The performance of neutral beam injection on HL-2A


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HL-2A NBI with total neutral beam power of 4MW at beam energy of 45-55keV is composed of two beamlines which are located at opposite of the torus in tangential direction injection. One of the two beamlines in which four ion sources are equipped for each has been operated successfully since 2007. In 2009 NBI experiment campaign, deuterium atomic beam with neutral beam power of 0.75MW at its energy of 36keV has been injected into the torus. The H-mode discharge has been observed using NBI and ECRH on HL-2A. The central ion temperature of 2.7 keV has been obtained with the line-average density of 1.5×10^{19} m^{-3} at neutral beam power of 0.6MW with beam energy of 35 keV. The fishbone instability and giant sawteeth are easily excited during NBI.

The investigating the ion source characteristic in an ion source platform and neutral beam injection performance are presented in this paper.

Keywords: NBI Ion source

1. Introduction

Since 2006, one of two beamlines with four ion sources for each had been building around HL-2A. In the end of 2007, neutral beam power of 300KW from two ion sources in the beamline was injected into the torus and giant sawteeth and high energy ions in the plasma was observed[1][5]. During the experimental campaign of 2008, total neutral beam power of 0.75MW from four ion source in the beamline had been injected into HL-2A and 2-fold ion temperature and giant saw teeth had been observed. The H-Mode discharge had been achieved at NBI and ECRH at plasma parameters of Ip=100KA, plasma density of 3×10^{19}/m^{3}. The storage energy in torus is about double during NBI.

Before installed these ion sources in the beamline, the characteristic of each ion source had been investigated in an ion source platform. The e-fold divergence of the beam is measured with Faraday cup array located 3.26m downstream from the ion source in the platform. The minimum beam divergence of 1.06°at extracted current of 13 A has been achieved at high voltage of 34.8 kV. It is observed that the beam divergence is very sensitive to high voltage applied the accelerator if ion beam current is invariant[2]. The proton ratio up to 65% at the ion current of 19.6A with the extraction voltage of 39.6kV is obtained, which is measured with an image spectrograph by Doppler shift effect of Balmer-α-radiation spectrum emitted from fast hydrogen atoms [3].

The ion sources for the NBI have been developed successfully and tested at an ion source platform. The ion beam energy of the limited at 40KeV has been achieved at ion beam current of 20A, because of high voltage limited at 40KeV. The plasma characteristic in chamber, the current flowing though each filament, multi-cusp-magnetic field configuration have been investigated. Ion beam power of 0.8MW for each source has been achieved in the platform successfully.

In the beamline, a calorimeter with water cooling pipes is located at near the injection port, downstream from these ion sources to measure the total beam power profile. At the beam energy of 35 KeV for four ion sources sustaining about 0.4 s with beam current up to 14 A for each source, total neutral beam power is about 0.75MW.

2. Ion source

The ion source with multi-cusp plasma generator has been developed to match the beamline as shown in figure 1. During developing the ion source, an ion source platform with its power supply, measurement, vacuum

Fig. 1 Schematic diagram of HL-2A NBI ion source

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