§17. Experimental Study of a New 1/3 Scaled Ion Source

Tsumori, K., Kaneko, O., Takeiri, Y., Osakabe, M., Ikeda, K., Oka, Y., Hamabe, M., Kawamoto, T., Asano, E., Asano, S., Ichihashi, K., Okuyama, T., Suzuki, Y. (TOSHIBA Co.)

We designed a new 1/3 scaled negative ion source to improve following two points. The first one is improvement of efficiency of negative hydrogen ion (H^-) yield to the input arc power. The efficiency reduces input electric power and makes the life times of arc filaments longer. The second point is to increase H^- beam efficiency, which are ratios of H^- currents to extraction and acceleration currents. Improvement of this efficiency reduces heat loads onto electrodes and decreases breakdowns between the electrodes and avoids melting the electrodes.

The H^- efficiency mainly takes part in plasma confinement of arc chamber. We designed an arc chamber to make plasma confinement better than older chambers. The old arc chambers had rectangular cross sections, while the new chamber has hexagonal cross section as described elsewhere in this annual review. This cross section is optimized with aid of some numerical codes.

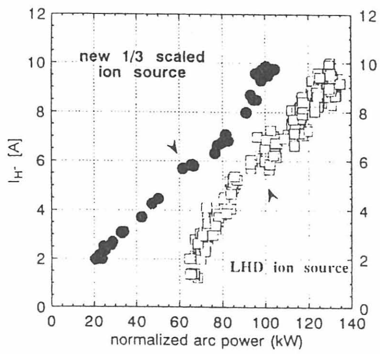


Fig. 1. Arc dependence of H^- currents in a new 1/3 scaled ion source (close circles) with that of a source for LHD-BL1 (open square).

Figure 1 shows the arc dependence of H^- current in the new 1/3 scaled source. For comparison the arc dependence in an ion source for LHD-NBI #1 is plotted in the same figure. Arc chambers of these ion sources have different volumes, and the scales of this figure are normalized to a volume of the new ion source. The arc efficiency to H^- current becomes obviously better in 1/3 scaled source. In case of the new source H^- current increases linearly to the arc power, and this suggests arc discharge is stable in all ranges of the arc power input.

The ion source for LHD consists of three electrodes' grids, which are plasma, extraction and grounded grids. Negative ions are extracted by applying an extraction voltage between the plasma and the extraction grid, and the H^- beamlets are accelerated between a gap of the extraction and the grounded grids. The electron deflection magnets EDMs are installed inside the extraction grid. The magnetic field deflects not only extracted electron beam but also H^- beam. In LHD ion source, trajectories of the deflected H^- beamlets were corrected by displacing aperture positions of the grounded grid. In this case the maximum degree of the displacement was about 3 mm and the beamlets were accelerated to a full energy. It could be a cause of electric breakdowns between the acceleration gap. The degree of displacement becomes smaller when the H^- beamlets is steered at the energy less than the full acceleration. As shown in Fig. 2 the new ion source consists of an additional steering grid SG. The grid is installed 3 mm apart from the outlet of the extraction grid. Retarding voltages is applied to the SG for adjustment of steering angles of the H^- beamlets.

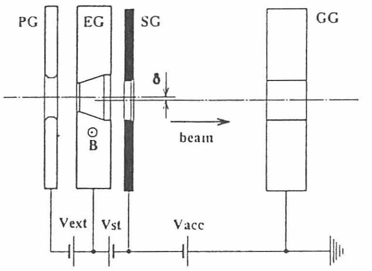


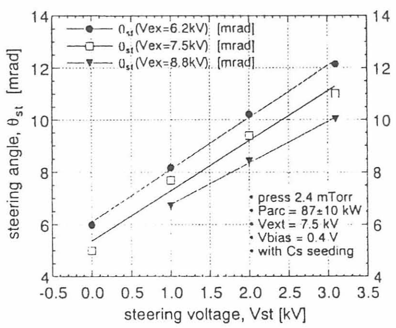
Fig. 2. Assembly of electrodes for a new ion source.

Beam ratios in the new source and the LHD source are indicated in Table 1. In the table Iext and Iacc show extraction and acceleration currents, respectively. Ratios of I_{H^-} / Iext and I_{H^-} / Iacc increase in the new source. The electron component is reduced in the beam. Heat load current onto grounded grid Igg is also reduced in the new source, and this is consistent with the electron reduction.

	new 1/3 source	LHD source
I_{H^-} / Iext	63 %	45 %
I_{H^-} / Iacc	75 %	65 %
Igg / Iacc	10 %	17 %

Table 1. Beam components in the new and LHD ion source.

Extracted H^- beam current and the profile are detected by a cross-type calorimeter array at 4 m apart from ion source. By fitting the profile with double Gaussian curve, beam steering angle was measured as a function of voltages to steering grid as shown in Fig. 3. Steering angle changes about 6 mrad by increasing the steering voltage from 0.0 kV to 3.1 kV.



s = 6.0874 + 1.9937 • Vst, (Vex = 6.2 kV)
s = 5.3536 + 1.9151 • Vst, (Vex = 7.5 kV)
s = 5.1743 + 1.5775 • Vst, (Vex = 8.8 kV)

Fig. 3. Beam steering angle by applying voltage to steering electrode.