PROPERTIES OF Al–Si–Cu–Zn BRAZING FILLER

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ABSTRACT The copper and zinc contents of Al-Si-Cu-Zn brazing filler alloy were examined to lower the brazing temperature of aluminum alloy materials from current 873K to 853K. The brazeability at 853K was enhanced with increasing the copper and zinc contents of the brazing filler. Also, the corrosion resistance of the brazing sheet was improved with the ratio of zinc/copper of the brazing filler. Furthermore, the erosion to fin at 853K was compared with that at 873K to confirm the influence of brazing temperature on erosion. As a result, at brazing temperature 853K erosion to fin was improved well.

Keywords: *brazing filler, Al-Si-Cu-Zn alloy, brazeability, flow factor, corrosion resistance*

1. INTRODUCTION

Aluminum alloy heat-exchangers for automobiles are assembled and brazed at approximately 873K in nitrogen atmosphere and in the presence of a noncorrosive flux. The heat-exchangers are in a direction of lightening in weight recently. Therefore, It is necessary to improve the strength of the core material of the brazing sheet as the thickness of the brazing sheet decreases. However, the melting point of the core material decreases by the addition of alloy elements to the core material, and the core material tends to melting during brazing at 873K. Moreover, the phenomena of buckling of fin during brazing tend to happen as the thickness of fin decrease. The purpose of this study is to develop the Al-Si-Cu-Zn brazing filler for use in brazing at 853K.

2. EXPERIMENTAL PROCEDURES

2.1 Materials

The compositions of experimental Al-Si-Cu-Zn brazing fillers shown in Table 1 are based on Al-11mass%Si alloy. These brazing fillers as clad materials were manufactured according to a conventional method including the mold casting, homogenization and hot rolling steps. Subsequently, The resultant brazing filler sheets were cladded to both surfaces of the core material having an alloy composition shown in Table 2. Furthermore, the clad sheets were cold-rolled and annealed. The brazing sheets having a thickness of 0.50 mm were manufactured. The clad ratio of brazing filler materials was set to be 10% of the whole sheet thickness per one surface.

Table.1 Chemical compositions of brazing fillers (mass%)

specimen	Si	Fe	Cu	Zn	Al
1	11.1	0.3	3.5	4.2	bal.
2	11.3	0.2	2.4	4.3	bal.
3	10.8	0.3	1.3	4.3	bal.
4	11.3	0.3	0.7	4.3	bal.
5	10.9	0.3	3.2	<0.01	bal.
6	11.0	0.3	1.3	2.0	bal.
7	11.2	0.3	1.3	<0.01	bal.
8	11.0	0.3	3.2	2.1	bal.

Table.2 Chemical compositions of core alloy (mass%)

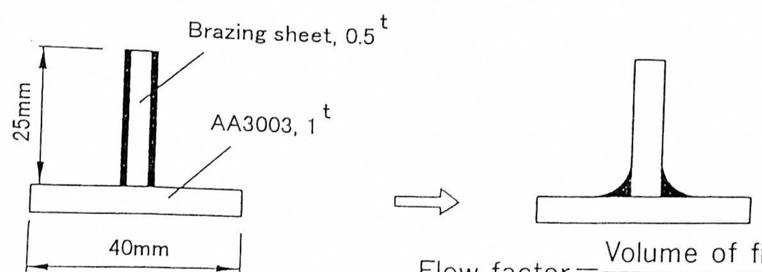
	Si	Fe	Cu	Mn	Al
core alloy	0.82	0.25	1.15	1.09	bal.

2.2 Brazeability

The brazeability of each specimen was evaluated by a fillet formation test on a T-joint that is shown in Figure 1. The vertical parts of the T-joints were the brazing sheets and the horizontal parts were AA3003 alloy. These T-joints were applied the flux that consisted of the mixture of $KAlF_4$-30mass%$K_2AlF_5 \cdot H_2O$ and were brazed in nitrogen atmosphere. The brazing was carried out at 853K. The holding time in the brazing temperature was 3 minutes. As shown in Figure 1, the fillet areas of the T-joints were measured and the flow factors were calculated. The flow factor indicates the proportion of the fillet to the cladded brazing filler. As the flow factor is large, the brazeability is good. It was judged that the brazeability was good, when the flow factor was larger than 0.5 in this research.

2.3 Corrosion resistance

CASS test (ASTM B368) was made for 180 hours as a corrosion resistance test. The samples for the CASS test were the brazing sheets heated at 853K for 3 minutes in nitrogen atmosphere. The sample were sealed except the center surface portion of the brazing sheets in order not to be subject to the influence of a section of the sheet ends. Then, the occurrence of pitting corrosion was



$$\text{Flow factor} = \frac{\text{Volume of fillet}}{\text{Volume of filler}}$$

Figure1. T-joint test specimen.

examined and the pit depths were measured. Also, the corrosion potentials of the brazing filler surfaces were measured in 5%NaCl solution saturated with oxygen by bubbling air through at room temperature. The saturated calomel electrode (SCE) was used for the reference electrode.

2.4 Effect of the brazing temperature on the erosion behavior

The fin of the Al-Mn-Zn-Si alloy was prepared in order to examine the influence of the brazing temperature on the erosion to fin. This fin was corrugated and was assembled with the brazing sheets. The brazing sheet t cladded with AA4045 and the fin were brazed at 873K. Also, the brazing sheet cladded with No.2 brazing filler and the fin were brazed at 853K. The holding time at the brazing temperature was 3.5 minutes each. The sections of joints of the sample after the brazing were observed and the degrees of the erosions to fin were compared.

3. RESULTS AND DISCUSSIONS

3.1 Brazeability

Figure 2 shows the influence the copper and zinc contents of the brazing filler on the flow factor of the T-joint test. Open circles in the figure shows the copper and zinc contents of the brazing fillers. The numbers that are entered in the figure is the flow factors corresponding to the brazing fillers. The brazeability at 853K was enhanced with increasing the copper and zinc contents of the brazing filler. No.2 and No.8 brazing fillers can be used for brazing at 853K.

3.2 Corrosion resistance

Figure 3 shows the maximum pit depths of each specimen after the CASS test for 180 hours.

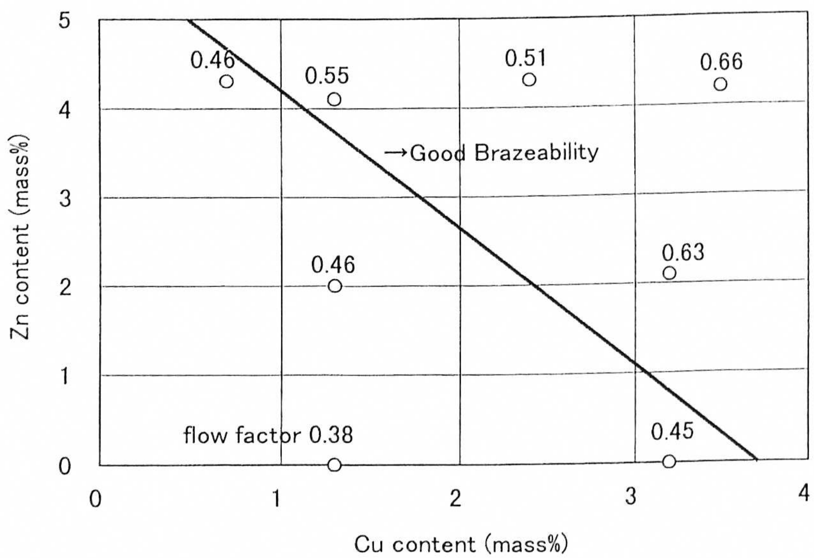


Figure2. Effect of Cu and Zn contents of Al-11mass%Si-Cu-Zn brazing filler on flow factor.

The numbers that are entered in the figure is the maximum pit depths corresponding to the brazing fillers. The corrosion resistance of the brazing sheet was improved in the area which ratio of zinc/copper of the Al-Si-Cu-Zn brazing filler was large. This result was similar to the result of Hisatomi et al [2]. Figure 4 shows the corrosion morphology of the brazing sheets cladded with No 4 and No.5 brazing fillers. No.5 brazing filler contains 3.2mass% copper and do not contain zinc. The corrosion of the brazing sheet cladded with No.5 brazing filler was the blistering corrosion that was growing between the brazing filler and the core material.

Figure 5 shows the corrosion potentials of the surfaces of the brazing sheets in 5%NaCl solution. The corrosion potential became lower, as the ratio of zinc/copper in the brazing filler increased. Also, the corrosion potential of the core material of shown in Table 2 was -700mV. The corrosion potential of the brazing filler that contains zinc less and contain copper a lot is nobler than that of the core material. Therefore, it is concluded that the blistering corrosion of the brazing sheet cladded with No.5 brazing filler resulted from the difference between the corrosion potential of the brazing filler and that of the core material.

For the above, it is found that the No.2 brazing filler has superior properties of brazeability at 853K and corrosion resistance.

3.3 Effect of the brazing temperature on the erosion behavior

Figure 6 shows the sections of the joint at brazing temperature 873K and 853K. The fin was broken by the erosion at 873K. However, the erosion to the fin is reduced at 853K. It is effective in the prevention of the erosion to lower brazing temperature from 873K to 853K.

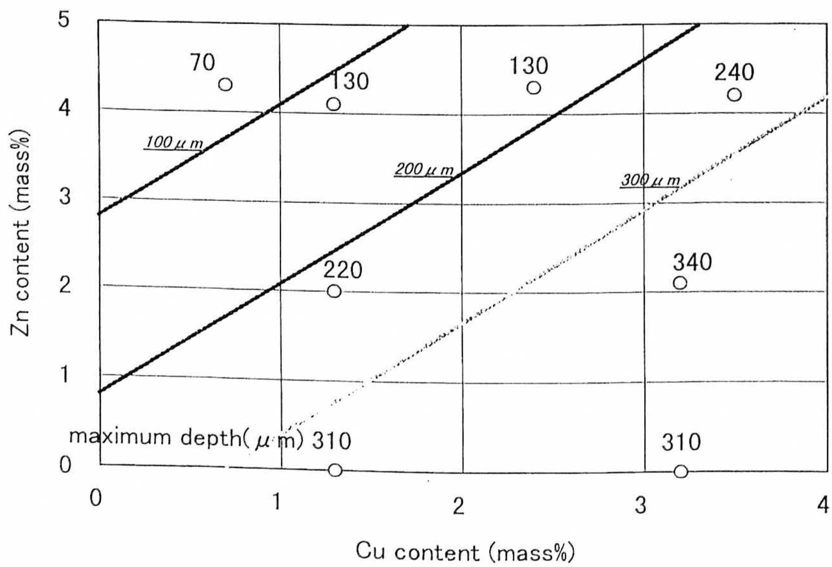
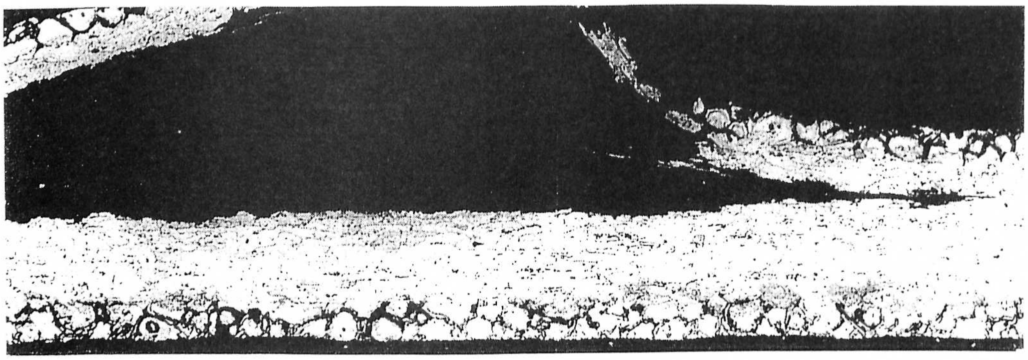
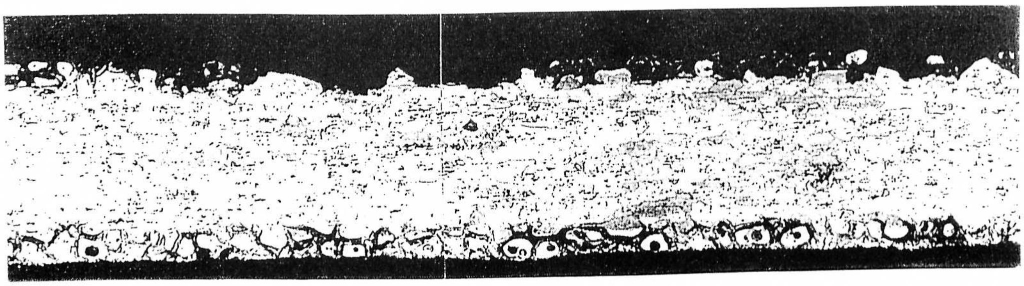


Figure3. Effect of Cu and Zn contents of Al-11mass%Si-Cu-Zn brazing filler on the maximum corrosion depth of the brazing sheet after CASS test for 180h.



(a) brazing filler:Al-10.9mass%Si-3.7mass%Cu



(b) brazing filler:Al-11.3mass%Si-0.7mass%Cu-4.3mass%Zn

100 μm

Figure4. Cross-sectional corrosion observation on the brazing sheet after CASS test for 180h.

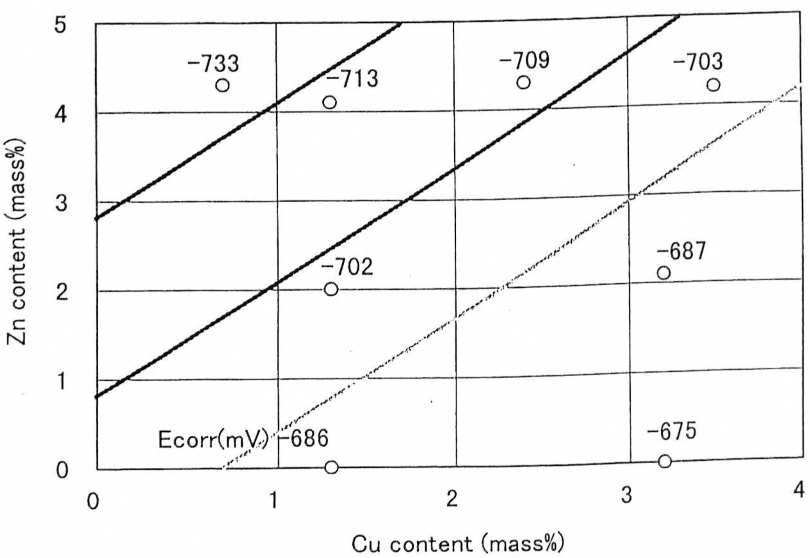
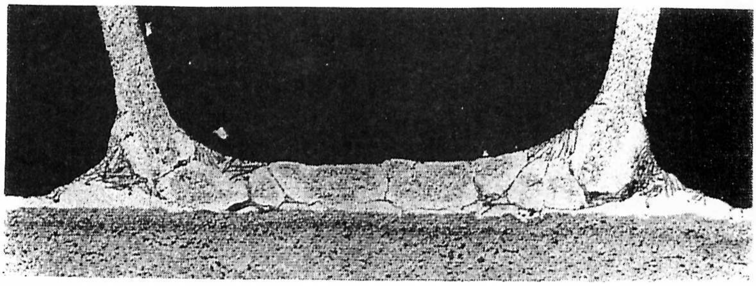
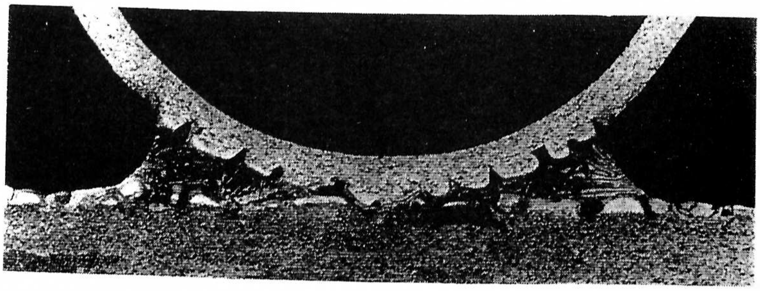


Figure5. Effect of Cu and Zn contents of Al-11mass%Si-Cu-Zn brazing filler on corrosion potential of the brazing sheet. (in 5%NaCl aq., room temp.)



(a) brazing temperature: 873K



(b) brazing temperature: 853K

100 μm

Figure6. Cross-section observations on the joints brazed at 873K,853K.

4. CONCLUSIONS

The effects of the copper and zinc contents of the Al-11mass%Si-Cu-Zn brazing filler on the brazeability and the corrosion resistance were investigated. Also, the influence of the brazing temperature on the erosion to fin was investigated. The follow results were obtained:

(1) The brazeability at 853K is enhanced with increasing the copper and zinc contents of the brazing filler.

(2) The corrosion resistance of the brazing sheet was improved with the ratio of zinc/copper of the brazing filler. In the case that the corrosion potential of the brazing filler is nobler than that of a core material, blistering corrosion results.

(3) It is effective in the prevention of the erosion to lower brazing temperature from 873K to 853K.

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