§5. Development of High-Power, Long-Pulse, High-Frequency Gyrotron and Improvement of Plasma Parameter in LHD by Use of the Gyrotron

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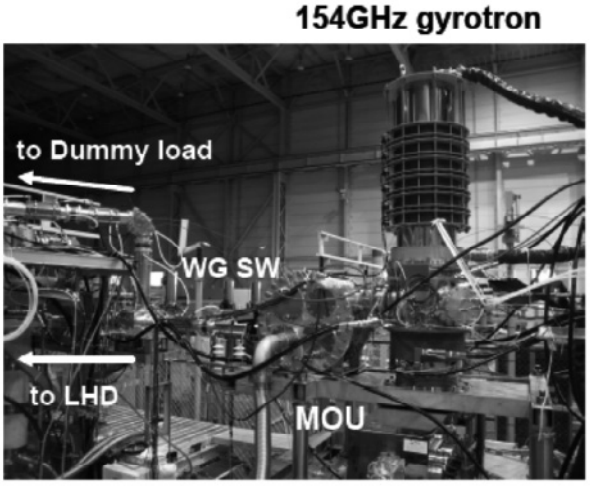
NIFS collaboration research program with University of Tsukuba has been conducted for the sake of development of high-power, long-pulse, high-frequency gyrotron and improvement of plasma parameter in LHD by use of the gyrotrons. Following to the successfully accomplished former program which resulted in three high-power 77GHz gyrotrons actively working for LHD experiment, this new program aims at realization of high-power and higher-frequency 154 GHz gyrotron to perform plasma heating at high-density region up to 14.7×10^{19} m^{-3}.

In 2012, fabrication of the 154 GHz gyrotron was completed at Toshiba Electron Tubes and Devices Co., Ltd. (TETD) and it was delivered to Univ. of Tsukuba. At Univ. of Tsukuba, an initial test of its performance was carried out. In the test operation, pulse width was 2 ms due to a restriction coming from the capability of power supply system at the beam current of ~50 A. Maximum output power from the gyrotron window of 1.06 MW was achieved, satisfying the designed value (see Fig. 1). The oscillation efficiency without collector potential depression (CPD) was 27.3 %. The measured frequency was 154.048 GHz and it was confirmed that the oscillating mode in the cavity was $TE_{28,8}$.

After the installation, cabling and tubing of the 154 GHz gyrotron to the gyrotron tank #4 in the heating equipment room of NIFS, conditioning operation searching for the optimum operational regime was started. CPD to improve the oscillation efficiency and two-step increase in the anode voltage to optimize the setting values of anode and body voltages and magnet currents were applied. Maximum output power from MOU of 1.17 MW with the oscillation efficiency of 40 % was successfully achieved with the CPD voltage of about 24 kV, as seen in Fig. 2.

During the LHD 16th experimental campaign in 2012, additional ECH power from the 154 GHz gyrotron worked well for breaking former records of central electron temperature T_{e0} at all the density range. Pulse width extension was performed as an on the job training, and 1.16 MW MOU output for 1 s was achieved. After the closing of the experimental campaign, conditioning operation for long pulse operation was performed by use of a dummy load. Performance in the long pulse operation is much improved compared with the former 77 GHz ones. A series of 0.35 MW, 30 min. operations were smoothly achieved, keeping the inner pressure of the gyrotron tube at a saturated and safe revel (ion pump current of a few micro A).



Parameters	Design
Frequency	154 GHz
Power	> 1 MW, 0.5 MW
Pulse Width	5 s, CW
Efficiency	50 % (with CPD)
Beam Voltage	80 kV
Beam Current	50 A
MIG	Triode
Oscillation Mode	TE28,8
Output Mode	Gaussian
Window	CVD Diamond
Collector	CPD (with sweeping coils)

Fig. 1. Photo of the 154 GHz gyrotron installed in RF equipment room in NIFS, and its designed parameters.

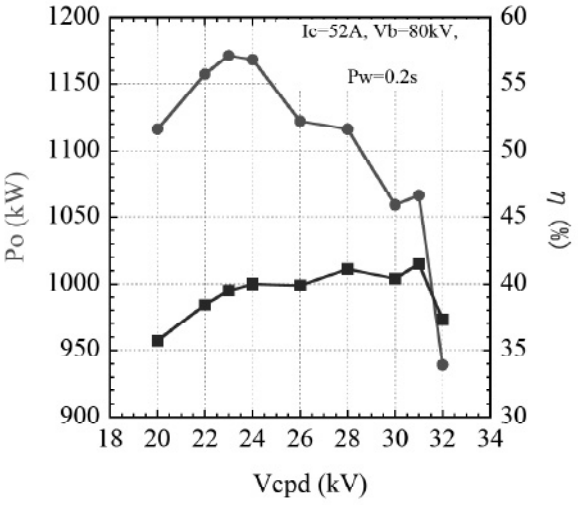


Fig. 2. Output power from MOU (red circles) and oscillation efficiency (blue squares) of the 154 GHz gyrotron as functions of potential difference between body and collector (CPD voltage).