HySA Systems
Hydrogen South Africa

IMPLATS
Distinctly Platinum

Department of
Science & Innovation

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Field trial of Hydrogen and Fuel Cell Forklift and Hydrogen Refueling Station at the Base Metal Refinery at Impala Platinum

Forklifts: Alternatives and challenges

Diesel	Electric	Fuel cell (FC)
Environment pollution	Time losses for the recharge / replacement of batteries	Compact and safe storage of the hydrogen fuel
Health hazard when working in confined space		
Noise		Hydrogen refuelling

Project Highlights

- The objective of this project co-funded by the DSI and Impala Platinum Ltd, South Africa, is to integrate metal hydride (MH) technologies for on-board hydrogen storage and refuelling into heavy-duty utility vehicles (test case – forklift) providing their efficient system solutions, through development of MH-based system components.
- The specific activities in the realising this objective included:
  - Integration of MH H storage and supply system in fuel cell powered forklift;
  - Development of the prototype forklift refuelling system with 50-200 bar 10 Nm^3/h MH compressor;
  - Start-up and field tests of the hardware at the site of industrial customer (Impala Platinum Refineries);
  - Development of a prototype fuel cell power module for the utility vehicles with built-in MH H storage and supply system

MH for FC forklifts: Motivation

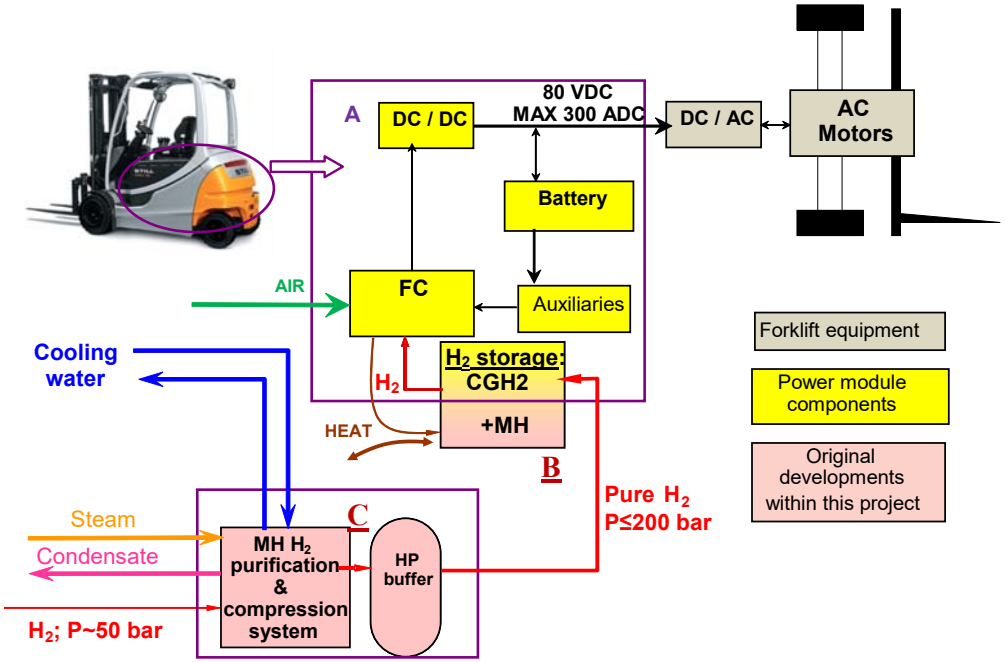
CGH2

MH

- ✓ Matured technology, systems available on the market (Plug Power, H2Logics, Proton Motor, PearlHydrogen);
- ✓ Fast refuelling;
- ➢ Safety and refuelling infrastructure (filling H_2 pressure ~350 bar);
- ➢ Space constrains;
- ➢ Additional counterbalance required (forklift operation safety).

- ✓ Compact + heavy: intrinsic solution of the counterbalance problem;
- ✓ Safety (lower standby H_2 pressure);
- ✓ Simpler refuelling infrastructure (filling H_2 pressure <200 bar);
- ✓ Limitations of charge / discharge rates (heat transfer issues);
- ✓ Availability & cost implications (no mass production).

System Concept



- STILL RX-60-30 electric forklift, 3 ton lifting capacity, 80 VDC bus voltage.
- Commercial on-board fuel cell power module (**A**; GenDrive 1000 160X-80CEA / Plug Power) replacing the forklift battery and equipped with:
  - built-in CGH2 hydrogen storage system and
  - MH hydrogen storage extension tank (**B**).
- Stationary hydrogen refuelling system (**C**) consisting of a low-pressure H_2 supply and a MH hydrogen compressor.

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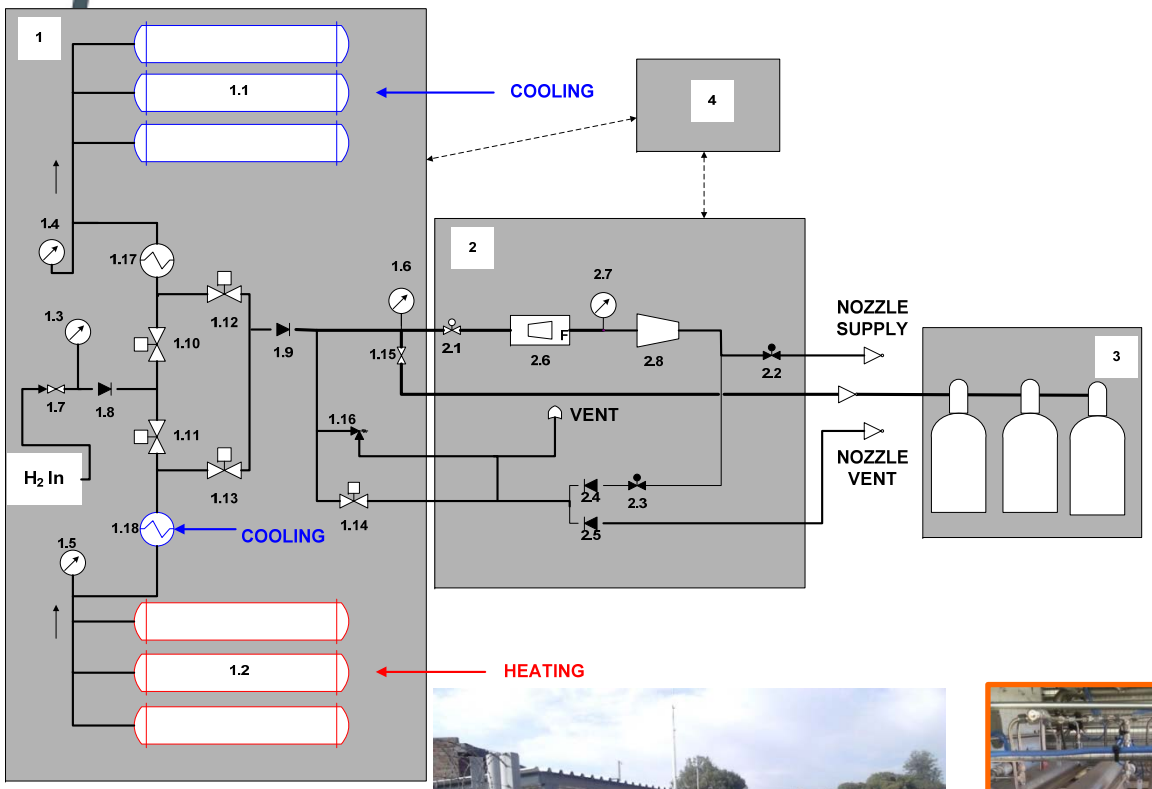
MH assisted refuelling system



1 – MH compressor
2 – H_2 dispenser
3 – buffer
4 – control system

- H_2 dispensing at P=0…185 bar. (controlled ramping);
- Maintaining high H_2 pressure (200 bar) for the dispensing system by the integrated thermally driven MH H_2 compressor;
- Use services available at the customer's site:
  - Pipeline H_2 (50-60 bar);
  - Low-grade steam (~140 °C);
  - Cooling water (15-20 °C);
  - Compressed air (5.5-7.5 bar);
  - Electric power (< 1 kW).
- Certified for the operation in the industrial environment.

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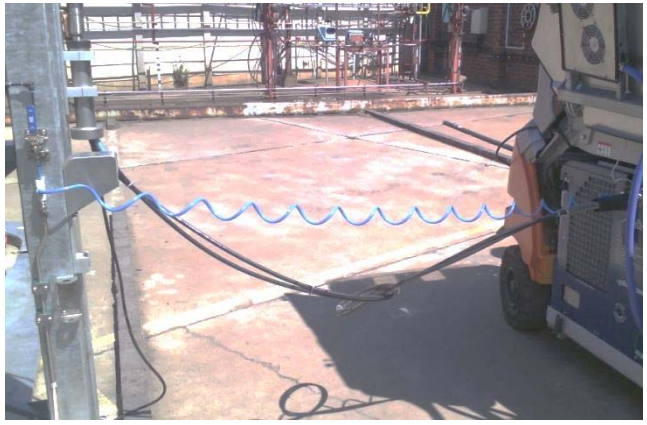
HySA Systems fuel cell forklift and refuelling station operating at Impala Platinum refineries



- Commissioned in October 2015, officially launched in March 2016
- **100% SA content:**
  - Forklift – MH extension tank
  - H_2 refuelling station with integrated MH compressor

- ~4500 operating hours (MH compressor)
- Compressed ~ 1500 Nm^3 H_2
- Dispensed ~ 1000 Nm^3 H_2
- Incurred costs breakdown:
  - o MH compressor parts – 25%;
  - o Assembling – 28%;
  - o Dispenser – 33%;
  - o Other costs – 14%.

- FC operation – 800 hours @ 12-15 kWe
- Incurred costs breakdown:
  - o Development & CAPEX – 70%;
  - o Maintenance – 20%;
  - o Operation & training – 10%.
- **Assuming life of 10 years with CAPEX & maintenance amortised over this period, 11% savings on the forklift due to the fuel cost were estimated by Impala Platinum.**

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Operation of the forklift in the industrial environment

Lessons learnt

Service of forklift power module

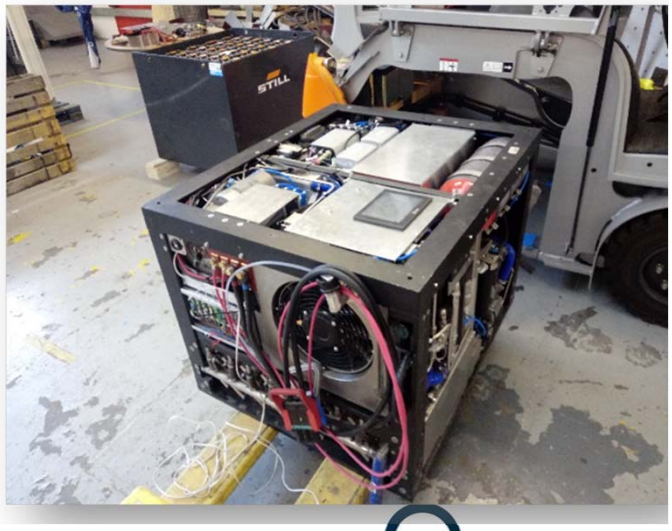
- **Forklift fuel cell power module:**
  - Main issues are related to BoP components (mainly Li-ion battery);
  - No major issues with MH H storage extension tank;
  - Full integration of the MH tank in the BoP of FC stack is necessary.

After service of H_2 refuelling station

- **H_2 refuelling station:**
  - Typical issues, mainly resulting in the drop of the MH compressor productivity and resolved during service works, included:
    - Contamination of pipelines with fine powder of the MH material;
    - Malfunctions of the control system;
    - Slow decrease of the productivity possibly caused by the accumulation of gas impurities in the system.

Locally developed forklift power module with integrated MH tank

- Advanced engineering solution: compactness and high weight necessary for the forklift counterbalancing
- IP: 1 patent granted, 1 pending
- Mostly South African content
- The system tested successfully (on-board STILL forklift; VDI60 protocol)
- Supported by SA industry (Impala Platinum) and EC (run ning H2020/RISE project)



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Main partners

Co-funder and customer. Partner in EU H2020 project aimed at commercialisation of MH technologies in utility vehicle applications

Co-development and manufacturing of MH systems and their main components (MH containers). Partner in EU H2020 project aimed at commercialisation of MH technologies in utility vehicle applications

Co-development and manufacturing of FC power module

Assistance in development of the MH materials and integrated systems. Partners in EU H2020 project aimed at commercialisation of MH technologies in utility vehicle applications.

Assistance in development, manufacturing and advanced characterisation of the MH materials. Partners in BRICS project aimed at facilitation of market penetration of MH technologies in integrated H_2 energy systems

Conclusions

- On-site operation have shown the feasibility of application of MH H_2 storage and compression technology in FC forklifts.

- The main challenge is to get a partner on-board to co-fund and facilitate the commercialization of the technology.