

§7. Effect of Modified Cusp Magnetic Field in Arc Chamber of H⁻ Source for NBI

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Neutral Beam Injectors (NBIs) are major heating devices in LHD, and are utilized to many experiments. Especially for mission experiments, higher power beam injections with more stable operation may be demanded. An improvement of negative-hydrogen-ion (H⁻) source performance is one of the key issues for such beam injections.

To extract larger H⁻ beam current, it is necessary to make more H⁻ dens in the vicinity of the plasma grid which is boundary electrode between an arc plasma and beam. To produce the high H⁻ density, a cusp magnetic configuration of an arc chamber of the source for 2nd beam line (BL2) was modified in LHD 15th campaign (15c). Modification concepts are 1) high-dens plasma production in filter magnetic field region, 2) broadening the high-dens plasma, and decrease flux to the arc chamber. A limitation of the modification is to utilize existing arc chambers. A plasma profile was estimated from calculated magnetic field lines and distributions of first electron from filaments. Although the first electron distribution does not completely conform to plasma one, it could be one of the indicators of the plasma profile evaluations because a part of measured plasma density profile with Langmuir probe was similar to that of the first electron one.

Figure 1 shows cusp magnet configurations of arc chamber and primary electron distributions from straight filaments until LHD 14th campaign (14c) and in 15c. In the magnetic configuration in 15c, a cusp magnet line of arc-chamber side wall at the nearest side of a back plate was removed, and polarities of the cusp magnets of the back plate were reversed. Electrons does not distribute to the plasma grid because collision and other property of plasma are not included in this calculation. In the magnet configuration in 15c, high-electron-density region in filter field area expands, and electrons reaching to chamber wall decreased.

Figure 2 shows arc efficiencies which are rates of H⁻ beam currents (here, acceleration drain currents (I_{acc}) are utilized.) to input arc power. In the case of the straight filament utilized, the 15c operation was performed with about 10 % higher arc efficiency than 14c one. The maximum pulse-averaged I_{acc} in 15c became larger than that in 14c, and reached to 41.3 A with 183 keV in beam energy from one source during 1.3 sec without voltage break down.

Although the decrements of the arc efficiencies in input arc power were observed by use of bent filaments to the PG and a back plate in LHD 12th to 14th campaigns, the decrement of the arc efficiency were not observed in 15c. In 15c, a distance between extraction and grounded grids was lengthened 65 mm from 60 mm. This could improve an

acceleration voltage holding, and the arc efficiency could have a linear relation even in high input arc power due to more easy operation. It needs more validation about the decrement of the arc efficiency.

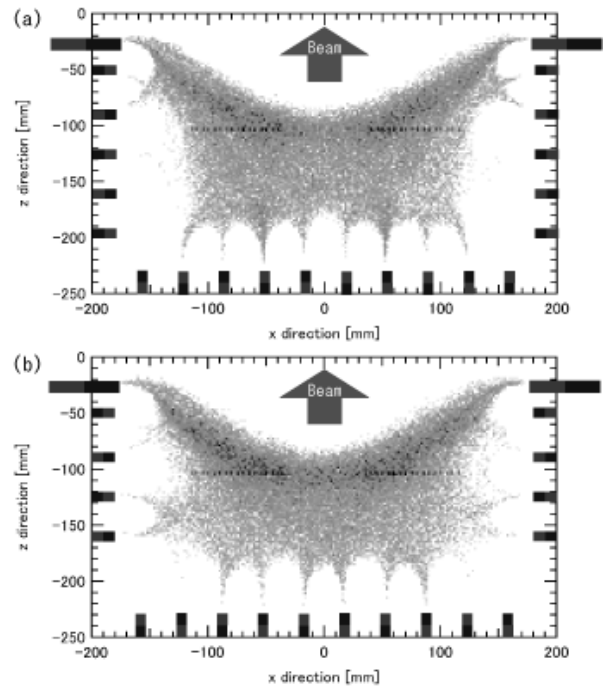


Fig. 1. Cusp magnet configurations of arc chambers and primary electron distributions from straight filaments until (a) LHD 14th campaign and (b) in 15th.

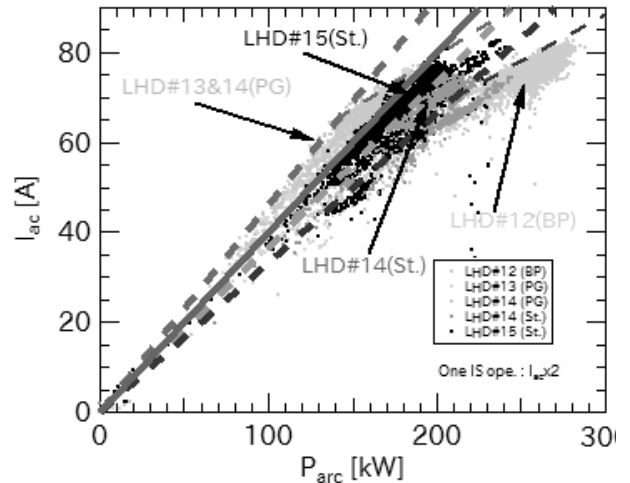


Fig. 2. Input arc power dependences of acceleration-power-supply drain current. The I_{acc} displays as twice in the case of the BL2 operation by use of only one H⁻ source to compare normal operation with using two H⁻ source. Denotations of St., BP and PG are filament shapes of straight and bent to the back plate and the plasma grid, respectively.