Closure, Detachment, and Energy Dissipation Studies Using the DIII-D Small Angle Slot Divertor

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A Small Angle Slot (SAS) divertor has been installed on the DIII-D tokamak to test concepts of enhanced heat dispersal using a combination of closure and directed recycling flux, with an aim towards future tokamak design optimization. Initial tests have demonstrated significant reduction in heat flux and Te < 10 eV across the divertor target for an extended range of operation, achieving detachment at substantially lower density ($\bar{n}_e/n_G \sim 0.4$) than in matched open-divertor discharges ($\bar{n}_e/n_G \sim 0.6$). These conditions can be obtained while maintaining high core plasma H-mode confinement. SAS operation has resulted in a confinement enhancement factor H_98Y2 up to ~30% better than the open divertor at the onset of detachment, as well as delaying the degradation in confinement due to enhanced radiation (X-point MARFE) to significantly higher (~30%) pedestal densities. Detailed transport and pedestal stability analyses indicate this confinement improvement is associated with improved pedestal temperature and pressure, which are primarily due to an increased temperature pedestal width. These results were obtained with the ion grad-B drift away from the SAS divertor. Neutral measurements within the slot confirm a significant buildup of neutral pressure in conjunction with the approach to detachment, decreased electron temperature and enhanced dissipation.

The divertor design combines a glancing/small angle target with a narrow slot that progressively widens away from the strike point. Previous fluid code (SOLPS/B2-EIRENE) analysis indicated that this geometry should be capable of significantly increasing the local neutral/molecular dissipation of energy in the slot compared to either vertical or horizontal target configurations. These modeling results are hypothesized to be due to a combination of neutral trapping and improving the neutral distribution along the divertor target, due to a self-consistent relationship between the incoming ion flux profile, recycling flow, and drifts within the slot. Further experimental research using this divertor configuration is planned to examine enhancements in impurity retention, to establish the role of drifts in a closed slot divertor and to target parameter scans to more closely study the time and spatial dynamics of detachment.

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