§30. Optimization of Fueling in Magnetically Confined Plasmas (Fueling Optimization Using H_α/D_α Lineemission Measurements in Heliotron J)

Nakashima, Y., Yoshikawa, M., Kohagura, J., Hosoi, K., Takeda, H., Ichimura, K., Kigure, S., Takahashi, S., Iwamoto, M., Hosoda, Y. (PRC, Univ. Tsukuba),
Kobayashi, S., Mizuuchi, T., Okada, H. (IAE, Kyoto Univ.),
Nishino, N. (Hiroshima Univ.),
Harada, T., Otani, Y., Kasajima, K., Kirimoto, M., Maruyama, M. (GSES Kyoto Univ.),
Shoji, M., Morisaki, T., Miyazawa, J.

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 more than $1\text{x}10^{19}\text{m}^{-3}$ using short-pulsed high-intensity GP (HIGP) method [1,2]. In this FY, to reveal the behavior of the particle confinement as well as the effect of the edge neutrals in the high density discharge by HIGP, we calculated the neutral particle transport using a Monte-Carlo simulation.

A full-torus plasma mesh which was based on the geometry of the vacuum vessel and magnetic configuration was used for the neutral particle transport simulation. The number of cells are 15, 512 and 28 in the radial, toroidal and poloidal directions, respectively. Three types of the particle source were introduced as the initial condition, the gas fueling from GP, the hydrogen recycling which was uniformly distributed at the wall surface and the recycling from "footprint". The source position of the footprint at the wall was determined from the collisionless orbit calculation. Figure 1 shows the particle source distribution in one toroidal section projected onto the wall surface as functions of toroidal and poloidal angle. The amount of the uniformly distributed wall and footprint sources were determined so as to reproduce the measurement data. The gas fueling rate has been calibrated prior to the experiment. As shown in the figure, a high footprint particle source was located at the opposite side of the helical coil.

Figure 2 shows the radial profile of the measured H_α/D_α-line emission intensity at the timing of before (×), during (♦) and after (•) HIGP. The simulation results were also plotted in the figure by solid lines. The calculated intensity using the three particle sources is almost consistent with the measurement data. However, some discrepancy can be seen in the outer torus side ($R > 1.3$m). The improvement in the particle source distribution is required for more precise estimation.

Figure 3 shows the radial profile of the neutral hydrogen density at the cross section where the footprint particle source is high. Asymmetry of the neutral density can be seen because the footprint source is located at the outer torus side. The simulation result predicts that the edge neutral hydrogen density decreases by 50% after the intense GP. In this discharge, the electron and ion temperature increased after the HIGP. Therefore, the decrease in the charge exchange or radiation losses in the peripheral region may have a contribution to improve the plasma performance. Now we are planning to apply momentum and energy transport analyses including the effect of the edge neutrals to understand the confinement characteristics of the high-density plasmas using HIGP method.

1) T. Mizuuchi, F. Sano, et al., IAEA-FEC2012, 8-13 Oct (2012), San Diego, USA, EX/P3-07.
2) S. Kobayashi, et al., 40th EPS conf. ECA vol. 37D, (2013) P1.148.

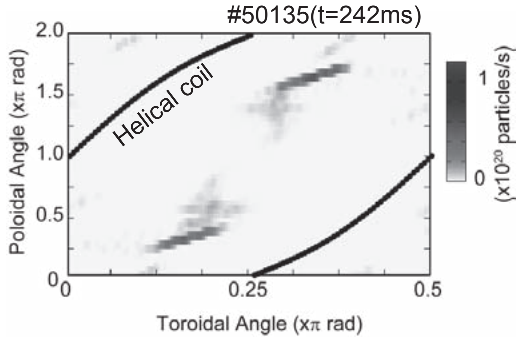

Fig. 1. The particle source distribution projected onto the wall surface in one toroidal section.

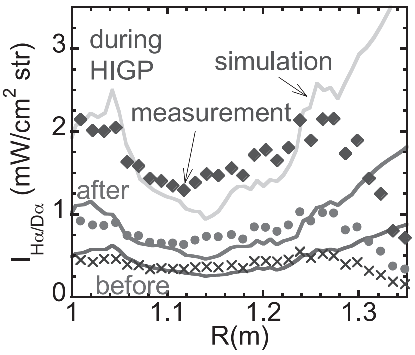

Fig. 2. Radial profile of H_α/D_α line emission intensity before (×), during (♦) and after (•) HIGP. The H_α/D_α emission intensity deduced by the simulation is plotted by solid lines.

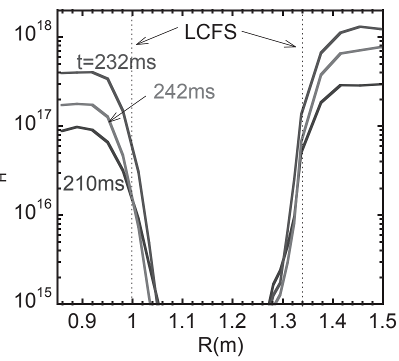

Fig. 3. Radial profile of neutral hydrogen density before (t=210ms), during (232ms) and after (242ms) intense GP at the location where the H_α/D_α emission profile is measured.