Design Study of an Experimental Rig for Hydrogen Isotope Storage Material Tests

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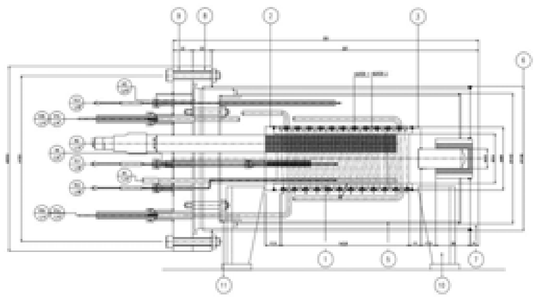
1. Introduction

With the development of fusion technology, it will be necessary to store large amounts of tritium in the reactor fuel cycle. To reach high-density storage of tritium, stable metal tritides are viewed as potential candidates. Metal tritide formers offer a safe and convenient method for tritium storage. Different metal tritides show different storage and delivery properties [1-2]. One of the remarkable properties of many metal tritides is the degradation of performance as a repetition of hydriding and dehydriding. Uranium and zirconium cobalt have suggested most applicable tritium storage materials [3]. Thus, to compare properties of tritium recovery and delivery of materials (uranium and zirconium cobalt), experimental rig was fabricated.

2. Design Feature and Fabrication of the Experimental Rig

In order to minimize difference between material test condition and operation condition in ITER, Experimental rig was design to downscale model of the cylindrical type full scale SDS bed (tritium 70 g) as shown in Fig.1. The capacity of the experimental apparatus is 1/100 scale of the SDS bed (tritium 0.7 g). Fig. 2 shows all components of the experimental rig. The bed is composed of the primary vessel and the secondary vessel. There are disk and cylindrical thermal reflectors between the primary vessel and secondary vessel to reduce radiation heat loss, and vacuum layer is formed between the primary and secondary vessels to decrease conductive heat loss. Ceramic heat insulating material between the connected parts of the primary vessel and secondary vessel is place to reduce heat transfer from the primary vessel to the secondary vessel. The secondary vessel is flange type. It is suitable for secondary vessel but the primary vessel is not use to flange because leakage can occurs by thermal cycle during hydriding/dehydriding test. Primary vessel consist of two-cable-heater of 220V/6kW, three hydrogen metal filter-tubes which was sintered (hydrogen inlet, outlet and pressure gauge, nominal pore size 0.05 ㎛) to protect migration of powder. Three thermocouples (k-type) are located inside of the secondary vessel, wall and bottom of the primary vessel in the experimental bed. The pressure of the system was measured with MKS Baratron gauges. As shown in table 1, Design pressure of the secondary vessel is 400 kPa at 100℃ and design pressure of the primary vessel is 500 kPa at 500℃ for safety.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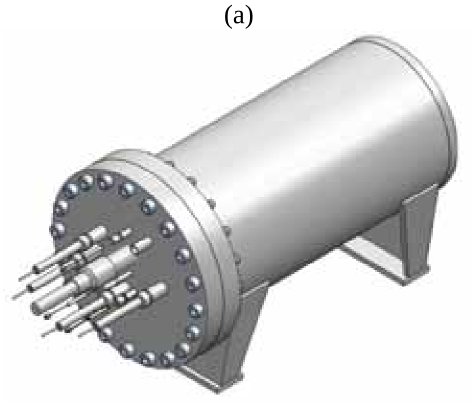
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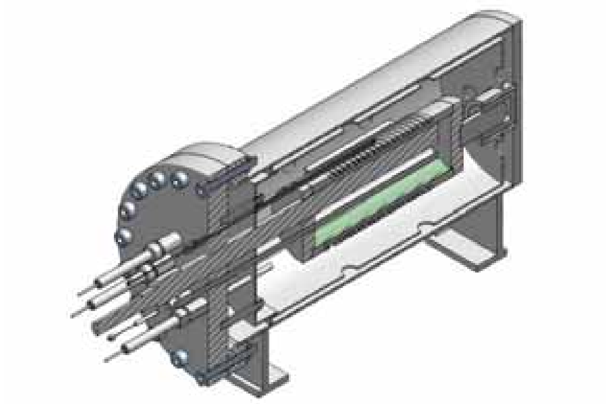
(c)
Fig. 1. (a) Detail plan (b) Conceptual design (c) Vertical sectional view of the experimental rig for hydrogen isotope storage material tests.

Fig. 3 shows brazing of two-cable-heater on primary vessel. Supporter was welded on outer surface of primary vessel for uniform brazing. And then, two cable heaters were brazed into groove of the outer surface of a primary vessel using BNi for fast heat transfer and durability. Its holding time is about an hour at 1060℃ in the vacuum furnace. Vacuum & leak inspections on the primary & secondary vessels for the fabricated the experimental bed were performed. These results were proved to have no leaks on the tubes of the primary & secondary vessels. The detection limit of helium leakage test was 1.0×10^{-12} Pa·m^3/s over 1 hour. The process of welding and inspection is performed by standard of ASTM SEC Ⅷ Div. 2.

Table 1. Design pressure and material of experimental rig.

	Design pressure	material
Primary vessel	500 kPa at 500℃	SUS 316
Secondary vessel	400 kPa at 500℃	SUS 304

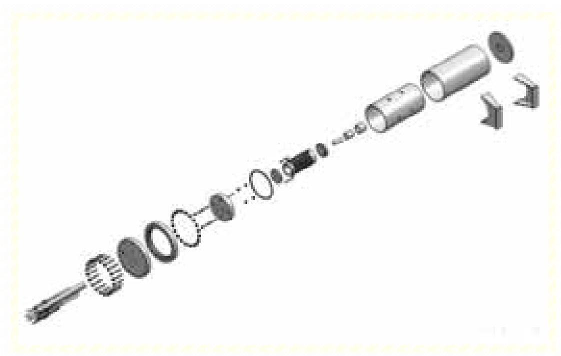

Fig. 2. Components of the experimental rig

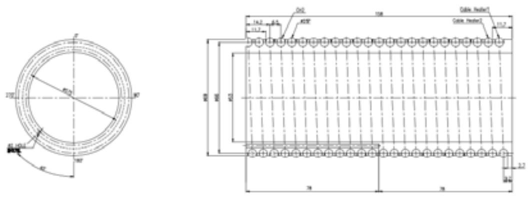

Fig. 3. Vacuum brazing of cable heaters on primary vessel

3. Conclusions

Our previous work was mostly zirconium cobalt hydride as a tritium storage material. Thus, the objective of the fabricated experimental rig has been to undertake a comparative study between uranium and zirconium cobalt as a tritium storage material under recovery and delivery test condition. We are expected to contribute to make criteria of tritium storage material selection through this study.

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