JOINABILITY OF BRASS ALLOY BY FURNACE AND MICROWAVE BRAZING

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Abstract

Comparing with conventional methods, microwave joining offers volumetric heating providing energy and time saving and enviromentally friendly processes which reduces power consumption. Brazing studies in conventional and microwave furnaces were conducted for brass alloy, in this study. Ag-306 alloy was used for brazing processes at temperature of 850 °C. After holding 10 minutes in both of furnaces, air cooling was applied all of the specimens joining by overlapping technique. The characterizations of joints had been carried out through optical microscopy, scanning electron microscopy for microstructural analysis, tensile and microhardness tests for mechanical properties.

Key Words: Brazing, Microwave joining, Furnace joining, Overlapping

1. Introduction

Many similar and dissimilar materials are joint with brazing proces which use heat, filler metal, and a flux. Even if melting temperatures of filler metals are below the melting temperatures of the workpieces, the melting temperature of the filler metal is different for joining process. Brazing process takes place above 840º F / 450 º C [1]. Brazing process is important for permanent joining, especially in electronic industry.

Conventional methods including blast furnace, induction furnace, electric arc furnace and crucible furnace for brazing waste a large amount of energy; therefore, microwave processing was introduced as a novel technique [2, 3]. Microwave furnace provides homogeneous heating where the energy is directly transferred to the material by electromagnetic field generated from electromagnetic waves with wavelengths range 10^3 to 1 mm and corresponding frequencies range 300 MHz to 300 GHz. Conversely, the material is heated nonhomogeneous where thermal energy is conducted from surface to the center which results in undesirable thermal gradients, in conventional furnace. Since microwaves provide volumetric heating there are several advantages of microwave furnaces such as high heating rate, shorter processing time, and low power consumption, manufacturing cost reduction and less environmental hazard [4, 5].

We have already carried out investigations on conventional and microwave joining methods of brass alloy. Both methods were applied for brazing in this study.

2. Experimental

Before joining, mechanical, chemical and ultrasonic cleaning were applied to the specimens. After grinding with emery paper of 120 grids, the specimens were immersed in nitric acid solution (65%) at room temperature for removing oxide layers then were rinsed in cold water and subsequently dried. Finally, ultrasonic cleaning were applied to the specimens in ethanol for 10 min.

Overlapping technique shown in Figure 1 was applied for brazed joints. The bulk plates of dimension 40 × 20 × 1 mm with a gap of approximately 0.4 mm were used for joining. The gap was filled with filler metal, powdered flux (dekapan), before joining. Overlap length was chosen as 6 mm in order to obey the "3t to 6t rule", where "t" is the thickness of thinnest of the two sheet metal pieces being brazed together [6].

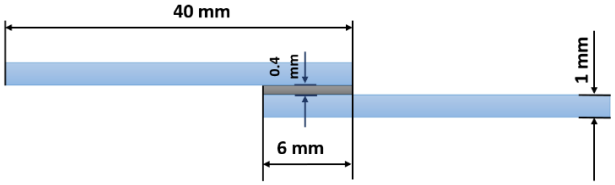


Figure 1. Schematic representation of overlap joining

Heraeus-KR 170 conventional and HAMILab-DS1500 microwave furnaces were used for joining applications. The filler metal was a Ag-306 alloy (30% Ag, 28% Cu, 21% Zn, 21% Cd) while the working temperature was 850 °C for brazing process. The furnace was heated to the desired temperature that takes 2 hours and then specimens were placed and held for 10 min, for conventional process. On the other hand, microwave furnace was heated with the specimens to the intended temperature simultaneously in 10 min and the specimens were held at this temperature for 10 min. Then the specimens were cooled to room temperature in the normal atmosphere.

Microstructure analyzes were done with Leica DM5000M optical microscope and Jeol JEM 6060 LV scanning electron microscopy (SEM). Elemental compositions were measured in IXRF (Integrated X-Ray Flourescence) system. Shimadzu HMV-2 Vickers Hardness Tester with HV0.025 was used for microhardness test analyzes. Tensile strength of the joints was evaluated by an Instron 3369 Universal Test Machine as per ASTM standard (ASTM Designation: E8/E8 M – 09, 2009).

3. Results and Discussion

Optical and SEM images of both conventional and microwave brazing at 850°C with different magnifications are given in Figure 2. Optical microstructures clearly indicate the integration of base metal and braze alloy in both of brazing methods. However, the difference in between is the solidification rates. Since microwave furnace heat a material faster, rapid solidification occurs, and hence the obtained microstructure in microwave furnace has thinner network structure than that of in conventional furnace.

The points on which EDS analysis were carried out are given in Figure 2 and Table 1 shows the average elemental compositions for both of conventional and microwave brazing. Point 1 and 2 stand for the base metal and interface, respectively. According to the result of EDS analysis, Ag and Cd were diffused from brazing alloy into the base metal. Furthermore, point 3 and 4 represent

different regions of the brazing alloy. In the grain boundaries which point 3, Ag and Cd elements while grain which consist of mostly Cu and Zn elements.

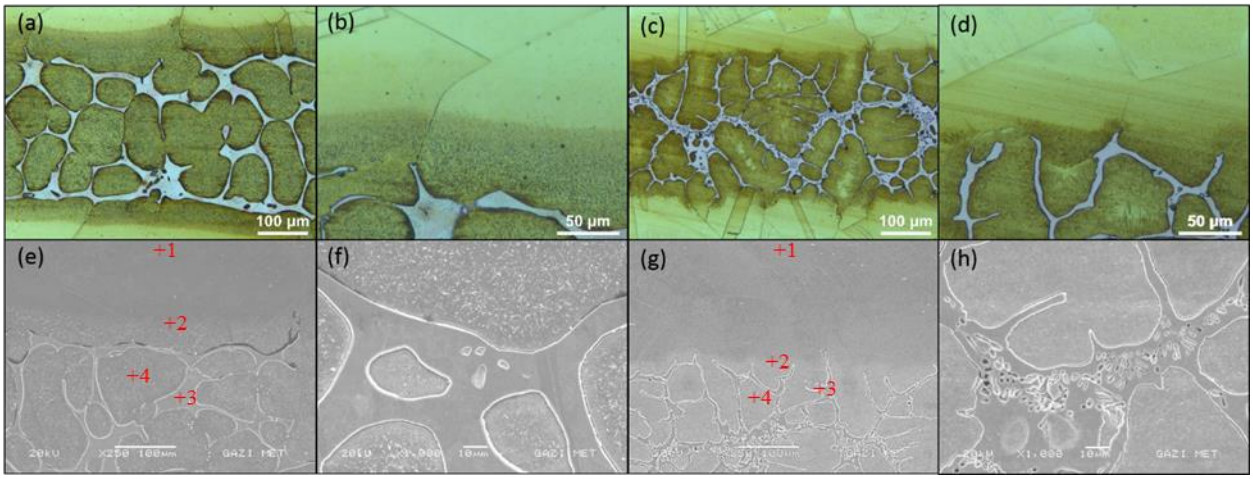


Figure 2. Optical micrographs of brazing in conventional furnace at (a) 200X, (b) 500X and in microwave furnace at (c) 200X and (d) 500X. SEM micrographs of brazing in conventional furnace at (e) 500X, (f) 1000X and in microwave furnace at (g) 500X and (h) 1000X.

Table 1. The results of EDS analysis for base metal, interface and brazing allloy.

Elements	1	2	3	4
Cu	71.7885	66.5845	2.0145	60.242
Zn	25.0595	25.7405	1.8675	26.3175
Ag	2.133	5.8425	64.709	11.5455
Cd	1.0415	1.8335	31.409	1.895

In the tensile tests, both specimens fractured in base metal and it shows that both brazings successfully joined the brass alloy (Figure *4*). The results of tensile test is given in Figure *3* .The plots showed that yield point for conventional and microwave brazing are 41 MPa and 78 MPa; tensile strengths are 226 MPa and 225 MPa; elongations are 119 % and 80 %, respectively. Both specimens showed similar tensile stresses but different elongations. Additionally, hardness results showed that microwave brazing was harder than furnace brazing resulted from solidification and microstructure differences.

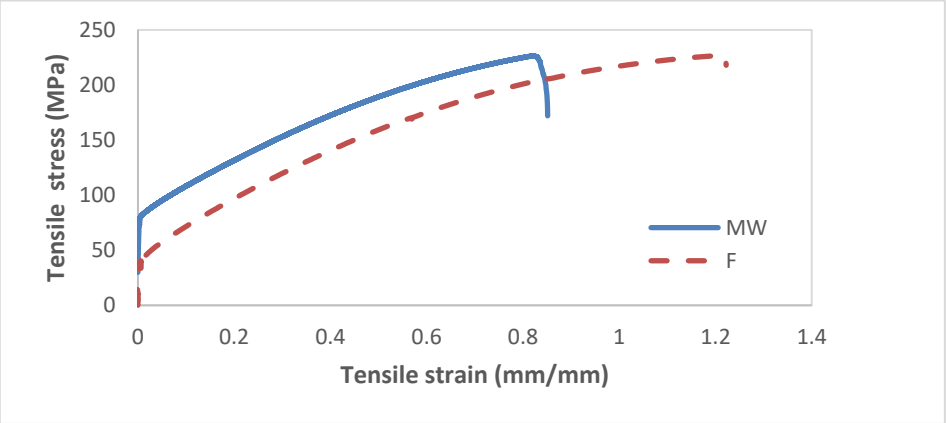


Figure 3. The tensile stress-tensile strain plot of brazed joints in conventional and microwave furnace.

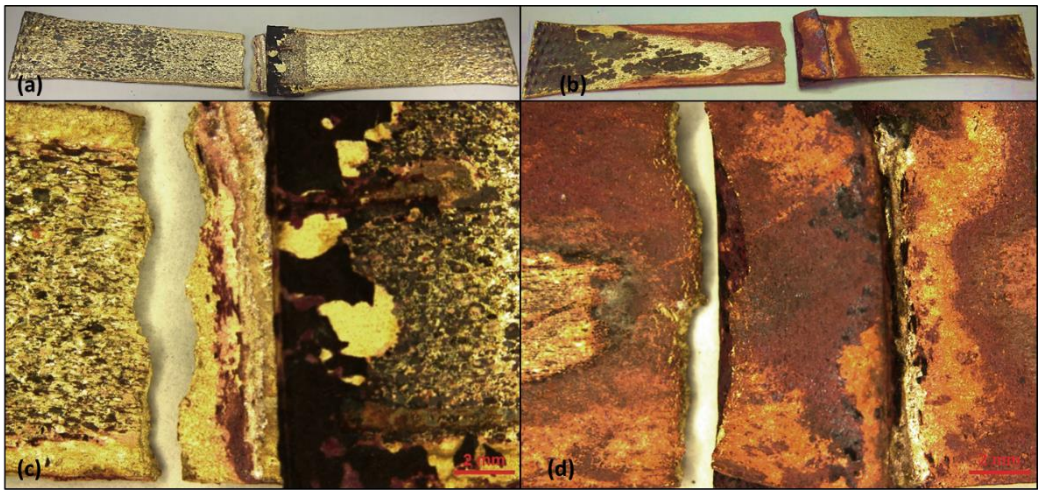


Figure 4. Macrographs of tensile fracture of brazing in conventional furnace at (a) and (c); in microwave furnace (b) and (d).

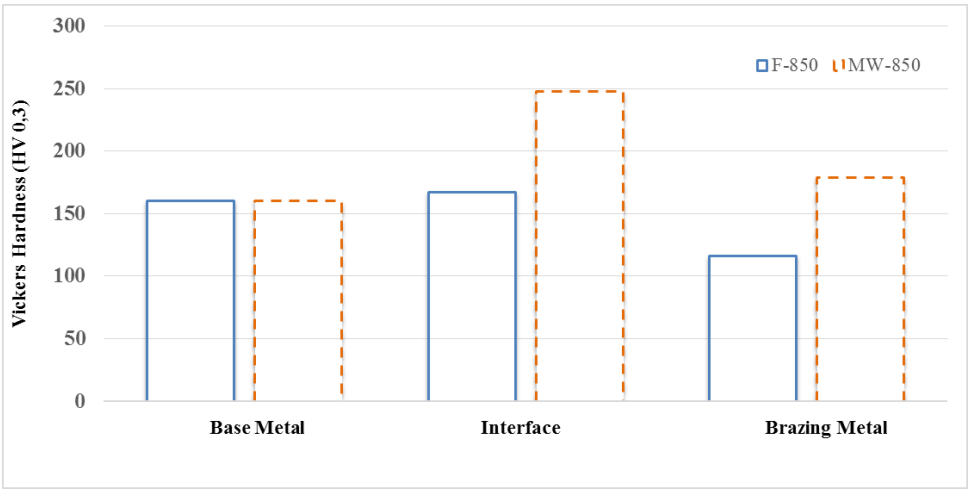


Figure 5. Microhardness values of base metal, braze and interface between them for conventional and microwave furnace.

Vickers microhardness values for conventional and microwave methods are 148 and 180 in base metal, 167 and 248 in the interface, 116 and 179 in brazing alloy, respectively. Since microwave brazing has dendritic like solidification, it has harder structure than conventional brazing. Similarly, as Figure *3* is seen, furnace brazing is more ductile than microwave brazing. On the other hand, due to diffusion of Ag and Cd elements from brazing metal into the base metal as seen in Figure 2, the hardness values of interface is higher than other two regions due to dispersion. Furthermore, the microhardness values of base metal and brazing metal are coherent with the literature [7, 8].

4. Conclusion

The joinability of brass alloy by conventional and microwave brazing have been studied, in this study. The results are:

- Brass alloy can be brazed successfully by conventional and microwave furnace.
- Brazing alloys showed different microstructure. Conventional brazing has regular grain structure while microwave is dendritic like grain structure.
- Ag and Cd diffuses from the brazing alloy into the base alloy.
- Both of the joinings fractured in base alloy.
- Both brazing has similar tensile stress but microwave has higher elongation percentage.
- Hardness values of microwave brazing is higher than furnace brazing.
- Microwave brazing time is shorter than furnace brazing.

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