## §22. Development of High-power ICRF Antenna

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A pair of Field-Aligned-Impedance-Transformer (FAIT) antennas for 4.5U and L ports was developed as shown in Fig. 1 for the ICRF heating experiment in LHD. The shape of antenna surface was determined by the calculation of connection length of magnetic field line for the radius of magnetic axis of 3.65 m. Faraday shield (FS) is aligned to the magnetic field lines and current strap is perpendicular to them. The main purpose of the antenna is high-power injection. In the transmission line, there is impedance transformer as shown in Fig. 2. The antenna impedance was deduced from the experimental result and the simulation of HAS antenna at the 3.5 port. By using the obtained antenna impedance, the diameter of inner conductor was optimized to increase loading resistance within the limitation of electric field on the transmission line and the voltage and current at the ceramic feed-through to protect them. The calculated loading resistance reached 10 Ω for both antennas. The strap was thickened and shortened compared to the HAS antenna to reduce the electric field in the antenna head. The design values of maximum electric field were set to 15 kV/cm and 30 kV/cm for the parallel and perpendicular direction to the magnetic field line, respectively. The maximum power of 1.6 MW/antenna is expected for the typical short pulse plasma discharge, which is limited by the electric field in antenna head. The head is compact and the Faraday shield area is small, therefore high power density of 13.5 MW/m$^2$ is expected.

For the steady-state operation, copper was used for several parts where heat load is intense or heat removal with the cooling water is difficult. For example, the covers of inner bellows and inside of Faraday shields are made of copper, and the outer bellows and inner conductor with small diameter are coated with copper. Faraday shields and the strap are coated with molybdenum to reduce temperature. The estimated maximum power during steady-state operation is approximately 1.2 MW, which is limited by the temperature of Faraday shield as shown in Fig. 3.

Another characteristic of the antenna is the easiness of impedance matching. Mutual coupling between U and L port antennas is thought to be low, for the two antennas are located in poloidal direction and the distance between two antenna loops is large (210mm). Antenna impedances of present antennas are changed during long pulse operation, therefore real-time impedance matching is necessary. However, FAIT antenna have thicker Faraday shield and the thicker and shorter strap and they are coated by molybdenum, therefore the deformation by the heat load is expected to be small and the change of antenna impedance will be small.

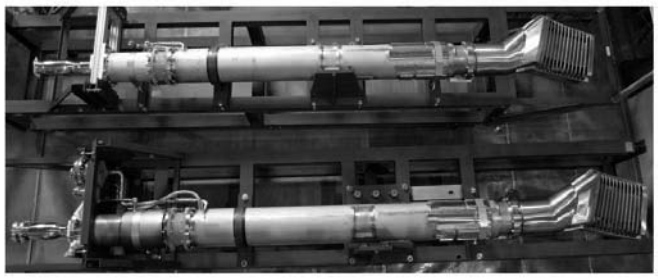

Fig. 1 FAIT antennas.

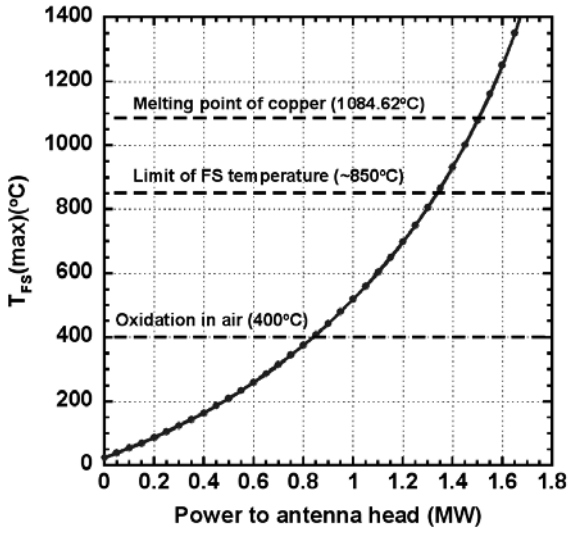


Fig. 3 Estimated temperature on Faraday shield.

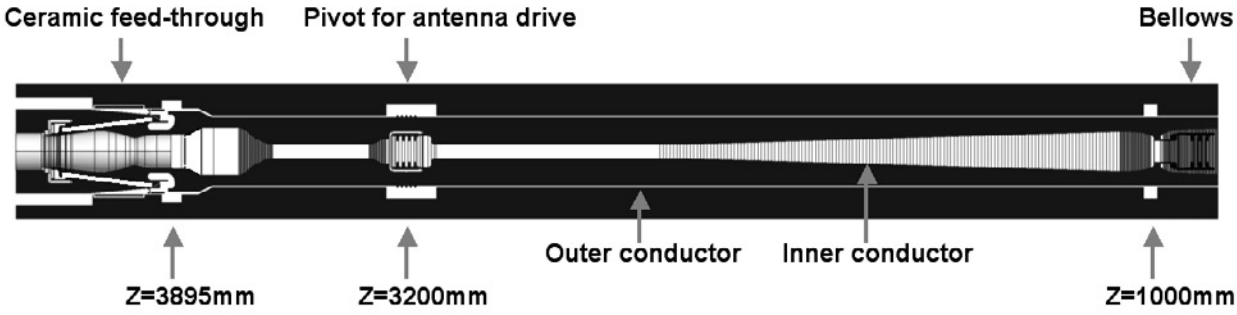


Fig. 2 Transmission line for 4.5U port antenna with the optimized impedance transformer.