Pitting Corrosion Property of Vacuum Brazed 7072 Clad Aluminum Alloy

The potential differential between clad and core materials maintains the corrosion resistance of A7072 clad A3003 aluminum alloy

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ABSTRACT. In the high vacuum brazing of A7072 clad A3003 alloy, the clad layer loses its alloying element, zinc, by vaporization and diffusion. However, by adding inert gas to the brazing furnace, the zinc content in the clad layer can be controlled according to the brazing pressure. Consequently, the pitting properties of this alloy, brazed over a wide pressure range, were researched. It was found in the laboratory test that the pit depth was not affected by the zinc content. Also, heat exchangers made of this alloy and brazed in a high vacuum showed superior pitting corrosion resistance in the laboratory tests and the field test.

It is concluded that, with A7072 clad A3003 alloy, there is a corrosion potential differential between the clad layer and the core metal after the high vacuum brazing, and that cathodic protection can be expected.

Introduction

To attain high pitting corrosion resistance, aluminum heat exchanger tubes in many instances are made of A7072 clad aluminum alloy. Also, the vacuum brazing process is selected in aluminum heat exchanger production. In vacuum brazing, however, A7072 clad tube loses its alloying element — zinc — by vaporization and diffusion. As a result, pitting properties may be changed following vacuum brazing.

For this reason, the relation between brazing pressure and the pitting properties of A7072 clad A3003 alloy was researched in the laboratory. Additionally, the corrosion behavior of the vacuum brazed heat exchanger made of A7072 clad A3003 tube was confirmed in both laboratory and field testing.

Experiment Procedure

Fundamental Tests

The T-joint test specimen used is shown in Fig. 1. It is constructed of A7072 clad A3003 alloy and A4004 clad Al-Mn-Zn alloy brazing sheet. The specimens were brazed over a wide range of brazing pressures. The chemical compositions of the materials used are shown in Table 1.

In Fig. 1, material no. 1 is A7072 clad A3003 alloy whose thickness is 0.5 mm (0.02 in.) and whose clad ratio is 10%. Material no. 2 is A4004 clad Al-Mn-Zn alloy whose thickness is 0.16 mm (0.006 in.) and clad ratio is 10%. The test specimens were brazed in the batch type vacuum furnace whose atmosphere is high vacuum or controlled by the inert gas.

The brazing conditions are shown in Table 2. To study the relation between the brazing pressure and the pitting property, the brazing pressure was changed from 10^{-5} torr to 760 torr.

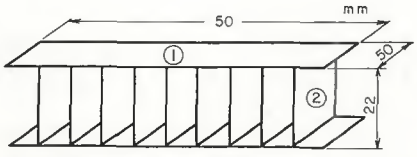

Fig. 1 — Test specimen for brazing

Results of Fundamental Tests

Configuration and Size of Fillets. The configurations and sizes of fillets were measured at the cross sections of T-joint test specimens. The results are shown in Fig. 2, and one example of micro structure of fillets is shown in Fig. 3.

The configurations and sizes of fillets are not affected clearly by the brazing pressures.

Zinc Content of Clad Layer. Zinc content at the surface, as measured by fluoluminescent x-ray analyzer, changed widely. For example, the zinc content was found to be 0.08% at the high vacuum condition and the same with

Table 1—Chemical Compositions of Materials Used, Wt-%

	A7072	A3003	A4004	Al-Mn-Zn
Mn	0.04	1.12	< 0.01	1.03
Mg	< 0.01	0.02	1.51	< 0.01
Zn	0.78	0.02	0.01	0.90
Cu	0.05	0.12	0.07	0.01
Fe	0.18	0.43	0.20	0.16
Si	0.22	0.20	9.50	0.07

Table 2—Brazing Conditions for Test Specimens

Pressure, torr	2×10^{-5}; 5×10^{-2} N_2; 2 N_2; 40 N_2; 760 Ar
Temperature, °C	600
Time, min	5, 10, 15

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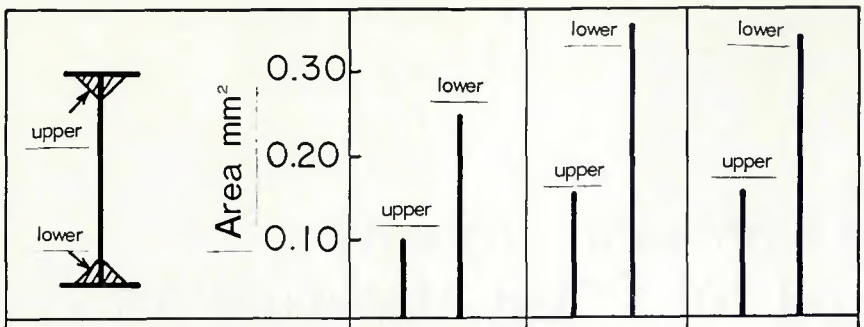

Pressure Torr	2×10^{-5}	40	760
Temperature °C	600	600	600
Time min	10	10	10

Fig. 2 — Average cross section area of fillets

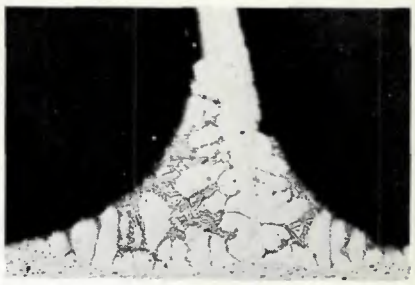

Fig. 3 — Microstructure of a fillet

base metal at the 760 torr condition.

The zinc distribution through the cross sections of specimens measured by the x-ray micro-analyzer was changed widely by the brazing pressures. Some examples of zinc distribution curves are shown in the Figs. 4-6.

The zinc residual ratios of brazed specimens were calculated. Zinc residual ratio is the value which is calculated by dividing the peak value of zinc distribution curves by the peak values of base metal. The relation between the brazing pressure and the zinc residual ratio is shown in Fig. 7. The zinc residual ratio increases sharply over several tens torr.

Corrosion Resistance of the Test Specimens. The pitting corrosion resistance of specimens brazed over wide pressure ranges was inspected. The salt spray test for 1000 hours(h) was used to compare the pitting corrosion resistance of specimens.

As shown in Fig. 8, the pit depths of all specimens are less than the depth of clad layer. As a result, a relation between zinc residual ratio and pitting depth could not be found.

Heat Exchangers Corrosion Tests

In the fundamental tests, the effect of residual zinc content on the pitting corrosion depth could not be determined. Consequently, the corrosion behavior of heat exchangers used as condensers in the car air conditioner systems was inspected.

The test condensers were brazed in a semicontinuous high vacuum brazing furnace at the production factory. They were constructed of A7072 clad A3003 tubes and A4004r clad Al-Mn-Zn alloy fins — Fig. 9.

The zinc content of A7072 clad tubes was analyzed. It was found that condenser tubes lose zinc, as shown in Fig. 10. The result was to use pure aluminum clad A3003 tubes.

The corrosion resistance of the condensers was inspected through the use of several tests as discussed under separate headings below.

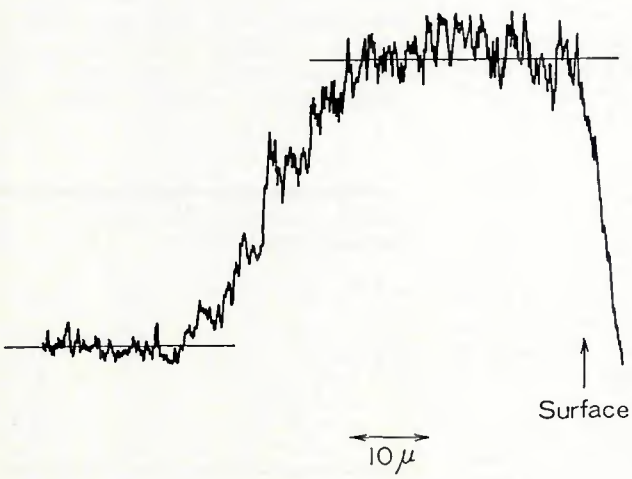

Fig. 4 — Zinc distribution in A7072 clad A3003 alloy

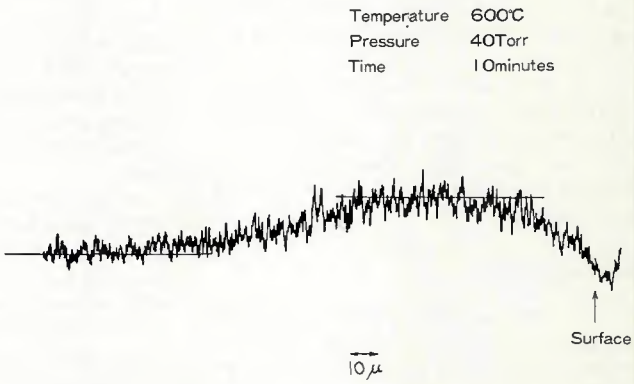

Fig. 5 — Zinc distribution of test specimen after brazing. Temperature — 600°C (1112°F); pressure — 40 torr; time — 10 min

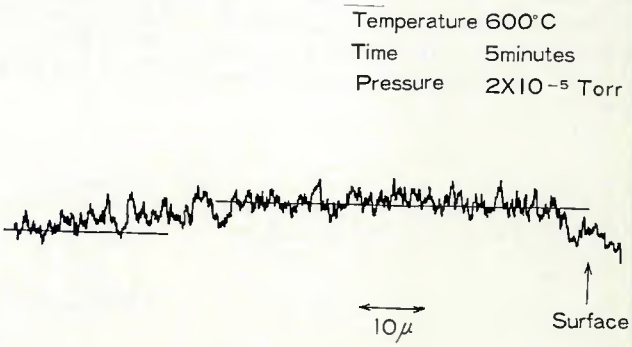

Fig. 6 — (right) Zinc distribution of a test specimen after brazing. Temperature — 600°C (1112°F); pressure — 2×10^{-5} torr; time — 5 min