§2. Development of an ECRH System for Large Helical Device

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Electron cyclotron resonance heating (ECRH) is one of the most important methods of plasma heating and production for tokamaks and stellarators. Large Helical Device (LHD) requires 10MW 84GHz and 168GHz ECRH system for initiating, heating and controlling plasma with 10keV and $10^{20}m^{-3}$ electron temperature and density, respectively.

This ECRH system consists of high power gyotrons, their high voltage power supplies, millimeter-wave transmission lines and antenna systems.

Gyrotrons which we are preparing are 0.5-1MW CW 84GHz gyrotrons for plasma production and steady-state experiments and 0.5-1MW, 5 seconds 168GHz gyrotrons for high temperature, high density plasma heating. Both kinds of gyrotrons are built-in converter type.

On the 84GHz gyrotron we have achieved 500kW 2sec., 400kW 10.5sec., and 50kW CW operations. Longer pulse operation at high power levels was inhibited by temperature rises of the output sapphire double-disk window. We are developing vacuum barrier windows for 1MW CW, using new conceptional windows with new materials.

The power supplies for 168GHz CPD (Collector Potential Depression) gyrotrons[1] are all solid-sate. They consist of collector, body and anode power supplies independently. The collector power supply, which has no crowbar circuits, is roughly regulated with GTO switching valves (60kV, 42A). The body and anode power supplies are highly regulated with high voltage, low current ability (90kV, 0.1A and 50kV 0.3A, respectively) and can be turned off within 10μsec. when gyrotron arcings occur. This system is working safely without any gyrotron damages. Figure 1 shows a set of power supplies constructed in the plasma heating laboratory building for initial gyrotron tests. The rest of the power supplies were constructed in the LHD main building.

Millimeter waves are transmitted from gyrotrons to LHD through long low loss transmission lines such as HE_{11} mode corrugated waveguides with the full length of about 100m, some miter bends, quasi-optical components and vacuum windows. In-vessel quasi-optical antenna system comprise four mirrors, one of which is movable and the rest are fixed. Launched beams are focused on the equatorial plane of the torus in elliptical shapes with waist size of 15 and 50 mm. Injection angle is adjustable by 15 degrees along major radius and 5 degrees along toroidal axis.

We are preparing to make tests combining each components.

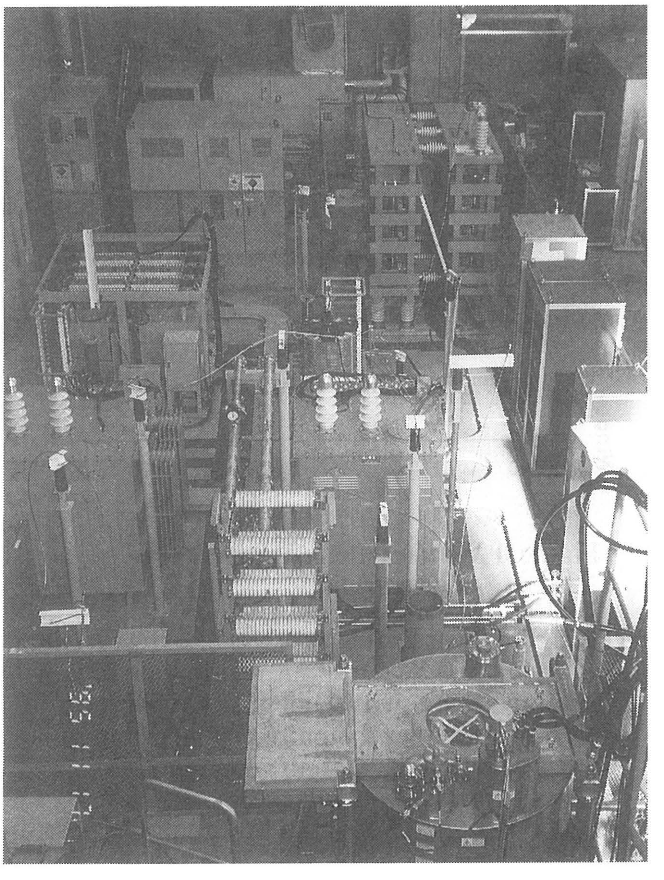

Fig. 1 A set of power supplies (collector, body and anode power supplies) constructed in the plasma heating laboratory building together with a super conducting magnet for a 168GHz gyrotron.

Reference

[1] K. Sakamoto, M. Tsuneoka, A. Kasugai, T. Imai, et al., Phys. Rev. Lett., vol. 73 (1994) pp3532-3535.