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Experimental Results of New Ion Source for Performance Test

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A new ion source has been designed, fabricated, and installed at the NBTS (Neutral Beam Test Stand) at the KAERI (Korea Atomic Energy Research Institute) site. The goalis to provide a 100 keV, 2MW deuterium neutral beam injection as an auxiliary heating of KSTAR (Korea Super Tokamak Advanced Research). To cope with power demand, an ion current of 50 A is required considering the beam power loss and neutralization efficiency. The new ion source consists of a magnetic cusp bucket plasma generator and a set of tetrode accelerators with circular copper apertures. The plasma generator for the new ion source has the same design concept as the modified JAEA multi-cusp plasma generator for the KSTAR prototype ion source. The dimensions of the plasma generator are a cross section of 59×25 cm^2 with a 32.5 cm depth. The anode has azimuthal arrays of Nd-Fe permanent magnets (3.4 kG at surface) in the bucket and an electron dump, which makes 9 cusp lines including the electron dump. The discharge properties were investigated preliminarily to enhance the efficiency of the beam extraction. The discharge of the new ion source was mainly controlled by a constant power mode of operation. The discharge of the plasma generator was initiated by the support of primary electrons emitted from the cathode, consisting of 12 tungsten filaments with a hair-pin type (diameter = 2.0 mm). The arc discharge of the new ion source was achieved easily up to an arc power of 80 kW (80 V/1000 A) with hydrogen gas. The 80 kW capacity seems sufficient for the arc power supply to attain the goal of arc efficiency (beam extracted current/discharge input power = 0.8 A/kW). The accelerator of the new ion source consists of four grids: plasma grid (G1), gradient grid (G2), suppressor grid (G3), and ground grid (G4). Each grid has 280 EA circular apertures. The performance tests of the new ion source accelerator were also finished including accelerator conditioning. A hydrogen ion beam was successfully extracted up to 100 keV /60 A. The optimum perveance is defined where the beam divergence is at a minimum was also investigated experimentally. The optimum hydrogen beam perveance is over 2.3 μP at 60 keV, and the beam divergence angle is below 1.0^{o}. Thus, the new ion source is expected to be capable of extracting more than a 5 MW deuterium ion beam power at 100 keV. This ion source can deliver ~2 MW of neutral beam power to KSTAR tokamak plasma for the 2012 campaign.

Keywords: Ion source, KSTAR, NB Heating, Neutral Beam