Application 2073

Investigation of mechanical properties and hydride breathing of TiMn2 (type AB2) compounds for metal hydride compressor applications

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During the last two decades, the field of metal hydrides has seen an incredible increase of activity due to the multiple applications that can be derived from them. Starting from the first application based on MH, the MH battery which still represents a 4% of the world market of secondary batteries, many other applications have been developed as, H2 purifications, heat pump engines, H2 compressors, stationary H2 storage systems, and so on. From all this applications, one that has to play a very important role in a future H2 economy is H2 compressors. The advantage of this system compared to mechanical compressors is the absence of mechanical parts and noise, and the safer and cleaner operation provided by these MH systems [1]. This method allows for efficient and reliable transformation of thermal or electrical energy into chemical energy of compressed H2 and it would be a fundamental part of photoelectrochemical H2 production systems where the H2 is produced at 1 bar pressure. Several parameters should be optimized for an efficient performance of the compressor, both for the material, the type of MH systems, their plateau pressure slope, hysteresis of the PCT curves, kinetics, and for the compressor itself, good coupling of the plateau pressure, number of MH systems, their synchronization, working temperatures, etc. The huge number of possibilities when combining all these factors makes the optimization of such a system a very complex task, unable to be solved by the trial and error method. Simulation of the MH compressor performance seems to be mandatory.

In this research we propose to investigate the mechanical properties and hydride breathing of AB2 TiMn2 type compounds. Two TiMn2 type samples with very different equilibrium pressure will be prepared at UAM by arc melting technique. Characterization of the products will be performed at UAM by x-ray diffraction and scanning electron microscopy techniques. The mechanical properties will be studied with the COMEDHY system developed by the host institution to obtain metal hydride parameters such as hydride breathing behavior, hydride density or sample porosity as a function of hydride pressure and temperature [2]. Several experiments will be conducted on the COMEDHY test bench, under different conditions of temperature and compactness for the hydride bed. These experiments may be long because the studied phenomenon is quite dependent on cycle life. Other characterization on relevant parameters will accompanied these measures, such as granulometry and compressibility of the hydride powder. Furthermore, the experimental results will be used as part of the input in a realistic simulation of a metal hydride compressor based on AB2 hydrides which

is currently developed by the applicant. The applicant will also benefit from the skills of the host institution in thermo-mechanical integration of hydrides in tanks in order to complete the simulation [3].

The research at the host institution would be part of the doctoral thesis of the applicant and will provide him with a scientific knowledge on mechanical properties of hydrides obtained from a group with a very high expertise in the topic.

References

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[2] Benoit Charlas, Olivier Gillia, Pierre Doremus, Didier Imbault, "Experimental investigation of the swelling/shrinkage of a hydride bed in a cell during hydrogen absorption/desorption cycles", International Journal of Hydrogen Energy, Volume 37, Issue 21, November 2012, Pages 16031–16041

[3] M. Botzung, S. Chaudourne, O. Gillia, C. Perret, M. Latroche, A. Percheron-Guegan, P. Marty, "Simulation and experimental validation of a hydrogen storage tank with metal hydrides", International Journal of Hydrogen Energy, Vol. 33(1), pp. 98-104, 2008