

Fuel Cell Underground Locomotive

Stefan Geiger, Fuel Cell Today, October 2002

A joint venture of the Fuelcell Propulsion Institute and Vehicle Projects has developed the world's first fuel cell-powered locomotive, an underground mining haulage vehicle.

Over the last ten months, the vehicle was tested in and out of laboratories. The final test took place at the Val-d'Or mine from 9 to 13 September 2002, where the locomotive continued to meet expectations and pulled 5 loaded cars without any difficulties (20 tons).



Fig1, Fuel Cell Locomotive under ground. Source: Fuelcell Propulsion Institute

Powered by proton exchange membrane fuel cells (PEMFC), coupled with reversible metal-hydride storage, the four-ton vehicle is now working on a regular basis at the Placer Dome's Campbell mine in Red Lake Ontario, Canada since 6 October 2002. The total project development costs of the locomotive were approximately US\$1.2 million.

Underground mining is probably the most promising application in which fuel cell vehicles can compete strictly on economic merit. This is partly due to the high purchasing price of the locomotive itself, the additional costs of putting a fuel cell in are less important.

This vehicle causes lower recurring costs and reduced ventilation costs, furthermore, the locomotive needs about one hour to refill its tank whereas conventional electric-powered vehicles need more than eight hours to get their batteries recharged. Compared to diesel-powered engines, which are theoretically more productive, the fuel cell-powered locomotive has the advantages of working at a low noise level and zero-emissions, which are important underground due to government emission regulations, as well as the obvious health and safety issues.

Vehicle Specifications

The base vehicle is a commercial battery locomotive manufactured by one of the project partners, RA Warren Equipment. One of the main design objectives was, to fit the fuel cell engine in the same place as the battery in the conventional locomotive. Only the metal-hydride storage subsystem rises about 20cm above the top of the vehicle due to the placement of the shock-absorbing hardware below the subsystem.



Fig2, Hydride Energy storage (left) and Fig3, Fuel Cell power system (right). Source: Sandia National Lab.

Even though low-temperature metal-hydride storage is generally considered too heavy for light-duty vehicles, it is still substantially lighter than lead-acid batteries. Remarkably, the locomotive is about 30% lighter than the commercial battery version, and before it can pull a train, ballast of approximately 1,100 kg must be added to bring it up to its specification of four tons.

Waste heat from the fuel cell stacks is used to keep the hydride bed near room temperature. The recharging of the bed will use gaseous hydrogen at 7 bars and is expected to require about one hour. The PEM fuel cell power system doesn't need any traction battery; therefore the vehicle is a pure fuel cell vehicle. The fuel cell, developed by Nuvera Fuel Cell Europe uses metal

bipolar plates and the two stacks give 104 Volts at 135 Amperes; each stack weighs about 30 kg.

Conclusions

The problems of vehicle emissions and noise have negative economic consequences, especially for underground applications. Fuel cell-powered vehicles can solve these problems and are already cost competitive due to greater net power, greater energy storage and faster recharging. Because weight is not an issue, safe and compact metal hydride storage is an ideal storage technology for underground locomotive applications.

Future Locomotive Projects

Currently, two other locomotive projects are under construction. The joint venture wants to develop a larger underground mine locomotive of about 10-25 ton size for haulage in metal mining or moving roof support shield and a full size surface engine for military applications.

In general, other companies and organisations have conducted studies into the use of fuel cells to power normal trains and trams. So far, action has been limited to very small-scale prototypes; no large-scale prototypes have been built although fuel cells and rail locomotives are a promising combination. For further information about the use of fuel cells in miscellaneous transportation (transport except cars and buses), visit <http://www.fuelcelltoday.com>.

The locomotive project partners:

Canada Centre for Mineral and Energy Technology (Underground testing), Fuelcell Propulsion Institute (industry advising and education), Hatch Associates Ltd (Safety analysis), Kappes, Cassidy & Associates (Surface test site Nevada), Mine Safety and Health Administration (Risk evaluation of vehicle), Nuvera Fuel Cells Europe (Fuel Cell stacks), Placer Dome Inc (Underground production test site), RA Warren Equipment Ltd (Base vehicle), Sandia National Laboratories/CA (Powerplant development), Stuart Energy Systems Inc (Vehicle refuelling), University of Nevada at Reno (Surface testing in Nevada), Vehicle Projects LLC (Prime contractor and project management)

For further information: www.fuelcellpropulsion.org