§ 19. Operational Test of Neutral Beam Injector Using High Z Ion Species in CHS NBI System

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Neutral beam injection (NBI) is powerful tool for heating of plasma in magnetic field, and has been installed to many confinement devices. NBI has also been used to performed various experiment, e.g. beam fueling, high energy particle transport, current drive, and the development of diagnostic methods, e.g. charge exchange spectroscopy, neutral particle analyzer, and so on. In order to investigate the physical property of α particle and Ohkawa current, high Z ion (helium, neon, argon) beam injection experiments have been proposed in CHS.

The test of high Z (neon, argon) beam operation was performed in CHS NBI-BL2, which was designed for hydrogen (30kV, 1MW). In conditioning mode operation, the deflection field was not used, because separated ion beam might not hit the beam dump, so all beam component hit the calorimeter. The neon beam profiles have been measured by calorimetric method on the calorimeter located at 2.0 m downstream from acceleration region, which is shown in Fig.1. The beam focus is sensitive to arc power of ion source and the most power concentrates in center region on calorimeter with 65V of arc voltage. The beam profile was assumed Gaussian profile and the beam width was estimated by 1/e holding length, which is shown in Fig.2. The neon beam is as narrow as hydrogen beam. The arc power which produces well-focused beam, increases with acceleration energy(25keV, 30keV, 35keV). According to optimization of beam focus, the injection of neon neutral beam needs to operate in a limited region in arc power and beam energy space, which is shown in Fif.3. Argon beam was also investigated and the property of argon beam is almost same as neon, which is not shown here.

The typical acceleration current is 24A for neon and 21A for argon. According to scaling law, $I_{beam} \propto Z^{1/2}$, and the experimental results are 2.0 times for neon and 2.4 times for argon larger than the scaling law. The reason for these large beam currents is considered that the plasma density of neon and argon discharge is significantly higher than that of hydrogen discharge, which is consistent with low arc voltage and high arc current of neon and argon discharge. Moreover the neutralization efficiency is almost 90% for neon and 90-95% for argon, which are very higher than that for hydrogen (60-70%). Thus it is obtained the very larger current of neutral beam than expectation.

In concluding, we can demonstrate that high Z ion beam can be produced by existing NBI system for hydrogen with large acceleration current beyond scaling law. The operation regions in arc power and acceleration energy space were determined for neon and argon. The test of helium beam is considered to have some problems and is left for future study.

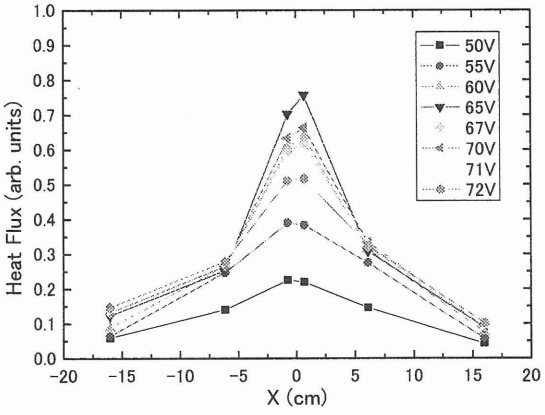

Fig.1 Neon beam profiles of 30keV on calorimeter.

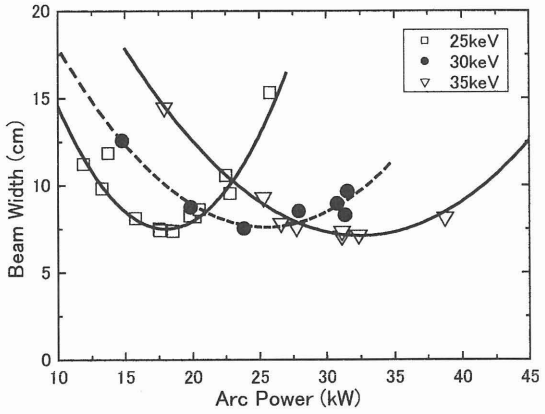

Fig.2 The beam width v.s. arc power of ion source.

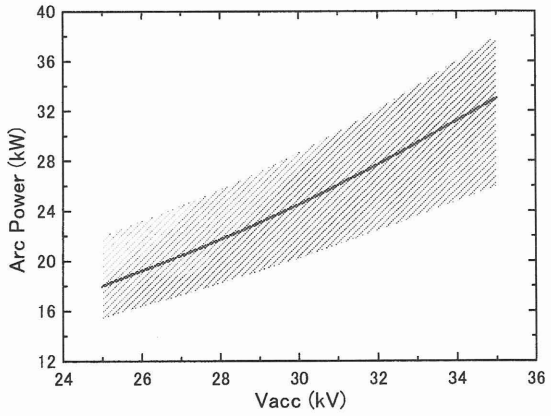

Fig.3 The operation region in acceleration energy and arc power space. In the hutched region, neon beam can through the injection port.