

## §24. Improvement of Negative Ion Beam Profile

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A neutral beam injection (NBI) system used for LHD has two negative ion sources. Improvement of the system efficiency is an important issue for high power beam injection. An extraction beam current has been limited by increasing a local heat-loading on the ground grid due to the nonuniformity beam production. So, we adopted a filament and an arc power supplies divided into twelve in order to increase a uniformity of the produced source plasma.

Negative hydrogen ions are produced by the arc discharge with tungsten filaments as cathode in a rectangular section (1450mm in height 350mm in width) of the arc chamber. Fifty hairpin-shaped filaments are installed in the arc chamber. Confinement magnetic field is made by external filter magnets and line cusp magnets. The arc discharge current distribution along the vertical axis was non-uniform in the case of the same voltage applied to each filament as shown in Fig. 1, where channel 1 and 2 are in the top, and channel 7 and 8 are in the bottom. Here, we used 24 filaments for these discharges without beam extracting. The discharge controlled uniformity without cesium, but a discharge uniformity collapsed when cesium was introduced. Figures 2(a) and (b) show profiles of the applied voltage and the arc discharge current in the case of cesium doping, respectively. We made the arc discharge strong at the bottom by increasing the filament number of the lowest channel from 2 to 3, because the arc discharge was strong in an upper area

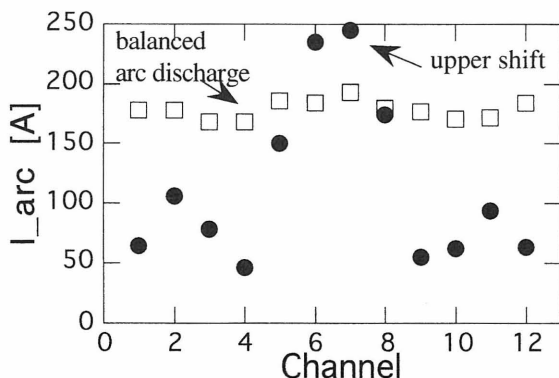


Fig. 1 Arc current distribution without Cs, circle shows a constant arc voltage supplied and square shows controlled voltage.

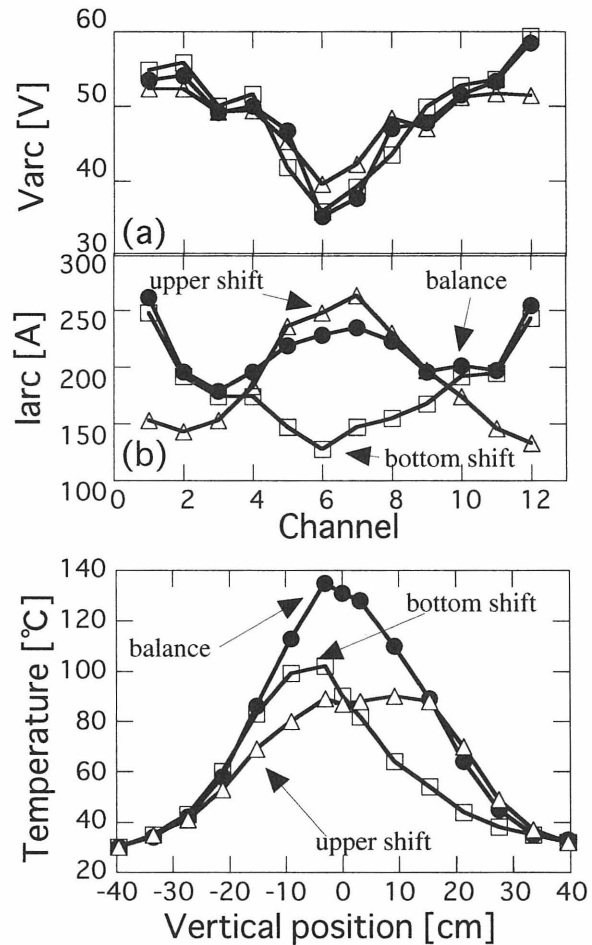


Fig. 2 (a) and (b) are arc discharge distribution patterns, (c) shows a temperature distribution of calorimeter.

by introducing cesium. The distribution of the arc current was sensitive to a voltage change of around 5 V. The beam profile was estimated with the temperature distribution measurement on the calorimeter as shown in Fig. 2(c). The beam uniformity was improved when the arc voltage of top and bottom was kept high.

We also examined a better filament arrangement. More uniform beam was produced when the filament voltage was supplied from the same power supply to filaments of a position of the same height. The arc discharge of each channel showed good independency in this connection. The beam distribution extracted from five grid segments was estimated by the beam profile measurement. The beam of 13.3% of the total beam was extracted from one grid (top or bottom), and the beam of 24.4% was each extracted from three center segments. The beam divergence was estimated to be 10 mrad.