4.1.4 Simulation of boundary plasma for HCSB-DEMO by 2D edge plasma transport code SOLPS 5.0

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The power handling capability is a crucial problem in toroidal magnetic confinement fusion devices. The power to be handling is a few tens of MW heating power at present and increases to over 100 MW at ITER. However, the total heating power of HCSB-DEMO is over 600 MW and heat power crossing CIB is 400 MW, which will make the power handling problem more crucial.

The SOLPS5.0 code solves a set of fluid equations describing the 2D radial-poloidal transport of a multi-species plasma with toroidal symmetry. All the ions have the same temperature $T_i$, which can be different from the electron temperature $T_e$, and each charge state is described as a separate fluid. Classical transport coefficients are used for the parallel transport. Given the lack of reliable physical models for the cross-field transport, it is appropriate to use this approximation, which is the simplest one introducing the least unknown variables. The values which are used, $D = 0.3 \, \text{m}^2 \cdot \text{s}^{-1}$ and $k = 1.0 \, \text{m}^2 \cdot \text{s}^{-1}$, result in a typical width of the power load profile around 5mm when mapped along magnetic field onto the mid-plane, and in a radial pressure gradients in the mid plane close to the experimental ballooning limit.

The electron and ion densities prescribed at the CIB, where is a few centimeters inside the core plasma. A 3 cm radial decay length is specified for temperature and neutral particles are absorbed at the outer edge of the grid. The usual sheath boundary conditions are applied on the targets. The drift terms in the fluid equations are switched off. Effective recycling coefficient $R$ of the wall is given by 0.99 for all the parts of the vacuum vessel. The SN computational grid used for simulation is calculated by EFIT equilibrium code according to the HCSB-DEMO plasma parameters.

The upstream density is an uncertain value for plasma operation and operational flexibility is very important, so it is indispensable to simulate the HCSB-DEMO divertor with different upstream density. The power crossing CIB is 400 MW with the assumption that the electron power $P_e$ is equal to the ion power $P_i$. Fig. 1 and Fig. 2 show the heat flux profiles at divertor targets with different upstream density. The peak heat flux point locates at the place where is a little outside the separatrix at divertor targets. At inner divertor, the peak heat flux at target is saturation when upstream density is less than $63 \times 10^{20} \, \text{m}^{-3}$, and it value is $17.8 \, \text{MW} \cdot \text{m}^{-2}$. At outer divertor, the peak heat flux at target keeps increasing with the reduction of the upstream density, it is $37.9 \, \text{MW} \cdot \text{m}^{-2}$ when upstream density is $0.54 \times 10^{20} \, \text{m}^{-3}$.

![Fig. 1. The heat flux profiles at inner divertor targets.](image1)

![Fig. 2. The heat flux profiles at outer divertor targets.](image2)