TEST METHOD FOR EVALUATING A BRAZEABILITY AND EROSION BEHAVIOR OF ALUMINUM BRAZING SHEETS WITH ERICHSEN FORMED SPECIMEN

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ABSTRACT New evaluation method was discussed in comparison with current method for evaluating brazeability and erosion behavior of aluminum brazing sheets. New method has used Erichsen formed specimen, the brazeability was evaluated by relation between the fillet formability and the forming height, and erosion behavior was evaluated micrægrphic observation of cross-section of brazed specimen. It was confirmed the brazeability and the erosion behavior of that was good agreement with current methods.

Keywords:*Erichsen formed specimen,brazeability,erosion behavior,aluminum brazing sheet*

1.INTRODUCTION

Brazed aluminum heat exchangers have been widely used for automobile, power generation and refrigeration industries. Thickness of aluminum brazing sheets is being reduced these days to meet with the light-weight design requirement from a viewpoint of protecting the earth environment. Not only improvement of characteristics such as corrosion resistance, post-braze strength is important, but also improvement of brazeability and erosion behavior is very important in the brazing sheets with thinner gage. And, selection of excellent evaluation method is key factor for improving brazeability and erosion behavior. Clearance fillability test and dropped test in specimen with several stretching rates are currently used, respectively[1,2,3]. Though these methods are useful for evaluation them, they have some problem such as, not easy to prepare, varing data widely, requiring two tests. We present new test method by using Erichsen formed specimen. This method can solve the problems the current methods have. That is , this method is easy to prepare, obtaining narrow variation data and can evaluate brazeability and erosion behavior with single specimen.

In this paper, a comparison of new test method and current method for evaluating a brazeability and erosion behavior was carried out . And the reason of choosing Erichsen formed specimen as candidate is follows :

1) Wettability can be evaluated from relation between fillet formability at dome and forming height shown as following Eq.1[3].

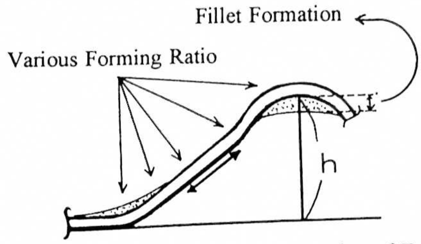


Fig.1 Shematic showing cross-section of Erichsen formed specimen after brazing

2) It includes wide range of forming ratio depend on positions for evaluating the erosion behavior .

$$\chi H = k \sigma l \cos\theta - \rho g h \quad (1)$$

where χH is forming height which fillet is formed, k is constant, σl is surface tension, ρ is density, θ is contact angle, g is gravity, and h is height.

2.EXPERIMENTAL PROCEDURE

2.1 Materials

Table 1 shows the chemical composition and construction of aluminum brazing sheets used in this test. The sheets have different brazeability each other as shown in Figure 2. Their brazeabilities were controlled by changing production process of the sheets(No.1,2,3).

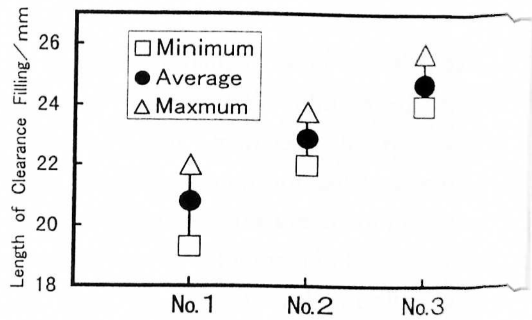


Fig.2 Clearance fillability test result of tested brazing sheets

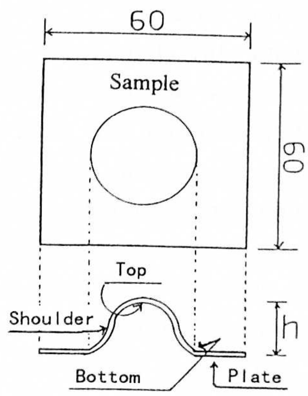
2.2 Brazeability and Erosion behavior

Figure 3 shows schematic diagrams of Erichsen formed specimen used in this test and clearance fillability test specimen which used in comparison. The brazeability of Erichsen formed specimens was evaluated by measuring the thickness of fillet formation at top and bottom of the dome after brazing as shown in Figure 3. The erosion behavior of Erichsen formed specimen and stretched specimen(30mmx200mm) was evaluated by micrographic observation of cross-section and measuring residual core alloy thickness. The erosion depth of filler alloy into core alloy was estimated from following Eq.2.

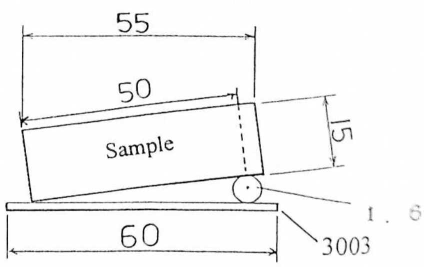
Table 2 and Table 3 shows the Erichsen formed height of specimen, stretching ratio of dropped specimen and conditions of brazing processes employed in this test, respectively.

$$\text{Erosion depth} = (CTB - CTA) / 2 \quad (2)$$

where CTB is the core alloy thickness before brazing, and CTA is the that after brazing.



Erichsen Formed Specimen



Clearance Fillability Test Specimen

Fig.3 Schematic showing test specimens

Table 1 Chemical composition and construction

Chemical composition(wt%)					Construction		
Alloys	Si	Fe	Cu	Mn	Clad Ratio	Sheet Thickness	Temper
Filler Alloy	7.50	0.20	0.00	0.00	10%	0.4 mm	O
Core Clloy	0.25	0.55	0.15	1.10	—		

Table 2 Erichsen formed height and stretching ratio

Erichsen Formed Height(mm)	Stretching Ratio(%)
4.0, 5.0, 6.0, 7.0, 8.0	0, 3.0, 7.0, 10.0 15.0

Table 3 Conditions of brazing processes

Brazing Process		Applied Flux and Quantity	O_2 concentration in atomosphere
Preheating	Brazing	KF — AlF system	
380 ℃ × 3min.⇒	610 ℃ × 2min.	3 g/m^2	100 ppm

3. RESULT AND DISCUSSION

3.1 Brazeability

Figure 2 shows the length of clearance filling of the sample No.1, 2 and 3 . The length of clearance fillability was longer in the order ;No.3, No.2, No.1, that is, the brazeability is better in the order ; No.3, No.2, No.1. On the other hand, these results varied widely, which is obtained as usual. It is considered that these scatters are unavoidable in the experimental procedure.

Photo 1 shows effect of Erichsen formed height on fillet formation of each sample, and Figure 4 shows the thickness of formed fillet which estimated from Photo 1, at top and bottom of the dome of Erichsen formed specimen after brazing. The thickness of formed fillet at top decreased with higher Erichsen formed height in every samples. The maximum critical height obtained fillet formation varied from sample to sample. The critical height of fillet formation of No.3 was 7mm and the heigest, which was the longest one of the length of clearance filling in the clearance fillability test, while that of No.1 was 4mm and the lowest, which was the shortest one of the length of clearance filling.

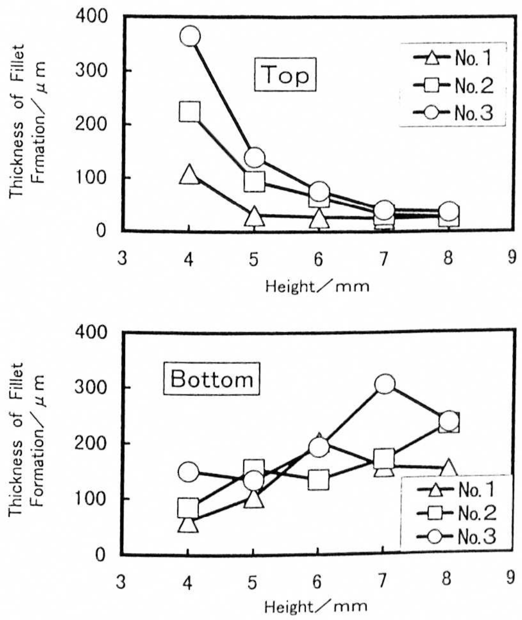


Fig.4 Effect of height of Erichsen formed on thickness of fillet formation

Furthermore, the thickness of fillet formation was thicker in the order;No.3, No.2, No.1. The reason of decreasing the thickness of fillet formation is due to increase height of Erichsen formed. That is, it is caused by increasing the value of ρ **gh** with heiger Erichsen formed height. The thickness of formed fillet at bottom increased with heiger Erichsen formed height and this tendency was same in every samples, and, the maximum thickness of the fillet was same order as the thickness of fillet at top.

Thus, evaluating the brazeability with Erichsen formed specimen was in good agreement with the clearance fillability test.

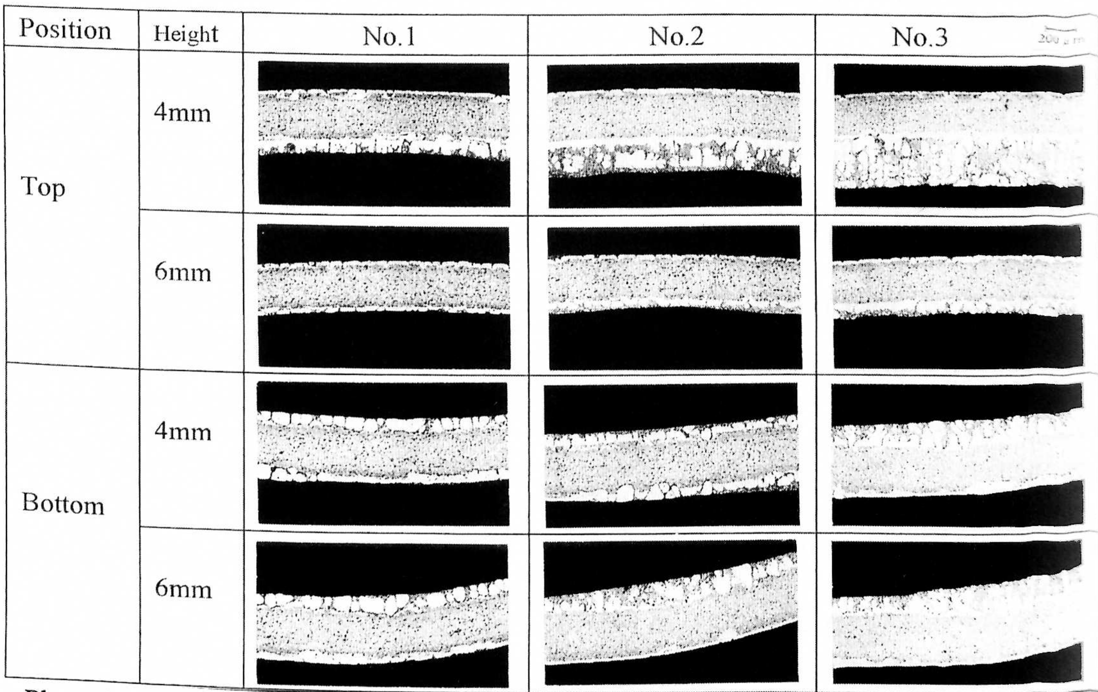


Photo 1 Effect of height of Erichsen formed on thickness of fillet formation

3.2 Erosion behavior

The relationship between Vickers hardness of stretched specimen in before brazing and the maximum erosion depth of filler alloy into core alloy is shown in Figure 5. Maximum erosion depth was observed in hardness about 40Hv, and the maximum erosion depth decreased with both increasing or decreasing hardness from this value. While, the maximum erosion depth in hardness of upper 40Hv varied from sample to sample, and the maximum erosion depth was

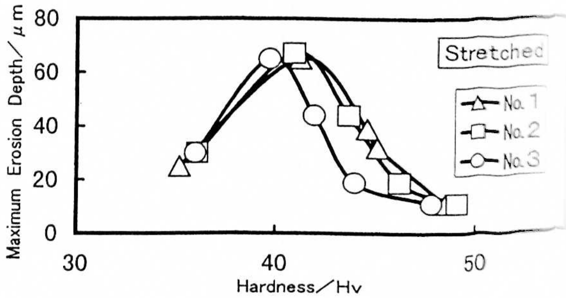


Fig.5 Relationship between Vickers hardness and the maximum erosion depth of the stretched specimen.

deeper in the order;No.1, No.2, No3.

Figure 6 shows the relationship between hardness and the maximum erosion depth of the Erichsen formed specimen and stretched specimen with sample No.1 and No.3. Relationship between hardness and the maximum erosion depth of Erichsen formed specimen was similar to that of stretched specimens one. Maximum erosion depth was observed in hardness about 40Hv, and that decreased with both increasing or decreasing hardness from this value. This result showed same manner in every sample. Here, the distribution of Vickers hardness of Erichsen formed specimen and stretched specimen was shown in Figure 7. The hardness of Erichsen formed specimen varied from position to position, and the range of hardness values include the those of stretched specimens.

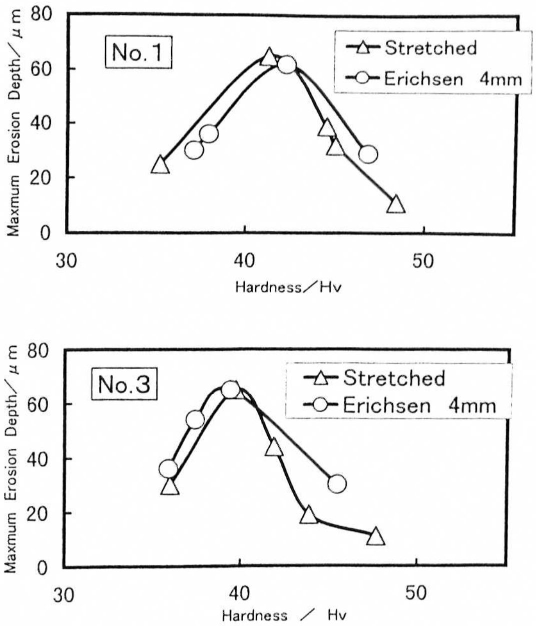


Fig. 6 Relationship between Vickers hardness and the maximum erosion depth.

Thus, evaluation of erosion behavior with Erichsen formed specimen was in good agreement with stretched specimen. That is, evaluation of erosion behavior can be carried out with single sample in Erichsen formed specimen.

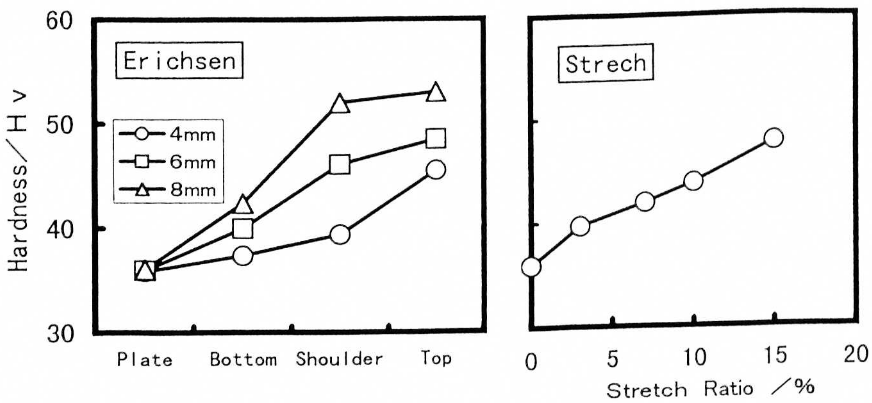


Fig.7 The distribution of Vickers hardness of Erichsen formed specimen and stretched specimen

4. CONCLUSION

Brazeability and erosion behavior of alumium brazing sheets with Erichsen formed specimen were investigated in comparison with current methods.

1) Brazeability in Erichsen formed specimen was good correlation with that in clearance fillability test, which was evaluated by measuring the thickness of fillet fomation at top of dome in.
2) Erosion behavior of Erichsen formed specimen was good correlation with that of stretched specimen too.
3) New evaluation method by using Erichsen formed specimen was confirmed as usuful method for evaluating both the brazeability and the erosion behavior of the aluminum brazing sheet with single specimen.

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