§14. Brazing-test of Cu Alloys to W by Using Three Kinds of Filler Materials

Tokitani, M.,
Masuzaki, S., Hirooka, Y., Muroga, T., Sagara, A.

The divertor armour material of the helical reactor is considering of tungsten monoblock because tungsten has important advantage for low hydrogen isotope retention, low sputtering yield. However, material selection of the cooling pipe and bonding technique between armour and pipe is currently under investigation. In the ITER case, copper alloy (CuCrZr) pipes are supposed to be joined by a brazing technique with Nicumu37 (Cu52.5%, Mn38%, Ni9.5%) filler material. This combination is not completely optimized for future fusion reactors, because the toughness of the CuCrZr at a high temperature over 450 ˚C is dramatically decreased by increasing the temperature. Under such a situation, another candidate Cu alloy is an oxide dispersion-strengthened copper alloy (ODS-Cu) such as GlidCop®. If the GlidCop® is selected for future fusion reactors, the filler material of Nicumu37 might not be able to be used for keeping a reliable brazing condition during an entire operation period. In this study, therefore, reliable brazing combination between "two kinds of Cu alloys" and "three kinds of filler materials" were investigated from a viewpoint of fracture toughness.

The size of the tungsten and Cu alloys are 30×30×18 cm^3 and 30×30×38 mm^3, respectively. 30×30 mm^2 surfaces are the brazing surface. The selected Cu alloys for this experiment are the CuCrZr and the GlidCop®. For the case of the GlidCop®, since the grains were elongated along the cold working direction, two kinds of block were extracted from the ingot. The first kinds of blocks were that they have a grain elongated perpendicular (⊥) to a brazing surface; others have a parallel (∥) to a brazing surface. The selected filler materials and their chemical compositions to be tested are summarized in Table 1. Brazing procedures were carried out in the high-vacuum furnace at the Metal Technology Co. Ltd. Since the temperature of the solid and the liquid phases are different each filler materials, two types of heat treatment procedures were selected as shown in Fig. 1.

After the heat treatment procedures, the brazed blocks were fabricated to be the small size specimens with the size of 36×5×1.5 mm^3. Then, a three point bending test was carried out by using the SHIMAZU Autograph in Okayama University of Science. Fig. 2 shows the stress-strain curves of the three point bending test for the nine combination patterns of the Cu alloys and the filler materials. Since the five specimens were prepared for one combination, there are five stress-strain curves in one combination. In the case of the No. 2 and 4, specimens were not able to be fabricated due to the fracture of the tungsten after the brazing. This might have been caused by any internal stress induced in the tungsten blocks. On the other hand, in the case of the No. 8, brazing was completely failed.

Therefore, the details of the discussions about the brazing toughness can be possible by the remaining six specimens. In the case of MBF-20, fracture stress was quite low as around 50 MPa and 100 MPa for the CuCrZr and GlidCop®, respectively. This means that the quality of the brazing was bad. In the case of the Nicumn37, the fracture stress was reached to ~200 MPa in the CuCrZr, while, in the case of GlidCop®, it was decreased to ~150 MPa, or completely failed of brazing. It seems to indicate that some chemical component, for example Cr in the CuCrZr might have acted as the effective intermediate object for the good brazing. Therefore, Nicuman37 would not be able to use in GlidCop®. The most superior fracture toughness among the three filler materials was BNi-6 in GlidCop® (⊥).Since the mechanical properties such as yield strength and high temperature toughness of GlidCop is more superior than that of CuCrZr, combination between BNi-6 and the GlidCop should be selected for a current candidate method of the brazing. However, since the fracture point of the No. 5 case in Fig. 2 was located on the tungsten bulk region where just away from the brazing point less than 1 mm, we were not able to get the absolute value of the brazing toughness of BNi-6. Therefore, further investigations are necessary for evaluating the absolute value of the brazing toughness of BNi-6. After that, we would be able to design the component.

Filler materials	Solid phase point	Liquid phase point	Cr	Cu	Mn	Ni	P	Si	Fe	B
MBF-20	969˚C	1024˚C	7			83		4	3	3
BNi-6	875˚C	875˚C				89	11			
Nicuman37	880˚C	925˚C		52.5	38	9.5				

Table 1. Chemical composition of the selected filler materials used in this study.

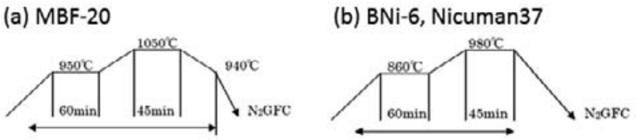

Fig. 1. Procedure of the heat treatment of (a) MBF-20 and (b) BNi-6 and Nicuman37 filler materials.

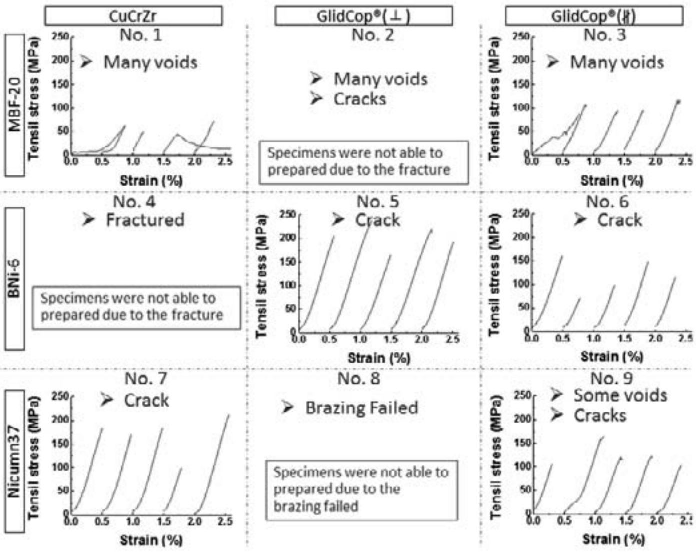

Fig. 2. Stress-strain curve of the three point bending test of the brazing point for the nine combination patterns of the Cu alloys and the filler materials.