Meshfree Simulation of Water Transport in the Cathode Path of Fuel Cells

virtual vehicle

Motivation

- PEM fuel cells need controlled air humidity (~80 %)
- Water generated by fuel cell is removed through the cathode path
- Water droplets at high velocity erode components at cathode path

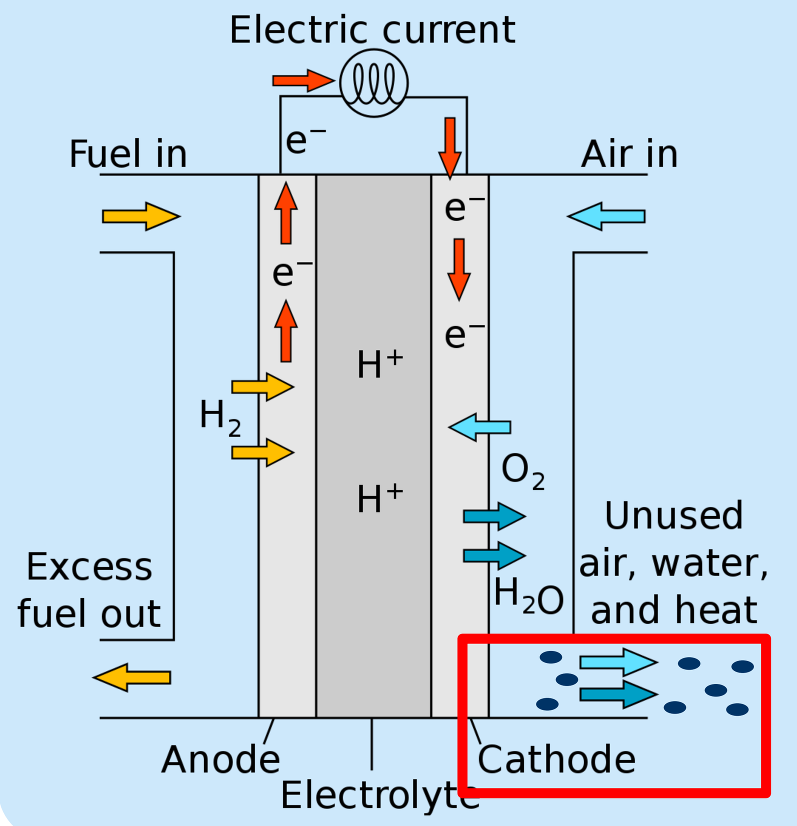
Project goal

- Simulation of water transport in cathode path

Methods

- Measurements on testbenches and fuel cell stacks
- Simulation with meshless method MESHFREE

Principle of a fuel cell



Anode:

$H_2 \rightarrow H^+ + e^-$

Cathode:

$H^+ + e^- + O_2 \rightarrow H_2O$

H_2O is transported away at the cathode path alongside the unused part of the air.

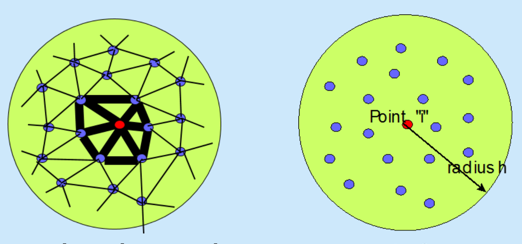
Setup

Measurement

A test plate (a) is positioned in front of a nozzle (c). Water is pumped through a hole with a syringe pump (b) from below. Cameras (d, e) are used to capture images of the liquid in the shear flow from the top and side.

Simulation

Meshfree simulates a fluid body as a cloud of freely moving information carriers, which makes it well suited for free surface flows.

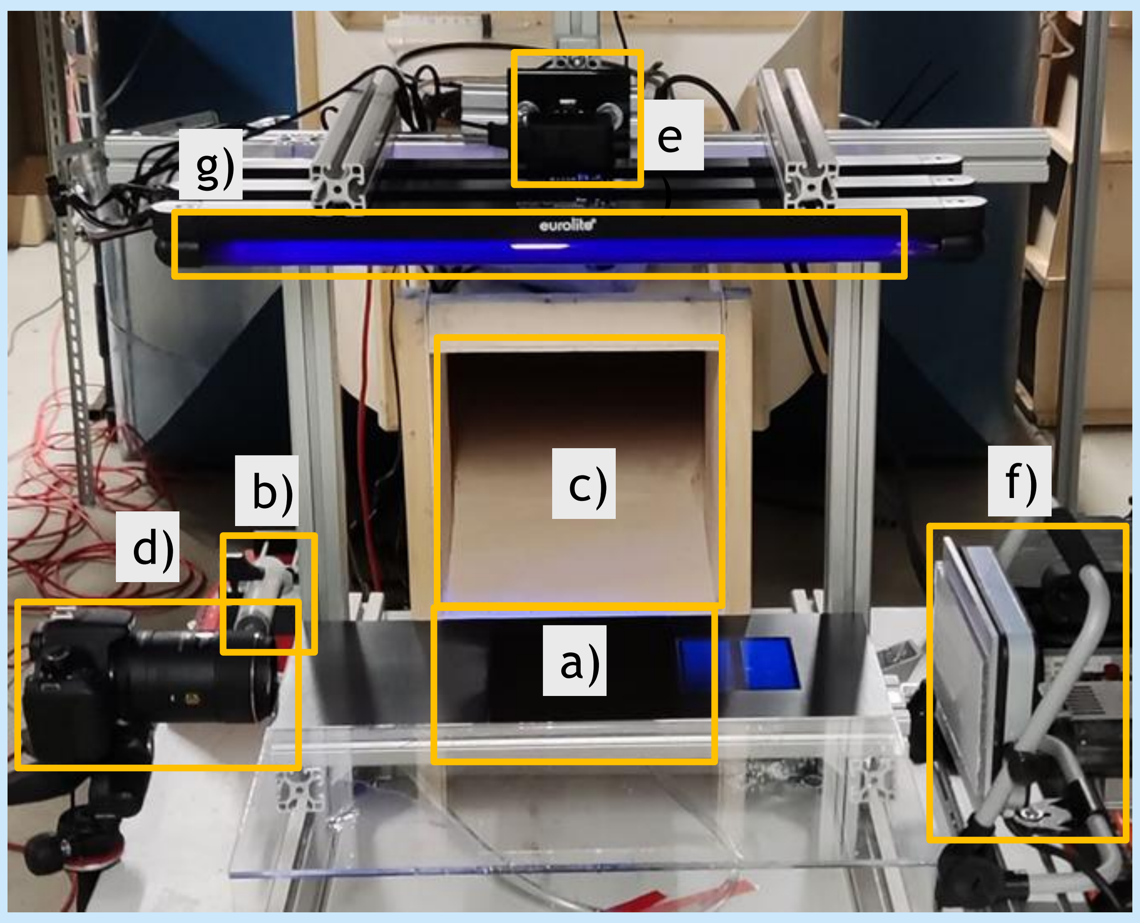


Standard mesh   Meshfree

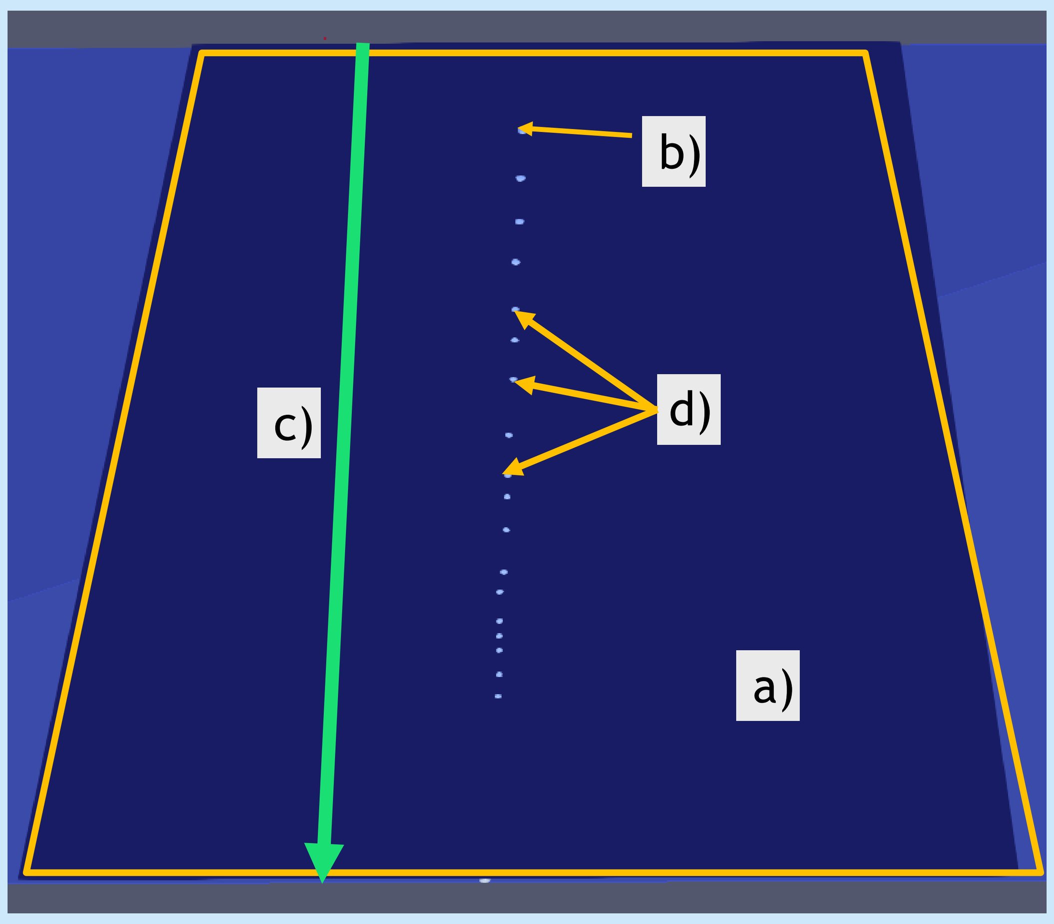
Parameters

- Surface: Varnished
- Air velocity: 22 m/s
- Water vol. flow: 1 & 15 ml/min

Measurement



Simulation



Legend

Measurement
- a) Test plate
- b) Syringe pump
- c) Wind tunnel
- d) Camera 1
- e) Camera 2
- f) LED
- g) UV light source

Simulation
- a) Test plate
- b) Water inflow
- c) Wind direction
- d) Simulated drops

Measurement techniques

- Shadowgraph imaging (d, f)
  - Height, shape, wetting angle
- Fluorescence imaging (e, g)
  - Regime, width, velocity

Simulation software

- Meshfree (Fraunhofer ITWM)
  - ➢ Meshless simulation software using the Generalized Finite Difference Method

MESHFREE Fraunhofer ITWM

Comparison of measurement and simulation

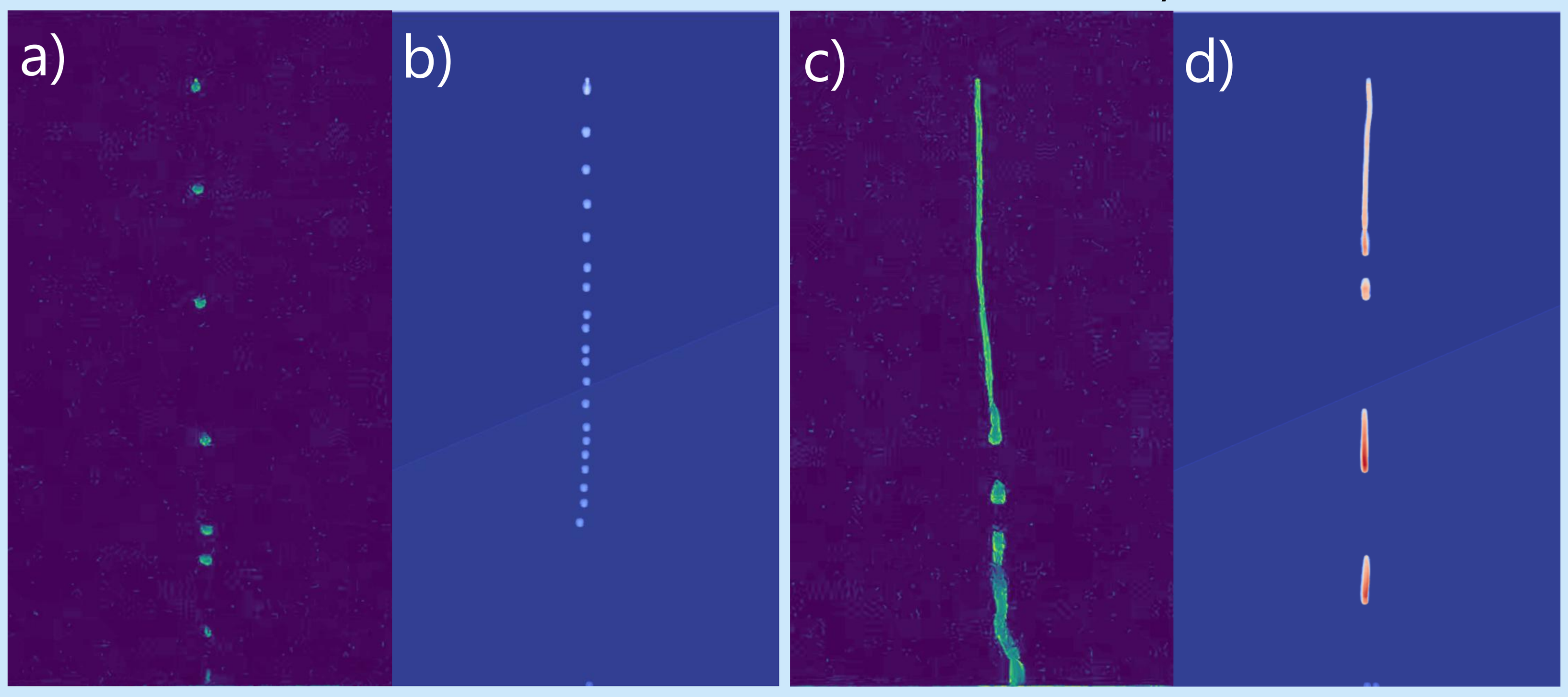
Fluorescence imaging results (a, c) compared to a simulation based on the experimental setup (b, d) in top view.

Shadowgraph results (e) compared to simulation (f) in side view.

Regimes

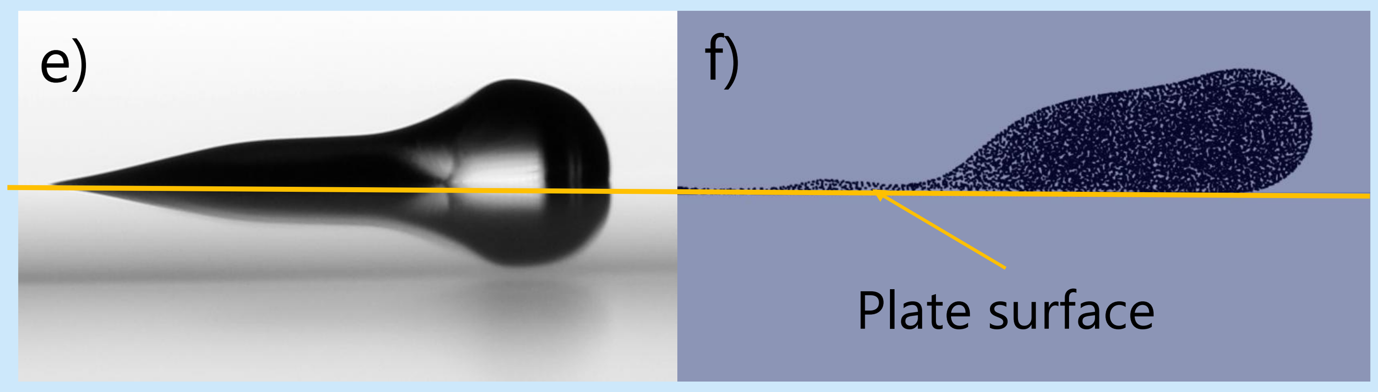
Measurement   Simulation   Measurement   Simulation

1 ml/min   15 ml/min



Droplet shape

Measurement 1 ml/min   Simulation 1 ml/min



Results

Regimes

- Transition from droplets (a) to rivulet (c) dependent on volume flow and surface type
- Transition of water regime reproduced in simulation (b, d)

Shape

- Tail of droplet not yet properly simulated
  - ➢ Further improvement of coupling between the phases
  - ➢ Further analysis of wetting angle influence

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Literature

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