

Scaling Down the Heat Transfer in Multipurpose Plants

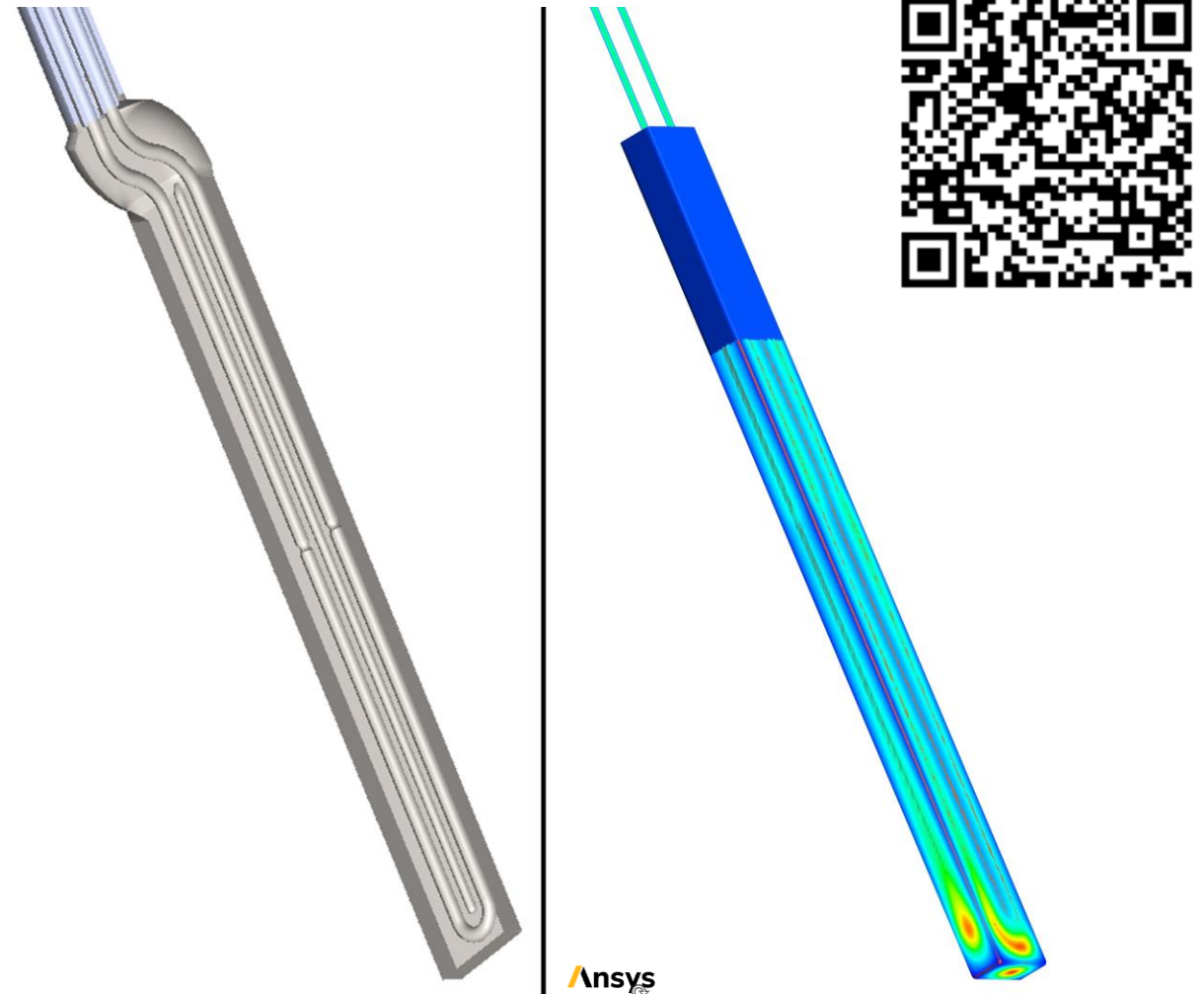
Prof. Dr. Andreas Zogg

Praxis Zirkel Life Sciences

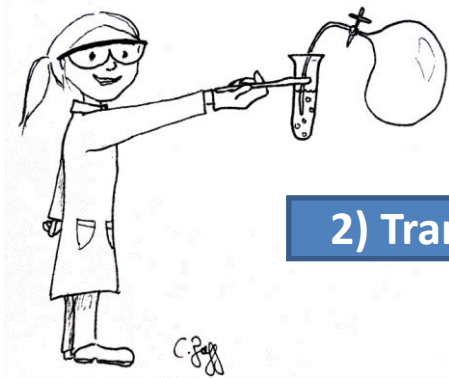
26.06.2024

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<https://www.fhnw.ch/plattformen/miniplant40/projects/>

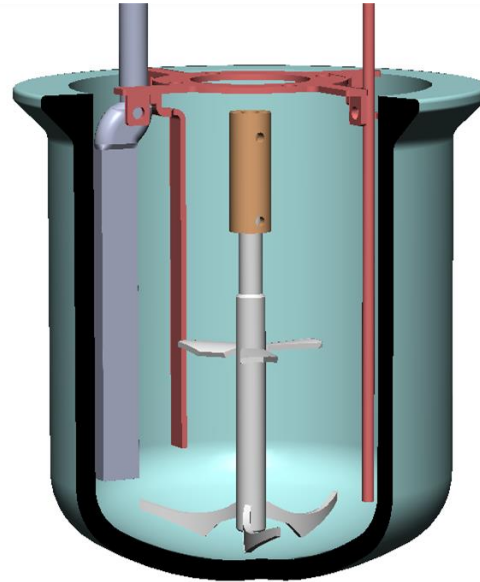


Einleitung



2) Transfer

Laboratory Process



Scale-Down-Reactor

1) Scale-Down

3) Scale-Up



Production Process

Inhalt

1. Einleitung

- Stand der Technik beim Scale-Up
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2. Zielsetzung des Projekts

3. Konkrete Aufgabenstellung: Scale-Down eines 4 m³ Hydrierautoklaven

4. Workflow:

- Design des Heiz/Kühlfingers
- Herstellung und Inbetriebnahme des Heiz/Kühlfingers
- Qualifizierung des Heiz/Kühlfingers im stationären Zustand

5. Anwendungsbeispiel: Hydrierung

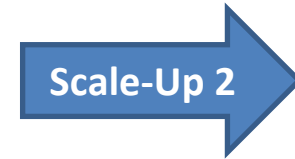
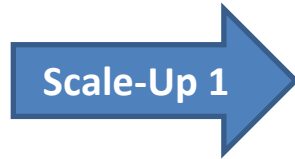
6. Outlook

Stand der Technik beim Scale-Up

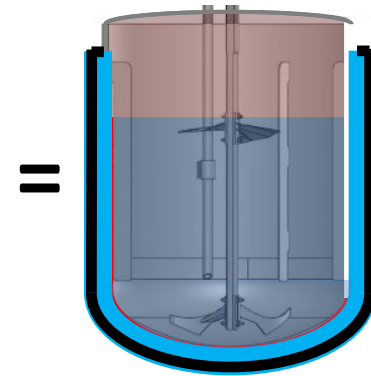
Laboratory: 0.1 ... 1 l

Pilot: 10 ... 100 l

Production: 1'000 ... 10'000 l

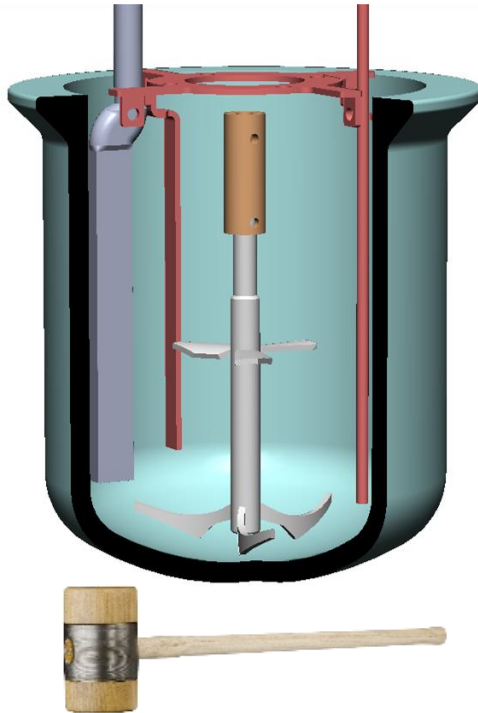


$$r = (\sqrt{\pi})^{??}$$



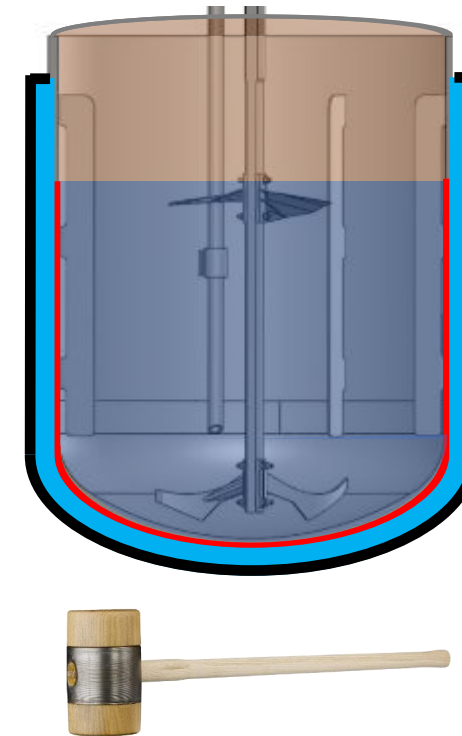
Vision für den zukünftigen Scale-Up

Scale-Down-Reactor
1 ... 10 l



Direct Scale-Up

Production
1'000 ... 10'000 l

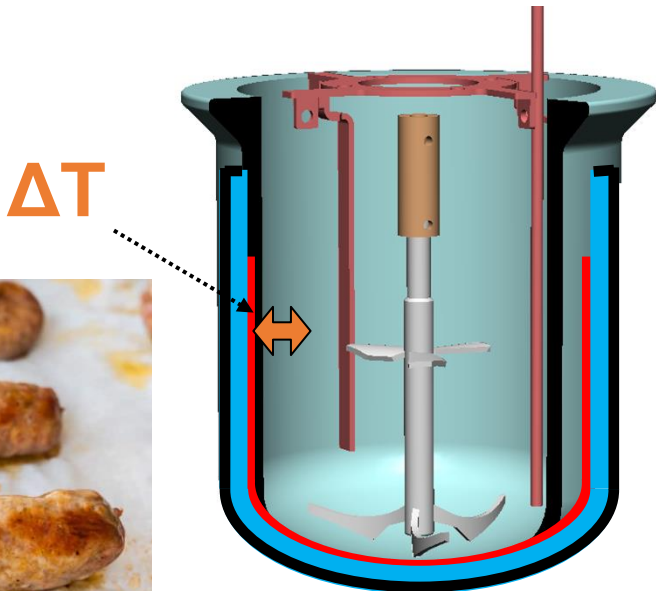


► Herausforderung: Scale-Up der Wärmeübertragung!

Stand der Technik der Wärmeübertragung beim Scale-Up

Standard Lab-Reactor: 1 l

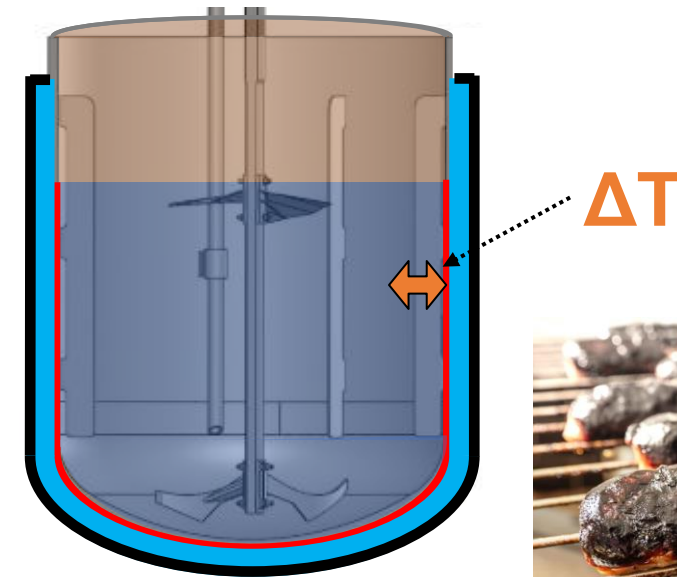
heat exchange via glass jacket



Direct Scale-Up ?

Production: 4'000 l

heat exchange via jacket

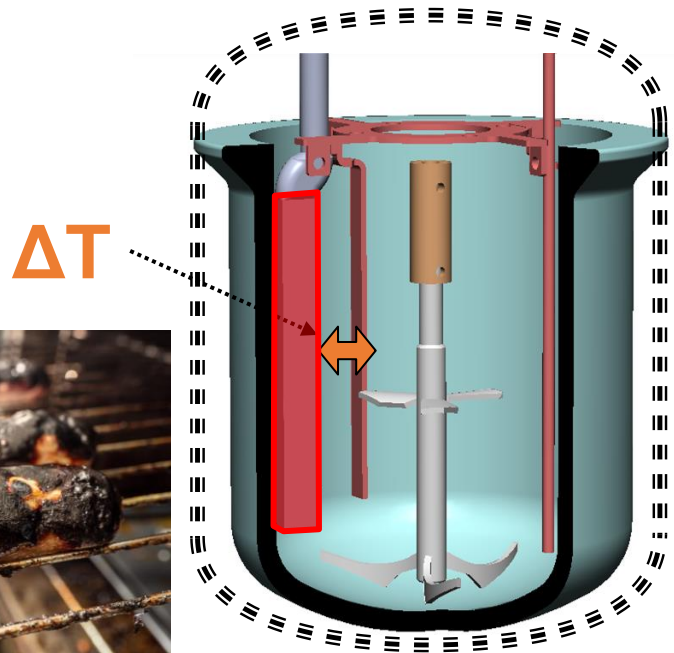


$\Delta T \approx 15 \times$ grösser
als im Labor !

Neuer Ansatz für die Wärmeübertragung beim Scale-Up

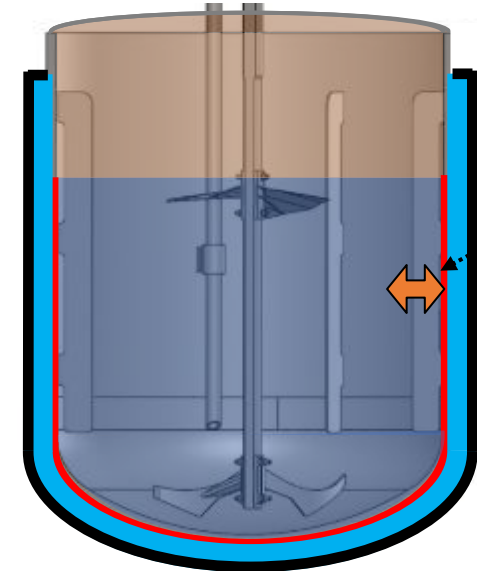
Scale-Down-Reactor: 1 l
Heat exchange via H/C-Finger

Production: 4'000 l
heat exchange via jacket



Adiabatic Shield

Direct Scale-Up



ΔT bleibt beim Scale-Up konstant

Zielsetzung des Projekts

The H/C-Finger should be designed to **simulate the impact of the wall temperature** as well as the **wall material** on the investigated process already in lab scale.

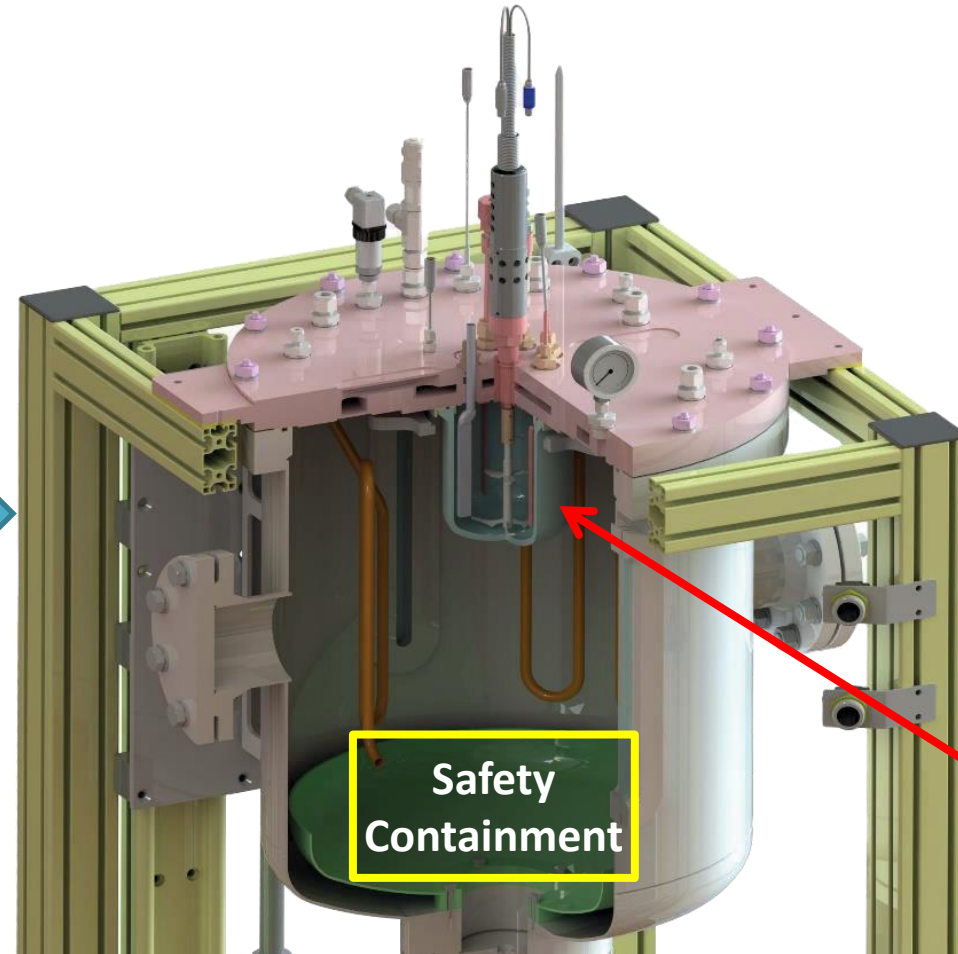
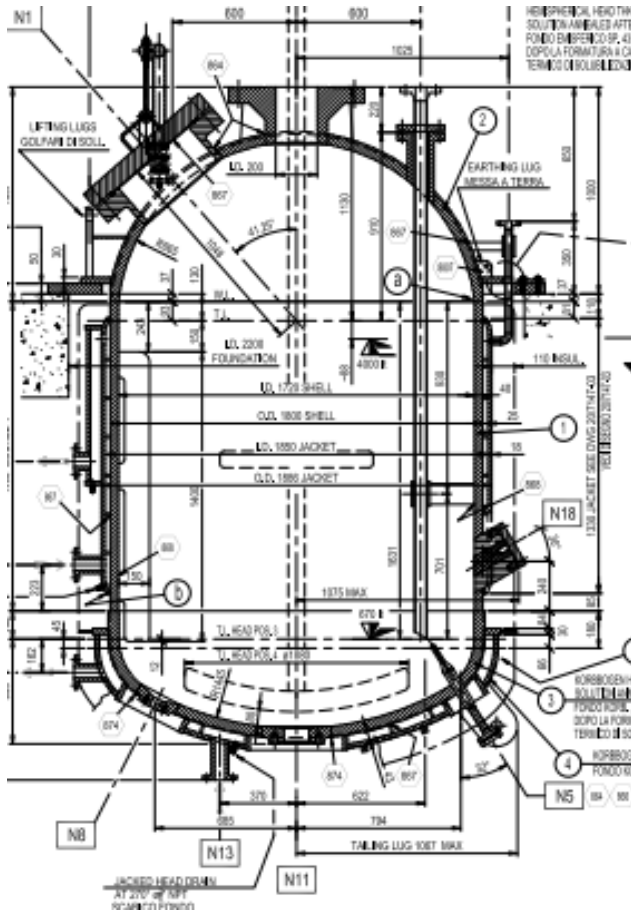
Effects such as ...

- ... **by-product formation** due to a hot reactor wall
- ... the formation of different **polymorphs** during crystallization due to a cold reactor wall
- ... the impact of **corrosion** on a catalytic process or product quality

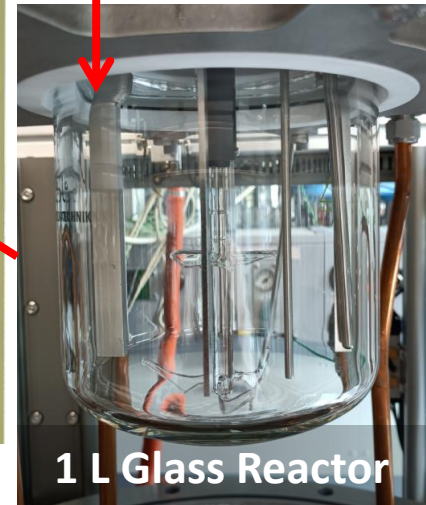
... can now be investigated prior to the scale-up to production scale.

→ The novel Scale-Down-Reactor thus **shortens the development time and minimizes the needs for intermediate process trials in pilot scale.**

Aufgabenstellung: Scale-Down des Wärmetransports eines Hydrierautoklaven (4 m³ -> 1 Liter)



Heating/
Cooling
Finger



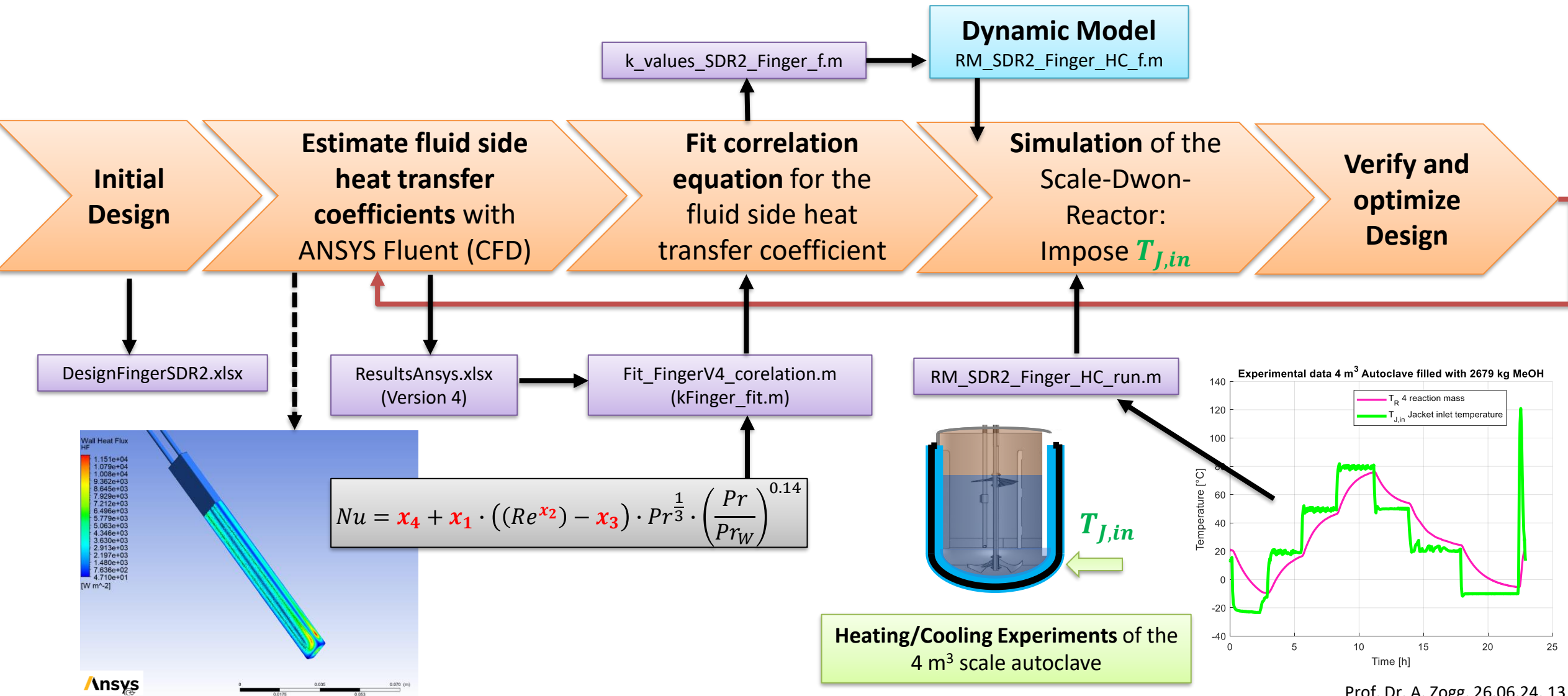
1 L Glass Reactor

Aufgabenstellung: Scale-Down des Wärmetransports eines Hydrierautoklaven ($4 \text{ m}^3 \rightarrow 1 \text{ Liter}$)

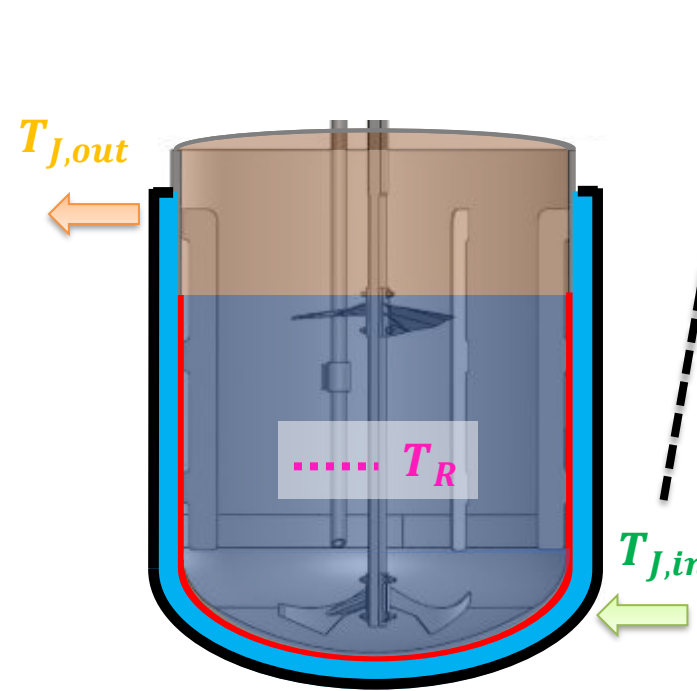
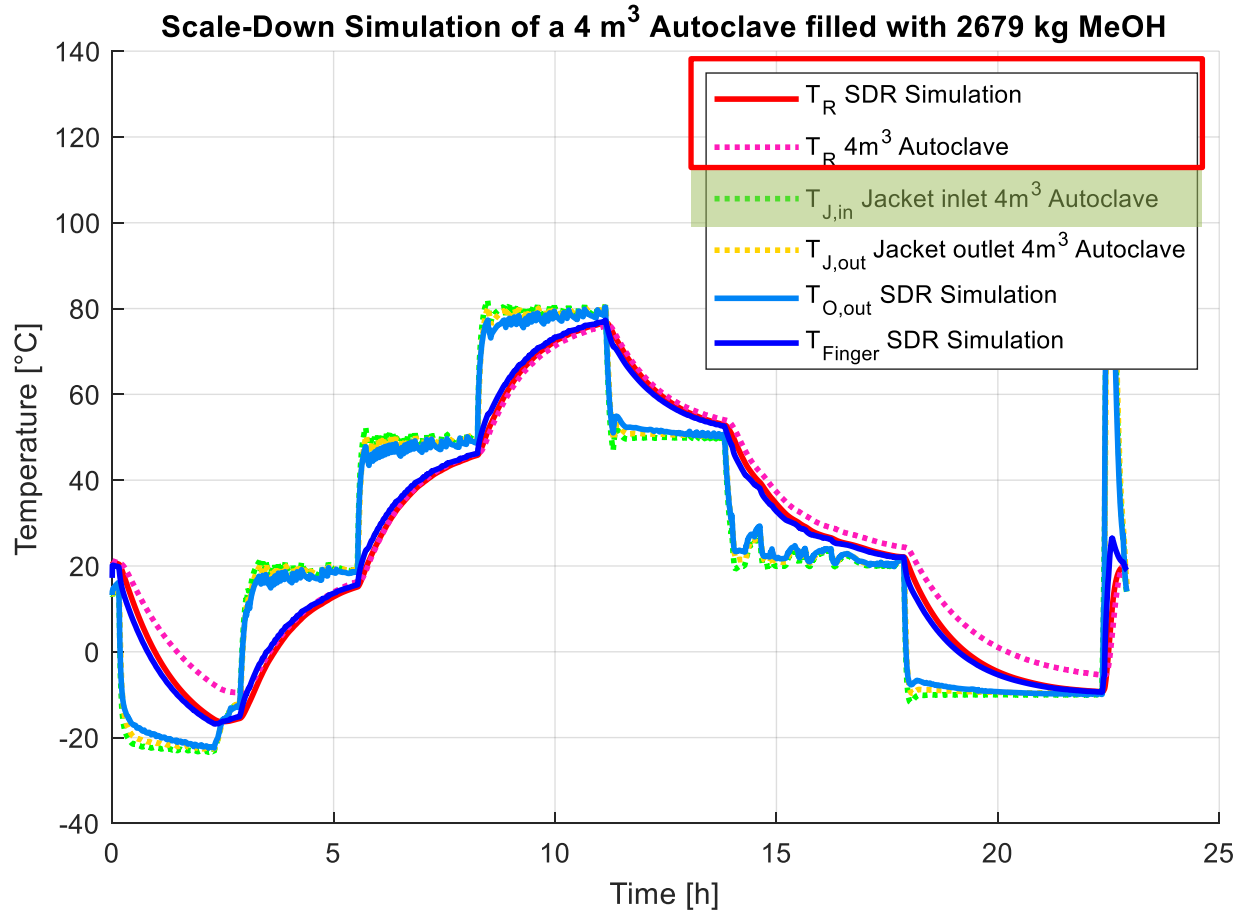
Conditions for the design of a Heating/Cooling-Finger:

- Similar **geometry** to a baffle of the production-scale reactor.
- Similar **volume to heat transfer area** ratio as the production-scale reactor.
- Similar **overall heat transfer coefficient** as the production-scale reactor.
- Similar **construction material** as the production-scale reactor wall (904L).

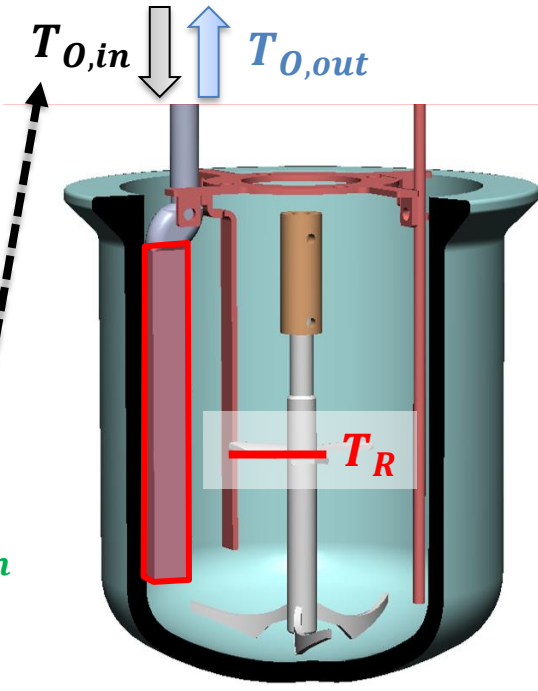
Workflow: Design of the Heating / Cooling Finger



Workflow: Design of the Heating / Cooling Finger



Messdaten aus dem
4 m³ Hydrierautoklaven



Simulation des Scale-
Down-Reaktors

Dynamic Model
RM_SDR2_Finger_HC_f.m

RM_SDR2_Finger_HC_run.m

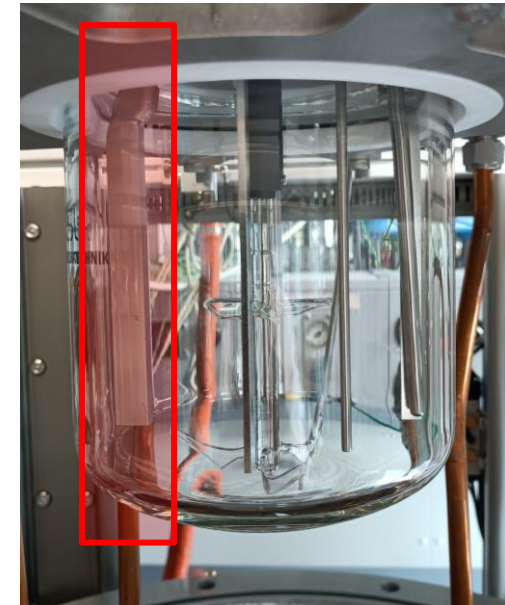
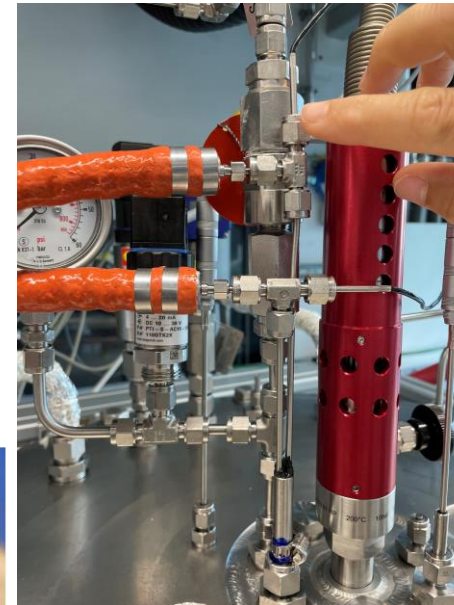
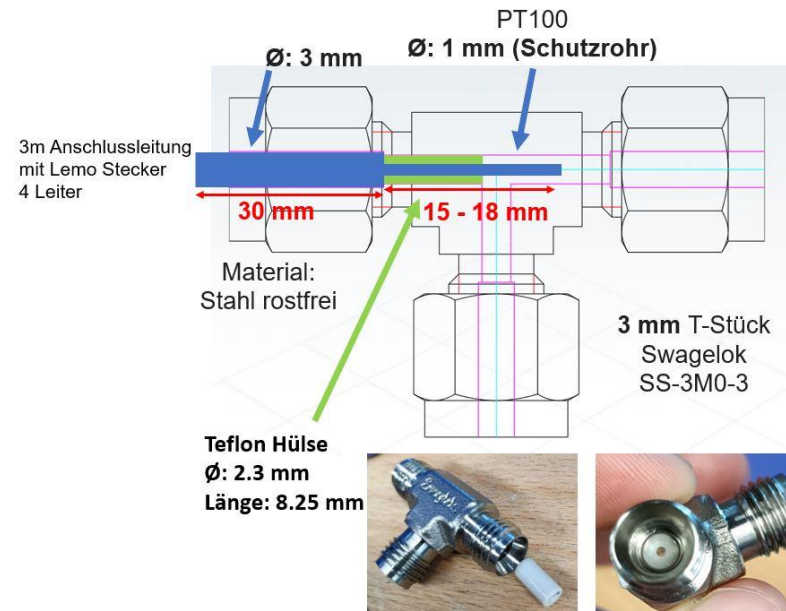
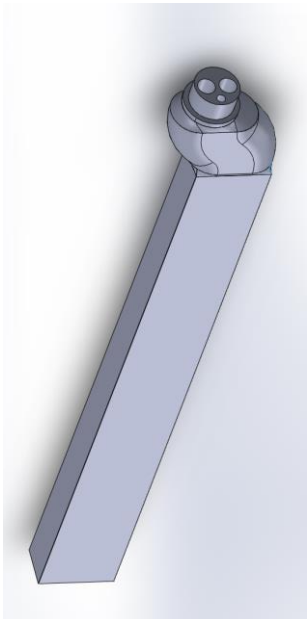
Workflow: Manufacturing and Implementation of the Heating/Cooling Finger

3D
Printing

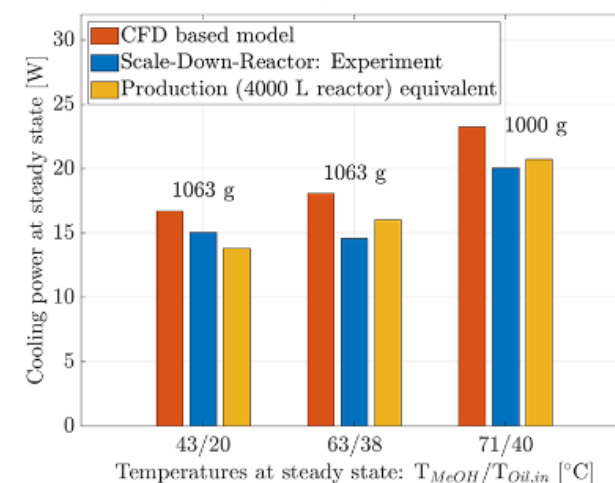
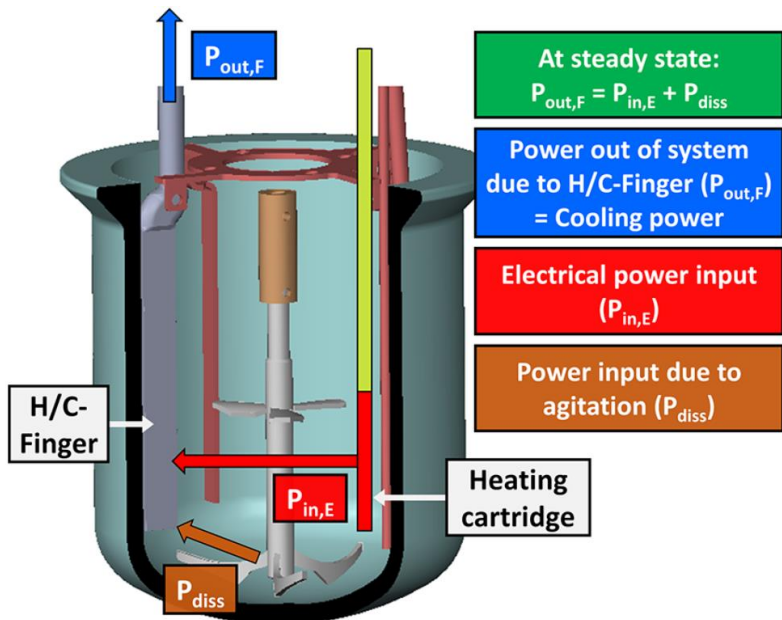
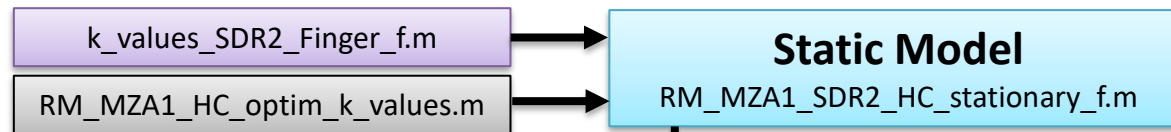
Assembly

Temperature Sensors for
reaction calorimetry

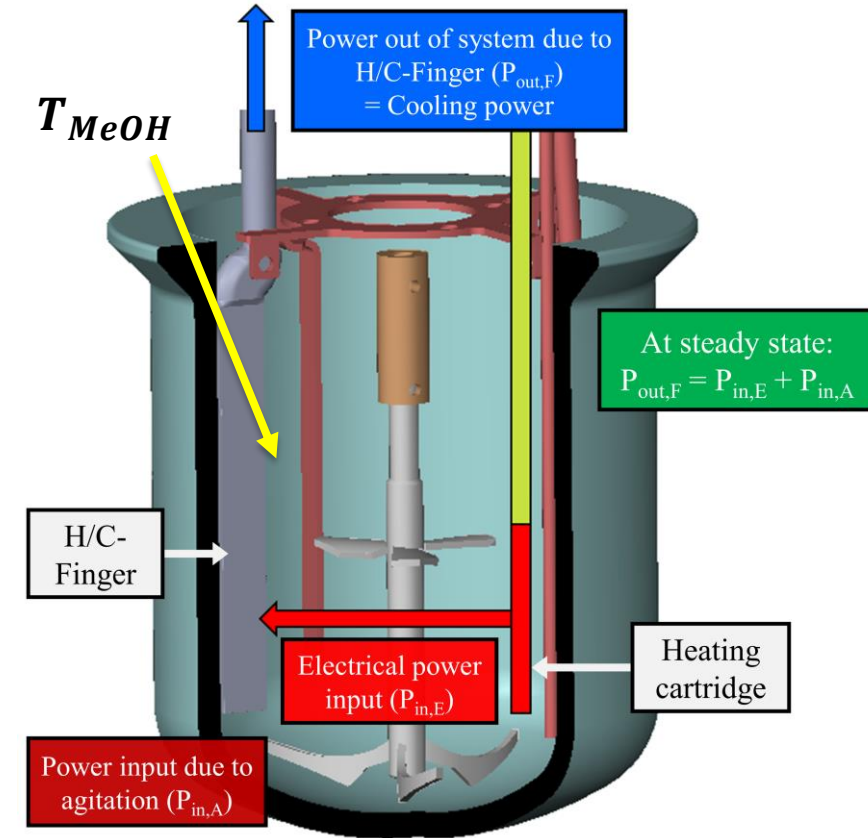
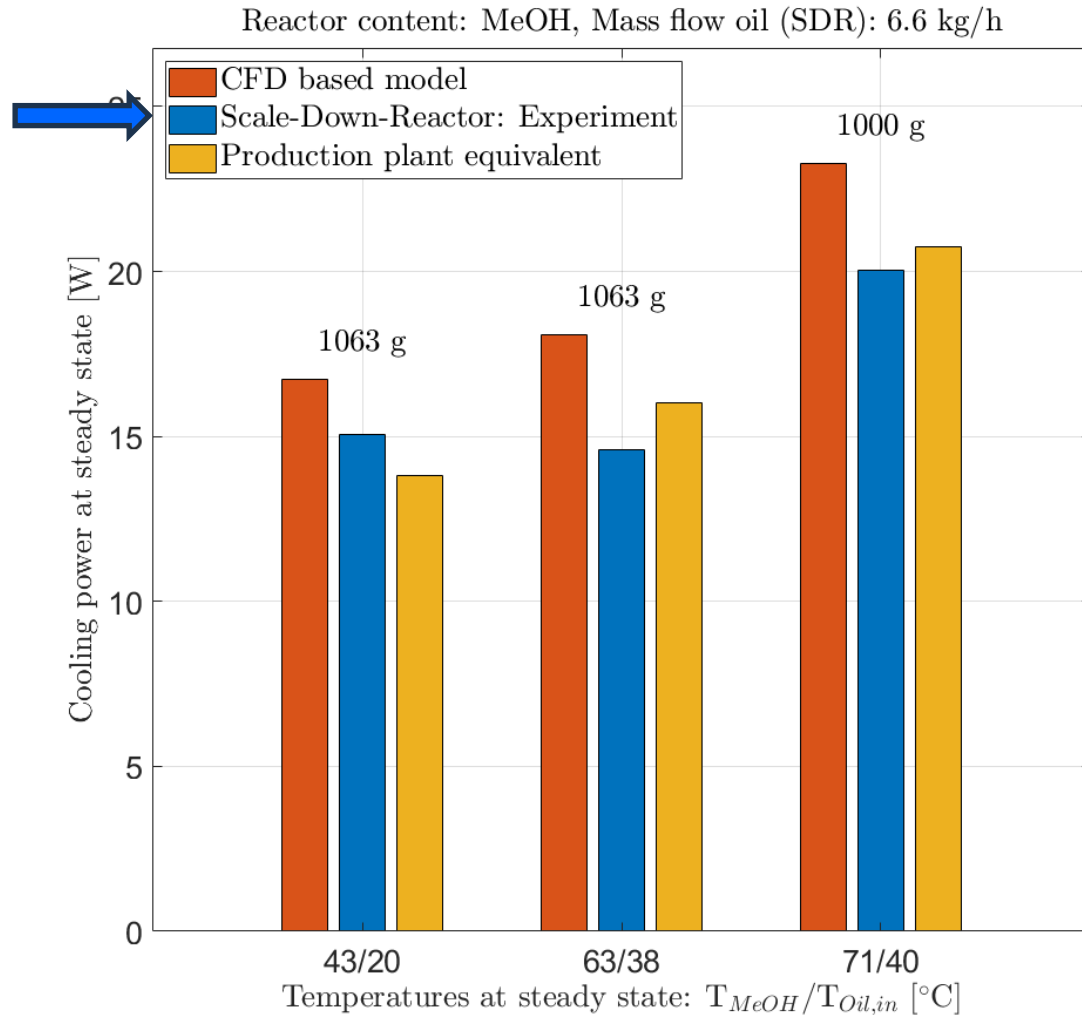
Implementation



Workflow: Qualification of the H/C-Finger at steady state

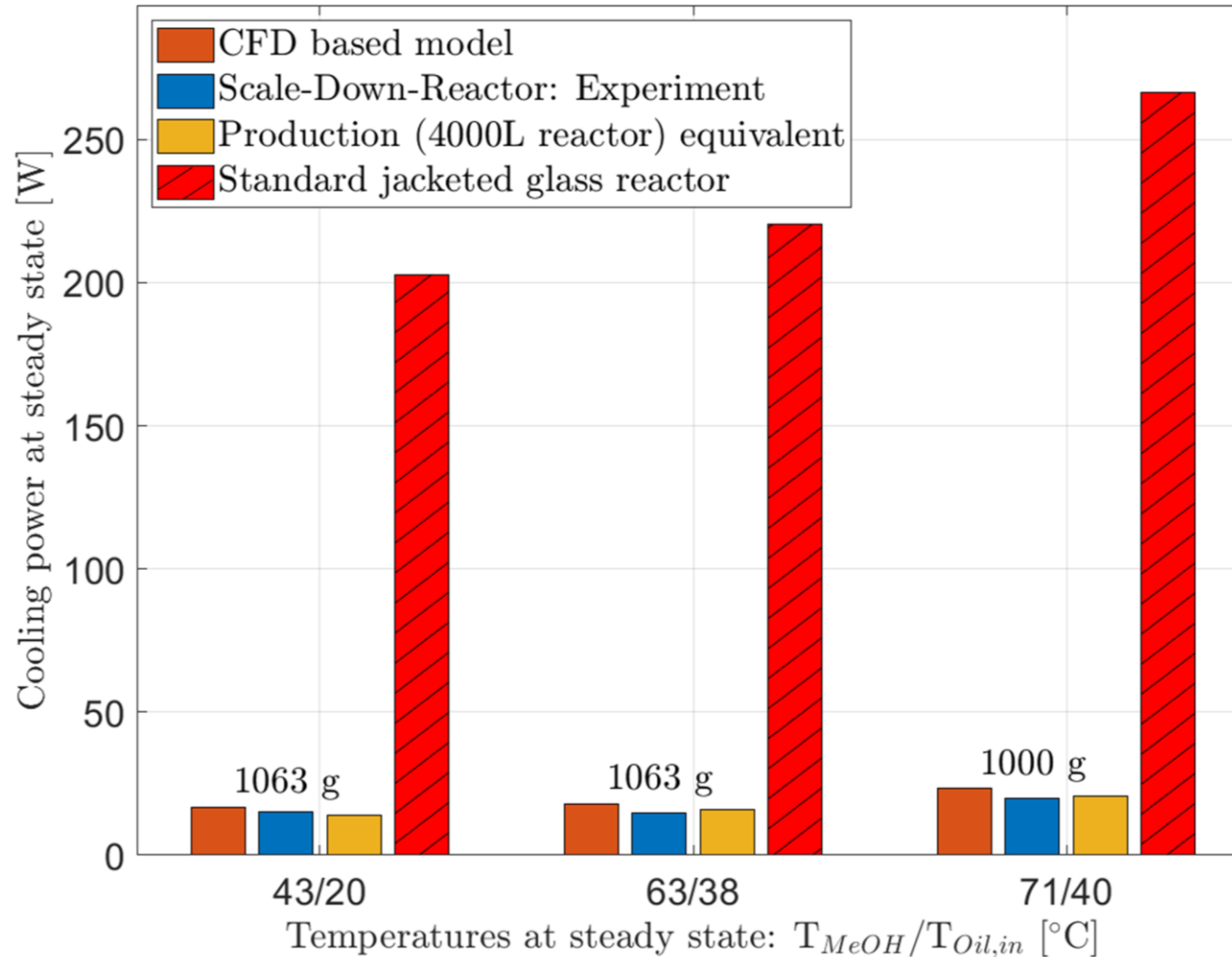


Workflow: Qualification of the H/C-Finger at steady state



Workflow: Qualification of the H/C-Finger at steady state

Reactor content:
Methanol

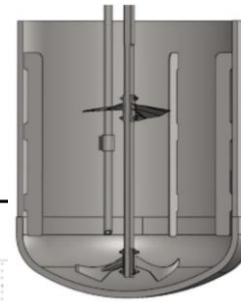


✓ The heat transfer of the Scale-Down-Reactor is similar to the production scale reactor.

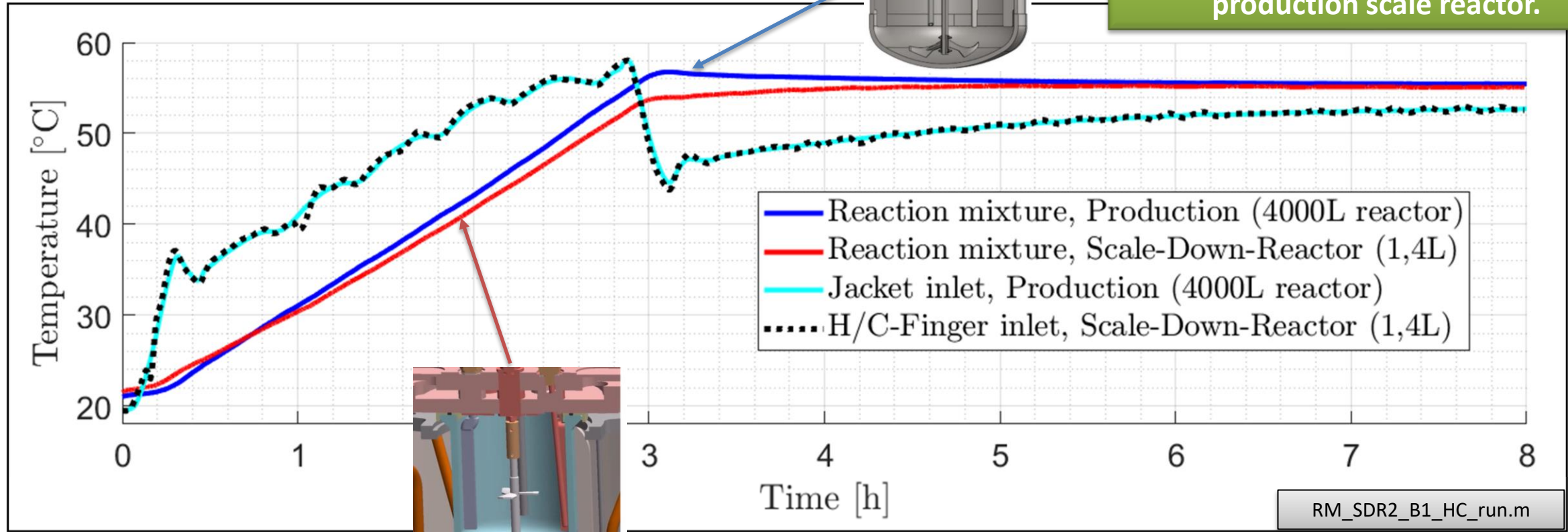
✓ Standard jacketed laboratory reactors are not representative!

Application: Hydrogenation

4 m³ Autoclave



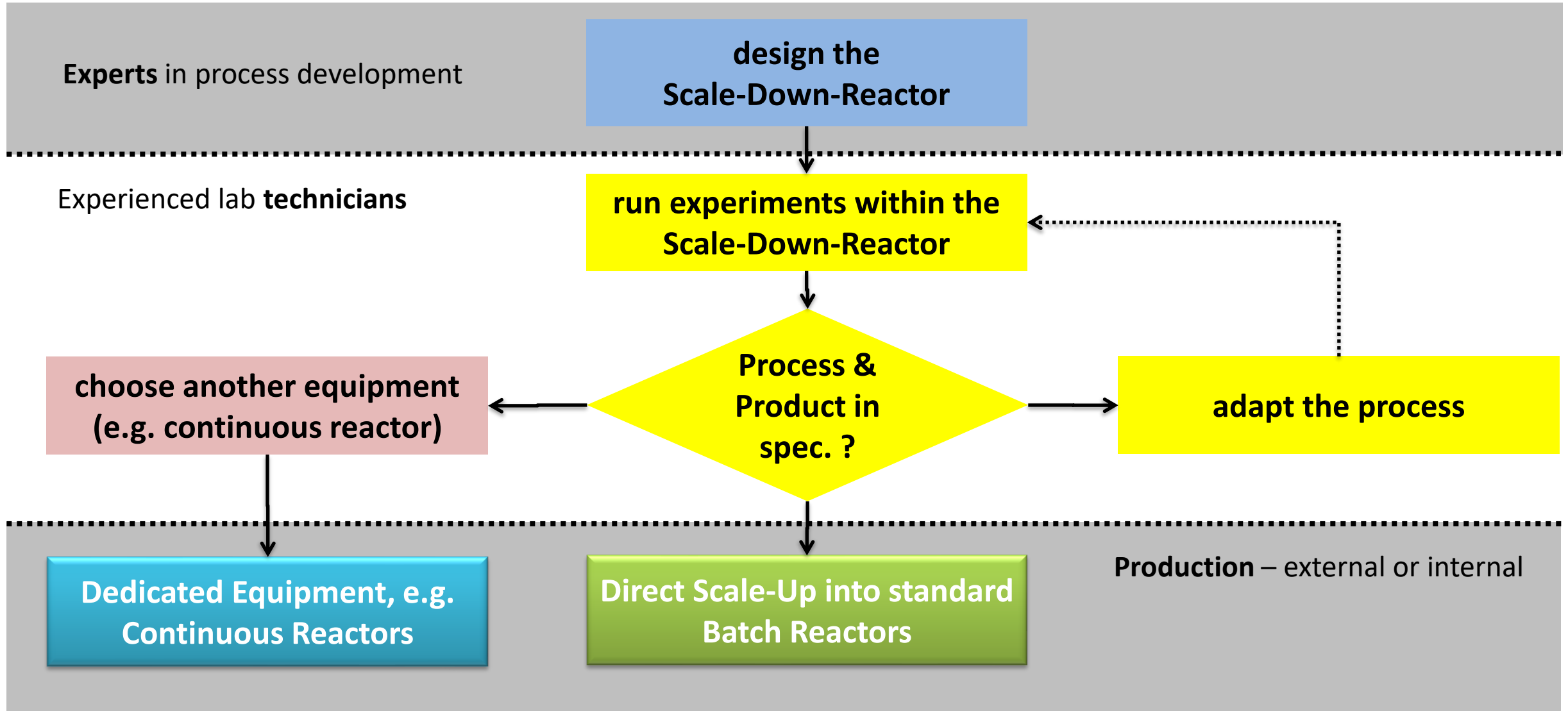
✓ The heat transfer of the Scale-Down-Reactor is similar to the production scale reactor.



1 L Scale-Down Reactor

RM_SDR2_B1_HC_run.m

Outlook: Proposal for a future Scale-Up-Strategy



Heiz/Kühlfinger an der FHNW in Muttenz



Heiz-Kühlfinger optimiert bei der Siegfried AG



$T_{O,in}$

$T_{O,out}$

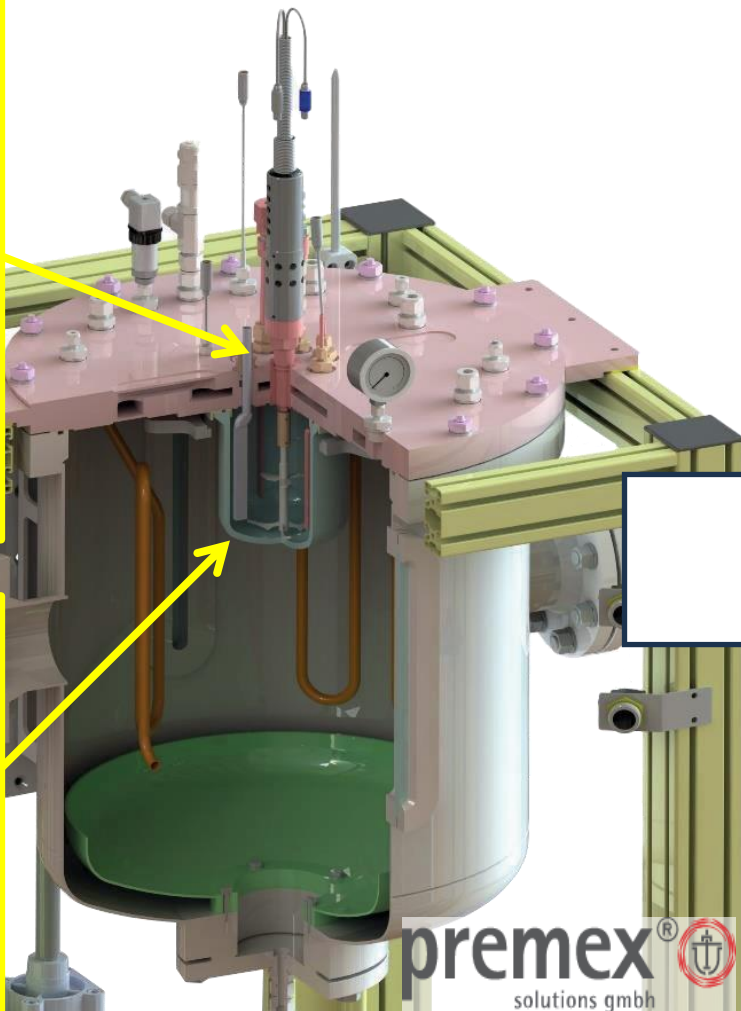
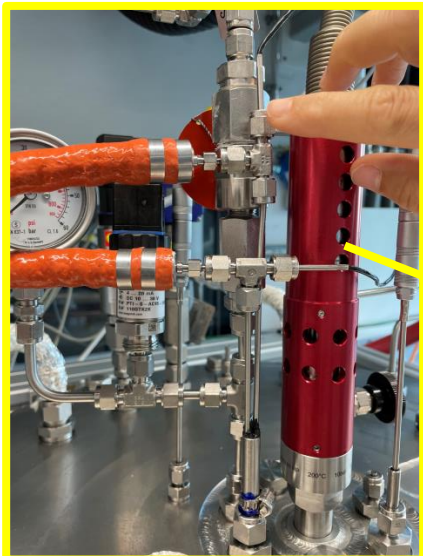
Siegfried

FERAMIC
3D METALLDRUCK

 **Allmetra**
measurement technology

Scale-Down Reaktor für Reaktionen unter Druck an der FHNW in Muttenz

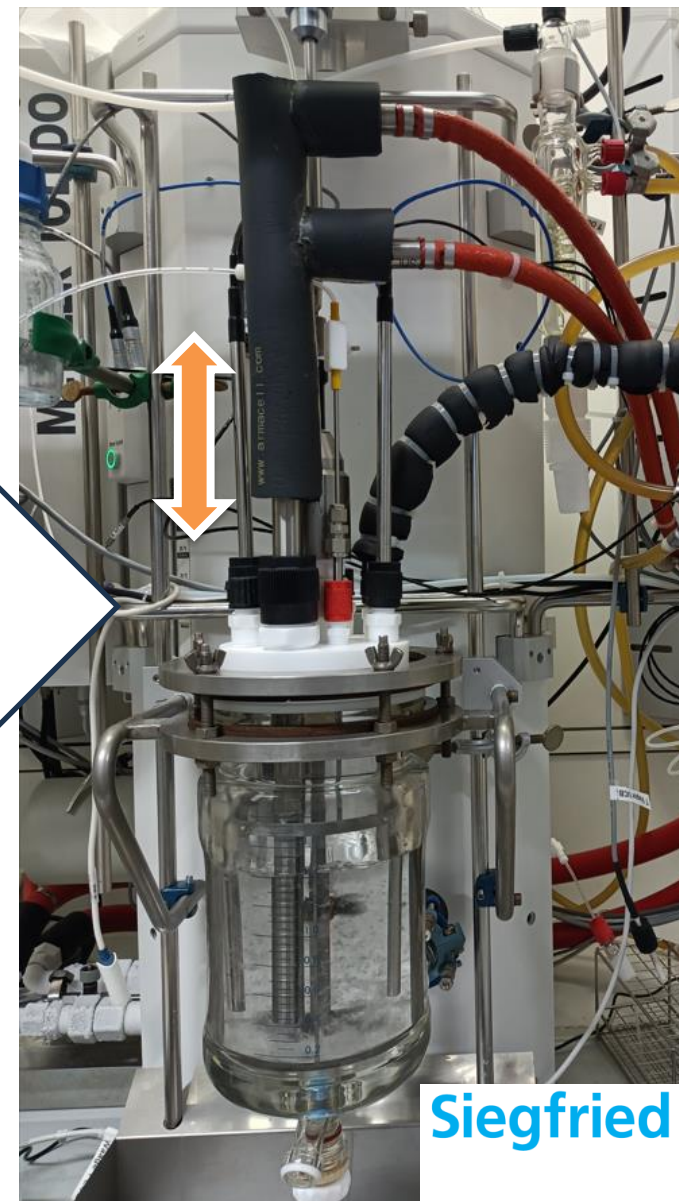
Heiz-Kühlfinger eingebaut im RC1 bei der Siegfried AG



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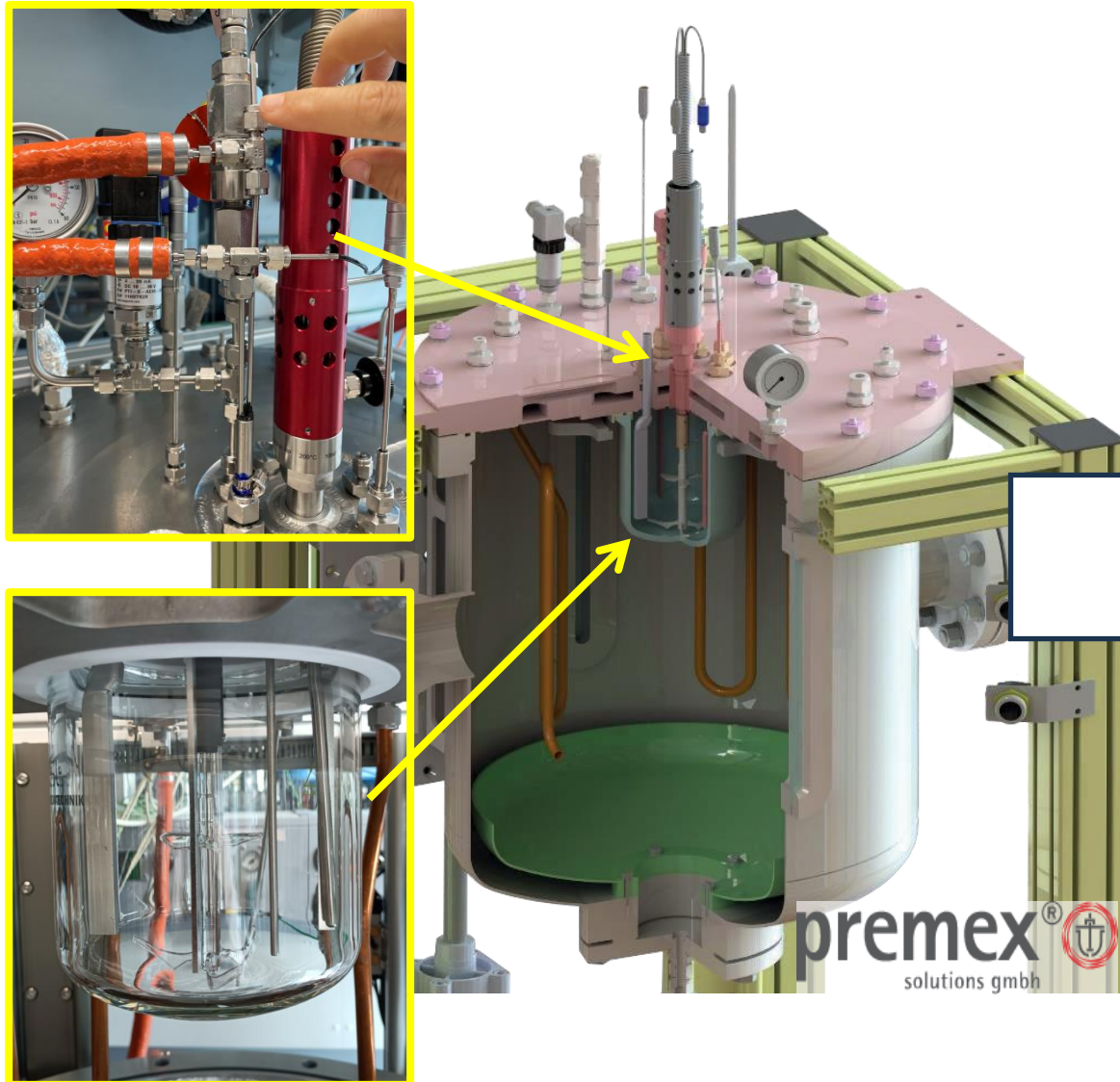
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Siegfried

Scale-Down Reaktor für Reaktionen unter Druck an der FHNW in Muttenz

Heiz-Kühlfinger eingebaut In einen normalen Laborreaktor

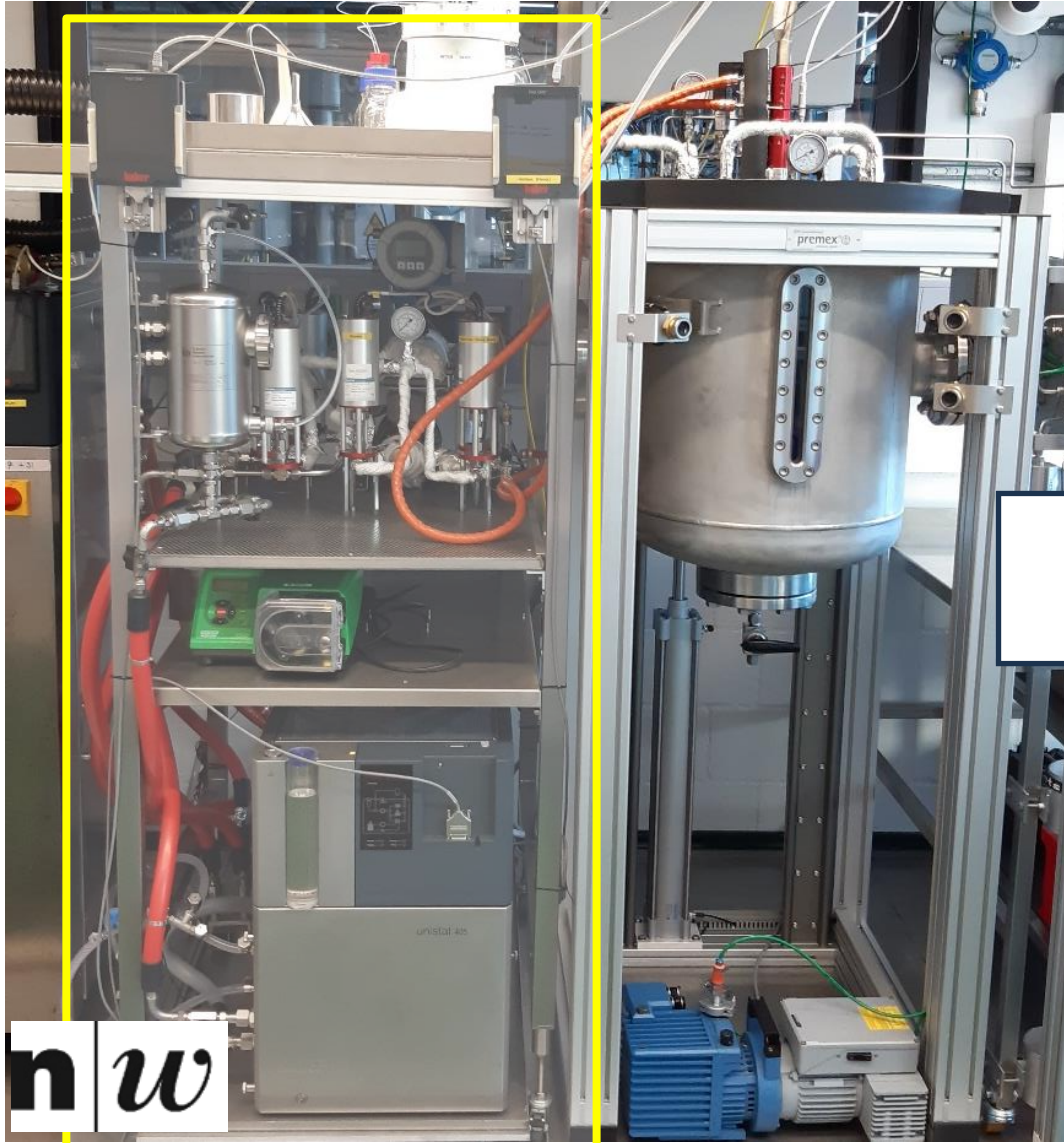


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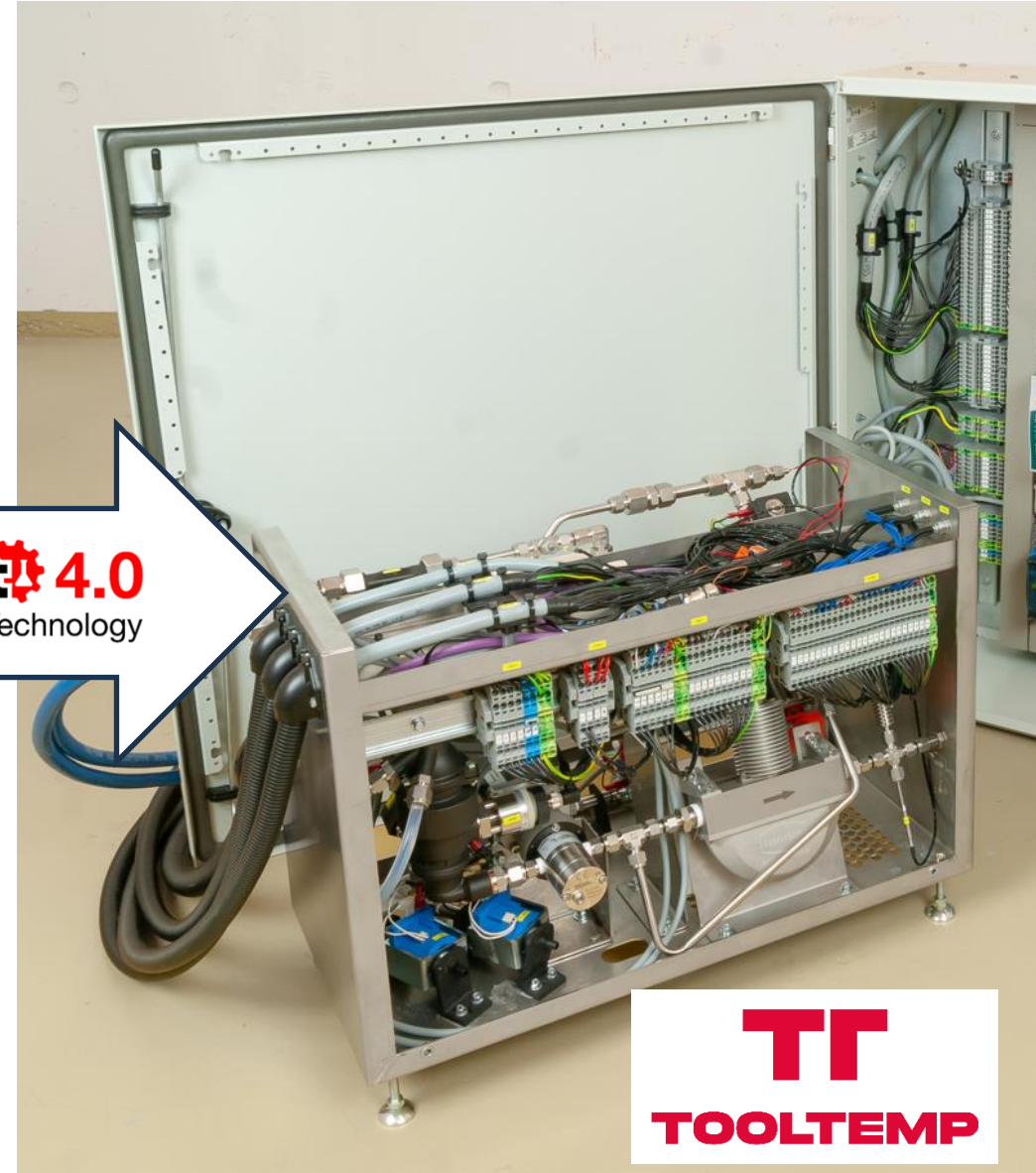
GlasKeller

Mischthermostat für den Scale-Down Reaktor an der FHNW in Muttenz



nw

Entwicklung eines kompakten Thermostaten für den H/K-Finger



MiniPlant 4.0
Innovative Process Technology

TT
TOOLTEMP

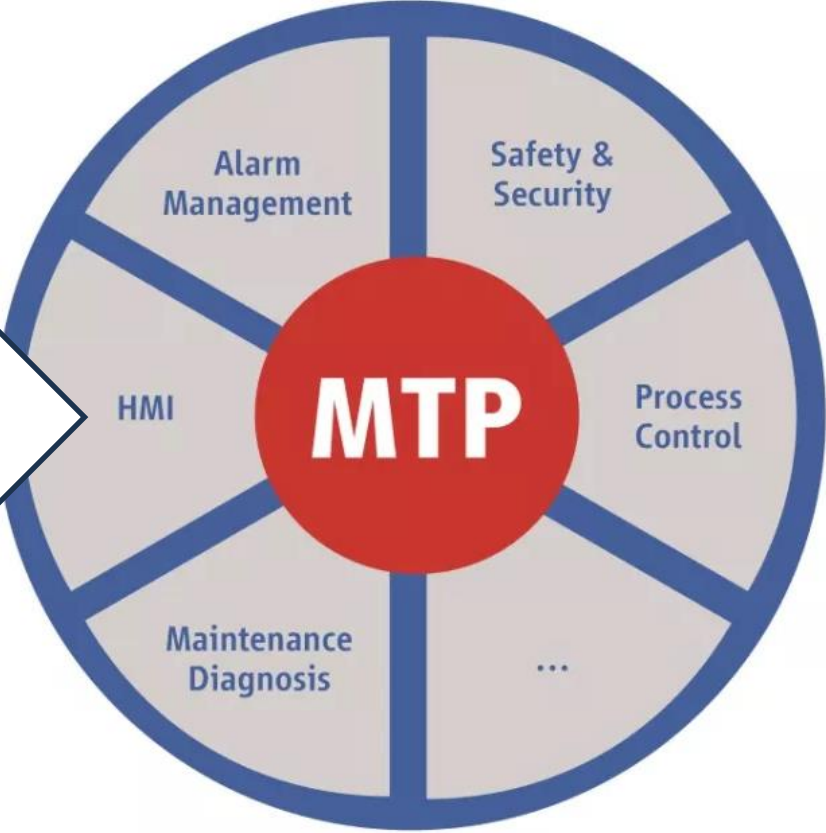
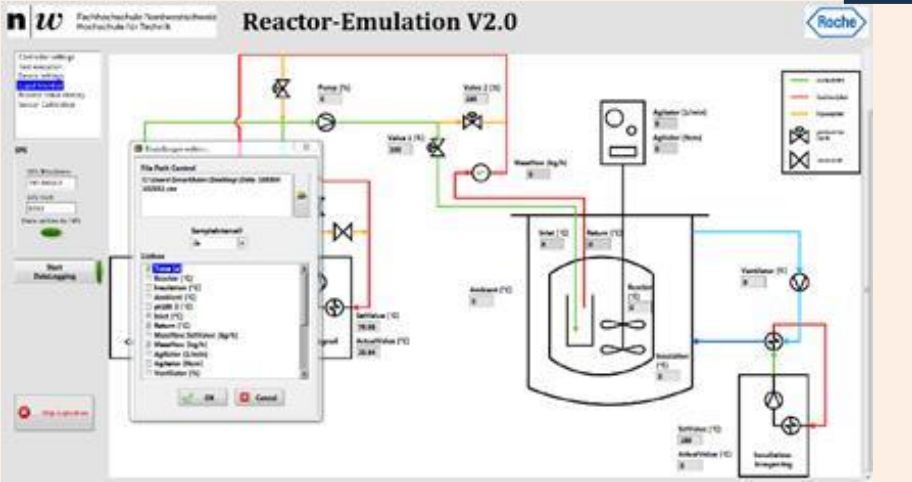
Automatisierung des Scale-Down Reaktors an der FHNW in Muttenz

Vision

SPS



Lab supervision system



J rome Blum, Karl-Heinz Langendorf, Prof. Dr. David Zogg.



Vielen Dank

Siegfried

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- ▶ Martina Hediger

Sponsoren:



- ▶ Marco Romanelli



Muttenz (HLS):

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- ▶ Christoph Hasler
- ▶ Pavel Dagorov
- ▶ Benedikt Brönnimann
- ▶ Ronny Hardegger
- ▶ Gonzalo Álvarez
- ▶ This Zahnd
- ▶ Kai Wegmann
- ▶ Christian D. Maier
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- ▶ **ToolTemp:**
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- ▶ **Feramic**
- ▶ Martin Hofer
- ▶ **GlasKeller**
- ▶ Andreas Stubbe
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