§6. Study for the Steady State Operation of Spherical Tokamaks

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1. Introduction

Spherical tokamak (ST) is a candidate for cost-effective fusion reactor and the improvement of the plasma performance of ST has been tried in many institutes which is including in the experimental groups of University of Tokyo by use of TST-2 devices. The experimental group of Kyoto University has been done the development of the plasma start up without ohmic heating coil by RF current drive on LATE devices. Steady state operation is also a key issue to realize a fusion reactor. In the research of tokamaks, steady state operation will become crucial point and the trials to do long pulse operations in a large tokamak, JT-60U started. The experimental group of Kyushu University has many experiences to sustain the plasma current by use of RF current drive.

The cooperation of these experimental groups under the assistance with NIFS has the possibility to make a new way to realize the fusion reactor using steady state operation of ST. To do experiments, RF (8.2 GHz, 200kW by 8 krystrons) is available in Kyushu University. Therefore TST-2 was carried into the facility for the experiments of TRIAM-1M. The power supplies to operate TRIAM-1M is hooked up the ohmic heating coil, toroidal field coil, poloidal filed coils of TST-2. Capability of these power supplies is enough to operate their coils and as the result, it is possible to do the feedback control of the plasma position. The photograph is shown as the following.

Fig. 1 The photograph of the TST-2 after the installation in the facility for the experiment of TRIAM-1M. TRIAM-1M is shown in top-left of the photograph. Black waveguides are connected from the 8.2GHz LHCD system for TRIAM-1M to TST-2. The white roof area at the left-bottom is that for the data acquisition system for TST-2. The cables for coils are installed on the top side of TST-2.

2. Experimental set-up

The schematic view of the connection between RF system and TST-2 are shown in Fig. 2. These two types antenna were available in changing density gradient associated with the relative position to the plasma and a mobavle limiter. The coupling of RF and plasma can be estimated by the RF leakage power and the reflected RF power to the waveguides.

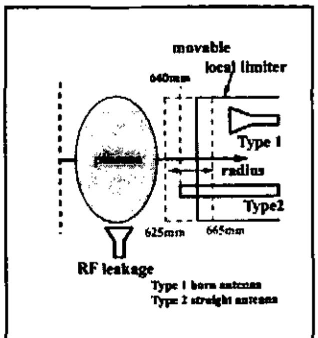

Fig.2. Schematic of two types of antennas relative to the plasma. The local limiter can be moved in the Green zone.

3. Experimantal Results

To obtain the long duration discharge, we try to inject the RF in steady vertical field and 0.3 sec discharge could be obtained as shown in Fig. 3. The discharge is terminated by the stop of the RF power. The measured density is less than the cut-off density of the RF of 8.2GHz.

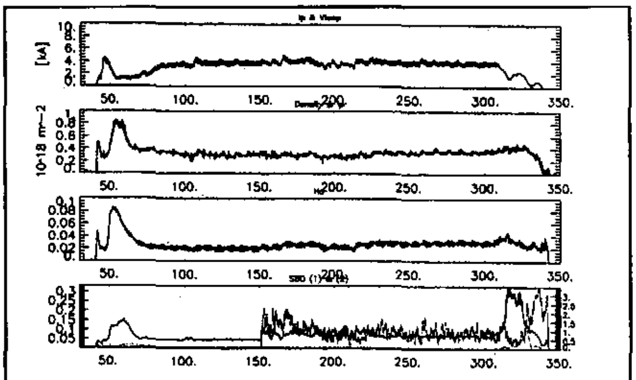

Fig. 3 Top figure shows the time evolution of plasma current, second one shows line integrated electron density, third one shows the intensity of Ha, and bottom one shows the soft X-ray signal measured by SBD(solid line) and SBD with Be filter(dotted line). Injected RF power is 100kW from the start of the discharge to 150ms and the power increases up to 170kW from 150 ms to the end of the discharge.

To investigate the current start-up capability in ST, the start-up experiment with the assist of the magnetic flux injection from vertical field coils was carried out. The maximum plasma current reaches up to 8kA[1].

To study the possibility of plasma heating and current drive by X- B scenario, RF power injection (net power ~ 100 kW) into an overdense plasma was done and the successful injection with low reflectivity could be obtained. The heating efficiency of EBW could not be estimated, lack of electron temperature measurements[2].

References

[1] Mitarai, O, et al., Rapid communication J. Plasma and Fusion res. Vol. 80, No.7 (2004)
[2] Kasahara, H., et al., Proc. the 31th EPS meeting (London) (2004).