The Performance Test of Induction Type Furnace for the Design of Tritium Desorption System

Eunkyung Jung*, Kyu Min Song, Byunwook Ko, Kahee Jeong, and Seungchul Park

KHNP Central Research Institute, 70, 1312-gil, Yusong-daero, Yusong-gu, Daejeon, Republic of Korea

*jungek1554@khnp.co.kr

1. Introduction

Since 2007, Wolsong TRF (Tritium Removal Facility) is operated and tritium removed from moderator and primary coolant system is safely stored in stainless steel vessels with titanium sponge (titanium bed). Tritium as high value material and product can be used in war industry, fusion research and medical care. In order to extract tritium from the titanium beds, new furnace system is developed. In this study, adsorption and desorption experimental apparatus with induction type furnace is introduced and tested. Hydrogen recovery rate as a performance index of the furnace is investigated as function of operating temperature.

2. Hydrogen adsorption and desorption experimental apparatus

2.1 Feature of hydrogen adsorption and desorption experimental apparatus

Main systems of this apparatus are the hydrogen adsorption and desorption system, and the vacuum exhaust system. The hydrogen adsorption and desorption system consists of a metering tank, induction type furnace, a RF controller and feed pumps (TMP, MBP). The amount of adsorption and the amount of desorption can be calculated by measuring the pressure change over time. The evacuation system removes impurity gases before filling the system with hydrogen, or removes remaining hydrogen in the next experimental step. The compressed air (CDA, Compressed Dry Air) module, the cooling water (PCW) supplied to the RF coil, and the cooling water supply part from the water bath for cooling the drawing heater were designed for the operation of the tritium extractor. In addition, a controller for all control and data acquisition was constructed. The scale of the device was made about 4m in width, and about 2.3m in height (Fig. 1).

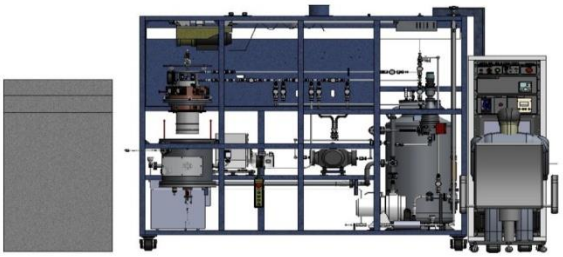

Fig. 1. Hydrogen adsorption and desorption experimental apparatus (front side).

2.2 Heat transfer analysis

During the hydrogen desorption, the thermodynamic limit on the PTC (pressure-concentration-temperature) curve) exists. For the sufficient desorption of hydrogen, the temperature should be raised to 650°C or more. When heating at that temperature, the most vulnerable part of the vessel is the tritium storage vessel's main valve. So, a heat exchanger is installed to remove the heat transfer generated by the vessel heating. Heat transfer analysis is performed to confirm the integrity of the valve portion [2].

3. Operation procedure

The hydrogen desorption is performed in four steps. As a first step, the vacuum evacuation was performed by using a rotary pump and TMP. The second step is the activation of the tritium storage vessel. The titanium bed is evacuated and the temperature of the titanium bed is heated by 525°C for 2 hours. When the activation is complete, close the valve and keep it in vacuum. The third step is the adsorption process. It is to fill the metering tank (MT) with hydrogen. The volume of the tank is 191.45L, so the pressure is 0.9768 atm. At this time, the pressure of the tank and the storage vessel temperature are recorded with time. The last step is to heat the storage vessel to perform desorption. First,

the metering tank and piping are evacuated in advance. Measure the pressure of the titanium bed while heating at set temperatures. When the temperature reaches the set temperature, the MBP (or TMP) is operated to transfer the hydrogen from the titanium bed to the metering tank. Measure the temperature and pressure of the metering tank over time.

4. Result & discussion

Five titanium beds are manufactured and tested. Experiments are performed at 500, 600, 650, 670°C to determine recovery rate with each different titanium bed for the independent experiment.

4.1 Activation and Adsorption

Before adsorption test, the titanium bed is activated. It is heated up to 525°C and evacuation for 2 hours to remove impurities in the vessel. This procedure is the same with that of manual in WTRF TGHSS. During the adsorption, the temperature of titanium bed can be increased very high so the hydrogen adsorption is performed separately by 10 times in 10 kPa units which is one tenth of the total hydrogen storage capacity.

4.2 Desorption

The pressure of the metering tank is measured according to the operation time. The pressure in the metering tank refers to the amount of hydrogen in the tritium storage vessel. The operating time is 24 hours and the initial pressure is 97.68 kPa. There are many differences in the recovery rate of desorption depending on the operating temperature. Fig. 2 is the result of the recovery rate depending on the operating temperature. At 550°C, the recovery rate is over 48% for 24 hours. At 600°C, the recovery rate is over 60. The recovery rate is over 80% at 650 and 670°C. It is expected that it takes about 48 hours or more to obtain a recovery rate of 90% or more.

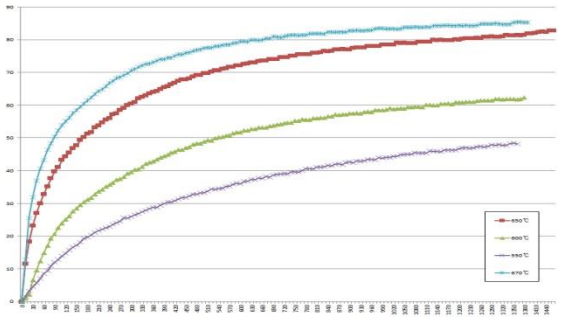

Fig. 2. The recovery rate in desorption process depending on the operating temperature.

5. Conclusion

The performance test of the hydrogen adsorption-desorption apparatus is performed. The amount of hydrogen desorption is determined by the temperature on the PCT curve of the titanium vs. tritium. It takes more than 48 hours to extract more than 90% of tritium at design temperature (650°C). To increase the yield of tritium, it is necessary to increase the operating temperature near 800 ~ 900°C. In this case, safety design should be considered to reduce the damage of the storage vessel. Induction type furnace is one of solutions to increase the safety and performance.

REFERENCES

[1] K. Song, “Introduction to Tritium Application Program in KHNP” KO-JA Tritium Workshop July 5-6, 2016, Seoul.

[2] E. Jung, et al., “Development of the Adsorption and Desorption Experimental Apparatus for Tritium Extraction from Titanium Bed”, Proc. of the KRS 2016 Autumn Conference, Oct. 10-14, 2016, Jeju.