§14. Evaluation of Cooling Performance and Material Damage of a Divertor Due to High Heat Flux

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A purpose of this study was a development of a divertor with an excellent integrity since a divertor plate of the LHD is exposed to local and rapid high heat fluxes. Steady state cooling performances, changes in surface structures, thermal and mechanical properties of the divertor mock-up were measured. In particular, fatigue life limits and the burnout heat flux due to thermal shocks were evaluated. A relationship between the properties and the burnout heat flux was studied, and these results will be useful to evaluation of the life limit and to development of the divertor plate.

A deflection-type electron beam heating apparatus with a 15kV-2A maximum power was designed and manufactured for cyclic and short pulse heating tests. Fig.1 shows the deflection-type electron beam heating apparatus. A divertor mock-up of plasma facing components with a cooling structure was also manufactured, and the burnout heat flux was evaluated quantitatively for various cooling conditions and structures. And then changes in thermal and mechanical properties of the joining boundary were measured and the integrity of joining parts of the divertor mock-up was confirmed.

The cyclic and short pulse heating tests were carried out on the divertor mock-up up to 15 MW/m^2. The surface temperature of a C/C composite and the temperatures of upper and lower parts of the joining boundary were measured. Fig.2 shows the relationship between the temperatures mentioned above and the shot number of a cyclic heat load of 10 MW/m^2. Those temperatures were constant during the cyclic heat load test, therefore, the integrity of the joining parts was confirmed under 10 MW/m^2. Fig.3 shows the surface damage of the divertor mock-up. In the case of a heat load of 10 MW/m^2, the integrity of surface structure of the C/C composite was confirmed, though the surface erosion was observed in the case of 15 MW/m^2.

It is necessary to select an adequate material and a structural design for the divertor in steady state operations of the LHD. These results obtained in this study will contribute to the design and the evaluation of the life limit of the divertor plate for the LHD.

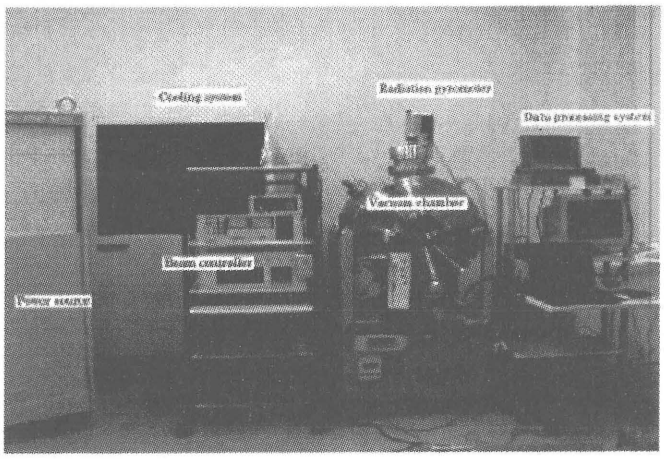

Fig.1 Deflection-type electron beam heating apparatus.

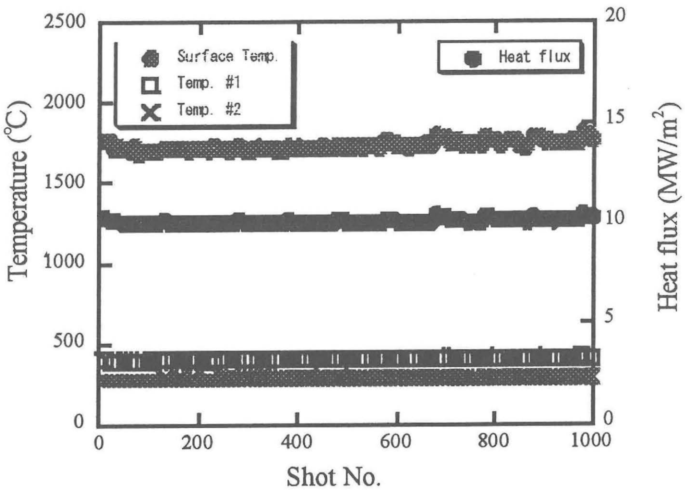

Fig.2 Relationship between the temperatures of a mock-up and the shot number of a cyclic heat load of 10 MW/m^2.

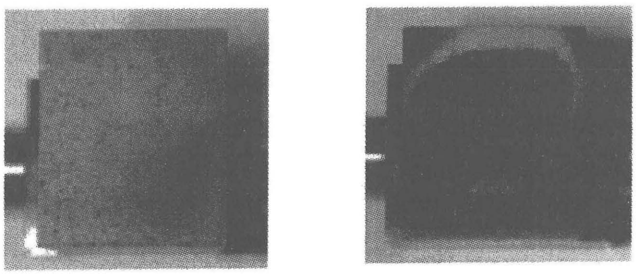

Fig.3 Surface damage of the divertor mock-up.

These results were presented at the Japan/US workshop on HHFC and PSI for Next Fusion Devices (2000.11.6-9, Osaka), at the RIAM forum 2000 (2000.6.1-2, Kyushu University) and at the 3rd joint meeting of PSI (2001.2.15-16, Kyushu university).