Restriction of Neutrals in the DIII–D Closed Divertor is Seen to Lower Core Fueling and Core Impurities*

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The effect of divertor closure in DIII-D on core fueling and carbon density for parameters relevant for next step experiments was examined with the 2-D fluid code UEDGE. We analyzed a range of experiments with the open and the closed divertor of several similar, unpumped H-mode discharges characterized by $n_e/n_{e,Greenwald} \approx 0.8$, $I_P = 1.37$ MA, $q_{95} = 4.1$, $\delta = 0.8$, and $P_{INJ} = 4.5$ to 7.0 MW. UEDGE analysis quantifies the effectiveness of the closed divertor in partially screening neutrals and impurities from penetrating the plasma core.

For these similar higher density, high triangularity discharges, we estimate from experiments that the deuterium ionization in the core (the fueling rate) was approximately ≈15%–20% lower with the closed configuration. UEDGE simulations show a doubling of the recycling current at the divertor targets in the closed divertor case. However, this increased source of recycled particles is partially screened from fueling the core, yielding numerical agreement with the experiment. UEDGE results (2-D plots of density, temperature, ionization, flux, etc.) indicate that the restriction of neutrals to a region close to the divertor plates in the closed divertor enables a higher T_e near the plates, increasing ionization between the plates and the X-point and hence decreasing core fueling. In the open divertor, recycled neutrals fill the whole divertor region and reduce T_e by charge exchange, thereby lowering the ionization efficiency and allowing a higher fraction of recycled neutrals to fuel the core.

UEDGE also calculated both the absolute carbon density ($Z_{eff} \leq 1.6$) and its relative change due to divertor closure. The closed divertor slightly reduced the carbon source from the walls near the divertor but effectively lowered the carbon flux along the SOL upstream from the X-point. These results tend to confirm that the closed divertor reduces carbon flow out of the divertor region, a factor in lowering carbon ion flux into the core. These UEDGE results are being compared with recent DIII-D data.

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