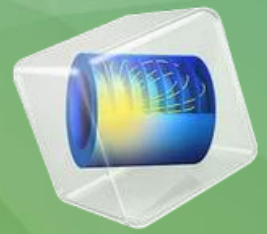
SIMULATION OF PRESSURE LOSS IN CHANNELS OF REDOX FLOW BATTERIES



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23.05. 2024, Lednice, COMSOL Multiphysics 2024

PRÍRODOVEDECKÁ FAKULTA UNIVERZITA PAVLA JOZEFA ŠAFÁRIKA V KOŠICIACH

InoHub Energy

Introduction

Pavol Jozef Šafárik University in Košice

Department of Physical Chemistry

Collaboration with Ino-Hub Energy

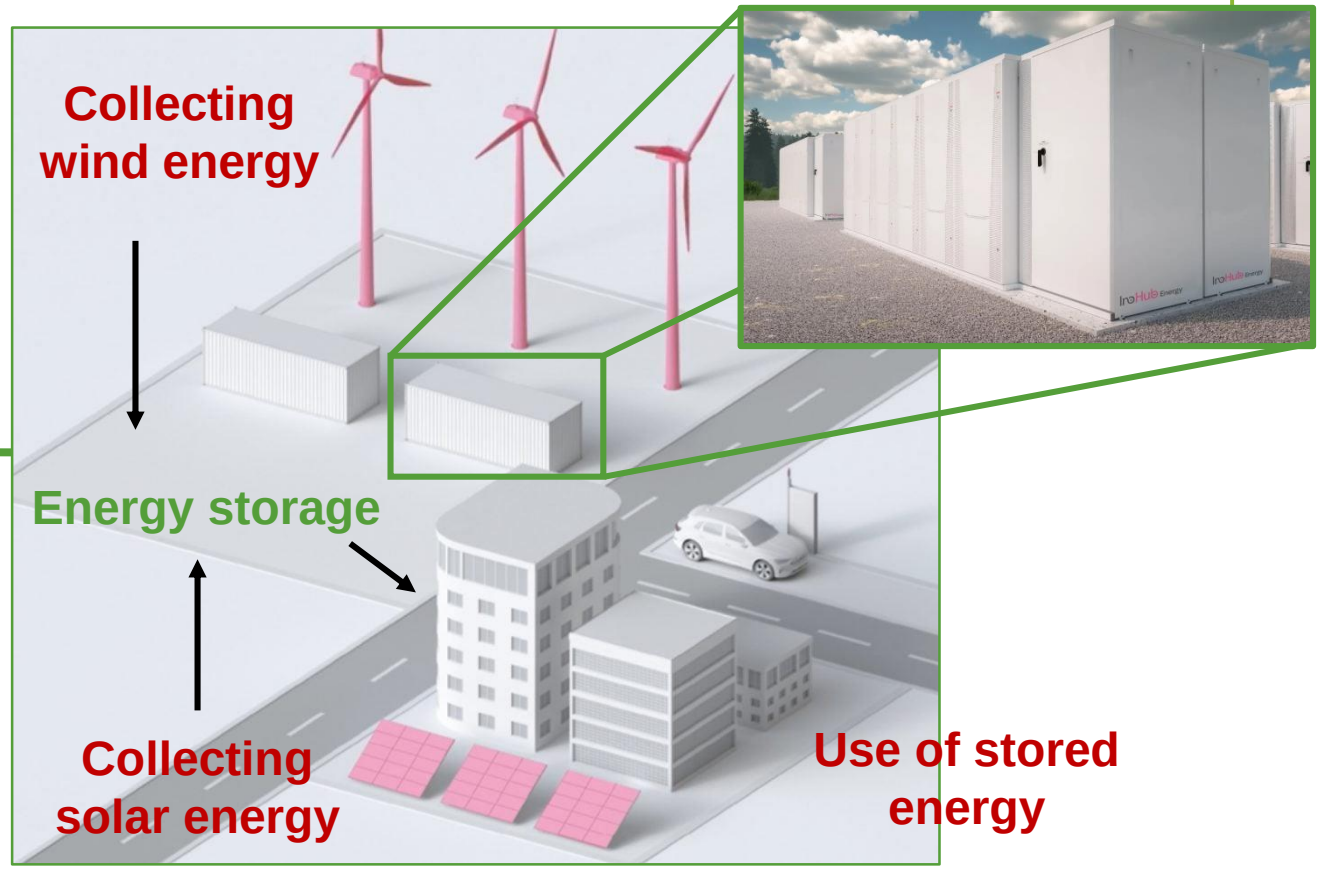
Important Projects of Common European Interest

IPCEI BATTERIES

Principal investigator

InoHub Energy

Concept

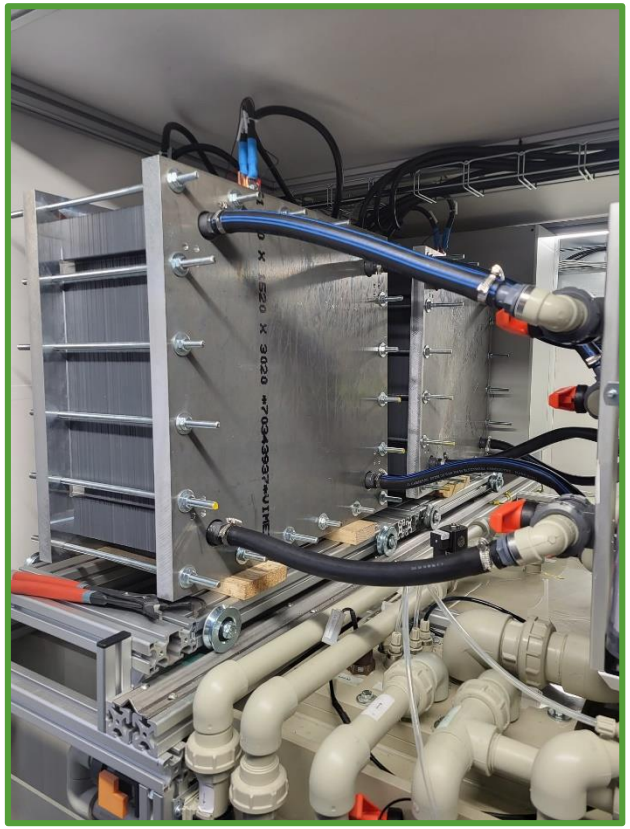


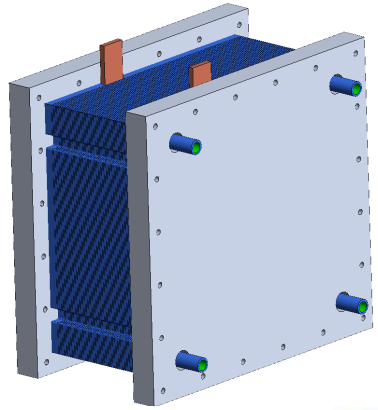
Collaboration with Ino-Hub Energy

Energy storage
Redox Flow Batteries

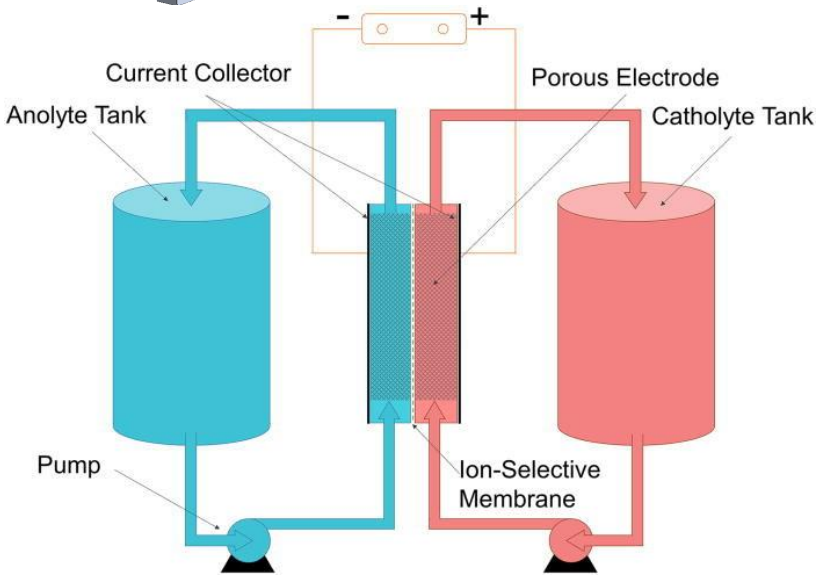
Kysucké Nové Mesto

8 stack demonstrator



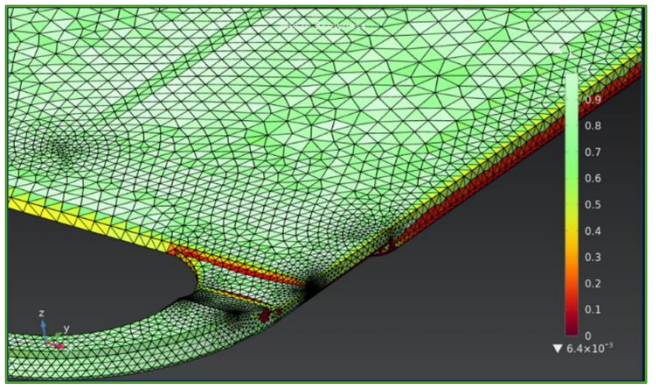


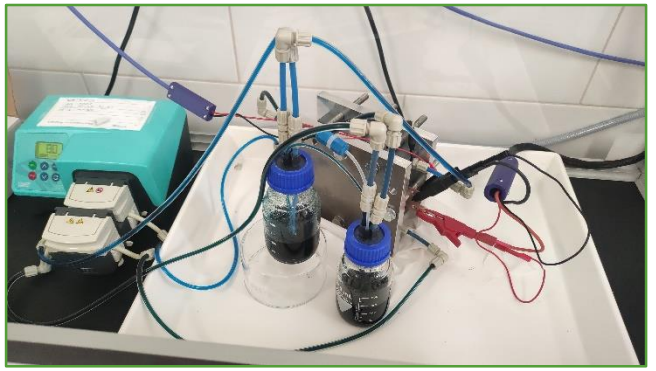
40-cell stack



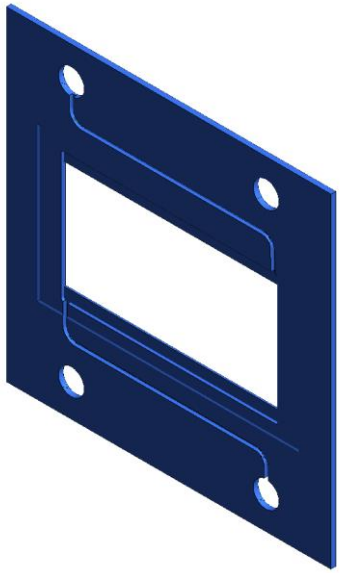
Collaboration with Ino-Hub Energy

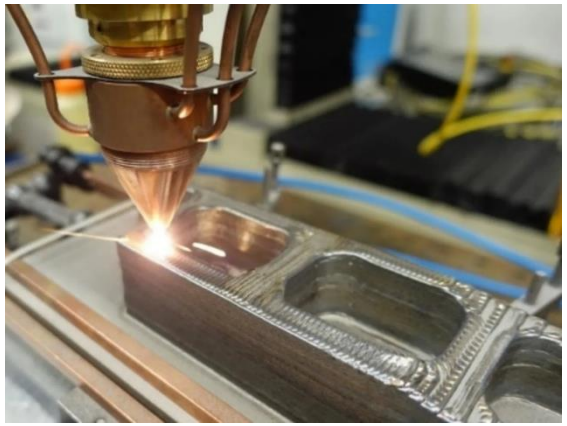
Prof. Andrea Straková-Fedorková
Head of the RFB and Li-Ion laboratory



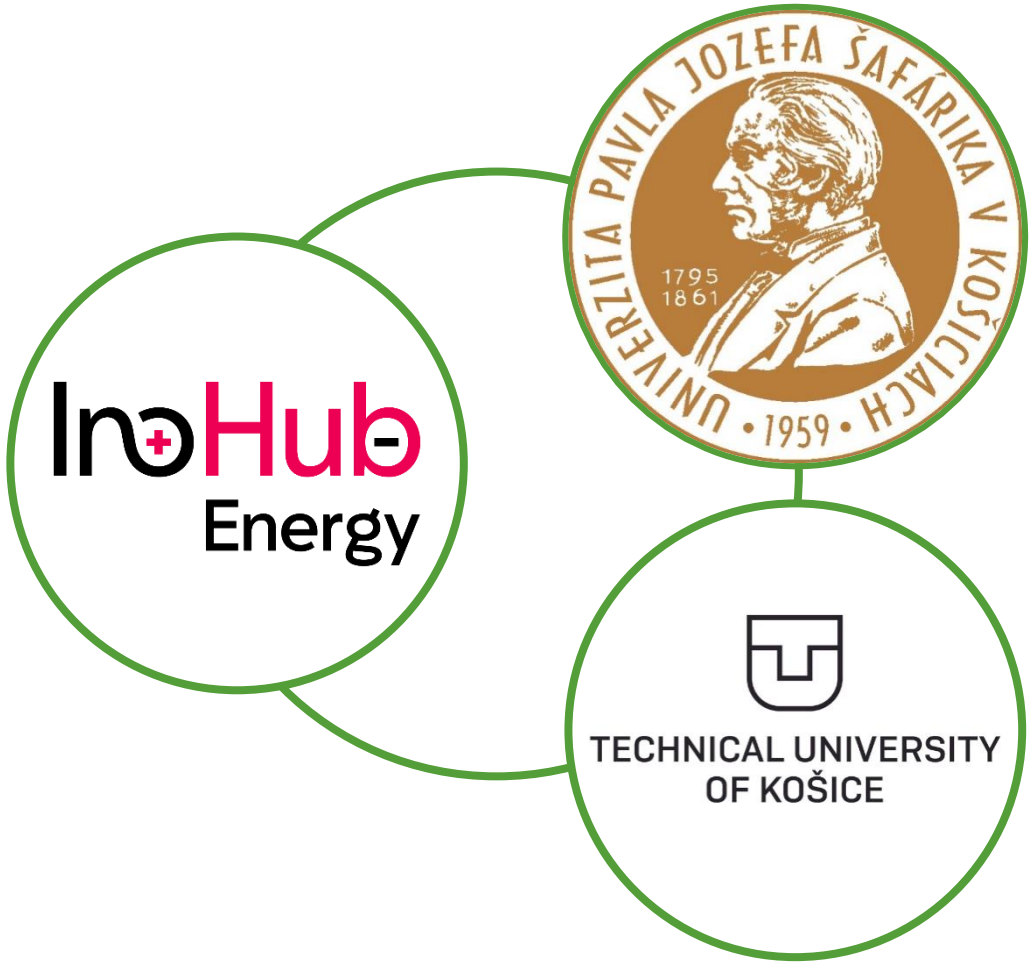


Collaboration with Ino-Hub Energy





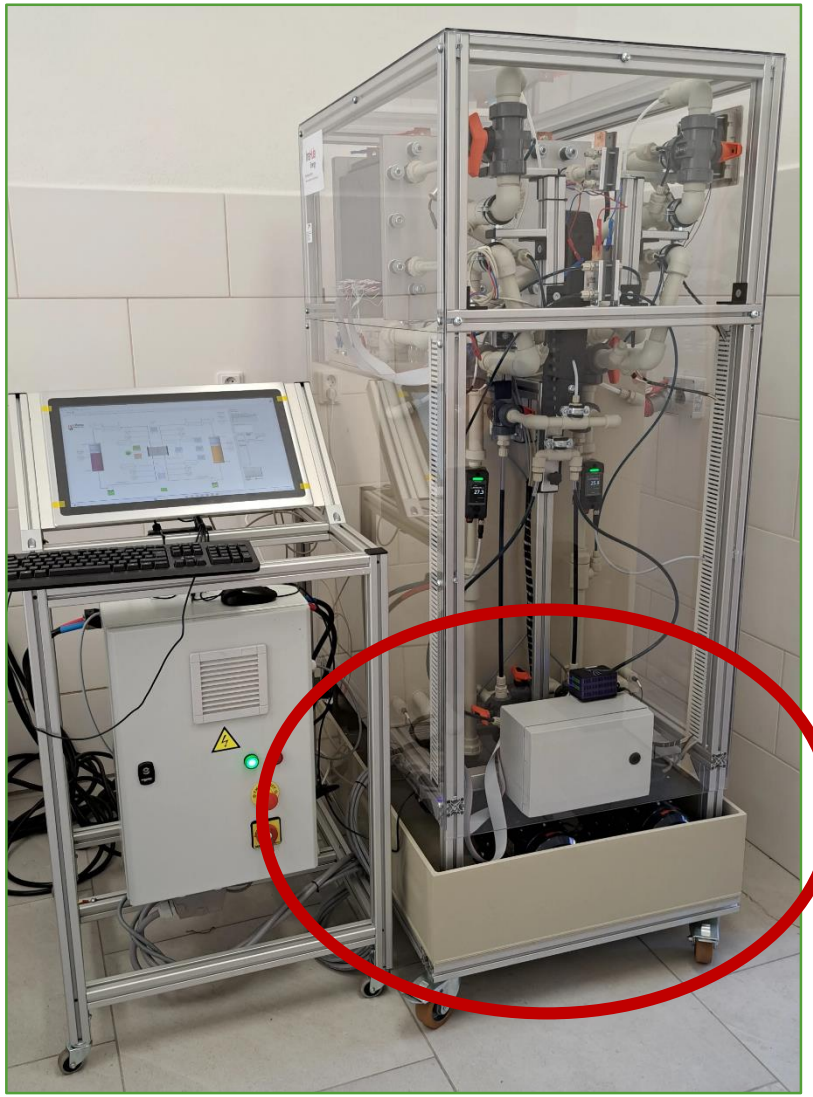
Collaboration with Ino-Hub Energy

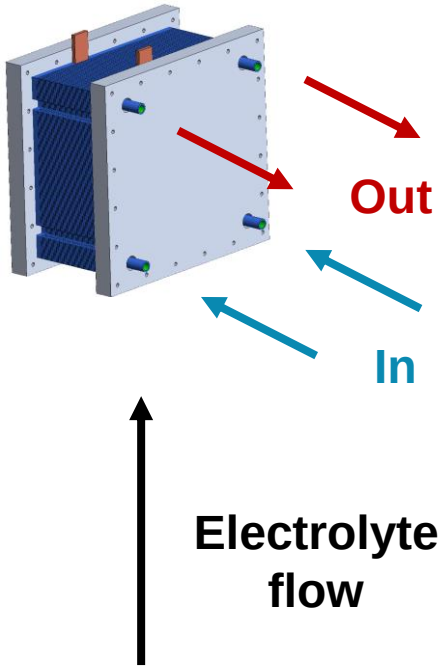


Future plans

Redox-flow battery factory in Kysucké Nové Mesto

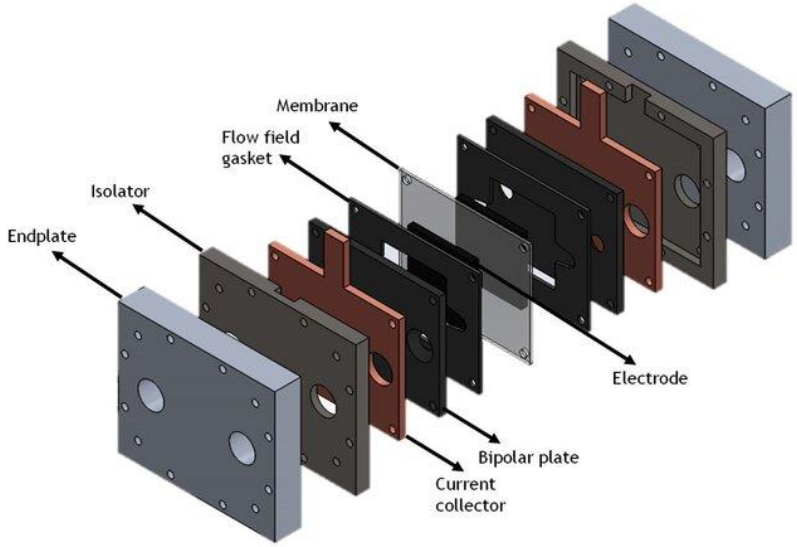
The reason for using simulations



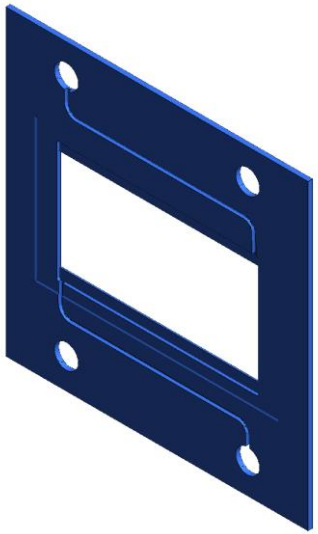


Electrolyte flow

Pumps



High cell pressure drop necessitates powerful pumps



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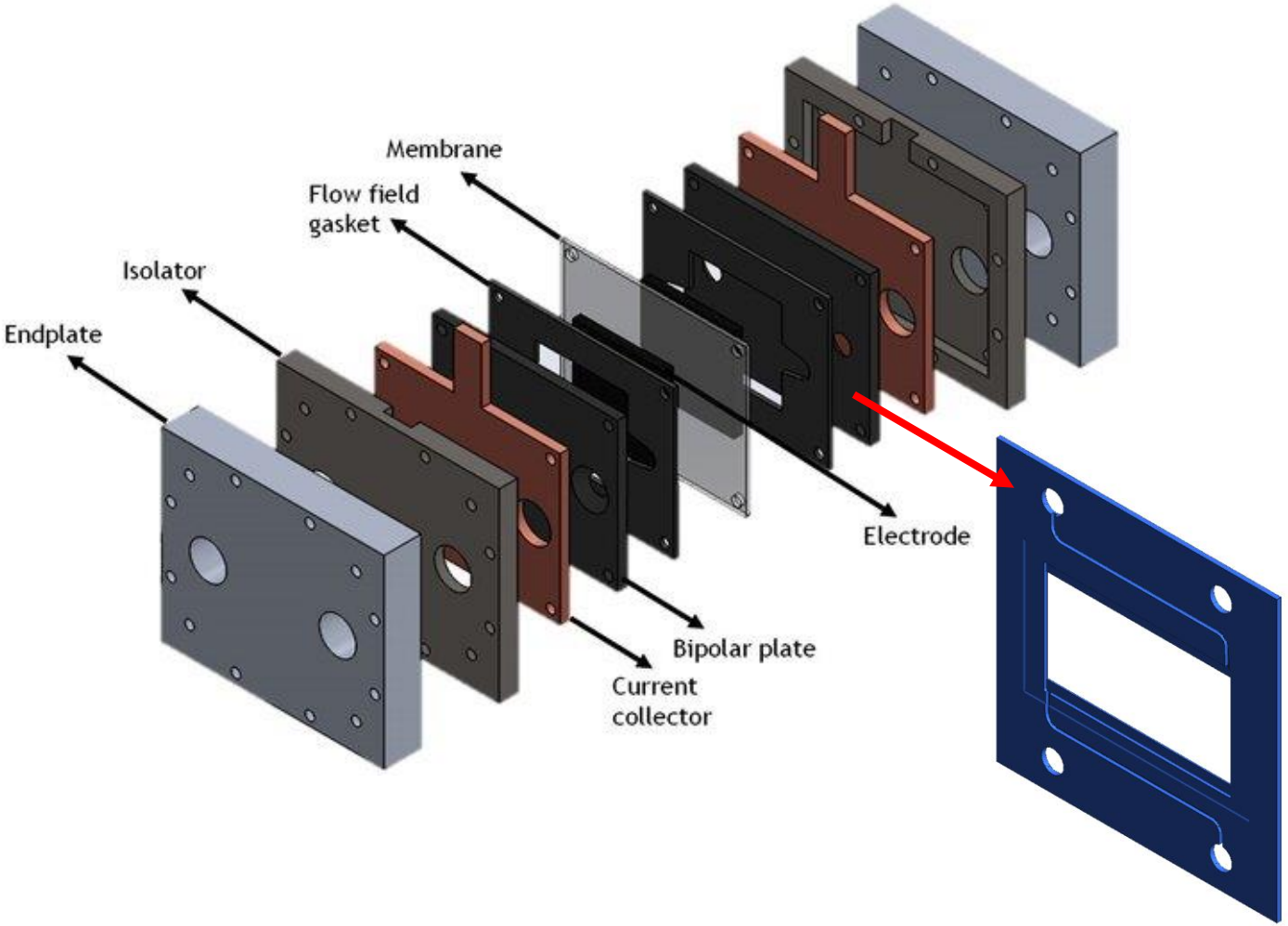

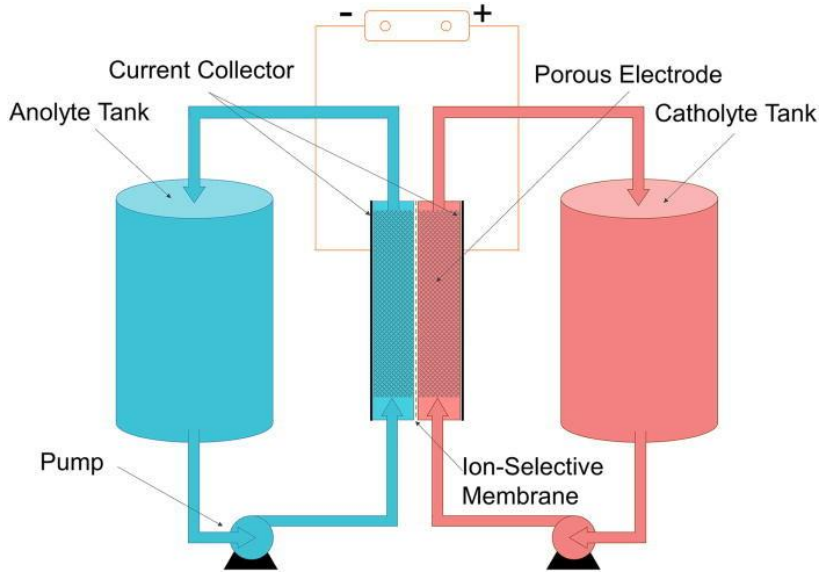

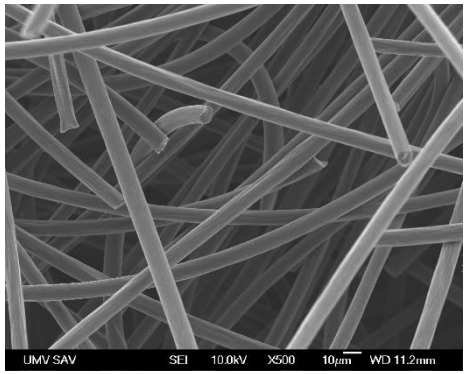

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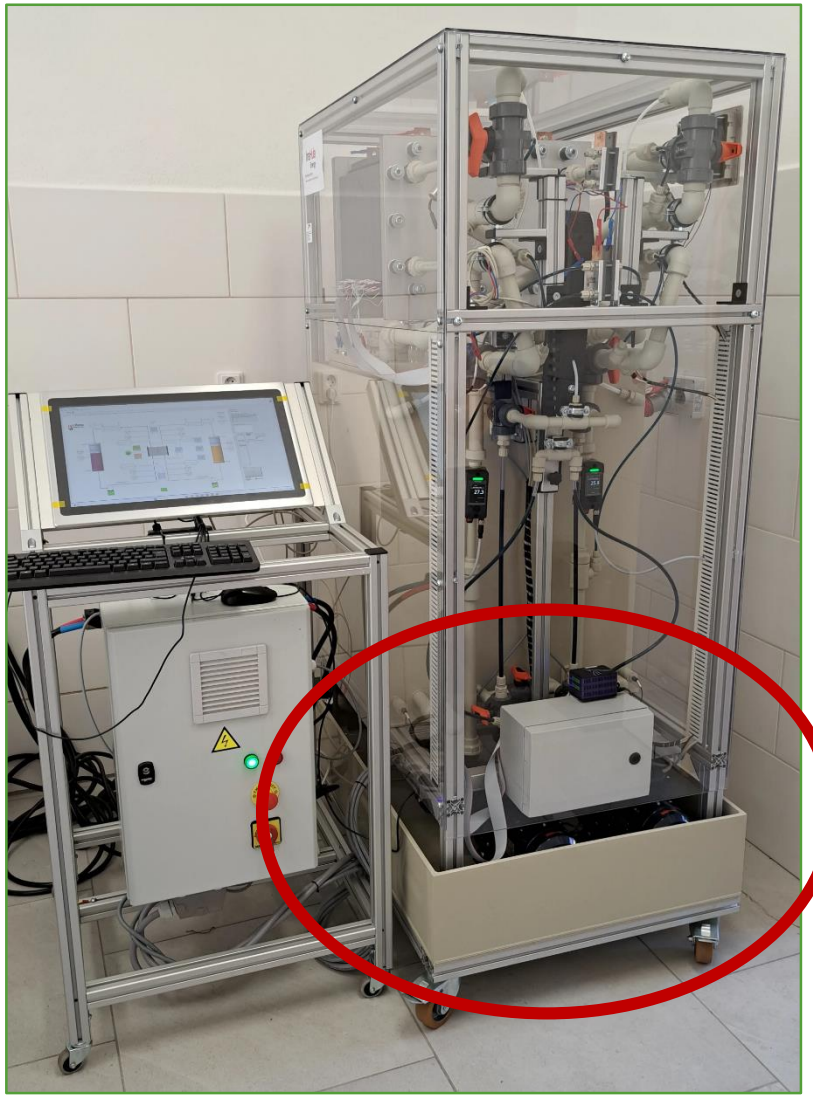
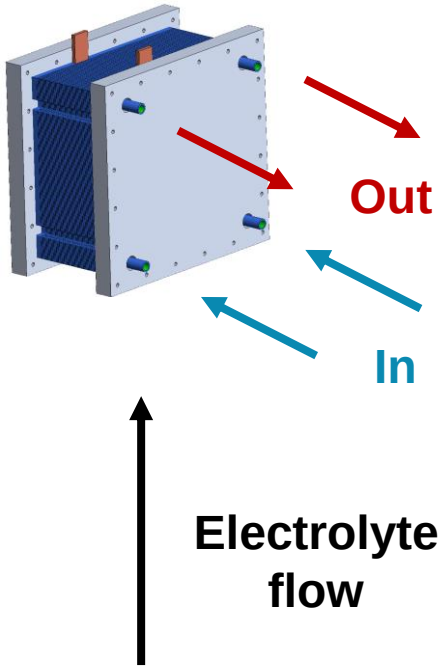
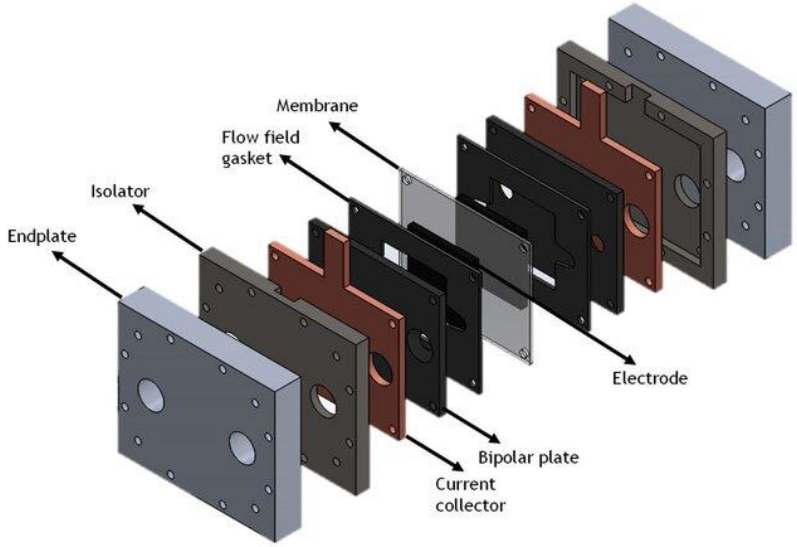




Electrolyte flow

Pumps



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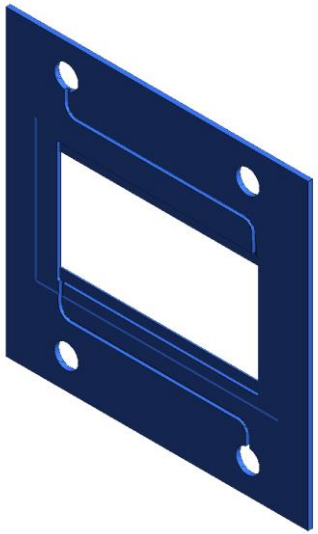
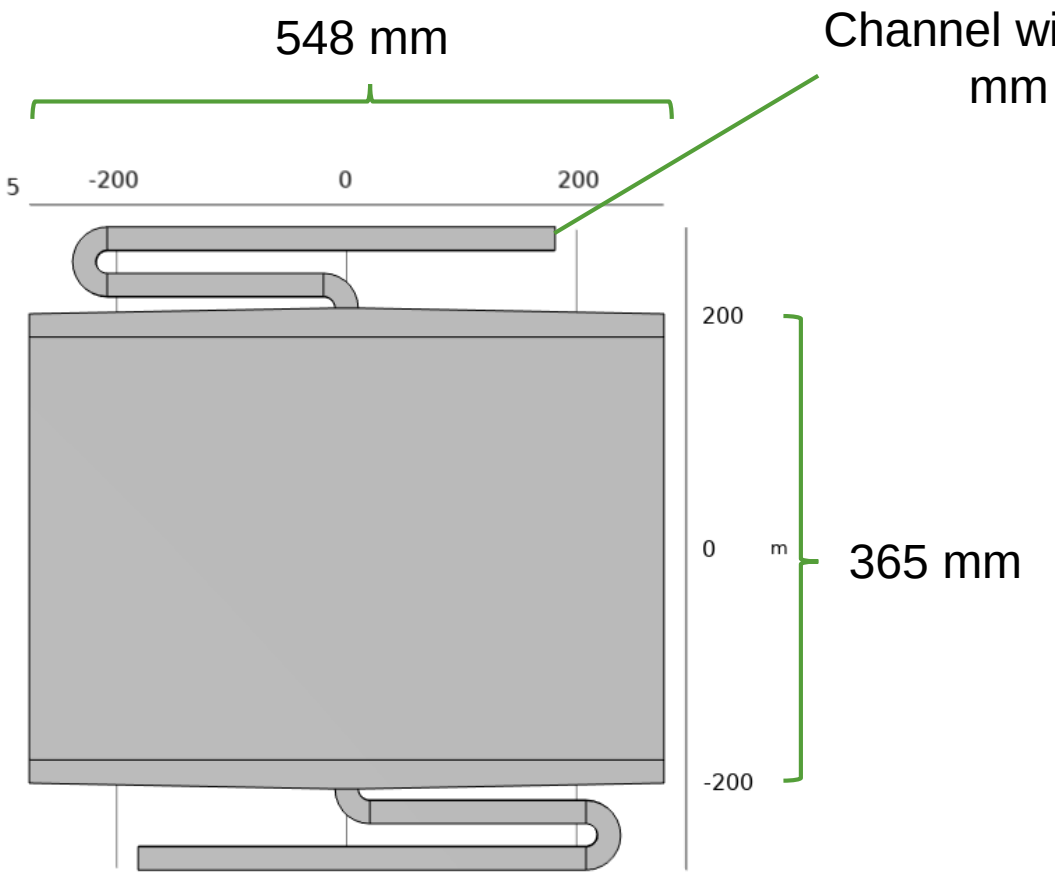
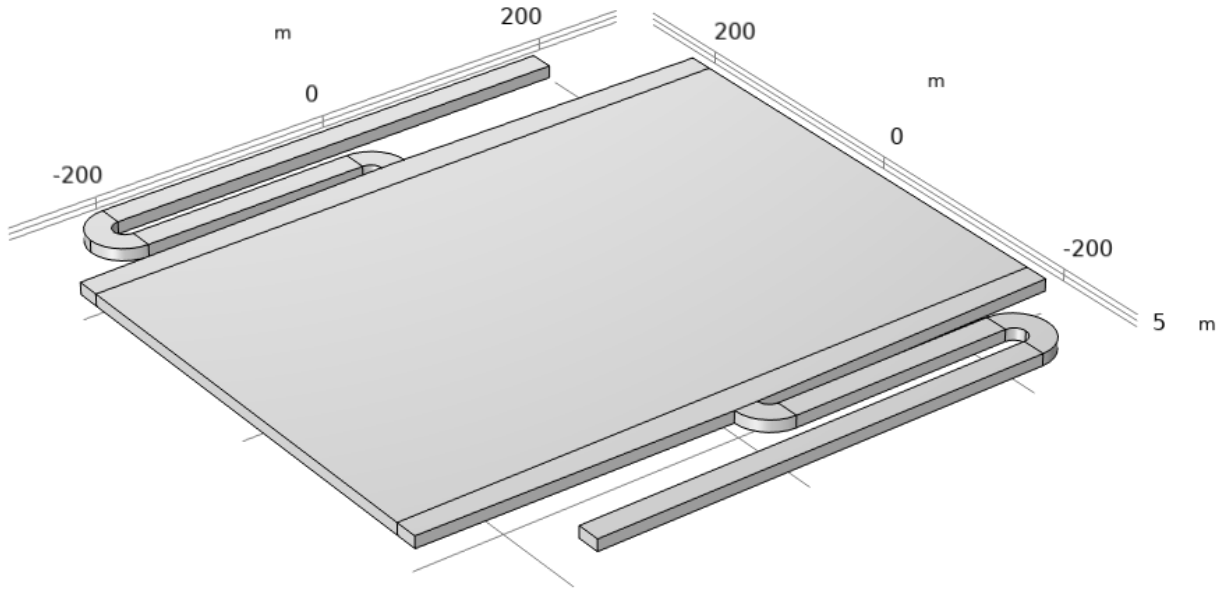


Definition of model in COMSOL

Geometry



Frame thickness 10 mm



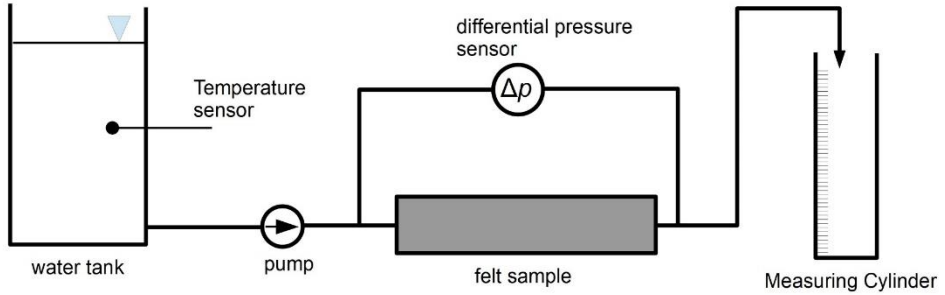
Definition of model in COMSOL

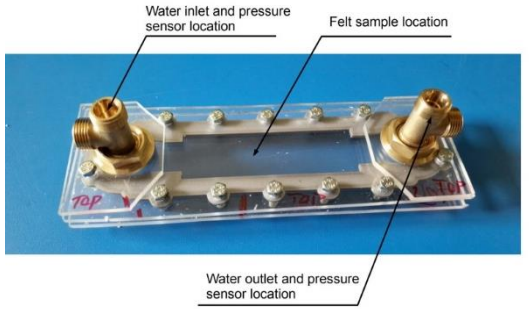
Material and physics definition

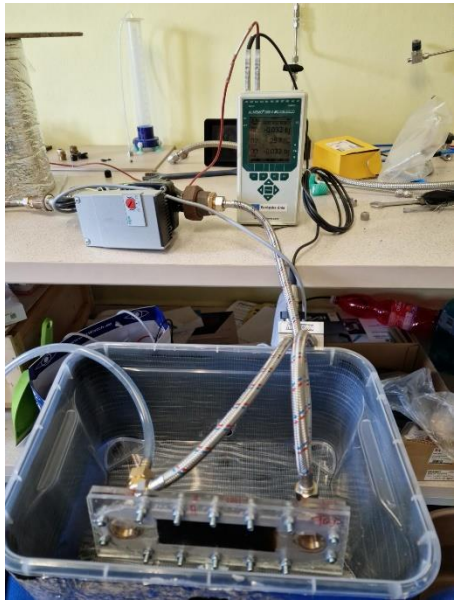
- Materials
  - Electrolyte *(mat1)*
- Laminar Flow *(spf)*
  - Fluid Properties 1
  - Initial Values 1
  - Wall 1
  - Inlet 1
  - Outlet 1
  - Equation View
- Free and Porous Media Flow *(fp)*
  - Fluid Properties 1
  - Initial Values 1
  - Wall 1
  - Porous Medium 1
    - Fluid 1
    - Porous Matrix 1
    - Equation View
  - Inlet 1
  - Outlet 1
  - Equation View

Property	Variable	Value	Unit
Permeability	kappa...		m^2
Density	rho	1340	kg/m^3
Porosity	epsilon	0.92	1
Dynamic viscosity	mu	4.820e-...	Pa·s

?







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  - Outlet 1
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Property	Variable	Value	Unit
Permeability	kappa...		m^2
Density	rho	1340	kg/m^3
Porosity	epsilon	0.92	1
Dynamic viscosity	mu	4.820e-...	Pa·s

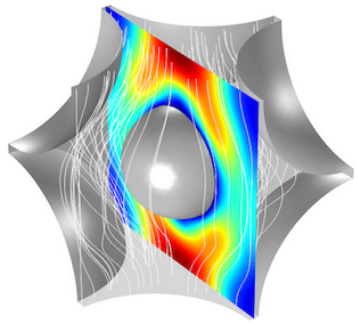
?

Estimating Permeability from Microscale Porous Structures

Application ID: 33331

This example shows how to estimate the permeability of a porous material by creating a detailed fluid flow model in a small unit cell. The result of the model is a lumped permeability of the material, which can be used in homogenized models using Darcy's law or the Brinkman equations. The permeability can be found under the Results->Derived Values node.

An even smaller unit cell could be used, 1/6 of the height of the current cell. This model has a few more cells added to it to make it more intuitive to visualize.



$$\kappa = u_{\text{out}} \mu \frac{L}{\Delta p}$$

Definition of model in COMSOL

Material and physics definition

- Materials
  - Electrolyte *(mat1)*
- Laminar Flow *(spf)*
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  - Initial Values 1
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    - Fluid 1
    - Porous Matrix 1
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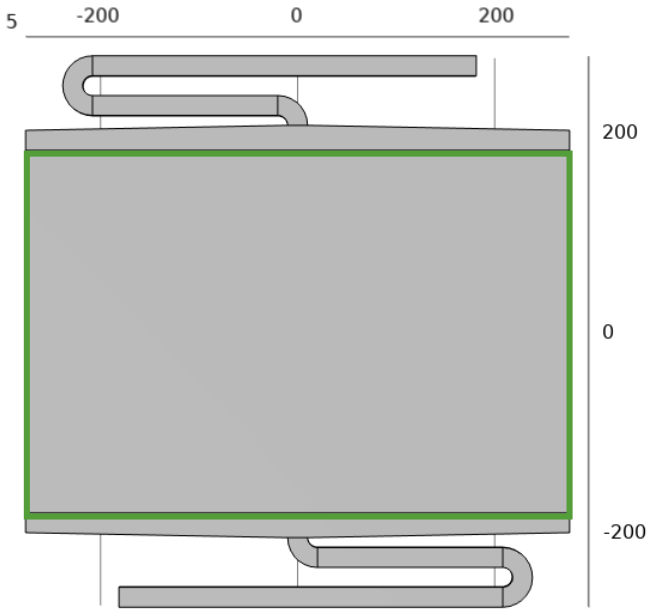
  - Equation View

Property	Variable	Value	Unit
Permeability	kappa...		m^2
Density	rho	1340	kg/m^3
Porosity	epsilon	0.92	1
Dynamic viscosity	mu	4.820e-...	Pa·s

$$\kappa_E = \frac{d_F^2}{16K_{KC}} \frac{\varepsilon_E^3}{(1-\varepsilon_E)^2}$$

$$\kappa = \frac{d_p^2}{180} \frac{\epsilon_p^3}{(1-\epsilon_p)^2}$$



Matrix Properties

Porosity:

ϵ_p From material

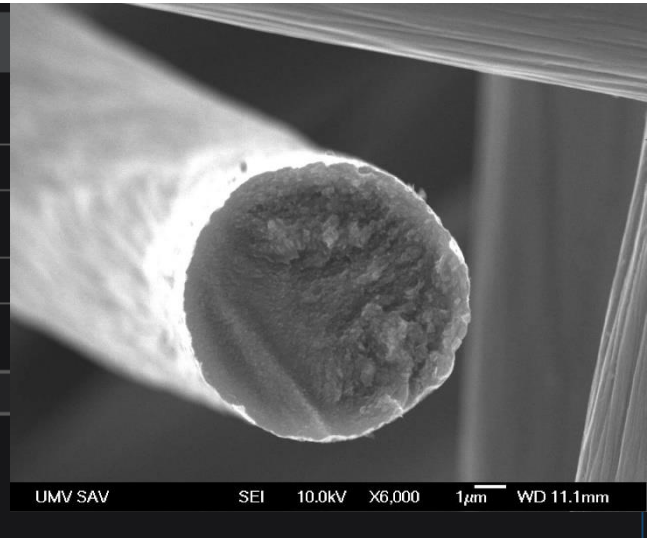
Permeability model:

Kozeny-Carman

Particle diameter:

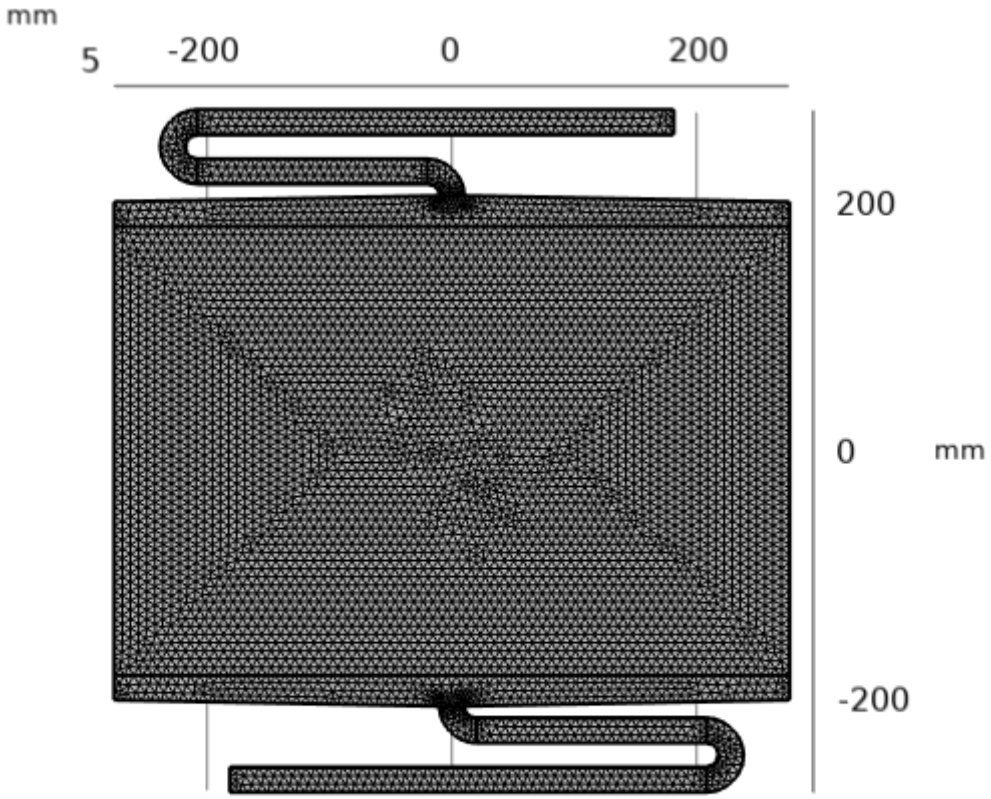
d_p 0.009[mm]

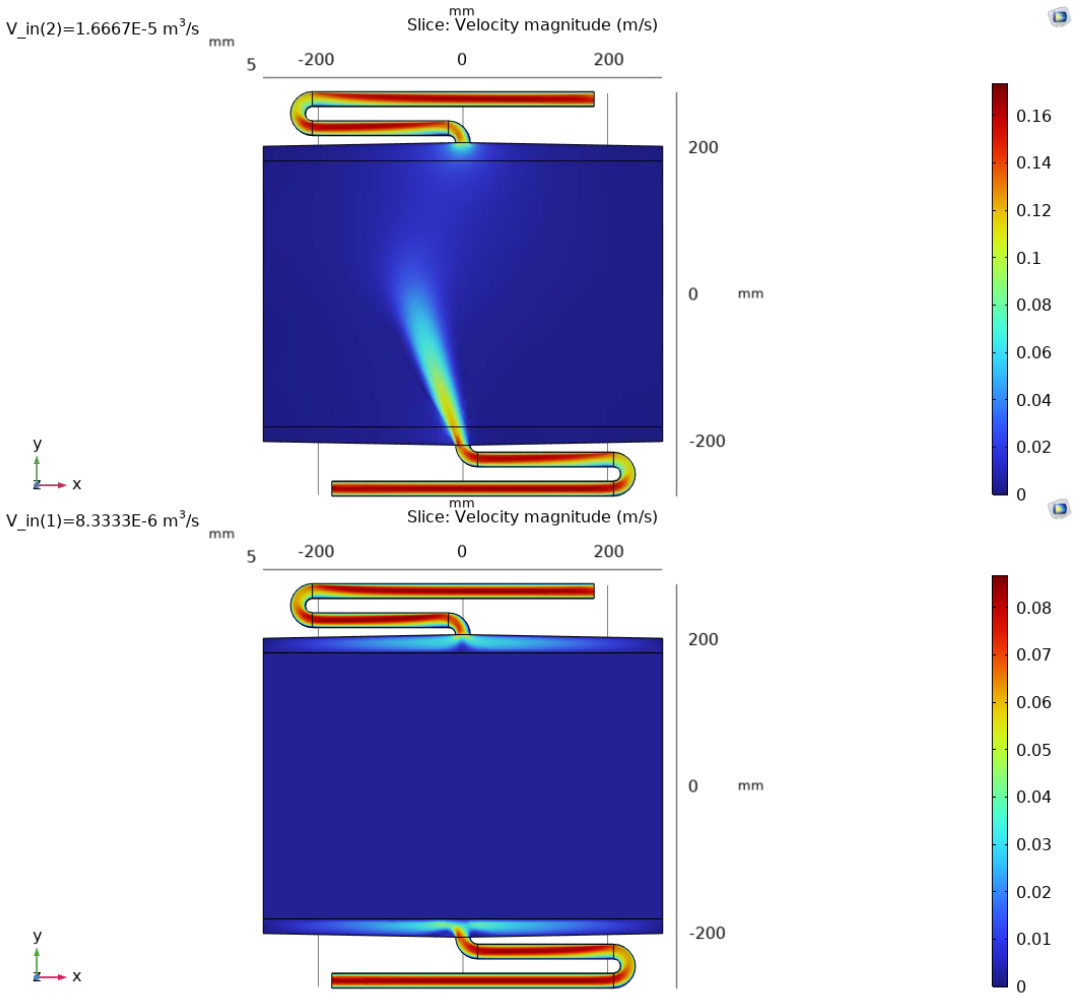
$$\kappa = \frac{d_p^2}{180} \frac{\epsilon_p^3}{(1-\epsilon_p)^2}$$



Simulation results

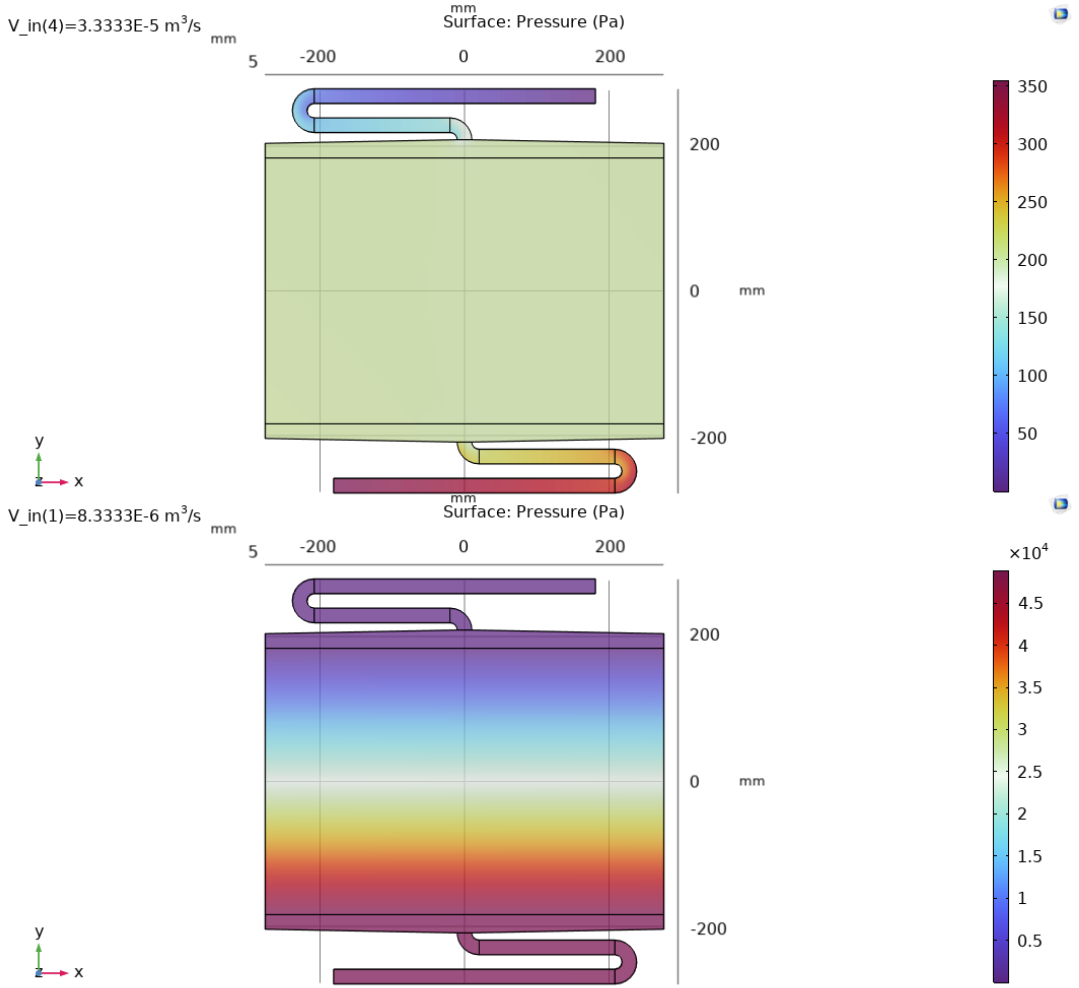
Mesh definition, velocity results



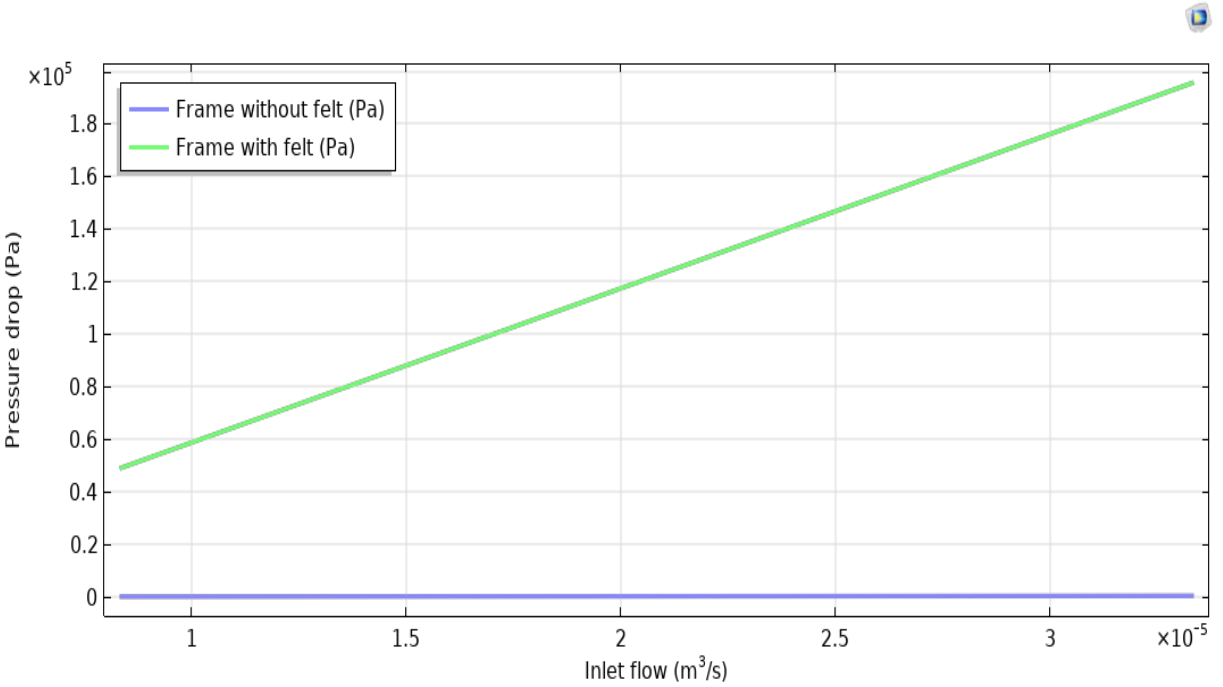


Simulation results

Mesh definition, pressure results

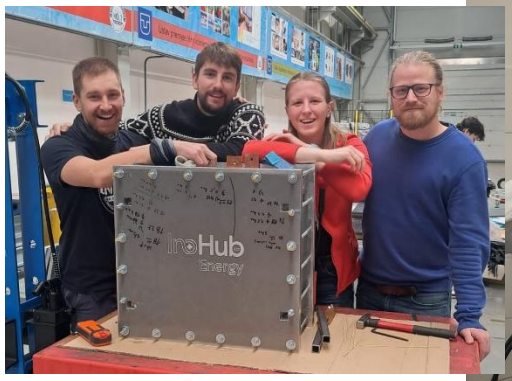


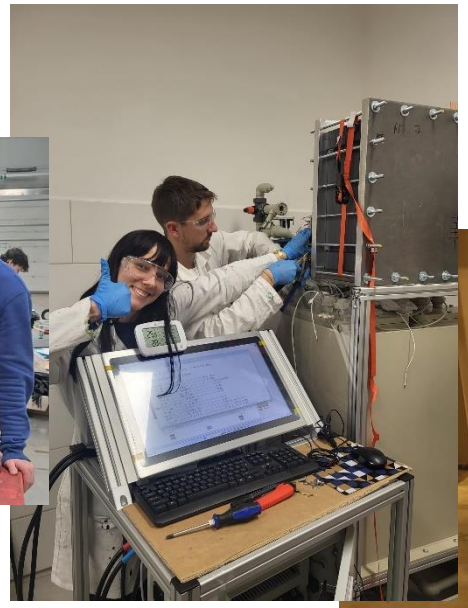
Inlet flow (L/min)	Frame without felt	Frame with felt
	Pressure (Pa)	Pressure (Pa)
0.50	57.65	48884.87
1.00	136.01	97808.83
1.50	234.70	146766.66
2.00	355.06	195741.15

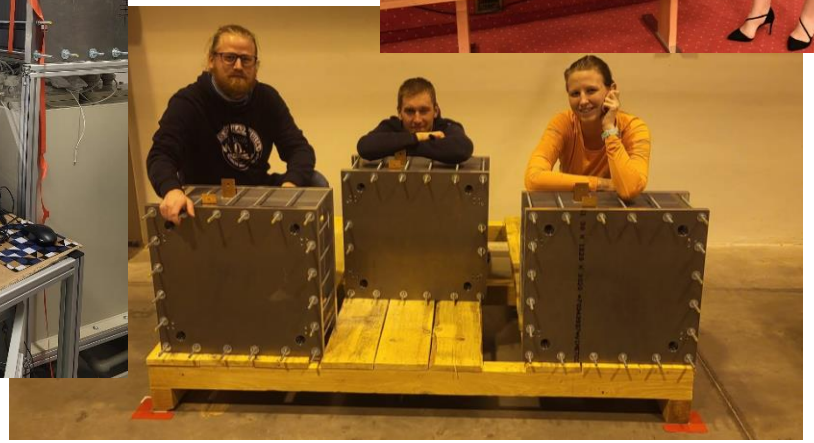


Special thanks to

Prof. Andrea Straková-Fedorková







Dr. Elena Romadina

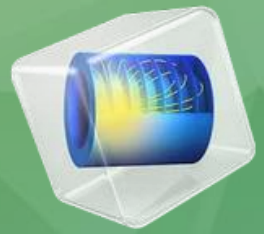
Dr. Juan Asenjo

Filip Dominik

Dr. Miroslav Palko

THANK YOU FOR YOUR ATTENTION!

InoHub Energy



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