Novel High-Pressure Metal Hydride Container for Hydrogen Compression

Moegamat Wafeeq Davids[1], Mykhaylo Lototskyy [1] and Siva Pasupathi [1],V. Linkov[1]

[1] HySA Systems, University of the Western Cape (UWC), South Africa

Ti based AB_2 - type metal hydrides are promising materials for hydrogen compression due to the high reversible capacity, and easily adjustable plateau pressure by metallic substitution and excellent cycle life. It has been shown that Ti–V–Mn based alloys, with C14 Laves and BCC phases, possess promising hydrogen absorption capacities with fast absorption/desorption kinetics at ambient temperatures. In particular, a $Ti_{0.5}V_{0.5}Mn{\sim}2$ alloy has shown good potential as a metal hydride to be used as part of a hydrogen compression system, with a reversible capacity of 1.9 wt.% at 260 K under H_2 pressure up to 350 bar and a plateau pressure which can be influenced by V substitutions [1].

In the current study a multicomponent C14 Ti – based AB_2 intermetallic (proprietary recipe of HySA systems) was used in a high pressure metal hydride container. Figure 1(a) presents the isotherms of hydrogen absorption at T=20˚C and hydrogen desorption at T=150˚C. The isotherms were calculated on the basis of fitting the experimental PCT data for this alloy taken in the range T= –20…+20˚C, P=0.1…200 bar, using the model of phase equilibria in hydrogen–metal systems which allows for the realistic extrapolation of the results outside pressure–temperature ranges where the experimental data were collected [2]. As it can be seen, this alloy allows for hydrogen compression from PL=100 bar (TL=20˚C) to PH=500 bar (TH=150˚C) with cycle productivity ΔC=115 NL/kg.

Figure 1(b) illustrates hydrogen discharge performance (backpressure regulator setpoint of 500 bar) of a prototype composite metal hydride container for high-pressure hydrogen compression developed by HySA Systems and its industrial partner [3]. The container filled with 0.86 kg of the C14-AB2 intermetallic mentioned above and charged with hydrogen at P(H2)=100 bar and T=10–15˚C was heated to T=150˚C with steam supplied to the inner heat exchanger of the container. It is seen that the increase of pressure (P) in the container begins after 2 minutes from starting steam supply, and after 6.5 minutes it reaches backpressure setpoint accompanied by the start of hydrogen release at P=500 bar. The hydrogen flow rate measured at the exit of the backpressure regulator quickly increases to ~20 NL/min followed by the gradual decrease to zero during ~25 minutes from start of the heating. During the operation in high-pressure H2 discharge mode, the temperature of container wall (carbon fibre wrapping), T(wall), does not exceed 100˚C while the steam temperature at the input (T(in)) and output (T(out)) of the container's heat exchanger is close to 150˚C. The amount of hydrogen desorbed at P=500 bar was of 86 NL, or 75% of the theoretical/equilibrium cycle productivity (see Figure 1(a))

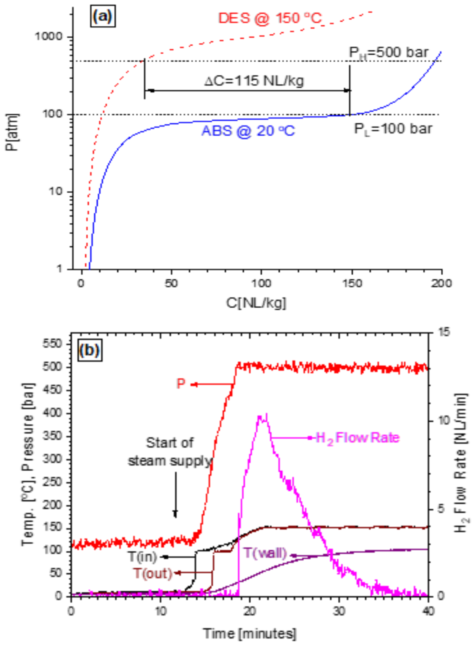

Figure: 1 (a) isotherms of hydrogen absorption at T=20˚C and hydrogen desorption at T=150˚C for C14-AB2 intermetallic (A=Ti+Zr, B= Cr+Fe+Mn+Ni), (b) hydrogen discharge performance of a prototype composite metal hydride container for high-pressure hydrogen compression.

Acknowledgemnts

The authors would like to acknowledge the Department of Science and Innovation (DSI) of South Africa within "Hydrogen South Africa" (HySA) Research, Development and Innovation Program. The authors also acknowledge financial support from South African National Research Foundation (NRF), grant numbers 116278 (MWD) and 132454 (MVL).

References

[1] M. Shibuya, et al., J. Alloys Comp. 475 (2009) 543

[2] M.V. Lototskyy, Int J Hydrogen Energy. 41 (2016)

[3] M. Lototskyy, V. Linkov, Int J Energy Res. 46 (2022)

m

Dr MW Davids completed his PhD in 2012 at the University of the Western Cape, working on hydrogen storage materials focusing primarily on the surface chemistry of these materials. Upon completion of his PhD, he pursued a post-doctoral research fellowship (2013-2017) at HySA systems, working on synthesizing metal hydride alloys and developing metal hydride compressors. Presently, his employed as a Key Technology Specialist on hydrogen technology-related applications at HySA Systems Competence Centre hosted by UWC.

Presentating author: Moegamat Wafeeq Davids, e-mail: mwdavids@uwc.ac.za tel: = +27 21 959 9319