§12. Analysis of Recycling Behavior and Optimization of Particle Fueling in Open Magnetic Field Plasmas

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In magnetically confined plasmas, optimization of particle fueling is a critical issue to achieve high performance plasmas. In particularly in tandem mirror devices, development of the plasma operation methods for the high density plasmas is an important subject to control the plasma condition for the divertor simulation. In this study, supersonic molecular beam injection (SMBI) was tried to understand the particle transport aiming at the development of the high density plasma operation.

SMBI was installed in the central cell of GAMMA 10 [1]. Two sets of the objective lens with dual blanch optical fiber bundles were installed in the central cell for the 2-dimensional (x-z, or y-z) high-speed camera measurement, which enables us to observe the plasma response to SMBI. The plenum pressure of SMIB was usually 1 MPa and pulse width was 0.5-1.0ms. Figure 2 shows an example of 2-dimensional image of visible light emission during SMBI in GAMMA 10 ICRF heated plasmas. In order to investigate the directivity of the injected molecular beam by SMBI, the full width at half maximum (FWHM) of the emission intensity in the axial direction is used as an index for the degree of expansion of SMBI. The FWHM-value decreased as increasing the plenum pressure, which shows the directivity of SMBI became higher.

Monte-Carlo simulation code (DEGAS) was carried out in order to analyze the behavior of neutral particle in GAMMA 10. Three-dimensional mesh-model for DEGAS has been applied to the central-cell [2]. A Fully 3-dimensional mesh-model has been applied to the central and anchor cells as shown in Fig. 3. In this model, the limiters and antennae of ion cyclotron radio frequency (ICRF) are precisely implemented in realistic configuration. The background plasma parameters (T_e, T_i, n_e, n_i, etc) were given based on the experimental data to each mesh. The neutral gas from the SMBI valve was modeled by introducing a σ_{div} parameter: an index of divergence angle of the initial particles. In the case that the angular profile of launched particle has a cosine distribution, the divergence angle index is σ_{div} = 1. The comparison between the simulation and experimental results was shown in Fig. 4. The hatched zone on Fig. 4 shows the FWHM obtained from the experimental results. The modeling of SMBI has to be carried out under the initial particle condition of σ_{div} = 0.4 - 0.5 in order to reproduce the experimental results in the case of the plenum pressure of between 0.2-1.0 MPa. These results suggest that there is a difference between SMBI and conventional gas puff in the initial condition of the divergence angle of the initial particles. A detailed configuration of the particle source will be investigated to discuss a penetration depth of the neutral particles from SMBI.

1) K. Hosoi et al., 21st Int. Toki Conf. (2011) Nov. 28th -Dec. 1st 2011,Gifu Japan, P2-82.
2) Y. Nakashima, et al., J. Plasma Fusion Res. SEREIS **6**, 546 (2004).

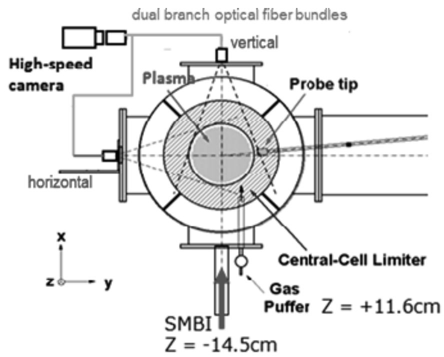

Fig.1. Schematic view of the central-cell cross-section and the locations of SMBI system and high-speed camera

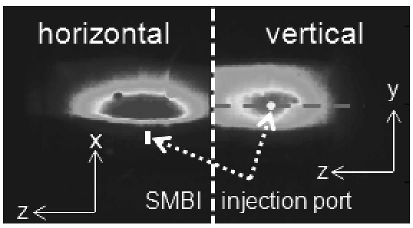

Fig.2. 2-dimensional image of visible light emission during SMBI from two direction.

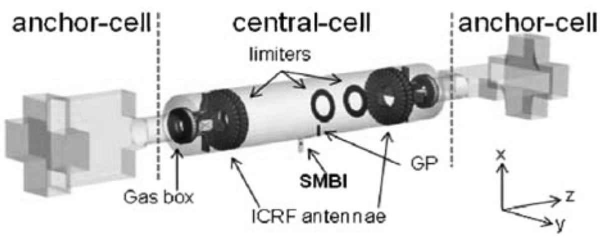

Fig.3. A fully 3-dimentional DEGAS mesh model with SMBI port.

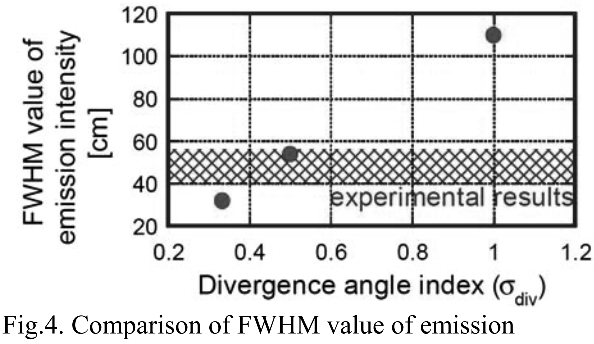

Fig.4. Comparison of FWHM value of emission intensity between experimental results and simulation results.