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Particle and power exhaust of new EAST lower tungsten divertor for advanced steady-state operations

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Significant progress has been made on the new lower tungsten (W) divertor with closed geometry and active water-cooling capability for steady state operations in EAST since 2021. The latest experimental results demonstrate that the new divertor exhibits strong particle exhaust capability and relatively high neutral retention in the divertor region, which facilitate both impurity screening and divertor detachment with respect to the less closed upper divertor. By using the new W divertor, the divertor detachment with a strong reduction of particle and heat fluxes has been achieved in lower single null (LSN) H-mode plasmas with the ion $B\times\nabla B$ drift towards the X-point. Compared with the upper divertor, the more closed lower divertor has a lower detachment density threshold. When the strike point locates on the horizontal target with divertor closure increasing, the detachment can be accessed more easily, which are in good agreement with the simulations during divertor design.
The impurity seeding with both argon (Ar) and neon (Ne) to reduce heat load has been performed in high-performance plasmas by leveraging the effect of drifts and impurity seeding location, and optimized divertor configuration coupled with strong pumping. A confinement improvement was observed with Ne seeding. For Ar seeding, the result indicates that Ar is more efficient at cooling electron temperature on divertor targets, which can lead to simultaneous enhancement of core and divertor radiation, accompanied with confinement degradation. In addition, the integration of large-ELM-suppression and detachment with H_98 ˜ 1 has been achieved with the new divertor configuration and Ne seeding. For active long pulse detachment control, 30s H-mode operation with a detachment-control duration of 25s has been achieved in EAST. A series of detachment or radiation feedback control techniques for core-edge integration have been further developed and demonstrated in long-pulse H-mode plasmas. During the feedback control phase, the plasma stored energy was well maintained at a stable level with T_et ˜ 5 eV near the strike point and H_98 > 1. These experiments demonstrated good compatibility of high core plasma performance with divertor detachment. It thus offers a highly promising plasma control scenario suitable for long-pulse high-performance H-mode operation in EAST, which is potentially applicable to future fusion reactors.

[1] L. Wang et al., Nucl. Fusion 62, 076002 (2022)
[2] G. S. Xu et al., Nucl. Fusion 61, 126070 (2021)
[3] L. Y. Meng et al., Nucl. Fusion 62, 086027 (2022)

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