§14. Characteristics of the Improved in-vessel Cryosorption pump for the Closed Helical Divertor in LHD

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In FY2015, the in-vessel cryo-sorption pump for the closed helical divertor has been improved in three toroidal sections to attain the further high exhaust performance in LHD. The pumping test shows the pumping speed of 20 m^3/s and the pumping capacity of 13,640 Pa m^3 in one toroidal section. The pumping speed of the improved type is twice higher than that of the previous type. The pumping capacity is about four times larger.

For effective particle control using divertor pumping, we have developed the cryo-sorption pump in the closed helical divertor since FY2012. In FY2014, the pumping performance of the cryo-sorption pump was successfully improved in one toroidal section, resulting that the pumping speed of 9 m^3/s is achieved, which is almost the same as the target pumping speed of one toroidal section[1]. However, the target of the pumping speed of the divertor is totally 100 m^3/s, and we have investigated the further development of the cryo-sorption pump to quickly achieve the target.

To increase the pumping speed, the exhaust conductance in the pump is needed to be high. The new pump structure is re-designed to maximize the conductance as shown in Fig. 1. The main characteristics is twofold: (1) The water-cooled blinds are no longer needed because the line of sight from a strike-point on the divertor plate to the LN_2-cooled components is interrupted by the dome structure, and (2) the area of the cryo-sorption panel is enlarged by the integration of the cryo-sorption pump and the dome structure.

To improve the performance of the cryo-sorption pump, the selection of an activated carbon is one of the key issues. In general, the activated carbon has the micro-pore and the meso-pore, whose volumes affect the pumping speed and capacity. We have examined the pumping speed and capacity of various types of the activated carbon in R&D device. Then, we found Shirasagi GH2X4/6 is the best activated carbon and decided it as the activated carbon of the improved cryo-sorption pumps.

The improved cyo-sorption pump has been successfully installed in three toroidal sections. The pumping speed and capacity were measured in one toroidal section, introducing constant and continuous hydrogen flow into the LHD vacuum vessel. The pumping speed up to 20 m^3/s was achieved, as shown in Fig. 2. The measured pumping speed is twice higher than that of the previous type. The pumping capacity of 13,640 Pa m^3 was also evaluated, which is about four times larger than that of the previous type. The capacity corresponds to the 4,400 hydrogen solid pellets used in LHD for a main fueling, which is adequate in the high density experiments.

In FY2016, one improved cryo-sorption pump will be added. It is estimated that the total pumping speed of 80 m^3/s in the cryo-sorption pump for the closed helical divertor will be attained. The effect on the local and global particle balances will be investigated in the next experimental campaign.

1) T. Murase *et al*., Plasma Fusion Res. **11**, 1205030 (2016).

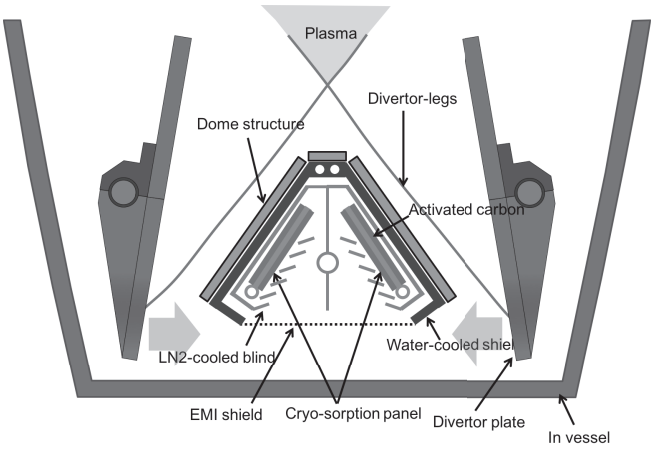

Fig. 1 Cross-section of the in-vessel new cryo-sorption pump. The effective pumping area of the cryo-panel is ~0.57 m^2 in one toroidal section.

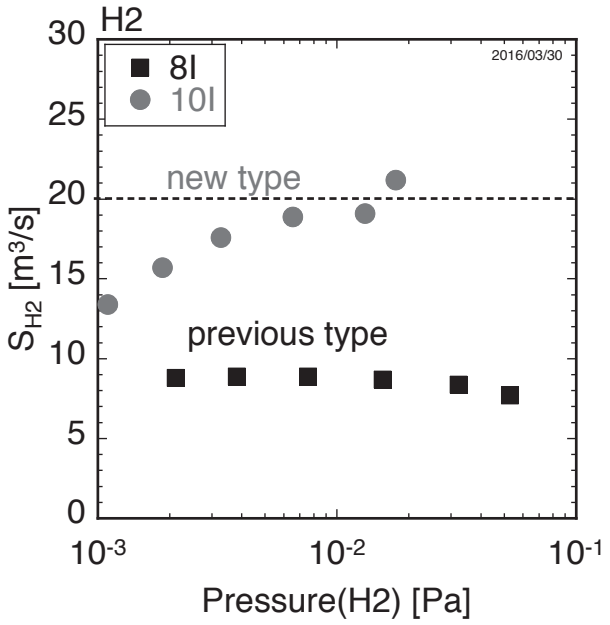

Fig. 2 Pumping speed as a function of the vacuum vessel (plenum) pressure.