§80. Increasing Density in QUEST by CT Injection Fueling

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Compact torus (CT) injection has been developed for an advanced fueling in fusion reactors. A CT injection experiment in a spherical tokamak (ST) started on the QUEST device in Kyusyu University under the NIFS bidirectional collaborative research in the last fiscal year. The CT injector (UH-CTI) installed on the QUEST (see fig.1) has a sufficient performance to penetrate into the center of a tokamak plasma at B_T= 0.8 T. The QUEST is designed for operation at B_T= 0.25 T for a steady-state mode (B_T= 0.5 T for a pulse mode). The injector can thus deposit fuel particles deeply in a ST plasma.

The primary aim of the experiment is to produce a high-density ST plasma by CT injection fueling. The experiment is also planned to explore possibilities to control CT penetration depth and particle deposition point by varying CT parameters, to study interaction between a high-temperature plasma and a CT plasmoid (magnetic reconnection, helicity conservation, excitation of waves), and to investigate ability of CT injection to assist ST plasma current start-up.

In this fiscal year, CT injection experiment was conducted to investigate the compatibility conditions for effective and efficient fueling in ST plasmas. CT plasmas were injected into non-inductive (NI) start-up ST plasmas by RF power and ohmic-heating (OH) ST plasmas. The CT injector was operated at the charging voltage (V_b) of 0.6 to 0.8 kV for the bias solenoid coil bank, and that (V_f) of 17 kV for the CT formation bank and that (V_a) of 25 to 27 kV for the acceleration bank. Figure 2 shows plasma responses to a CT injection in an OH ST plasma, in which RF power (8.2GHz) is injected between 2.1 and 2.3 s. The line-average electron density increases by a factor of 9. In the sample shot, the injector was operated at V_b= 0.8 kV, V_f= 17 kV, V_a= 25 kV. In such a condition, the CT plasma speed and density have been obtained to be 150 km/s and 5 $\times 10^{21}$ m^{-3}, respectively. In the experiment that a CT was injected into a NI ST plasma (the inboard null configuration) in the last fiscal year, the electron density rapidly increased, while the plasma current suddenly dropped to be less than 20% after a quiet phase of few ms. In the sample shot for the OH ST plasma, the plasma current remained at roughly 93% after CT injection as shown in fig. 3. The difference between the plasma current responses might be due to robustness of ST plasmas to CT injection.

We have also prepared a trigger system to synchronize the actions of the CT injector and the thomson scattering system developed by Drs. Takase and Ejiri group (the University of Tokyo). This allows us to investigate changes due to CT injection in electron temperature and density profiles. We intend to perform the CT injection experiment mainly in OH ST plasmas to optimize CT parameters and QUEST conditions for effective and efficient fueling.

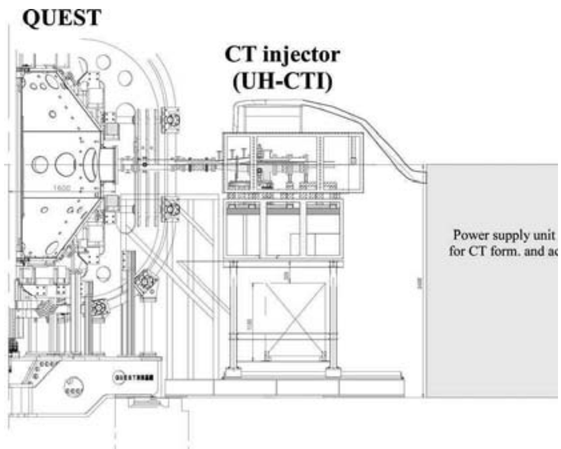

Fig. 1. A schematic drawing of UH-CTI installed on QUEST

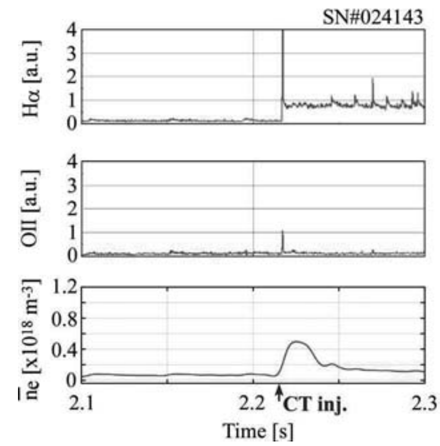

Fig. 2. Plasma responses to a CT injection.

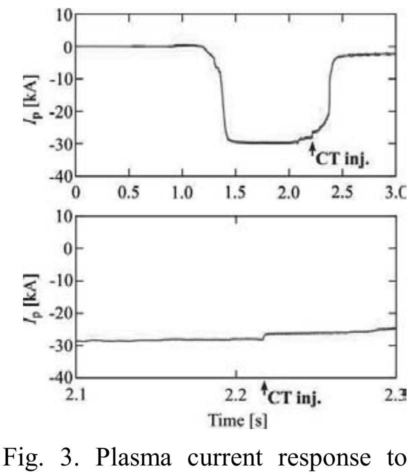

Fig. 3. Plasma current response to a CT injection. The lower plot is enlarged at the timing of the RF injection.