§15. Development of Steady State Operation of ICRF Fast Wave Loop Antenna for the LHD

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The fast-wave loop antenna for LHD is planned to be used as the steady state heating tools. The development program was started in 1993[1)]. In the test stand, high voltage and long pulse operation had been tested by using the realistic R&D antenna. Due to the low loss and high VSWR circuit, the high voltage and high current test was carried out by the relatively low RF power of lower than 100 kW. The results of the test set operations is shown in Fig.1. The vertical axes indicate the maximum RF voltage and current on the vacuum coaxial line. The figure shows two series of test using two kinds of ceramic feedthrough. In both cases, we successfully achieved high voltage/current tests at around 40kV/800A. These operations were limited by the outgas inside the vacuum chamber which finally caused the RF discharge and sudden impedance mismatching. In the case of LHD heating experiment, several ohms coupling resistance is expected and impedance matching must be more easy. These steady state operation test confirms the reliability of the present system design.

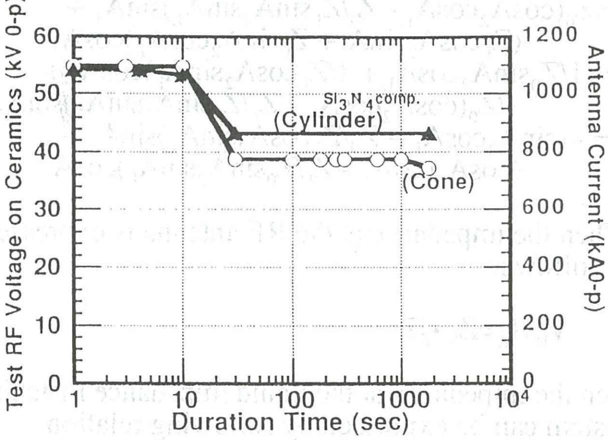

Fig.1 Long pulse test records of the R&D antenna are plotted. Two kinds of ceramic feedthrough were used in the tests.

The design work of the LHD steady state antenna images about 500 kW operation for 30 minutes per single loop. At this operation level, RF dissipation loss can be removed by the circulating water. The severest heat load is the charged particle influx to the carbon protectors along the magnetic field lines on the both antenna sides. On the assumed plasma heat load distribution, the temperature increments of the carbon plates are calculated by using the finite element calculation code ANSYS. It considered the radiation power, the particle flux along the magnetic field and the RF dissipation loss of the induction current. Figure 2 shows the temperature distribution of the carbon protector and cooling water channel. The temperatures of the top edge and lower edge of the protector are shown in Fig.3 by changing the antenna position which can be controlled by the swing motion. The calculation condition corresponds to the 3MW CW input power to the plasma. The top edge temperature can be suppressed below 500°C by increasing the distance between plasma and top edge of the protector of over 3 cm. It is still reasonable distance to get the substantial plasma coupling resistance.

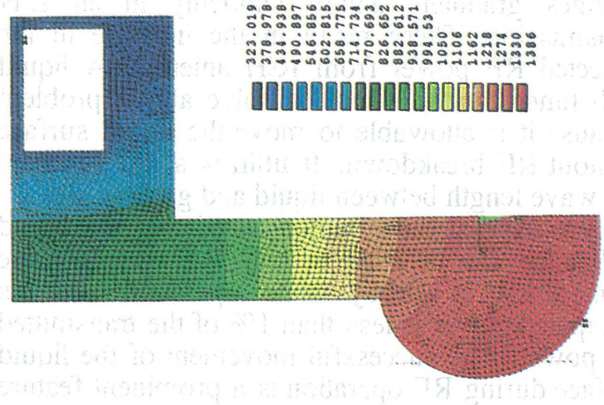

Fig.2 Temperature profile calculation of the carbon protector of loop antenna by ANSYS code.

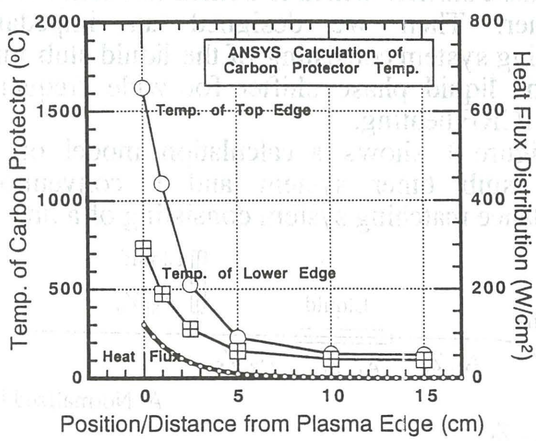

Fig.3 Calculated temperature increments of the carbon side protector by ANSYS code are shown by changing the top edge position of the antenna.

Reference

1) T. Mutoh, et.al., Journal of Plasma and Fusion Research. SERIES, Vol.1, (1998) 334