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Experimental Studies In The Ion Source Of 5MW Neutral Beamline For HL-2M Tokamak

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A 5MW neutral beam injector has been developed for HL-2M tokamak. In this neutral beam injector there are four 80kV×45A×5s ion sources. The ion source is a rectangular bucket ion source with magnetic multi-pole line-cusp. The discharge chamber of the source is a water-cooled, oxygen-free copper rectangular column with 56cm in length, 26.6cm in width and 24cm in depth. The 16 hair-pin-shaped tungsten filaments, which are 1.5mm in diameter and 15cm in length, are attached to the filament holders at the top of the chamber. The arc chamber wall serves as anode, which is surround by 7 circles of Co-Sm permanent magnets to form axial line-cusp magnetic field, with the magnetic strength of about 2000G at the inside surface of the wall. The extraction system is composed of 4 actively water-cooled grids including plasma grid, gradient grid, deceleration grid and ground grid with extraction area of 13.5cm×42cm and 564 apertures with 6.9mm in diameter.

Experimental studies are operated in the ion source test bed. The dependence of extraction current and arc discharge efficiency on arc current is obtained with different connection ways among negative end of filament, plasma grid, probe plate and arc chamber, as it is shown in Fig.1. The extraction current increases almost linearly with the arc current. The connection way that plasma grid connects to the negative end of filaments with a 10 ohm resistance is the best to get stable arc discharge and higher arc discharge efficiency, for this connection way has minimum anode area and negative potential of extraction grid respect to the anode, and the resistance avoids localized discharge between arc chamber and extraction grid.

Doppler shift spectroscopy is used to measure the beam species, with observation angle at 45 degrees with respect to the beam axis. With scanning arc current shot by shot, the relations between beam ratio of H^+, H_2^+ and H_3^+ and arc current are obtained, which are shown in Fig.2. The ratio of H^+ increases with arc current and reaches about 50% when the arc current at 500A.

Gas input flow is scanned shot by shot in extraction experiment with arc current at 200A, 300A, and 400A separately. The experimental result is shown in Fig.3. With gas input flow increasing, arc voltage decreases, deceleration current increases and arc efficiency increases first and then decreases, which are in agreement with the results obtained in gas pressure scanning experiment on HL-2A. The gas input flow for highest arc efficiency increases with arc current. The extraction current remains decreased which is different with the result obtained in the ion source of HL-2A.

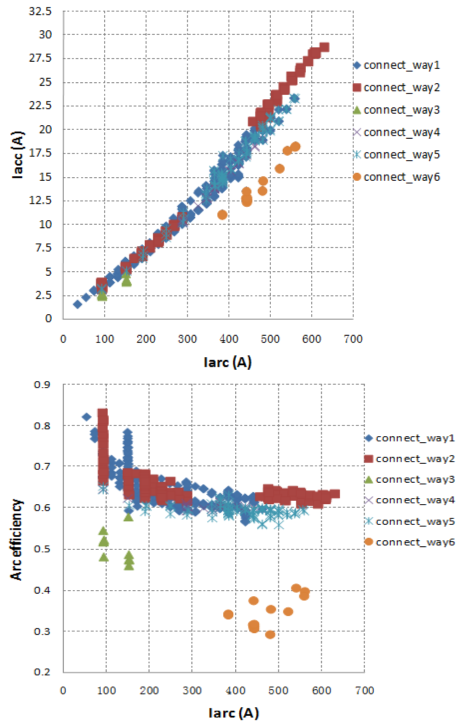

Fig.1 The dependence of extraction current and arc efficiency on arc current

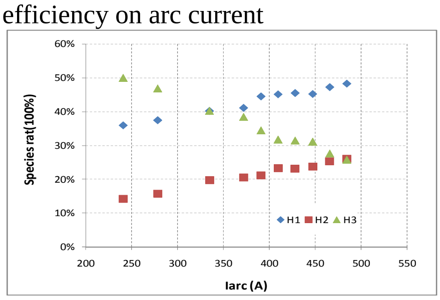

Fig.2 The variation of beam species with arc current

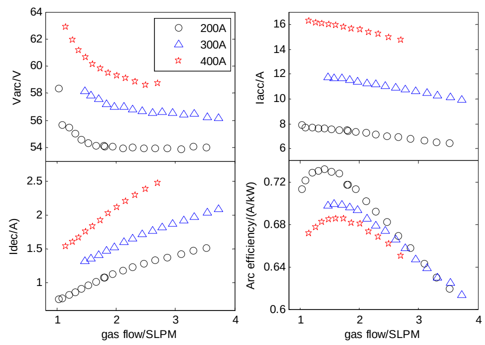

Fig.3 The change of arc voltage, deceleration current, extraction current and arc efficiency with increasing gas input flow