DEVELOPMENT OF A NEUTRAL BEAM ION SOURCE FOR OFF-AXIS BEAM INJECTION AND LONG PULSE OPERATION

R.M. Hong[1], H.K. Chiu[1], C.J. Murphy[1], and J.T. Scoville[1]

[1] *General Atomics, PO Box 85608, San Diego, Califórnia 92186-5608*

Corresponding author: Hong@fusion.gat.com

Since 1987, the DIII-D tokamak has utilized up to eight neutral beam ion sources in four beamlines for plasma heating and current drive. Extending the beam system capability will provide additional experimental flexibility and enable the experimental program to achieve new understanding of fusion physics. Upgrading two beamlines to provide off-axis beam injection capability and extending the beam pulse length without lowering the beam power are two of the goals for the next 5 years. Currently, the pulse length of deuterium beam ion sources operated at 80 keV is limited to 3 seconds due to heat handling capability of some beamline internal components, especially the pole shields of the magnet used to bend the residual energetic ions back to ion dump. A narrower ion beam has higher probability of being bent back to the ion dump through the bending magnet without hitting the magnet pole shield, thus reducing the power deposited on the pole shield. With the reduction of deposited power on the pole shield, the reliable lifetime of the pole shields can be increased and the beam pulse length may be extended beyond the current limitation without the need for active cooling of the shield. The reduced heat flux has been confirmed by a performance test of a modified ion source with narrower ion extraction area. Operating the ion source with higher beam energy can compensate for the reduction in beam power due to the smaller ion extraction area.

Off-axis beam injection requires tilting the entire beamline, including ion sources, from the horizontal position. Physics experiments require an adjustable beam injection angle and beam deposition location in the plasma with comparable injected power at each angle. To meet this requirement, we need to be able to tilt the ion source with respect to the horizontal midplane, and a well-focused beam is also necessary for the off-axis beam to clear the tokamak vessel port into the plasmas with optimum beam transmission efficiency. Modeling of the beam divergence has shown that we need to modify the existing DIII-D ion sources to produce more focused beams in order to get transmission of the full 2.5 MW beam through the smaller port need for off-axis aiming. Performance testing of a tilted ion source was successfully completed and a more strongly focused ion source is being fabricated and will be tested in late Spring 2010. This paper summarizes test results and compares them with an existing unmodified ion source.

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