# §17. Optimization of Fueling in Magnetically Confined Plasmas ~ Analysis of Neutral Behavior and Optimization of Particle Fueling in Open Magnetic Field Plasmas ~

Kobayashi, S., Mizuuchi, T., Okada, H., Kemmochi, N., Harada, T., Kitimoto, M. (Kyoto Univ.), Nishino, N. (Hiroshima Univ.), Nakashima, Y., Sakamoto, M., Yoshikawa, M., Kohagura, J., Hosoi, K., Takeda, H., Ichimura, K., Kigure, S., Takahashi, S., Iwamoto, M., Hosoda, Y. (PRC, Univ. Tsukuba), Shoji, M.

In magnetically confined plasmas, optimization of particle fueling is an important subject to achieve high performance plasmas. In GAMMA10 tandem mirror, supersonic molecular beam injection (SMBI) has been demonstrated as a new particle fueling method to produce high density plasmas[1]. In this FY, a Laval-type nozzle has been newly mounted as the SMBI valve in order to improve the effectiveness of fueling by SMBI[2]. The effect of the Laval nozzle on the fueling is compared with the results using a straight nozzle and no nozzle cases.

The schematic drawing of the SMBI with the Laval nozzle, plasma and camera measurement system is shown in Fig. 1. The SMBI system is installed at the bottom of the GAMMA 10 central cell midplane. As shown in Fig. 2, the Laval nozzle is made of Al covered with a stainless steel plate to prevent the heat load onto the nozzle by the edge plasma, which is set close to the plasma boundary. A fast camera is used to observe the two sets of the two-dimensional (i.e., x-z, and y-z) emission image by SMBI using dual branch optical fiber bundles. The fueling experiments were carried out in ICRF heated plasmas. The plenum pressure of SMBI was changed from 0.3 to 2.0 MPa and the pulse width was usually set to be 0.5 ms.

Typical image measured with the fast framing camera at the timing of SMBI is shown in Fig.3. In this case, the straight nozzle was used. The image from the horizontal viewing port provides us the information of the effective penetration length of the particle fueling by SMBI. The directivity of the particle fueling by SMBI is estimated by the image from the vertical port. We used the full width at half maximum (FWHM) of the distribution of the emission intensity at the broken line on the camera image from the vertical port as an index of the directivity of the molecular beam by SMBI (the broken line was drawn over the SMBI injection port). The intensity of the light emission around the SMBI injection port changes according to the amount of fueling from SMBI. However, the shape of the intensity profile (i.e. the value of FWHM) generally does not change as the intensity change. Then, the FWHM is determined at the timing with the peak intensity to obtain the best signal-to-noise ratio. Figure 4 shows the FWHM of emission intensity as a function of the plenum pressure. The FWHM of emission intensity in the Laval nozzle case is about a half of the no-nozzle and is 70% of the straight nozzle cases. This result indicates the Laval nozzle has a capability to improve the directivity of the gas fueling by SMBI. In the next experimental campaign, we are planning to obtain the dependence of directivity on the plenum pressure to clarify the effectiveness of the Laval nozzle quantitatively. The numerical simulation is also planned to understand the physical mechanism of the particle fueling by SMBI.

1) K. Hosoi, et al. 9th Int. Conf. Open Magnetic Confinement, Aug. 27th - 31st, 2012, Tsukuba, Japan P-2.
2) K. Hosoi, et al., 30th JSPF Ann. Meeting (2013) 04aE55P.

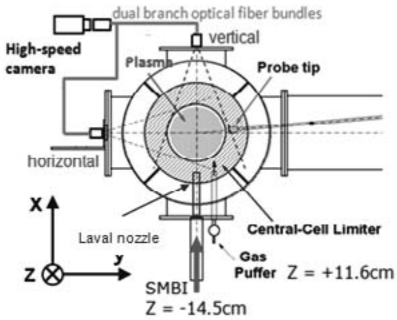


Fig. 1. Cross section of the GAMMA 10 central cell midplane, SMBI with Laval nozzle and the viewing areas of the fast framing camera using dual branch optical fiber bundles.

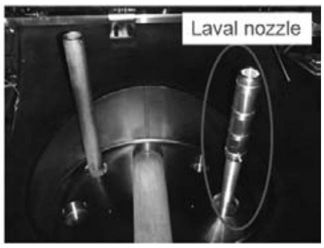


Fig. 2. Photographs of the Laval nozzle for SMBI installed in the GAMMA 10 central cell midplane.

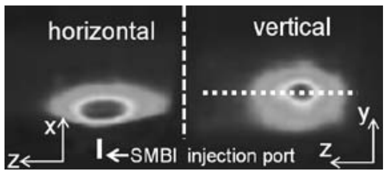


Fig. 3. Typical image of the fast framing camera. Left and right images are obtained by the dual branch optical fiber bundles located at the horizontal and vertical viewing ports, respectively.

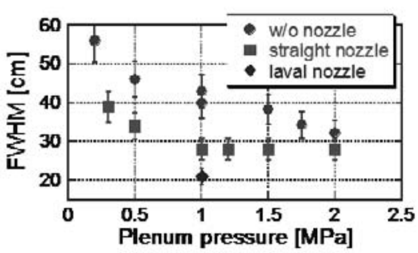


Fig. 4. FWHM of emission intensity as a function of the plenum pressure in Laval, straight and no nozzle cases.