§11. Observation of the Gas Stream in the Vacuum Exhaust Pipe Line for the Design of Exhaust Detritiation System

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A fusion test device will be conducted the deuterium plasma experiment following the hydrogen plasma experiment. In the deuterium plasma experiment, a small amount of tritium will be produced in the vacuum vessel by D-D reaction. The produced tritium will be exhausted from the vacuum vessel via the vacuum pumping system. Tritium is a radioactive isotope of hydrogen. It decays to ^{3}He by emitting beta ray with the half-life of 12.32 year. Thus, tritium must be handled carefully from the viewpoint of radiation protection and safety. In NIFS, to reduce the amount of tritium released into environment, the exhaust detritiation system [EDS] will be installed for removal of tritium in the exhaust gas from the large fusion test device. However, since the purpose of a fusion test device studies and reveals the high temperature plasma physics, the plasma discharge is pulsed operation of few seconds. Also, the auxiliary systems such as plasma heating systems are equipped with crysorption pumps for evacuation of light gas species. The sorption pump has to be regenerated the cry sorption panel. At that time, the exhaust gas flow will be huge in a short period of time. A similar variation of gas stream is made by the roughing pumping of the vacuum vessel. Therefore, the gas stream will be irregular and varies very much. In order to design the EDS, it is important to observe the variation of the gas stream in the exhaust gas.

For the observation of the gas stream and the hydrogen concentration in the vacuum exhaust gas, a mass flow meters and hydrogen sensors were installed in the exhaust piping line. The range of mass flow meters was from 0 Nm^3/h to 20 Nm^3/h and from 0 Nm^3/h to 300 Nm^3/h, respectively. The hot wire semiconductor type for high sensitive monitor from 0% to 10% and the thermal conductivity type for high concentration from 0% to 100% were used for the hydrogen sensors. A hygrometer is used as an auxiliary equipment. The data sampling interval was 1 seconds.

Figure 1 shows the variation of the roughing pumping flow rate of LHD vacuum vessel. In this case, the maximum flow rate was 309 Nm^3/h. The maximum roughing pumping flow rate of NBI vacuum vessel was obtained as LHD roughing pumping flow rate. Therefore, when the vacuum vessel is pumped from atmosphere, the required flow rate of EDS is about 300 Nm^3/h. Figure 2 shows the example of the variation of hydrogen concentration and exhaust flow rate under plasma experiments. After the plasma experiments were started, the hydrogen concentration in the exhaust piping line became high. Although the flow rate was at low level during the experiments, the hydrogen concentration was kept at few percent less than explosion limit concentration, 4 %. In this case, the exhaust gas can be treated continuously by the EDS at the constant flow rate. On the other hands, the regeneration of cryo sorption system was conducted at the weekend. Figure 3 shows the example of the variation of hydrogen concentration on Sunday. In this case, the flow rate was kept few Nm^3/h and the variation of hydrogen concentration was broken out and the maximum hydrogen concentration was over 7%. The irregular gas stream makes the normal process operation of EDS harder. Therefore, the EDS is designed that the irregular process gas stream is stored temporally in the large volume tank. After the gas storage, it will be treated gradually with other process gas. We will conduct the exhaust gas processing at the 19 cycle plasma experiment to verify the designed EDS.

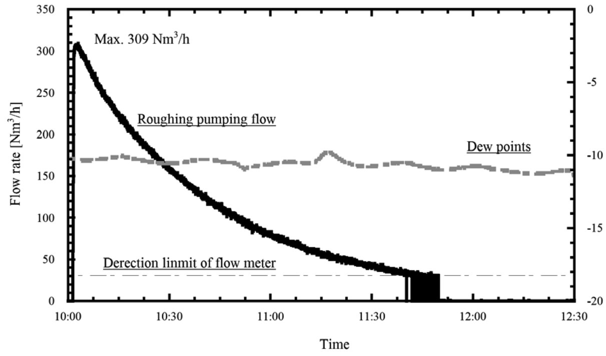

Fig. 1. The variation of the roughing pumping flow rate of LHD vacuum vessel.

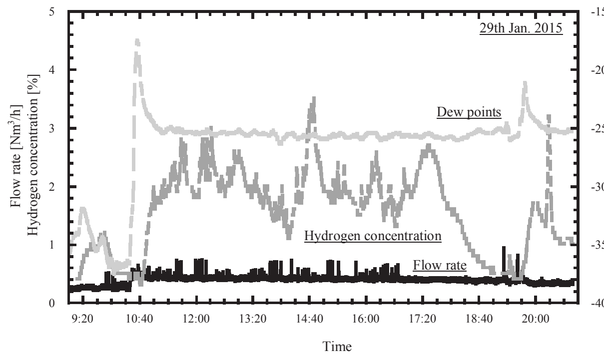

Fig. 2. The example of the variation of hydrogen concentration and flow rate under plasma experiments at 29th Jan. 2015.

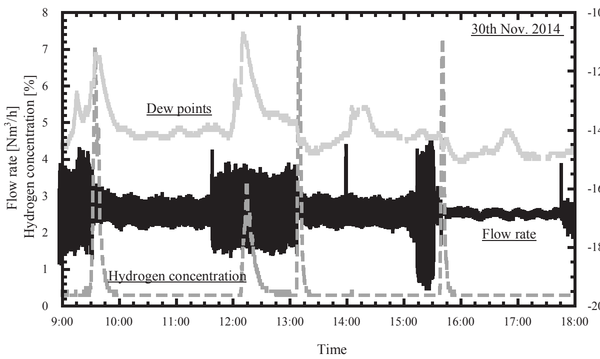

Fig. 3. The example of the variation of hydrogen concentration and flow rate on Sunday, 30th Nov. 2014.