§12. Evaluation of Material Damages Due to High Heat Flux and Divertor Cooling Characteristics

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A purpose of this study was to evaluate the material damages and the cooling characteristics due to local and transient high heat fluxes to the divertor plate for the Large Helical Device (LHD). Particularly, we evaluated thermal fatigue properties and the heat flux of burnout that couldn't be carried out by the Active Cooling Teststand (ACT). And the microstructures and the mechanical properties of plasma facing materials were also examined.

A deflection-type electron beam heating apparatus, that the maximum power was 30kW and cyclic and short pulse heating tests were possible, was designed and manufactured. And the divertor model specimens of plasma facing components were also manufactured and the material damages and the cooling characteristics were examined quantitatively. [12] And then the integrity of the metallurgical joint of the divertor and the characteristic change of the joining part were evaluated.

Fig. 1 shows the total system of the deflection-type electron beam heating apparatus manufactured in this study. The apparatus was constructed mainly the power source, the beam controller, the vacuum chamber, the cooling and the data processing systems. The merit of this apparatus was to have two targets for the beam irradiation, so cyclic heat load tests were possible by the mobility of electron beam irradiation.

Fig. 2 shows the carbon divertor model specimen manufactured in this study. A C/C composite (CX-2002U made by Toyo Tanso co., ltd.) as an armor material was joined metallurgically with oxygen free copper having a cooling pipe by a titanium foil of 0.05 mm in thickness. For the divertor model specimen, thermal response and cyclic heat load tests were carried out as one cycle of 10 sec irradiation and 15 sec interval. In the heat load tests, temperatures of the surface and the joining parts were measured at the conditions of various heat fluxes, different thickness of the armor tile and various water coolant speeds. The cyclic heat load tests were performed up to 1000 cycles on various heat fluxes.

Consequently, the useful testing apparatus for plasma facing materials could be constructed and the joining process of the C/C composite material was established in this study. The temperatures of the carbon divertor model specimens increased linearly with increasing of the heat flux and were almost constant during 1000 cyclic heat load tests. The good integrity of the carbon divertor model specimen was confirmed up to 1000 cyclic heat loads of 12 MW/m^2 and about 2000 degrees C. These results were useful knowledge for the safety design and the life estimation of the high performance plasma facing components.

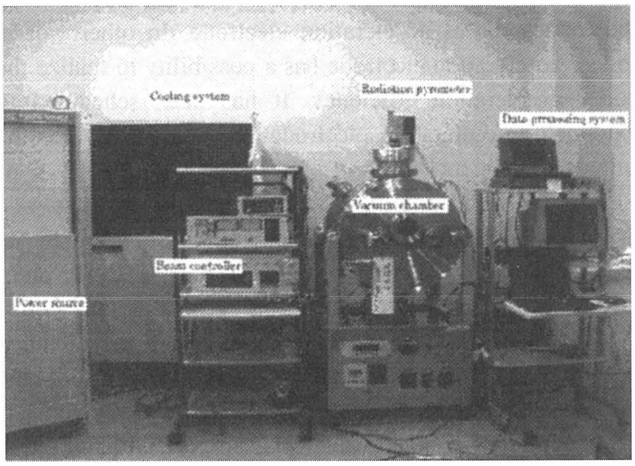

Fig. 1 Deflection-type electron beam heating apparatus.

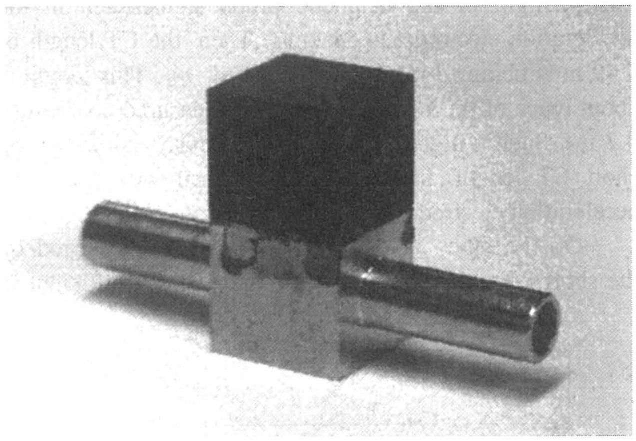

Fig. 2 Carbon divertor model specimen.

References

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