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Beam Ion Performance and Power Loads in the ITER Pre-Fusion Power Operating Scenarios (PFPO) with Reduced Field and Current

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The ITER Pre-Fusion Power Operating (PFPO) phase will include half-field/half-current (2.65T, 7.5 MA) and one-third field (1.8T, 5MA) operating scenarios, which ought to allow H-mode access even with limited heating [1].

While PFPO-1 relies only on ECRH and ICRH to achieve the H-mode, in PFPO-2 also the neutral beams will be applied. In the PFPO phases, the plasma will consist of either hydrogen or helium, and will operate at about half of the Greenwald density. Beam operation at low densities requires lower acceleration voltages due to shine-through constraints, so that the maximum beam energy in PFPO is limited to below 870 keV for He plasma.

The goal of this contribution is to determine power loads, due to both charged and neutral particles, to the ITER first wall from neutral beam heating in both the one-third and half-field scenarios, as well as determine the over-all beam performance (heating, current-drive and torque to the plasma) using the full beam capabilities envisaged for both scenarios. The ASCOT suite of codes was used for this purpose since it allows including the effect of ferritic inserts which, due to the lowered field values, can not work in the manner they were designed for. Since the pre-fusion phase will also serve as a relatively benign environment for testing various ITER subsystems, notably ELM mitigation methods, we shall also address the effect of ELM Control Coils (ECC) on fast ion containment.

In the absence of the ECC's, the beam ions are found to be very well confined. For instance, in the half-field scenario, using the full beam power of 33 MW, power losses are less than 0.1%, with peak power of 130 kW/m2. Shine-through, on the other, is non-negligible: even in the flat-top phase of the discharge the shine-through was 1.8% of the 870 keV beam power, with a corresponding peak power of 680kW/m2. Additional simulations were carried out to determine the electron density resulting in a peak power load of less than 1MW/m2. By varying electron density while keeping the plasma quasineutral and the plasma composition constant, the critical density was found to be approximately 4·1019m-3.
[1] M Schneider et al., 'Modelling of third field operation in the ITER pre-fusion power operation phase', in this conference

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