§1. Design and Evaluation of Gaseous Tritium Recovery System Using Membrane Type Dehumidifier in LHD

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In order to realize the planned deuterium plasma experiments using the Large Helical Device (LHD), the National Institute for Fusion Science (NIFS) is planning to install a system for tritium recovery from exhaust gas.

While adopting typical tritium recovery systems, NIFS has also made plans for the development of a compact reduced-waste recovery system by applying a membrane type dehumidifier [1)]. The applicability of a commercially available membrane dehumidifier has been evaluated experimentally, with the results indicating such a membrane is feasible for practical application [2)].

As the next step, we have carried out the basic design of the actual tritium recovery system for LHD having a treatment capacity of 300 m3(NTP)/h and a tritium recovery rate of more than 95% [3-4)].

To confirm the design specifications of the tritium recovery system with a polymer membrane module, we examined the dehumidification characteristics and optimal operation control method under system operating conditions [5)].

Dehumidification Characteristics of the single module

The dehumidification characteristics necessary for application of the polymer membrane module to the actual removal system were clarified under the system operating conditions.

The experiments were carried out using a commercially available polyimide hollow-fiber module (Ube Industries, UM - 10, OD: 90 mm, L: 1160 mm) and the small test apparatus having the capacity of 1/10th (30m3/h) and applying the same flow control system as the actual tritium recovery system .

As shown in Fig.1, a recovery ratio of tritiated water vapor exceeding 95% (a decontamination factor of 20) can be expected by setting the purge ratio to 0.15 under an operating pressure of 0.7 MPa(G). If the purge ratio is increased to 0.3, a recovery ratio of 99.9% is expected using the polymer membrane module.

Optimal Operation Control Method

By making the dew point at the module exit a control index, and carrying out PID control of the purge gas flow rate, the target dew point can be made constant under the condition of a constant product gas (dry air) flow rate.

However, in the case where the product gas flow rate changes sharply, overshooting of the dew point cannot be ignored.

If the purge ratio for attaining the target dew point is known in advance for each product gas flow rate, overshooting of the dew point upon changes in the product gas flow rate can be suppressed with fixed purge ratio operation instead of PID control.

In this operation, it is also possible to largely cancel the overshooting by tuning the timing between the change in the purge gas flow rate and the change in the product gas flow rate.

Comparison of size of dehumidifier system

The potential miniaturization of the removal system and consequent reduction in radioactive waste generation were estimated for application of a polymer membrane module instead of a MS adsorption column at a treatment flow rate of 300 m^3(NTP)/h.

Using the necessary membrane module design, the installation area of the system could be reduced to one-half that using MS adsorption columns, and the volume of radioactive waste generated could be reduced to one-quarter.

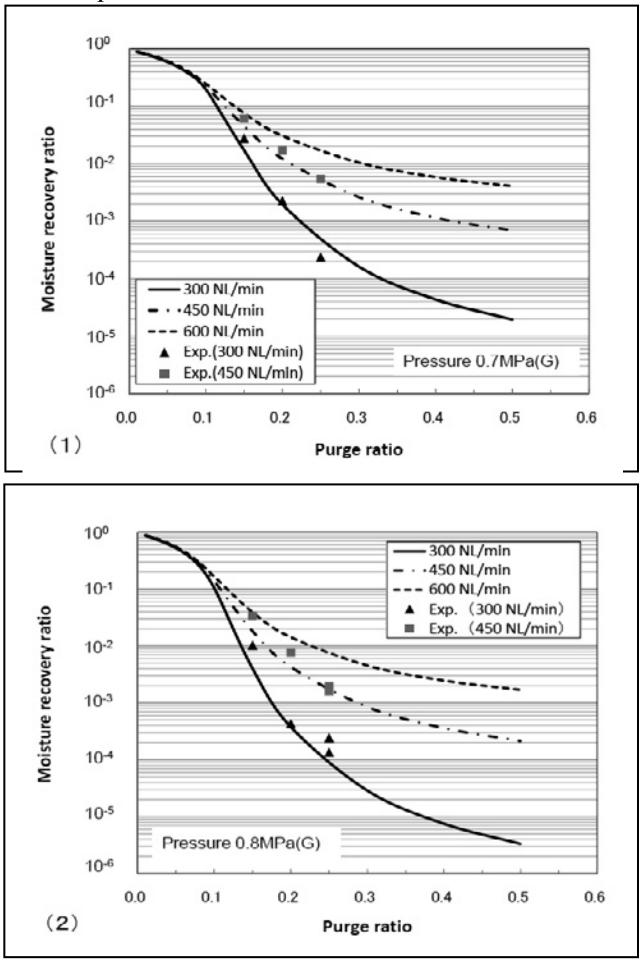

Fig.1 Relationship between moisture recovery ratio and purge ratio at (1) 0.7MPa(G) and (2) 0.8MPa(G)

1) Y. Asakura, et al., Fusion Sci.Technol., Vol.48, 401 (2005)
2) Y. Asakura, et al., Fusion Sci.Technol., Vol.54, 75 (2008)
3) Y. Asakura, et al., J. Nucl. Sci. Technol., Vol.46, 641 (2009)
4) Y. Asakura, et al., Fusion Sci.Technol., Vol.60, 136 (2011)
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