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Neutralizer experiment of KSTAR NBTS system

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ABSTRACT

A general neutralizer experiment was carried out to establish the operational coil current of the bending magnet, the neutralization efficiency of an ion beam with various parameter (beam energy, gas flow rate). Suggested operational coil current which was already studied for the bending magnet, was confirmed through a thermocouple installed at the middle of each ion dump and WFC (water flow calorimetry) system. The calculated optimum coil currents agree with the experimental coil current to penetrate each ion dump. Neutralization efficiency was measured by the WFC system. It depends on the gas flow rate and beam energy and a gas injection more than 800 sccm was needed to attain a equilibrium neutralization. Maximum efficiency was measured at more than 60% at 40 keV and less than 30% at the 80 keV of the hydrogen beam.

1. Introduction

A neutral beam test-stand system (NBTS) is being developed and tested as an auxiliary heating and current drive system for the Korea Superconducting Tokamak Advanced Research (KSTAR). The design requirements of the long pulse ion source for the KSTAR NBI system were a deuterium ion beam of 120 kV/65A, a beam pulse length of 300 s and an initial test beam of 90 kV/45A for 20 s with hydrogen ions. The prototype beamline components have been developed for an NB total power of 8 MW (4 MW from hydrogen beams), which originates from the deuterium ion beam, and is injected to the core plasmas of KSTAR, with three ion sources in a beamline.

The key points of this system are to extract an ion beam from the ion source and to transmit it into the tokamak as much as possible at a high potential (120 kV). The efficiency of the transmitted beam power is a very important factor and the extracted beam from the ion source must be a neutral beam to avoid an electromagnetic effect from the tokamak. Thus, as well as increasing the ion beam currents and power, increasing the neutralization efficiency is important to heat the plasma in the tokamak. Actually the neutralization efficiency has been determined by the cross section area of the beam species particles and the total gas line density for the beam energy, up to now, thus it seems to be sufficient only to study it theoretically, thus most studies to develop this system have focused on the development of a large ion beam current and a high energy. In order to inject a neutral beam power satisfactorily, however, one must confirm the neutralization efficiency during the experiments comparing by the calculation data. In this paper, general neutralizer experiment for the KSTAR NBTS including the optimum operation of the bending magnet and neutralization efficiency at each beam energy (40–80 keV) are discussed.

2. Experimental layouts and operation conditions

2.1. Prototype long pulse ion source (LPIS)

Performance of the ion source and neutralization efficiency of energetic ions are the key issues. Among these, the prototype LPIS

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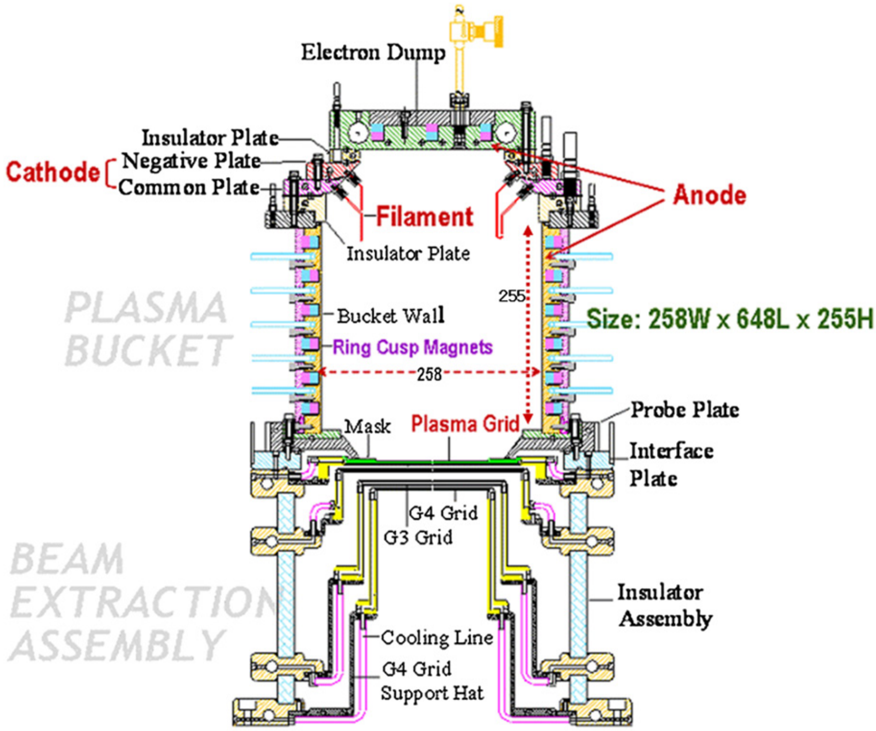

Fig. 1. Assembly drawing of the KSTAR NB prototype ion source.

consists of a magnetic cusp bucket plasma generator and a set of tetrode accelerators with 568 circular copper apertures [1] (Fig. 1). Hydrogen gas is injected into the arc plasma generator and ionized, and then the positive ions are accelerated through a potential gradient to form an ion beam. For a beam energy (40–80keV) grid potentials of gradient, suppressor and ground grids are 81% of full energy, −2 kV and 0 kV. A negative potential is applied to the suppressor grid to keep the electrons, produced outside the accelerator section, from entering it where they would be accelerated into the plasma generator. The arc discharge of the LPIS was operated up to an arc power of 60 kW (about 90 V/650 A) depending on the optimum beam optics. Hydrogen gas was injected at 160–560 sccm into the arc plasma generator through a system of mass-flow controllers (MFCs). All of the components

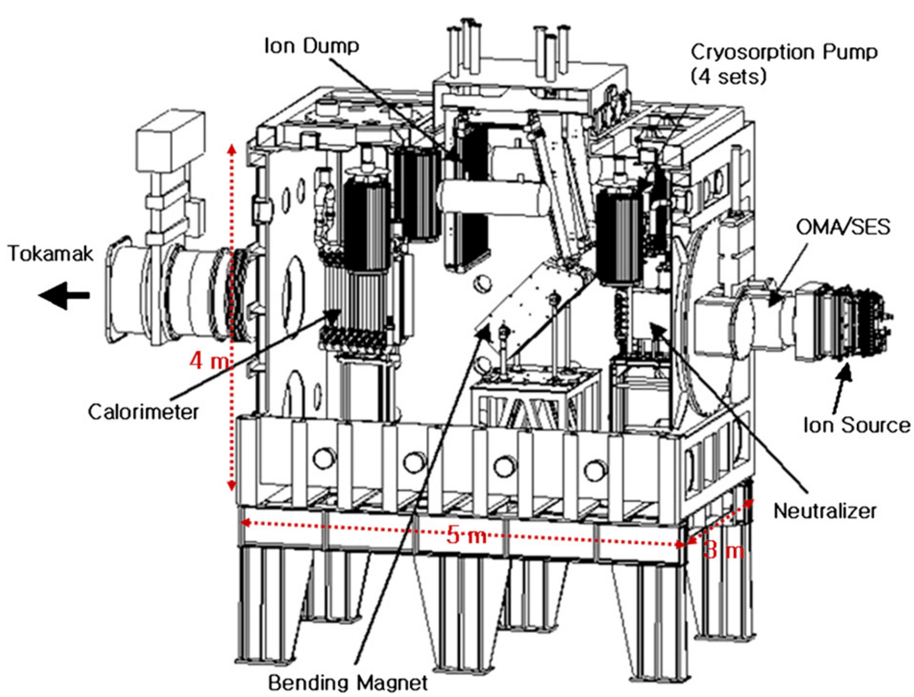

Fig. 2. Layout of the KSTAR NBTS system.