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Transport Simulation Analysis of Peripheral Plasma with the Open and the Closed LHD Divertor

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Transport of plasma, neutral and impurities in peripheral regions is closely linked to the configuration of the device. The divertor configuration of LHD (Large Helical Device) has been modified to the closed one to control neutral transport and achieve effective pumping. In order to make comparisons of the open and the closed LHD divertor, a new calculation mesh covering the ergodic, the divertor-leg and the vacuum regions has been developed for three-dimensional transport code EMC3-EIRENE. This paper presents simulation analysis of transport and validation with experimental measurements.
A series of simulations with the both divertor configurations was carried out with the electron density from 1x10^19 to 8x10^19 /m^3 at the last closed flux surface (LCFS) and a fixed heating power of 8MW to simulate a density-buildup in a discharge. The typical electron temperature on the divertor plates decreases from 40eV to less than 5eV during the density scan. The simulations involve plasma-wall interactions such as hydrogen recycling and impurity generation.
An influence of the change from the open to the closed configuration is observed as increase of the plasma source. The source increases mainly in the legs in low-density discharges and in the ergodic region in high-density discharges. The electron temperature on the divertor plates becomes low in the case of the closed configuration because of the large plasma source. The increase of plasma source and difference of neutral transport cause increase of neutral density under the dome structure by a factor of ten in the closed configuration. The ratio of the pressure between the both configurations and its dependence on the electron density at the LCFS are in good agreement with measurements.
Transport of carbon sputtered from the plasma-wetted surfaces with a fixed sputtering yield was simulated. The increase of plasma-neutral interaction enhances particle flux onto the surface, and hence the number of sputtered carbon increases in the case of the closed configuration. The amount of carbon ions in the leg increases during the density buildup regardless of the configurations but reduction of carbon accumulation in ergodic region, i.e. impurity screening, is observed when the electron density is high. The impurity transport is significantly affected by parallel flow in the ergodic region with long flux tubes.

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