Commissioning test of a hydrogen diffuser in various hydrogen concentrations

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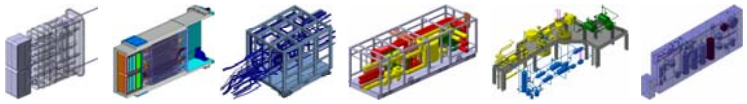
ABSTRACT :. Tritium extraction system (TES) is one of the ancillary systems to extract the tritium produced from breeding blankets and to supply the purified tritium to the fuel cycle of a fusion reactor. Cryogenic molecular sieve beds (CMSB) and Ambient molecular sieve beds (AMSB) extract Q2 and Q2O during the adsorption phase and the diffuser purifies the regenerated hydrogen isotopes during the desorption phase. Array of TBS relevant size unit tests of TES have been performed using PGLoop facility. Adsorption performance tests of large scale CMSB were carried out using various parameters of total pressure, flow rate and partial pressure of hydrogen [1]. As a next step, desorption experiments using regeneration loop of the CMSB module coupled with the diffuser module that purifies hydrogen isotopes by hydrogen permeation are planned. Therefore, it is necessary to assess unit performances of the Pd/Ag diffuser before the next series of experiments. In this paper, results of commissioning test of the diffuser are introduced.

Overview of HCCR TBS

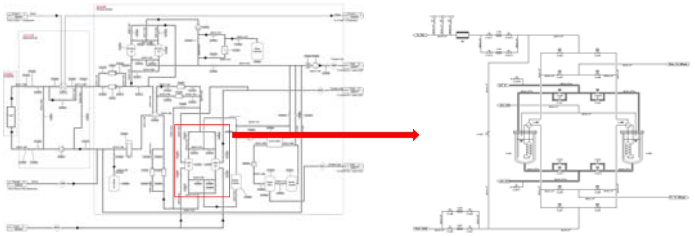
◆ Helium Cooled Ceramic Reflector (HCCR) TBS has been developed with overall objectives of testing and validating design concepts of tritium breeding blanket relevant to DEMO or fusion power plants
- ceramic as breeder, beryllium as multiplier, graphite as reflector and RAFM steel as structural material
- Graphite reflector is adopted to reduced the amount of beryllium while TBR remains

◆ The HCCR TBS consists of TBM-set and ancillary systems such as HCS, CPS, TES, PF, AEU, etc.



Objectives

◆ Experiments of cryogenic hydrogen adsorption and desorption have been performed using PGLoop
- To evaluate the adsorption and desorption performance of the CMS module in TBS-relevant scale
- To confirm operational procedures with control logics to be applied for HCCR-TBS on various operational states

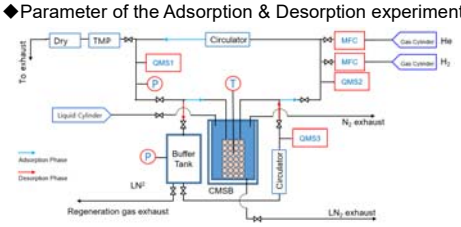


PGLoop

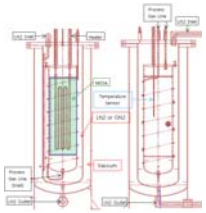
◆Feature of PGLoop
- Basic tests for unit process, adsorption phase and desorption phase
- Gas circulation module, Gas control module, AMS module, CMS module, Diffuser & storage module, Vacuum module, etc.

Adsorption & Desorption experiment

◆Parameter of the Adsorption & Desorption experiments



< Schematic flow diagram of adsorption and desorption experiment >



< Diagram of Cryogenic Molecular Sieve bed >

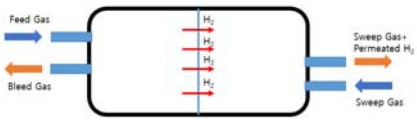
- Summary of the Desorption experiments

	Parameters				Results	
No.	Pressure at CMSB inlet [kPa]	H2 concentration [%]	H2 partial pressure	Flowrate [SLPM]	H2 adsorbed [stand. L]	H2 adsorption capacity [mol/g]
1-1	120	0.090	103	70	382	3.367E-4
2-1	120	0.072	103	70	379	3.334E-4
2-2	120	0.073	103	70	379	3.334E-4

Diffuser experiment

◆Procedure
- Purge the Diffuser to remove oxygen and air in the operation line
- Heat up to around 380℃
- Supply the Feed gas containing hydrogen of various concentration
- Measure the concentration of hydrogen permeated to the sweep side

< Breakthrough curve of the experiments >

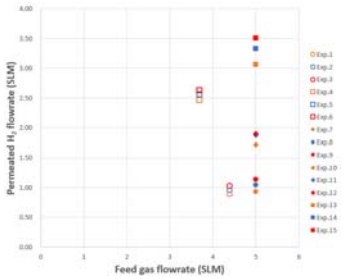


< Adsorption isotherm for H2 >

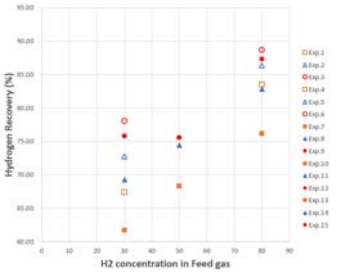
- Summary of gas conditions in diffuser experiments

	Parameters		
No.	Mix gas concentration (%)	Feed gas Flowrate (SLM)	Feed gas pressure (kPa)
1	30	4.38	120
2	30	4.38	150
3	30	4.38	200
4	80	3.68	120
5	80	3.68	150
6	80	3.68	200
7	30	5	120
8	30	5	150
9	30	5	200
10	50	5	120
11	50	5	150
12	50	5	200
13	80	5	120
14	80	5	150
15	80	5	200

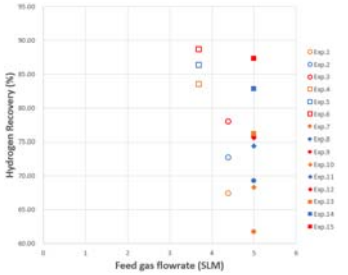
◆Result



< Permeated hydrogen flowrate according to feed gas flowrate >



< Hydrogen recovery according to H_2 concentration>



< Hydrogen recovery according to feed gas flowrate >

- More hydrogen was permeated at higher pressure when compared at the same flowrate and hydrogen concentration of the feed side.
- Hydrogen recovery of the diffuser shows at least 60% in lower concentration of hydrogen.
- As the flowrate of the feed side was increased, hydrogen recovery was decreased.
- In future, experiments under more conditions are planned to be performed to evaluate the performance of the diffuser.

Summary : Commissioning tests were successfully performed for several conditions with respect to pressure, flowrate and hydrogen concentration at feed side. It was confirmed that it showed a similar tendency when compared with other papers. More experiments are planned to be performed to clearly understand the characteristics of the diffuser. In the future, diffuser experiments will be carried out in conjunction with the CMSB module to investigate integral performance during desorption phase.

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