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Upgrade of 70 GHz ECRH/ECCD system for the Heliotron J Device

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Electron cyclotron resonant heating and current drive (ECRH/ECCD) is one of the efficient heating methods in fusion plasma experiment. In the Heliotron J device, a collector potential depression (CPD) type gyrotron at 70 GHz manufactured by GYCOM and a new power supply manufactured by Nisshin Pulse Electronics Co. has been recently introduced in order to extend operation capability for the plasma experiment. The objective of this research is to optimize the gyrotron operation and find the stable operation regime for plasma physics experiments.

Gyrotron and power supply

Main specification of the RF output at the gyrotron window is listed in Table 1. The DC voltages up to -57 kV and +22 kV are supplied to cathode and body, respectively. This operation condition is different from a gyrotron operation test at GYCOM, -50kV and +30kV, which may be due to the difference of magnetic field distribution in cryomagnet. The available maximum power at gyrotron window is 514 kW at I_{beam}=26 A, I_{body} = 26 mA.

A high-voltage power supply has also been upgraded in order to extend the operation capability. Table 2 shows the main features of the power supply. The double-pulse injection is possible in a plasma shot, and the gyrotron output power can be modulated up to 100% at 10 kHz by either beam voltage or body voltage. Since a capacitor bank is used, lower cathode voltage makes the pulse length longer, 250 msec.

Parameters of gyrotron (Kyoto university operation)	Test result
1. Operating frequency (f = 70.0 ± 0.1 GHz)	69.99 GHz
2. RF power pulse duration	0.5 s
3. RF power value	514 kW
4. Cathode voltage	57 kV
5. Cathode current	26 A
6. Body voltage	22 kV

Table 1 Gyrotron specification.

Power supply specification	Test result
1. Beam voltage	-80 kV
2. Beam current	40 A
3. Body voltage	+30 kV
4. Body current	+100 mA
5. Pulse length	250 msec
6. Modulation	10 kHz

Table 2 Power supply specification.

Transmission line and launcher

A matching optics unit (MOU) is connected with the gyrotron window in order to couple the Gaussian beam to the HE_{11} waveguide mode with high efficiency. The measured power loss at the MOU is 15 %. The HE_{11} mode is transmitted by 2.5 inch oversized corrugate waveguides of around 20 meters long including three miter bends, a polarizer, a power monitor and a waveguide switch. The measured transmission efficiency is 87%. The transmitted waves are injected into the Heliotron J vacuum chamber through a barrier window, and a launching system with a focusing mirror and a steerable flat mirror.

ECRH Operation

After the system is completed, an operation power map was taken. The body voltage/magnetic field dependence are shown by Fig.2 and 3 respectively. The maximum injection power is 360 kW. The ECRH/ECCD system has been routinely operated for plasma production, heating and current drive since last August in the Heliotron J device.

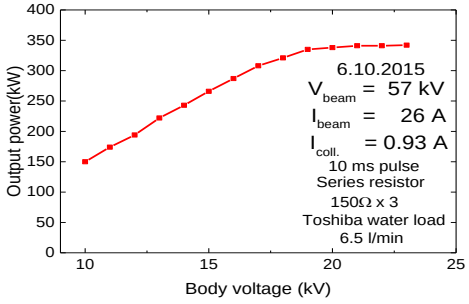

Fig. 2 Body voltage dependence of gyrotron power after transmission.

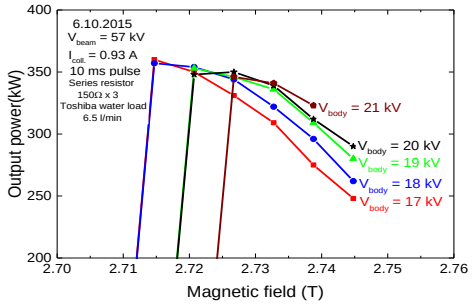

Fig. 3 Magnetic field dependence of gyrotron output power after transmission.