§1. Simulation Analysis of the Pumping Speed Properties of a Cryo-sorption Pump for the Closed Helical Divertor in LHD

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The properties of the pumping speed of a cryo-sorption pump designed for the closed helical divertor are analyzed for improvement of the pumping system design. The cryo-sorption pump is composed of three main parts: an activated charcoal panel cooled by gas helium, chevrons cooled by liquid nitrogen, and water cooled blinds. The chevrons and blinds are designed for minimizing heat load on the charcoal panel by radiation from heated divertor plates without serious pumping speed reduction.

The dependence of the pumping speed on the particle absorption ratio on the charcoal panel is investigated using a three-dimensional neutral particle transport simulation code (EIRENE). The simulation was performed in a three-dimensional grid model for the pumping system. Figure 1 is a bird's eye view of the grid model in which the area of the charcoal panel is $192 cm^2$ (one side). The 50% transparent mesh and the dome structure are not included in the model for simple calculation. Test particles, which are representative of neutral hydrogen molecules, are released from the lower half part of the divertor plate with an energy corresponding to a room temperature of 300K. The particle reflection ratio on the surface of the components of the pumping system (except for the panel) was set to 1.0 (no absorption). Thus, tracking of the test particles is carried out until the all test particles are absorbed on the panel. The total current of released hydrogen molecules from the divertor plate is set to 0.5A in the simulation.

Figure 2 shows cross sections of the density profile of neutral hydrogen molecules in the cases of four different particle absorption ratios on the charcoal panel, indicating that the ratio of the neutral density near the panel on that near the divertor plate approaches to unity for low absorption ratio (~0.1). The pumping speed is estimated from the number of absorbed test particles by normalizing the neutral density near the divertor plate. Closed circles in Figure 3 gives the trend in the calculated pumping speed for various absorption ratios, in which the pumping speed is obtained by normalizing the neutral pressure to 0.1Pa ($n_{H2} \sim 2.5\times10^{13} cm^{-3}$), and it is converted into the pumping speed for one toroidal section ($0^o < \phi < 36^o$), where the area of the panel is $1{,}720 cm^2$ (both side). It shows that the pumping speed drastically decreases for low absorption ratios.

The pumping speed under the condition of reduced conductance of the water cooled blinds is investigated by plugging the lower half area of the inlet of the blinds in the grid model (see Fig. 1). The calculations for various absorption ratios are shown in Figure 3 (open squares), which indicates that the pumping speed drops to about 60-70%. The simulation proves that the pumping speed strongly depends on both the conductance of the pumping system and the absorption ratio of the charcoal panel.

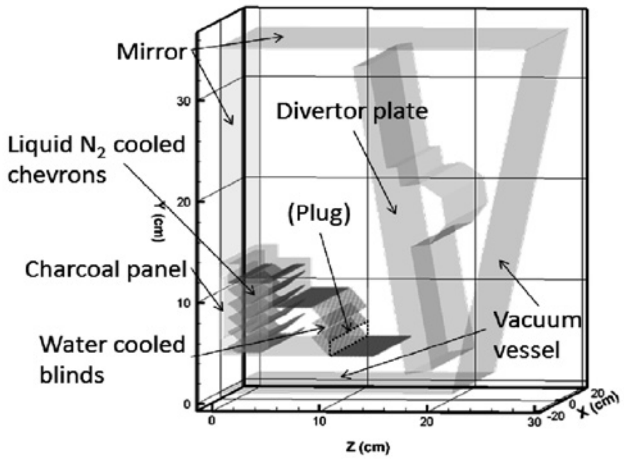

Fig. 1. Bird's eye view of the three-dimensional grid model for analyzing the properties of the pumping system.

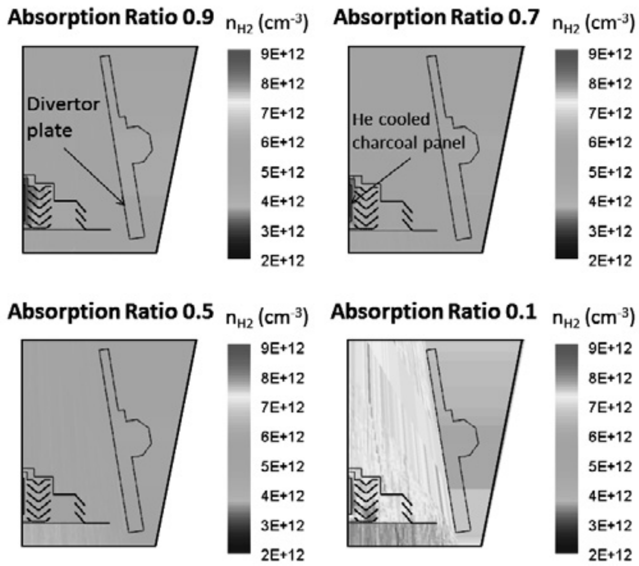

Fig. 2. Density profile of neutral hydrogen molecules for various absorption ratios of the charcoal panel.

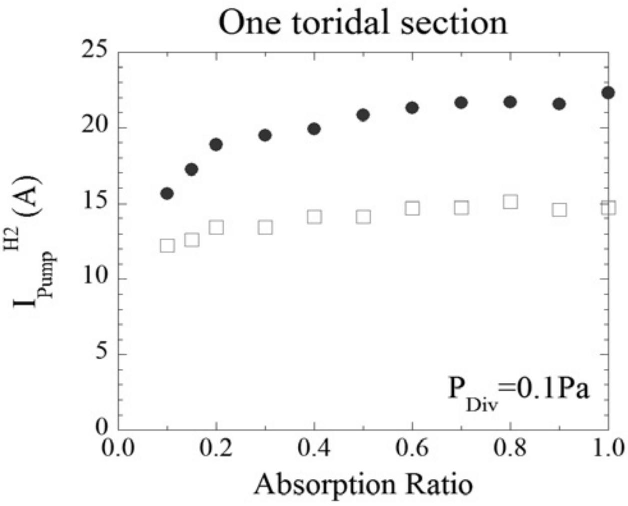

Fig. 3. Trend in the calculated pumping speed for various absorption ratios of the panel with and without reduced conductance of the water cooled blinds.