HEATSTACK

WHY FUEL CELLS?

Fuel cells have shown great promise for use in **residential micro-Combined Heat and Power (mCHP) generation** due to their **high electrical efficiency and ability to run on conventional heating gases**, but high manufacturing costs remain key to widespread adoption in Europe. The objective of the project is to reduce the cost of mCHP domestic systems by 50% so that the whole life cost of mCHP become cost-competitive with conventional domestic heating systems, supporting the drive towards reducing greenhouse gas emissions.

ABOUT HEATSTACK

This 45-month project, funded through the FCH Joint Undertaking and Horizon 2020, is focused on **reducing the cost of the fuel cell stack and heat exchanger** – the 2 most expensive components within the fuel cell system – which together represent the majority of total system manufacturing costs.

The project has partners in 4 countries: the UK, Germany, Italy and the Czech Republic. Senior Flexonics UK are the project coordinator, supported by PNO UK, research partner the University of Birmingham and 4 commercial partners: Sunfire, ICI Caldaie, Vaillant and Senior Flexonics CZ. Key technical achievements and results, from the entire project duration, are presented by partner below.

Two main approaches were used to achieve the overall objectives:

1) **improving the manufacturing processes** to improve quality and reduce the time to manufacture;
2) **improving durability** such that the SOFC mCHP system as a whole has a longer life.

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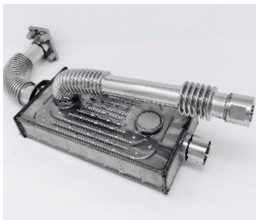
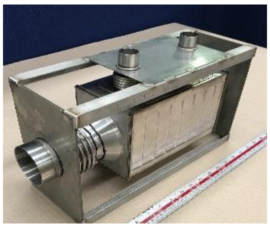
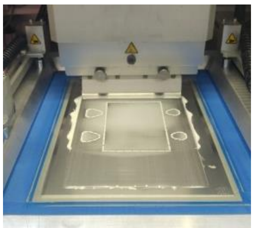
senior Flexonics

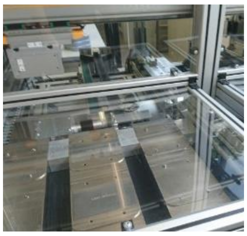
- Developed a **production-ready CAPH** using AluChrom 318 – a novel material investigated by the University of Birmingham – that gives **robustness, cost effectiveness and industry leading low levels of Cr leakage.**
- Simulation for developing a **design that can be used in different applications** and which functions at different temperatures, pressures and flow rates.
- **Patent-pending CAPH** has a contra flow design, works up to 1000^{o}C, **proven effectiveness of over 90%** and very low pressure drop for both fluids.
- Overcame manufacturing challenges presented by using AluChrom, including very **significantly modifying the form of the gas plate** and **improving laser welding consistency and quality** by changing the weld tool and parameters.
- Significant **investment in equipment and tooling for process efficiency** – manufacturing of the CAPH using new processes proves that the **cycle time (to build 1 unit) is reduced by over two thirds**.
- **Transferred, installed and recommissioned the new equipment and tooling** from the development site at Crumlin (South Wales) to the manufacturing facility at Olomouc (Czech Republic) **ready for low-volume production**.

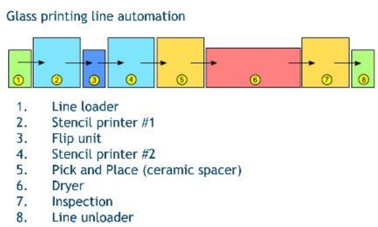



sunfire

- **Printing of the glass seals** was chosen as the method with the **best value for industrial stack production**.
- Devices for printing were designed and built, and 2 printing slurries were developed.
- The **first printing tests showed good results** were achieved for thin layers.
- **Fuel cell stack production processes** development, with laser measurement in operation and a **first core unit design completed**.
- **Process automation** development includes a **completed first line design**.
- Once process parameters were fixed, **10 prototype SOC stacks with printed glass seals were produced and used for intensive testing and product verification**, including mechanical compatibility, electrical properties and long-term stability of the SOC stack.
- The **optimized SOC stack was integrated with the CAPH from Senior Flexonics into Sunfire Home units**. Further performance tests showed these technologies are **ready for use in series production**.



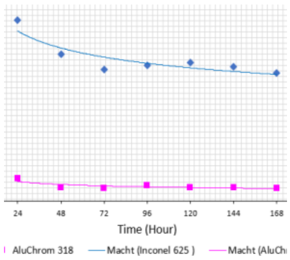


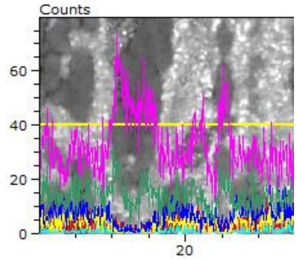


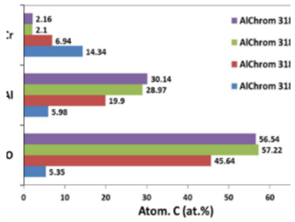
UNIVERSITY OF BIRMINGHAM

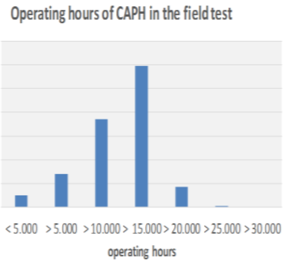
- **Denuder technique used to quantitatively analyse the chromium vaporisation** from Inconel 625 and AluChrom 318. Cr evaporation rate for AluChrom 318 is approx. one order of magnitude lower than for Inconel 625.
- Formation of a dense and continuous alumina scale on the alloy surface could effectively reduce the high temperature Cr leakage in the long term.
- **Low cost, low Cr evaporation and excellent high temperature corrosion resistance make AluChrom 318 highly suitable for CAPH application**.
- Applied research shows that **AluChrom has improved Cr leakage rates when compared to all other materials after just 150 hours**.

- With Inconel, Cr oxide forms on surface and remains there. SS 309 also forms Cr-Mn spinel, which spalls and breaks from surface. Aluminised SS309 loses Alumina surface and is replaced by Cr-Mn spinel. **AluChrom surface reduces Cr oxide content and increases Alumina**.
- **Investigated pre-heat treatment for material optimisation** to address Cr2O3 formation around the exhaust outlet (cold zone) and a fast Al oxidation rate around the exhaust inlet (hot zone). **The best corrosion resistance was for samples pre-treated at 1100°C for 1 hour** – 98% reduction of oxidation rate and 90% reduction of Cr evaporation.









Vaillant

- **Field testing results** (from 2013 to 2017) **were positive for HEATSTACK** and total **over 3.4 million operating hours**.
- The maximum single CAPH operating times achieved at that point were 28,600 hours with Inconel and 19,700 hours with AluChrom.

ICI CALDAIE

- **Integrated the Senior Flexonics heat exchanger prototypes** into their test rig and adapted the fume line to conduct **testing in the widest range of conditions** possible and to **improve the quality of data collected**.
- Monitored the prototypes over the testing period so that a **thorough evaluation of performance** could be conducted.

PROJECT COMMUNICATION & DISSEMINATION

Project objectives, progress and results have also been published externally. HEATSTACK featured at the 2019 Bruges Workshop Series on Fuel Cell Systems during the 12th Workshop on Progress in Fuel Cell Systems, was promoted at the Hannover Messe (2019 and 2018), presented at Fuel Cell and Hydrogen Joint Undertaking's flagship event in November 2018, and sponsored the 2018 Joint European Summer School Fuel Cell, Electrolyser, and Battery Technologies. HEATSTACK research has been the focus of two scientific papers and a range of other publications.

If you would like more information about HEATSTACK, you can contact us via:

- Website: http://www.heatstack.eu/contact/
- LinkedIn: HEATSTACK Project
- Twitter: @HEATSTACK_EU

Channels managed by PNO on behalf of all partners.

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