§55. Evaluation of Thermal Shock Resistances for a Bonding Material of C/C Composite and Copper as a Divertor for the LHD

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A purpose of this study is to contribute to the safety design and the development of high performance plasma facing components. A bonding material consisting of a carbon fiber reinforced carbon composite (CX-2002U) bonded to oxygen-free copper (Cu) and incorporating an interlayer plate of molybdenum (Mo) was developed for high bonding strength and homogeneous thermal conductivity[1]. The thermal shock resistances has been reported previously[2]. In this study, the specimens were heated by electron beams of the Active Cooling Teststand (ACT). The dynamic hardness test was performed and the microstructures were examined by Scanning Electron Microscope (SEM) and X-ray Micro Analyzer (XMA).

Fig. 1. shows the parameter B which is a slope of a curve of relation between ratio of load to depth and depth on loading in the dynamic hardness test and is known to be proportioned to strength of the material. The temperature of the specimen raised up to 500℃ once by the electron beam heating. The parameter B increases suddenly at the layer of molybdenum (Mo) and iron (Fe) as before heating. One of the reasons is considered to form intermetallic compounds or alloys of Mo with Fe. In the brazing layer of Cu block and Mo plate, small thermal cracks perpendicular to the layer and small delamination cracks were observed and the parameter B decreases a little in the area.

Fig. 2. shows the parameter B in the dynamic hardness test for the specimen heated eleven cycles from 70℃ to 650℃ that is near the temperature of silver brazing. The parameter B increases suddenly at the brazing layer of Cu block and Mo plate. The area is Mo-rich layer containing Fe. As the same as the above, intermetallic compounds or alloys of Mo with Fe is considered to be formed. In the brazing layer, a large delamination crack was observed at -1.09mm distance from the boundary of Mo plate and CX-2002U block. At the both sides of the crack, parameter B scatters and decreases a little because of releasing of residual stress in the bonding process.

The bonding material did not fracture by electron beam heatings, however, thermal and delamination cracks propagated in the brazing layers and intermetallic compounds or alloys of Mo and Fe was considered to be formed. Therefore, it is considered to need to study and to develop further the methods of brazing.

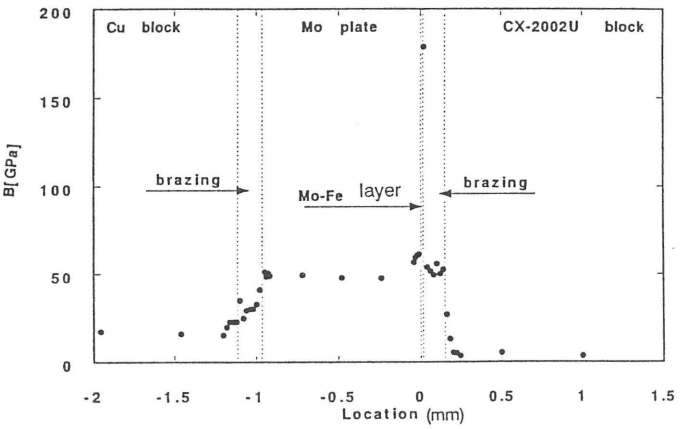

Fig. 1. Parameter B of the bonding material after electron beam heating up to 500℃ once.

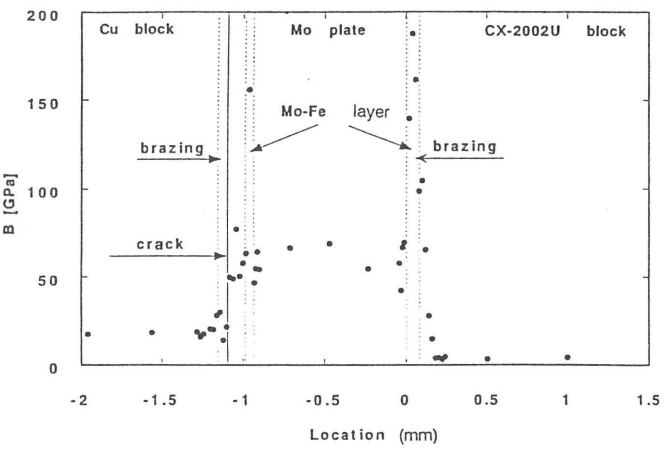

Fig. 2. Parameter B of the bonding material after eleven cycles of electron beam heating from 70℃ to 650℃.

References

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2) Kurumada, A., Oku, T. et al., The Collaboration Report of NIFS (1994).