03Dp02

JT-60SA用中性粒子入射装置の再起動に向けた改造
Reconstruction of JT-60SA Neutral Beam Injector for restarting of JT-60SA

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The most powerful neutral beam injection system (NBI) in the world is now under upgrading to re-start the operation for JT-60SA. This NBI consists of eight beamlines for perpendicular beam injection (PNBI) and four beamlines for tangential beam injection (TNBI) using two positive ion sources per each beamline, and two beamlines using negative ion source (NNBI). The requirement of the injection power is 2MW in each PNBI and TNBI (1.6 MW in the initial phase) and 5 MW in each NNBI, that is, 34 MW in the total.

Originally, this system was used for JT-60U. Toward to JT-60SA, points as shown in Fig.1 are modified as follows. i) Water-cooled beamline according to extension of a pulse length from the original 30 s to 100 s, ii) enhancement of a cancelling system of a residual magnetic field from JT-60SA, iii) better maintainability for the stable operation over annual operation, and iv) improvement of the negative ion source of the NNBI to meet the requirement of 500 keV, 22A for 100 s.

The progress related to item i) is a completion of design of a drift duct to connect the NBI to the cryostat and a protection tube between the cryostat and the vacuum vessel. Originally, these components were inertial cooled-one, but the active cooling has to be considered for 100 s. The issue is to realize both of complicated structure with water-cooled configuration and assembling work in the narrow space. The special zig and work procedure have been also developed in the design.

Countermeasure to the stronger residual magnetic field from JT-60SA related to item ii) is the most critical point for the NBI to realize the allowable heat flux on the beamline. The cancelling system of this magnetic field consists of the magnetic shield plate and the cancelling coil. Firstly, the validation of the simulation model has been completed by comparing with the experimental result of 1/4-scale model. Then, the full-scale design was completed as shown in Fig.2

The part related to item iii) is mainly the construction of the huge control system of the NBI. To realize the annual stable operation, timely repairment is required. For this, this system is constructed by the commercial products of Labview, PLC etc by QST team. The main communication test from the JT-60 main system to the front of the power supply have been completed by 2019.

One of remaining issues in the negative ion source development is to produce 500 keV beam for 100 s with the relevant current density (130 A/m^2). Stable voltage holding with the margin of 20 %, that is, 600 kV, was confirmed in the real JT-60 accelerator. Since the beam current was limited up to 0.5 A due to the capability of the test facility, the ion source part was replaced to the small ion source in the beam test. The countermeasures to perform the stable negative ion production were examined in this test, such as the temperature control of the chamber wall for the stable negative ion production and protection system of the filaments. Finally, since these worked properly as designed, 500 keV, 154 A/m^2 beam has been successfully achieved for 118 s. The details are reported in the presentation of 03Dp03.

Thus, upgrading of NBI is in progress as scheduled.

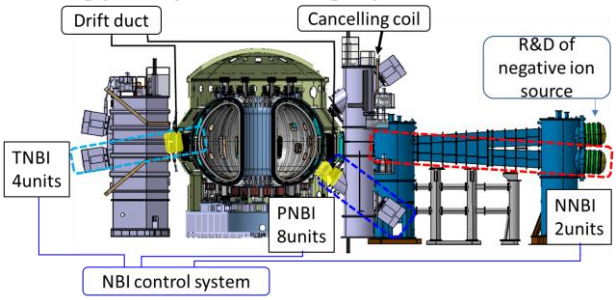

Fig.1 NBI for JT-60SA and modification part

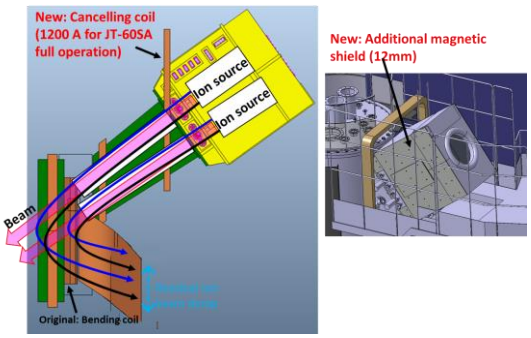

Fig.2 Cancelling system of the residual magnetic field