H-W11

Non-Inductive Plasma Current Start-up Experiment by Electron Cyclotron Heating in the CPD Device

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Establishment of non-inductive plasma current start-up scenario in tokamaks may lead to an ambitious design of fusion reactors based on spherical torus (ST) without central solenoid (CS) which realizes greatly reduced construction cost in a compact shape. Various methods for non-inductive current generation such as electron cyclotron heating and current drive (ECH/ECCD), lower hybrid current drive (LHCD), coaxial helicity injection (CHI), poloidal-flux swing operation and so on, are being applied and tested in many tokamaks.

The method based on ECH/ECCD can potentially realize the discharge initiation (breakdown), plasma current start-up and sustainment, and therefore is applied on the CPD device, which is a small ST with a height of 1.2m and a vessel major radius of 1.2m. Since density in ST can easily exceed the cutoff density of injected EC wave and heating of core plasma region by incident wave itself becomes difficult, it is essential to convert the injected electromagnetic wave into electron Bernstein wave (EBW) which has no cutoff and can reach the plasma core region.

In order to investigate the efficient condition for the mode conversion and deduce the favorable injection mode and angle, three different injection modes at 8.2GHz are applied from eight tubes of CW klystrons. 1) Four tubes are used for X-mode and perpendicularly injected to the magnetic field. 2) Other two tubes are for co-O-mode injection, the injection angle of which can be adjusted to the same direction with the flow of the current driving electrons' flow by a simple mirror placed near the launchers, and 3) the remaining two tubes are for counter-O-mode, the injection angle of which is adjusted in the opposite direction to the current driving electrons' flow.

Figure 1 shows a waveform of discharge with X-mode injection at Pinj~45kW. Just after breakdown plasma current (Ip) is immediately generated and reaches ~0.6kA, then gradually increases upto ~1.2kA under steadily kept vertical magnetic field. After this, Ip is further increased by increasing the vertical field strength (Bv) gradually until the end of microwave pulse, and finally reaches ~1.6kA. The largest Ip achieved at each Bv level shows a roughly proportional increase with Bv as shown in figure 2 although there is an offset Bv (~5G) suggesting the existence of error field. Larger Ip can be expected by the undergoing optimizations of injection conditions and wall conditionings.

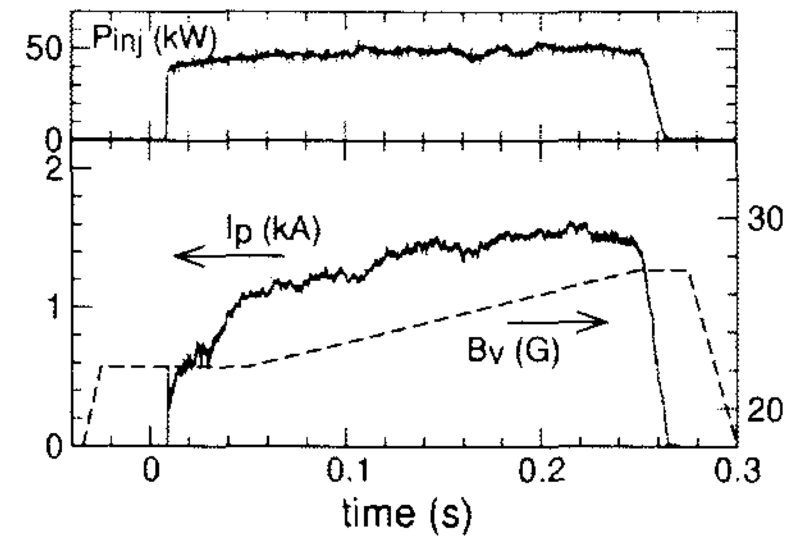

Figure 1. Waveform of X-mode discharge

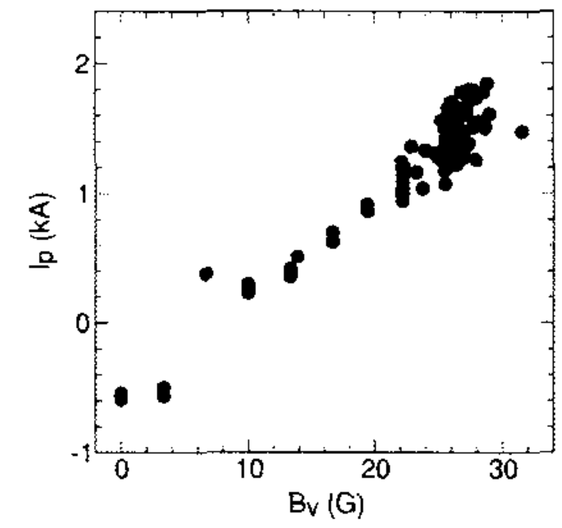

Figure 2. Achieved plasma current