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Advanced Power Exhaust Studies for New Lower Tungsten Divertor of EAST under High Power and Steady State Operations

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Divertor is one of the key components in Tokamak. The control of heat flux and erosion of the divertor target is one of the grand challenges facing the design and operation of next-step high-power steady-state fusion. It is essential to efficiently dissipate power in the divertor to ensure the maximum steady-state power load at the divertor target below 10 ~ 15 MW/m^2. In addition, adequate reactor lifetime dictates near zero-erosion at solid PFCs, so the electron temperature at the divertor target plates must be maintained at a low temperature with Te ≤ 5 ~ 10 eV to suppress erosion.

In response to this challenge, recently Experimental Advanced Superconducting Tokamak(EAST) has launched a new initiative to develop and validate the advanced divertor concepts for the design of new lower tungsten divertor. In general, developing an advanced divertor configuration requires: (1) Increasing divertor closure by divertor baffling to improve divertor screening for recycling neutrals and impurities, hence increasing divertor neutral pressure, thus enhancing divertor particle and power exhaust. Several divertor configurations with various target inclination angles are modelled to evaluate the effect of divertor closure on detachment. The modeling results show that increasing divertor closure can significantly trap more neutrals with the same upstream separatrix density and hence decrease the onset of detachment. Moreover, with increasing divertor closure the divertor radiated power is also increased and the peak heat flux density at the divertor target is reduced. (2) Optimizing magnetic configuration to extend the plasma wetted area through flux expansion, and increasing the divertor volume by increasing the field line length. Based on the flexible poloidal field control system in EAST, some alternative advanced magnetic configurations, i.e., quasi snowflake (QSF)[1] , aka X-divertor and fishtail divertor (FTD)[2] have been attempted for the new lower tungsten divertor. According to the modeling results, QSF and FTD can significantly reduce the peak heat flux density at the lower outer target by the magnetic flux expansion and outer strike point sweeping respectively. Furthermore, an alternative advanced divertor coupling divertor closure with advanced magnetic configuration (QSF or FTD) in EAST can further facilitate new lower tungsten divertor detachment, which may provide a promising means for the design of advanced divertors in future fusion devices.

References:

[1]G. Calabro, et al, 2015 Nucl. Fusion 55 083005
[2]X.D. Zhang, et al, 2nd IAEA Technical Meeting on Divertor Concepts, Suzhou, China, 13-16 November 2017

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