§8. Study of High Coupling ICRF Antenna for LHD

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For the ion cyclotron range of frequencies (ICRF) heating in the Large Helical Device (LHD), a new antenna (wide-strap antenna) was designed for the high-power and steady-state plasma heating by the various ICRF heating methods i.e. minority ion heating, higher harmonic heating, and mode conversion heating. Present antenna has a singe current strap with the width of 30 cm. Distance between Faraday shield and center strap is about 1 cm. To prevent arcing between Faraday shield and center strap, the distance between them was enlarged to 1.6 cm. For steady-state operation, the distance between plasma and antenna must be large (>10 cm) to mitigate heat load on the antenna. Coupling with plasma decreases with the distance, therefore high coupling antenna is necessary.

To study the coupling dependency on the strap width, simulation of electromagnetic field was conducted with a simple model of ICRF antennas as shown Fig. 1-(a). For this simulation HFSS (High Frequency Structure Simulator, Ansoft) was used. The antenna length was 70.5 cm, distance between strap and back-plate was 9.4 cm, and graphite protectors were attached on the both sides of the back-plate. Power was fed from top and bottom with coaxial lines of specific impedance of 50 Ω. Material with the relative dielectric constant of 81 (same with water) was located in front of antennas as a load. The distance between the load and Faraday shield was 10 cm. The boundaries of cubic calculation-space except for back of antenna were set as radiation boundary. Figure 2 shows the relation between VSWR (Voltage Standing Wave Ratio) on the transmission line and applied frequency with various strap width in the case of only one antenna. Low VSWR means high coupling. It was found that by widening the strap, VSWR decreases especially at the frequency where the strap length coincides with the quarter of wavelength in the antenna. Another calculation was done by using two antennas with wide straps of width of 53 cm. The dashed lines in Fig. 3 are VSWR with the 0-π and 0-0 current phases on straps, respectively. The difference was caused by the mutual coupling between two antennas, and the 0-0 current phase was better for high coupling. The circles with solid line are the calculated result with a twisted antenna shown in Fig. 1-(b), which is fitted to the LHD plasma and the vacuum vessel. The scattering was caused by the reflection from vacuum vessel. This antenna is expected to have high coupling around the frequency of 40 MHz.

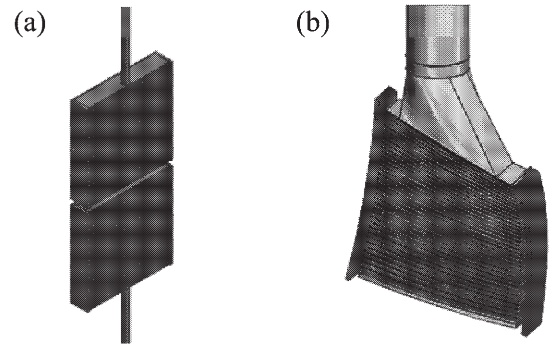

Fig.1 (a) Simplified wide-strap antenna model. (b) Twisted wide-strap antenna model in LHD.

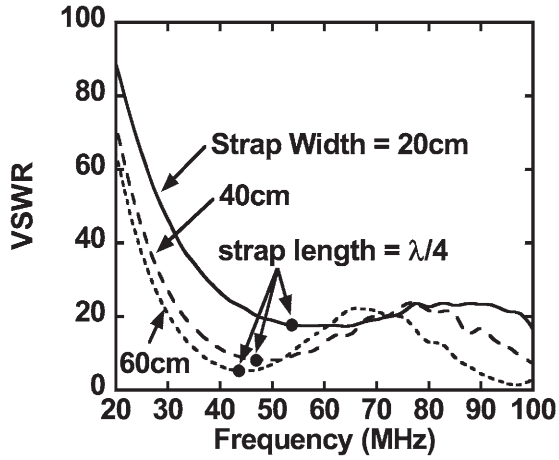

Fig.2 Dependency of VSWR on frequency and strap width.

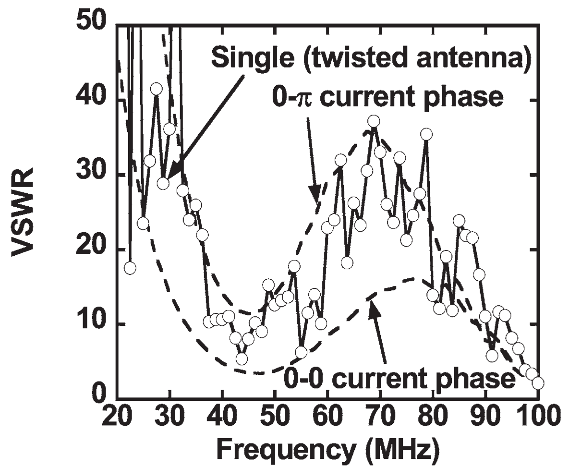

Fig.3 VSWR for two simplified antennas (dashed lines) and for the twisted antenna (circles with solid line).