Low equilibrium pressure metal hydride for hydrogen storage in a renewable energy system.

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INTRODUCTION

One of the most promising technologies for storing energy is the production of hydrogen through water electrolysis powered with renewable energy sources and its storage. There are different ways to stored hydrogen but the most efficient and safe is as solid metal hydride since it has no compression and liquefaction costs [1]. The hydrogen storage system filled with a low equilibrium pressure hydride-forming alloy can be charged quickly by using a hydrogen generator. This hydrogen can be used later to power a H_2/Air PEM fuel cell for obtaining electricity efficiently [2]. In this work, the behavior of an integrated system consisting in a PEM hydrogen generator and a low pressure hydrogen storage system is studied.

EXPERIMENTAL

The hydrogen generator is a PEM water electrolyzer with a very low internal resistance, which delivers hydrogen of high purity >99.9999% at a maximum flow of 1 L min^{-1} and a maximum pressure of 0.8 MPa (cutoff pressure).

The hydrogen storage device consists of a cylinder of stainless steel 304L 50 mm outer diameter, 2 mm thick and 200 mm long. It has internal and external aluminum extended surfaces to promote heat transfer and consequently to increase the hydrogen absorption. It contains 500 g of AB_5 hydride-forming alloy ($LaNi_5$). The physicochemical properties of the hydride-forming alloy were obtained through pressure-composition isotherms in a Sievert type equipment. For the experiments, the hydrogen generator was connected to the metal hydride container by a hydrogen-calibrated digital mass flow controller (Sierra Smart-Trak 2 Series 100). The hydrogen pressure was measured by using an Omega PX603 pressure transducer .

The characterization of the storage device during hydrogen charging consisted in monitoring its internal dynamic pressure [3] and the temperatures of the external wall and at the center inside the container for different hydrogen flow rates. The container was considered fully charged when the amount of absorbed hydrogen is about 70 sL, which is the nominal capacity.

RESULTS AND DISCUSSION

The optimal working conditions to achieve full charge of the storage device at the maximum hydrogen flow rate supplied by the water electrolyzer were determined.

The charge efficiency of the hydride container is a function of hydrogen flow rate. For hydrogen flow rate in the 0.2-1.5 L min^{-1} range, hydrogen charging attains the 100% of the total capacity of the container (70 sL), while at flow rates higher than 1.5 L min^{-1} an appreciable decrease is observed. This behavior can be attributed to the fact that at high hydrogen charge rates, the exothermic effect of the hydriding reaction begins to prevail and consequently the metal hydride temperature in the container and the dynamic equilibrium pressure increase. Thus, a less amount of hydrogen is absorbed because the hydride dynamic plateau reaches the cutoff pressure before all the hydrogen is absorbed.

CONCLUSIONS

A hydrogen storage device was built, showing a good performance to absorbe hydrogen provided from a low pressure hydrogen generator which can delivers hydrogen at 1 L min^{-1} and pressure of 0.8 MPa. Under these conditions, it is possible to refill the storage device to its maximum capacity in 70 min, without using additional compression. This satisfactory behavior is achieved using a low equilibrium pressure hydride-forming alloy and an internal and external finned metal hydride container configuration.

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