§1. Analysis of the Pumping Efficiency of a New Cryosorption Pump for the Closed Helical Divertor in LHD

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Improvement of the particle pumping efficiency in the cryosorption pump installed in the Closed Helical Divertor (CHD) region is an urgent task in LHD. Thus, a new cryosorption pump, in which no water cooled blinds for shielding liquid nitrogen (LN_2) cooled components, is proposed. The pumping efficiency in the new pump is calculated by a three-dimensional neutral particle transport simulation code (EIRENE).[1)]

A cross section of the new cryosorption pump installed in the most inboard side of the torus, is illustrated in Figure 1. A LN_2 cooled panel is mounted at the central part behind a dome structure. Components cooled by LN_2 with blind plates for taking in neutral particles are installed at the back side of the dome. Two cryosorption panels cooled by gas helium are covered with LN_2 cooled components. The blinds are aligned so as not to expose the panels to the divertor plasma and components with room temperature (>300K). The LN_2 cooled panel installed in the central part has a role for minimizing the number of the LN_2 cooled blinds, and it can shade the blinds from divertor plates which temperature can be heated up to more than 1,000K in plasma discharges. By installing the cryosorption panel and the LN_2 cooled components along the back side of the dome, water cooled blinds for protection of the cryosorption panel and the LN_2 cooled components from radiation emitted from the divertor plates is not needed. It is effective for enhancing the pumping efficiency.

Figure 2 shows a three-dimensional model of the new pump for the neutral particle transport simulation code. Simplified pumping structures only in the right half part are considered in this model, which includes a divertor plate and vacuum walls in the inboard side of the torus. Thin colored lines in the model indicate the calculated trajectories of test particles which represent neutral particles (hydrogen molecules and atoms) in this simulation. The neutral particle density and temperature in each grid are derived from the total path lengths of the test particles in the grid cell in the model. In this simulation, test particles (hydrogen molecules) are released from the lower half part of the surface on the divertor plate with a velocity which kinetic energy corresponds to 1,000K.

The left, near and back sides of the model are treated as mirror plates to simulate all the pumping structures, and the top side of the model is set as an exit for the test particles. It is assumed that the particle reflection rate on the both side of the cryosorption panels is 0.0 (absorption), and that on the other components is 1.0 (reflection). In this model, the divertor plasma (the plasma density: $n_e=1\times10^{13}cm^{-3}$, and the electron/ion temperature: $T_{e,i}$=30eV) is distributed from the surface of the lower half of the divertor plate to over the top of the dome structure.

The calculated particle pumping efficiency and the density profile of neutral hydrogen molecules for the original and the new pump are shown in Figure 3. The pumping efficiency is defined as I_{He}/I_{Div}, where I_{He} is the current of the test particles reaching the cryosorption panel, and I_{Div} is that released from the divertor plate. The simulation shows that the pumping efficiency in the newly designed pump (0.066) is higher than that in the original pump (0.025) by more than a factor of two.

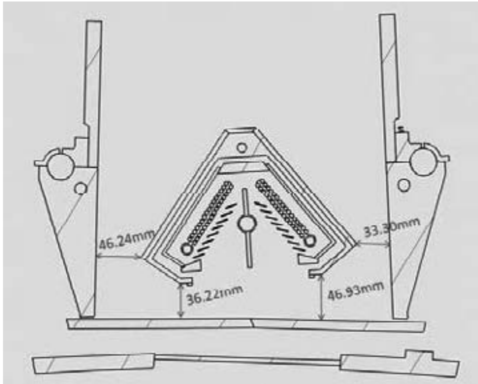

Fig. 1. A cross section of the structure of the new cryosorption pump for the closed helical divertor.

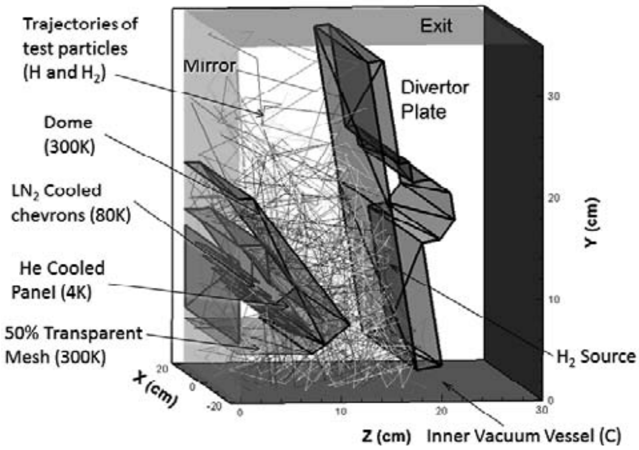

Fig. 2. A three-dimensional model of the newly designed pump for neutral particle transport simulation.

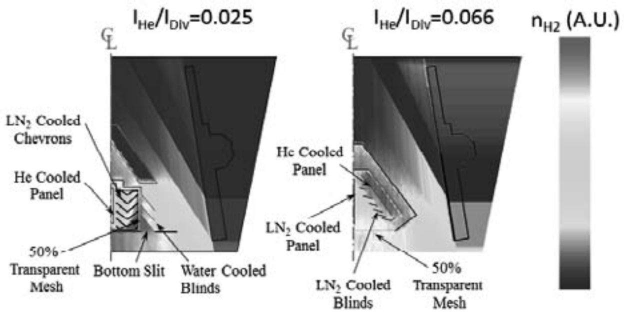

Fig. 3. The density profiles of neutral hydrogen molecules in the original (b) and the new pump (b).

1) Reiter, D. et al.: Fusion Sci. Technol. **47** (2005) S1106.