

### §3. Development of Water Detritiation System Using Combined Electrolysis Catalytic Exchange under Reduced Pressure

Yamamoto, I., Enokida, Y., Tsushima, S., Kobayashi, N., Abe, Y., Shiozaki, T. (Nagoya Univ.), Asakura, Y., Uda, T., Sugiyama, T.

When the deuterium plasma experiments are carried out in the Large Helical Device, large amount of tritiated drainage will be discharged by the experiments. Although the tritium concentration of the drainage is very low we have a plan to reduce the volume of the drainage by isotope separation, i.e., tritium removal. We have examined a Combined Electrolysis Catalytic Exchange (CECE) process in order to apply it to the system of water detritiation.

In the previous research<sup>1), 2)</sup>, we have developed a reduced-pressure method as a means of enhancing the separation factor in water-hydrogen chemical exchange reaction. The main purpose of this investigation is to apply a reduced-pressure method to the CECE process and to show the superiority of this method.

#### i) Experimental apparatus

The separation column is a Pyrex glass tube with 25 mm internal diameter and 90 cm total length. The column is filled with alternating layers of Kogel catalyst (5 cm) overlain by a Dixon gauze ring (15 cm). The Kogel catalyst, supplied by Showa Engineering Co. Ltd., consists of 0.8 wt% Pt deposited on styrene-divinylbenzene copolymer.

Hydrogen gas which was generated in the Solid Polymer Electrolysis electrolyzer (Fig. 1) was mixed with saturated vapor in a humidifier and then supplied from the bottom of the column. The mixed gas was extracted from the top of the column after removal of water vapor by a condenser operating at 5 °C. The condensed water was returned to the top of the column. In addition to this reflux liquid, pre-heated distilled water was supplied from the top of the column. Water passing through the column was partially discharged from the bottom of the column.

The degree of vacuum in the separation column was controlled at a constant value by a vacuum controller and an oil-free scroll vacuum pump.

#### ii) CECE experiments under reduced pressure

Hydrogen-deuterium isotope separation by the CECE equipment was performed at 101 kPa, 70 °C and 12 kPa, 40 °C. The flow rate of hydrogen gas (4.0 NL/min) and the feed rate of distilled water (4.0 g/min) were set at the same

values for both tests. The flow rate of water vapor estimated as the sum of reflux liquid and water vapor escaping through the condenser became 1.4 g/min at 101 kPa and 4.2 g/min at 12 kPa. The hydrogen isotope ratio in gas and liquid samples (HD/H<sub>2</sub> and HDO/H<sub>2</sub>O) were measured using a stable isotope ratio mass spectrometer.

Separation factor of the water phase  $\alpha$  and the hydrogen gas phase  $\beta$  are defined as follows with the abundance ratio  $R$  of HDO to H<sub>2</sub>O or HD to H<sub>2</sub>:

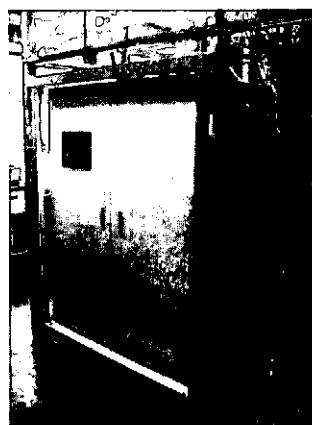
$$\alpha = R_{(\text{Feed water})} / R_{(\text{Extracted water})}$$

$$\beta = R_{(\text{Extracted hydrogen gas})} / R_{(\text{Feed hydrogen gas})}$$

The results obtained are summarized at Table 1. It was found that the process temperature could be lowered without reducing the molar fraction of water vapor in the stream by reducing the column pressure. Under condition of equal throughput, the separation factors at 12 kPa were larger than those at 101 kPa. These facts demonstrated the superiority of this method even for the CECE process.

Table 1: Comparison in different operating pressure

| Operating pressure [kPa]                           | 101      | 12      |
|--|----------|---------|
| Equilibrium temperature [°C]                       | 70       | 40      |
| Ratio of molar flow rate<br>Hydrogen : Water Vapor | 1 : 0.45 | 1 : 1.3 |
| Separation factor $\alpha$ [-]                     | 2.7±0.1  | 2.8±0.1 |
| Separation factor $\beta$ [-]                      | 5.5±0.2  | 6.8±0.2 |



Model: HS1001  
Showa Engineering Co. Ltd.  
  
Max. production rate: 1 m<sup>3</sup>/h  
Hydrogen purity: 99.99 %  
Output pressure: 0.2 MPaG  
Dew point: 5 °C  
Cell current: below 1.2 A/cm<sup>2</sup>

Fig. 1: Solid Polymer Electrolysis electrolyzer

#### Reference

- 1) Sugiyama, T., *et al.*: *J. Nucl. Sci. Technol.*, Vol. 41, No. 6, pp. 696-701, June (2004).
- 2) Abe, Y., *et al.*: Proc. AESJ Fall Meeting 2003 (in Japanese), Part I, p. 159, Shizuoka, September (2003).
- 3) Abe, Y., *et al.*: Proc. AESJ Spring Meeting 2004 (in Japanese), Part I, p. 83, Okayama, March (2004).