§2. Neutral Particle Transport Simulation in an Optimized Closed Divertor Configuration for Efficient Particle Control in LHD

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The control of the plasma periphery is found to be essential for sustaining super dense core (SDC) plasmas. Thus, a closed divertor is planned for particle control in the plasma periphery. The analyses of neutral density profiles by a fully three-dimensional neutral particle transport simulation code (EIRENE) and a H_α emission detector array with polarization separation optics show that the neutral particle density is relatively high in the inboard side of the torus for R_{ax}=3.60m in which good energy confinement has been achieved. For this reason, the installation of closed divertor components in the inboard side is favorable for efficient particle control. The simulation shows that the closed divertor components (slanted divertor and baffle plates, a dome) can enhance the neutral density by more than one order of magnitude compared to that in the present open divertor case.

Installation of target plates near upper/lower ports can enhance the neutral density in the inboard side by changing the position of the strike points and preventing the neutral particles from escaping along the space between two helical coils. The target plates intersect two divertor legs on which magnetic field lines are connected from inboard side to upper/lower side.

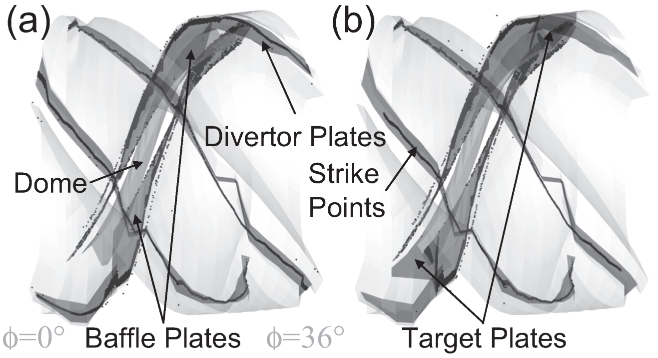

Fig. 1. Strike point distribution in the case without (a) and with target plates (b) for R_{ax}=3.60m.

The effect of the target plates is investigated from the viewpoints of the distribution of the strike points and the neutral particle transport in the plasma periphery. Figure 1 shows the calculations of the strike point distribution in the case of the closed divertor configuration without (a) and with the target plates (b). The position of the strike points are changed by installation of the target plates, which contribute to the enhancement of the density of neutral particles in the inboard side. The ratio of the number of the strike points in the inboard side to that of all strike points is calculated by tracing the magnetic field lines with including a particle diffusion effect. The ratio is about 0.5 and 0.8 in the case without and with the target plates, indicating that the target plates can significantly enhance the neutral density in the inboard side of the torus.

The neutral density profiles in the closed divertor configuration are calculated by using the three-dimensional neutral particle transport simulation code. Figure 1 shows the grid model for the closed divertor configuration where the both toroidal ends are treated as periodic surfaces. The plasma parameter profiles inside of the ergodic layer are determined from the calculations by the EMC3-EIRENE code (P_{input}=8MW, n_e^{LCFS}~3×10^{19}cm^{-3}, S_{total}=3.6×10^5A). The plasma parameter profiles on the divertor legs are calculated by a one-dimensional plasma fluid analysis along the magnetic field lines. Recent detailed measurements with a fast ion gauge indicate that the vacuum pressure in the inboard side is in the order of 10mPa for the present open divertor. The particle reflection ratio on the divertor plates are defined to be 0.6 such that the density of neutral hydrogen molecules in the inboard side is about 10mPa in the open divertor configuration.

Figure 2 illustrates the density profiles of the neutral hydrogen molecules without (a) and with the target plates (b). It shows that enhancement of the neutral density (n_{H2}) in the inboard side up to about 140mPa. The target plates are effective to form high neutral density region (~150mPa) in secluded spaces which are surrounded by the target plates, vacuum walls and the baffle plates. It indicates that installation of additional vacuum pumping systems in the secluded spaces can be effective for efficient particle control in the plasma periphery.

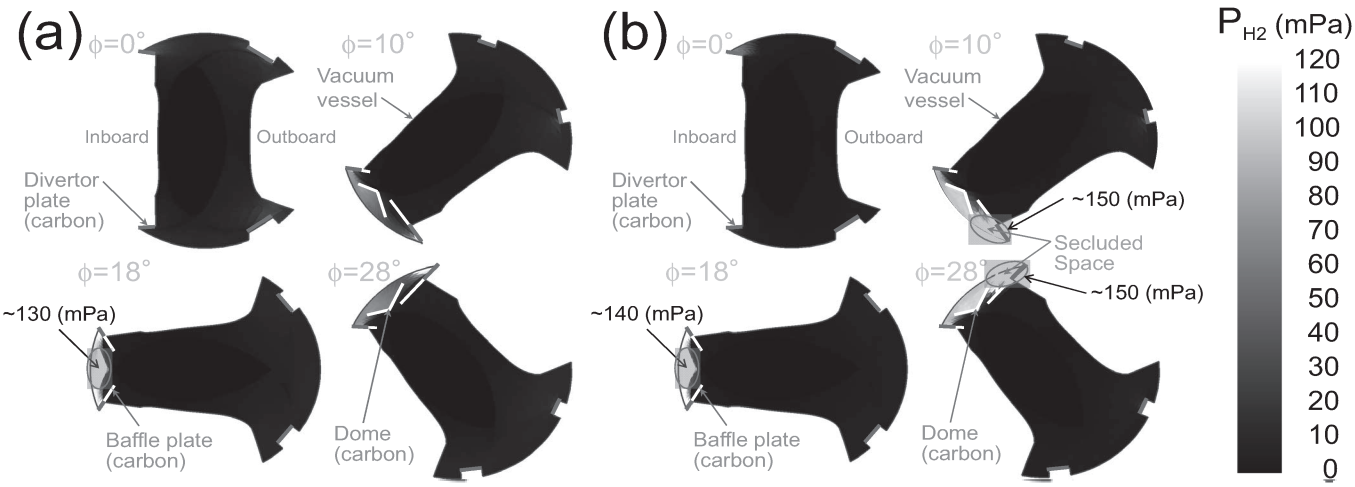

Fig. 2. Density profiles of neutral hydrogen molecules in the case without (a) and with target plates (b) for R_{ax}=3.60m.