Effects of low central fuelling on density and ion temperature profiles in reversed shear plasmas on JT-60U

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Reversed shear (RS) plasmas have been developed in JT-60U with internal transport barriers (ITBs) to establish an advanced steady-state operation scenario. In these plasmas, positive-ion based neutral beam (P-NB) with beam energy of 80-85 keV has been mainly used. The P-NB provides central fuelling, which is different from a reactor relevant condition. JT-60U also has negative-ion based NB (N-NB) with beam energy of 350-380 keV and electron cyclotron wave heating (EC), which can provide the reactor relevant condition in relation to fuelling as well as electron heating. The density (n_e) ITB has large impacts on fusion output and impurity accumulation. Therefore, it is important to investigate the n_e ITB formation with low central fuelling. Furthermore, another important issue is relation between the n_e and ion temperature (T_i) ITBs, because an ion temperature gradient mode is suppressed with a large n_e gradient. In this paper, effects of low central fuelling on the n_e and T_i ITBs were investigated.

RS plasmas were produced with low and high central fuelling at a plasma current of $I_p = 1$ MA and a toroidal magnetic field of $B_T = 3.7$ T. In the low central fuelling case, EC (~ 2.5 MW), N-NB (~ 4.6 MW) and P-NB (~ 3.3 MW for diagnostics) were injected during I_p ramp-up phase. In the high central fuelling case, only P-NB (~ 10.4 MW) was injected during I_p ramp-up phase. The central fuelling rate was estimated to be 3.9×10^{20} /s in the low central fuelling case, which includes 3.2×10^{20} /s from P-NB and 6.6×10^{19} /s from N-NB. On the other hand, the central fuelling rate was estimated to be 1.0×10^{21} /s in the high central fuelling case. Central fuelling rate is smaller by a factor of 2.5 in the low central fuelling case than that in the high central fuelling case. The electron temperature (T_e) ITB is quite different for two cases due to the electron dominant heating in the low central fuelling case. The difference in T_e produced the different q profile in the central region. In the low central fuelling case, wide current hole was produced due to higher T_e. The n_e and T_i ITBs were formed in the region of $r/a = 0.4$-0.6 for both cases and the ITBs with low central fuelling case were similar to those with high central fuelling case. In the central region ($r/a \leq 0.4$), the T_i profile was flat in the low central fuelling case due to wide current hole. On the other hand, the T_i profile was peaked in the high central fuelling case. The T_i gradient increased with the n_e gradient, but their causality was not clear. These results indicated that central fuelling is not largely affect the n_e and T_i ITBs. The n_e and T_i ITB formation is also discussed with edge fuelling by gas-puffing in the low central fuelling case.