§54. First Fuelling Experiments by CT Injection on QUEST

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Accelerated compact torus (CT) injection has been devised as a fuelling method for fusion reactors. CT injection experiments were conducted on the compact PWI experimental device to study dynamics of CT plasmoid in the penetration process and to trial CT plasma exposure on wall materials in Kyusyu University under the NIFS bidirectional collaborative research. The new CT experiment was started to study on advanced fuelling into spherical tokamak (ST) plasmas on QUEST in this fiscal year.

The UH-CTI injector installed on QUEST has achieved central penetration in the JFT-2M tokamak at B_T= 0.8 T. The ST device of 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). Thus the UH-CTI has a sufficient performance to penetrate a CT plasma deeply into QUEST. The CT injection experiment is planned 1) to explore possibilities to control CT penetration depth and particle deposition point by varying CT parameter, and the technological establishment for deep fuelling, 2) to study interaction between a high-temperature plasma and a CT plasmoid (magnetic reconnection, helicity conservation, excitation of waves), 3) to investigate ability of CT injection to assist ST plasma current start-up, and 4) to attempt to drive plasma flow by tangential CT injection on poloidal or toroidal planes in ST.

In this fiscal year, the CT injector with a drift tube was installed on the QUEST device, and then the initial test of the CT injector was carried out. The injector is set on a sliding stage by QUEST to be installed perpendicularly on the magnetic axis on the midplane. In the performance test, the currents of CT formation and acceleration have reached the respective currents of 350 kA and 400 kA with a rise time less than 10 μs to meet the rated values, resulting in successful CT formation and acceleration. In the preliminary CT experiment, a CT plasma was injected in a non-inductive ST plasma during a long flat-top in plasma current driven by 8.2 GHz ECCD. A rapid increase due to CT injection in electron density was observed, while in plasma current sudden drop followed by a quiet phase of few ms, as shown in fig.1. Thereafter, strong turbulent phase at the plasma edge was also observed with a fast camera. In addition, CT injection into a Ohmic heating ST plasma was tested. Figure 2 shows that the plasma density is rapidly increased without a plasma disruption by CT injection, in which a highly dense CT plasma is injected with a CT speed of about 360 km/s as shown in fig.3.

As stated above, the preliminary experiment of CT injection was successfully demonstrated on QUEST. We intend to perform a CT injection experiment mainly in an ohmic heating ST plasma to optimize CT parameters for effective fuelling in QUEST.

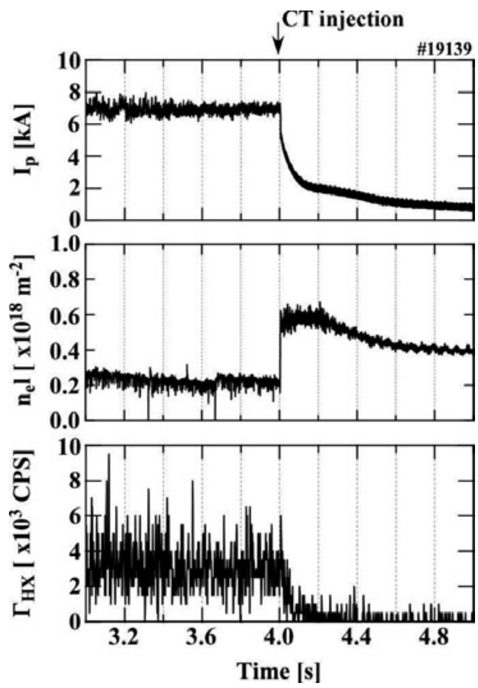

Fig. 1. Plasma responses to CT injection in a non-inductive ST plasma.

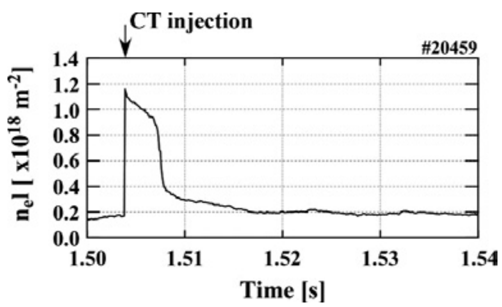

Fig. 2. Plasma density response to CT injection in an ohmic heating ST plasma.

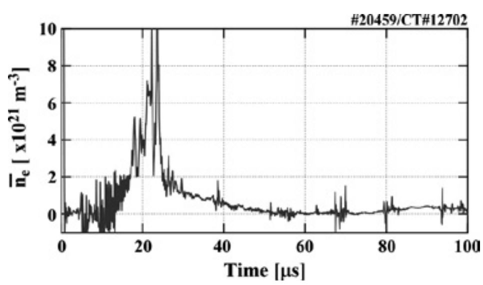

Fig. 3. Plasma electron density in the CT injected into the OH-plasma (#20459).