§7. Heating and Current Drive Experiments on the TST-2 Spherical Tokamak

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The purpose of this collaborative research is to perform heating and current drive experiments using radiofrequency (RF) waves on spherical tokamak (ST) plasmas. This research aims at establishing the scientific basis for RF heating and current drive in plasmas with very high dielectric constants, with the eventual objective of developing innovative methods for plasma start-up and steady-state sustainment.

The TST-2 spherical tokamak at the University of Tokyo is a major ST device in Japan, with R = 0.38 m and a = 0.25 m (aspect ratio R/a = 1.5). It has already achieved toroidal magnetic fields of up to 0.3 T and plasma currents of up to 0.14 MA. TST-2 has the advantages of ample experimental time and flexibility with short turn-around time for hardware modifications. RF power of up to 400 kW in the frequency range 10–30 MHz is available, and heating and current drive experiments using the high-harmonic fast wave (HHFW) at 21 MHz are being performed using this equipment. In addition, four transmitters at 200 MHz, previously used on the JFT-2M tokamak, have been transferred from JAEA. This frequency is suitable for testing plasma current ramp-up by the lower hybrid wave.

In order to understand electron heating by HHFW, it is necessary to measure the electron temperature increase directly. In addition, it is very important to measure the waves excited in the plasma. A direct electron temperature measurement by Thomson scattering became possible, and an electron temperature increase from 140 eV to 210 eV was observed under a certain condition. In discharges in which the electron temperature increases are small, parametric decay instability (PDI) is often observed by RF probes and microwave reflectometer. The strength of PDI correlated with the degraded electron heating by HHFW. The causality between electron heating and PDI is being investigated.

The preparation of lower hybrid current drive and plasma current start-up experiments on TST-2 has started by collaboration between the University of Tokyo RF group and the NIFS RF group during Fiscal Year 2007. Testing and adjustments of the 200 MHz transmitters transferred from JAEA have begun. Their relocation to the Kashiwa Campus of the University of Tokyo has necessitated installation of transmission lines, modifications to the transmitter power supplies including the installation of a switchgear to enable sharing of the capacitor bank between the 21 MHz and 200 MHz systems, and preparation of the control system, including interlocks. In Fiscal Year 2007, calibrations of measurement devices related to the transmitter system, installation of transmission lines, preparation of the power supplies, and optimization of the control sequence, and tuning adjustments of the transmitters were performed. So far, output powers of 40 kW and 140 kW were obtained from transmitters #2 and #3, respectively. Comparison of LPA, IPA, FPA output powers between the two transmitters, and power dependences of the LPA, IPA, FPA output powers for transmitter #2 are shown in Fig. 1. This result indicates that the final amplifier tube for transmitter #2 is not functioning properly. Further testing will continue in Fiscal Year 2008. In addition, electrical characteristics of the combline antenna, planned to be used for the current drive experiment, were measured.

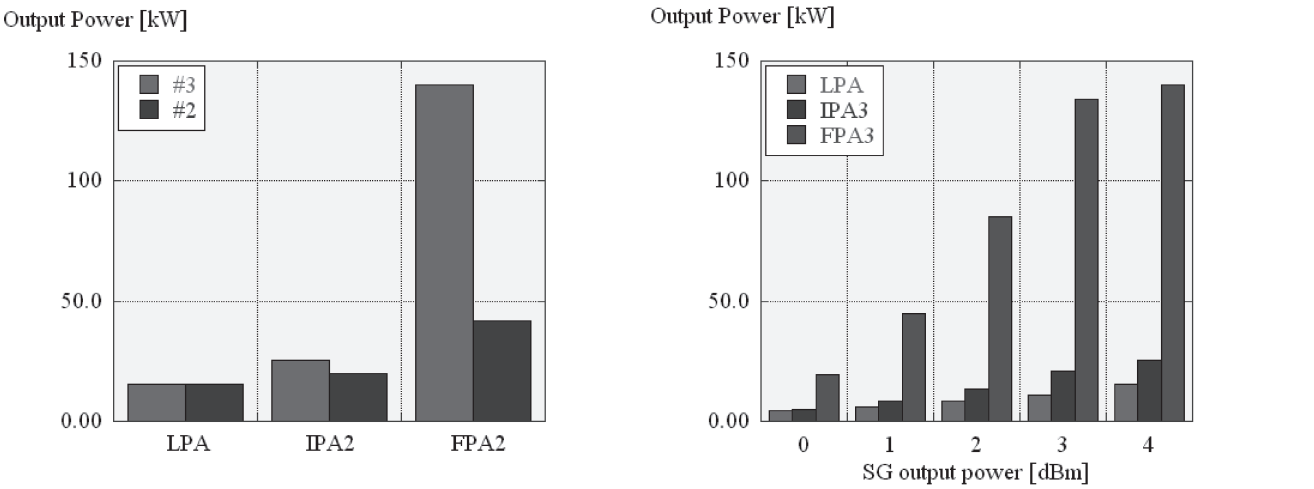

Fig. 1. Comparison of LPA, IPA, FPA output powers between transmitters #2 and #3 at a plate voltage of 7 kV (left). Power dependences of the LPA, IPA, FPA output powers for transmitter #3 (right).