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ZrCo Powderization Characteristics in a Tray-Type Metal Hydride Bed

Doyeon Jeong, Hongsuk Chung*, Dongyou Chung, Daeseo Koo
Korea Atomic Energy Research Institute, , 1045 Daedeokdaero, Yuseong, Daejeon 305-353, Korea
**Corresponding author: hschung1@kaeri.kr*

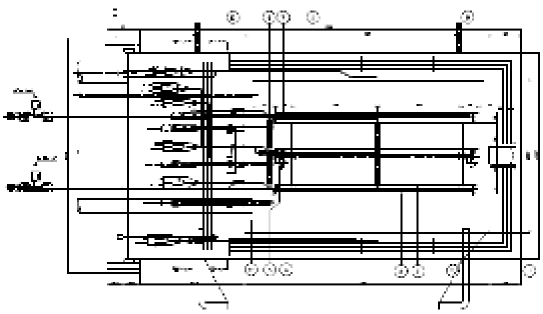
1. Introduction

The major subsystems of the inner deuterium/tritium fuel cycle of a nuclear fusion tritium plant are the Tokamak Exhaust Processing (TEP) system, the Storage and Delivery System (SDS), the Isotope Separation System (ISS), and the Analytical System (ANS). The use of tritium in future nuclear fusion machines calls for a careful design of all tritium exposed parts of the reactor, particularly for the entire fuel cycle to minimize the inventory and to accomplish safe handing of tritium [1-7]. Systematic R&D on the ZrCo-hydrogen system characteristics, i.e., effect of an activation (vacuum annealing) of ZrCo, powderization by a repetition of a hydriding/dehydriding, rates of a hydriding and dehydriding, the effect of endothermic and exothermic reaction heats, heat transfer from a heater to a ZrCo powder packed bed, etc. is essential for the development and operation of the ZrCo hydride beds for a nuclear fusion tritium plant application. In the present study, initial activation procedures of as received ZrCo and the hydriding and dehydriding characteristics of $ZrCoH_{1.0}$ (1^{st}-4^{th} experiment) were experimentally investigated.

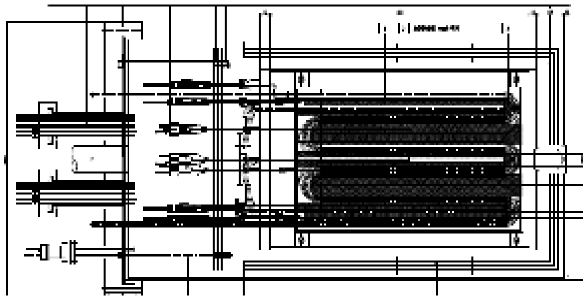
2. Characteristics and Structure of a ZrCo bed

For the development of the SDS bed, a ZrCo bed was designed as shown in Fig. 1. The SDS bed consists of a primary vessel containing ZrCo hydride and a secondary vessel. In the primary vessel, coaxial heater tubes directly heat up the $ZrCoH_x$ to desorb the hydrogen isotopes.

He loop in the primary vessel removes and measures the tritium decay heat. In the secondary vessel, vacuum blocks the heat of the primary vessel. The secondary vessel is kept under a vacuum during a calorimetry operation.



(a) Vertical cross-section view of the primary vessel.



(b) Horizontal cross-section view of the primary vessel.

Fig. 1. Structure of ZrCo bed for tritium storage

3. Experimental Apparatus

The experimental apparatus for the hydriding reaction of the ZrCo reactor is shown in Fig. 2.

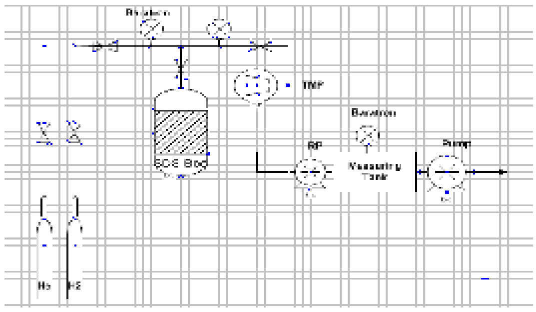


Fig. 2. Experimental apparatus for the ZrCo hydriding and dehydriding reactions

The experimental system was evacuated by using an Oil rotary pump and a vacuum pressure of 2.0 × 10^{-4} Pa was attained by using a turbo molecular pump TMP. The pressure of the system was measured with MKS Baratron gauges. The temperature of the reactor was measured by a K–Type thermocouple. The temperatures and pressure were monitored by using Labview software. ZrCo chunks were placed in the bed.

As received ZrCo chunks were initially annealed at about 500℃ for 8 h under vacuum to remove any surface contaminants such as moisture and oxygen adsorbed on the surface of ZrCo chunks. High purity hydrogen (99.999%) gas was introduced into the experimental system through moisture and oxygen traps.

For a hydriding, ZrCo was reacted with the hydrogen ingressed through SUS filter placed in the tray. For a dehydriding, hydrogen gas released from the ZrCo hydride was transferred to the measuring

tank (260L) by a rotary pump.

4. Conclusion and further work

Recovery and delivery rate of hydrogen from $ZrCoH_{1.0}$ were measured (Fig. 3-4, Table 1). Hydrogen was absorbed into a ZrCo of 1241g at room temperature.

No. of hydriding/dehydriding repetition	Hydriding / Dehydriding (90%, Pam³/s)	Hydriding / Dehydriding (99%, Pam³/s)
1	4.44 / 5.98	3.11 / 4.35
2	28.05 / 8.09	7.10 / 6.64
3	27.80 / 6.07	6.87 / 3.89
4	28.06 / 5.99	7.10 / 3.82

Table 1. Activation enhancement ($ZrCoH_{1.0}$)

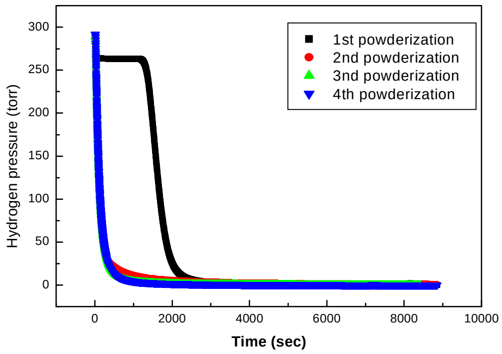


Fig 3. Hydriding behavior of $ZrCoH_{1.0}$

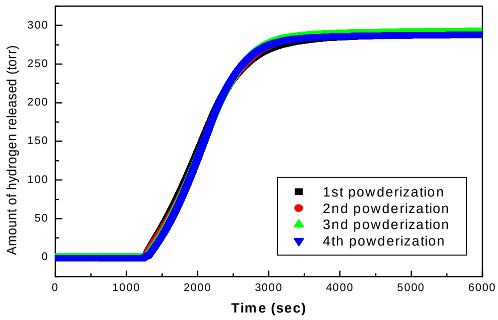


Fig 4. Dehydriding behavior of $ZrCoH_{1.0}$

Based on this basic research, the following is going to be identified for further work. Further test items are the measurement of recovery rate, a delivery rate, and an in-bed tritium accountancy.

Acknowledgements

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