§49. High Heat Flux Tests of Mechanically Jointed Divertor Plates Designed for LHD

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The maximum heat flux on the helical divertor plate of LHD in the first step is estimated to be 5 MW/m^2 and 0.75 MW/m^2 for 10 s operation mode and steady operation mode, respectively. To develop divertor plate which can be used under such high heat fluxes, some kinds of mechanically jointed divertor plates(MJDP) have been fabricated and tested using a mechanical vibrator and a heat flux test stand with a 100kW EB source called ACT[1]. The vibrator was used to evaluate the mechanical properties of the divertor plates. The MJDP basically consists of an iso-graphite tile, a water cooling pipe, and a pair of backing plates, which are assembled and fixed with some bolts as shown in Fig.1. Thin carbon sheets called CARBO FIT or PERMA FOIL

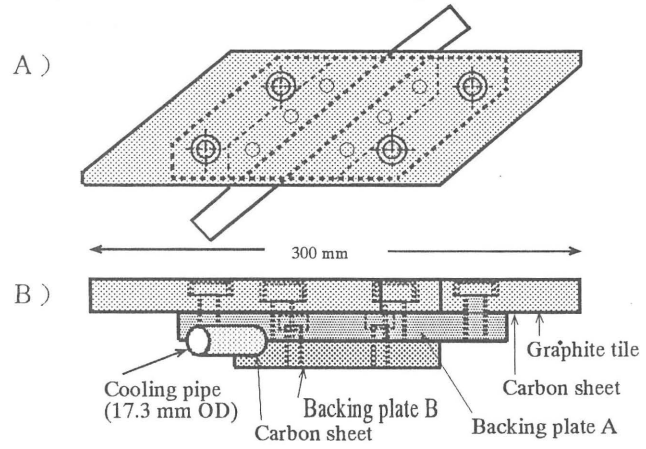

Fig.1 Construction of MJDP designed for LHD.

is used as a compliant sheet between the graphite tile and the upper backing plate, and between upper backing plate and a cooling pipe to improve the heat transfer efficiency at the interfaces. The effect of the compliant sheet was reported previously[2,3]. The thermal properties of the plate are evaluated by measuring Ts,Tu, and Tl, which are the temperatures at surface of the tile, bottom of the tile, and top of the backing plate, respectively. For the optimization of construction and condition of MJDP, steady state heat loading tests have been carried out under heat fluxes up to 1.4MW/m^2 as parameters of ①thick-ness of the sheet and graphite tile, ②size and number of the bolt, ③material and size of the backing plates, ④material and surface roughness of the cooling pipe, and ⑤bolt torque for fixation.

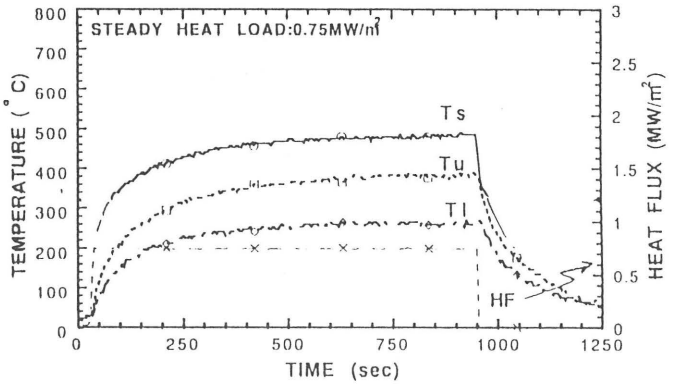

Fig.2 Typical thermal responses of MJDP under a steady heat flux of 0.75 MW/m^2.

Fig.2 shows typical thermal responses of the MJDP under a heat flux of 0.75 MW/m^2 and a water flow rate of 8.5 m/sec. Ts, Tu, and Tl increase gradually with the loading time. However, they nearly saturate after about 500 seconds. The surface temperature of the tile is less than 600 ℃ even at 1000 sec. The set of test results indicate that the thermal properties of the MJDP depend largely on the holding structure of the cooling pipe with two backing plates and material of the cooling pipe, and the improved MJDP can be used up to 1.2 MW/m^2 using a copper cooling pipe and up to 0.8 MW/m^2 using a stainless steel pipe. However, low cost, easy installation into vacuum vessel, maintenance free, and high reliability are also required for the MJDP of LHD. To apply to the divertor plates of LHD, more improvement of the MJDP must be done.

In order to ensure the mechanical safety of the MJDP assembled with some bolts, vibration loading tests have been carried out with an air compressor which ables to generate strong hybrid vibrations with an amplitude of $1m/s^2$ and frequencies of 160Hz and 1000Hz. The mechanical vibrations were applied through the cooling pipe of the MJDP for 75 hours. However, no damage of tile, no looseness of the bolts, and no slipping of the cooling pipe against the backing plates were observed during the test.

References

1)Y.Kubota, N.Noda, et al.: NIFS-MEMO-13(1994).
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3)Y.Kubota, N.Noda, A.Sagara, et al.:to be published in a special issue of Vacuum(1996).