Activation of ZrCo for Hydriding Reaction

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1. Introduction

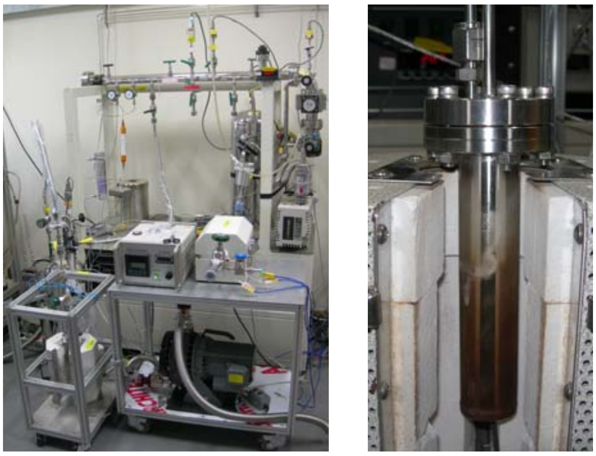
The roles of the ZrCo hydride vessel in the ITER storage and delivery system (SDS) are to store and supply the D-T fuel during the DT plasma operation. The hydride vessel requires the performance of a fast recovery and delivery of D-T. It has been considered that D-T gases stored in the ZrCo hydride vessel should be supplied rapidly to the tokomak through a gas injection system (GIS). And the system measured the amount of hydrogen accurately to supply constant D-T gases. The ZrCo powder, which was loaded in the vessel, has excellent hydriding/dehydriding properties such as non-nuclear material and low reactivity with air. It was powdered small through a repetitive hydriding/dehydriding operation. In view of constant flow rates, the powderization of ZrCo is very important [1]. In this paper, we performed powderization using an experimental apparatus that was fabricated in order to measured the state of ZrCo after hydriding/dehydriding.

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 is storing and measuring hydrogen, a ZrCo reactor which is used for hydriding/dehydriding of hydrogen, a rotary pump and a TMP (turbo molecular pump), and a scroll pump which is delivering hydrogen from the ZrCo bed to the tank. The ZrCo reactor was a cylinder type and has a metal filter which was sintered.

For this paper, 20.01g of ZrCo powder was loaded into the ZrCo reactor. 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 for the powderization of ZrCo. The experiment was carried out using 1.8 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 reactor. And we have measured pressure and temperature for 40 minutes. In the case of the dehydriding process, ZrCo was heated, as shown in Fig. 2. We measured pressure and temperature for 115 minutes and performed dehydriding by opening the valves of the ZrCo reactor in 10 minutes.

The hydriding/dehydriding of ZrCo was repeatedly carried out until the powderization was complete.



(a) Experimental apparatus (b) Reactor
Fig.1 Hydriding and dehydriding apparatus

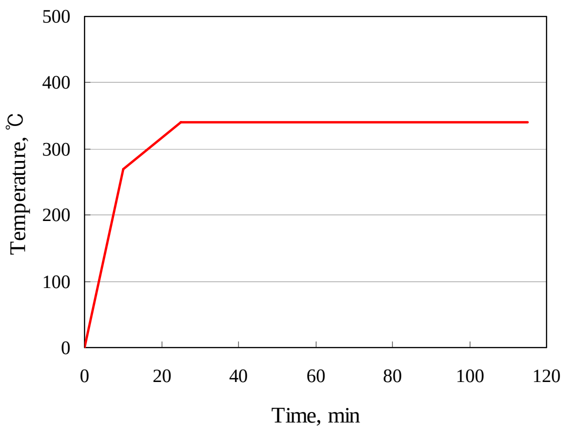


Fig. 2 Temperature of the heater during dehydriding

3. Results and Discussion

The pressure change is shown for each hydriding/dehydriding of ZrCo (Fig. 3). Table 1 and Table 2 show the hydriding and dehydriding rate when the amount of hydrogen was 90% and 99% each in a high vacuum tank. Also, Fig. 4 shows the initial and final state of ZrCo powder. Before the ZrCo powder was powdered, the reaction occurred slowly during hydriding/dehydriding. But the pressure change pattern became almost the same through a repetitive hydriding/dehydriding operation. In the case of a hydriding rate/ dehydriding rate, those were almost similar except for the 1st hydriding/dehydriding of ZrCo. Therefore, it was estimated that the powderization of ZrCo finished early because the ZrCo used initially had a small diameter.

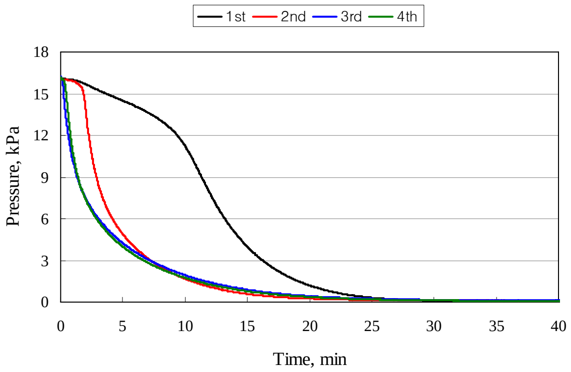


Fig. 3 The pressure change during hydriding

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

Run	90% of hydriding process		99% of hydriding process	
	Absorbed H_2	Hydriding rate	Absorbed H_2	Hydriding rate
1st	2.43 L (2.70 L)	0.23 Pa·m^3/sec (1128 sec)	2.67 L (2.70 L)	0.18 Pa·m^3/sec (1652 sec)
2nd	2.39 L (2.66 L)	0.43 Pa·m^3/sec (614 sec)	2.63 L (2.66 L)	0.20 Pa·m^3/sec (1441 sec)
3rd	2.41 L (2.68 L)	0.40 Pa·m^3/sec (669 sec)	2.65 L (2.68 L)	0.16 Pa·m^3/sec (1788 sec)
4th	2.42 L (2.69 L)	0.42 Pa·m^3/sec (628 sec)	2.66 L (2.69 L)	0.19 Pa·m^3/sec (1539 sec)

Table 2. 90%, 99% of Dehydriding rate

Run	90% of dehydriding process		99% of dehydriding process	
	Absorbed H_2	Dehydriding rate	Absorbed H_2	Dehydriding rate
1st	2.24 L (2.49 L)	0.08 Pa·m^3/sec (3070 sec)	2.46 L (2.49 L)	0.07 Pa·m^3/sec (3729 sec)
2nd	2.36 L (2.62 L)	0.06 Pa·m^3/sec (4413 sec)	2.60 L (2.62 L)	0.04 Pa·m^3/sec (6374 sec)
3rd	2.27 L (2.52 L)	0.06 Pa·m^3/sec (4227 sec)	2.50 L (2.52 L)	0.04 Pa·m^3/sec (6411 sec)
4th	2.22 L (2.46 L)	0.05 Pa·m^3/sec (4540 sec)	2.44 L (2.46 L)	0.04 Pa·m^3/sec (6617 sec)

(a) before (b) after

Fig. 4 The state of ZrCo powder before and after powderization

4. Conclusions

The ZrCo was completely powdered. It had a uniform particle size. The hydriding/dehydriding of ZrCo was performed using an experimental apparatus. It was found that the powderization of ZrCo was almost complete by four times the hydriding/dehydriding operation.

Acknowledgement

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REFERENCES

[1] Hongsuk Chung et al., ITER Tritium SDS Design Verification, KAERI/RR-2879/2007(2008).