A PEMFC Stack with Extended Operating Temperature Range up to 120 °C

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Why extended temperature range?
- stack for automotive applications: able to perform transient operation at high load even with critical cooling conditions (higher power required → higher heat production):
  - long uphill drive
  - driving in hot areas, e.g. deserts (reduced cooling)
- downsizing of cooling system:
  - lower cooling power is necessary (increased heat dissipation) if higher stack temperature is allowed
  - shorter cooler operating time (energy/fuel saving)
  - smaller cooler size (space/weight saving in vehicles)

Wide-temperature-range stack goals
- development of a PEMFC stack:
  - 2.5 – 5 kWel (module)
  - 30 – 60 cells
- feasibility of WTR-conditions:
  - extended temp. range up to 120 °C
  - 20 temperature cycles feasible – duration of each cycle: 65 min → aim: reversible maximum power loss at 120 °C with unmodified humidification: 30 %
- durability test:
  - long-term test over 1000 h

Assembling of 30-cell stack
- single cell voltage behaviour during long-term test at 70 A (0.49 mA/cm²):

Experimental results

Polarization curve

- high homogeneity of 30 single cell voltages
- all 30 cells are fed homogeneously with reactants

Long-term test
- > 1000 h at 70 A: output power 1.5 kWel
- degradation rate nearly constant: linear voltage drop
- 16 % power loss in 1000 h (ca. 250 W, 3.5 V)

Thermal cycles 90–120 °C
- 20 thermal cycles at 70 A (0.49 A/cm², 1.5 kW)
- cycle duration: 1:05 h → 45 min transient operation (90 → 120 °C) + 15 min cool-down (120 → 90 °C) + 5 min recovery (90 °C)
- gas humidification: on both sides 100 % at 90 °C (cycle start), then no variation
- goal: max. 30 % power loss within a cycle

Information obtained on:
- reversible power loss within a cycle → membrane drying
- irreversible degradation → stack stability over all cycles

- stable reversible power loss within a cycle: 21 ± 1 %
- irreversible stack power loss at 90 °C: 33 W in 22 h → < 0.1 %/h, 1.5 Wh or 50 mW(h-cell)
- good stack stability over all cycles

Irreversible stack performance drop is small enough for automotive applications

Outlook: water management considerations
- determination of gas humidity at stack gas in/outlet for anode and cathode (4 sensors)
- shorter stack with 15 cells, 1.25 kWel
- steady state measurements:
  - I: 0.33, 0.66, 1.00 A/cm²; RH: 30, 55, 80%
  - goal: mathematical correct balancing model of incoming, outgoing and produced water verified by experimental results

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Knowledge for Tomorrow

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