Contribution ID: **37** Type: **Poster**

Assessment of X-point target divertor configuration for power handling and detachment front control

Thursday, 20 October 2016 14:00 (4h 45m)

The challenges that will be facing the divertor in a tokamak-based fusion reactor prompt the search for innovative divertor configurations that use non-standard magnetic geometry and additional X-points. Standard tokamak edge plasma transport codes such as UEDGE and SOLPS can be invaluable tools for exploration and evaluation of alternate divertor configurations for potential performance enhancements; however the presence of secondary X-points in the divertor has, up to now, hindered such application. A recent upgrade to UEDGE allows including a secondary X-point in the divertor, and in the present study UEDGE is used to analyse the recently proposed X-point target divertor that combines a radially extended outer leg with a secondary X-point placed in the outer leg volume. It is found in the modeling that as the input power into SOL is reduced to a threshold value, the outer divertor leg transitions to a fully detached state with the detachment front localized near the secondary X-point. Reducing the power further results in the front shifting upstream but remaining stable. As the power is reduced, the detachment front eventually moves to the primary X-point, which is associated with an X-point MARFE. However, for the X-point target divertor a fully detached divertor regime is maintained over a factor of 5-10 variation in the input power while for an otherwise similar parameter variation performed with a standard vertical plate divertor a much smaller detachment operational window is found. These results suggest that a stable, fully detached divertor operation over a wide parameter range may be realized for a tokamak with radially extended outer divertor legs.

Paper Number

TH/P6-32

Country or International Organization

USA

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Session Classification: Poster 6

Track Classification: THD - Magnetic Confinement Theory and Modelling: Plasma–material interactions; divertors, limiters, SOL