Modeling of ejectors applied in PEMFC systems

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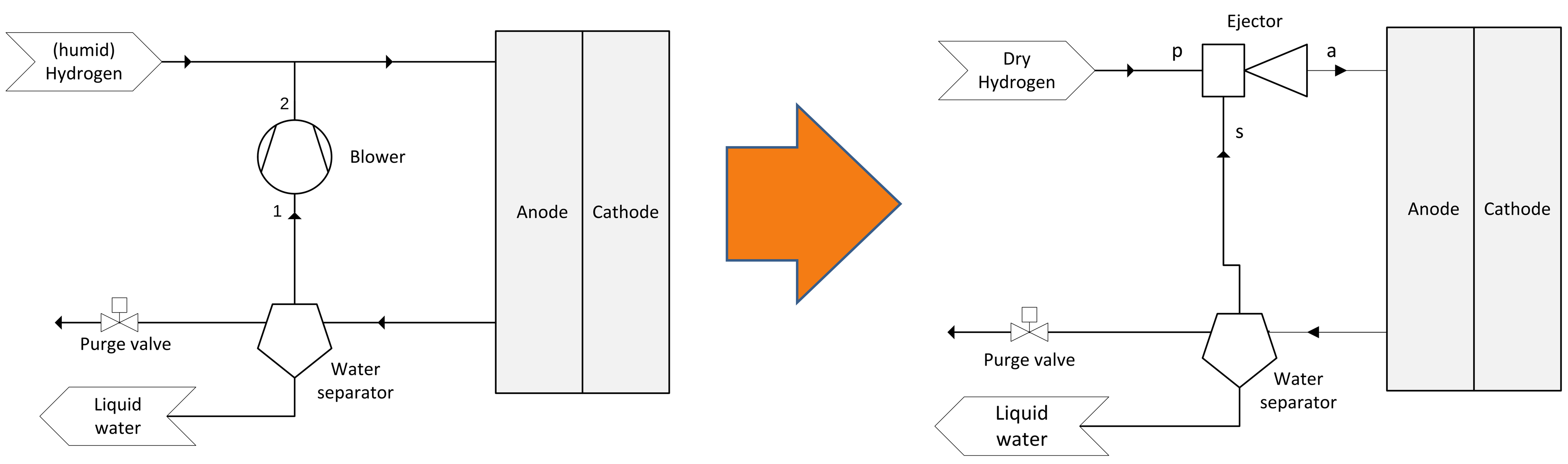
How ejectors increase efficiency

- Operation of PEMFCs with $\lambda_{H_2} > 1$ requires a recirculation of the unconsumed hydrogen to achieve high fuel utilization efficiencies [1]
- Substituting active recirculation with a blower (Figure 1, A) by passive recirculation with an ejector (Figure 1, B) saves electrical power → the system efficiency increases

A Active recirculation

B Passive recirculation



Maximum increase of the system efficiency:

$$\eta_{increase} = \frac{(\lambda_{H_2}-1)\cdot\frac{\kappa}{\kappa-1}\cdot\frac{R_m}{M_{H_2}}\cdot(T_2-T_1)}{H_u} \approx \begin{cases} 0{,}12\ \% \ @\ \lambda_{H_2} = 1{,}5 \\ 2{,}7\ \% \ @\ \lambda_{H_2} = 12 \end{cases}$$

→ Dependent on the choice of λ_{H_2}

Figure 1: Schematics of the anode circuit: Active recirculation (A) vs. passive recirculation (B)

Model setup and results

- Implementation of stationary, 0-D and single-phase ejector models in Matlab®; consideration of fixed geometry ejectors
- Thermodynamic analysis of three basic ejector operating strategies → in Figure 2: Single choking mode
- Calculation of pressure, temperature, velocities, relative humidity and geometric parameters at each specified state point

The ejector performance - in terms of the achievable ejector outlet pressure - depends on the values of the operating parameters of the FC stack, i.e. the temperature, pressure and RH at the anode outlet, as well as the electric load and the stoichiometric factor.

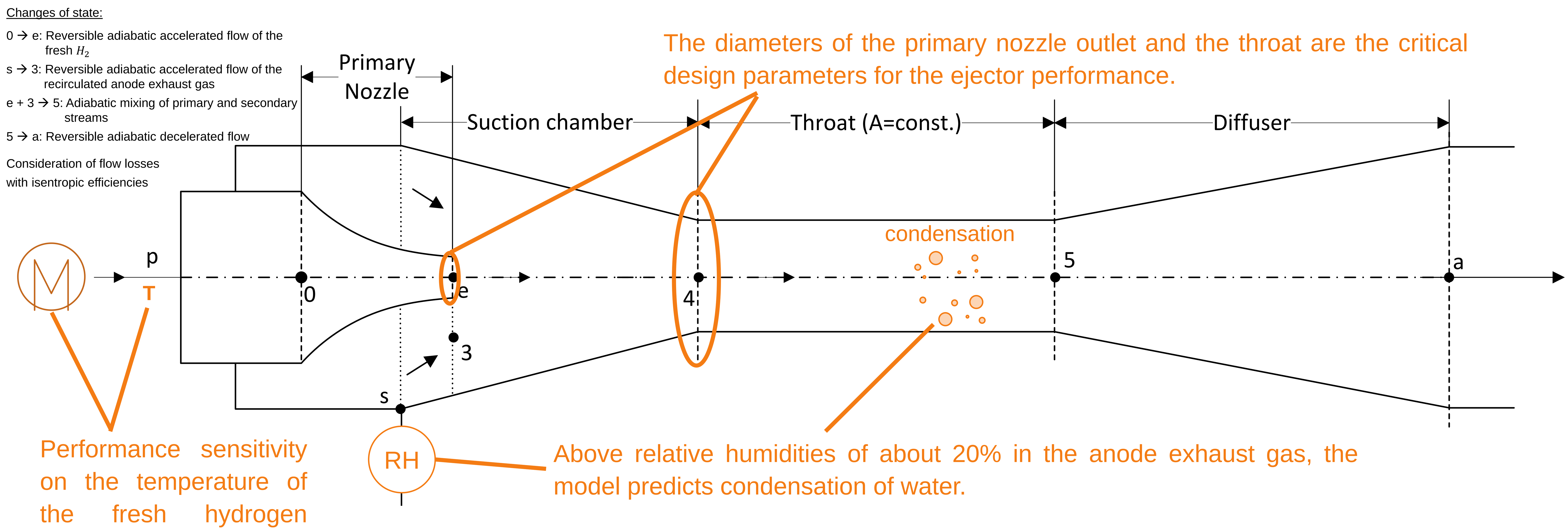


Figure 2: Structure of the single choking ejector (according to [2])

Outlook

- Performing of further simulations also on the other two operating strategies: Double choking [3] as well as single choking in Figure 3
- Experimental validation of the simulation tool on optically accessible ejectors
- Identification of the most appropriate ejector type with the best technical feasibility and adaptation to the fluctuating operating conditions of the FC stack

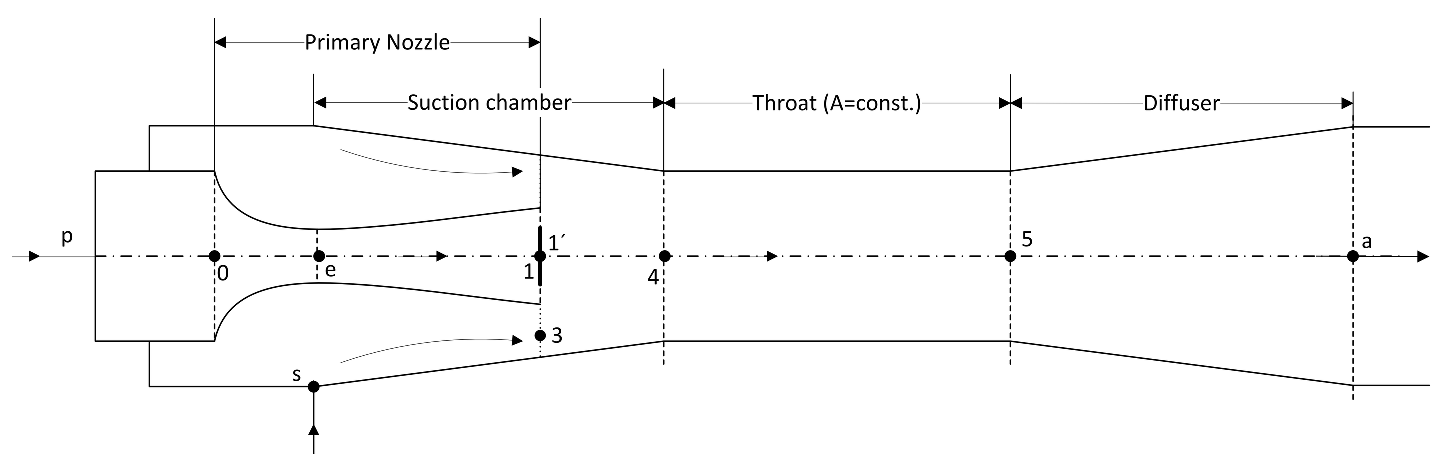


Figure 3: Structure of the single choking ejector with a shock in the outlet cross section of the primary nozzle

Literature

[1] Barbir F. PEM fuel cells: Theory and practice. 2nd ed. Amsterdam: Elsevier/Acad. Press; 2013.
[2] Flügel, Gustav. Berechnung von Strahlapparaten, VDI-Forschungsheft 395; 1951.
[3] Huang B.J, Chang J.M, Wang C.P., Petrenko V.A. A 1-D analysis of ejector performance. International Journal of Refrigeration; 1999.

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