§8. Development of Exhaust Gas Treatment System for LHD

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In order to carry out deuterium plasma experiments on the Large Helical Device (LHD), NIFS is planning to install a system for the recovery of tritium from exhaust gas. As well as adopting proven conventional systems, NIFS is planning to apply the latest technologies. The following specific methods have been selected for final evaluation for actual applications.[1]

(A) Membrane Dehumidifier for Vacuum Vessel Purge Gas Treatment Unit

Oxidized tritium (tritiated water vapor) contained in the purge gas is usually removed using an absorbent column. However, if a dew point of less than -60 °C could be obtained using a polymer membrane dehumidifier, the equipment could be reduced in size and a more stable dehumidifying performance could be expected.

(B) High Sensitivity Tritium Monitor for Online Gas Phase Tritium Monitoring Unit

A real-time monitor has not been commercially available for concentrations under 5×10^{-4} Bq/cm^3, which is 1/10 of the regulation value for tritiated water vapor in the exhaust gas. Using the hydrogen pump, it is possible to lower the effective detection limit by greater than an order of magnitude, by concentrating the hydrogen-isotope gas (including tritium) and by removing the radon gas which is mixed in at the monitoring stage.

In order to make efficient developments, two collaborated researches have been carried out.

1) Study on polymer membrane type dehumidifier for tritium removal [Shizuoka Univ.]
2) Development of hydrogen gas pumping apparatus applying proton conducting ceramics [TYK]

Development status is summarized as follows.

① Membrane dehumidifier

In order to elucidate the performances under atmospheric pressure at the permeate side, we carried out experiments using a commercially available polyimide hollow-fiber filter module (Ube Industries, UM-XC5, O.D.: 90 mm, L: 710 mm). It has been demonstrated that the targeted dew point (from -60°C to -90°C) is obtained stably at the treatment gas flow rate of 100 NL/min by controlling conditions of the feed gas pressure and the purge gas flow rate optimum.

However, a time delay in reaching the targeted dew point cannot be disregarded in the membrane dehumidifier. In order to improve the transitional performances, we have designed the system that combined the membrane dehumidifier and the absorbent column, as shown in Fig.1.

This hybrid system has been verified to eliminate the time delay efficiently. It has also been confirmed that the dry air obtained from the membrane dehumidifier could be used for the regeneration of the absorbent during steady state operation periods. The hybrid system is planning to apply in LHD.

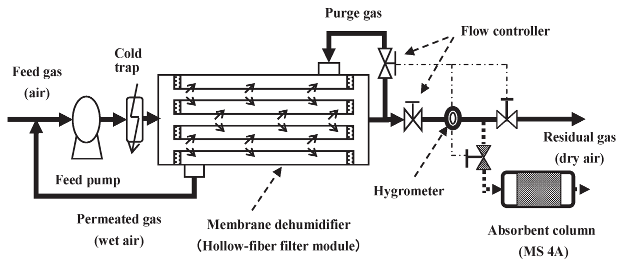

Fig.1 Modified membrane dehumidifier

②Hydrogen pump for high sensitivity tritium monitor

As the hydrogen pump, we have made the tube shape electrolysis cell of $CaZr_{0.9}In_{0.1}O_{3-\alpha}$ with one end closed and with platinum electrodes (O.D.: 13 mm, I.D.: 12 mm, L: 340 mm, effective electrode area: 63 cm^2).

Steam in the argon gas fed to the inside of the electrolysis cell is electrolyzed by the constant current and hydrogen is extracted to the outside of the cell. The extracted hydrogen was continuously supplied in the argon gas circulating in the closed-loop with the volume of about 2 liters. As shown in Fig.2, hydrogen in the argon gas could be concentrated lineally with pumping times and reached to 6% about 50 minutes. The tritium monitor applying the hydrogen pump is planning to design based on the present results.

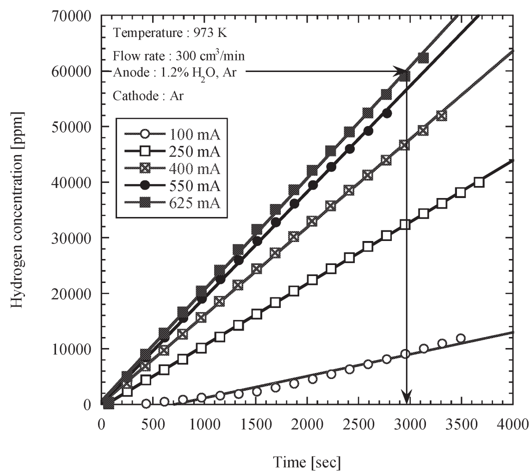

Fig.2 Hydrogen pump test results in closed-loop

Reference

[1] Y. Asakura, et al., Fusion Sci.Technol.,Vol.48,401(2005)