Summary FuncHy 2006

1st Int. Workshop on Functional Materials for Mobile Hydrogen Storage

September 20 – 22, 2006, GKSS Research Centre, Geesthacht

1. Desorption Temperature ⇒ Operating Temperature of hydride Materials

GM: PEM-FC requires operating temperatures of 80°C, preferably below

MPI KF: new temperature-stable membranes could allow for operating temperatures up to 150°C

BMW: Internal Combustion Engine (ICE): higher temperatures up to 200°C possible, also longer refuelling times > 3 min tolerable.

Conclusion: Only for ICE or future PEM-FC operating temperatures above 100°C are possible, otherwise efficiency will decrease

2. Reaction Enthalpy and Pressure ⇒ Refuelling Temperature, Desorption Temperature

GM: Target ΔH -20 kJ/mol H2

GKSS for max. operating pressure, also higher pressures ≈ 100 bar are tolerable therefore $\Delta H \leq -30$ kJ/mol H_2 might be allowable for solid state storage (SSS)

VW desorption pressure should be higher than 1 bar
hydrogen flow out of tank system should be at least 2 g/sec H_2
hydrogen flow must be supplied also at low tank filling level

Conclusion: The ideal storage material should have a total reaction enthalpy between -20 and -30 kJ/mol H_2, the operating pressure during filling is allowed to be 100 bars or above, the tank system reliably has to deliver 2 g of H_2 per second at all filling levels.

3. Refuelling Time

Industry: $t \leq 3$ min, max. $t \sim 5 – 10$ min

4. Fuel Requirements

are given by requirements of fuel cells.

Today 99.999 pure H_2 required.

5. Cyclability

DC > 500 refuelling cycles with minimum loss of capacity

6. Costs

GM: 2000 € for complete tank system allowable

7. Safety aspects

CGS and LHS safe enough for commercial use, in contrast to fossil fuels no explosion to be anticipated, but rather quiet hydrogen burning

8. Competitors

Compressed gas storage (CGS): CGS in 700 bar tank (made of fibre reinforced plastics) state of the art.

GM: target of the development should be, to be better than CGS concerning capacity, weight and costs, not the DOE 2007, 2010 or 2015 targets

TUHH Also recycling aspects have to be taken into account ⇒ problem for CGS in FRP tank.
Development potential for CGS and also liquid hydrogen storage (LHS) seems to be limited

GM Development of new materials for CGS will extend the limits

DC System capacity of 5 – 6 wt.% requires materials capacity of 8 – 9 wt.%.
CGS now at about 6 wt.%

GM Further competitors Hybrid and Full Electric Vehicles, also vehicles driven by synthetic fuels

GKSS Are Lithium-Ion-Batteries a serious alternative?

FZK Mitsubishi is building prototype cars based on commercial available vehicles with Li-Ion-Battery (e.g. http://www.mitsubishi-motors.de/unternehmen/presse/news?newsId=96D08501-0908492A-C0A80143-6B089916) with an operating range of 250 km (2005)
What about costs and available reserves of Lithium?

FZK up to now available Li-Ion-Batteries not suitable for cars due to safety problems. This might change due to new membrane developments (⇒ DEGUSSA).

GM but battery costs up to now much to high (K. Taube: status 2003 about 2 – 4 times of target value of US Advanced Battery Consortium of 500 $/system)

Conclusion: to be competitive, a solid state storage tank system has to be a higher capacity (⇒ material capacity > 8 – 9 wt.% H_2), a lower total weight (⇒ heating/cooling system, safety aspects) and costs (max. system cost of 2000 € allowable) than advanced compressed gas tanks. The DOE targets are less important for the industry.

9. Further investigation tasks

TUHH Data for heat capacity, heat conductivity and heat transfer coefficients needed for simulation of tank system, measurements possible at Helmut-Schmidt-University (Prof. Kabelac)

System integration of hydrogen storage material of high importance
provision of cooling during refuelling (⇒ reaction enthalpy, refuelling time)
provision of heating during hydrogen desorption (⇒ operating temperature)
packing density of hydride powder
operating pressure
hydrogen flow in and out of tank (⇒ refuelling time, provision of minimum hydrogen flow)
safety aspects
and more

Role of „catalysts“ to be investigated in greater detail
what is their role in hydrogen dissociation and diffusion?
are these the rate limiting steps?
what is their role in diffusion of metallic species in the bulk?
do they act as catalysts or as diffusion promoters?

What is the reason for the poor reversibility of some systems?

Why does the concept of reactive hydrides also work in two step reaction mechanisms?

How can the target of a one step mechanism be reached?

No need for investigation of other light metal hydride systems.

Investigation of physically adsorbing materials not topic of the project.