Thermal Control Characteristics in a Small Scale Hydrogen Isotope Storage Bed

Dongyou Chung [a], Jungmin Lee [a], Daeseo Koo [a], Hongsuk Chung [a*]
[a]*Korea Atomic Energy Research Institute, 989-111 Daedeokdaero, Yuseong, Daejeon 305-353, Korea*
[*]*Corresponding author: hschung1@kaeri.kr*

1. Introduction

Hydrogen isotope gases needed for the daily operation of the tokamak of nuclear fusion plants are safely stored in and supplied from beds [1]. Metal tritides are currently proposed for the safe and high density storage and delivery of tritium gas during the operation of fusion machines. Different metal tritides show various storage and delivery properties. Among the many metal tritides, uranium and zirconium cobalt have been suggested as two of the most applicable tritium storage materials [2-5]. A small-scale bed was fabricated to compare the properties of tritium recovery and the delivery of materials. It should be equipped with a heat control. Thus, in this study, we have performed thermal control tests (heating, cooling, and thermal insulation) of the small-scale bed.

2. Experiments

2.1 Experimental Apparatus

Fig. 1 shows front and vertical views of the small-scale bed for hydrogen isotope storage material tests. The small-scale bed is able to use approximately 0.7 g of tritium. The bed is composed of primary and secondary vessels. There are disk and cylindrical thermal reflectors between the primary and secondary vessel to reduce radiation heat loss. Ceramic heat insulating material between the connected parts of the primary vessel and secondary vessel is placed to reduce heat transfer from the primary vessel to the secondary vessel. The secondary vessel is a flange type. It is suitable for a secondary vessel, but the primary vessel does not use a flange because a leakage can occur by thermal cycling during hydriding/dehydriding tests. The primary vessel consists of two cable heaters of 3kW/heater (220V), and three sintered metal hydrogen filter-tubes for a hydrogen inlet, outlet and pressure gauge (nominal pore size of 0.05 ㎛) to protect the migration of powder. Fig. 2 shows the primary vessel's brazed two-cable-heater. Two cable heaters are brazed into the groove of the outer surface of the primary vessel using BNi for a fast heat transfer and durability. Three thermocouples (k-type) are located inside the secondary vessel, and the wall and bottom of the primary vessel in the bed. The pressures of the system are measured with MKS Baratron gauges. The design pressure of the secondary vessel is 400 kPa at 100℃ and the design pressure of the primary vessel is 500 kPa at 500℃ for safety. Vacuum & leak inspections on the primary & secondary vessels are to be performed. These results were proved to have no leaks on the tubes of the primary & secondary vessels.

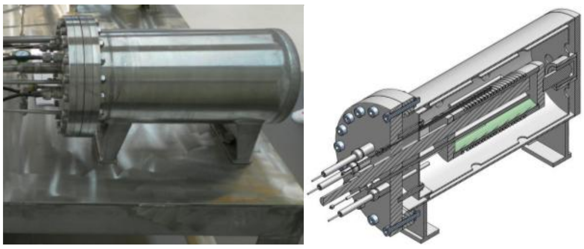
(a) (b)

Fig. 1. (a) Front and (b) Vertical sectional views of the small-scale bed for hydrogen isotope storage material tests.

Fig. 2. Primary vessel brazed two-cable-heater.

2.2 Heating Test of Primary Vessel

Table I shows the heating test condition of the primary vessel. It is equal to the dehydriding procedure of the ZrCo bed.

2.3 Cooling Test of Primary Vessel

For an evaluation of the cooling properties, the cable heater was powered down after heating of the primary vessel up to 430℃. Then, cooling of the primary vessel was performed under two secondary vessel conditions (a vacuum, and a He atmosphere of 800 torr) up to room temperature respectively.

2.4 Thermal Insulation Test of Secondary Vessel

The secondary vessel temperatures were measured for a thermal insulation test in the primary vessel temperatures of 100℃, 200℃, 300℃, 400℃. The primary and secondary vessel were continuously pumped using rotary pump and turbo molecular pump to maintain a high vacuum pressure.

Table I: Heating test condition of primary vessel

Temperature (℃)	Time (min)	1st/2nd vessel
Room temp.	0(heating start)	vacuum
270	10(heating)	vacuum
340	15(heating), 60(maintaining)	vacuum
500	10(heating) 60(maintaining)	vacuum

3. Results and Discussion

Fig. 3 shows a temperature transient and heating pattern of the primary vessel during the heating test. The measured and setting values of the primary vessel temperature are almost the same. Some overshooting of the heater occurs but is negligible. Fig. 4 shows the temperature transient of the primary vessel during the cooling test. The primary vessel cooling time of experimental condition A up to room temperature is about 30 hours, and that of experimental condition B is about 10 hours. Fig. 5 shows the pressure and temperature transient of the small-scale bed during a thermal insulation test. Increasing primary vessel temperature, results in a ΔT and secondary vessel pressure increase.

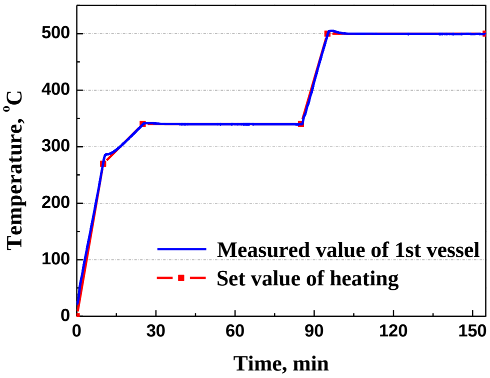

Fig. 3. Temperature transient and heating pattern of the primary vessel during heating test.

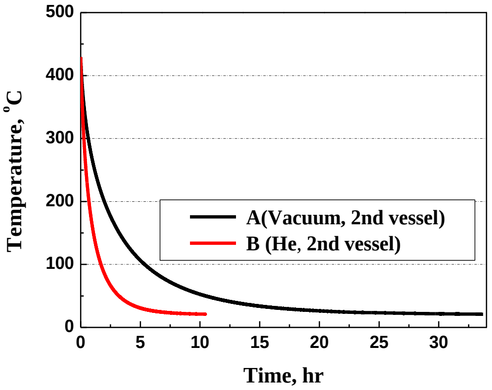

Fig. 4. Temperature transient of the primary vessel during cooling test.

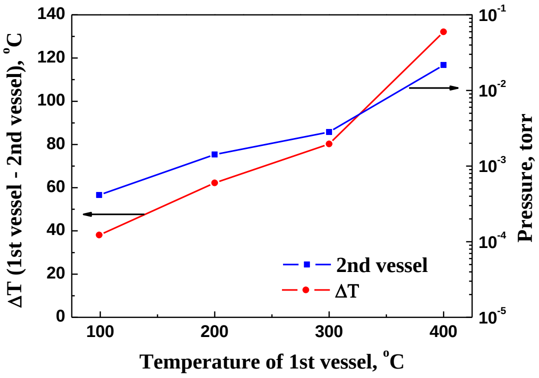

Fig. 5. Pressure and temperature transient of the small scale bed during thermal insulation test.

4. Conclusions

In this study, we carried out thermal control tests (heating, cooling, and thermal insulation) of a small-scale bed. The performance of the cable heater for heating the primary vessel satisfied our requirements. As shown in Fig. 4, experimental condition A is more suitable for rapid cooling of the small-scale bed. Thermal insulation performance of the small-scale bed demand improvement as addition of thermal reflectors. We are going to apply these results to the bed design.

Acknowledgements

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