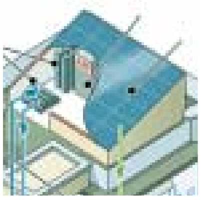

Hydrogen Storage in Hydrides for Safe Energy Systems

HYSTORY

Objectives

Hydrogen storage is a key enabling technology for the introduction of the 'Hydrogen Economy' and the extensive use of hydrogen as an energy carrier. High pressure compressed gas storage is energy intensive and liquid H_2 storage even more so. Storing H_2 in solid metal hydrides (MH) from which it can be readily recovered by heating is an alternative and safe, highly volume efficient storage method. Conventional MH however suffers from low weight efficiencies and the challenge is to improve them to conform to specifications set by the practical applications. In response to these challenges, HYSTORY aspires to advance the state-of-the-art in three MH classes and develop hydrides based on lightweight, low cost elements with improved H_2 storage properties. The final aim is to provide a storage technology that is attractive both economically and environmentally. The new H_2 storage systems will be integrated and tested in stationary (power generation) fuel cell applications and assessed for potential use in marine applications.

Challenges/Problems addressed

Hydrogen can be stored as a compressed gas (up to about 700 bar), as a liquid (20 °K) and in solid state compounds. The first two methods are established technologies with several limitations the most important of which is their energy intensive character. Liquefaction, for example, consumes nearly 30% of the total energy contained in the hydrogen and in addition requires expensive equipment and energy to retain hydrogen in the liquid state. Solidification requires even more energy, and compression of H_2 up to say 35 MPa requires nearly 20% of its total energy content. Solid state materials are attractive due to improved safety, a high energy density (in particular volumetric density) and a better energy efficiency (no compression or liquefaction). During the last few years a number of carbon structures have attracted attention as possible hydrogen storage media. However, most of the claimed H_2 storage capacities are unrealistically high and could not be reproduced by other investigators, and at present carbon-based materials for hydrogen storage seem quite far from market applications. MH have for several decades been the most promising materials for H_2 storage. In fact, following the "oil-crisis" of the seventies, a new rechargeable battery technology emerged as a result of research on solid state hydrogen storage in metal alloys, the metal hydride battery (NiMH). The annual battery production has now exceeded 1 billion cells corresponding to 6000 tons of H_2 storage alloy. Thus, there exist large-scale industrial production methods and handling procedures for MH. Adopting a clever industrial policy, the Japanese Ministry of International Trade and Industry has managed to ensure that more than 80% of this production takes place in Japanese industry. Further MH applications have so far been limited by relatively low gravimetric density, poor kinetics for absorption/desorption, expensive materials and/or complicated procedures for activation. Recent research has shown though that these limitations can be overcome.

Project structure

The HYSTORY partnership includes all key players namely industrial end-users (Statkraft, ABB, Kockums), material manufacturers (Treibacher, SCMM-Aumas) and research institutes (IFE, Stockholm University, CNRS, NCSRD). The workplan is structured as follows:

On the storage materials side, the project focuses on 3 classes of MH with a view to improving and optimising their H_2 storage properties for effective use in stationary energy systems.

The first MH class (A) involves the Zr-based, Ti-V-Ni containing, multiphase compounds. While present practical applications of these alloys attain 1.8 wt.% of H_2 storage capacity, HYSTORY goal is to develop and test alloys reaching 2.5% to 3% and capable of operating at low temperatures (<60°C). The aim in the first phase of the project is to design and construct a prototype tank on a laboratory scale (1-5 kg of alloy) while in the second phase a full scale tank (200 kg of alloy) will be developed and tested.

The second MH class (B) considered is the activated magnesium hydrides. The aim is to improve capacity (through careful selection of activators), working temperature (target is to lower the current 260-280°C by about 60°C depending

Figure 1: Hydrogen-powered "clever" building operated by ABB in Stockholm.

on the type of the connected high temperature fuel cell) and production process for the activated powders (aiming at cost reductions by moving from "pure" to "metallurgical" Mg alloys). The design and development of a laboratory scale tank is foreseen (1-5 kg of alloy) with the objective of obtaining an operational system with a capacity of 5 to 6 wt.%.

The third MH class (C) relates to the complex MH – alanates. These are complex metal hydrides which are mixed ionic-covalent compounds. They can serve as reversible hydrogen storage media, in particular when catalysed by transition metals such as Titanium. Current laboratory scale capacities of these hydrides reach 5%, but the present poor H_2 release kinetics need improvement. The aim is to decrease material stability and enhance kinetics down to temperatures of the order of 100°C targeting again the recent generation of high temperature fuel cells. The design and construction of a small scale tank will be realised for the first time for this MH class (1-5 kg of material).

On the applications side, the project is designed such that a pilot system based on at least class A MH will be effectively tested for stationary applications and assessed in sufficient detail for marine applications. Classes B and C should at least be tested and evaluated at the laboratory scale for the requirements of high temperature fuel cells in similar type of applications. Two end-users are large power generation companies that will integrate, test and evaluate the qualified hydrides and tanks as a viable storage option towards premium power generation (back-up power, quality power) in a pilot plant using a fuel cell (~10-50 kWe). A third end-user (large manufacturer of marine vessels) will assess the performance of the qualified hydrides and tanks in marine applications.

Expected impact and exploitation

The project has started recently (end 2002) and is currently ongoing. Of high importance for the exploitation of the new storage systems is the cost of the storage that today is rather high for MH to be a competitor to compressed H_2. However, customers would appreciate the **lower volume** demand of hydrides and **higher safety** compared to conventional storage alternatives. The **weight** of the storage unit is also of importance, but in stationary applications to a much lesser extent than in mobile applications. The aim of the end-users is to use the new storage media to demonstrate generation of premium power (back-up power, quality power) by use of fuel cells. There is a great market potential for this technology where typical users are banks, IT centres, hospitals etc. The developed technology will also be applied in pilot plants for production and distribution of hydrogen as well as in buffers for renewable energies. An important exploitation aspect is the potential use of the MH-based storage systems in the "***Clever Building***" operated by ABB (see Figure 1). Finally, the results of the project will be exploited in the marine market in particular with respect to auxiliary power units for merchant ships.

INFORMATION

References: ENK6-CT-2002-00600

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Hydrogen Storage in Hydrides for Safe Energy Systems (HYSTORY)

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Partners:
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- Stockholm University (S)
- Centre National de la Recherche Scientifique (F)
- National Centre for Scientific Research Demokritos (GR)
- Treibacher Auermet Produktions (A)
- SCMM René Aumas (F)
- Statkraft (S)
- ABB Group Services Center (S)
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