Manufacturing and Helium Leakage Tests of a Rectangular Tray-Type Tritium Getter Bed

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Abstract. To verify an applicability of ZrCo hydride to nuclear fusion fuel cycles, a new bed design using rectangular tray configuration was developed at KAERI (Korea Atomic Energy Research Institute). In the present paper, details of manufacturing of a ZrCo bed and preliminary heating test are described. The first full scale ZrCo bed was fabricated by brazing the tray plates, cable and cartridge heaters and helium flow pipe for in-bed calorimetry. Brazing could improve heat transfer for rapid hydrogen delivery from ZrCo hydride in the bed. Cylindrical and circular thermal reflectors were placed in between the primary and secondary vessels to minimize heat loss from the primary vessel to the secondary vessel, and for reduction of outer surface temperature of the secondary vessel to below ~ 60℃. Feed-through connections of the heater tubes and thermocouple tubes located outside of the secondary vessel. Helium leak inspections on this bed proved its integrity. Both the primary and secondary vessel leak rates were less than 1 x 10^{-10} Pa·m^3 /s indicating no leakage.

1. Introduction

Tritium plant of nuclear fusion fuel cycles is comprised of the Tokamak Exhaust Processing (TEP) system, the Isotope Separation System (ISS), the tritium Storage and Delivery System (SDS) and the Analytical System (ANS), etc. The main function of the SDS is to store and supply D-T fuel gas for DT plasma experiments [1-2]. The SDS bed stores D-T gas as a metal hydride form. Different innovative ZrCo hydride bed design has been developed at KAERI [3-9]. A new ZrCo hydride bed containing 1241g of ZrCo, which forms a tritium storage bed as $ZrCoT_{2.8}$, was fabricated. Brazing of the tray plates, cable heaters and decay heat simulation heaters (cartridge heaters) and helium flow pipe for in-bed calorimetry was employed in the bed manufacturing. Helium leakage test performed on the primary and secondary vessels showed the He leak rate to be < 1 x 10^{-10} Pa·m^3 /s. A series of demonstration tests of hydrogen recovery and delivery performance and in-bed calorimetry measurements are under way by using this new bed model. In the present paper, details of manufacturing of the ZrCo bed its helium leakage tests are described.

2. Fabrication

2.1. Preparation of Components

The ZrCo bed composed of three rectangular trays (Fig.1), wire mesh bags loaded with ZrCo powder (SAES, Italy), the primary and secondary vessels and thermal reflectors was fabricated. The ASME VIII div. 2 pressure vessel design code was applied. Each tray consists of a pair of cable heaters (5mm OD, STS316L, 3kW each), a decay heat simulation heater (cartridge heater, 3.2mm OD, STS316L, 8W/30V), a folded helium flow pipe (He loop, 6.4mm OD, STS316L) and three hydrogen inlet filter tubes (6.35mm OD x 318mm L, STS316 powder sintered, pore size 0.5μm). Eight rectangular wire mesh bags (Fig. 2: 315mm L x 30mm W) x 3.4mm H, mesh sheet thickness 0.08mm, mesh size 130 μm, STS304) were loaded with ZrCo powder (total 414g per tray), and were placed on the upper surface of each tray(Fig. 3). The primary vessel (design pressure 0.5MPa, design temperature 575℃, STS316) forms a pressure boundary and the secondary vessel (design pressure 0.4MPa, design temperature 100℃, STS304) provides a pressure and tritium confinement boundary. Three cylindrical and circular thermal reflectors (STS304) were placed in between the primary and secondary vessels for minimization of heat loss from the primary vessel to the secondary vessel, and for reduction of outer surface temperature of the secondary vessel to below ~ 60℃. To measure temperatures under the different experimental operations such as vacuum annealing of ZrCo powder, hydriding, dehydriding and in-bed calorimetry, 15 thermocouples were placed at the strategic locations in the primary and secondary vessels.

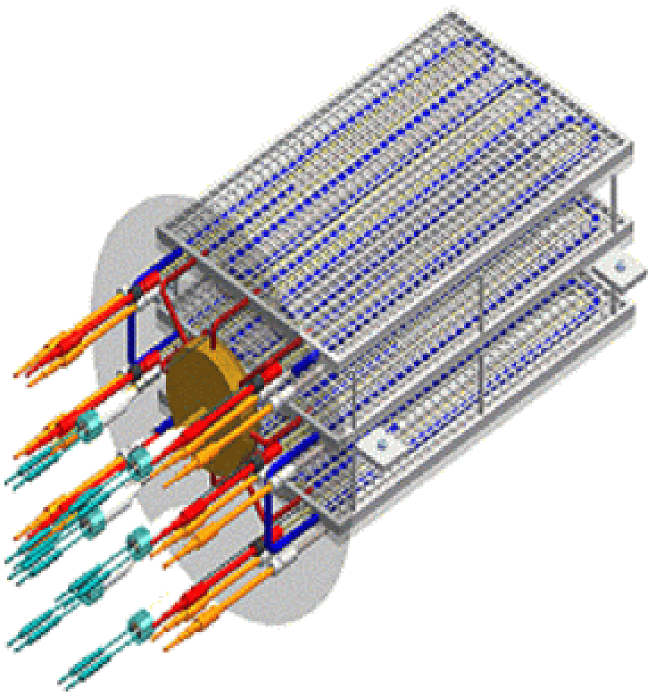

Fig. 1. Assembly model of three rectangular trays.

Fig. 2. ZrCo mesh bag fabrication.

Fig. 3. Fabrication process of the tray type ZrCo bed.

2.2. Brazing of Components

Fig. 4 shows brazing (~ 1 hr at 1040℃) of three plate assemblies in the electric vacuum furnace. Fig. 5 shows a 3D view of the first full scale ZrCo bed assembly model. It shows feed-through of cables, simulation heaters and thermocouples.

Fig. 4. Brazing of three rectangular tray plates.

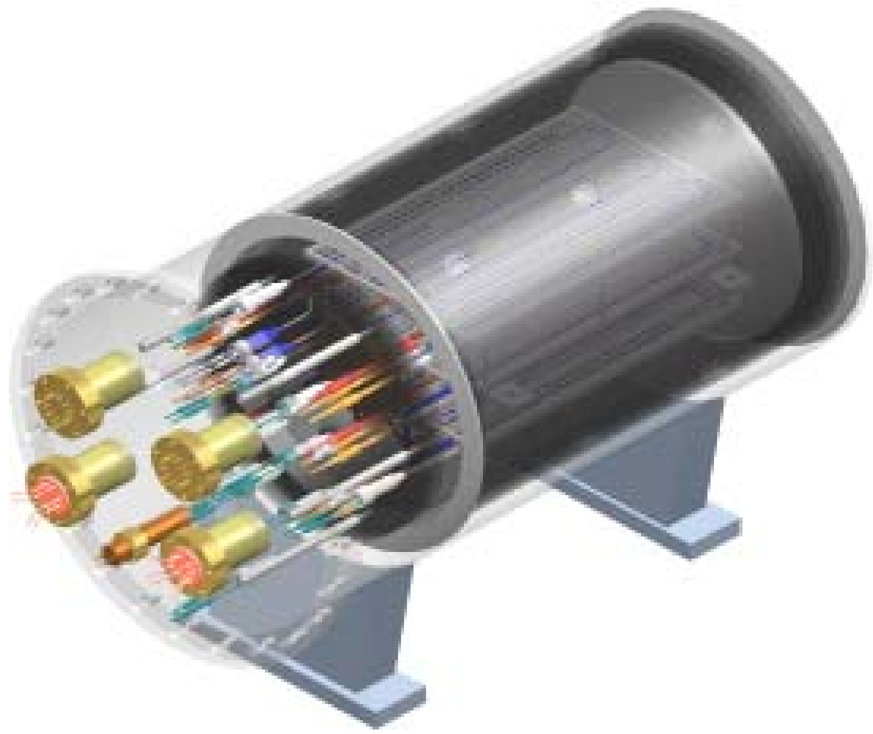

Fig. 5. 3D view of the rectangular tray type bed model.

3. Helium Leak Test

Vacuum and helium leak inspections were carried out on the primary and secondary vessels, vessel penetrations and feed-through to check leak tightness of the bed (Fig. 6). The results indicated no leak on the primary and secondary vessels and all penetrations and feed-through. The detection limit of helium leakage detector was 10^{-12} Pa・m^3/s and the measured leak rates were < 1.0 x 10^{-10} Pa・m^3/s (Fig. 7). No leakage was observed.

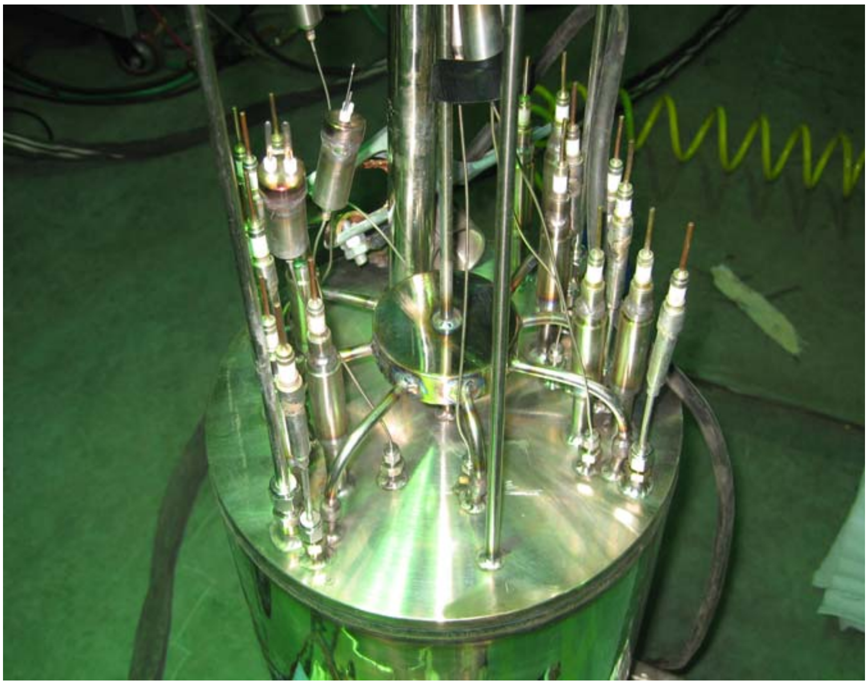

Fig. 6. Helium leak test for the primary and secondary vessels.

Fig. 7. Typical display in the helium leakage tests.

4. Concluding Remarks

A new bed design using rectangular tray configuration was developed at KAERI. The objective of this new design is (i) achievement of rapid hydrogen delivery performance on the ZrCo hydride bed, (ii) demonstration of in-bed calorimetric measurement using decay heat simulation heaters, (iii) simplification of the bed internal configuration for an improvement of operation reliability and (iv) saving of manufacturing cost. He leak rate of the bed was $< 1.0 \times 10^{-10}$ Pa · m^3/s. A series of demonstration tests of hydrogen recovery and delivery performance and in-bed calorimetry measurements are under way by using this new bed model. Depending on the experimental results, further improvement for the rapid delivery of hydrogen from the ZrCo hydride bed will be implemented.

Acknowledgements

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