ARTICLE IN PRESS

INTERNATIONAL JOURNAL OF HYDROGEN ENERGY XXX (2013) 1–10

Available online at www.sciencedirect.com

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journal homepage: www.elsevier.com/locate/he

A dynamic two phase flow model for a pilot scale sodium borohydride hydrogen generation reactor

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ARTICLE INFO

Article history:
Received 19 September 2013
Received in revised form
11 November 2013
Accepted 16 November 2013
Available online xxx

Keywords:
Sodium borohydride
Numerical simulation
Modelling
Hydrogen storage
Two phase flow

ABSTRACT

A two-dimensional, non-isothermal and dynamic model was developed to describe a sodium borohydride/hydrogen reactor for stationary use. All relevant transport phenomena were treated in detail and the kinetic model developed previously by the authors was introduced into the algorithm. In this paper the reactive solution was modelled as a two phase flow; with this approach the impact of the hydrogen production on the solution stirring could be observed and quantified.

Results showed that not all ruthenium deposited on the nickel foam was used efficiently as catalyst. In fact, most of the reaction occurred in the surface of the catalyst foam and around 70% of the deposited catalyst was not used. The influence of the catalyst foam position in the solution and the design of the perforated plastic support were analysed in order to find the optimum experimental conditions. It was also demonstrated the importance of the two phase flow approach for a correct simulation of the solution stirring and heat transfer.

1. Introduction

There is no doubt that hydrogen will be a major clean energy carrier in the near future. However, the establishment of a sustainable hydrogen-based economy has been delayed due to several unsolved problems in the supply chain. In particular, storage of appropriate hydrogen amounts has been proven to be a challenge for the scientific community. In addition to the traditional and well established methods to store gases (high pressure gas tanks and liquefied gas tanks) several other storage methods and materials have been studied extensively over the last years in order to meet the requirements of specific applications where the traditional methods cannot be applied. Within such storage methods and materials are encountered metal hydrides [1], on-board reforming of hydrocarbon into hydrogen [2], metal organic frameworks [3,4], organic hydrides [5] and chemical storage [6,7]. Chemical storage, particularly using liquid-phase hydrogen materials, is one of the safe alternatives to hydrogen storage. These materials have relatively high hydrogen content and more important have the potential to be used as hydrogen sources suitable for portable fuel cells. Among them boron based compounds, such as sodium borohydride [8–11], ammonia borane [12], and hydrazine borane [13], have been largely investigated over the past years. These materials have common advantages, they all have high hydrogen storage capacity, they are soluble in water, stable in air, and they can release hydrogen under mild operational conditions through hydrolysis. These features make them an attractive storage material to be conjugated with portable fuel cell systems. However, several problems still need to be

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0360-3199/$ – see front matter
http://dx.doi.org/10.1016/j.ijhydene.2013.11.078