§38. High Heat Flux Tests of Real Size Mechanically-joined Materials for Divertor Plates of LHD

Kubota, Y., Noda, N.

As described in the report[1], the thermal property of compact size mechanically-joined material can be improved drastically using a thin carbon sheet at the interface(between graphite tile and copper plate) of the material. Expecting the effect, thin carbon sheets were applied to the real size mechanically-joined materials as a compliant sheets.

Several types(type 1-6) of real size mechanically-joined materials for divertor plates of LHD have been constructed, and the thermal properties have been evaluated using a high heat flux test stand with a 100 kW electron beam gun called ACT[2]. These materials consist mainly of a graphite tile, carbon sheet, and copper backing plate with a cooling pipe, which are tightened with some bolts for type 1-4 and with two cramps for type 5,6. Fig.1a-b show the cross-sectional views of type 1 and 6 for the examples.

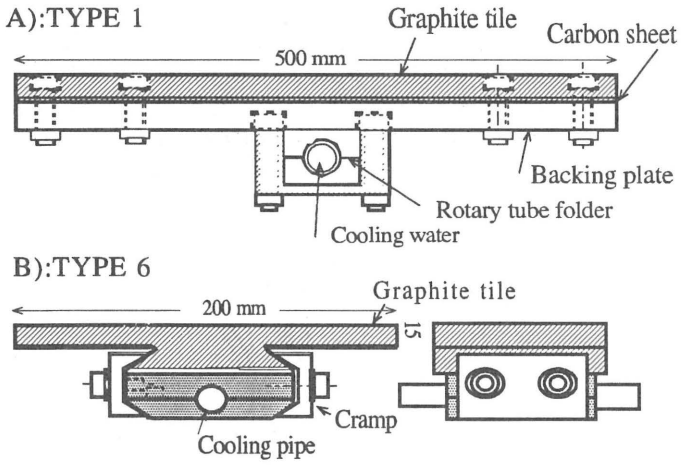

Fig.1 Cross-sectional views of real size mechanically-joined C-Cu materials for divertor plate. A): type 1, B): type 6.

The mechanical and thermal properties of these materials have been evaluated. First, the contact pressure distribution at the interfaces between graphite tile and copper plate of these materials were measured with pressure-sensitive films called prescale. The results obtained for type 1-4 showed that there is no large effect of thin carbon sheet as a compliant sheet, which differs from the results with the compact size mechanically-joined materials except near fixing bolts. This result comes from the ratio of distance(bolt to bolt) to thickness of the tile and copper plate. However, for the materials of type 5-6, there is the useful effect of carbon sheet because of low ratio of distance to width.

Second, thermal properties of these materials have been evaluated with temperatures(Ts, Tu, Tl) at the tile surface, upper jointed region and lower jointed region of the materials measured by an optical pyroscope and two thermo-couples. High heat flux tests of these materials have been carried out under heat fluxes of up to 3 MW/m^2 and cooling water flow rate of 8.5 m/s. Then beam irradiation area on tile surface is defined 5×9 cm^2 with a beam limiter made of copper/carbon mechanically-joined plates with a groove.

Fig.2 indicates the temperature differences Tu-Tl versus the heat flux for type 1-6. Low temperature difference means high effective thermal conductance at the jointed surface of the material.

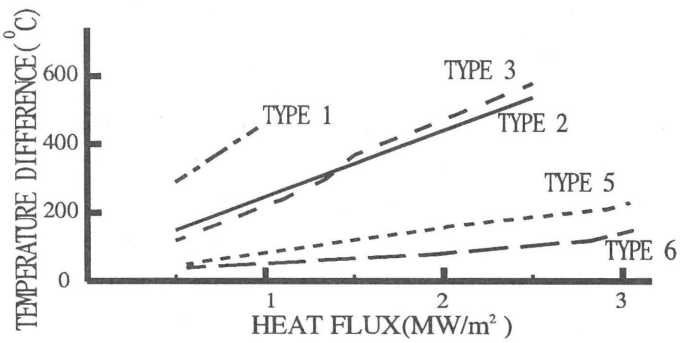

Fig.2 Temperature differences Tu-Tl versus the heat fluxes for type 1-6.

The constructions of the former types(type 1-4) are very simple. However, the effective thermal conductivity is low compared to that of the later types and there is a large thermal stress between the graphite tile and copper backing plate because of different thermal expansion rates. On the other hand, the later types(type 5,6) have a good thermal conductance and less stress at the tile and plate.

References

1)Y.Kubota, N.Noda, A.Sagara, et al., NIFS Internal Report, NIFS-MEMO-16(1995).
2)Y.Kubota, N.Noda, A.Sagara, et al., NIFS Internal Report, NIFS-MEMO-13(1994).