§2. Correction of Beam Profile by Modifying Aperture Shape of Steering Grid II

Tsumori, K., Nagaoka, K., Osakabe, M., Ikeda, K., Takeiri, Y., Kaneko, O., Oka, Y., Shibuya, M., Asano, E., Sato, M., Kondo, T. (NIFS)
Asano, S., Watanabe, J., Suzuki, Y., Ichihashi, K., Okuyama, T. (TOSHIBA Co.)

Heat load carried by accelerated beams onto grounded grids (GG) is one of the essential points to increase the beam power and the pulse duration in large scaled hydrogen negative ion (H^-) sources for the neutral beam injection (NBI). In the acceleration of the H^- ions, some part of H^- beam separates to hydrogen atoms and electrons via the collision of H^- ion and H_2 gas diffused from the ion source. The electrons are accelerated after the collision and their trajectories are bent by the magnetic field leaked form the ion source. The electron beams collide onto the GG, and the spatial concentrations of the electron beams are high enough to melt the GG surface. It is, therefore, effective to reduce the H2 gas load inside accelerator and to design the GG with smaller beam accepting area. To realize those two conditions, the beam accelerator consisting of steering grid (SG) and multi-slot grounded grid (MSGG) has been applied to one of the beam line for LHD-NBI since 2002 [1]. A cut view of the accelerator is indicated in Fig. 1. As shown in the figure the MSGG has a high transparency, which is twice higher than the conventional multi-circular aperture grid, and gas conductance between SG and MSGG is expected to be lower. In 2003, the maximum injection energy and power of 189 keV and 5.7 MW have been achieved using the ion sources with the accelerator [2].

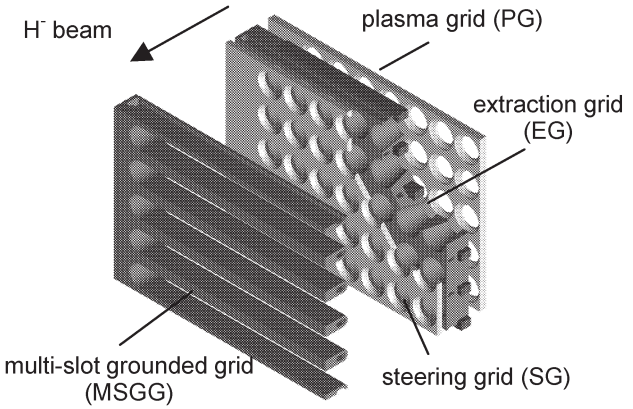

Fig. 1. A cut view of beam accelerators with the steering grid, SG, and multi-slot grounded grid, MSGG.

Although the accelerator with the MSGG has an advantage to increase the injection power, the system involves a large demerit caused by the different symmetry of electric field near the SG and MSGG [3]. The influence is observed as the separation of focal condition in the direction of the slot long and short sides; the feature is not observed in accelerators consisting of multi-circular aperture grids. Figure 2 shows the beam widths in the both directions as the functions of voltage ratio (*Rv*) of acceleration voltage (*Vacc*) to extraction voltage (*Vext*). In the practical operation of the ion source, Rv is chosen in the gray area in Fig. 2, and the beam profile elongates in the one direction. The profile distortion induces the irregular concentration of the beam inside the beam line, and the beam injection port and beam dump had been melted.

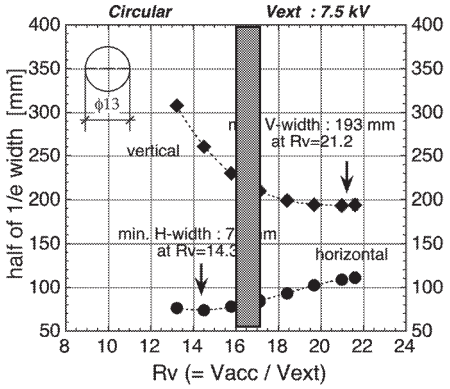

Fig. 2. e-folding half width of beam profile as a function of voltage ratio (*Rv*) of acceleration voltage (*Vacc*) to extraction voltage (*Vext*). The solid circles and solid diamonds indicate the widths parallel and perpendicular to the slot-long-side of the MSGG, respectively. The shape of the SG aperture is circular on with the diameter of 13 mm.

The investigation has been done to decrease the separating focal condition using a small-scaled ion source consisting of the SG with multi-racetrack apertures [3]. There are some differences in small-scaled source and LHD ion source, for instance the grid gaps, applied voltages and so on. The SG with racetrack apertures is investigated to confirm the validity for the reduction to focal separating characteristics in LHD-NBI.

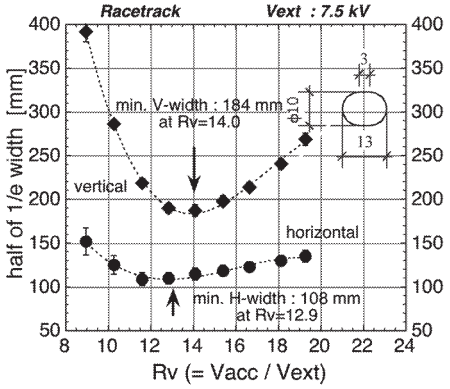

Fig. 3. e-folding half width of beam profile as a function of voltage ratio (*Rv*). The data was obtained with use of the accelerator with MSGG and racetrack SG apertures (ϕ10x13 mm).

The focal characteristic on a combination of the SG race-track apertures and MSGG is indicated in Fig. 3. The long and short sides of the racetrack are 13 and 10 mm, and the long side corresponds to the slot long side of the MSGG. The voltage ratios obtaining the minimum widths in the long and short direction of MSGG slot become closer in the system with racetrack-SG apertures comparing to that with circular apertures. By modifying the shape of SG aperture, the damages inside the beam line is considered to decrease, but also the beam port-though efficiency is expected to increase.

[1] K. Tsumori et al, Rev. Sci. Instrum, 75 5 pp.1726-1728 (2004)
[2] K. Tsumori et al, proceedings of 20th IAEA conf, FT/1-2b, Vilamoura (2004).
[3] K. Tsumori et al, proceedings of 10th International Symposium on the Production and Neutralization of Negative Ions and Beams, Kiev, (2004).