Study of local closure effect of the Divertor structure on Detachment Density in CFETR

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Abstract

The local closure effect of the divertor structure has been studied on the detachment density in CFETR by using the scrape-off layer plasma simulation (SOLPS) code. The divertor geometry near the striking point was set as a semicircle structure. The local closure of striking point was changed by reducing the radius of the semicircle step by step with all the other parameters fixed the same. The simulation results reveal that the heat flux show great differences in low density case and high density case. In low density case, the applied of semicircle structure (r=10cm) can hardly change the heat flux of the striking point. Yet, for the high density case, the semicircle structure will greatly reduce the temperature of the striking point, thus enhance the density of the neutral gas. In other words, the increased local closure effect will significantly reduce the heat flux of the striking point and help reduce the threshold density of the detachment.

\textbf{Setup of simulations}

- Transport coefficients
  - For pedestal region, D, ze, zi and v are determined by fitting the Te, Ti, ne and P profiles given by OMFIT.
  - For SOL region, D, z, zi and v are assumed and make sure the power decay length at OMP similar to the value predicted by T. Eich et al and smooth connection with the core values at separatrix.

\textbf{Upstream profiles}

- A set of upstream profiles including (ne, n\textsubscript{He}, P, Te and Ti) can be got which is good agreement with the results from OMFIT in pedestal region.
  - Ti is much higher than Te due to higher q\textsubscript{s}, which is reasonable for CFETR with low edge collisionality (n<50).
  - Furthermore, EPED model is rather more concern about the structure of pressure in pedestal than the profiles of Temperature and density.

\textbf{Thermal conductivity coefficients:}

\[ \chi = \frac{1}{\tau} \left( \frac{\partial T}{\partial r} \right) \]

\[ \chi_{\text{eff}} = \chi_{\text{P}} \chi_{\text{n}} \]

\[ \chi_{\text{P}} = \frac{2}{\lambda_{\text{P}}} \]

\[ \chi_{\text{n}} = \frac{2}{\lambda_{\text{n}}} \]

\textbf{Results}

- Low density case: 3\times10^{16} m^{-3}
  - In low density case: the increased local closure wouldn’t affect the peak power and density on the target.
  - In high density case: the increased local closure effect can significantly suppress peak temperature, thus the peak power on the target. Yet, the temperature of plasma far out is still high.

- High density case: 6\times10^{18} m^{-3}
  - The semicircle structure will help to concentrate the neutrals on the strike point.

\textbf{Discussion}

- In summary, the increased local closure effect will significantly reduce the heat flux of the striking point and help reduce the threshold density of the detachment.

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