

Molten Carbonate Fuel Cells Research Capabilities

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Overview

Experimental activities on Molten Carbonate Fuel Cells are performed at our laboratories. Different aspects during fuel cell operation are deeply investigated in collaboration with our partners. Different Test Facilities are available at ERSE/AFCo, suitable for single cells, subscale stacks or full scale power systems.

Goals

Development of shared Test Procedure to characterize the performance of a single component or the entire system

I. General

Single cell

ERSE lab, Milan (MI - Italy)



certainty analysis and tight control of the operating parameters have been considered to achieve research goals. Each component has been designed in order to limit the calculated uncertainty below defined values.

Uncertainty of single cell voltage measure: 3 mV

Sub-scale stack

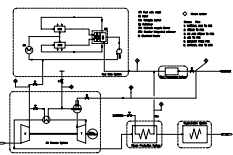
ERSE lab, Milan (MI - Italy)



Uncertainty of single cell voltage measure: 5 mV
Uncertainty of stack voltage measure: 0.1 V

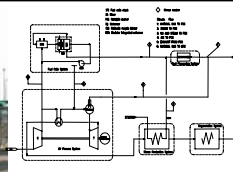
Full-scale stack

GP2 hybrid MCFC-MTG - AFCo, Bosco Marengo (AL - Italy)



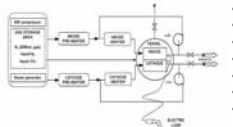
- 2 Stacks
- Horizontal vessel
- 1 M.I.R. (modular integrated reformer)
- 1 Cathodic blower
- 1 Electrical heater (for start-up)
- 1 Microturbine Turbec T100
- Nominal power: 250 kW
- Operative pressure 3.5 bar(a)
- Operative temperature 650 °C

TECNODEMO hybrid MCFC-MTG - AFCo, Bosco Marengo (AL - Italy)



- 1 Stack
- Horizontal vessel
- 1 M.I.R. (modular integrated reformer)
- 1 Cathodic blower
- 1 Microturbine Turbec T100
- Nominal power: 100 kW
- Operative pressure 3.5 bar(a)
- Operative temperature 650 °C

NIC conditioning and test facility for full scale stacks - AFCo, Terni (TR - Italy)



- Allows different stack sizes
- Horizontal vessel
- High temperature anodic blower
- High temperature cathodic blower
- Operative pressure 2-5 bar a.
- Operative temperature 600-700 °C
- Gas from storage to simulate different operating conditions
- Allows stack conditioning

Performance III. Main Focus

Steady state test on single cell and sub scale stack

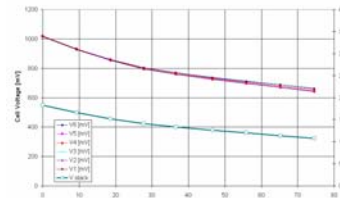
200-300 h at fixed load: checking of the variability of operating parameters

parameter	units	% var.
V_i	mV	0.31
A_i	A	0.03
T_i anode	°C	0.09
T_i cathode	°C	0.07
H_2 anode	Ncc/min	0.04
N_2 anode	Ncc/min	0.04
CO_2 anode	Ncc/min	0.10
O_2 cathode	Ncc/min	0.04
N_2 cathode	Ncc/min	0.03
CO_2 cathode	Ncc/min	0.02
H_2O anode	g/h	5.07

parameter	units	% var.
V_{stack}	V	0.21
I_{stack}	A	0.05
$V_{single\ cell}$	mV	0.72
$T_{Manifolds}$	°C	0.17
$T_{single\ cell}$	°C	0.55
H_2 anode	NI/h	0.12
CO_2 cathode	NI/h	0.08
N_2 anode	NI/h	0.26
CO_2 anode	NI/h	0.11
N_2 cathode	NI/h	0.24
Air cathode	NI/h	0.02

Load variable tests

Different conditions are tested on single cell and stack:

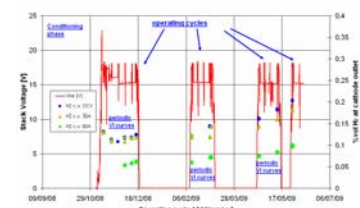


1 kW stack power curve

- Oxidant utilization at fixed load
 - Fuel utilization (FU) at fixed load
 - VI curve at constant gas flow rates
 - VI curve at constant FU (power curve)
- 30-60 min each single step (1pt/min)

Investigated ranges:
0-200 mA/cm² Current Density
20-80% reactants utilization

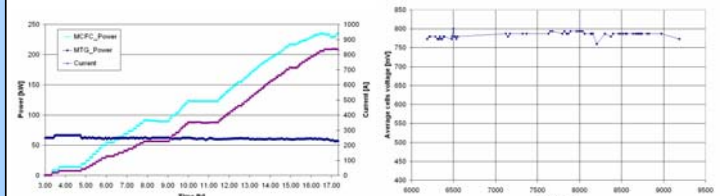
Thermal cycling test on sub scale stack



Procedure:
500 h hot time cycles with periodic VI curves at constant gas flow rates

- Main investigated parameters:
- iR measurement
 - H₂ or other specific tracer (He, N₂) cathode and anode crossover
 - Performances and repeatability

Full scale tests

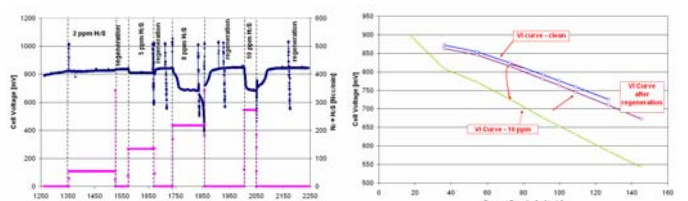


Integrated performance test of GP2 Hybrid Plant fed by natural gas

Long steady state test (3000 h) of TECNODEMO plant fed by natural gas

Pollutants effects on performance and life

First stage development of H₂S anode poisoning procedure on single cell



Poisoning procedure

- N₂ at anode substituted with N₂+H₂S
- Poisoning phase at 100 mA/cm² -75 h at least
- Recovery phase with pure gases at 100 mA/cm²
- Periodic VI curves during poisoning and after recovery

Preliminary results

- 20 ppm_v stream: irreversible damages
- 1-10 ppm_v almost complete recovery is noticed
- Repeatability of performance decreasing
- Influence of poisoning procedure