IMMORTAL

IMPROVED LIFETIME STACKS FOR HEAVY DUTY TRUCKS THROUGH ULTRA-DURABLE COMPONENTS

Project ID	101006641
PRR 2024	Pillar 3 – H_2 end uses: transport
Call topic	FCH-01-2-2020: Durability-lifetime of stacks for heavy duty trucks
Project total costs	EUR 3 825 927.50
FCH JU max. contribution	EUR 3 825 927.50
Project start - end	1.1.2021–31.3.2024
Coordinator	Centre national de la recherche scientifique, France
Beneficiaries	Albert-Ludwigs-Universität Freiburg, AVL List GmbH, FPT Industrial SpA, FPT Motorenforschung AG, Johnson Matthey Hydrogen Technologies Ltd, Johnson Matthey plc, Pretexo, Robert Bosch GmbH, Université de Montpellier

https://immortal-fuelcell.eu

PROJECT AND GENERAL OBJECTIVES

Immortal aims to develop high-performance and high-durability membrane electrode assemblies (MEAs) and their components, specifically designed for use in heavy-duty trucks. The project intends to develop load profile tests specific to heavy-duty trucks, and apply these tests, and accelerated stress tests, to MEAs at both the subscale and the short-stack levels. The results of load profile testing will also be used to validate a novel lifetime prediction method, and the method used to predict the lifetime of project MEAs. The project will assess the results through a technoeconomic evaluation and facilitate heavy-duty fuel cell powertrain validation and provide system recommendations.

NON-QUANTITATIVE OBJECTIVES

Immortal contributes to activities in Mission Innovation's hydrogen innovation challenge through cooperation with the US Department of Energy's Million Mile Fuel Cell Truck consortium. Several workshops were held with the consortium, and with Japan's fuel cell platform. These included discussions on, inter alia, heavy-duty stressors, the second-generation Toyota Mirai and advanced characterisation techniques.

PROGRESS AND MAIN ACHIEVEMENTS

- Developed a nanofibre-reinforced membrane with exceptional durability in an MEA in accelerated stress testing at 90 °C, comprising 120 000 wet/dry cycles at open-circuit voltage corresponding to 2 200 hours in an accelerated stress test, without rupture.
- Developed MEAs comprising project materials that reached the 2024 strategic research and innovation agenda target for heavy-duty vehicles of 1.2 W/cm^2 at 0.65 V, and came within 5 % of the annual work programme target of 1.2 W/cm^2 at 0.675 V (for generation 2 MEAs), giving a Pt load of 0.32 gPt/kW.
- Developed a regression model for fuel cell degradation forecasting with an emphasis on the prediction confidence interval (uncertainty).
- Developed a method for creating accelerated durability tests for fuel cells, based on Markov chains..
- Established a lifetime prediction method and validated it using 1 500 hours of load profile testing.
- Obtained a predicted power loss of 10 % after 30 000 hours (for baseline MEAs), which corresponds to the annual work programme target.
- Identified the principal contributor to power loss during load profile testing as the loss of electrochemically active surface area from the cathode catalyst.
- Developed a modal load profile test from actual truck mission profiles.
- Achieved more than 7 500 hours of load profile testing on short stacks without catastrophic failure.

FUTURE STEPS AND PLANS

Immortal finished in March 2024 and the final activities were:

- finish the stack test;
- complete post-mortem analytics of MEAs from the last stack load profile test;
- provide heavy-duty fuel cell powertrain validation and system recommendations;
- complete a techno-economic evaluation.

Future plans including carrying forward the learning and most prospective materials from Immortal to future heavy-duty MEA development projects, in particular 'High performing ultra-durable membrane electrode assemblies for trucks' (Highlander).

PROJECT TARGETS

Target source	Parameter	Unit	Target	Achieved to date by the project	Target achieved?	SOA result achieved to date (by others)	Year for reported SOA result
SRIA (2021–2027) and AWP 2020	Cell voltage at 1.77 A/cm^2	V	675	0.642 (within 5 % of project/AWP target)		675	2021
	Durability	hours	30	10 % power loss after 30 000 hours		8 500	2020
Project's own objectives	Catalyst surface area and mass activity	cm^2/gPt and A/mgPt	Exceeding reference Pt and with better retention after accelerated degradation cycles than reference Pt/C	Two catalyst designs achieved this objective	✓	N/A	N/A
	Membrane durability in MEA AST cycles	cycles	50 000	110 000		N/A	N/A
AWP 2020	Cell voltage at 1.77 A/cm^2	V	675	661		675	2021

Clean Hydrogen Partnership
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