§2. Development and Temperature Control of Ceramics Divertor Plates

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Ceramics (SiC/SiC composites, B_4C and others) are expected to be used as an armor tile material of divertor plate for the LHD during long pulse operations because of the low chemical sputtering. In this study, divertor plate model specimens made of SiC/SiC composite materials were manufactured as one of the plasma facing components having high performances. And the integrity of the divertor plate model specimens was tested by a deflection-type electron beam heating apparatus.

SiC/SiC composite materials tested in this study were HINICALOCERAM and NICALOCERAM made by Nippon Carbon Co., Ltd., and A-2-200 which made by Polymer Infiltration Process method (PIP) using the HI-NICALON SiC fiber by Ube Industries, Ltd..

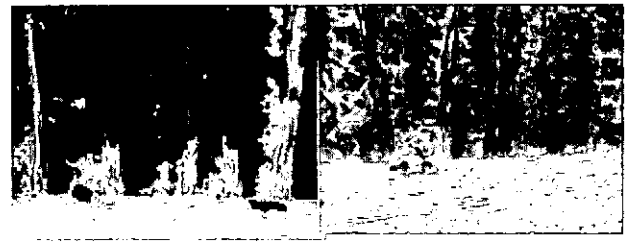
SiC/SiC composite materials from 4 to 10 pieces (20x2-5x5 mm) were joined with an oxygen-free copper block (20x20x20 mm) having a cooling pipe (7 mm in inner diameter, 10 mm in outer diameter and 70 mm in length) after polishing and acetone washing. Titanium (0.05 mm in thickness) and copper (0.01 mm in thickness) foils were used for their joining, and a molybdenum plate (0.5 mm in thickness) was inserted for a relaxation of thermal stresses. The joining specimens were held for 30 minutes at 1000 degrees C in a vacuum of $1x10^{-5}$ Torr. [1-3]

In heat load tests, heat fluxes from 1 to 6 MW/m^2, that one cycle was 10-sec irradiation and 15-sec interval, were irradiated to the divertor plate model specimens by a deflection-type electron beam heating apparatus. The water coolant speed was 15 l/min at 15 degrees C. And the shear strengths of the joining parts were measured and the microstructures were observed by SEM before and after heat load tests.

Fig. 1 shows entering conditions of eutectic alloy to SiC/SiC composite materials. In the cases of the porous HINICALOCERAM and NICALOCERAM, copper-titanium eutectic alloy entered to pores in the materials more than that of the dense A-2-200. So their shear strengths were higher than that of the A-2-200.

By insert of a molybdenum plate, cracks due to residual thermal stress weren't observed at the joining part and the shear strength of the joining interface increased. So good joint of the SiC/SiC divertor plate model specimen was confirmed.

Fig. 2 shows SiC/SiC divertor plate model specimen after heat load tests. The surface temperature of the SiC/SiC composite material increased abruptly with increasing heat flux, and the surface eroded remarkably. The distribution of surface erosion corresponded to that of heat flux. And fine thermal cracks were observed in the matrix of SiC/SiC composite materials.



(HINICALO., NICALO.) (A-2-200)

Fig. 1 Entering conditions of eutectic alloy. (x100)

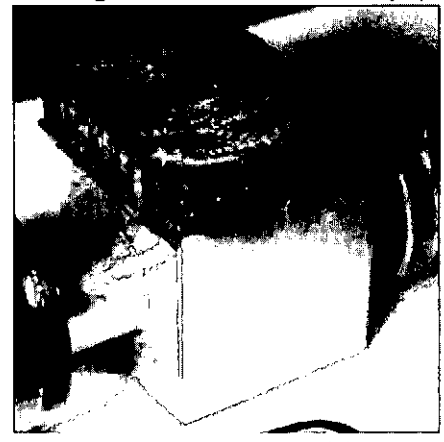


Fig. 2 SiC/SiC divertor plate model specimen after heat load tests.

Consequently the joining process of SiC/SiC composite materials was established, however, SiC/SiC composite material was necessary to be improved the thermal conductivity, fracture toughness and the resistance to erosion as the next step task. These results were useful knowledge for development of ceramics divertor plates having high performances.

References

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