§3. Improvement of Energy Confinement with Local Island Divertor (LID)

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A local island divertor (LID) has been proposed for the edge plasma control of the Large Helical Device (LHD) to enhance helical plasma performance. The first experimental study to demonstrate the principle of the LID was done on the Compact Helical System (CHS).

CHS was operated with a toroidal magnetic field B_0 of 0.9 T and a magnetic axis position R_{ax} of 99.5 cm. When R_{ax} > 97.4 cm, the $\iota/2\pi$=1 flux surface is well inside the vacuum vessel wall. The plasma was produced by ion cyclotron range of frequency heating (ion Bernstein wave, IBW) and/or second-harmonic electron cyclotron heating (ECH) and was heated by 0.82 MW tangential neutral beam injection (NBI) at 38 keV.

The plasma parameters are found to change when the island is formed. With the perturbation field δB on (corresponding to the standard island configuration) [1] and at a fixed level of gas puffing, the averaged electron density n_e and the OV radiation intensity decrease significantly, compared with those without δB. Figure 1(a) shows n_e's with and without δB. Figure 1(b) shows that the stored energy measured with a diamagnetic loop also decreases slightly, but its reduction rate is much smaller than that of n_e, because T_e increases, as observed by a YAG Thomson scattering system. Using these data, the temporal evolution of the energy confinement time τ_E is obtained, normalized by that of the LHD scaling law, $\tau_{LHD} = 0.17a^{2.0}R^{0.75}B_0^{0.84}n_e^{0.69}P_{tot}^{-0.58}$, where a, R, and P_{tot} are the averaged plasma radius, the major radius and the total absorbed power, respectively. The normalized τ_E with δB on is larger than unity and longer than that without δB, especially after the gas puffing. This indicates a modest improvement of the energy confinement, although the estimation of P_{tot} with δB is a little uncertain because n_e is low. A comparison of the stored energy is also made between the discharges with and without δB at the fixed line average density. We found that the stored energy in the discharge with δB is about 20% higher than that without δB.

The experimental results have clearly demonstrated the fundamental function of the LID, that is, the particle flow is guided to the back side of the divertor head by the island magnetic field structure, and pumped out. The leading edges of the divertor head, located inside the island, are also found to be protected from the outward heat flux from the core. The LID experiment has provided us critical information on the edge plasma behavior, and is helping us to optimize the design of the LID on LHD.

We have not yet completed the experimental analysis, but the results analyzed so far are very encouraging in terms of effectiveness of the LID.

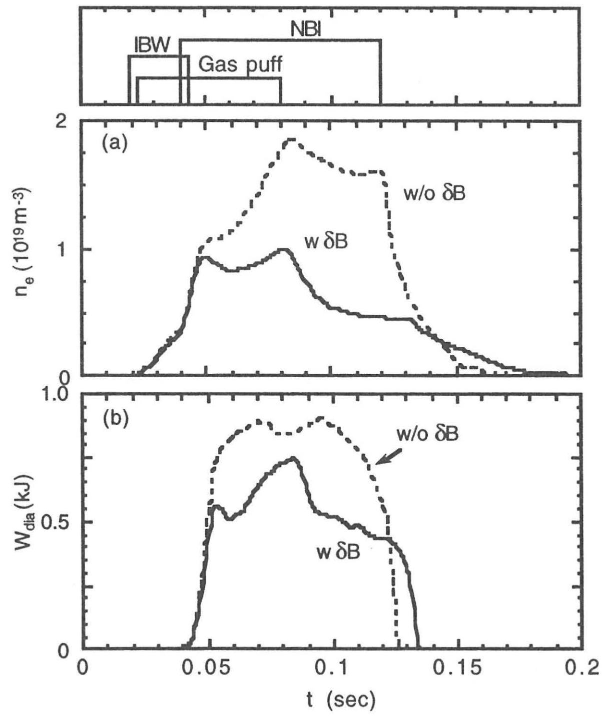

Fig. 1. Comparison of two discharges with and without δB. (a) Averaged electron density n_e. (b) Stored energy W_{dia}.

Reference

1) Komori, A., *et al.*, in *Plasma Physics and Controlled Nuclear Fusion Research 1994*, Seville (IAEA, Vienna, 1996), Vol. 2, p. 773.