WP 6 - Stack engineering, BoP design, prototyping and testing

Sebastiaan Herregods, Lisa Geerts & Clara Niño

Accelera by Cummins (Hydrogenics)

Clean Hydrogen JU AEMEL & JRC workshop

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Accelera by Cummins

INTRODUCING ACCELERA

The new brand for New Power, Cummins' fifth business segment, focused on zero-emission technologies.

Cummins & Accelera

Engines

Power generators

Components

Distribution

Electrolysis

Fuel cells

Batteries

e-Traction

Accelera by Cummins

190
Countries

59.9K
Global employees

1.3M+
Engines built

10.6K
Distributor & dealer locations

$1.1B
Invested in research & development

103 YEARS
of industry leadership

*2021 figures

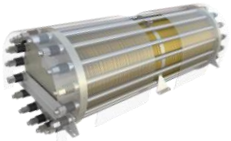
Accelera by Cummins

Accelera's Core Technologies

Electrolyzers

Creating solutions for industrial and commercial hydrogen generation and megawatt-scale energy storage

Industrial processes and fueling stations: PEM generator, alkaline hydrogen generator



ALK
87 kW
17Nm³/h

PEM
2,5 MW
500 Nm³/h

Fuel Cell Systems

Creating and integrating fuel cells for mobility and stationary power applications

Electric mobility: heavy-duty truck, transit bus, rail

Utility: microgrids, megawatt-scale grid firming and renewable integration

Commercial/Industrial: manufacturing, data centers, water treatment facilities, hotels/resorts

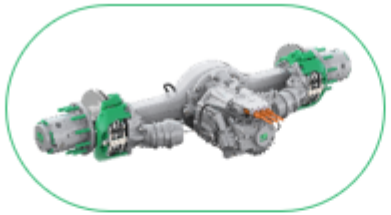
Electrified Components

Creating technologies and products for commercial battery electric vehicles and battery energy storage systems

On-highway: transit bus, school bus, medium-duty truck, walk-in van

Off-highway: construction equipment, terminal tractor, material handling, energy storage systems

Components: battery modules, battery packs, PCAs



ePowertrain Systems

Creating technologies and delivering eAxles for electrified vehicles

On-highway: medium-duty truck, heavy-duty truck, walk-in van, transit bus, school bus

Off-highway: construction equipment, terminal tractor

Components: integrated eAxles

Traction Systems

Creating technologies and delivering electric traction systems for electrified vehicles

On-highway: medium-duty truck, heavy-duty truck, walk-in van, transit bus, school bus

Off-highway: construction equipment, terminal tractor

Components: motors and inverters for remote mount and eAxle

Accelera Electrolyzer Manufacturing Expansion

Country	Belgium	Spain	Canada	USA	China	China (in JV with Sinopec)
City	Oevel	Guadalajara	Mississauga	Fridley	Shanghai	Foshan
Status	Extension	New	Extension	Conversion	New	New
HyLYZER® PEM cell stacks	●		●		●	
HySTAT® ALK cell stacks	●					
HyLYZER®-500	●			●		●
HyLYZER®-1000	●	●	●			●
HyLYZER®-5000		●		●		
HySTAT®- 100	●					

GLOBAL ANNUAL CAPACITY: 2-3 GIGAWATTS IN 2024

WP 6 - Deliverables & Milestones

Goal:

Design, engineering and testing of a 2 kW AEM cell stack and electrolysis system to validate AEM electrolysis technology

DELIVERABLES

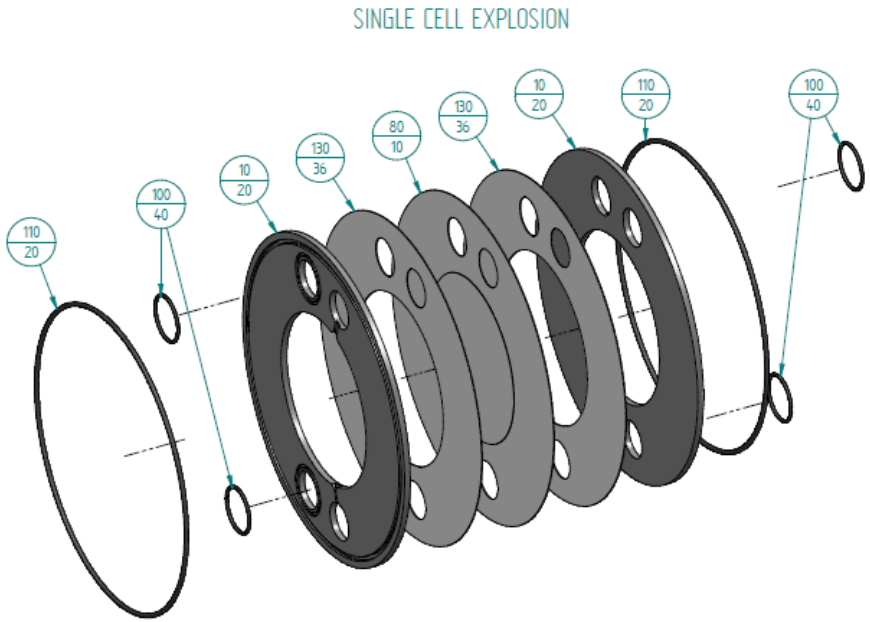
- **D6.1** - Report on stack engineering and assessment under high current density, high temperature and pressure
- **D6.2** - Validation of AEM electrolysis stack performance and durability in endurance tests and load cycling operating conditions

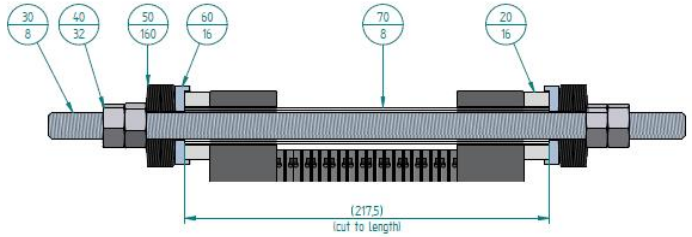
MILESTONES

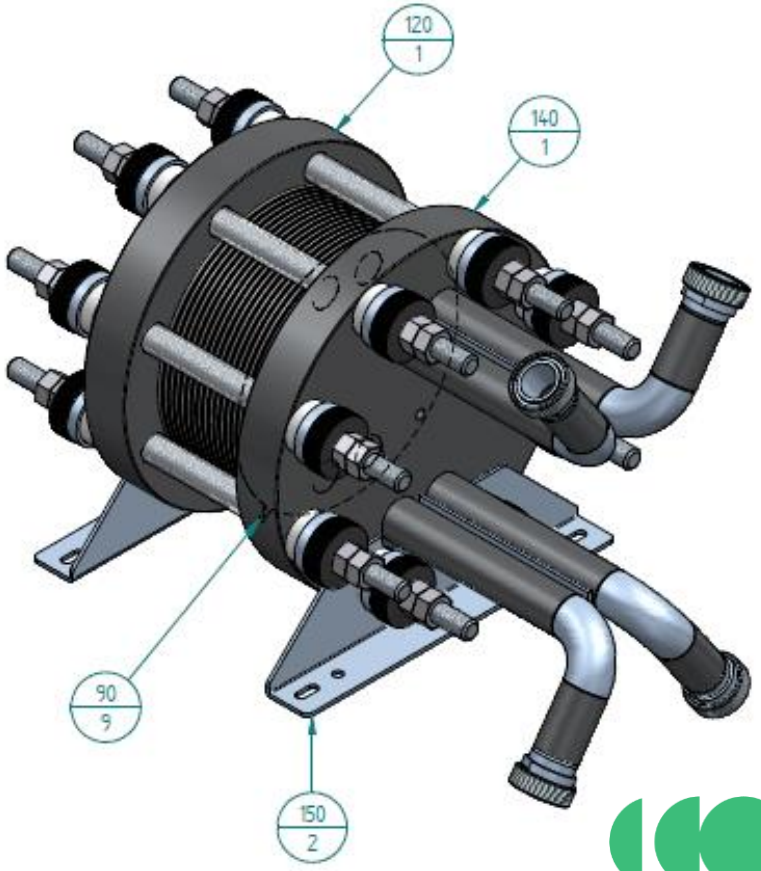
- **MS 10** - Validation of AEM technology at stack level: 10 cells, > 100 cm^2 active area, current density ≥ 1 $A \cdot cm^{-2}$ with an average cell potential < 1.8-2 V, hydrogen production rate > 0.4 Nm^3/h
- **MS 11** - Improved stack efficiency: < 50 kWh/kg
- **MS 12 -** Enhanced stack durability: 2000 h test at 1 $A \cdot cm^{-2}$ showing efficiency loss < 3 %/year

WP 6 – Stack engineering

- Cell Stack design completed
  - Mechanical strength of End flange calculation according to ASME.
  - Calculation of Tie rod Torque.
  - FEA of the structure rings



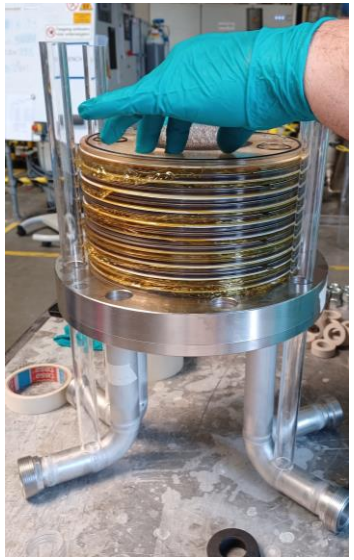




Stack Assembly

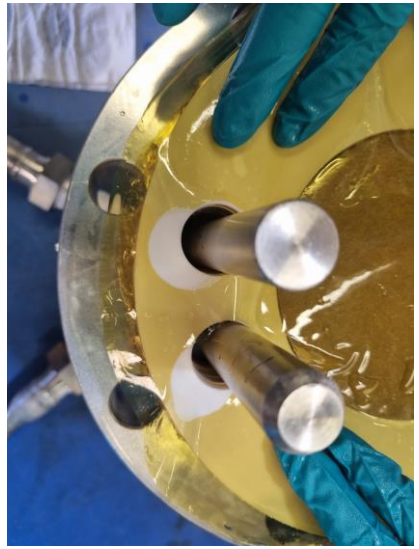
24 hours exchange in 0.5 M KOH prior to assembly

Membranes wrinkling

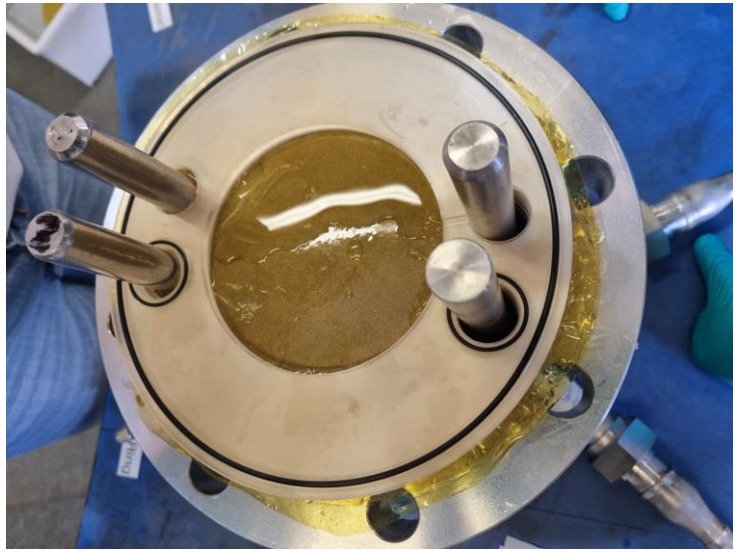


Full stack (10 cells)

Stack Assembly



Reworked membrane

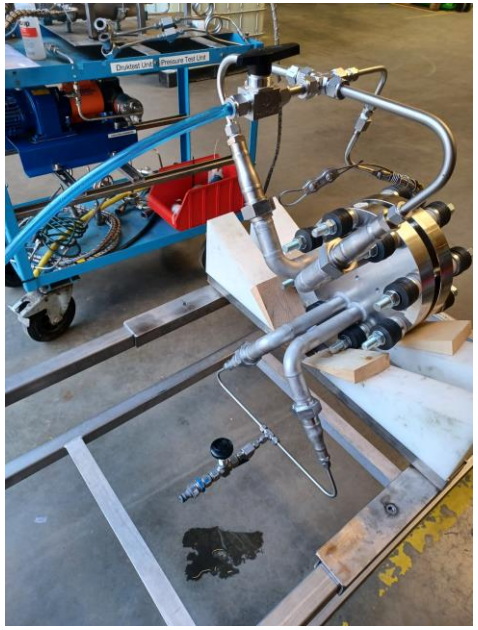


Non wrinkled membrane

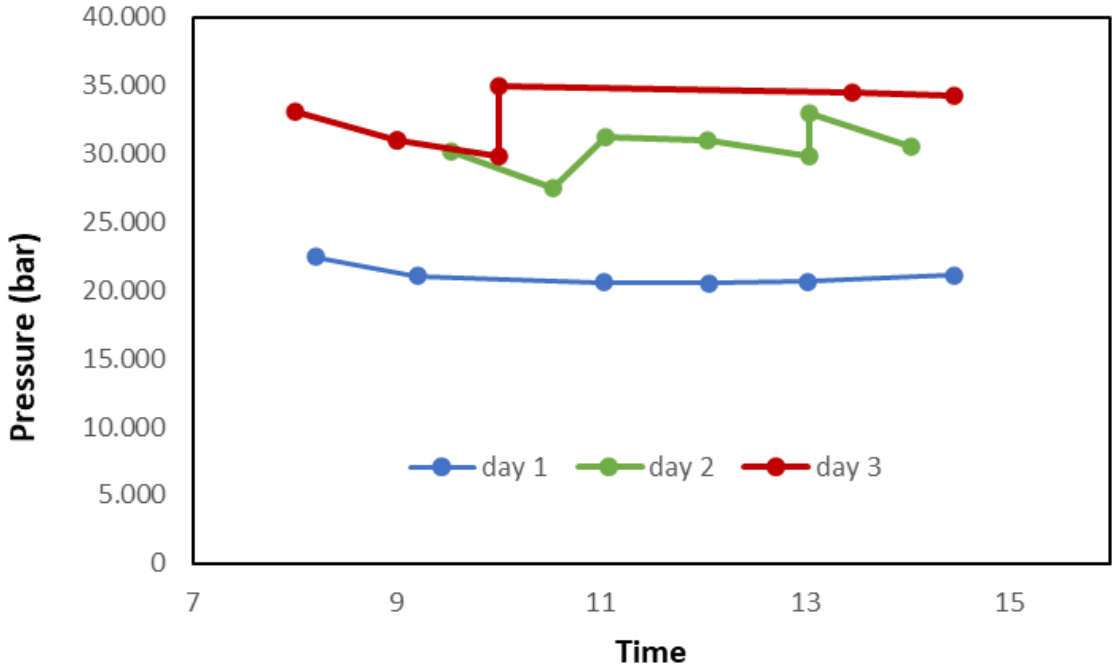
Preassembled MEA

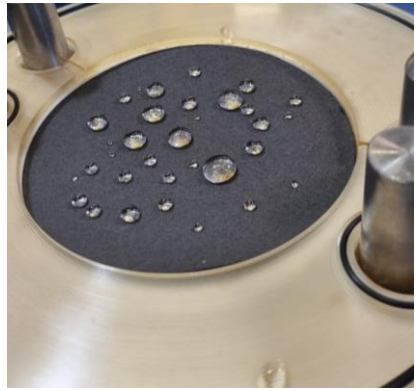
2nd Full stack (10 cells)

Hydrostatic pressure test



Example: setup for pressure test





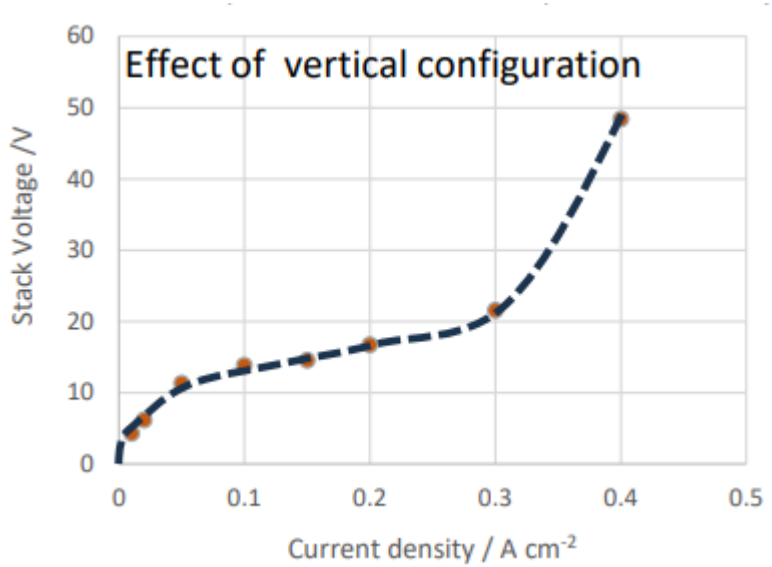
Succesfull 35 bar Pressure test (10 cells)

- Repressurazation (H_2O) needed, slow
- Hydrophobic substrate

Stack Testing

Vertical Orientation

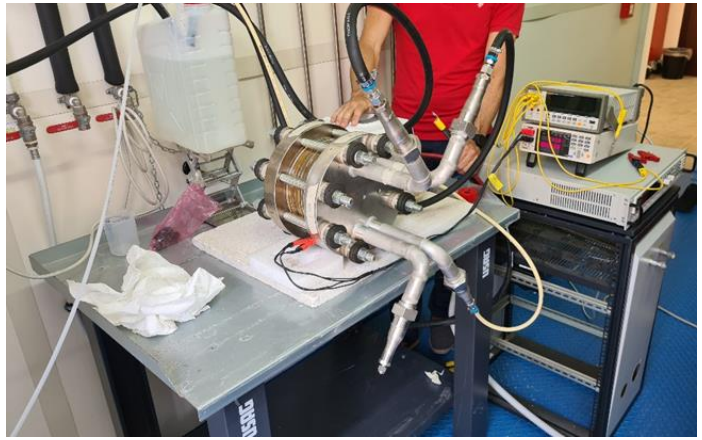
ANIONE Stack tested under ambient pressure under vertical configuration with KOH recirculated to the anode. Cell numeration



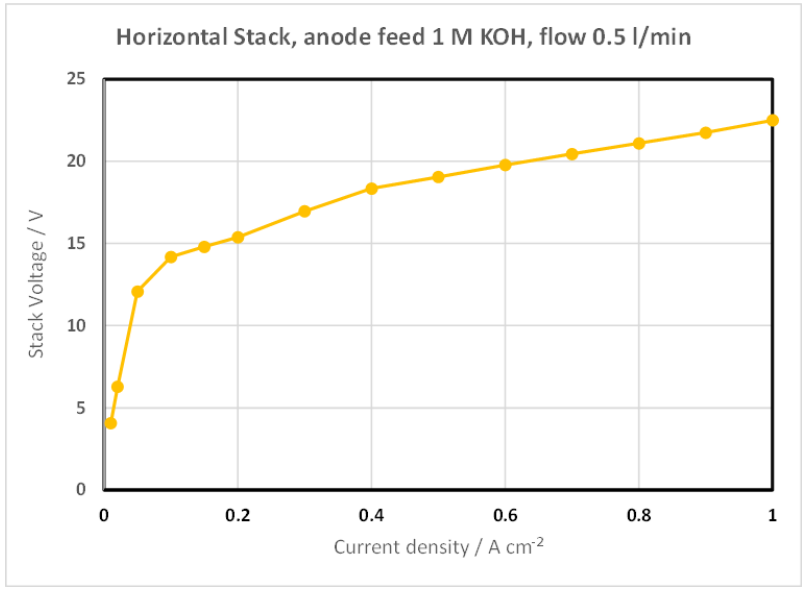
Drastic mass transfer limitations observed.

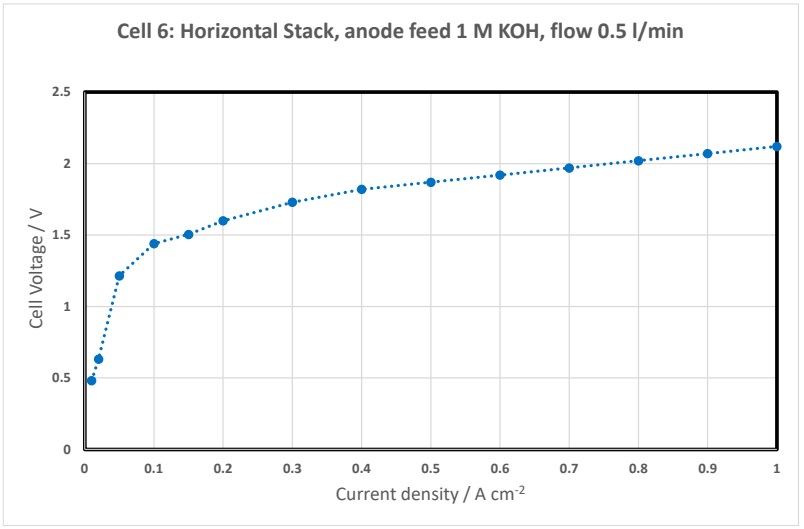
Stack Testing

Horizontal Orientation



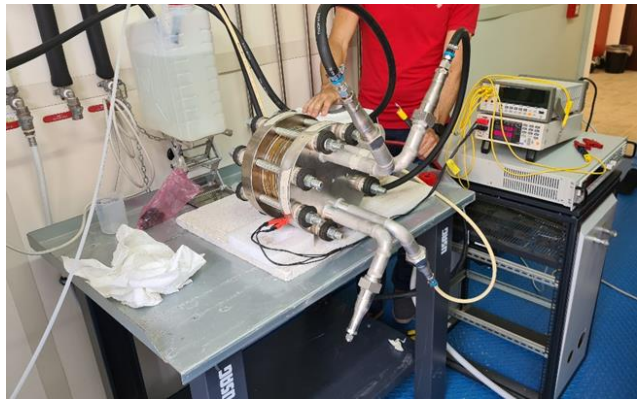
ANIONE Stack tested under ambient pressure under horizontal configuration with KOH recirculated to the anode. Cell numeration: 1 to 10 from back to front.
ANIONE Stack tested under ambient pressure under horizontal configuration with KOH recirculated to the anode. Cell numeration: 1 to 10 from back to front.





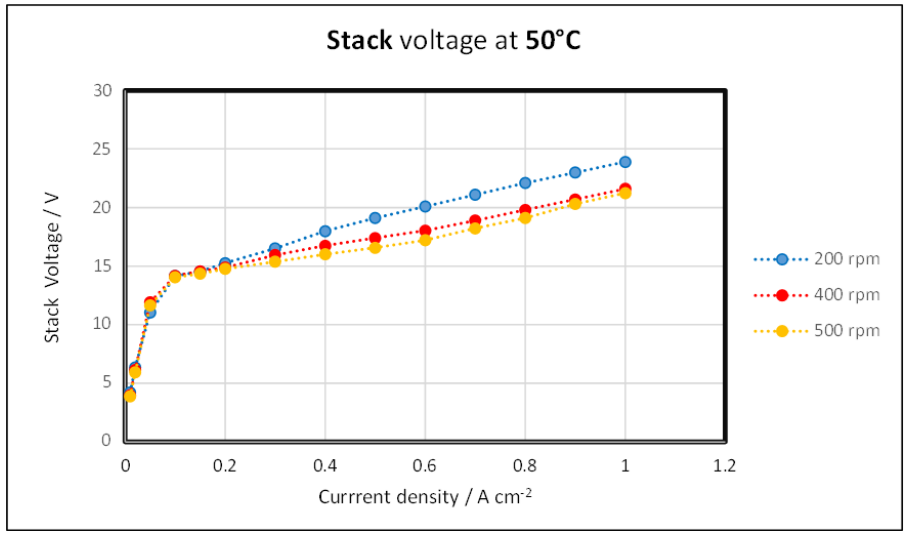
Stack Testing

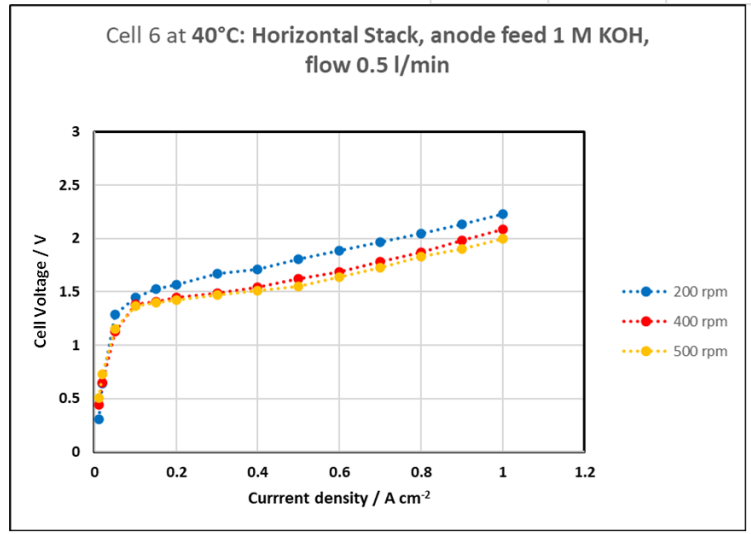
Effect of flow rate



ANIONE Stack tested under ambient pressure under horizontal configuration with KOH recirculated to the anode. Cell numeration: 1 to 10 from the bottom to the top. Top corresponds to the stack plate integrated with the pipelines. KOH inlet on the bottom

rpm	flow
200	0.5 l/min
300	0.75 l/min
400	1 l/min
500	1.25 l/min



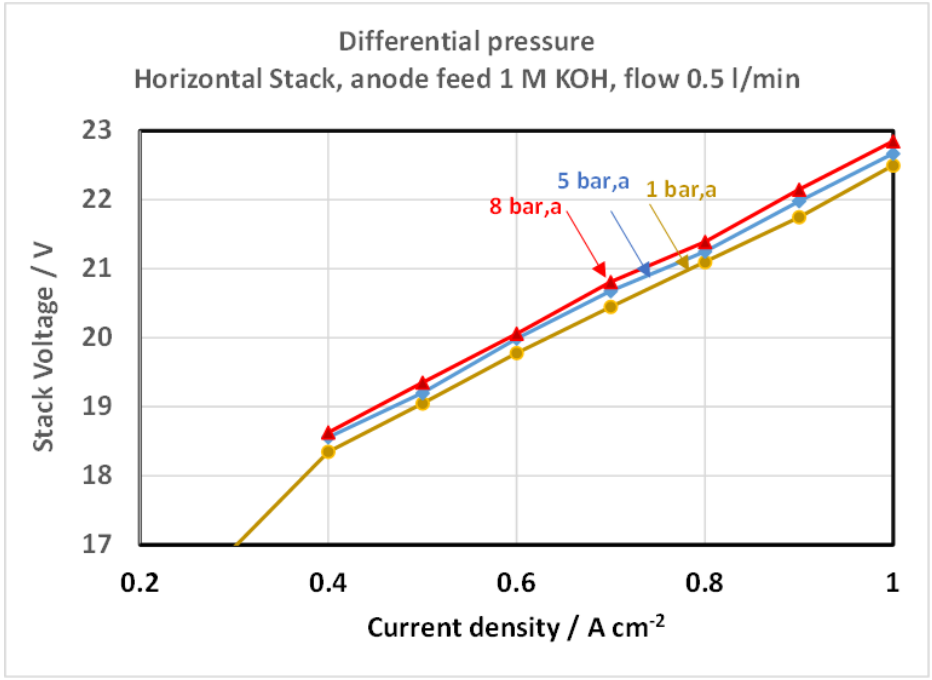


Increased flowrate leads to improved performance

Stack testing

Effect of Pressure

ANIONE Stack tested under differential pressure mode under horizontal configuration with KOH recirculated to the anode. KOH inlet on the bottom

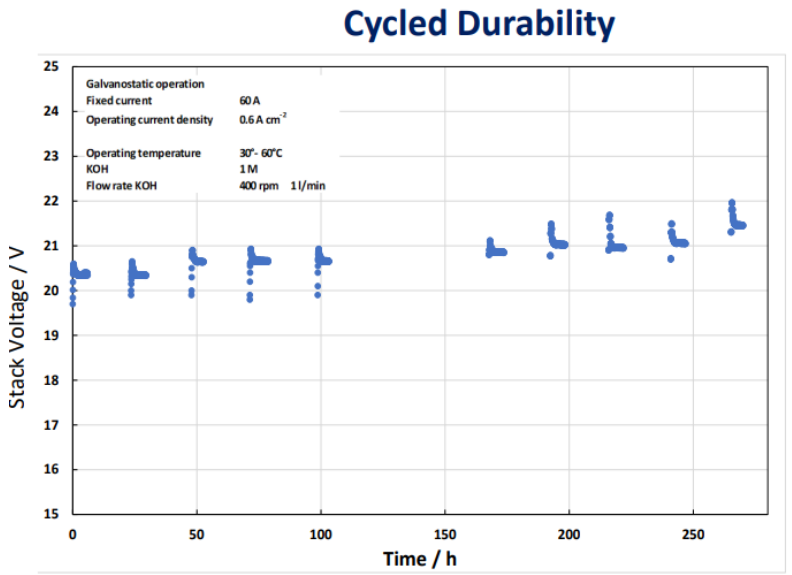


an increase of stack voltage mainly associated to the Nernst law effects but no relevant increase of mass transfer issues.

Stack testing

Effect Cycling (Durability)

ANIONE Stack tested under differential pressure mode under horizontal configuration with KOH recirculated to the anode. KOH inlet on the bottom



Voltage increase and production decrease in second week (membrane damage?)

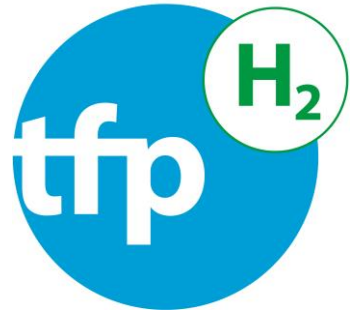
Stack testing

Parameter	Result	Target
Stack Performance	21 V for the stack (i.e. ~2.1 V/cell) at 1 A cm^{-2} (100 A) at ~ 50 °C with recirculation rate of 1M KOH 1.25 ml/min/cm^2	1.8-2 V/cell at 1 A cm^{-2} –MS10
Voltage efficiency	71% vs. HHV at 1 A cm^{-2} (100 A) at temperatures up to 50 °C with recirculation rate of 1M KOH 1.25 ml/min/cm^2	86% vs. HHV –MS10
Stack Capacity	0.398 ± 0.0.05 Nm^3/h at 1 A cm^{-2} (100 A)	Hydrogen production rate > 0.4 Nm^3/h –MS10
Faradaic efficiency	97 % at 1 A cm^{-2} (100 A)	>99 % at 1 A cm^{-2} –MS7
Stack Energy efficiency	69 % vs HHV	80 % vs HHV –MS11
Stack energy consumption of about 57 kWh/kg H_2	57 kWh/kg H_2	50 kWh/kg H_2 –MS11
Stack power	>2 kW	2 kW (10-cells with 100 cm^2 active area) –MS10

Stack testing

- Dissassembly and post investigation to be conducted on 1st full stack
- 2nd stack assembled to be tested

Thank you!



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