Case Study L

Company: Fuel Cell Recovery (FCR) Project
Location: United Kingdom
Product: Hydrogen Fuel Cell stack
Type: Project
Maturity: Piloting
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Companies involved: Microcab Industries Ltd, High Speed Sustainable Manufacturing Institute Ltd (HSSMI Ltd), MCT Reman Ltd, Env-Aqua Solutions Ltd and Hydrogen London

The aim of the FCR Project is to establish how hydrogen fuel cell stacks (HFCs) in Fuel Cell Electric vehicles (FCEVs) can be recovered once they reach the end of life, so that the optimal value can be recuperated, by extending their service life. The project will lead to the generation of new product designs, process designs, closed loop supply chain designs and business models that facilitate fuel cell remanufacturing.

The consortium for this project consists of five UK-based organisations, each with a stake in a closed loop hydrogen fuel supply chain. The project lead, Microcab, is a lightweight FCEV manufacturer (Fig. 14), committed to offering its newest vehicle through a CE business model which incorporates car sharing, low carbon mobility and remanufacturing. The project manager, the High Speed Sustainable Manufacturing Institute (HSSMI), is a not-for-profit research institute. MCT Reman, are one of the UK's leading powertrain remanufacturers and their interest in the project lies in the impact that the electrification of the automotive industry will have on future remanufacturing. Env-Aqua Solutions Ltd is a recycling consultancy with over 25 years' experience in the electronics and industrial waste treatment and pollution control sector. They are tasked with developing solutions for the recycling of the fuel cell materials. Hydrogen London is part of the Greater London Authority (GLA) and is tasked with supporting the UK's transition towards a Hydrogen economy.

Fig. 14 Microcab vehicle

Motivation for Remanufacturing

This project has two key drivers: the opportunities of a CE and the future impact that HFC technologies will have on the automotive landscape. Due to European and national policies set to reduce CO2 and NOx emissions, vehicle propulsion systems are moving away from traditional combustion engines, towards low carbon hybrid and electric powertrains. As a result, many automotive manufacturers are developing new HFC vehicle technologies. With the increased production and consumption of these new technologies, come new challenges around how to optimally recover the components and materials within them at the end of life.

With the growing stringency of the End of Life Vehicle (ELV) directive, coupled with the potential commercial opportunities, it is absolutely critical that automotive manufacturers and producers of these components understand how to do this from the very start[1].

Product Description

A HFC is an electrochemical device that generates electricity through a chemical reaction, a result of hydrogen being fed to a catalyst coated membrane on one side and oxygen on the other, to produce an electrical current. The only emission is water. A cell is made up of multiple layers of parts and coatings to permit this reaction taking place. Multiple cells are then combined together to create a fuel cell stack which allows for an increase in the amount of power output.

Design for Remanufacturing

The team's work has concentrated on the diagnosis, disassembly, replacement and testing of three separate 3kW HFC stacks. Through the development of new processes and equipment, the team has been able to replace faulty cells in a stack, with high performing cells from another stack. This results in a remanufactured stack which matches the performance and specification of the original version. The pilot remanufacturing process has highlighted the need to adapt the product design based on certain guidelines. These include:

- Choice of joining methods, fasteners and part connections – (eg avoiding gaskets attached with strong adhesive)
- Material choice – (lightweighting increases fragility of components, and therefore risk that the parts could break during handling. This risk is compounded when the material chosen is inherently brittle eg flow field plates made of graphite.
- Integration of RFID tags, electronic data logs and sensors – sensors to measure voltage and temperature of the individual cells in order to identify their condition, would allow faults to be picked up before they have a negative knock on effect on other cells, also triggering the remanufacturing operation.
- Tracking history of faults and changes, as well as data about Bills of Materials, known failure modes, test data and original performance and build specifications would be beneficial.

Other aspects of the product design which facilitate the product's remanufacturability, but which are already inherently integrated in fuel cell design include: part standardisation, modularity, and upgradability.

Environmental Benefits

The expected benefits[2] of remanufacturing include:

- reduced reliance on precious and finite raw materials (specifically Platinum Group metals)
- reduction in used products and materials going into waste streams

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[1] *When these vehicles reach the end of their life, the automotive industry and fuel cell producers will become accountable for the responsible collection, recovery and disposal of them under the End-of-life Vehicle directive. There is also a significant economic incentive for recovering fuel cells at the end of life. They feat*

ure materials such as platinum and palladium which are expensive, precious metals with finite reserves.

[2] At the time of writing a full LCA is underway and will provide an assessment of the environmental impact of the developed remanufacturing process in relation to new manufacturing and recycling of HFCs.

- reduced energy consumption and CO_2 emissions by displacing new production
- accelerating the development of robust fuel cell technology and more eco-friendly transport

Economic Benefits

The expected economic benefits will be realised in the form of:

- materials savings from reusing existing materials compared with buying new
- energy savings compared with producing new
- mitigation of future financial penalties for noncompliance
- offsetting landfill tax costs by recovering retained value within fuel cells
- revenue from selling second life fuel cells

Social Benefits

The expected social benefits will be realised in the form of:

- the creation/retention of skilled and semi-skilled jobs in the recycling and remanufacture industry and will help support jobs in the wider automotive industry
- enabling people with limited financial means to purchase second-hand/renewed products at a fraction of the price of newly manufactured,
- a reduction in carbon generated will help mitigate air and water pollution, improving air quality and hence the health of the population.
- MCT Reman anticipate that, if the project is successful, they could see a potential business revenue growth of 20% for the company with a 10% growth of personnel employed at MCT to support a remanufacturing process for hydrogen fuel cells

Business Models

The work on the relevant business model for Microcab is ongoing.

Future Challenges

Besides the wider challenges associated with HFC vehicles and hydrogen infrastructure development, future challenges relating to their remanufacture lie in the complex development of hybrid manufacturing and remanufacturing lines which are scalable from low to high volumes, which can accommodate a range of different fuel cell types.