§39. Research and Development of Plasma Facing Components for LHD

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To develop and prepare reliable plasma facing components for LHD, high heat flux tests of various kinds of materials have been carried out since 1991 by using an electron beam test facility called ACT[1], which consists of a 100 kW electron gun, vacuum vessel, and cooling water pumping system as shown in Fig.1.

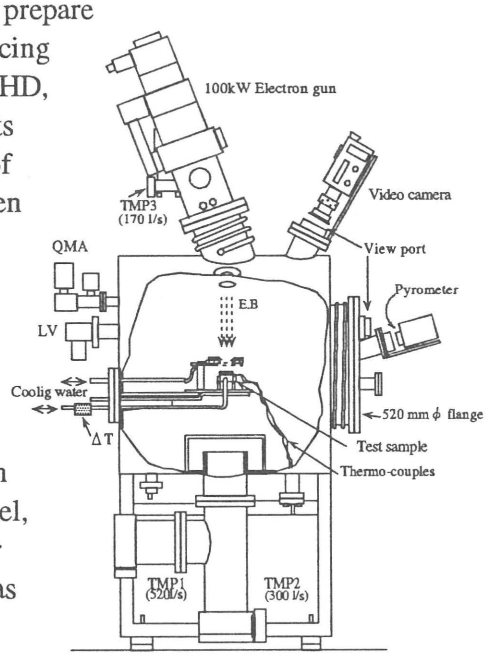

Fig.1 Electron beam test facility ACT

The materials tested by ACT in the last physical year are some kinds of C-Cu brazed materials, mechanically-contacted C-Cu materials, and B_4C coated C/C composites. The test results are as follows.

① Thermal fatigue tests of F/CC(flat plate type C-Cu brazed material with C/C composite armors) were performed up to 1000 thermal cycles under a heat load of 10 MW/m^2 and 803 thermal cycles under 12 MW/m^2, total of 1803 cycles. No damage or no large change in the thermal properties of the material was observed after the thermal cycles tests.

② High heat loading test of M/CC(monoblock type C-Cu brazed material with C/C composite armors) was carried out without any troubles under heat loads of 5-14 MW/m^2 and a cooling water flow rate of 8.5 m/s. The heat load of 14 MW/m^2 is the highest one in the heat load tests performed ever at ACT. The high heat loading test of brazed material under up to 20 MW/m^2 is scheduled in 1994.

③ For the evaluation of thermal shock resistance in a coated surface, electron beam irradiation tests of B_4C coated materials were performed under heat loads of up to 10 MW/m^2 for period up to 5 sec. As a base material, C/C composites CX2002U without a water cooling channel was used. The surface temperature of the material reached near 2000 ℃ during electron beam irradiation. However, no damage and no crack on the coated surface of about 100 μm in thickness was observed after the test.

④ Some kinds of mechanically-contacted C-Cu materials for divertor plate of LHD have been designed as shown in Fig.2, and four types(A-D) of the materials were actually constructed to evaluate the thermal properties. The type(A) made of a carbon plate and copper heat sink connected with molybdenum bolts is more simpler for the construction compared to the others, which is useful for the fabrication cost and maintenance as change of armor tile. On the other hand, the type(B-D) of the materials are complex compared to the type(A). However, strong cooling effect can be expected due to the wide contacted area at the boundary of carbon armor and copper sink. High heat loading tests have been carried out under heat fluxs of 5-13 MW/m^2 for these four mechanically-contacted materials. A set of the test results indicated that type C and D of materials with C/C armors have better thermal properties than we expected from the construction. More systematic evaluation studies for the mechanically-contacted materials will be performed in 1994.

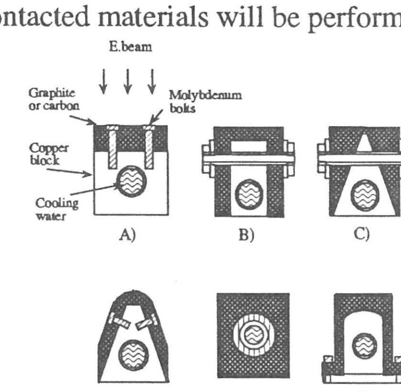

Fig.2 Cross-sectional views of mechanically-contacted C-Cu materials.

Reference

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