Initial tests for design data of a ZrCo bed

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1. Introduction

Korea shares construction of the ITER, and responsible to supply DT fuel gas storage and delivery system (SDS)[1] which is a part of the tokamak fuel cycle. We have recently developed an innovative bed design concept, i.e., fast heat transfer response ZrCo bed characterized by cylindrical thin layer of ZrCo packing and large heating area contacting ZrCo powder for fast heating as well as large cylindrical filter surface and large vacuum pumping conductance for rapid delivery of DT(orT_2) from the SDS tritium storage beds[2-6]. Initial tests of hydriding and dehydriding for design validation of a ZrCo bed designed for ITER application were carried out by using H_2 gas.

2. Design

The first full scale ZrCo bed designed for ITER application is composed of primary (first pressure boundary) and secondary vessels (tritium confinement and pressure boundary) as well as internal and external He flow loop. The former vessel contains (i) the ZrCo layer (8mm thickness, weight of ZrCo 894g), (ii) inner and outer heaters (Total 3.2 kW) for heating the ZrCo layer from both surfaces, (iii) Cu fins to enhance heat transfer from two heaters to the ZrCo hydride layer, (iv) tritium decay heat simulation heaters and eight folded He flow copper line embedded in the ZrCo layer to simulate in-bed calorimetric measurement of the SDS bed which stores tritium. To prevent tritium permeation through the secondary vessel during different operation of the SDS bed at elevated temperatures (300~550℃), the space between two vessels contains 6 thermal reflectors and provides a high vacuum zone for (v) reduction of the outer surface temperature (< ~80℃) during different operation of the SDS bed at elevated temperatures (300~550℃), and minimization of radiation heat loss during the in-bed calorimetric measurement. To achieve precise calorimetric measurement of the tritium decay heat simulation heaters in the range of ~0.1-~20W, two-staged He gas heater is incorporated into the external He loop, which supplies He into the primary vessel at a constant temperature (20~50℃) with an accuracy of ∓ ~ 0.1℃. ITER reference code of the ASME VIII Div. 2 was applied to the present vessel design. Fig. 1 shows a cross-section view of the primary vessel of the ZrCo bed.

3. Experimental

The heating conditions during preheating and hydriding is shown in Table 1.

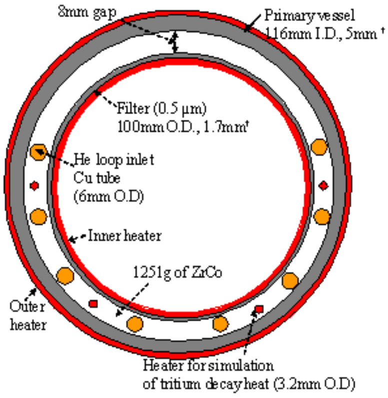

Fig. 1. Cross-section view of primary vessel of cylinder-type ZrCo bed.

Table1. Heating conditions during preheating and dehydriding.

Time	Temperature
10 (min)	RT→340°C (Outer heater), RT→340°C (Inner heater)
80 (min)	340°C (Outer heater), 330°C (Inner heater heater)

Table2. Hydriding Time and Temperature of ZrCo Hydride during Dehydriding

Pressure in H_2 loading tank(kPa)	90% hydriding time (min)	99% hydriding time (min)	ZrCo layer temp. (℃)
90	2.05	2.95	288
50	7.4	37.6	240

4. Results and Discussion

Figs 2 and 3 show hydrogen pressure change at the H_2 gas loading tank and ZrCo layer temperature change during hydriding. Table 2 summarizes the results of the hydriding test. For the test of loading tank pressure of 50kPa, time for the 90% and 99% hydrogen absorbed by the ZrCo bed were 7.4 and 37.6 min. respectively. For the loading pressure of 90kPa test, 90% and 99%

hydrogen was absorbed much shorter time than that for 50kPa test.

Fig. 3 shows temperature rise due to a large exothermic reaction heat (XrCo + $xH_2/2 \rightarrow$ ZrCoHx + ΔH (-82.81 kJ/molH_2) occurred during hydriding of the ZrCo layer. The peak temperature for higher loading pressure of 90kPa is much higher than that for 50kPa. This fact proved that faster hydridings rate is achieved by higher temperature rise caused by the exothermic reaction.

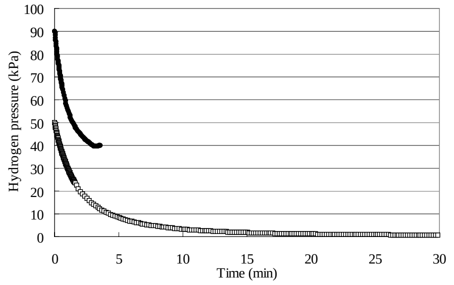

Fig. 2. Hydrogen pressure change during hydriding.

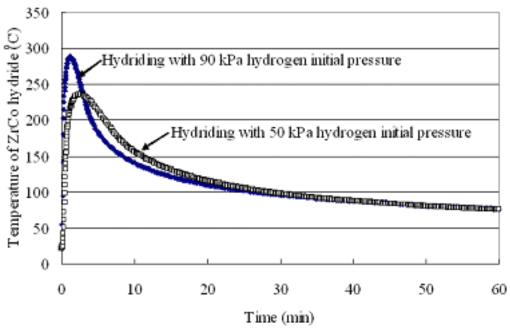

Fig. 3. Temperature change of ZrCo layer during hydriding.

Fig. 4 shows temperature change of the ZrCo hydride layer and integral amount of H_2 released from the hydride during a typical dehydriding test. Although a small amount of disproportionation reaction cannot be avoided, relatively higher preheating temperature of 340℃ which leads to a higher equilibrium hydrogen pressure of 20kPa was applied as the present initial tests.

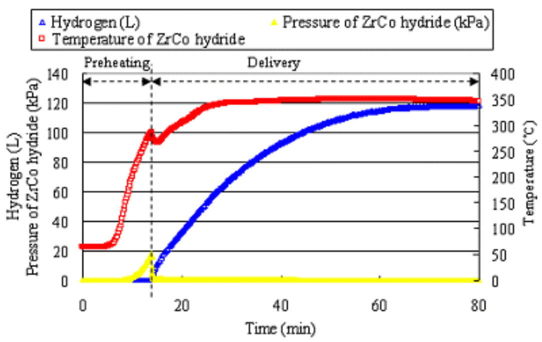

Fig. 4. Transient of hydrogen release, hydrogen pressure and ZrCo hydride layer temperature during dehydriding test.

Fig. 5 shows temperatures measured at different location in the ZrCo hydride bed during dehydriding test. It was confirmed temperatures of ZrCo hydride are below the optimum hydridings temperature for fast delivery. This fact indicates that heater power (total 3.2kW) installed in this bed is not enough to overcome the effect of endothermic reaction heat (ZrCoHx $\rightarrow$ZrCo + $x/2H_2$ +ΔH (-82.81 kJ/molH_2)), and necessary to increase the heater power at least by factor 2 for ITER application.

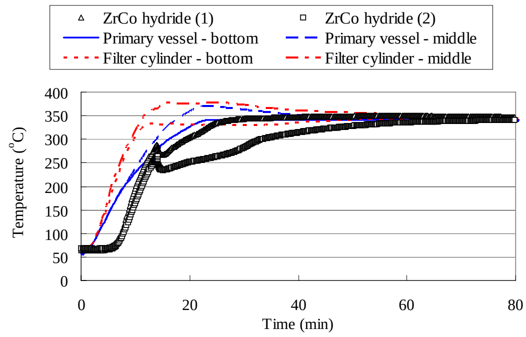

Fig. 5. Temperature transient in the ZrCo bed during dehydriding test.

5. Conclusions

It was confirmed that total heater power installed in the first full scale bed should be increase at least two times for fast delivery of DT gas for ITER. It was also proved that the higher hydrogen absorption is achieved by higher H_2 gas loading pressure.

Acknowledgements

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