# Metal hydride hydrogen storage tank for fuel cell utility vehicles

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The use of fuel cells (FC) in heavy duty utility vehicles, including material handling units / forklifts or underground mining vehicles, has a number of advantages over similar battery-driven vehicles including: constant power during the entire shift, and shorter refuelling time as compared to the time to recharge the battery. Most of vehicular FC power systems demonstrated so far have utilised compressed $H_2$ stored in gas cylinders at pressures up to 350 bar. This solution, however, results in too light weight of the FC power modules for the utility vehicles which require additional ballast for a proper counterbalancing to provide vehicle stability. In the undeground applications, the use of pressurised hydrogen (≥20 bar) is not acceptable at all for the safety reasons. A promising alternative is the application of metal hydrides (MH) for the on-board hydrogen storage [1].

The "low-temperature" intermetallic hydrides with hydrogen storage capacities below 2 wt% can provide compact $H_2$ storage simultaneously serving as a ballast. Thus, their low weight capacity, which is usually considered as a major disadvantage to their use in vehicular $H_2$ storage applications, is an advantage for the heavy duty utility vehicles [2].

Here, we present new engineering solutions [3,4] of a MH hydrogen storage tank for FC utility vehicles which combines compactness, adjustable high weight, as well as good dynamics of hydrogen charge / discharge.

The tank is an assembly of several MH cassettes. Each cassette comprises several MH containers made of stainless steel tube with embedded (pressed-in) perforated copper fins and filled with a powder of a composite MH material which contains $AB_2$- and $AB_5$-type hydride forming alloys and expanded natural graphite. $H_2$ input / output pipelines are ended by gas filters inside the MH containers and connected to a common gas manifold from the opposite side. The assembly of the MH containers staggered together with heating / cooling tubes is encased in molten lead followed by the solidification of the latter.

During lead encasing, the inner space of the MH containers is evacuated providing initial activation of the MH material. After cooling down, the MH cassette is filled with pressurised $H_2$ for the initial $H_2$ charge which starts immediately and completes in about 1.5 hours.

One MH cassette comprising of five ∅51.3x800 mm MH containers (each filled with ~3 kg of the MH material) has hydrogen storage capacity about 2.5 $Nm^3$ $H_2$. When heated with a running water to T=40–50 °C (typical coolant temperature during the operation of a PEMFC stack), the cassette can release more than 60% of this maximum amount at the $H_2$ flow rate of 25 NL/min that corresponds to 1 hour long full load operation of 2.5 kWe stack at 50% efficiency. Furthermore, at the heating temperature about 40 °C and $H_2$ output flow rate of 15 NL/min (equivalent to the stack power of 1.38 kWe at the same efficiency) the $H_2$ release remains stable during >2 hours providing utilisation of ~80% of the stored $H_2$.

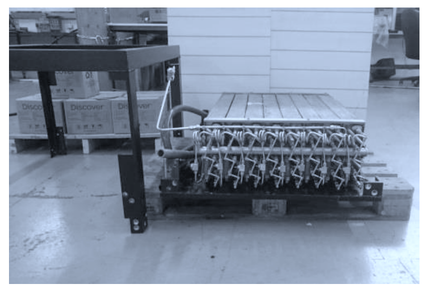

Figure 1. MH tank installed in the frame of FC power module for 3 ton electric forklift.

Figure 1 shows MH tank which comprises of eight MH cassettes described above and is intended for the storage and supply of $H_2$ in a PEMFC power module for forklifts being developed by HySA Systems. The tank can provide >2 hour long $H_2$ supply to the fuel cell stack operated at 11 kWe ($H_2$ flow rate of 120 NL/min). The refuelling time of the MH tank (T=15–20 °C, P($H_2$)=150–180 bar) is about 15–20 minutes.

**Acknowledgements**

This work is funded by Impala Platinum Ltd. (South Africa) and South African Department of Science and Technology within HySA program (projects KP3-S02 and KP8-S05). The international collaboration is supported by the EC, Grant Agreement number: 778307 – HYDRIDE4MOBILITY – H2020-MSCA-RISE-2017

**References**

[1] M.V. Lototskyy, et al,. Progr. Natur. Sci., 27 (2017) 3-20
[2] M.V. Lototskyy, et al,. J. Power Sources, 316 (2016) 239-250
[3] M.V.Lototskyy, et. al, Patent application WO 2015/189758 A1
[4] M.V.Lototskyy, et. al, Patent application UK 1806840.3 (2018)

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