R&D Activities at the Laboratory of Sorption Processes

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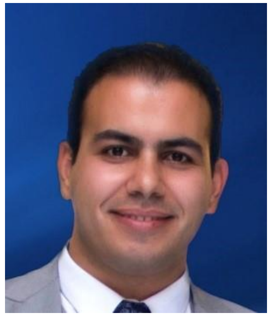

Jeremy Weindler, M.Sc.

Contents

- **Sustainable and reliable adsorptive machine**

  Designing an efficient Adsorber/Desorber Plate Heat Exchanger (APHE)

- **Ohmic heating**

  Experimental setup and first results

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- **Sustainable and reliable adsorptive machine**

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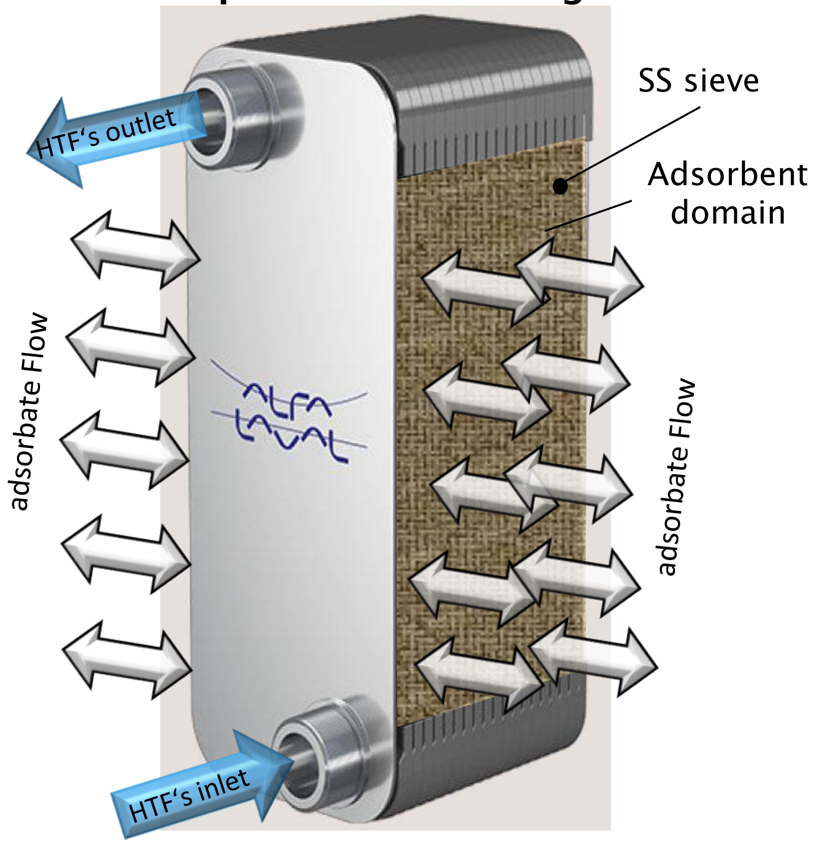
Tested Commercial Plate Heat Exchangers

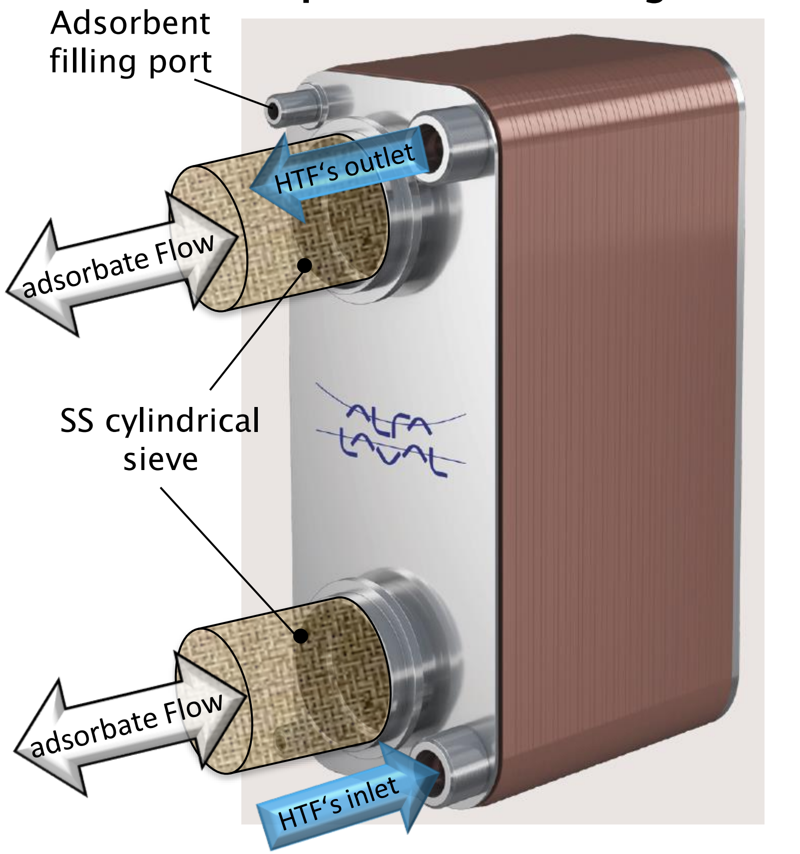
- Gas / Liquid plate heat exchangers
- Each Consists of stainless steel plates brazed together with nickel.
- Designed to handle asymmetric volume flows with exceptionally high performance.

Open-Structured Asymmetric plate Heat Exchanger



GLX30 PHE, AlfaLaval, Sweden

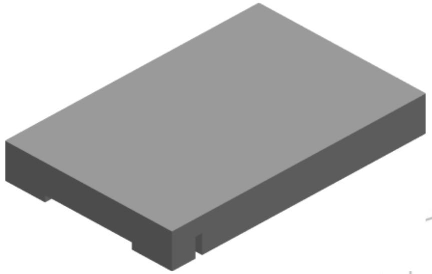
Closed-Structured Asymmetric plate Heat Exchanger



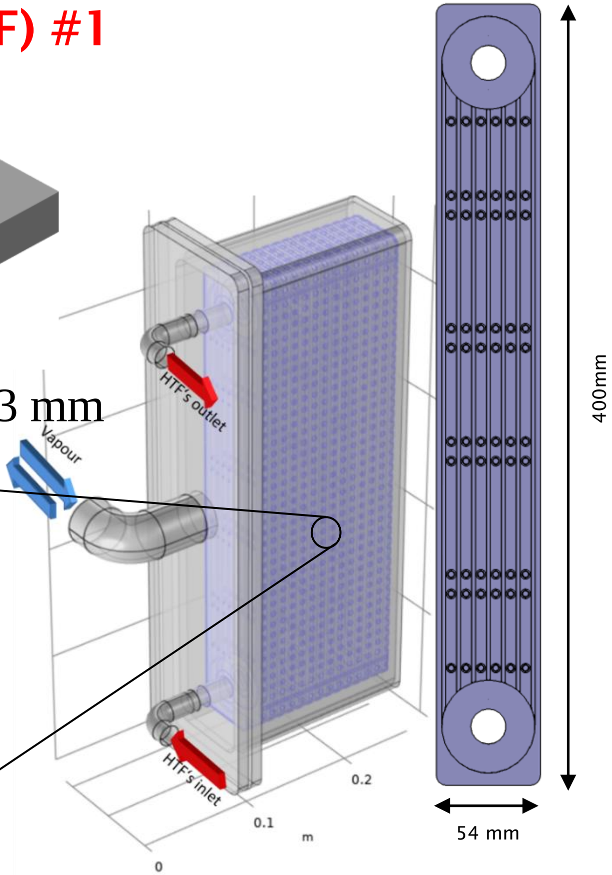
GL50 PHE, AlfaLaval, Sweden

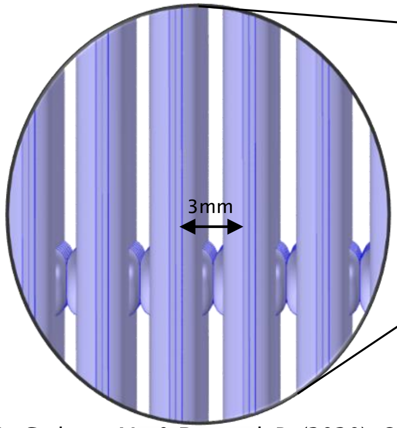
Studying the effect of the heat and mass transfer characteristic lengths (HTCL&MTCL)

Test frame (TF) #1



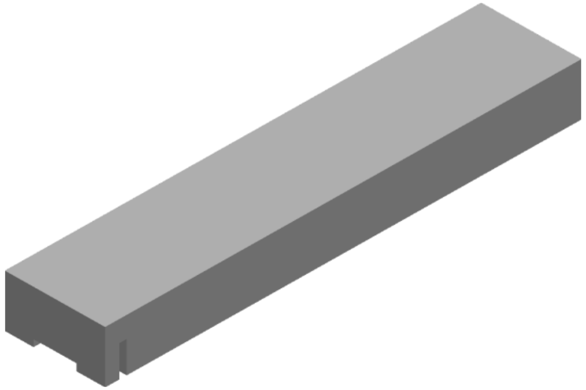
27 mm x <u>1.5 mm</u> x 13 mm





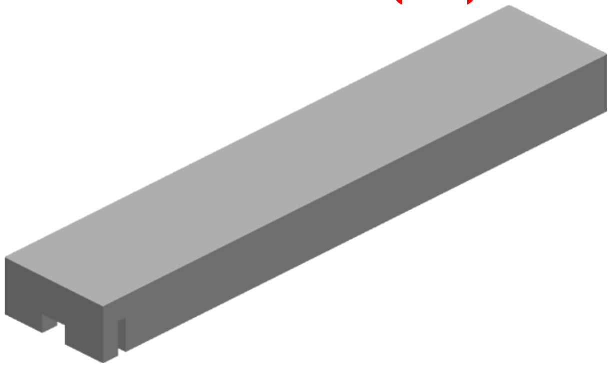
Mikhaeil, M., Gaderer, M., & Dawoud, B. (2020). On the development of an innovative adsorber plate heat exchanger for adsorption heat transformation processes; an experimental and numerical study. *Energy*, *207*.

Test frame (TF) #2



58.5 mm x <u>1.5 mm</u> x 6 mm

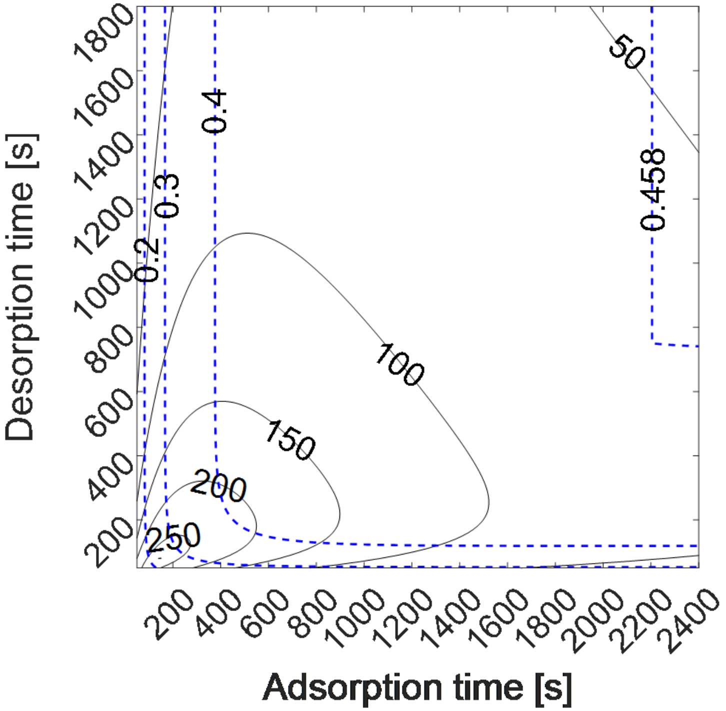
Test frame (TF) #3



58.5 mm x <u>3 mm</u> x 3 mm

GLX30 APHE

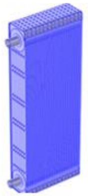
SCP – COP Chart



The *SCP* (black continuous lines) and *COP* (blue dashed lines) for the <u>OTH APHE</u> calculated at T_{ev}=10°C, T_{cond}= 35°C and T_{des}=90°C

Mikhaeil, M., Gaderer, M., and Dawoud, B. (2022). On the Application of Adsorber Plate Heat Exchangers in Thermally Driven Chillers; An Experimental and Analytical Study. *Appl. Thermal Eng., 220, 119713.*

Comparison between the performance of the two investigated APHEs and an optimized finned tube adsorber plate heat exchanger at operating conditions of 10/35/90°C



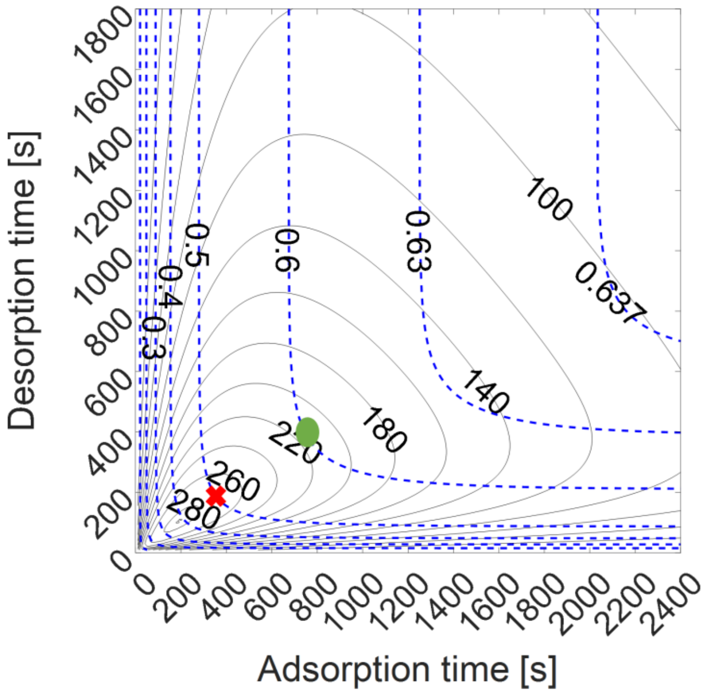
	Newly Introduced APHE	GLX30 APHE	Finned tube adsorber heat exchanger
τ_{ads}, s	257.7	586.1	243.5
R^2	0.9957	0.9913	0.9908
τ_{des}, s	81.1	103.0	105.5
R^2	0.9834	0.9813	0.9942
Optimum t_{ads}, s and t_{des}, s	150, 80	240,120	200, 125
SCP_{max}, W·kg^{-1}	263.6	131.9	268.0
$COP_{SCP_{max}}$	0.242	0.147	0.51
SCP^*_{max}, W·kg^{-1}	308.6	154.5	268.0
$COP^*_{SCP^*_{max}}$, -	0.271	0.168	0.51
target SCP^*, W·kg^{-1}	268.0	268.0 can't be realized	268.0
COP^* target SCP^*, -	0.42		0.51
t_{ads}, s and t_{des}, s at target SCP^*	380, 180		200, 125

Optmized closed structured APHE

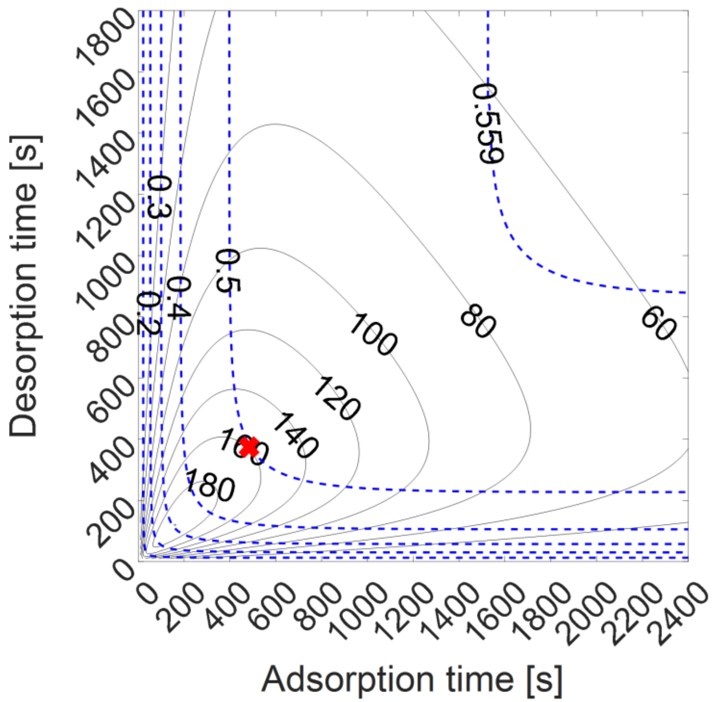
Specifications of the new APHE, designed for <u>10 kg of Siogel grains</u>

Specification	value
HTF's inlet and outlet ports diameter (mm)	18
Thickness of one plate (mm)	0.3
Thickness of end plates (mm)	2
Number of plate-pairs, in case of gap between each two successive plate-pairs = 6 mm	20
Width of the PHE (mm)	280
Length of the PHE (mm)	500
Volume of the adsorbent domain (L), with gap between each two successive plate-pairs = 6 mm	13.16
Volume of the HTF domain (L)	0.808
Volume of the metal domain, with end plates (L)	2.337

10/30/90 °C



10/35/90 °C



At 10/35/90°C operating conditions, the new closed-structured APHE provides 158.6*W/kg* at target *COP* of *0.5*, while the open structured APHE of OTH could not achieve a *COP* higher than 0.458.

The SCP (black solid lines) and COP (blue dashed lines) calculated for the new APHE. The red cross symbols refer to the operating points at a COP target of 0.5. The green point refers to the operating points at a COP target of 0.6 at 10/30/90 °C

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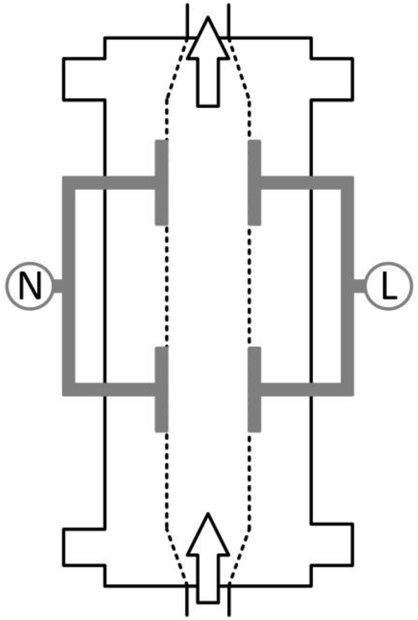
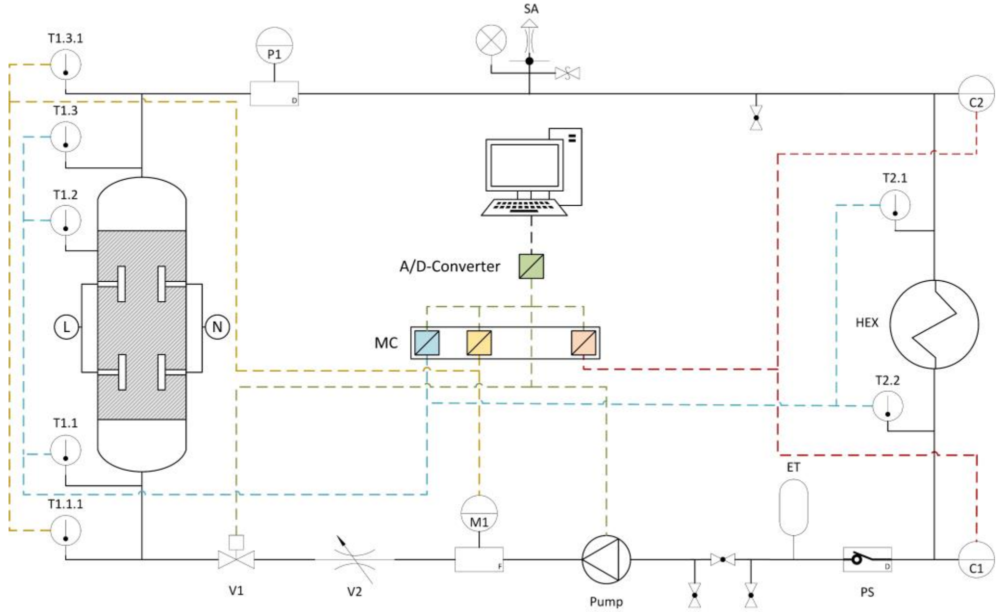
Ohmic-Heating Setup



Scheme of the developed Ohmic-Heating Prototype based on the continuous ow principle.



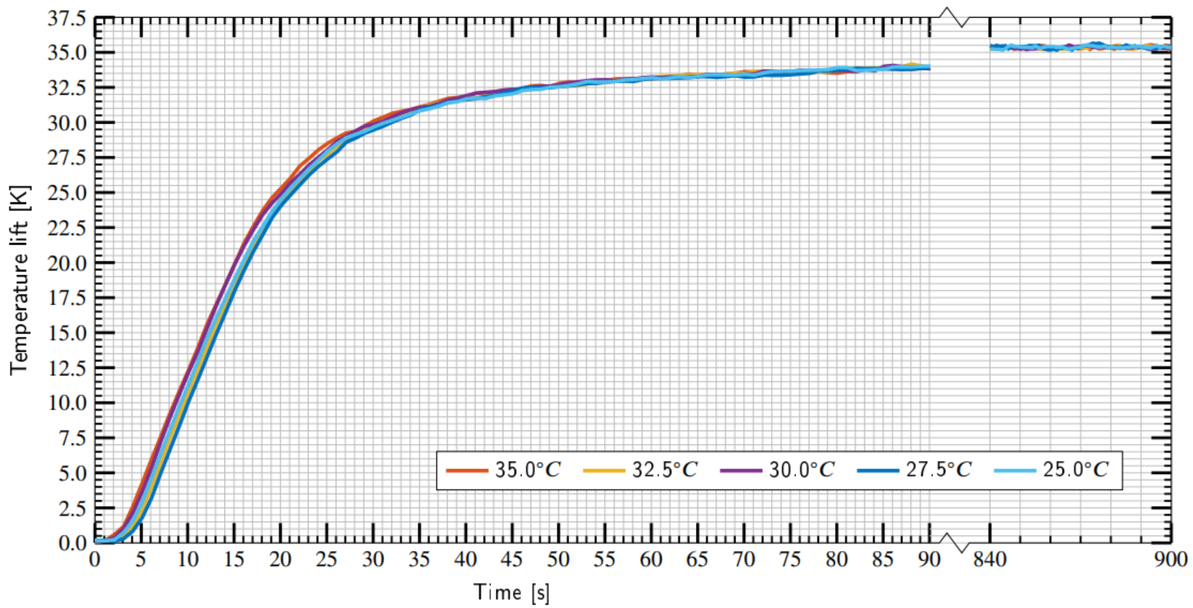
Plant schematic with the main components, measuring and control devices and illustration of the communication with the central LabVIEW based measuring and control system.

Photo of the laboratory test facility with the ohmic heating reactor, sensors and actuators and the electric boxes.

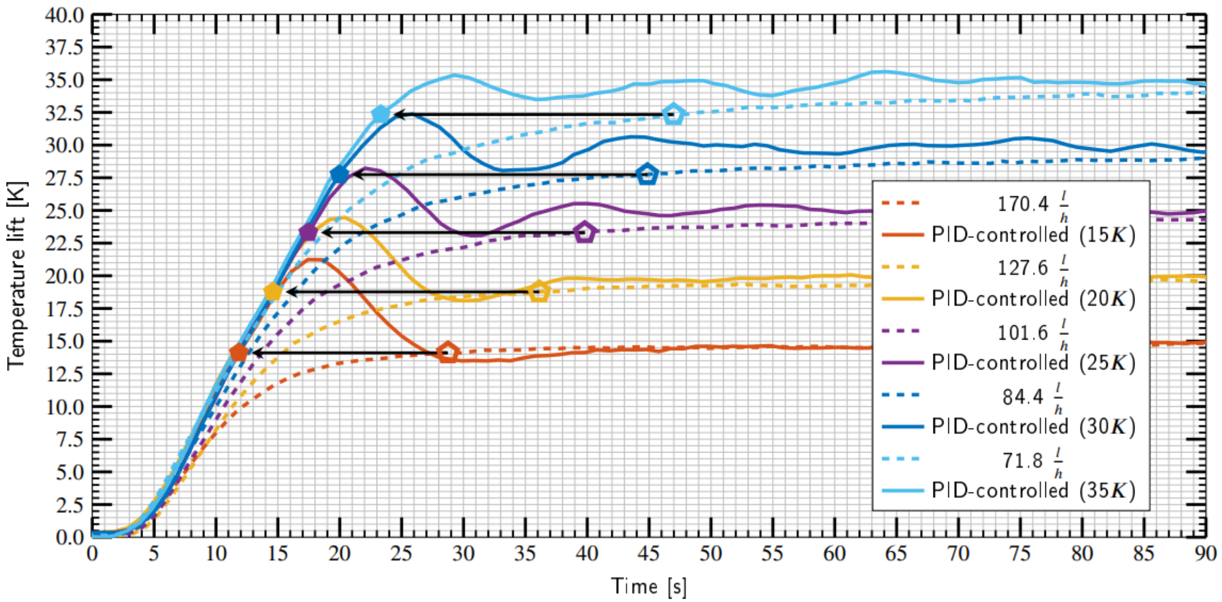
Ohmic-Heating: Working principle

Ohmic heating generates heat in the fluid itself. This is achieved by applying an **alternating current** across a **conductive fluid** with a specific electrical resistance, which results in a **direct conversion of the electrical energy into heat** through the generation of the so-called **joule energy**.

First results



Results a test mode exploring the dynamic thermal response of the ohmic heating reactor at a constant volume flow rate of 71.8 l/h and a step function of the electrical power of 3000W at the time 0 seconds at five different return temperatures



Test mode on the response time of the ohmic heating reactor at constant volume flow rates and a step function of the electrical power to 3000W at the time 0 seconds. Representation of five operating cases with different volume flow rates and corresponding stationairy temperature lift in 5K steps from 15K to 35K. Marked time points of the RUT τ_{50} (triangle), τ_{80} (diamond) and τ_{95} (pentagon).

Key finding

Temperature lift is independend from return temperature with a measured conversion efficiency of 97.52% ± 0.16%

Key finding

Targeted temperature lift can be achieved in a very short time even with low electrical power

Future applications

- Heating of LiBr-Solutions
- Desalination of seawater
- Organic synthesis in the chemical and pharmaceutial industry

Thank you very much for your kind attention.
Questions are more than welcome!