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V1	28.05.2024	First Version	Marcus-Benedict Buntz	Henk Jan van Gerner

List of Acronyms and Abbreviations

Abbr.	Description	Abbr.	Description
2-PC	Two-phase cooling	MEA	Membrane Electrode Assembly
A/C	Aircraft	MCU	Motor control unit
AM	Additive Manufacturing	MTBF	Mean Time Between Failure
Bar(a)	Bar absolute pressure	MTC	Motorised turbo-compressor(s)
Bar(g)	Bar gauge pressure (differential)	NM	Nautical mile
BoP	Balance of Plant	OCV	Open circuit voltage
BPP	Bipolar plate	OEM	Original Equipment Manufacturer
CCM	Catalytic coated membrane	PAX	Passengers
CRA	Cell Row Assembly	PFSA	Perfluorosulfonic acid
CA	Consortium agreement	PGS	Power Generation System
CFD	Computational fluid dynamics	PoC	Proof of Concept
CL	Catalyst layer(s)	POD	PGS Unit
DCE	Dissemination, Communication and Exploitation	PPS	Propulsion Power System
DoE	Design of Experiment	PEM	proton exchange membranes
DMU	Digital mock-up	PEMFC	Proton Exchange Membrane Fuel Cell
EASA	European Union Aviation Safety Agency	PM	Particulate matter
EOL	End of Life	RAC	Ram Air Channel(s)
FC	Fuel Cell	RH	Relative humidity
FEM	Finite Element Method	SAF	Synthetic aviation fuel
FL250	Flight level 250 (= 25,000 ft)	SLM	Supporting layer manufacturing
GDL	Gas Diffusion Layer	SoA	State of the Art
GHG	Greenhouse gas	SoGDL	Seal-on-GDL
GT	Gas turbine	SRIA	Strategic Research and Innovation Agenda
GUI	Graphical User Interface	SSTR	Short Stack Test Rig
HX	Heat exchanger(s)	TMS	Thermal Management System
IP	Intellectual property	TEFO	Total Engine Flame Out
IPN	Interpenetrating polymer networks	TO	Take-Off
IPR	Intellectual property rights	ToC	Top of Climb
ISA-35	International Standard Atmosphere	TOGA	Take-Off and Go-Around
KPI	Key Performance Indicator	TRL	Technology Readiness Level
KSO	Key Strategic Orientations	VOC	Volatile organic compounds
L2	Liquified hydrogen		

1. Executive Public Summary

This report summarizes the activities of Aerostack in BRAVA WP3.1 “Small-scale 2-phase cooled fuel cell demonstrator” and gives an overview of the current status. To allow demonstration of two-phase cooling, a suitable fuel cell short stack is being designed and a two-phase mechanically pumped loop system for integration into a fuel cell test bench is developed by NLR.

For the development of the short stack, Aerostack follows an iterative development process, which means to rapid prototype flow-fields in graphite and test their performance with the new coolant and improve the design if necessary. A homogenous coolant flow distribution is crucial for fuel cell performance and lifetime. Flow maldistribution causing hotspots in the polymer electrolyte membrane needs to be prevented in any case. Therefore, the design activity is supported by CFD and thermal FEM modeling to improve the coolant flow distribution and provide suitable flow-fields for testing. The approach and methods are described in the first part of this report.

Besides the coolant distribution, another important fact for fuel cell longevity are the operating conditions. The switch from sensible heat transfer to latent heat transfer imposes a strong inlet temperature gradient and downstream a constant temperature value for the majority of the fuel cell active area. This is challenging for the water-management inside the cell, since gas channels could be flooded by condensate water at the inlet. Figuratively speaking, the first few centimeters of the inlet equal a rainforest, while the following largest part equals a dry desert. To cope with this situation in a 2-phase cooled cell, a large parameter study with a Modelica/Dymola model was performed in order to identify suitable operating conditions. The report describes the use of the design of experiment method for test planning and using a regression analysis to evaluate the large set of results.

The last part of the report describes the activities preparing for testing. On material level, first test results are available and discussed with background on the test method. On component level, a thermal cell was designed to test the current flow-field with 2-phase cooling ex-situ via heaters which was already shipped to NLR for testing. In parallel the development of the mechanically pumped two-phase cooling system for integration into Aerostack’s fuel cell test bench is coordinated. The report summarizes the activities and gives an outlook on upcoming tasks.

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Project partners:

#	Partner short name	Partner Full Name
1	A-D	AIRBUS OPERATIONS GMBH
2	A-E	AIRBUS OPERATIONS SL
3	AER	AEROSTACK GMBH
4	CNRS	CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE
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