§4. Application of Membrane Dehumidifier for Gaseous Tritium Recovery 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. The applicability of a commercially available membrane dehumidifier has been evaluated experimentally, with the results indicating such a membrane is feasible for practical application. Based on performance test results, the optimum specifications of the membrane dehumidifier are evaluated quantitatively.

Evaluation Procedures of Membrane Dehumidifier

In order to elucidate the performance of the dehumidifier under atmospheric pressure at the permeate side, we carried out experiments using commercially available polyimide hollow-fiber filter modules (Ube Industries, UM -XC5, OD: 90 mm, L: 710 mm). **Figure 1** shows the flow of the membrane dehumidifier, in which the permeate flow rate is kept at the constant value necessary to achieve the target dew point by regulating the purge gas flow rate automatically.

A differential model for the present process (counter-current flow process) is shown in **Fig. 2** . In the differential model, the flow of the tube and shell side of the fiber is assumed to follow a plug flow model, and pressure loss along the flow direction is ignored.

Considering the flow rate change in a small part of the module with an area dA, the material balance equation can be described as follows:

$$\frac{dF_1}{dA}=\left(\frac{Q_1}{\delta}\right)(p_H\times x-p_L\times y) \tag{1}$$

$$\frac{dF_2}{dA}=\left(\frac{Q_2}{\delta}\right)\{p_H\times(1-x)-p_L(1-y)\} \tag{2}$$

$$x=\frac{F_1}{(F_1+F_2)} \tag{3}$$

$$y=\frac{P_1}{(P_1+P_2)} \tag{4}$$

Where, Q1 is permeation coefficient of water vapor and Q2 is the one of air. δ is film thickness and p is pressure.

Analytical Parameters and Calculation Conditions

Considering the maximum available feed pressure (0.8 MPa), the dependence on feed pressure was analyzed in the range 0.6 – 0.8 MPa. The permeate side was set at atmospheric pressure (0.1 MPa), according to the present operating conditions. The feed gas flow rate was changed from 100 – 300 L(STP)/min in order to estimate the maximum rate in the actual system.

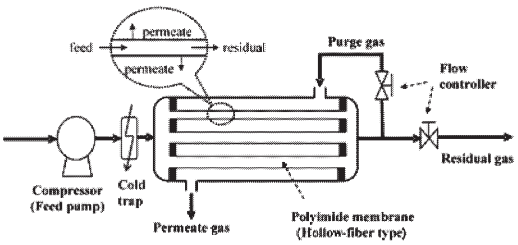

Fig.1 Design of the detritiation system for LHD.

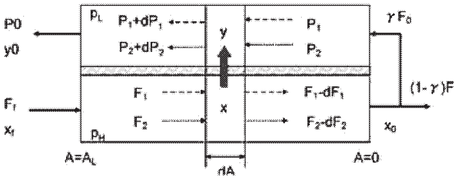

Fig.2 Differential model for membrane dehumidifier

Results and Discussion

Figures 3 and **4** show the dependence on the feed flow rate from 100 L (STP)/min, which represents the present maximum experimental condition, to 300 L (STP)/min at feed pressures of 0.7 and 0.8 MPa (abs.). At a feed flow rate of 100 L/min the calculated results show good agreement with the experimentally obtained results at all three feed pressures, except in the low residual gas purge rate region.

The calculated results suggest that the present module can deal with an increase in the feed flow rate up to 200 L(STP)/min under feed pressures of 0.7 – 0.8 MPa when the target dew point is assumed to be −60°C (water vapor concentration of 11 ppm).

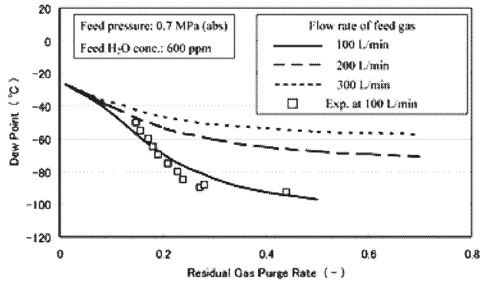

Fig.3 Dehumidifier performance at 0.7Mpa

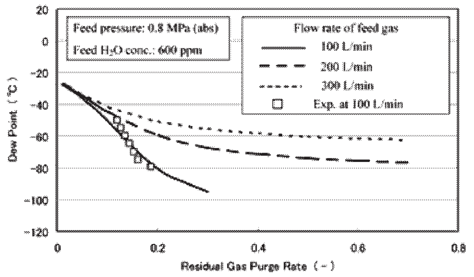

Fig.4 Dehumidifier performance at 0.8Mpa

[1] Asakura, Y. et al., J.Nucl.Sci.Technol.,Vol.46,641(2009)
[2] Asakura, Y. et al., Annual Report of NIFS, p474 (2007)