§51. Deep Fuelling Experiments on QUEST Using CT Injection

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Compact toroid (CT) injection has been proposed as a method of deep fuelling in a fusion reactor. In Japan, after CT injection experiments on JFT-2M at Japan Atomic Energy Agency (JAEA), the CT injector of UH-CTI (the former HIT-CTI), the power supplies and the related equipment were moved to the Advanced Fusion Research Center in Kyusyu University in 2005. Since then, CT injection had been conducted on the Compact Plasma wall interaction experimental Device (CPD) to study dynamics of CT plasmoid in the penetration process and also to trial CT plasma exposure on wall materials.[1,2] In 2008, the new ST device of QUEST (Q-shu University Experiment with Steady-State Spherical Tokamak) was completed. CT injection experiment has been also planned to study on advanced fuelling into ST plasmas on QUEST. The purposes are as follows; 1.Exploration of possibilities to control CT penetration depth and particle deposition point by varying CT parameter, and the technological establishment for deep fuelling, 2.Research on interaction between a high-temperature plasma and a CT plasmoid (magnetic reconnection, helicity conservation, excitation of waves), 3.Investigation of ability of CT injection to assist ST plasma current start-up, 4.Attempt to drive plasma flow by tangential CT injection on poloidal or toroidal planes in ST.

QUEST was designed to be operated at B_T= 0.25 T for a steady-state mode (B_T= 0.5 T for a pulse mode). Here, in simple theory, the central penetration of a CT into a ST plasma requires that the kinetic energy density of the CT $D_{CT,E}$ should exceed the magnetic energy density of the toroidal field $W_B= B_T^2/2\mu_0$ at the ST plasma center. The required $D_{CT,E}$ on QUEST is less than 25% of that at B_T= 1 T on JFT-2M. The CT injector has a sufficient performance to be utilized as a fueller for ST plasmas on QUEST. Thus a CT plasmoid readily penetrates into an ST plasma, leading to deposition of the fuel particles at the high-field side beyond the magnetic axis. In order to launch the CT injection experiment, the CT injector needs to be removed from CPD and be installed on QUEST as shown Fig.1. The injector will be set up perpendicularly on the magnetic axis on the midplane. The lower docking stage for the CT injector was fixed up in this fiscal year. Measurement systems in CT injection experiments have been also prepared. To measure density increment in QUEST, a laser interferometer has been designed. The density in a CT plasmoid ejected from the CT injector can be high of the order of 10^{21} m^{-3}. Here, for a CT density of 5×10^{21} m^{-3} and its fuelling efficiency of 40 %, the total particle inventory is estimated at about 5×10^{20}, which corresponds to a density increment of 2×10^{20} m^{-3} in an ST plasma with a volume of 2.2 m^3. The increment is much higher than a predicted density of 1×10^{19} m^{-3} in an ST plasma at a plasma current of 100 kA. In the initial experiment, therefore, CT plasma should be generated at rather low density less than 1×10^{21} m^{-3}. In addition, we have considered introducing photodiode array to observe behavior of a CT plasma and its particle diffusion in a ST plasma. After these preparation, we intend to install the CT injector on QUEST and conduct the initial test of CT injection in the next fiscal year.

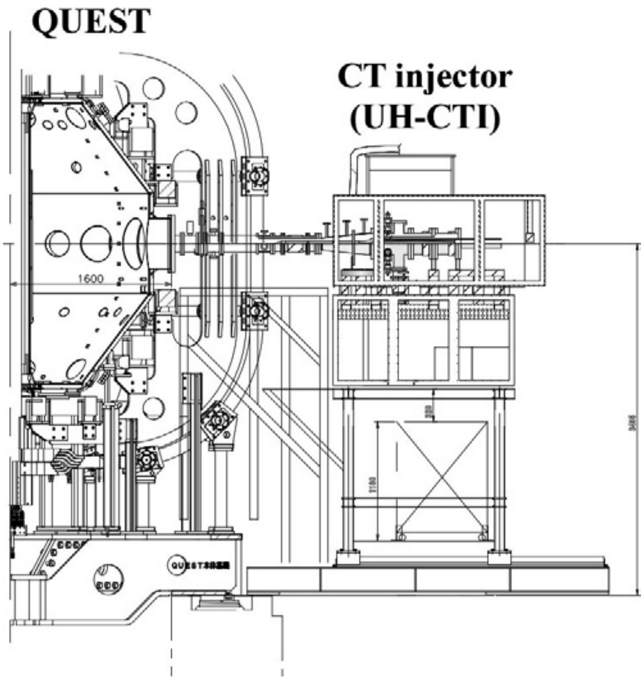

Fig. 1 Rendering of UH-CTI installed on QUEST.

1) Bhattacharyay, R. et al.: Nucl. Fusion 48 (2008)105001.
2) Honma, H. et al.: J. Plasma Fusion Res. SERIES 8 (2009)1015.