§ 57. Neutral Beam Current Drive Efficiency in LHD

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Neutral beam injection (NBI) is powerful tool for heating of plasma and non-inductive current drive in magnetically confined fusion plasmas, and has been installed to many devices. In helical device, no toroidal plasma current is need for production of magnetic configuration, however, boot-strap current is spontaneously driven in high beta plasmas. Thus the control of plasma current is also important in helical devices from viewpoint of the control of rotational transform.

Three negative-ion-based neutral beam injectors have been tangentially installed in LHD, and 10MW of total port-through power and 180keV of beam energy have been achieved in 6th campaign. Neutral beam current drive (NBCD) has been observed in NBI plasma in LHD. In order to investigate the property of NBCD, NBCD experiments have been performed in 6th campaign of LHD. The toroidal current was estimated by the saturated current of long pulse NBI (5s, 1.5-2MW) plasma with the magnetic configuration of R_{ax}=3.6m and B_{ax}=1.5T. The NBI BL1 (ctr) and BL3 (ctr) have been used in this experiment and co-beam injection was performed in the reversed field condition. Only hydrogen gas was operated by density feed-back gas puff, and density scan was performed, which is shown in Fig. 1. The toroidal current changes the direction corresponding to the beam direction and decreases with plasma density. The magnitude of toroidal current is different in the case of co-beam and ctr-beam, and the offset is considered as boot-strap current, which increases with plasma density. The boot-strap current estimated by this offset is proportional to W_{dia}, which is shown in Fig.2. This implies that the neutral beam driven current and boot-strap current are able to be experimentally estimated each other from total toroidal current.

The efficiency of NBCD is given by

$$\eta = I_{NBCD} n_e R / P_{dep},$$

where n_e, R and P_{dep} are electron density, major radius and deposition power of neutral beam, respectively. The efficiency of NBCD determined experimentally is 0.07-0.2x10^{19}A/W/m^2 and is compared with results of other experiments, which is shown in Fig.3. The efficiency of NBCD in LHD is almost same as that given in DIII-D. It seems that the beam energy dependence of η comes clear in high electron temperature region.

In concluding, neutral beam driven current and boot-strap current can be determined by offset of toroidal current between co- and ctr- beam injection, and the efficiency of NBCD is 0.07-0.2x10^{19}A/W/m^2, which is almost same value as that of DIII-D. The investigation of the effects of Z_{eff}, magnetic ripple and estimation of current profile are left for future study.

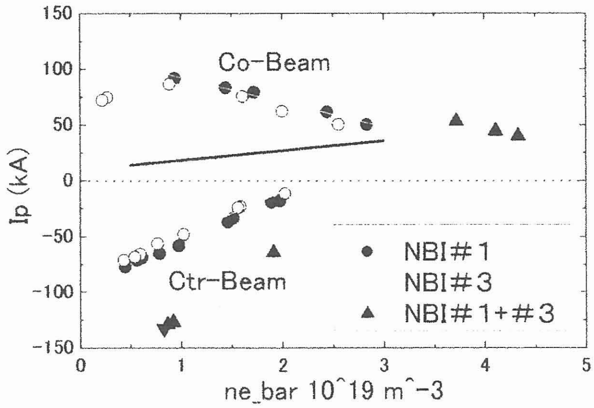

Fig.1 The dependence of plasma density on troidal current.

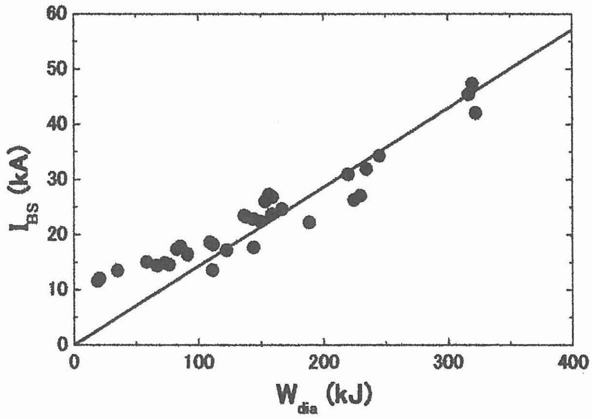

Fig.2 Boot-strap current v.s. W_{dia}.

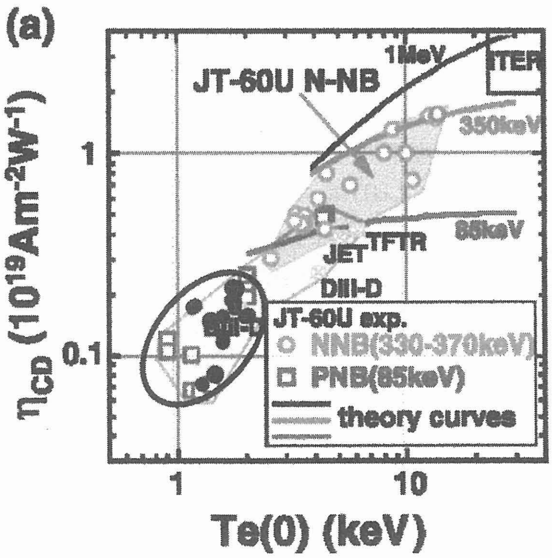

Fig.3 The efficiency of NBCD in LHD (solid circles in ellipse) and in other devices[Nucl. Fusion 41, 1575 (2001)].