On the Anode Exhaust Gas Recirculation of PEM Fuel Cells using passive Ejectors

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Ejectors for efficient FC-Systems

- Advantages (compared to active recirculation with a blower):
  Simple structure, low weight, high durability, no power consumer
  (→ maximum increase of the system efficiency ~ 2.8 %)
- Challenges:
  Passive device with a fixed geometry, wide mass flow range of the PEMFC, recirculation of a multi-component mixture

Modeling - single choking ejector

- Stationary, 0-D and single-phase model implemented in Matlab® [1]
- Calculation of p, T, c, a, Ma and RH at each specified state point

Modeling is indispensable to gain a basic understanding of the thermodynamic processes in the ejector and its operating behavior

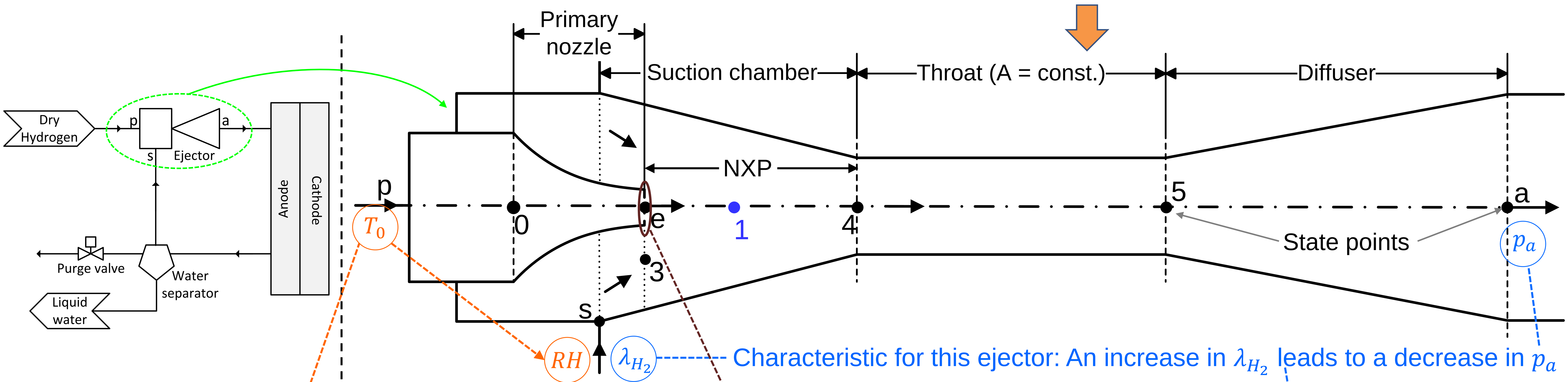


Figure 1: Simplified sketch of the anode circuit with passive recirculation (left) and the considered single choking ejector (right) [1].

Higher ejector performance (and better prevention of condensation) by heating with the waste heat from the PEMFC

An underexpanded jet is advantageous

The diameter of the primary nozzle outlet is a critical design parameter for the ejector performance.

The isentropic efficiency of the primary nozzle has a major influence on the ejector performance

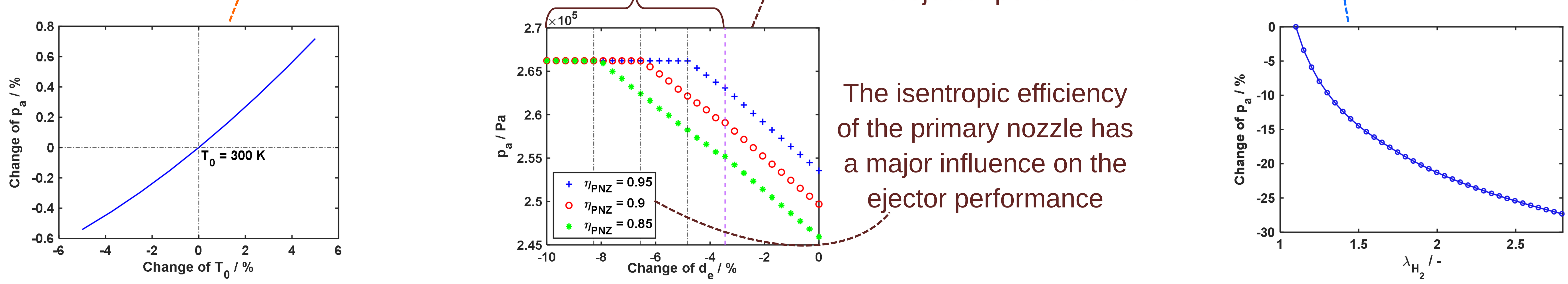
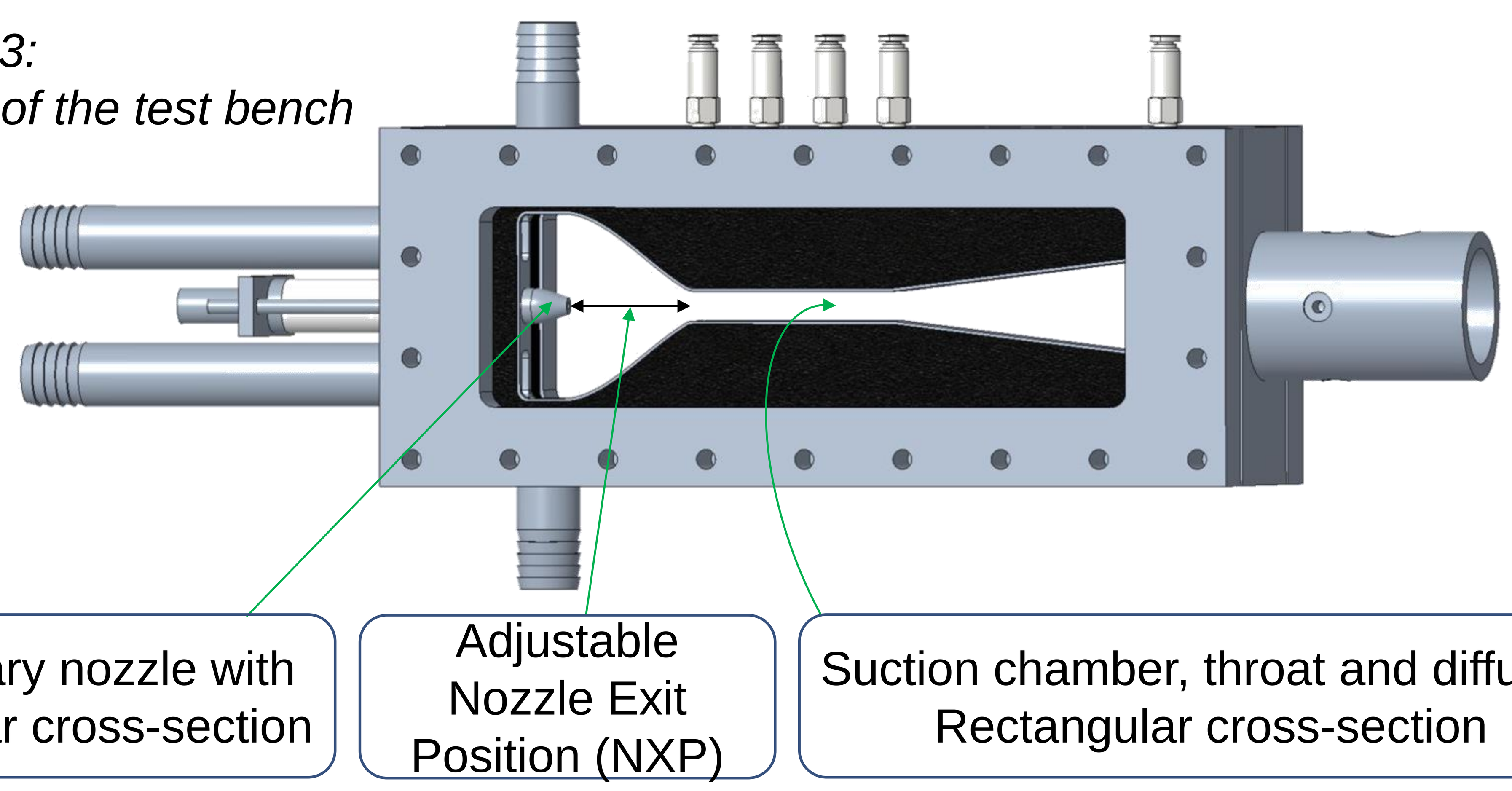


Figure 2: Simulation results (qualitatively): Dependence of the ejector outlet pressure on the temperature of the fresh hydrogen (left), the primary nozzle throat diameter (middle) and the stoichiometric factor of hydrogen (right) [1].

Optically accessible ejector for experimental validation

Figure 3: Set up of the test bench



What do we need to measure?
- Pressure
- Mass flow rate
- Temperature
- RH

Optical accessibility for *in situ* measurements:
- Structure of the primary jet behind the nozzle outlet
- Mixing of primary and secondary flow
- Possible condensation effects

Conclusions & Outlook

Simulation model:
- Calculation of specific operating points → Determination of the operating range of the PEMFC in which the ejector can be used
- Sensitivity analysis: Potentials and limitations for the ejector operation

Experimental validation:
- Thermodynamic analysis: Achievable pressure rise, required throat length
- Determination of suitable calibration values for the simulation model

→ Aim: Design tool for ejectors by combining modeling and experiments

Literature

[1] Lindacher N, et al. *Development of an Ejector Model for PEMFC Systems*. Submitted to Fuel Cells : From Fundamentals to Systems. Paper is still in review; 2024.

Acknowledgements

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