§29. Optimization of Fueling in Magnetically Confined Plasmas ~ Fueling Optimization Using Hα/Dα 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, several fueling methods have been tried to control the plasma profile and performance: Supersonic molecular beam injection (SMBI) and shot-pulsed intense gas puffing (Intense GP)[1]. Recently, we obtain high density plasmas more than $1\times10^{19}m^{-3}$ by the intense GP method. In this study, we report on the behavior of the hydrogen recycling for the high density plasma discharge using the combination of the Hα/Dα line-emission measurements and a Monte-Carlo simulation.

Figure 1 shows the waveform of the high density plasma discharge, which is obtained in the NBI heated plasmas in the configuration with lower toroidal magnetic component (low ε_t). The intense GP, several times higher than that for the normal fueling, is applied from t=210 to 220 ms. In this period, small degradation of the stored energy is observed. After the stopping GP, the stored energy increases up to 6 kJ in accordance with the reduction of Hα/Dα intensity and increase in the edge AXUV intensity. The radial profile of the electron temperature (T_e) and density (n_e), the ion temperature (T_i) and the Hα/Dα intensity ($I_{H\alpha}$)[2] is plotted in Fig. 2 before (t=210ms), during (232ms) and after (242ms) intense GP. Due to the intense GP, n_e at the core region increases twice from t=210ms to 232ms, while the change in T_e is small. After the intense GP, T_e and T_i in the peripheral region increase remarkable, then the increase in the stored energy is caused by the increase in the edge temperatures. The maximum density more than $1\times10^{19}m^{-3}$ was observed around r/a=0.4 after the intense GP. The Hα/Dα intensity decreases about 50% from 232ms to 242ms, while its profile shape does not change significantly. Since the change in n_e is small between the two timings, this phenomenon indicates the reduction in the hydrogen density in the plasma after the intense GP. The effect of the Shafranov shift due to the plasma beta ($\langle\beta_{DIA}\rangle \sim 0.8\%$) will be investigated in the next experimental campaign.

To reveal the behavior of the neutral hydrogen in the high density discharge, we examine the neutral particle transport using a Monte-Carlo simulation. We introduce three types of the particle source as the initial condition, the gas fueling from GP, the hydrogen recycling which is uniformly distributed at wall and the recycling from footprint. The footprint source is determined from the orbit calculation. Although the Hα/Dα intensity from the simulation in the outer torus side (R > 1.3m) is higher than the measurement, the edge neutral hydrogen density decreases by 50% after the intense GP. Therefore, the decrease in the charge exchange or radiation losses in the peripheral region may have a contribution to improve the edge plasma performance. The distribution of the footprint source will be improved to interpret the hydrogen recycling more precisely.

At the phase of the sudden drop of $I_{H\alpha}$, the reduction in the edge density fluctuation by beam emission spectroscopy[3] and the increase in the co-rotating plasma flow are also observed. Now we are preparing a transport code for Heliotron J device to understand the characteristics of the heat/particle transport for the high density plasma.

1) T. Mizuuchi, F. Sano, et al., IAEA-FEC2012, 8-13 Oct (2012), San Diego, USA, EX/P3-07.
2) S. Kobayashi et al., Rev. Sci. Inst. **77**, 10E527 (2006).
3) S. Kobayashi, et al., Rev. Sci. Inst. **83**, 10D535 (2012).

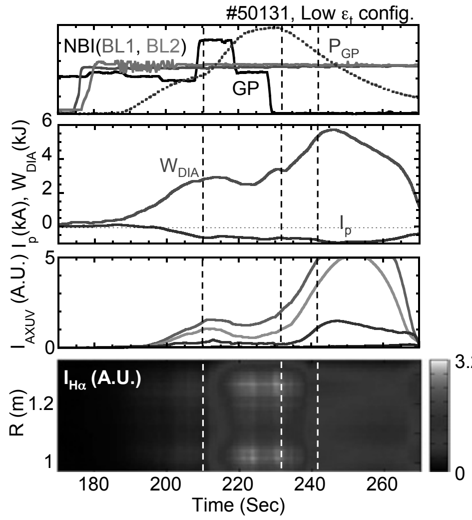

Fig. 1. Time evolution of heating/fueling, stored energy (W_{DIA}), toroidal current (I_p), AXUV intensity (I_{AXUV}) and Hα/Dα line emission intensity ($I_{H\alpha}$).

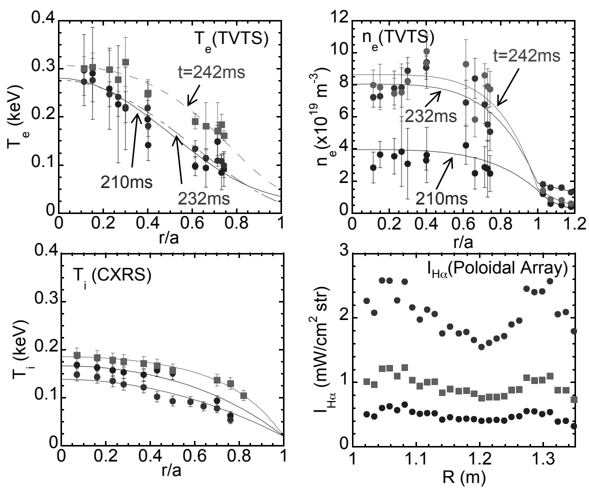

Fig. 2. Radial profile of electron temperature, electron density, ion temperature and Hα/Dα intensity before (t=210ms), during (232ms) and after (242ms) intense GP.