Recycling control with a flowing liquid Li limiter in high confinement, high heating power H-modes in EAST

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Reduction of fuel particle recycling is one method to achieve high confinement H-mode discharges in tokamaks. An innovative series of experiments to apply flowing liquid lithium (FLiLi) limiters for continuous recycling control has been performed in EAST [1-5], using the known property of hydrogen gettering by Li.

The FLiLi is designed for a flow rate of 2cm^3/s, which pumps ~10^{22} D/s during discharges. During FLiLi operation, the D_α emission normalized by density and/or neutral pressure from upper and low divertors gradually decreased with increasing Li emission from FLiLi. Gas balance confirmed a progressive increase in fuel retention: the retention ratio, defined as the fraction of fuel retained on the walls divided by the total injected fuel, increased from -0.8 to 0.1 with repeated FLiLi insertion. This observation qualitatively confirms that the FLiLi limiter supplied fresh, unreacted Li during the discharge for continuous particle control, avoiding the normal wall saturation that can occur in long pulse operation. Furthermore, we found that fuel particle control was further enhanced as both as FLiLi was moved closer to separatrix, and as heating power was increased. Compared to daily pre-run evaporative Li coatings, the divertor D_α emission was ~3x lower with limiter temperature operated in the range 330℃-380℃ over a range of auxilary heating power from 2-8.3 MW. In addition, edge localized modes (ELMs) were nearly completely eliminated in RF-heated H-mode plasmas with only RF heating due to reduced recycling; the duration of the ELM mitigation phase was extended in most recent FLiLi experiment, as compared to the first two FLiLi experiments [5]. Using both the reduced recycling and the newest FLiLi design features, H-mode discharges with auxiliary heating up to 8.3 MW and plasma stored energy up to 280kJ, amongst the highest levels achieved in EAST, were demonstrated [6].

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