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Control and experimental characterization of a methanol reformer for a 350W HTPEM FC system

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- System specifications of the Serenergy H3-350
- Experimental setup
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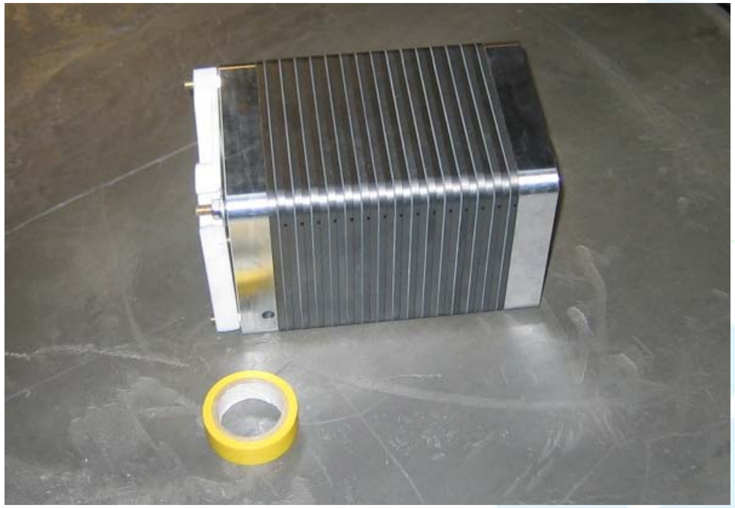
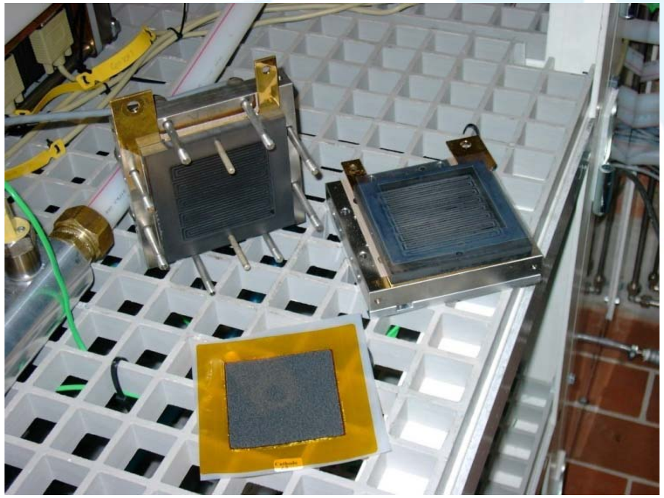
High temperature PEM fuel cells





High Temperature PBI based PEM Fuel Cell

- Membrane polymer: PBI (polybenzimidazole)
- Proton conductor : H_3PO_4 (Phosphoric acid)
- Fuel cell temperature: 120-200 ^{o}C
- Typical operating range: 160-180^{o}C

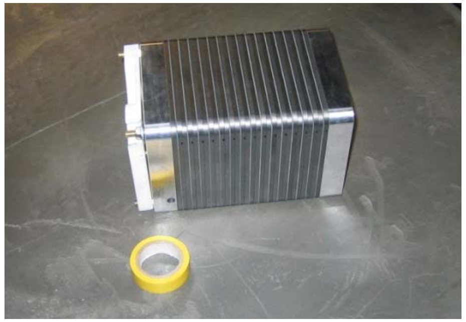
Advantages

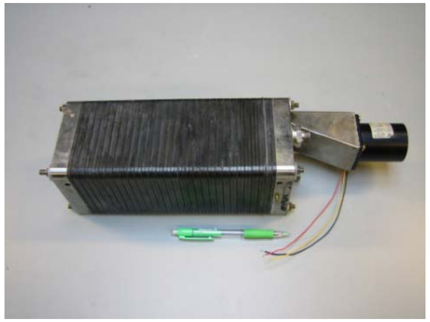
- Less complex than <100ºC membranes
- CO tolerant up to 2-3%
- No humidity control = Simple stack and system design
- Cooling possible at all ambient conditions

Disadvantages

- Lower cell voltage than LTPEM
- Long start-up time because of high temperature
- Liquid water should not e present

From prototype to commercial product





www.serenergy.dk

Integrated methanol reformer high temperature PEM fuel cell system

Mobile Battery Charger

System specifications:

DC/DC converter controlled output

Rated output power	350W
FC stack voltage	21-28.5V
Max. current	16A@21V
Stack Cooling	Cathode air cooled

Operating conditions:

Fuel composition 60%vol methanol 40%vol water

Fuel consumption	440 mL/hr
Evaporator temperature	≈170^{o}C
Reformer temperature	200-300^{o}C

System parameters

Weight	13.7 kg
Volume	27 L

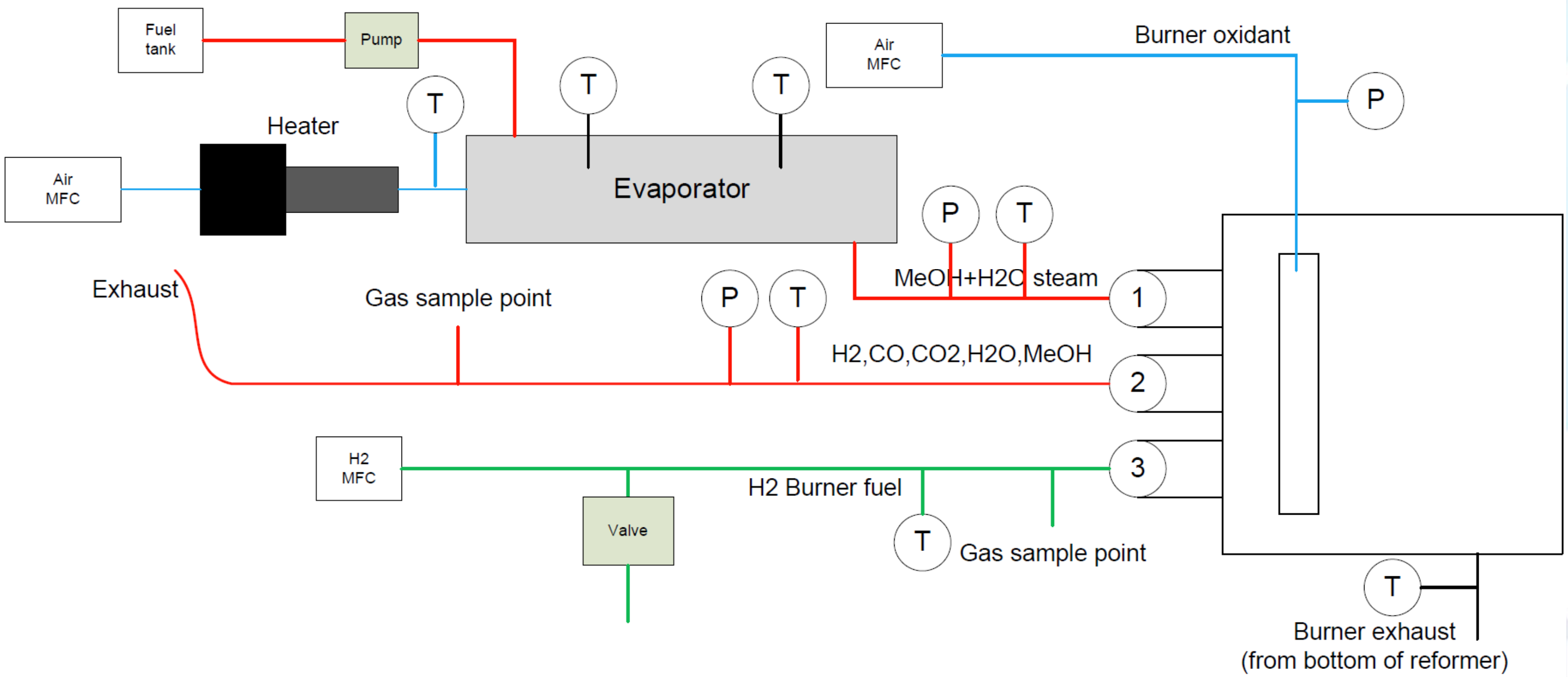
Experimental system layout using H3-350 reformer and evaporator

Heat demand:

FC stack cathode exhaust is during normal operation used to supply heat for the evaporation process. A burner is integrated in the reformer to supply heat for the steam reforming process using anode excess H_2.

Experimental setup:

FC stack cathode exhaust is emulated using a mass flow controlled heated airflow.
Burner hydrogen is supplied by a mass flow controller in order to characterize the reformer system.



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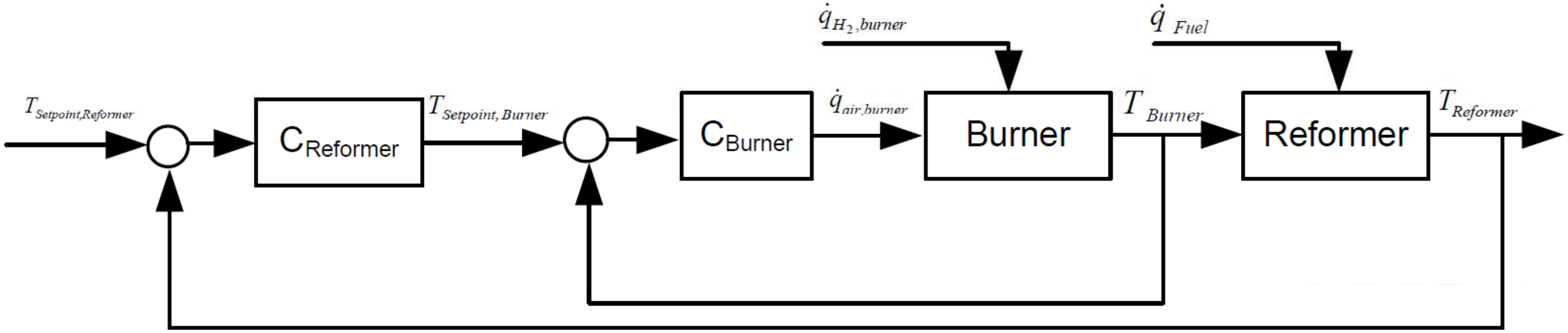
Critical system parameters and events

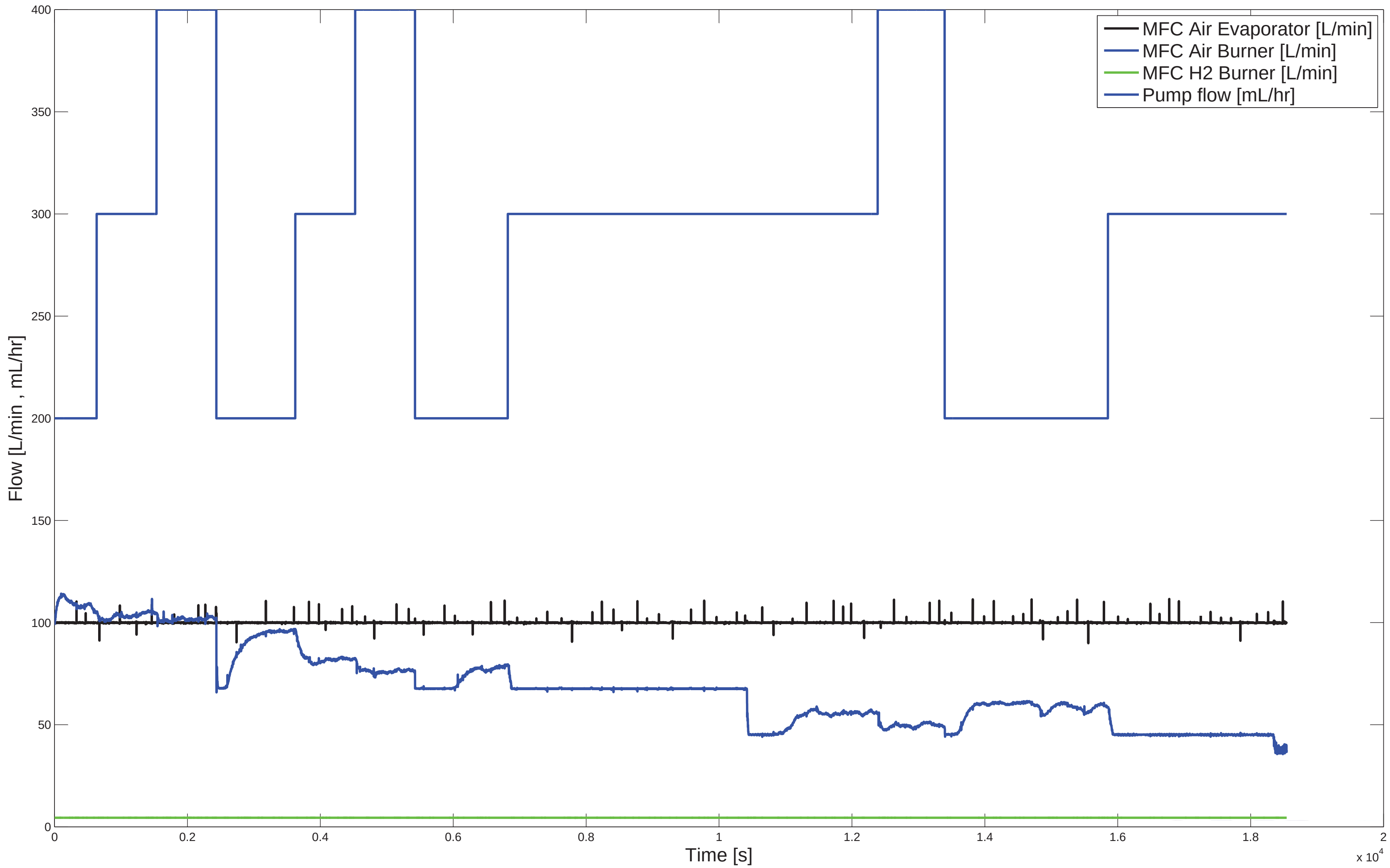
- Open circuit operation
- Fuel starvation (**prediction of excess fuel cell anode hydrogen**)
- Minimum Air/Burner fuel ratio to avoid flash-back
- Reformer temperature control

Reformer temperature control

- Temperature controlled by adjusting burner air flow
- Cascade control structure
    - Inner Burner control loop
    - Outer Reformer catalyst bed control loop



System input flows



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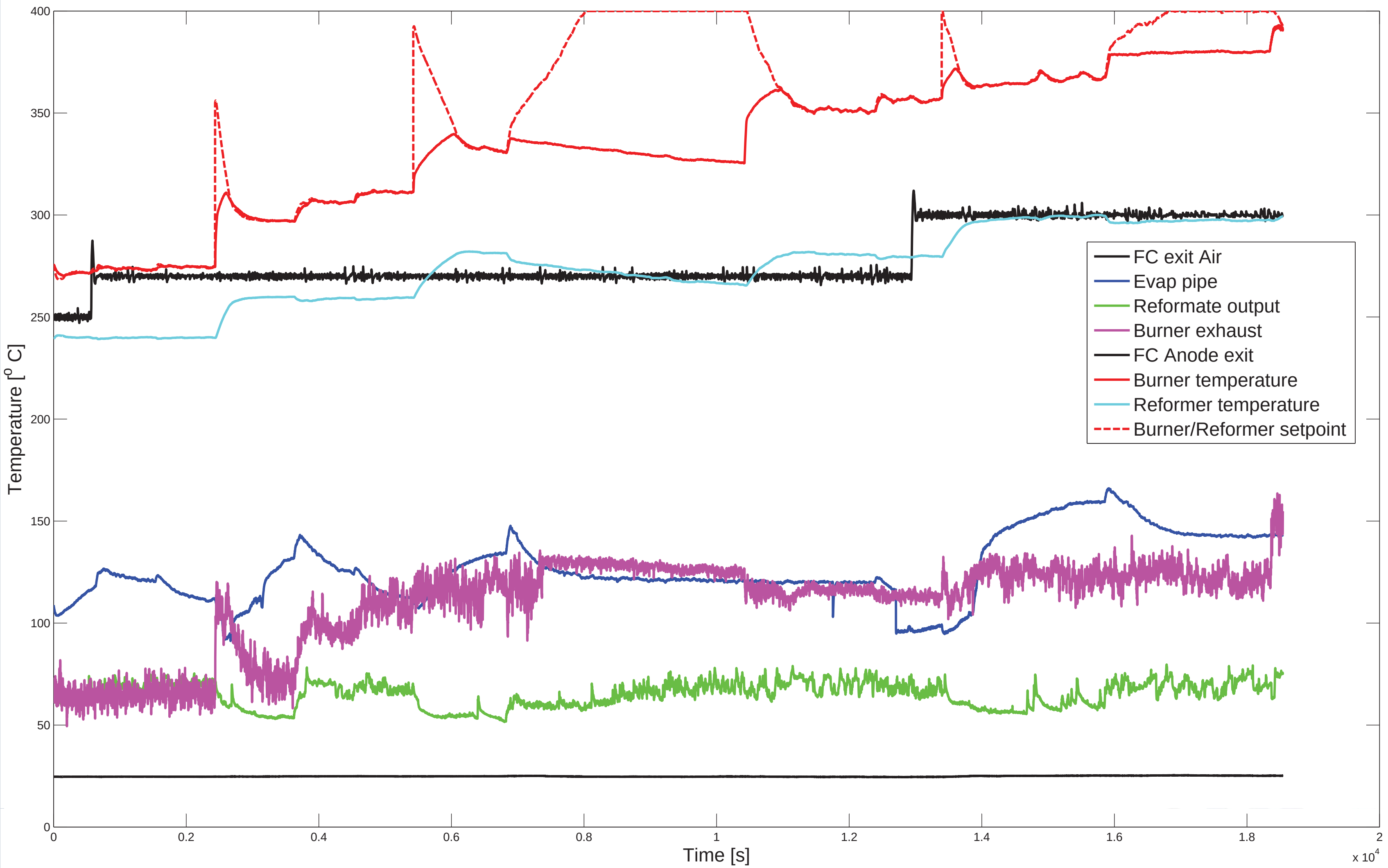
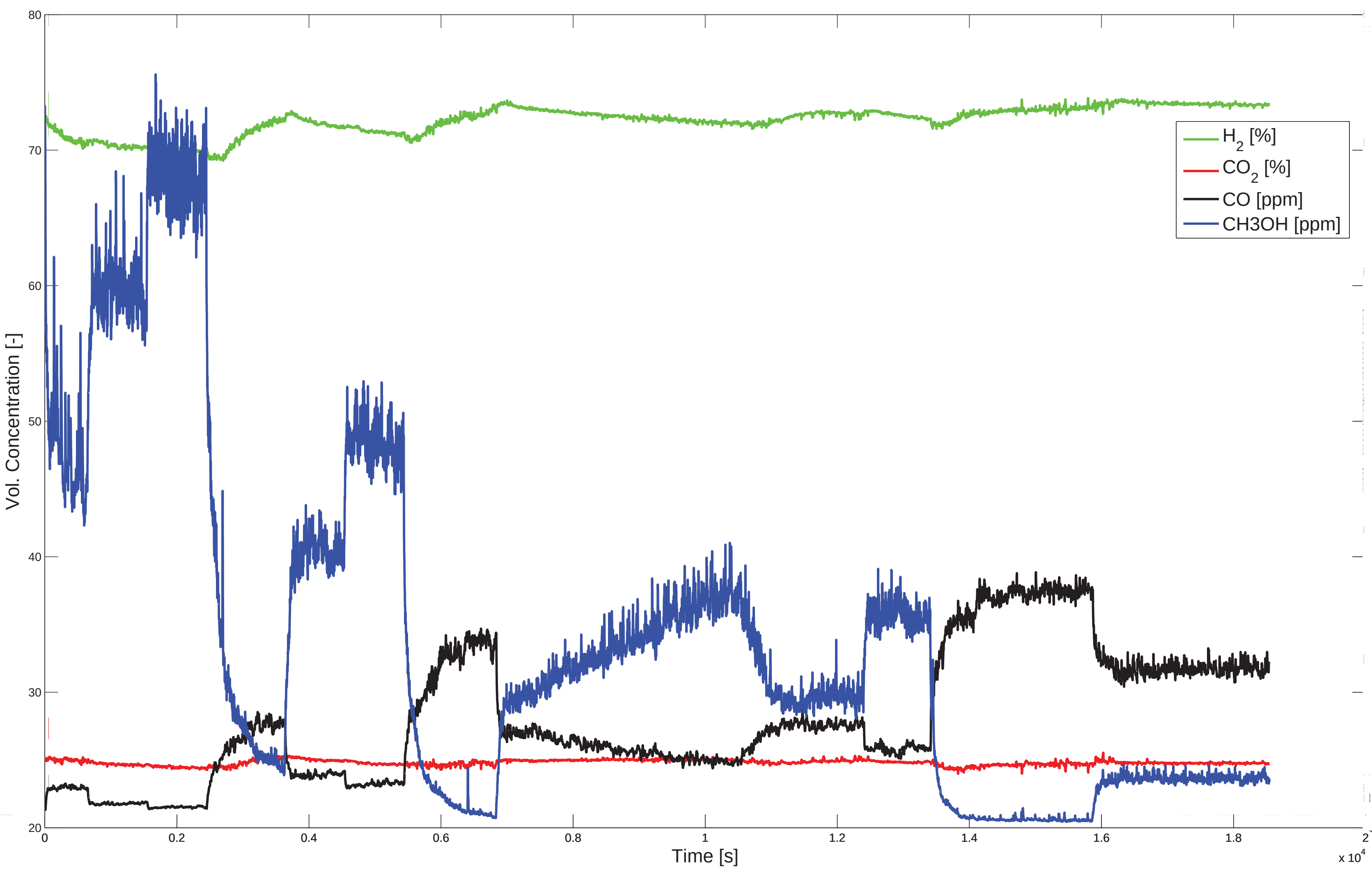
System temperatures



Reformate gas compostion



Summary and Outlook

Conclusions

•The developed experimental setup makes it possible to conduct a detailed transient characterization of the methanol reformer system, by independently enabling the control of the evaporator and burner.

•System is tested with the developed control strategy at different temperatures and methanol pump flows, showing stable predictable operation.

•The CO level is within acceptable ranges for HTPEM FC operation, but increased FC operating temperatures are suggestable for increased system performance. And short transient excursions to high CO values need to be taken into account (Effects of methanol slip are to date unresolved but under examination).

Future work

•Experimental integration of fuel cell and reformer.
•Analysis of system operating range. Minimum fuel pump flow vs. evaporator heat demand.
•Analysis of transient system capabilities, development of simulation models.
•Optimization of system control structure with respect to disturbances
  - Load change rates
  - Efficiency
  - Low CO content.

•Online prediction of important system states usable a control parameters.
•Simulation of full fuel cell reformer system for use in different application cases.
•**5kW reformer / fuel cell system testing.**

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