EFFICIENCY OF NEUTRAL BEAM NEUTRALIZERS IN JET AND ITER

M.Porton, E. Surrey

EURATOM/CCFE Fusion Association, Culham Science Centre, Abingdon, Oxon, OX14 3DB, UK

Corresponding author: michael.porton@ccfe.ac.uk

Neutral beam neutralizer efficiency plays a key role in determining the overall efficiency of NB systems. A shortfall against predicted neutralization efficiency was first observed for the JET gas neutralizer during testing of its prototype[1]. Experimentation has since demonstrated both the presence of background plasma and elevated gas temperatures of up to 900K[2], suggesting that the reduced efficiency may be due to a reduction in gas density. It is thought that the background plasma is generated by reactions of the beam with the neutralizer gas, and that gas heating is the result of momentum transfer from fast particles created by either dissociation of gas in the beam path or by plasma ions accelerated, neutralized and reflected at the neutralizer walls.

Historical modifications to the neutralizer design in accordance with observations from models produced little improvement in the neutral beam power delivered to JET. These previous models were unable to capture details of the flow within the neutralizer, which defines the degree to which the elevated gas temperature influences the reduction in gas density. By contrast, recent application of computational fluid dynamics (CFD) techniques has permitted the development of a three-dimensional model with accurate simulation of the transition-continuum gas flow[3,4].

This paper describes the development of the neutralizer models from an initial global heating balance for the gas alone[5], through to the use of CFD to provide a consistent beam-plasma-gas system. The results from models in 1D, 2D and 3D are compared with the experimental data from the JET neutralizers for a range of beam power. It is demonstrated that for the JET neutralizer a full 3D computation is necessary to correctly capture the behaviour of the beam-plasma-gas system and the inclusion of neutralizer gas dynamics provides new insights to local effects within the system. The analysis is extended to the ITER neutralizer for which the gas heating effect is small, primarily due to the four channel design[6] and the validity of reduced dimensional modelling is discussed.

Overall, the importance of capturing the full complexity of neutral beam neutralizers is highlighted; of all the models considered only the 3D model utilizing CFD can be shown to definitively agree with experiment. The necessity of developing 3D modelling capability to support the design of future DEMO systems is demonstrated not only for beam neutralizers but for other beam components that include a fluid element, such as the duct.

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