Dependence of H-mode Power Threshold and Energy Confinement on Toroidal Plasma Rotation in the DIII-D Tokamak *

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Understanding the influence of the plasma rotation and its shear on the physics of H-mode plasmas is important for increasing the performance of these plasmas. Investigations in this area have been advanced at DIII-D following major modifications to the neutral beam injection (NBI) system to allow for simultaneous NBI in both the co and counter directions to the direction of the plasma current. Variations in the injected neutral beam torque as a result of changing the ratio of the co and counter beams have shown that the power required to induce the transition from L-mode to H-mode plasmas (L-H transition) is dependent on the applied beam torque. For upper single null discharges in which the ion grad-B drift is away from the X-point, the L-H transition power threshold is reduced by up to a factor of 3 by changing from predominantly co-injection (4-6 MW) to predominantly counter-injection (<2 MW). The mechanisms for such a torque (and, hence plasma rotation) dependence are being investigated from analyses of the edge plasma rotation, the edge radial electric field and the edge plasma turbulence. Preliminary results indicate that the edge poloidal turbulence flow changes direction prior to the L-H transition resulting in a significant velocity shear that may be strong enough to induce the transition. Further to these results, the thermal energy confinement time is observed to increase by 50% in H-mode plasmas as the injected neutral beam torque is changed from balanced to predominantly co-injected. No increase in confinement time is observed in L-mode plasmas with increased co-injected torque. These results pose significant implications for the low toroidal rotating plasmas expected in ITER for which the assumptions and extrapolations for H-mode threshold power and confinement need to be re-examined in light of these torque and plasma rotation dependences. Separate studies have established active feedback control of the toroidal rotation. This has been achieved through real time measurements of the toroidal rotation using charge exchange recombination spectroscopy together with the application of co and counter beam torque managed by the DIII-D plasma control system. Subsequently, experiments have been performed in which both the toroidal rotation and the normalized beta were simultaneously controlled at predefined values. Results on all these studies will be presented together with implications for ITER.

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