§34. Optimization of Fueling in Magnetically Confined Plasmas (Fueling Optimization Using H_α/D_α Line-emission Measurements in Heliotron J)

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In magnetically confined plasmas, optimization of particle fueling is an important subject to achieve high performance plasmas. In Heliotron J, we have obtained high density plasmas around $1\mathrm{x}10^{19}\mathrm{m}^{-3}$ using short-pulsed high-intensity GP (HIGP) method [1]. In this FY, we have compared the characteristics of the radial profile of the plasma quantities between the hollow and peaked density profiles n_e [2].

The radial profile of the electron density, electron temperature and ion temperature are shown in Fig. 1(a) and 1(b). In the hollow n_e case, the plasma is initiated by NBI using pre-ionization method by non-resonant microwave. On the contrary, the 70GHz 2^{nd} harmonic ECH is used for the plasma initiation in the peaked n_e case. The balanced NBI heating (~1MW) was applied for the both cases. The main difference in the operational scenario is gas fueling. In the hollow n_e case, a high intensity gas puffing (HIGP) method was applied for 10ms, while it is 30ms for the peaked one. However, the strength of HIGP is about 40% higher in the hollow n_e case. As a result, maximum gas pressure at the gas puffing port is about 10% higher in the peaked n_e case. As shown in Fig. 1, the maximum electron density was about $0.9\times10^{20}\mathrm{m}^{-3}$ at r/a=0.6 for the hollow n_e case and it is $1.3\times10^{20}\mathrm{m}^{-3}$ at the core for the peaked one. Higher electron and ion temperatures were found in the hollow n_e case. Note that the H-mode transition with an increase in stored energy and a reduction in the edge fluctuations was observed in the hollow n_e case. The ion temperature in the peripheral region is about 50% higher than that in the peaked one and the steep temperature gradient was seen.

The beam absorption profile is calculated using FIT3D. The FIT3D code consists of three numerical calculations, beam birthpoint profile (HFREYA), re-distribution of fast ion (MCNBI) and Fokker-Planck analysis (FIT). Since the re-distribution of fast ion is estimated using orbit following calculation in Boozer coordinate systems, the effect of the re-entering fast ions is neglected. Comparison of the radial profile of the plasma pressure and the NBI power absorption between the two cases is shown in Fig. 2. For the hollow n_e case, the absorption power in the peripheral region is smaller than that for the peaked case because the beam-ions produced by counter NBI escape easily. However, a higher plasma pressure is observed in the peripheral region. The H_α/D_α intensity in the hollow n_e case is about 70% as that for the peaked one, suggesting that the neutral density in the peripheral region is lower than the peaked n_e case. The lower neutral density condition leads to a reduction in the CX loss, which contributes to the improvement in the pressure in the peripheral region.

In the case of the peaked n_e case, the energy confinement time (τ_E^{EXP}) normalized to the international stellarator scaling law (τ_E^{ISS95}) is about unity, while an improvement in the normalized energy confinement time $\tau_E^{EXP}/\tau_E^{ISS95}$ is obtained in the hollow n_e case. We are applying the transport analysis code TR-Snap into Heliotron J to reveal the transport characteristics. The isotope effect on the edge temperature characteristics is a future work.

1) S. Kobayashi, et al., 40th EPS conf. ECA vol. 37D, (2013) P1.148.
2) S. Kobayashi, et al., Plasma Conference 2014, 2014/Nov/18-21, Niigata, 19pE-4.

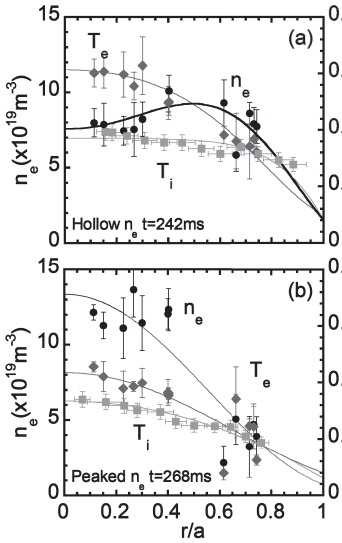

Fig. 1. Radial profile of electron density, electron temperature and ion temperature in the (a) hollow and (b) peaked density profile cases.

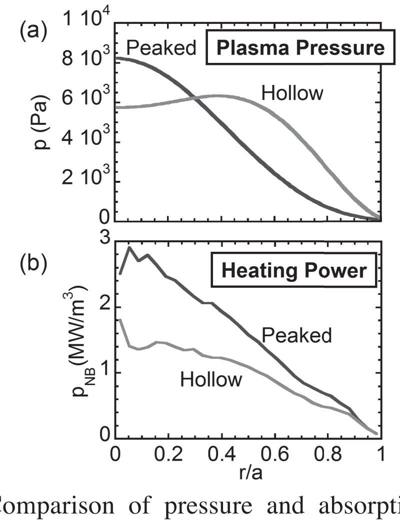

Fig. 2. Comparison of pressure and absorption power profiles between hollow and peaked density profile