Bed system performance in helium circulation mode

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1. Introduction

As a part of the International Thermonuclear Experimental Reactor (ITER) Project, We have conducted an experiment for storing hydrogen to depleted uranium and zirconium cobalt (Refs.1-6). The helium blanket effect has been observed in experiments using metal hydrides. The collapse of the hydrogen isotopes are accompanied by the decay heat and helium-3. Helium-3 dramatically reduces the hydrogen isotope storage capacity by surrounding the metal. This phenomenon is called a helium blanket effect. In addition the authors are working on the recovery and removal techniques of helium-3. In this paper, we discuss the equipment used to test the helium blanket effect and the results of a helium circulation experiment.

2. Experiments

Figure 1 shows the test rig of the helium blanket effect experiment. The test rig consists of a ZrCo bed, 2.6 L tank, manifold, metal bellows pump (MBP), rotary pump, turbo molecular pump (TMP), MFC, MFM, pressure gauge, vacuum gauge, DAQ, and HMI system.

Fig. 1. Test rig of helium blanket effect experiment.

The HMI system of test rig was designed with LabVIEW. Using the HMI system, it is possible to control the equipment such as pump, MFC and acquire the data. We can verify the data in real time and draw graphs using live data. The amount of time saved is shown below of the screen, and we can save the data during the desired period of time. In addition, this system based on the schematic diagram, so, it is convenient to view.

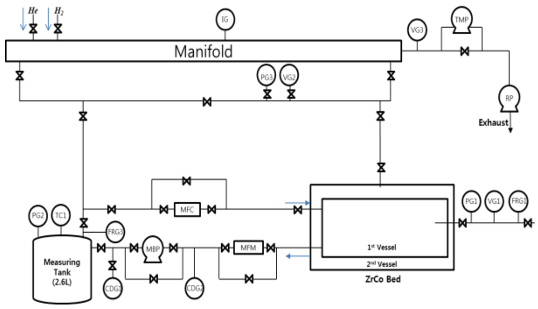

Fig. 2. Schematic diagram of helium blanket effect experiment test rig.

Fig. 2 shows a schematic diagram of the helium blanket effect experiment test rig. Fig 2 shows the positions of the valve and equipment and indicates the direction of the gas flow.

3. Experimental Results

3.1 Helium circulation

The helium circulation experiment was carried out in the following order. First, we filled the amount of helium to the 2.6 L tank, and then ran the MBP.

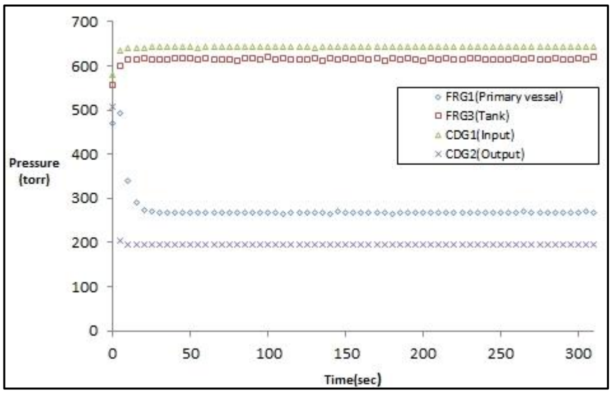

Fig. 3. Pressure in the circulation of 765 torr helium.

Fig 3 shows the pressure in the circulation of 765 torr helium. The pressure difference between the front and back of the MBP is 446 torr. The pressure of the tank and the bed also show the influence of by the MBP. Figs. 4 and 5 show the pressure in the circulation of 860 torr helium and 965 torr helium. The pressure difference between the front and back of the MBP is 482 torr and 536 torr.

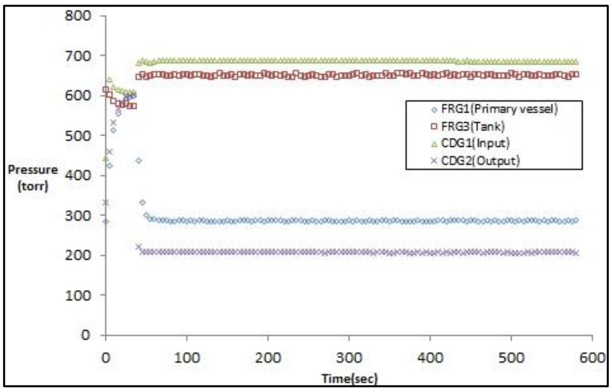

Fig. 4. Pressure in the circulation of 860 torr helium.

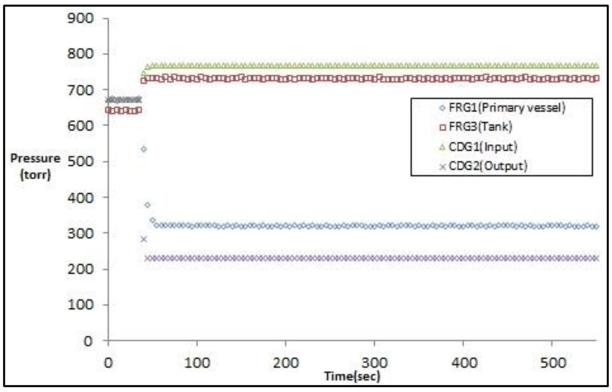

Fig. 5. Pressure in the circulation of 965 torr helium.

3.2 Change process gas of MFC

MFC and MFM of our test rig are set to measure the flow of the hydrogen. However, the actual gas used in the experiment is helium. Therefore, it is necessary to recalculate the flow rate of the MFC and MFM for helium. The gas conversion formula is as follows.

$$\text{OG flow rate } \times \frac{CF\ of\ CG}{CF\ of\ OG} = \text{CG flow rate} \quad (1)$$

OG is the original gas, CG is the current gas and CF is the conversion factor. The CF of hydrogen is 1.008, and the CF of helium is 1.386. The maximum hydrogen flow rate of the MFC is 30 SLM, and if we convert the gas into helium, the maximum flow rate is 41.25 SLM. First, the flow rate of hydrogen is shown in Table 1. We then calculate the flow rate of helium using formula 1.

Table 1: Flow rate of the hydrogen

	MFC (SLM)	MFM (SLM)
765	0.8	0.9
860	1	1
965	1.2	1.2

The actual flow rate of helium is shown in table 2.

Table 2: Converted flow rate for the helium

	MFC (SLM)	MFM (SLM)
765	1.1	1.2375
860	1.375	1.375
965	1.65	1.65

The current flow rate is less than the error value, and thus we can-not control the flow rate. To increase the flow rate, we need to adjust the amount of the initial helium.

4. Conclusions

Helium-3 is created by the collapse of the hydrogen isotope. The helium-3 produced surrounds the storage material surface and thus disturbs the reaction of the storage material and the hydrogen isotope. Even if the amount of helium-3 is small, the storage capacity of the SDS bed significantly drops. This phenomenon is the helium blanket effect. To resolve this phenomenon, a circulating loop was introduced. Using a circulating system, helium can be separated from the storage material. We made a helium loop that includes a ZrCo bed. Then using a metal bellows pump, we tested the helium circulation. A study on controlling the flow rate and research on more efficient gas circulation will be conducted.

ACKNOWLEDGMENTS

This research was supported by the National Fusion Research Institute and the National R&D Program through the National Research Foundation of Korea (NRF), which is funded by the Ministry of Science, ICT & Future Planning (NRF-2009-007065).

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