Vacuum Brazing of Aluminum Using Al-12%Si System Filler Alloy†

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Brazing of aluminum and its alloys has been performed using very aggressive fluxes such as chlorides and fluorides to remove their adherent stable oxide films. But recently fluxless brazing are recommended from the point of view of the contamination by fluxes and corrosion by residuals. Vacuum brazing[1)-3)], one of the recently developed fluxless brazing, is rapidly gaining acceptance because various filler alloys had been developed for the purpose of removal of surface oxides on base plate. Although these filler alloys enhanced the component reliability and working efficiency, many of these alloys contain metals which react with aluminum oxides and form volatile oxides such as MgO. The purpose of the present work is to braze commercial pure aluminum plate (3mm, 1100Al) using Al-Si system eutectic filler alloy.

Photograph 1 shows the appearance of a laboratory vacuum (2×10^{-5} Torr) furnace, a pump and a control panel. Tee type joint specimens as shown in Fig. 1 are set in this electric furnace. Brazability was compared by the extent of fillet formation and its optical microscopy. Filler alloys (nominal silicon content is 11–13%) with 1.6mm diameter and 20mm length were set closely to both sides of web member of the specimen.

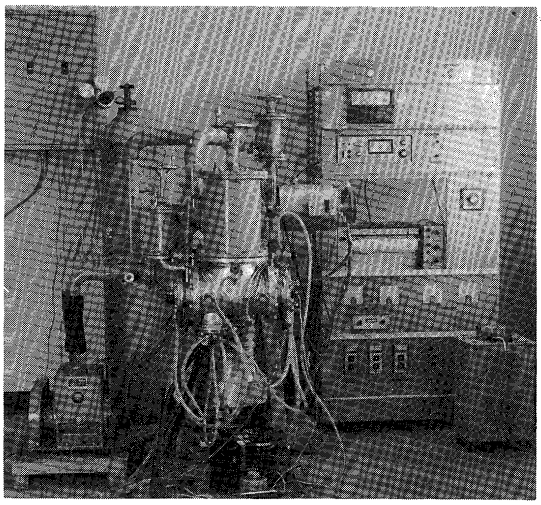

Photo. 1 Appearance of the vacuum brazing equipment

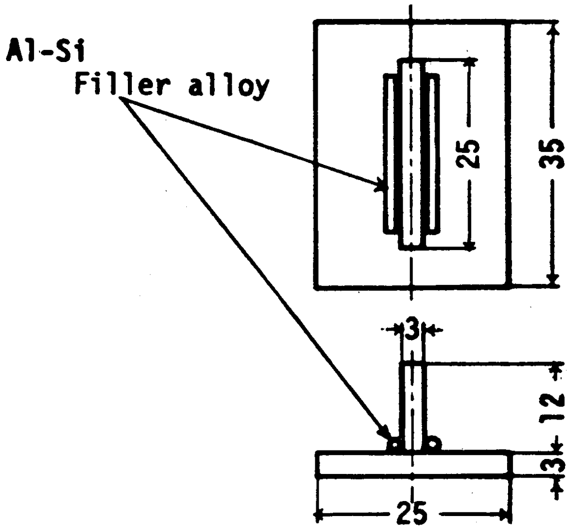

Fig. 1 Shape and size of specimen

Representative heating and cooling curves are shown in Fig. 2. Curve (a) shows the temperature of thermo-

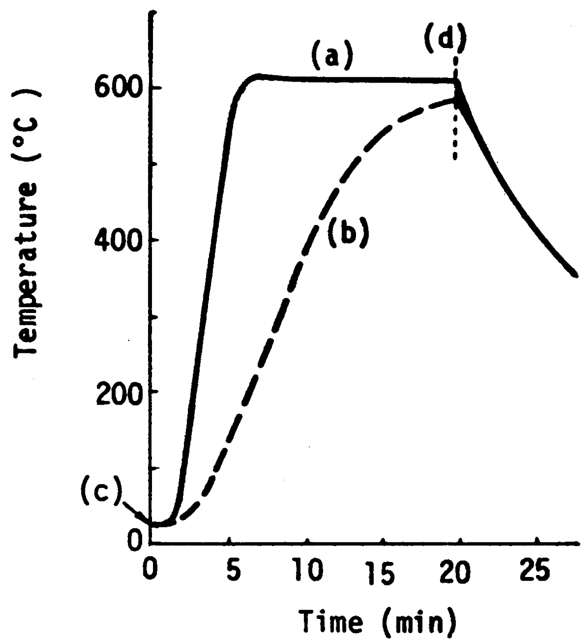

Fig. 2 Representative heating and cooling curves

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couple located 1 cm away from the specimen in the furnace. Curve (b) is the temperature of a supporting plate which holds the specimen horizontal. It takes about 18 min for melting of filler alloy and formation of fillet after heating started. In this experiment as brazing temperature is controlled by the thermocouple of curve (a), brazing temperature is designated as the plateau of curve (a) and brazing time is the interval from (c) to (d) in Fig. 2. Brazing temperature range is between 600–630°C and brazing time is fixed to 20 min.

In the first stage of this work, specimens were pretreated in H_2SO_4 (20–30%, 60–70°C) or in NaOH (5–10%, 40–70°C). After etching in each bath, specimens were rinsed with water and immersed in HNO_3 (50%, room temperature) and then rinsed and dried by acetone. Many of the specimens treated under these conditions, however, showed poor brazability, i.e. little fillet formation was obtained even they were heated at 630°C which was about 25°C higher than general recommended brazing temperature for the used filler alloy. On the other hand the specimens merely ground with emery papers (#600) showed fillet formation even at 603°C heating.

Then, following experiment was conducted using emery paper ground specimens. The results indicate that the specimens brazed at 610°C and 620°C show good brazability (Photo. 2). As the molten area of base plate heated at 620°C was larger than that of the base plate heated at 610°C, following tests were conducted at about 610°C. Good brazability of emery paper ground specimens compared to that of chemical treated ones suggests that the surface structure including roughness, thickness and type of adherent species on base plate influences the fillet formation. Then, specimens were ground prior to vacuum brazing with various roughness of emery papers (#80–#1500). The results indicate that the specimens ground with the most rough paper (#80) and the most fine paper (#1500) showed little fillet formation, however, the specimens ground with medium rough papers (#400 or #600) showed successful fillet formation. Although the degree of fillet formation was not changed linearly with the roughness of emery paper, it may be believed that the difference of the way of contact between filler alloy and base plate due to the difference of surface roughness of base plate corresponds to the difference of brazability. Vacuum annealing (500°C, 30 min) of base plate before joining improved brazability to some extent, especially the specimens ground with #80 or #1500 emery paper showed fairly good fillets.

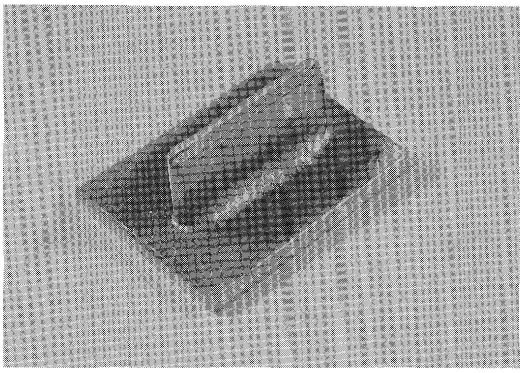

Photo. 2 Appearance of specimen brazed at 610°C

From these observations, it is hypothesized that the removal of the volatile adhesives and/or disappearance of Beilby-like surface layer may relate to the brazability of this system.

References

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