FUEL CELLS AND HYDROGEN
JOINT UNDERTAKING

HEATSTACK

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Programme Review Days 2018

Brussels, 14-15 November 2018

PROJECT OVERIVEW

- Call year: 2015
- Call topic: H2020-JTI-FCH-2015-1 Production Ready Heat Exchangers and Fuel Cell Stacks for Fuel Cell mCHP
- Project dates: April 2016 to March 2019 extended to June 2019
- % stage of implementation 01/11/2017: 70%
- Total project budget: €2,899,760
- FCH JU max. contribution: €2,899,760
- Other financial contribution: None
- Partners: Senior UK Ltd, Senior Flexonics Czech s.r.o, Vaillant GmbH, The University of Birmingham, ICI Caldaie SPA, PNO Consultants Ltd, Sunfire GmbH

PROJECT SUMMARY

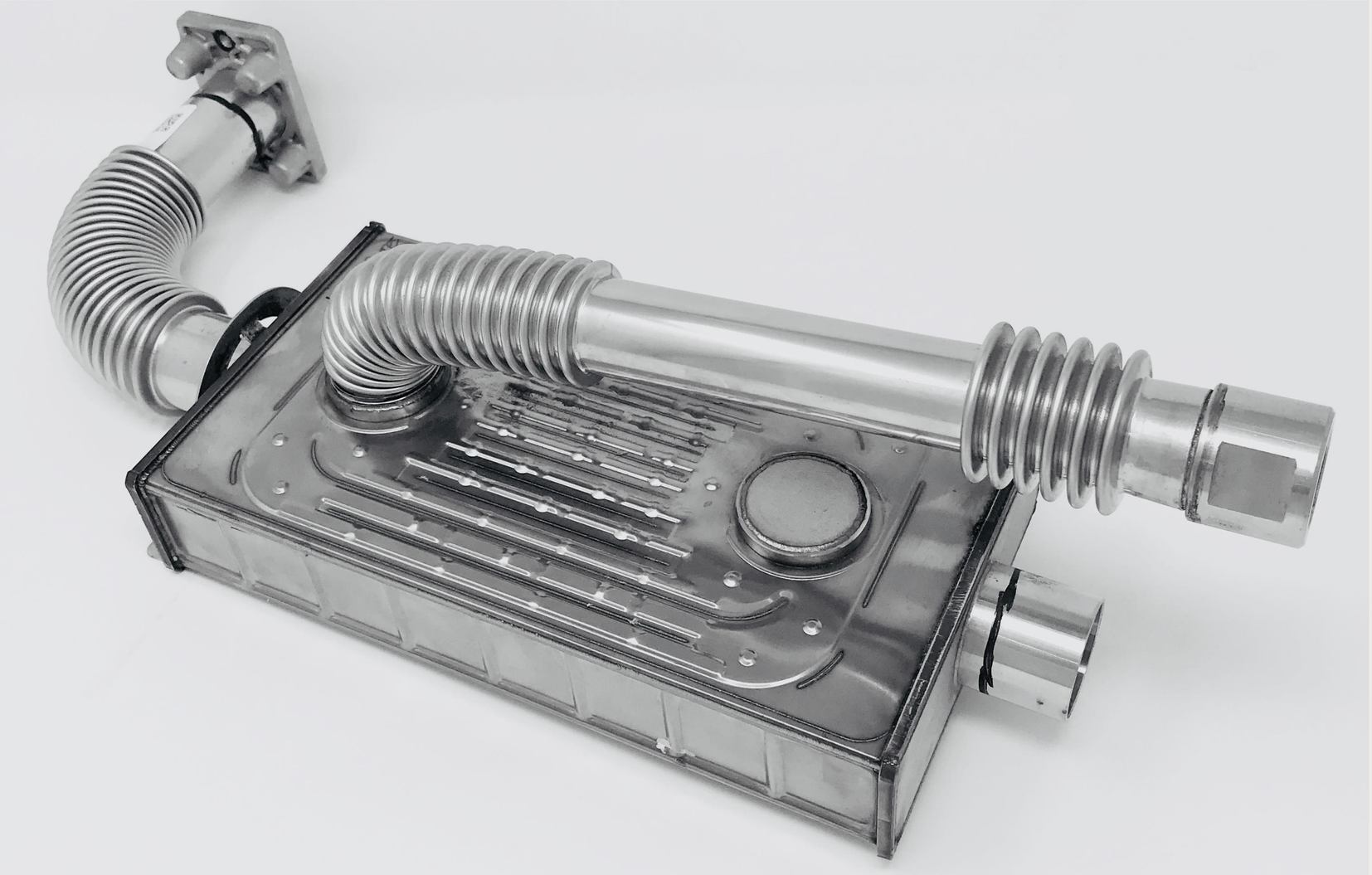
- HEATSTACK, Production Ready Heat Exchangers and Fuel Cell Stacks for mCHP
- Objectives
  - Significantly reduce the number of cells in the Cathode Air Pre-Heat from the current 28
  - Reduce the amount of glass material in the SOC stack by 50%
  - Reduce the time to manufacture a CAPH from 8.83 to 1.35 hours.
  - To generate a commercial document for 10,000 CAPHs / year that meets cost targets
  - To develop and prove tooling to meet objectives 2 and 3
  - To develop AluChrom as the material of choice for the CAPH
  - To have a production feasible repair method for CAPHs leaks
  - Develop a pilot production line for SOC glass seals
  - Run long-term performance on components (PACE)
  - Business plan to increase volumes to a critical mass

PROJECT SUMMARY

- Senior have a European Patent granted for the CAPH.
- HEATSTACK is developing and proving off AluChrom material for the CAPH
- HEATSTACK has proven the superiority of a stainless steel with alumina surface
- HEATSTACK has almost completed the proving off the CAPH tooling and processes
- Senior are also selling prototype CAPHs to a Japanese company (outside of HEATSTACK)

- The concept of the CAPH for mCHP can be used for a variety of applications. Other SOFC systems, Electolysers, micro Turbine recuperators.

CAPH image



Risks and Challenges

There were four main risks or challenges when the project started.

Business development – Is there really a market for mCHP fuel cell systems? And if there is when will the European market hit 100,000 / year (Senior and Sunfire would target 10,000 of these sales) This is still a major risk and needs to OEMs to develop the market. Vaillant the OEM within the consortium made a decision to stop the commercialization of FCmCHP systems. Sunfire have taken over as both the stack and mCHP system developer.

CAPH material – A stainless steel with >3.5% stainless steel was expected to recuperate its alumina surface and significantly reduce Chromium Evaporation. The challenges were was this true? Could it be formed? Could it be welded and give leak tightness within the specification? Was it durable in service?

Could CAPH cycle times be reduced to achieve target times?

Could the application of glass material to the SOC be automated?

PROJECT PROGRESS – Business Development

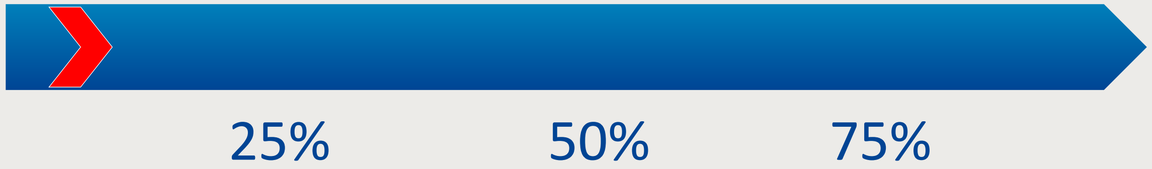
Achievement to-date Now

100 prototype level CAPHs

10,000 production CAPHs

Senior have been sent an RFQ for up to 7,000 units / year by 2024

Achievement to-date December 2017



When in 2017 Vaillant withdrew from FCmCHPs progress and confidence was lost

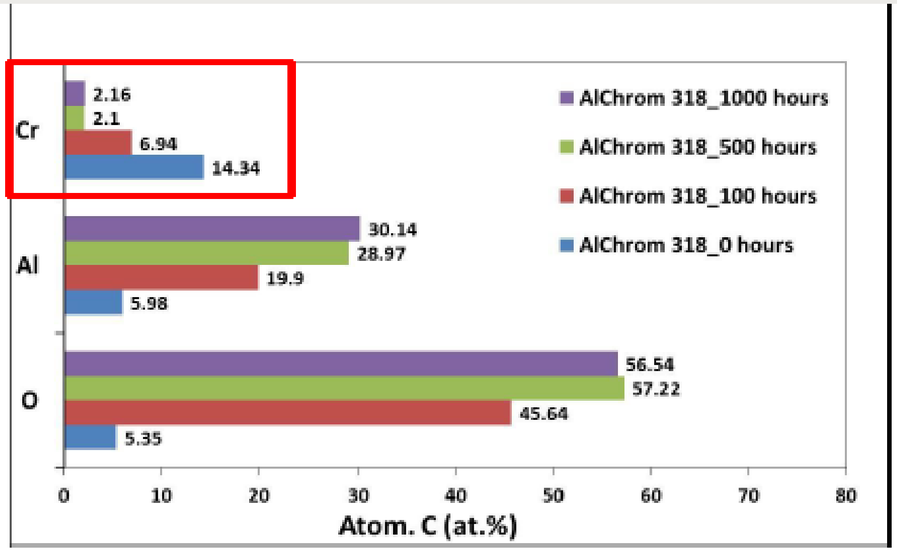
PROJECT PROGRESS – AluChrom Material – Cr evaporation

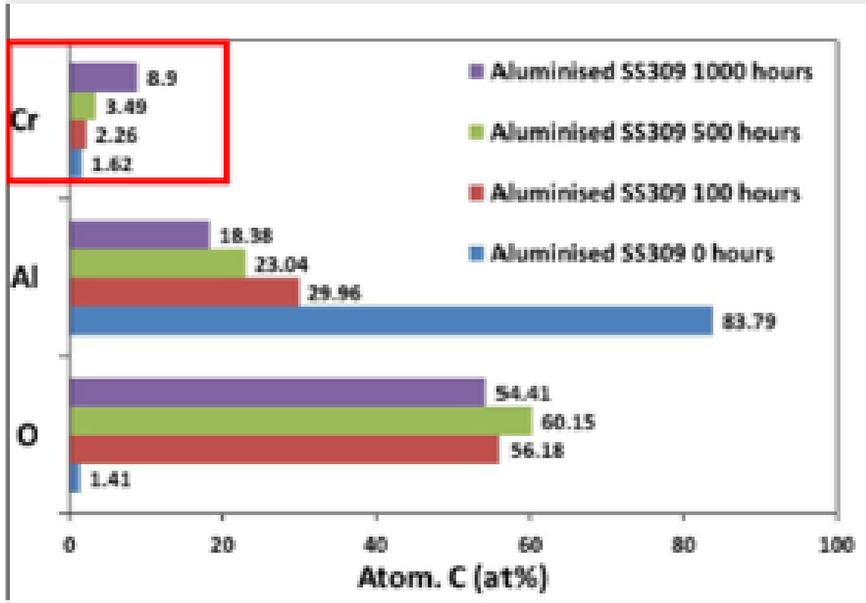
Achievement to-date Now

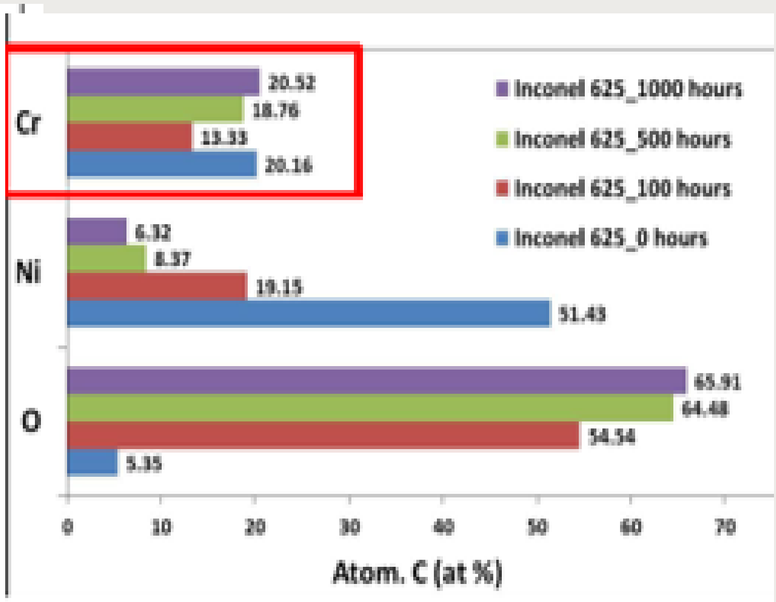
Info from material supplier

25% 50% 75%

100% confidence in performance







Test Conditions: 850 °C; 6.0 L/min Airflow; 3 vol% H_2O.

Equipment: Normal tubular glassware for high temperature corrosion test;

Denuder Technique for evaporated Cr collection.

PROJECT PROGRESS – AluChrom Material – Forming and welding

Achievement to-date Now

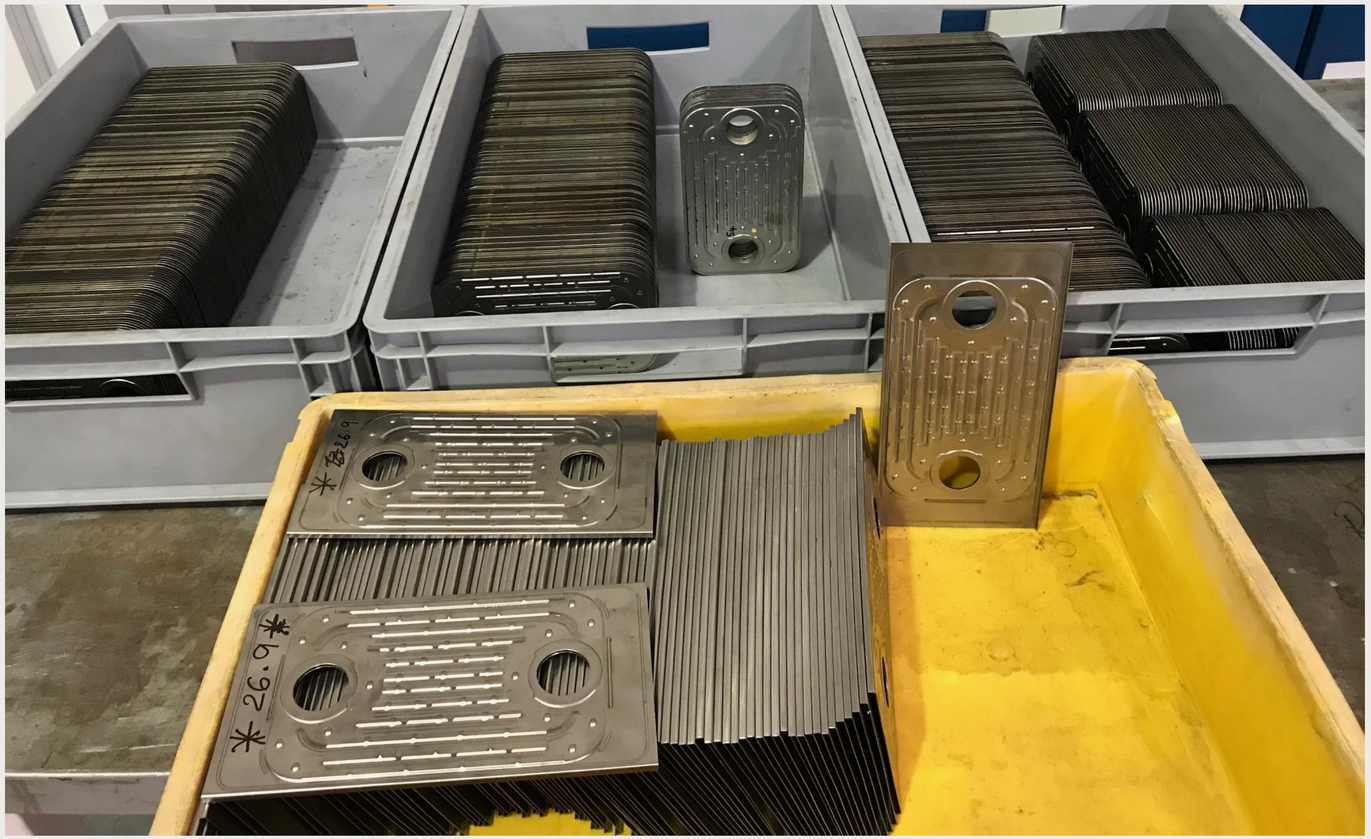
Aluchrom Yhf trialled - splits

AluChrom 318 Forming and welding

25% 50% 75%

Over 3,000 plates formed with no splitting concerns.

85 stacks and 1360 cells welded. Some low level rework but process is within expected limits.



PROJECT PROGRESS – AluChrom Material – Durability

Achievement to-date Now

Minimal field data

Units run for 40,000 hours

25% 50% 75%

Vaillant Fuel cell G5
Cathode Air Heat exchanger Al Cr

Number	Serialno.	Object	Installation Date CAPH	Exchange Date	Operating-hours	Stock
1	5200N4	5013	12.02.2015	09.05.2016	9915 h	
2	5199N9	5049	12.02.2015	17.05.2015	10496 h	
3	5110N0	5321	04.02.2015	11.05.2016	7001 h	
4	5114N4	5328	17.11.2015	14.02.2017	10534 h	Remscheid
5	5206N0	5376	25.11.2015	19.09.2017	11185 h	
6	5143N3	5378	19.11.2014	13.12.2017	25242 h	
7	5201N0	5389	16.09.2015	12.06.2017	11035 h	Remscheid
8	5202N6	5405	24.04.2017		6419 h	

Note: There have been no abnormalities in field.

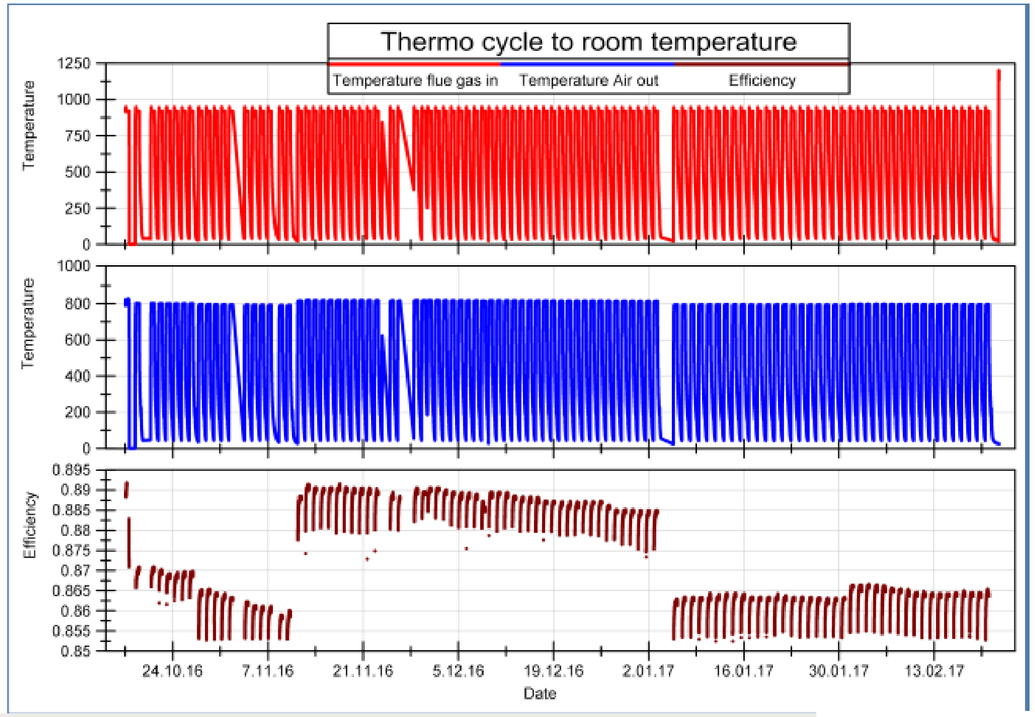
Current status Fuel cell in field: 49 Systems are running.

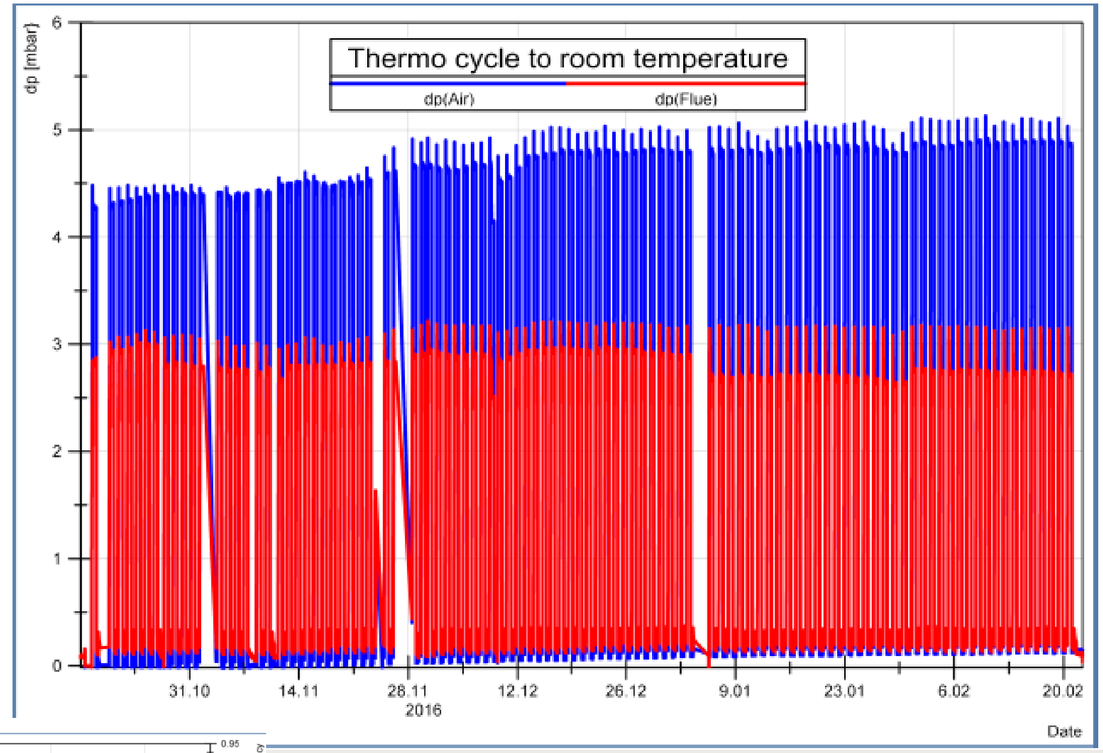
4.204.631 running hours

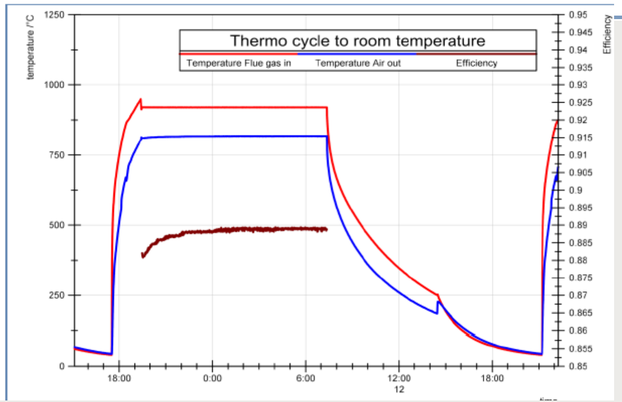
Eight AluChrom CAPHs adapted to fit pre HEATSTACK mCHP have run.

Sunfire need to put 500 units into the field and run for extended period to sign off. (PACE)

Durability of CPAHs – Passed thermal cycle







PROJECT PROGRESS – Automated application of glass material

Achievement to-date Now

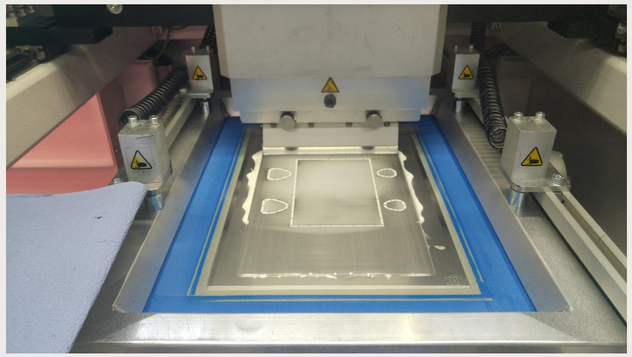
By hand → Fully automated

25% 50% 75%

Process Development

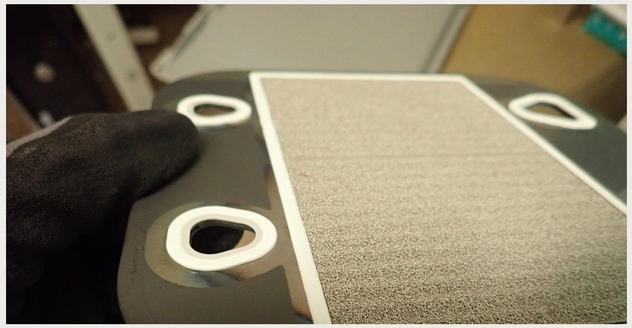
Sunfire develops an printing process for the SOFC glass seal. Included Steps:

- Process design study → achieved
- Development of a glass paste with tailored rheology attributes for printing application → achieved
- Development of a 2-step stencil printing process → 75%
- Evaluation in Stack manufacturing trials →50%

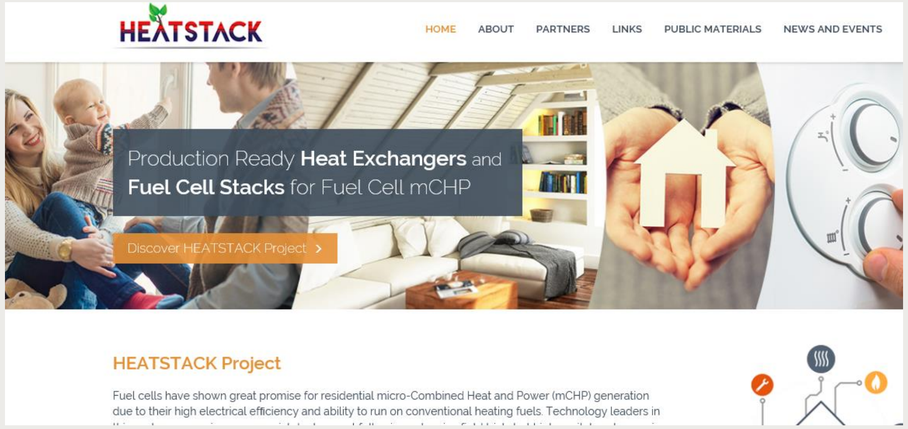


Process Automation

- Planning of a full / partially automated production line for printed glass seal →50%
- Establishing of suitably quality control →50%



Communications Activities



EXPLOITATION PLAN/EXPECTED IMPACT

Exploitation

The exploitation strategy focus is market introduction and rapid uptake, considering the anticipated market size for the two components (CAPH and SOC stack) as well as the SOFC mCHP system – the initial route to market for Senior's CAPH and Sunfire's SOC stack will be through the system being developed by Sunfire. To support this, Vaillant, the original end-user partner that has taken a strategic decision to step back from this technology, has conducted a knowledge and technology transfer to Sunfire. Furthermore, Sunfire will link HEATSTACK with the large-scale demonstration project PACE via their participation in both projects and relationship with Senior. Senior are also working outside of HEATSTACK to develop business

Impact

Senior have made the strategic decision to locate heat exchanger production and the new laser welding process in SFO Olomouc in the Czech Republic whilst Sunfire will decide when to introduce partially and fully automated fuel cell stack production lines. It is anticipated that project output and this relationship will support Sunfire in their aim of starting production in 2020.
The relationship built with ICI Caldaie, including HEX testing during HEATSTACK, will support the broader development of mass manufacturing of heat exchangers for fuel cell CHP technologies in Europe. As the project's academic/research partner, the University of Birmingham enhances their research base and reputation from activities carried out in HEATSTACK. PNO's participation enhances their portfolio and reputation for innovation services such as project coordination/management and communication, dissemination and exploitation planning/strategies.

Dissemination Activities

Dissemination activities conducted in the first half (18 months) of the project to engage with stakeholders:
Attending 13 events, e.g. 12th European SOFC & SOE Forum and Hannover H2FC Fair
Delivering 6 publications: external (news features in Fuel Cells Bulletin/Science Direct and scientific paper in ECS journal) and internal (e.g. project brochure/factsheet)
Achieving almost 3,500 website views from 14 news articles and nearly 200 connections made on social media/LinkedIn from 300 posts.

Patent EP 2 607 830 High Effectiveness Gas to Gas Heat Exchangers was granted 12-09-2018

Public deliverables include the HEATSTACK website (D8.3), logo, brochure and leaflets etc. (D8.4), materials for promoting the project's final event (D8.5) and teaching materials (D8.6) – all of these are ongoing or due by project end.

Horizontal Activities

Research and development undertaken for HEATSTACK featured in teaching materials/presentations at the Joint European Summer School on Fuel Cell, Electrolyser and Battery Technologies (JESS 2018).
HEATSTACK was also a sponsor of JESS 2018, thus disseminating the project to the next generation of academic researchers and industry professionals.

SYNERGIES WITH OTHER PROJECTS AND PROGRAMMES

Interactions with projects funded under EU programs

- HEATSTACK feeds directly into PACE: Market introduction of Sunfire Home mCHP systems with the achievements of HEATSTACK
- SOFC stack achievements (glass seal technology) will also bring further cost reduction to other Sunfire applications like the Commercial-scale SOFC systems of COMSOS or the electrolyser systems developed in GrInHy and GrInHy 2.0