Hydriding and Dehydriding Performance of a Tray-Type Hydrogen Isotope Storage Bed

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1. Introduction

The roles of the ZrCo hydride bed in the ITER storage and delivery system (SDS) is to store and supply the D-T fuel during DT plasma operation. The hydride bed requires the performance of fast recovery and delivery of D-T [1, 2]. The storage material of tritium has been used to store and deliver tritium from the storage vessel. The ZrCo powder, which is the storage material of tritium, has an excellent hydriding/ dehydriding property. It has a slow chemical reaction property in case of contact with air. It is a non-nuclear material [3, 4]. In this study, we present hydriding and dehydriding characteristics of the tray type $ZrCoH_x$ SDS bed with different stoichiometries (x = 1.0, 1.5, 1.8, 2.0) for a nuclear fusion application.

2. Experimental Apparatus and Method

Fig. 1 shows the experimental apparatus used for this study. The experimental apparatus consists of a high pressure tank which stores and measures the hydrogen, a ZrCo Bed which is used for hydriding/dehydriding of hydrogen, a rotary pump and a TMP (turbo molecular pump), and a scroll pump which delivers hydrogen from the ZrCo bed to the tank. The ZrCo bed is a tray type and has a metal mesh filter. The bed is composed of the primary vessel and the secondary vessel. There are 3 trays in the primary vessel. Each tray of the primary vessel contains the metal hydride (ZrCo) and a vacuum layer is formed between the primary and secondary vessels.

In this study, 1241 g of ZrCo powder was loaded into the ZrCo bed. First of all, the ZrCo was always vacuum annealed at 500℃ and in a high vacuum by using a rotary pump and a turbo molecular pump before the hydriding/dehydriding. Hydriding/dehydriding was performed 5 times using 1.0 mole of stoichiometry for the powderization of ZrCo. The experiment was carried out using 1.0, 1.5, 1.8, 2.0 moles of hydrogen. In the case of hydriding process, hydrogen valves were opened and hydrogen was introduced from a high vacuum tank to the ZrCo bed. And we have measured pressure and temperature for 30 minutes. In the case of the dehydriding process, ZrCo was heated, as shown in Fig. 2. We performed dehydriding by opening the valves of the ZrCo reactor in 10 minutes and then measured pressure and temperature for 75 minutes.

(a) Experimental apparatus

(b) Tray type ZrCo bed

Fig. 1. Hydriding and dehydriding apparatus

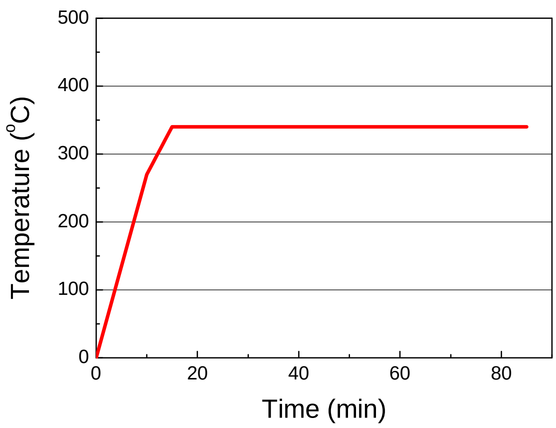

Fig. 2. Temperature of the heater during dehydriding

3. Results and Discussion

The pressure change is shown for each hydriding/dehydriding of ZrCoHx (x = 1.0, 1.5, 1.8, 2.0) (Fig. 3-4). Table 1 and Table 2 show the hydriding and dehydriding rates for 90% and 99% operation. Fig. 3 shows that rapid pressure reduction occurs in all the hydrides. And Fig. 3 shows that saturation time to form hydrides almost did not change with the increase of stoichiometry. Table 1 and 2 shows that the hydriding rate/dehydriding rates were enhanced with the increase of stoichiometry. Therefore, it is estimated that the $ZrCoH_{2.0}$ is the most effective stoichiometry.

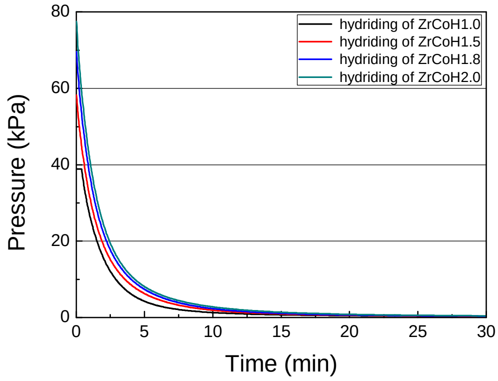

Fig. 3. Pressure change during hydridings of ZrCoHx

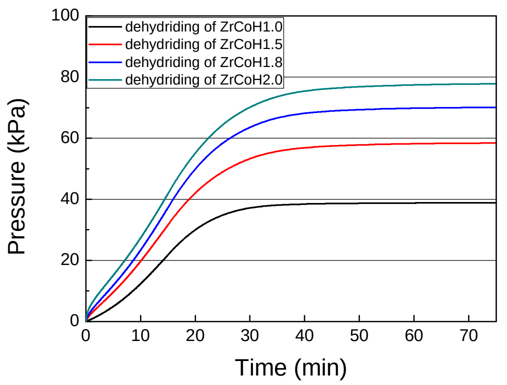

Fig. 4. Pressure change during dehydridings of ZrCoHx

Table 1. 90% and 99% of the hydriding rate

90% of hydriding process		99% of hydriding process	
ZrCoHx	**Hydriding rate**	**ZrCoHx**	**Hydriding rate**
$ZrCoH_{1.0}$	28.28 Pa·m^3/sec	$ZrCoH_{1.0}$	7.21 Pa·m^3/sec
$ZrCoH_{1.5}$	42.38 Pa·m^3/sec	$ZrCoH_{1.5}$	12.49 Pa·m^3/sec
$ZrCoH_{1.8}$	51.10 Pa·m^3/sec	$ZrCoH_{1.8}$	15.44 Pa·m^3/sec
$ZrCoH_{2.0}$	57.19 Pa·m^3/sec	$ZrCoH_{2.0}$	10.08 Pa·m^3/sec

Table 2. 90%, 99% of Dehydriding rate

90% of dehydriding process		99% of dehydriding process	
ZrCoHx	**Dehydriding rate**	**ZrCoHx**	**Dehydriding rate**
$ZrCoH_{1.0}$	5.94 Pa·m^3/sec	$ZrCoH_{1.0}$	3.66 Pa·m^3/sec
$ZrCoH_{1.5}$	7.79 Pa·m^3/sec	$ZrCoH_{1.5}$	4.76 Pa·m^3/sec
$ZrCoH_{1.8}$	9.21 Pa·m^3/sec	$ZrCoH_{1.8}$	5.84 Pa·m^3/sec
$ZrCoH_{2.0}$	10.08 Pa·m^3/sec	$ZrCoH_{2.0}$	6.31 Pa·m^3/sec

4. Conclusions

The ZrCo used was completely powderized. The hydriding/dehydriding of ZrCoHx was performed using an experimental apparatus. It was found that the powderization of ZrCo was almost complete by four times of the hydriding/dehydriding operation. Hydriding and dehydriding characteristics of tray type ZrCoHx SDS bed with four different stoichiometries for ITER application was performed in this study. Hydriding/dehydriding time was almost same once if ZrCo was powderized. And hydriding/dehydriding rates were enhanced with the increase of stoichiometry.

Acknowledgement

This work is supported by the Ministry of Education, Science and Technology of Republic of Korea under the ITER Project Contract.

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