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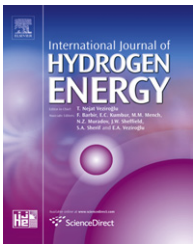

Experimental study and characterization of metal hydride containers

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ABSTRACT

Two metal hydride containers were built at the laboratory respecting a simple and modular design for the purpose of getting useful knowledge about the similarity of elements of metal hydride containers relevant in the prediction of larger size storage unit behaviour. In this paper, we present a description of the containers and an investigation of the parameters influencing the hydrogen storage performance.

1. Introduction

Metal hydrides as hydrogen storage media offer various beneficial features such as high volumetric storage capacity, large number of charge–discharge cycles and safety. Metal hydrides are formed from the exposure of certain metals or alloys to hydrogen at ordinary temperatures and pressures. One of the major drawbacks inherent in metal hydride is the poor heat and mass transfer characteristics, which emphasises the design of the storage device. Early heat and mass transfer studies on metal hydrides were based on the mass and energy balance of hydride beds (Powers and Cummings [1] and Yu et al. [2]). Corresponding research activities on the kinetics of hydrogen sorption were carried out towards the advancement of metal hydrides as storage media. Goudy et al. [3] reported an experimental study on the reaction kinetics of metal hydrides which ascertained the importance of heat transfer in controlling the hydrogen storage time. Later on, Kawamura et al. [4] developed a lumped parameter model for hydride beds. Since then, many models dealing with the theoretical aspects of metal hydrides have appeared in literature. The majority of the work on theoretical issues of metal hydride in the recent past dealt with one dimensional treatment of metal hydride beds. Ram Gopal and Srinivasa Murthy [5] developed a dimensional heat transfer model based on the experiments carried out on a cylindrical metal hydride reactor filled with $MmNi_{4.5}Al_{0.5}$. Their model and experiments confirmed the importance of heat transfer as a rate controlling sorption phenomena. Several two dimensional models [6–11] treated the metal hydride bed as an exothermic porous media. These studies showed that the hydrogen absorption rate is high near the reactor walls and established the importance of bed thickness as the major geometric parameter that influences the hydriding process. Several numerical and experimental studies [12–21] investigated the effect of heat and mass transfer on the metal hydride. They showed the effect of heat transfer on the charge and discharge process of metal-hydrogen reactor. In addition, the effect of different parameters (flow mass and temperature of the cooling fluid, applied pressure, and hydrogen container volume) has been discussed

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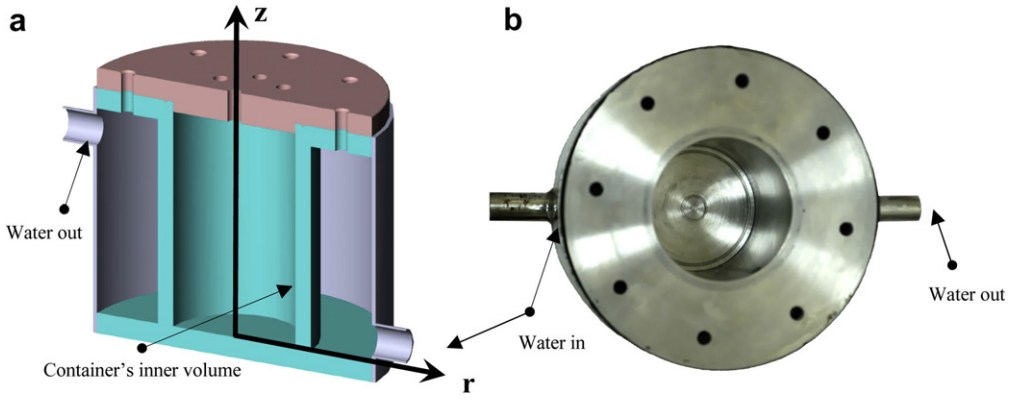

Fig. 1 – Container T_1. (a) 3D model, (b) real geometry.

and the outcome shows that a good choice of these parameters is vital.

However, the importance of physical configuration of the storage device and the associated geometric parameters are not fully represented in the studies reported so far. The region near the walls where the temperatures are lower gets saturated with hydrogen earlier and forms a reaction front that propagates into the inner hotter regions of the reactor. While the mechanism of hydride formation is independent of the geometry of the reactor, the shape of the reaction front and the speed of its movement depend on the reactor configuration.

In the present work we will focus on studying a new configuration of a metal hydride container with concentric heat exchanger equipped with stainless steel fins. It's also our target to decipher the effect of the variation of the operational parameters (flow mass and temperature of the cooling fluid, applied pressure) on the sorption processes.

2. Experimental set-up

Both designed containers, T_1 and T_2, are manufactured with stainless 316-L. The main component parts of the containers are detailed below:

Container T_1:

- Cylindrical body: internal diameter = 80 mm, external diameter = 110 mm, interior height = 110 mm, thickness of the bottom = 15 mm;
- A lid: diameter = 180 mm, thickness = 10 mm.
- The positions of the thermal couples are (r = 10 mm, z = 25 mm; r = 30 mm, z = 10 mm; r = 30 mm, z = 20 mm).

Container T_2:

- Cylindrical body: internal diameter = 60 mm, external diameter = 80 mm, interior height = 120 mm, thickness of the bottom = 10 mm;
- A lid: diameter = 120 mm, thickness = 10 mm.
- The positions of the thermal couples are (r = 27 mm, z = 70 mm; r = 23 mm, z = 40 mm; r = 24 mm, z = 10 mm).

Concerning the T_1 container (Fig. 1), the heat exchange is carried out through the lateral side of the reactor by means of a heat exchanger. This heat exchanger is implemented by mounting a sealed cylindrical shell outside the reactor and coaxially to it. The heating/cooling fluid flows in the zone between the outer and the inner diameter of, respectively, the

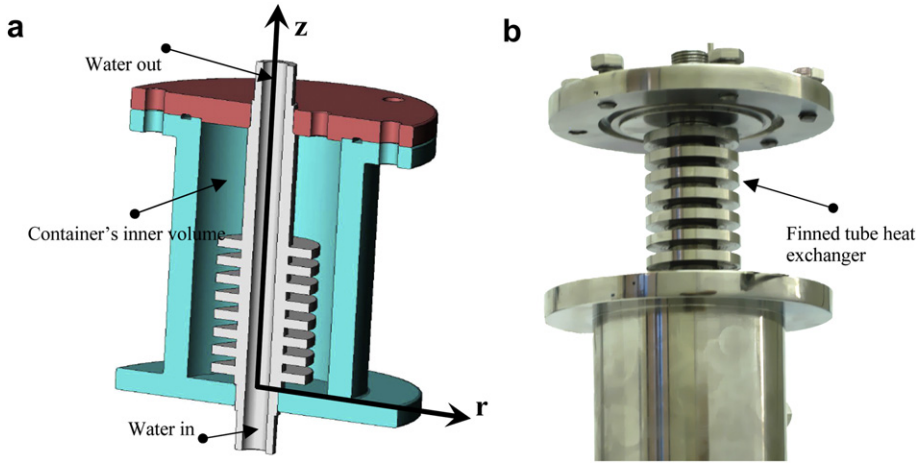

Fig. 2 – Container T_2. (a) 3D model, (b) real geometry.