INCREASING CURRENT DRIVE EFFICIENCY IN DEMO BY INDUCTION OF COUNTER-ROTATION

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In current designs for the Conceptual Demonstration Fusion Power Plant (DEMO), a large proportion of the auxiliary power is consumed by the neutral beam systems used for heating and current drive. It is known that if the plasma is rotating in the same direction as the fast ions produced by the beams, then the efficiency of the current drive is reduced. However, if the plasma could be induced to rotate against the fast ions, the efficiency of the current drive would be increased, reducing the auxiliary power required by the neutral beam systems and/or the necessary beam acceleration energy. In this paper we estimate what power savings could be achieved, and examine possible methods for driving the counter-rotation.

Keeping the plasma density ($\langle n_e \rangle = 0.96\times10^{20}$ m^{-3}, D-T) and temperature (T_{i0}=30 keV) constant, if a counter-rotation of M=-0.2 could be achieved, it is estimated that this technique could lead to power savings of up to 15% of the wallplug power requirements of the deuterium neutral beams, reducing the injected power by 30 MW. Conversely, with the same counter-rotation and keeping the original injected power, beam energies could be reduced from 1.5 MeV to 1.0 MeV whilst driving the same current. Numerical simulations using the Monte Carlo TRANSP/NUBEAM code confirm these calculations.

From the back electron current term, it is possible that a counter-injected high-Z beam using neon or argon would not only effectively induce rotation counter to the main beams, but also drive additional co-current. DEMO is expected to have a high radiative fraction to protect the divertor and consequently some method of seeding the core with radiating impurities is required in any case. Alternatively, rotation against the torque of the main beams could be induced by charging the plasma and generating a radial electric field. This could be achieved through the use of ICRH to encourage ion loss from the edge of the plasma, or by tangential beam injection at the edge of the plasma to suffer prompt ion orbit losses onto a recovery target. The power requirements of these methods and corresponding reductions in the main beam injector energy will be discussed.

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