§43. Accelerated Compact Toroid Injection into the Spherical Tokamak CPD Device

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Compact Toroid (CT) injection experiment has been performed on the Compact Plasma wall interaction experimental Device (CPD) in Kyusyu University to study on advanced fueling into Spherical Tokamak (ST).

The aims of this CT injection experiments are as follows; 1) Development of refueling method into the core plasma in a reactor with researching interaction between a high-temperature plasma and a CT plasmoid (magnetic reconnection, helicity conservation, excitation of waves), 2) Investigation of ability of ST plasma start-up by CT injection, 3) Drive of plasma flow by tangential CT injection on a poloidal or toroidal plane in ST to promote the development of the research of two-fluid effects on high-β ST plasmas.

In the last fiscal year, the UH-CTI (the former HIT-CTI) of a CT injector, the power supplies and the related equipment, possessed by the University of Hyogo, were moved from Japan Atomic Energy Agency (JAEA) to the Advanced Fusion Research Center in Kyusyu University. Withstand voltage tests on the power supply units and bench tests of the CT injection system were successfully conducted.

In this fiscal year, performance tests have been carried out in a stand-alone set of CT injector. The currents of CT formation and acceleration have reached the rated currents of 350 kA and 400 kA, respectively, resulting in successful CT formation and acceleration. 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 kinetic energy density was investigated by varying the charging energy storage capacity of the CT accelerator bank ($E_{acc.}$), as shown in Fig. 1. For this UH-CTI injector, the average $D_{CT,E}$ at $E_{acc.} > 12$ kJ ($V_{acc.} = 16$ kV) exceeds $B_T^2/2\mu_0 = 36$ kJ/m^3 under typical conditions of $B_T = 0.3$ T on CPD.

The preliminary experiments of CT injection have been performed on CPD.[1] Figure 2 shows the CT injector and CPD. The CT injector is installed perpendicularly to the magnetic axis on the midplane of CPD. As a monitor of CT injection into the CPD chamber, H_α spectrum was measured. The intensity depended on the CT accelerator voltage $V_{acc.}$. At $V_{acc.} = 0$ kV corresponding to gas injection (non-CT injection), the spectrum was not observed. In addition, behavior of a CT plasma into CPD was observed by using a fast camera (Nishino, N., Hiroshima Univ.). CT plasmas could reach the center stack of CPD. It also appeared poloidal coils (PF1,7) closest to the port of the CT injector had adverse effects on CT penetration into CPD.

Reference

1) Hanada, K. et al: Ann. Rep. NIFS (2006-2007)

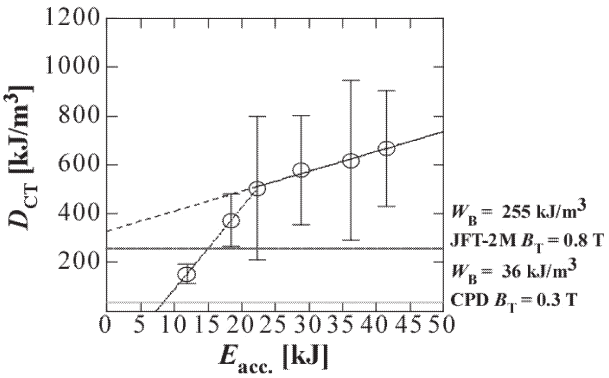

Fig. 1 Dependence of CT kinetic energy density on the energy storage capacity of the acceleration bank.

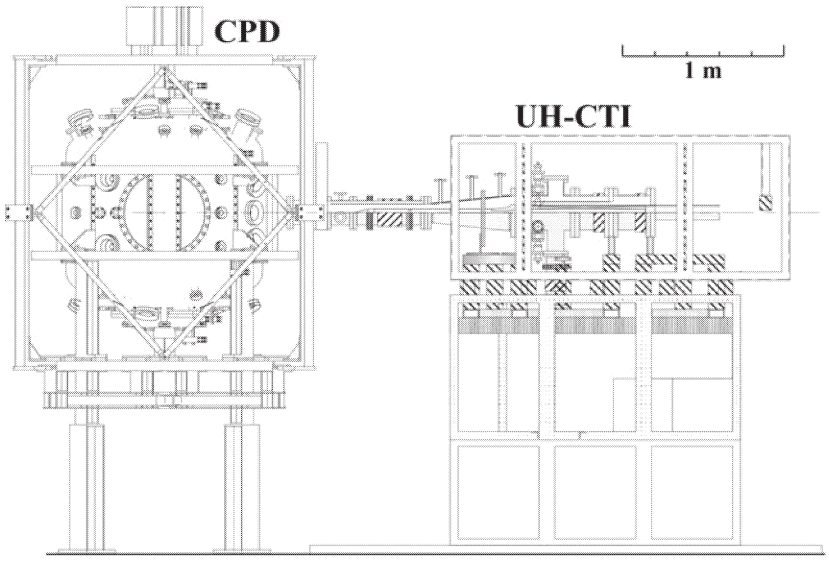

Fig. 2 UH-CTI installed on CPD.