§17. Power Deposition Profile of NBI Heating in the LHD Plasma

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The experiments applying the NBI heating system started in the LHD, where the negative ion sources system (P_{NBI}=15MW, E_b = 180keV) has been used. In this paper we have studied the power deposition profile of the NBI heating in LHD assuming the plasma parameter obtained experimentally.

The ionized position of neutral beam particles (beam birth profile) are calculated by NBI deposition code[1]. In this code the configuration change by finite beta effects is included using the Boozer coordinates based on the MHD equilibrium. The cross-section for the neutral beam ionization is evaluated using the analytic fitting by Janev, et al.[2], where the multi-step ionization effect and the multi-impurity effect are considered. In the birth profile calculation we assume the ratio of impurities as C:O:Fe=1:1:0.1 for both the proton and helium plasma cases.

Figure 1 shows the shine through rates of the neutral beam as a function of plasma density at the center, n_0. The radial profiles of the density and temperature are assumed as

$$n(r) = (n_0 - n_w)\{1-(r/a)^8\} + n_w, \quad (1)$$
$$T(r) = (T_0 - T_w)\{1-(r/a)^2\} + T_w, \quad (2)$$

where n_w and T_w are the density and temperature at the plasma boundary (last closed magnetic surface), respectively. The beam energy is assumed to be 100keV. We can see that more than 90 % of the injected power is deposited at the density region higher than $2\times10^{19}\mathrm{m}^{-3}$. The shine through rate is lower for helium plasmas because of higher value of Z_{eff}.

After the birth profile calculation, the beam particles are followed until the slow down of beam energy. Since the tangential beam injection is applied in LHD, the radial diffusion of beam particle due to helical trapped motion would be small for a relatively low temperature case. So we only consider the prompt orbit effects on the beam distribution in this paper. The prompt orbit is evaluated by the orbit following Monte Carlo code using Boozer coordinates. The slowing down process is solved without orbit effect based on the Fokker-Planck model[3].

The power deposition profile of NBI heating in the LHD (standard configuration :R_{ax} = 3.75m) are shown in Fig. 2. We set the plasma parameters as $T_{e0} = T_{i0}$ = 1.6keV, Z_{eff} = 2.0, B_0 = 1.5T. We can see the peaked deposition profile in the higher density case and the deposited power is about two times larger than that of the lower density case. It is also found that about 30 % of the total heating power is absorbed by ions in both cases.

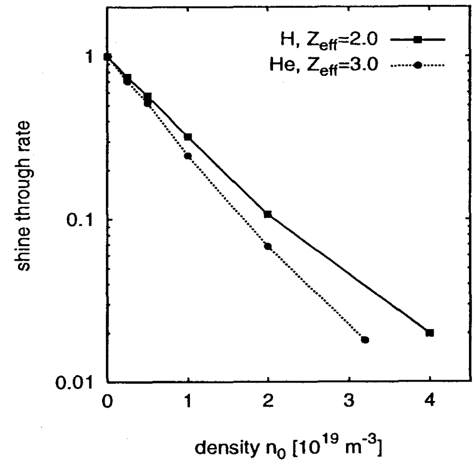

Fig. 1: *Shine through rate of injected neutral beam as a function of the density at the plasma center. [$T_{e0} = T_{i0}$ = 1.6keV]*

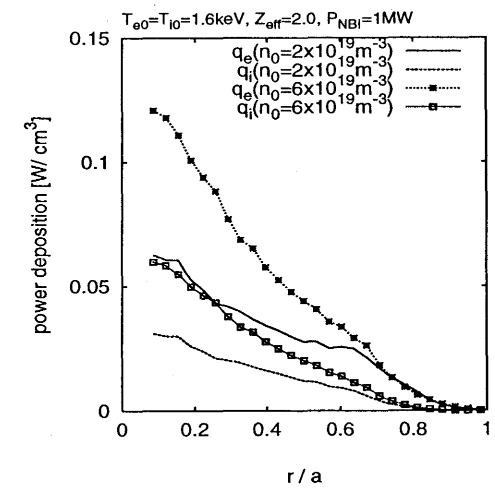

Fig. 2: *Power deposition profile of NBI heating for two different densities; n = 2 and $6\times10^{19}\mathrm{m}^{-3}$.*

References

1) Murakami, S., et al., Trans. Fusion Technology **27** (1995) 256.
2) Janev, R.K., et al., Nucl. Fusion **29** (1989) 2125.
3) Callen, J.D., et al., in *Plasma Phys. Contrl. Nucl. Fusion Res. 1974 (Proc. 5th Int. Conf.)*, IAEA, Vienna (1975) 645.