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§1. Design Problems of Cryogenic Pressure Swing Adsorption System for Hydrogen Isotope Separation in Fusion Fuel Cycle

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Decontamination of H atoms is one of the most important processes in the DT fusion fuel cycle. For the purpose of application to the isotope separation system in the DT fuel cycle, we have been carrying out the R & D of a pressure swing cryogenic adsorption process (PSA) for hydrogen isotope separation.[2,3] Using an existing apparatus of PSA with single column in NIFS, we examined breakthrough curves of D_2 or/and HD tracers included in a hydrogen gas mixture with cryogenic adsorption columns packed with synthetic zeolites of SZ-4A, SZ-5A and SZ-13X at 77.4 K of the liquefied nitrogen temperature. With experimental results the curve-fitting analyses gave us fundamental but valuable engineering data.[1] And also, using the same PSA apparatus, the cyclic PSA process operations of evacuating desorption, priming carrier H_2 replenishment and isotopic replacement adsorption were performed, demonstrating the successive isolation of H_2 from the H_2-D_2 mixture while the successive enrichment of D_2 in the recovered gas mixture, where the applicability of the PSA process to the DT fusion fuel cycle was verified.

In this academic year, this joint-research project made up a plan to design the next stage apparatus of a PSA process system for hydrogen isotope separation and then to complete its production in this fiscal year. The design was considered satisfying the specifications aiming at its efficient, automatic and productive operation. Then, a smart PSA system could be developed consisting of two or three columns working cyclic three processes in their merry-go-round combination.

Figure 1 shows a snapshot of the newly made apparatus of a pressure swing cryogenic adsorption process system using three adsorbent-packed columns. This PSA apparatus has the personal computer governing an on/off switching hub conducting the magnetic valves of compressed air lines actuating the pneumatic values controlling the hydrogen gas process streams. The on/off commands also can be given manually from the board of switching buttons as shown in Fig. 1. The computer, however, checks the on/off conditions whether valves are conducting the PSA processes under a safety operation mode or not, where the computer issues only a warning for missing an appropriate switching but prevents the switching which will be the trigger of a serious trouble in the cryogenic apparatus treating hydrogen gas.

This PSA apparatus can operate the continuous isotope separation in two multi-column combination modes; one is of alternation by twin columns, of which one is in charge of the isotope separating process by replacement adsorption after the pressurizing process by carrier H_2 replenishment while the other in the evacuating recovery process, and the other mode is cyclic of merry-go-round by triplet columns, which are in charge of the evacuating recovery process, the punishment process and the standby after it, and the isotope separation process by isotopic replacement adsorption and the standby after it, respectively.

The new apparatus is going to make a contribution to the R & D project of DT fuel cycle for the FFHR, with valuable results from experiments of continuous hydrogen isotope separation.

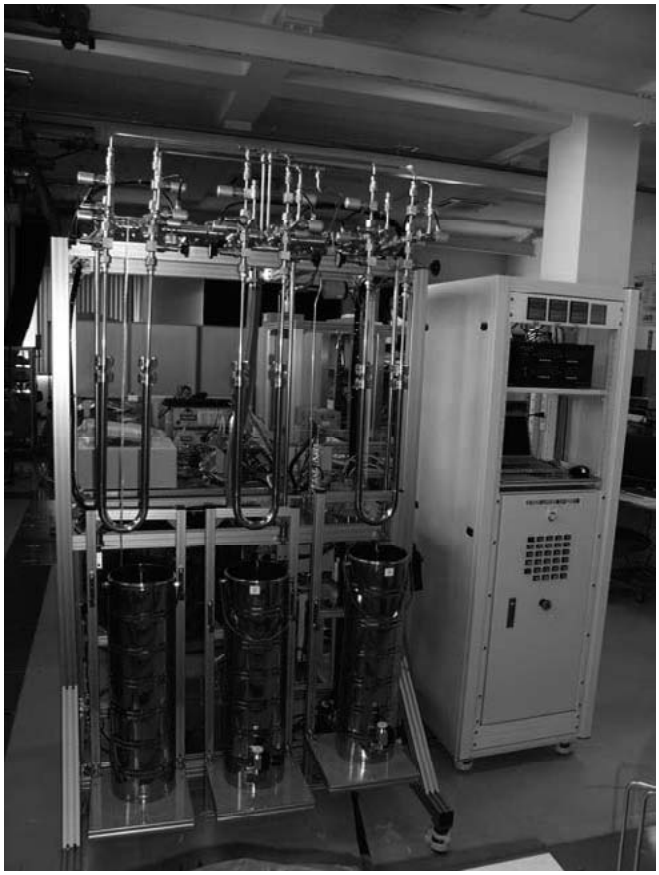

Fig. 1 Snapshot of the newly made apparatus of a pressure swing cryogenic adsorption process system with three packed-columns for hydrogen isotope separation.

1) Kotoh, K. et al.: 10th Int. Conf. Tritium Sci. Technol. (TRITIUM 2013), Nice, France, Oct. 21-25, 2013; in press, *Fusion Sci. Technol*. (2014).
2) Kotoh, K., Moriyama, S. et al.: *Fusion Eng. Des.* **88** (2013) 2223.
3) Takashima, S. and Kotoh, K.: *Fusion Eng. Des.* **88** (2013) 2366.