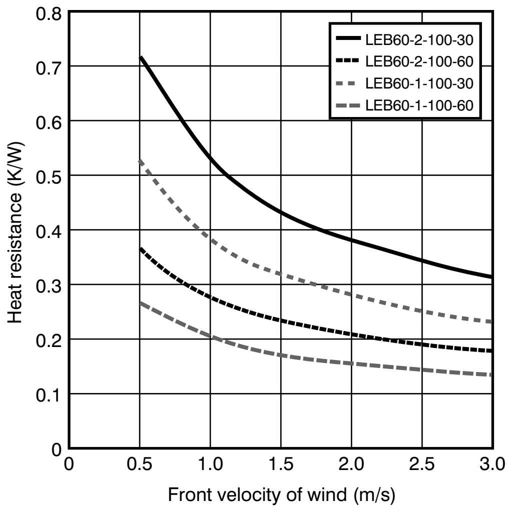


Figure 7 Heat releasing characteristics of LEB-sink.

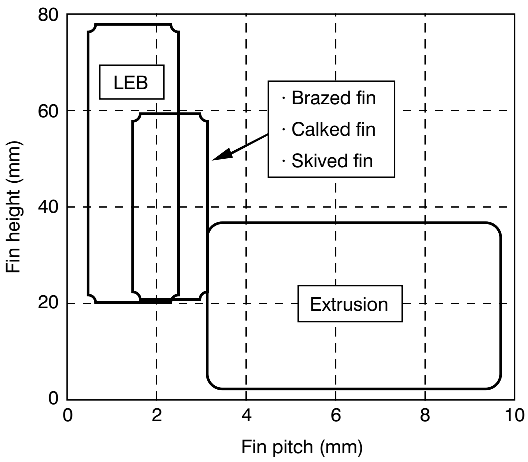


Figure 8 Comparison of product range by manufacturing process.

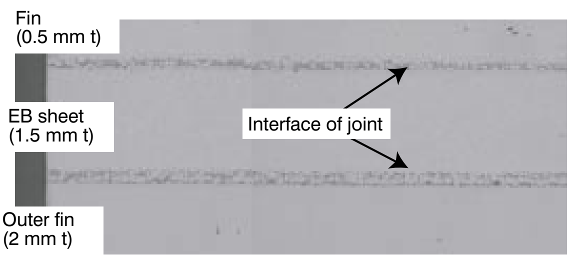


Photo 3 Microstructure of LEB-sink section.

ranging from small to large can be made.

2. Because of the high-quality brazed bonding joint strength is high. Photo 3 shows the microstructure.

3.1.3 Applications

We consider that LEB-sinks are suitable for the following applications.

- Medium-scale (products for servers using a Peltier element)
- Large-scale (for inverters)

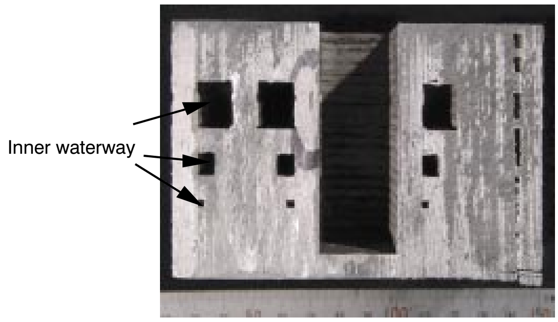
3.2 Laminated Mold

3.2.1 Concept

The laminated mold is a block made from numerous sheets that have been pre-cut based on CAD data and laminated. The block also functions as a heat exchanger with complex inner waterways [3]. This makes it possible to produce blocks that were virtually impossible until now. The EB method is used in laminated bonding. Currently development is proceeding jointly with Laminated Mold Laboratory Co., Ltd. Photo 4 shows the appearance of a trial laminated mold and of its half section. Figure 9 shows the hardness distribution in the brazed joint.

Block size: 100 × 100 × 64 mm

Photo 4-1 Appearance of laminated EB mold.



Lamination details
· E6061 2-mm thick 23 pieces
· EEB 0.8-mm thick 22 pieces

Photo 4-2 Appearance of half section of the mold.

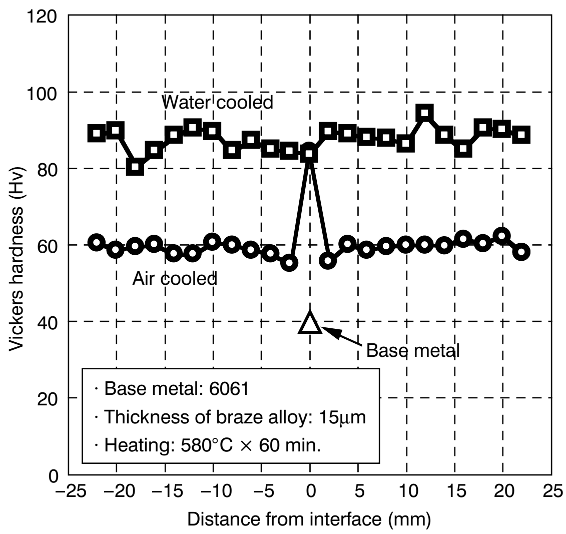


Figure 9 Hardness distribution in brazed joint.

3.2.2 Features

1. High-cycle production by blow molding of resin is possible. The shot cycle increase is minimized because the rise of the temperature of the water-cooled mold is reduced.
2. The molds for rubber and foaming which require air venting are easily produced.
3. Delivery is quicker.

3.3 Others

Other possible applications for the EB method include jackets for water-cooled PCs, cooling plates for semi-conductors and vacuum vessel, and the like. Figure 10 shows the development tree of the EB process. Photo 5 shows the appearance of a water-cooled jacket.

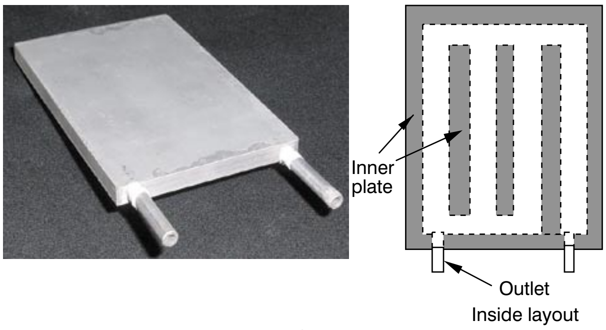


Photo 5 Appearance of water-cooled jacket.

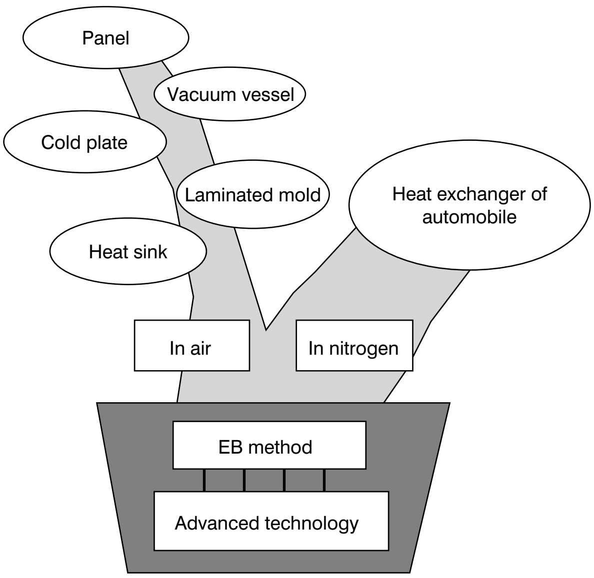


Figure 10 Development tree of EB process.

4. CONCLUSION

As was stated above, the EB method has much of unique features not found in conventional brazing methods, and we therefore hope to broaden its applications. At present however there are some limits to its application, namely

1. The joint design in the air is confined to lap joints.
2. Because of the formation of MgO film, Al alloys containing more than 1-% Mg cannot be brazed.
3. Because of the melting point, Al-Cu alloys and casting alloys cannot be brazed.

REFERENCES

1) Japanese Patent Application: TOKUKAI 2002-18570
2) Products Catalog of Sky Aluminum. (in Japanese)
3) Takaya et al.: Molding Technology, Vol. 18 No. 8, 156-157. (in Japanese)