

Digitale Prozessmodelle für die Herstellung von thermoplastischen Verbundbauteilen



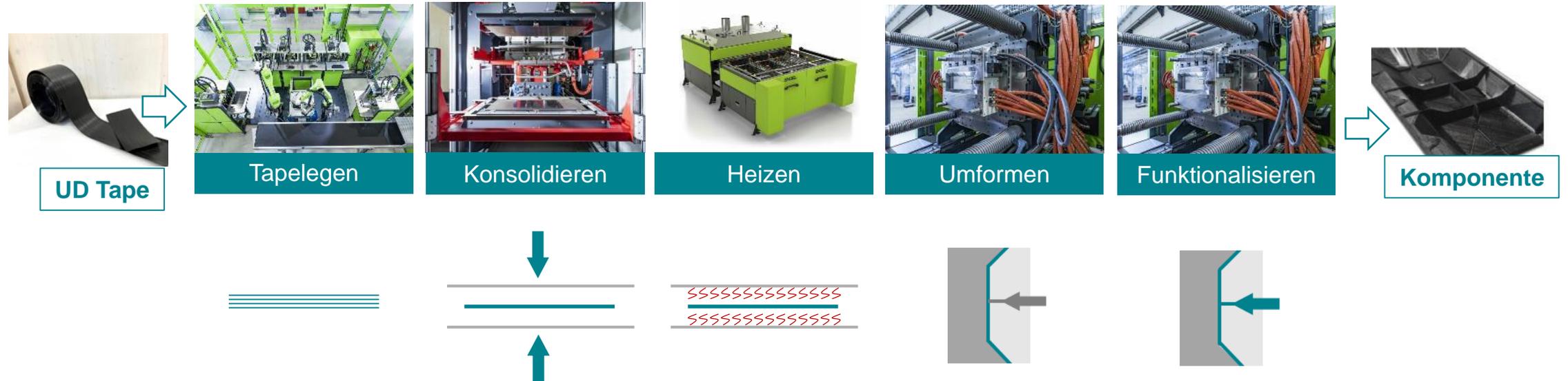
Eva Kobler
Research Scientist
CHASE Competence Center GmbH

Verarbeitung thermoplastischer Composites

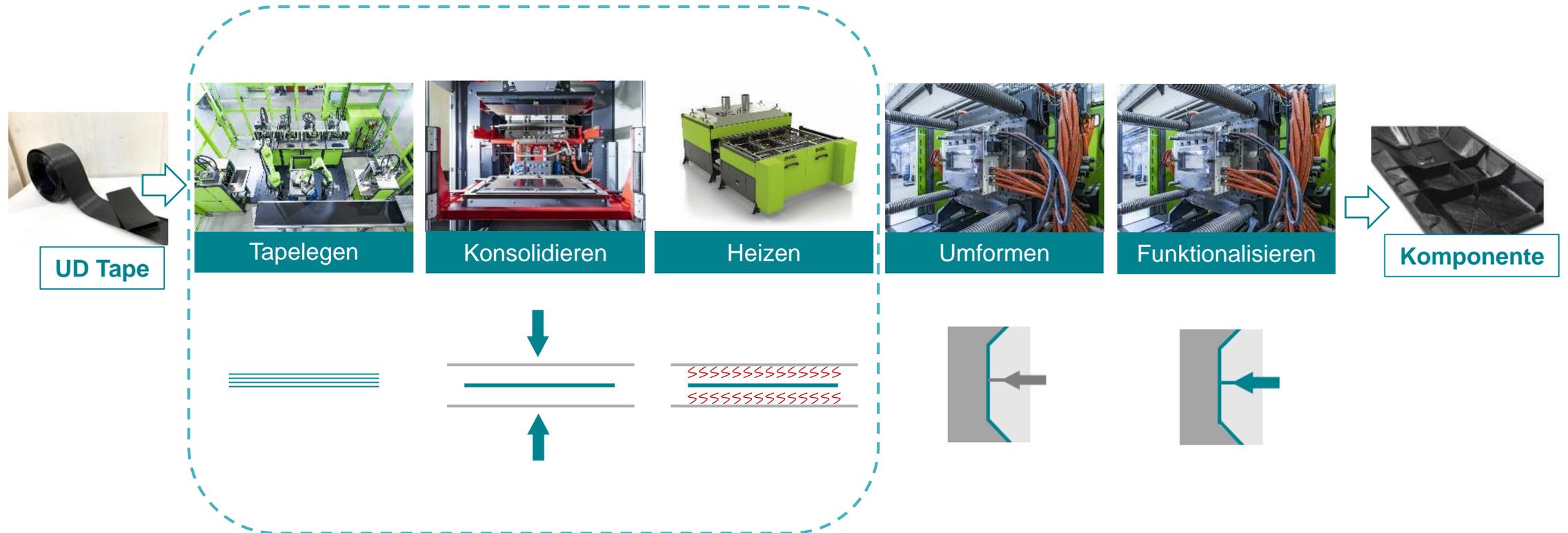


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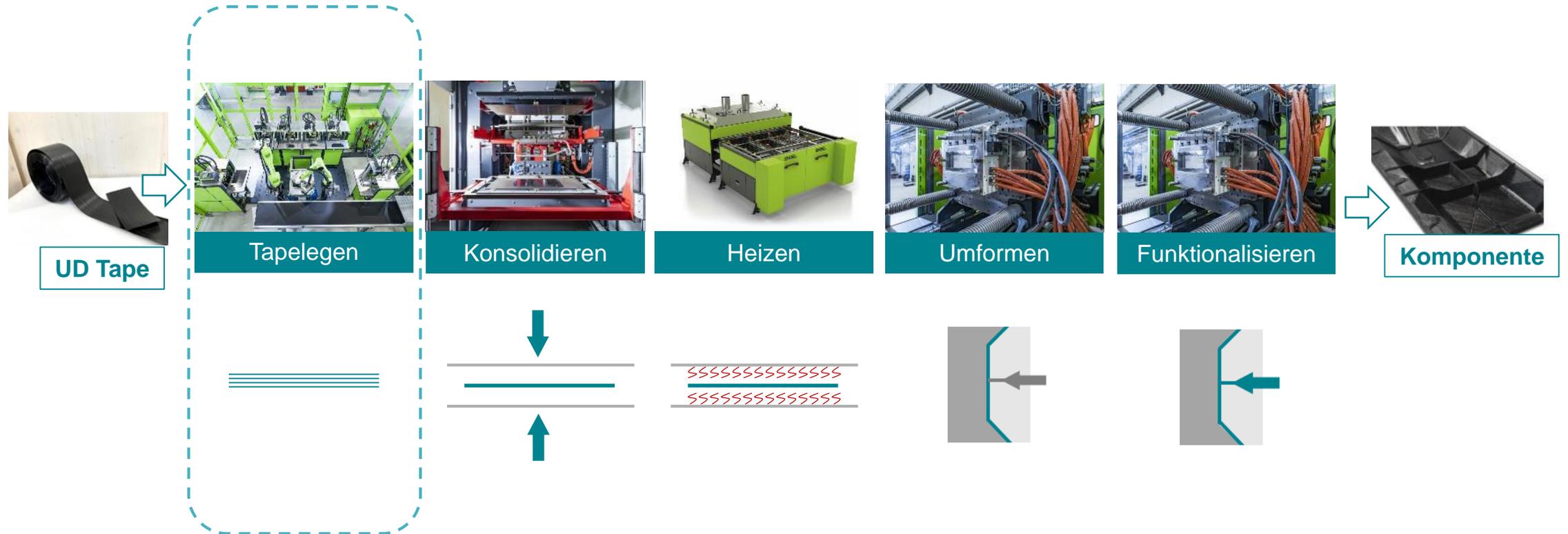
Verarbeitung thermoplastischer Composites



Verarbeitung thermoplastischer Composites



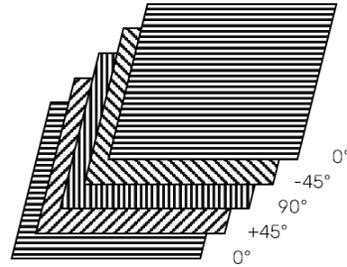
Verarbeitung thermoplastischer Composites



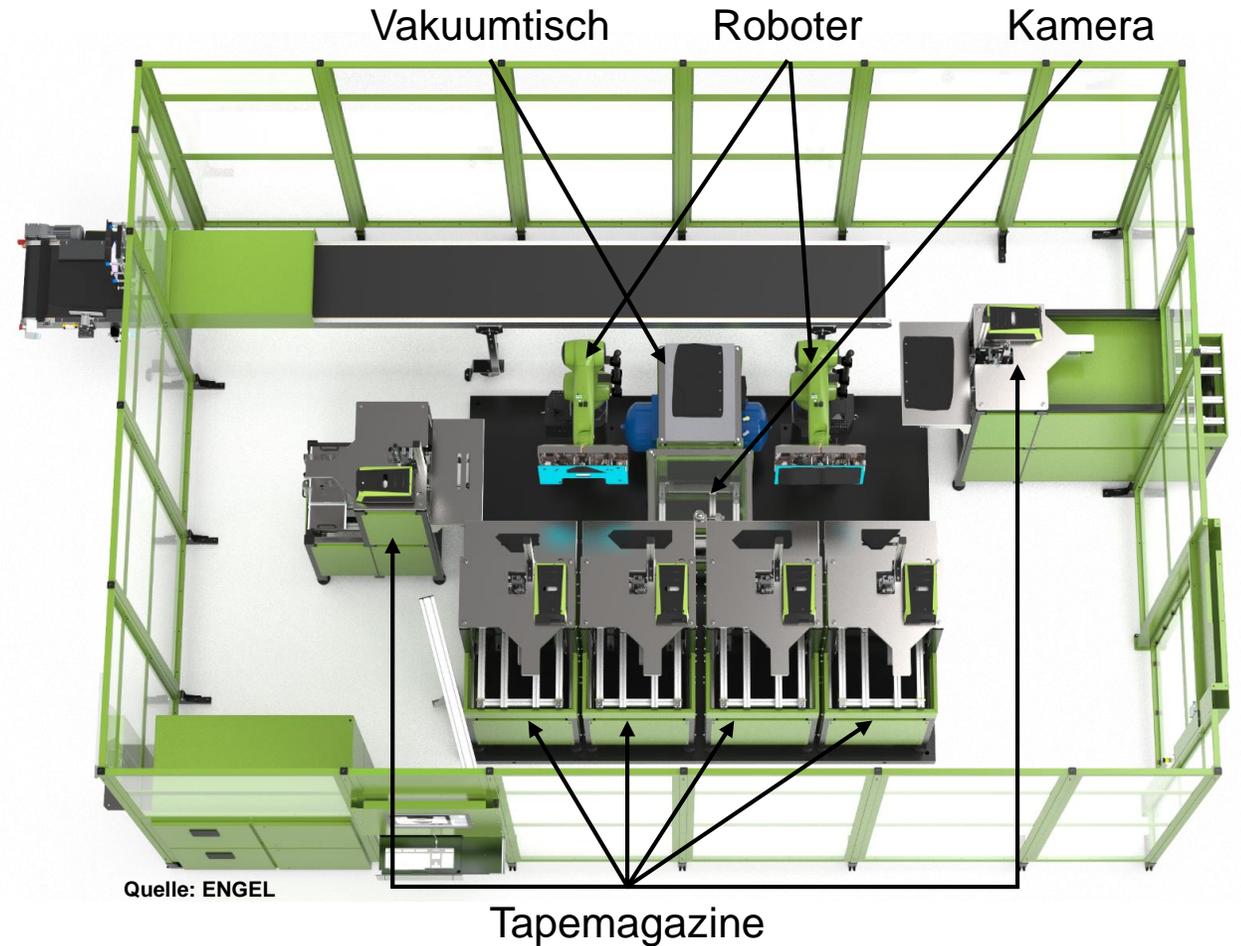
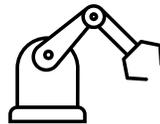
Tapelegen



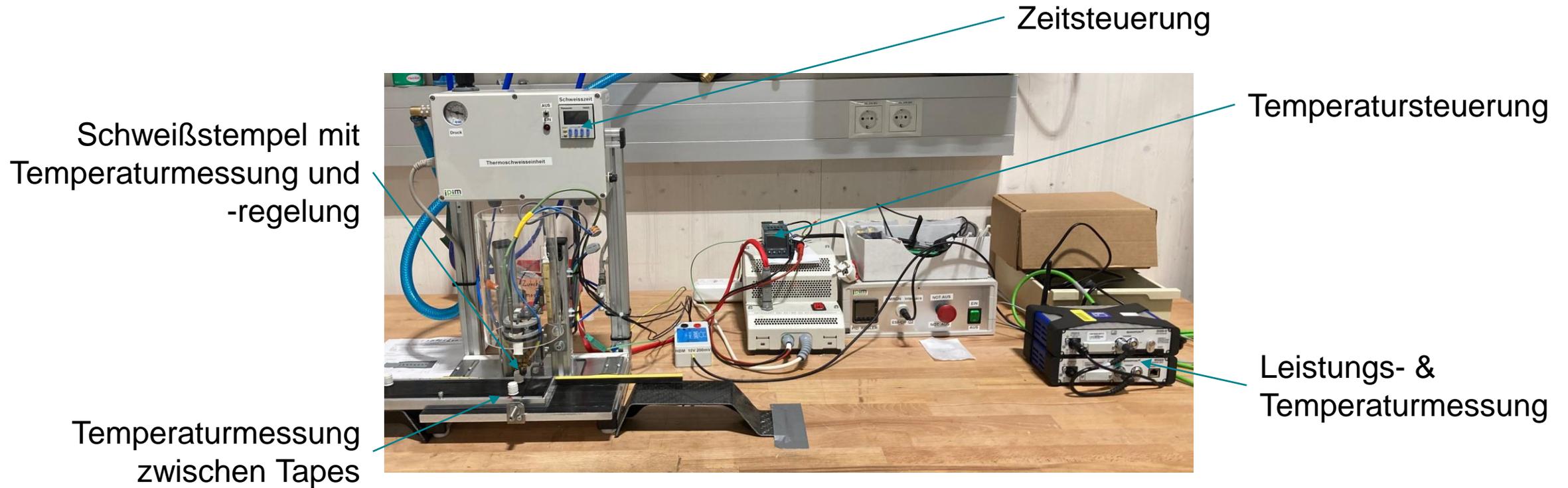
UD Tape



Aufnahme
aus
Magazin



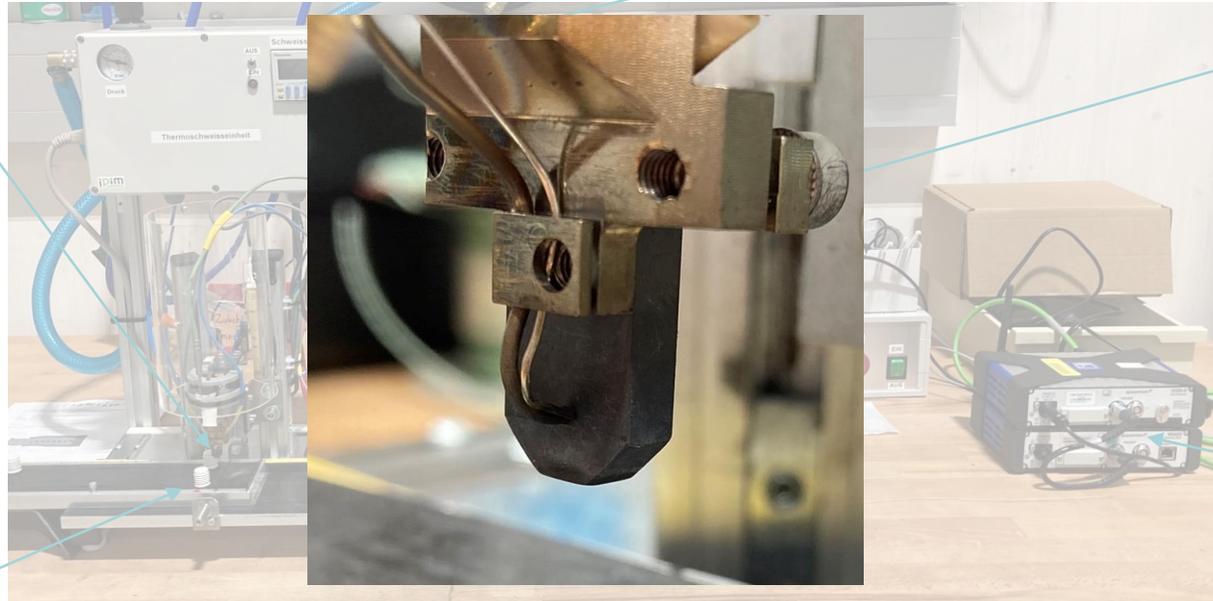
Tapelegen



Tapelegen

Schweißstempel mit
Temperaturmessung und
-regelung

Temperaturmessung
zwischen Tapes



Zeitsteuerung

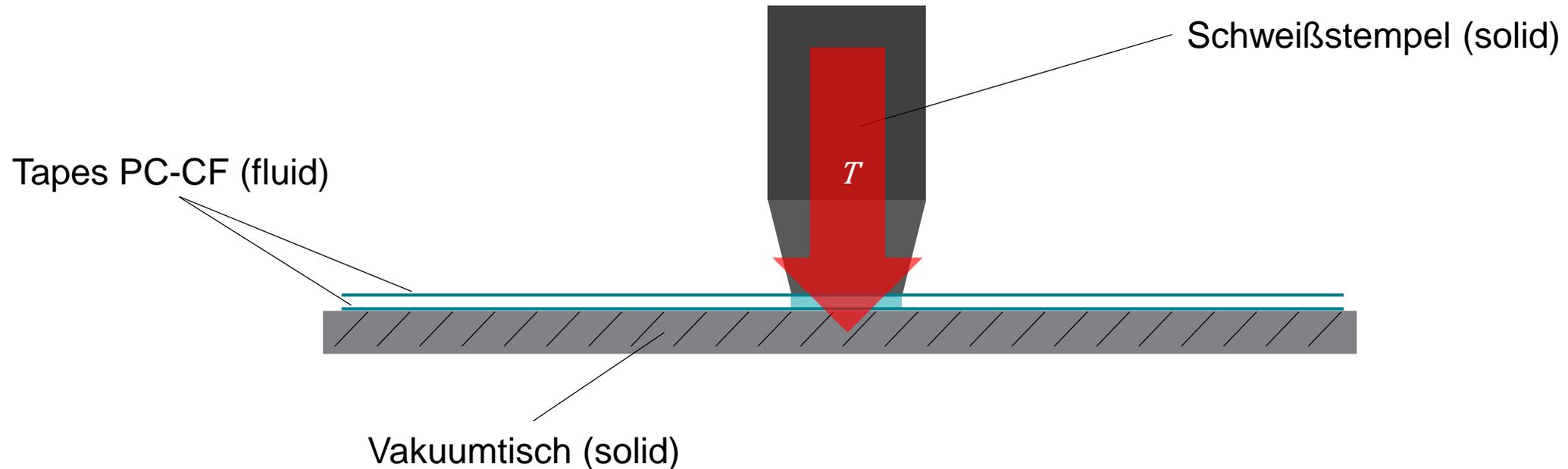
Temperatursteuerung

Leistungs- &
Temperaturmessung

Tapelegen

CFD tool OpenFOAM®

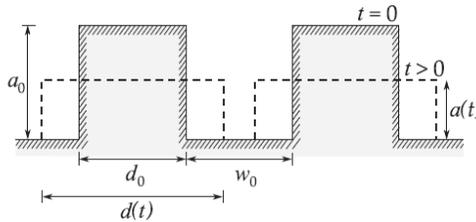
$$\underbrace{\frac{\partial \rho e}{\partial t} + \nabla \cdot \rho \vec{u} e - [\nabla \cdot \vec{u} p]}_{\text{Innere Energie}} + \underbrace{\frac{\partial \rho K}{\partial t} + \nabla \cdot \rho \vec{u} K}_{\text{mechanische Energie}} = \underbrace{\nabla \cdot \alpha_{eff} \nabla e + \rho S}_{\text{thermische Energie}}$$



Tapelegen

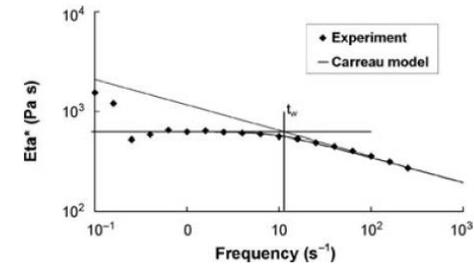
Kontaktentwicklung:

$$D_{ic}(t_c) = D_{ic,0} \left[1 + 5 \left(1 + \frac{w_0}{d_0} \right) \left(\frac{a_0}{d_0} \right)^2 \int_0^{t_c} \frac{P_{app}(t)}{\eta_0(T(t))} dt \right]^{\frac{1}{5}}$$



Diffusion:

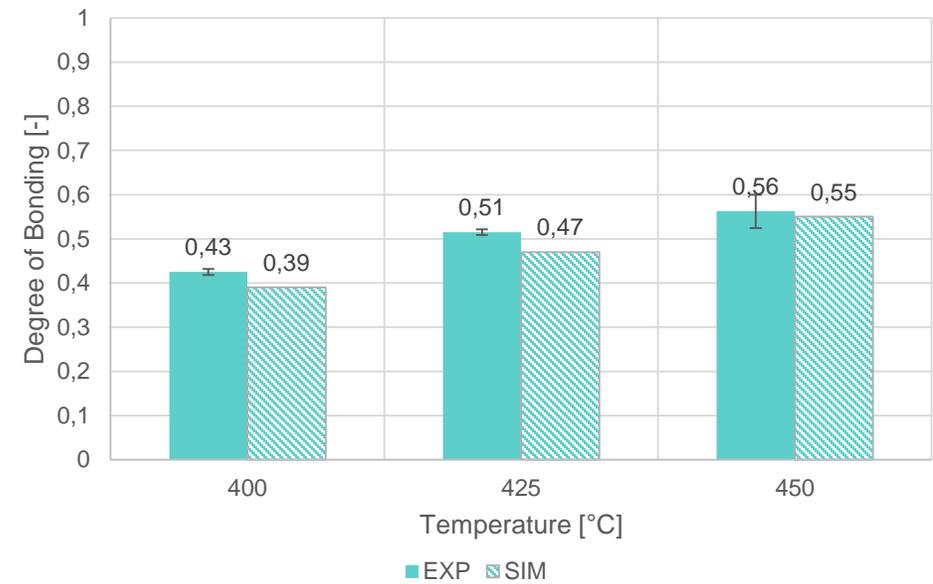
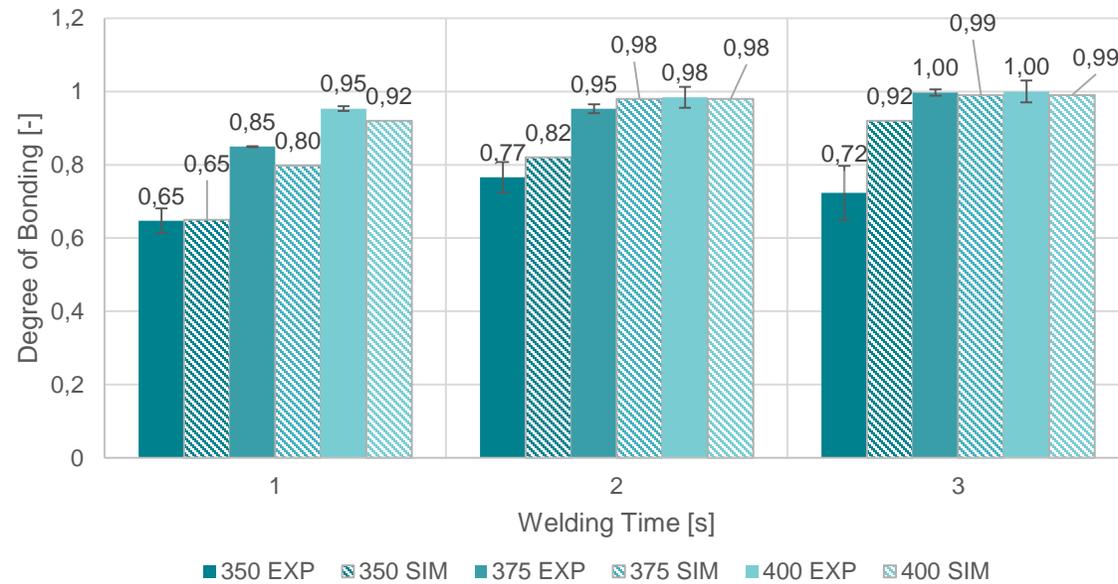
$$D_h(t) = \frac{S(t)}{S_\infty} = \left[\int_0^t \frac{1}{t_w(T(t))} dt \right]^{\frac{1}{4}}$$



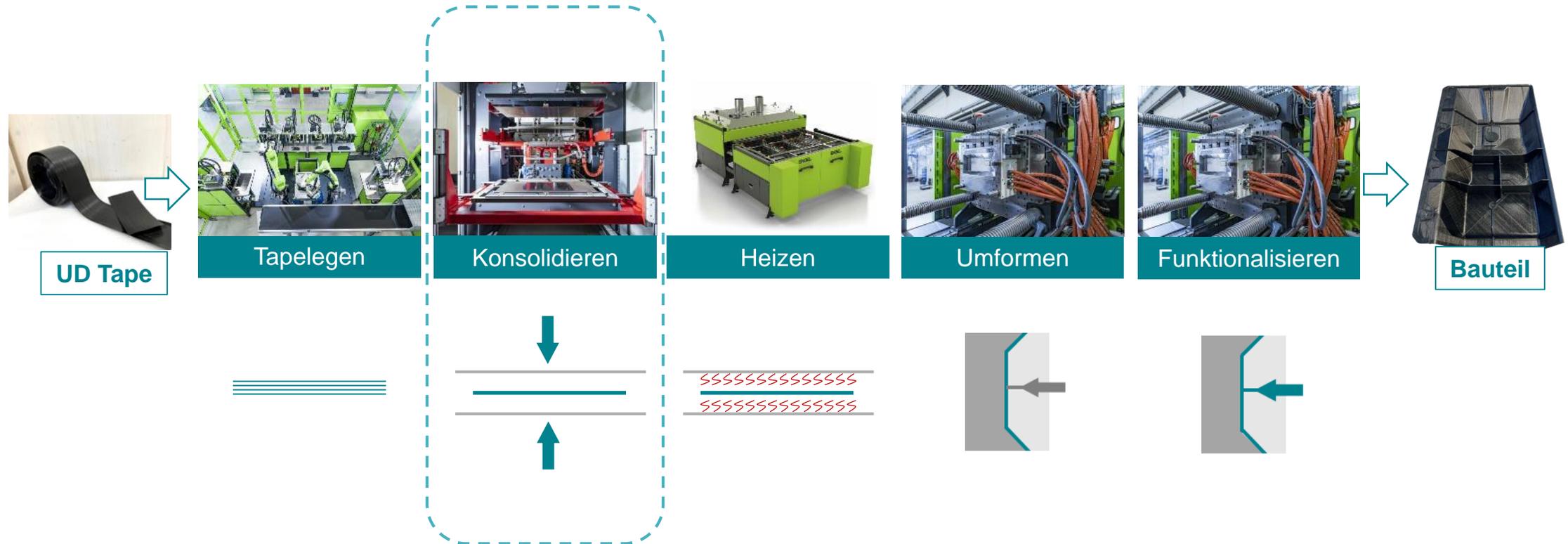
$$D_b(t) = D_h(t)D_{ic}(t_c) = [0,1]$$

Quelle: Khan et al.: Identification of Some Optimal Parameters to Achieve Higher Laminate Quality through Tape Placement Process

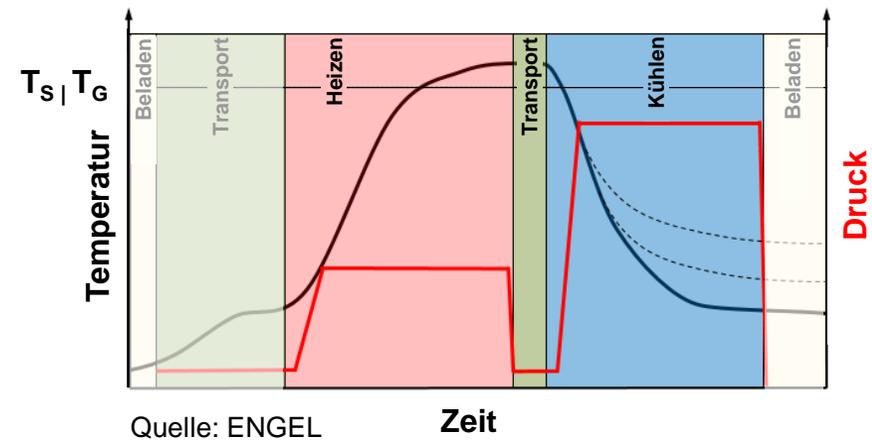
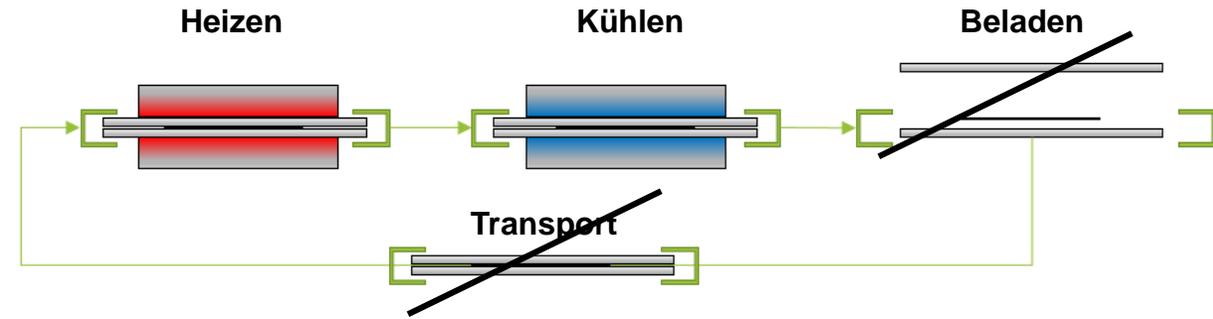
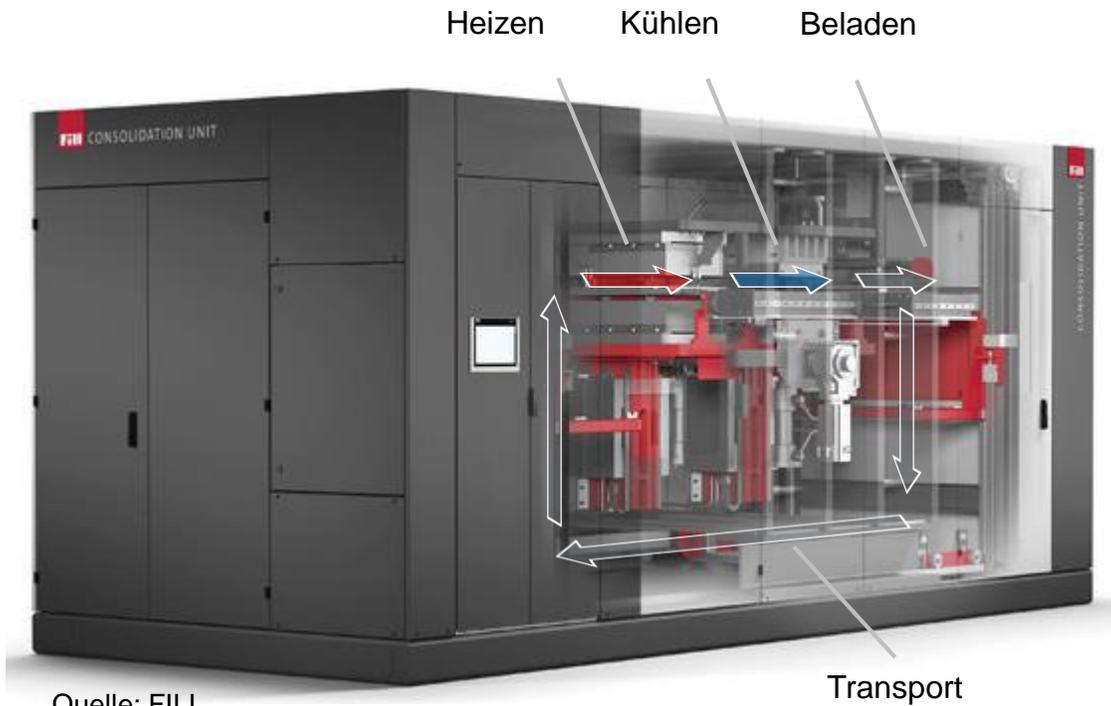
Tapelegen



Verarbeitung thermoplastischer Composites

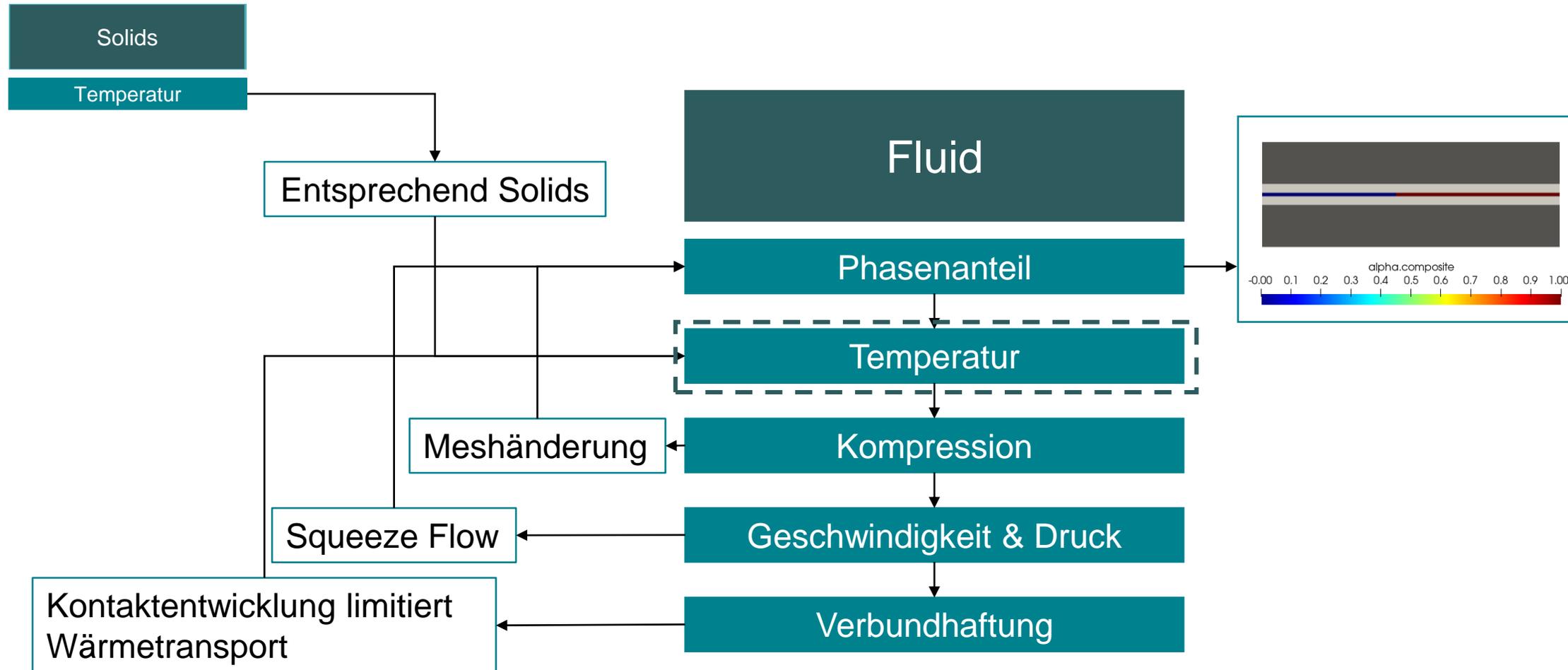


Konsolidieren



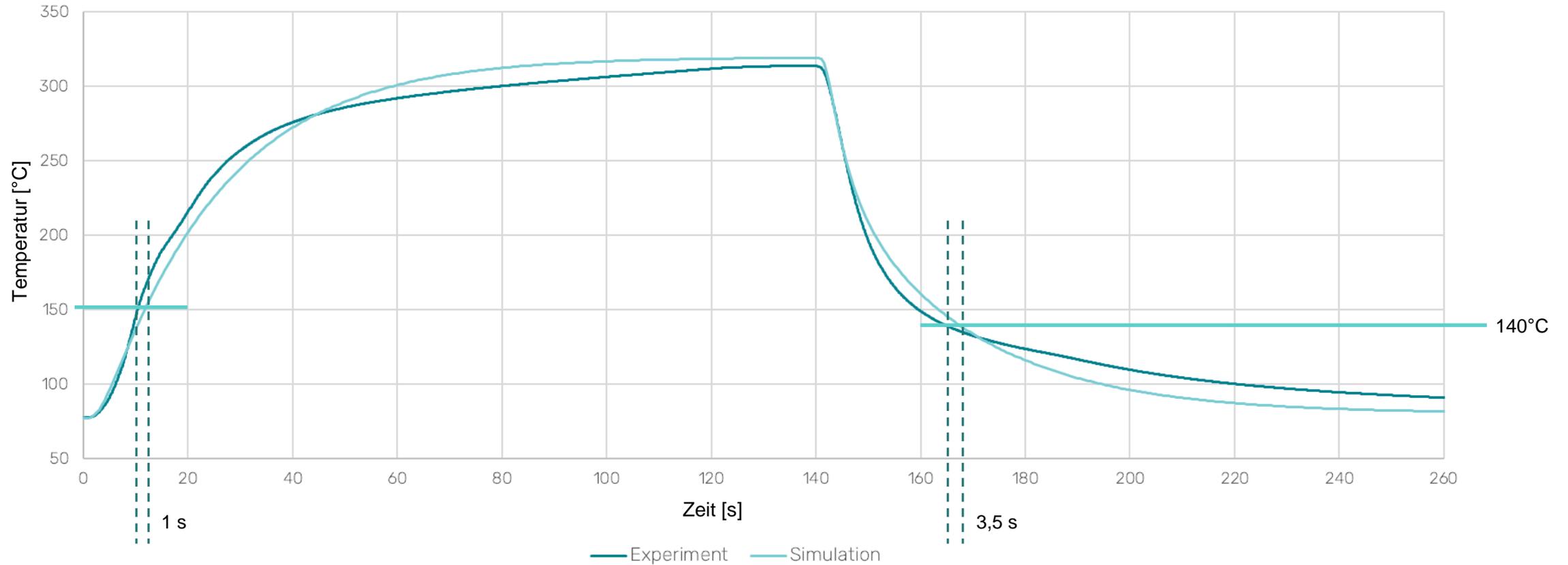
Beladen & Transport wird nicht modelliert

Konsolidieren

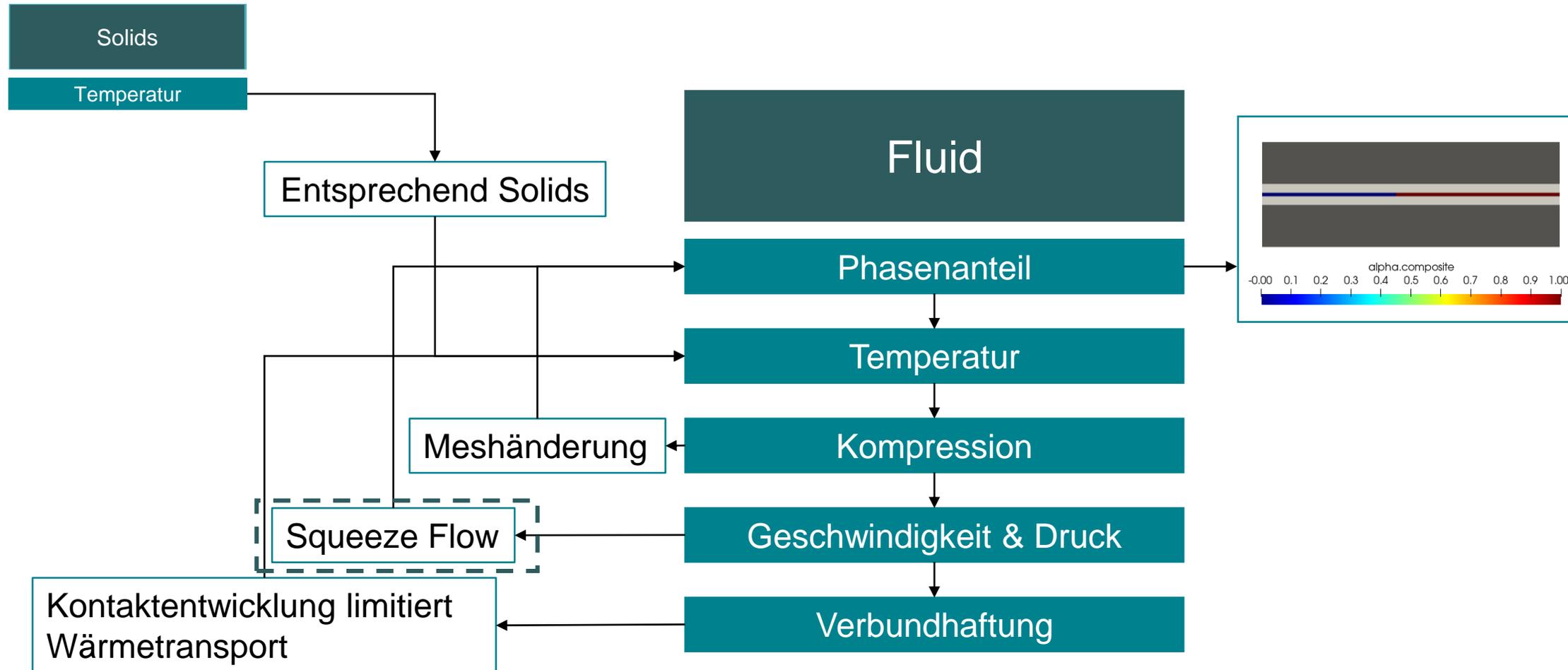


Vergleich - Temperatur

PC-CF



Konsolidieren



Vergleich – Squeeze Flow

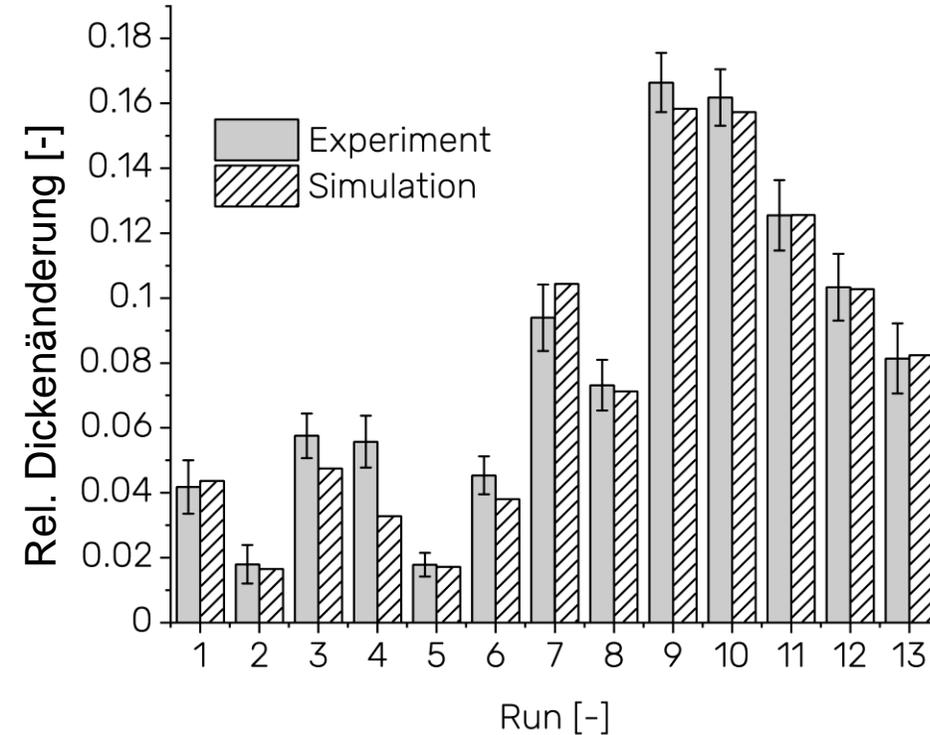
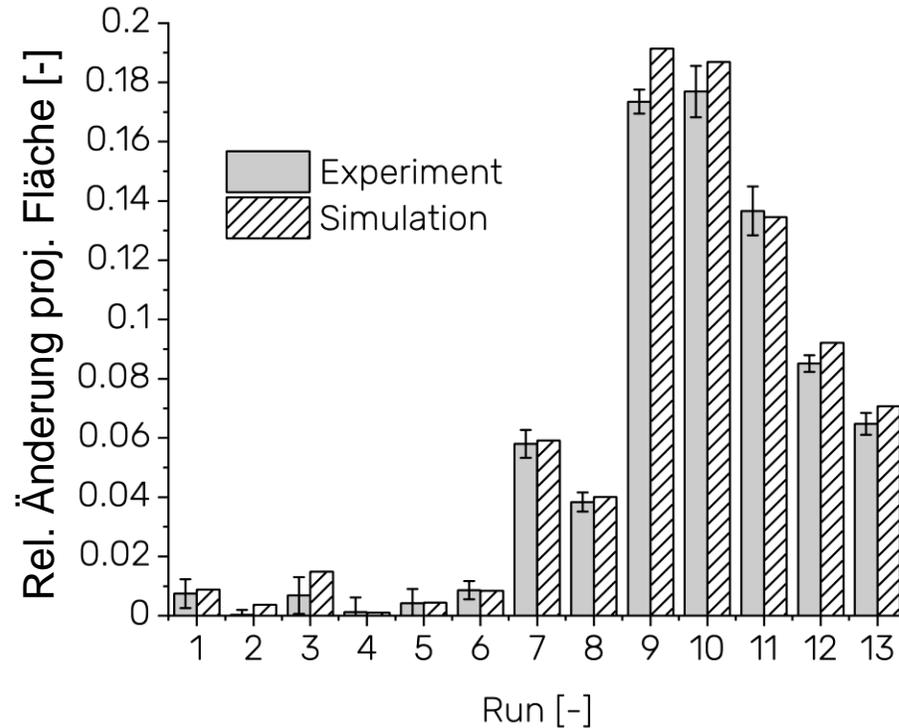
PC-CF

Run Number	Hot Press Temperature [°C]	Cold Press Temperature [°C]	Holding Time [s]	Hot Press Pressure [bar]	Cold Press Pressure [bar]
1	200	100	5	5	30
2	200	60	10	1	30
3	200	60	15	5	10
4	200	140	5	3	10
5	200	140	15	1	20
6	250	60	5	1	10
7	250	140	15	5	30
8	250	100	10	3	20
9	300	60	5	5	20
10	300	140	10	5	10
11	300	60	15	3	30
12	300	140	5	1	30
13	300	100	15	1	10

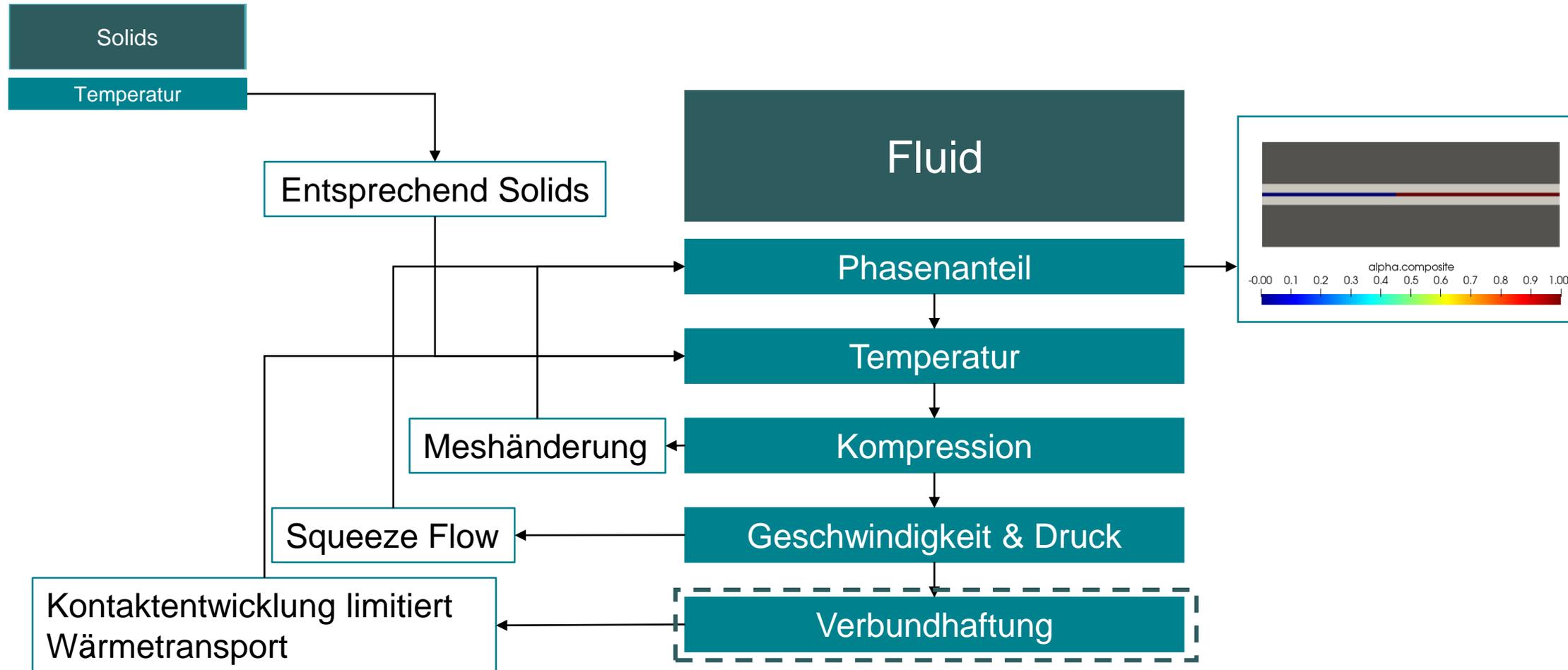
Table 3.4: Final design for the screening test.

Vergleich – Squeeze Flow

PC-CF

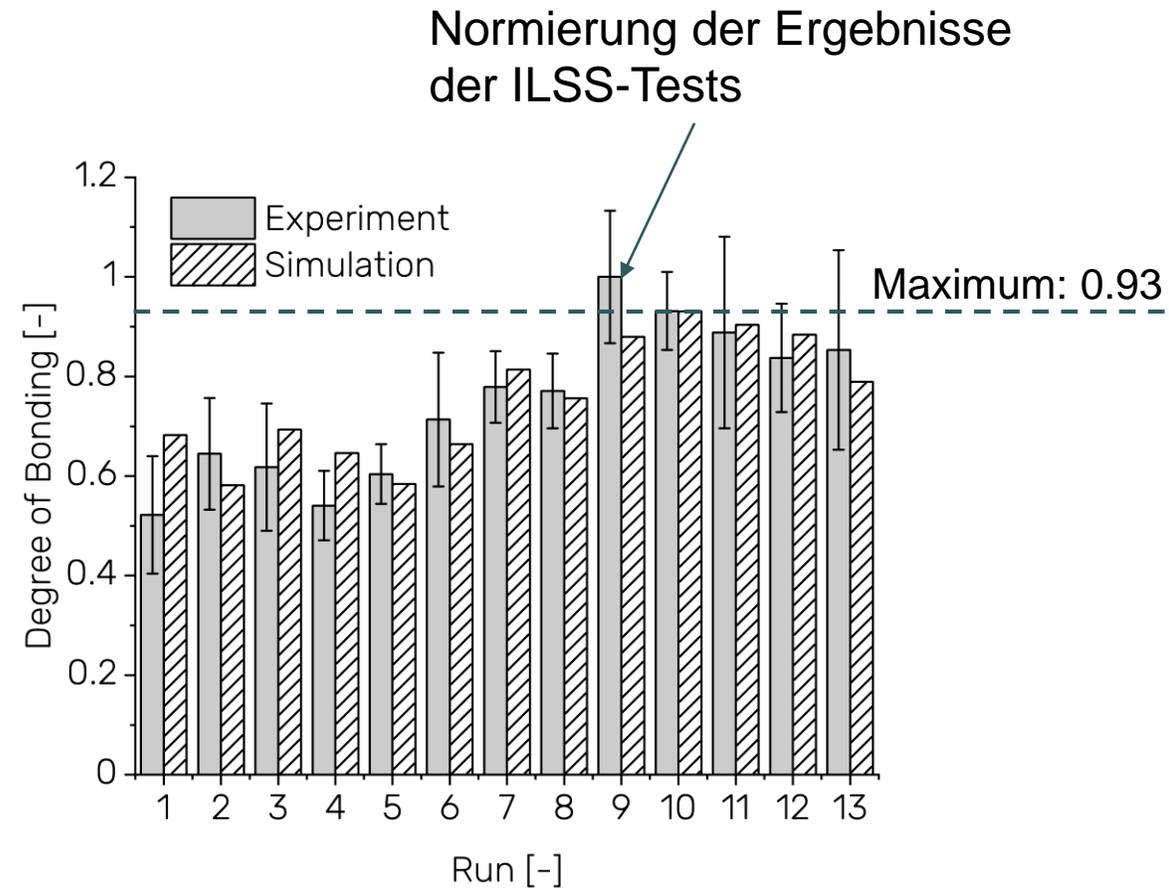


Konsolidieren

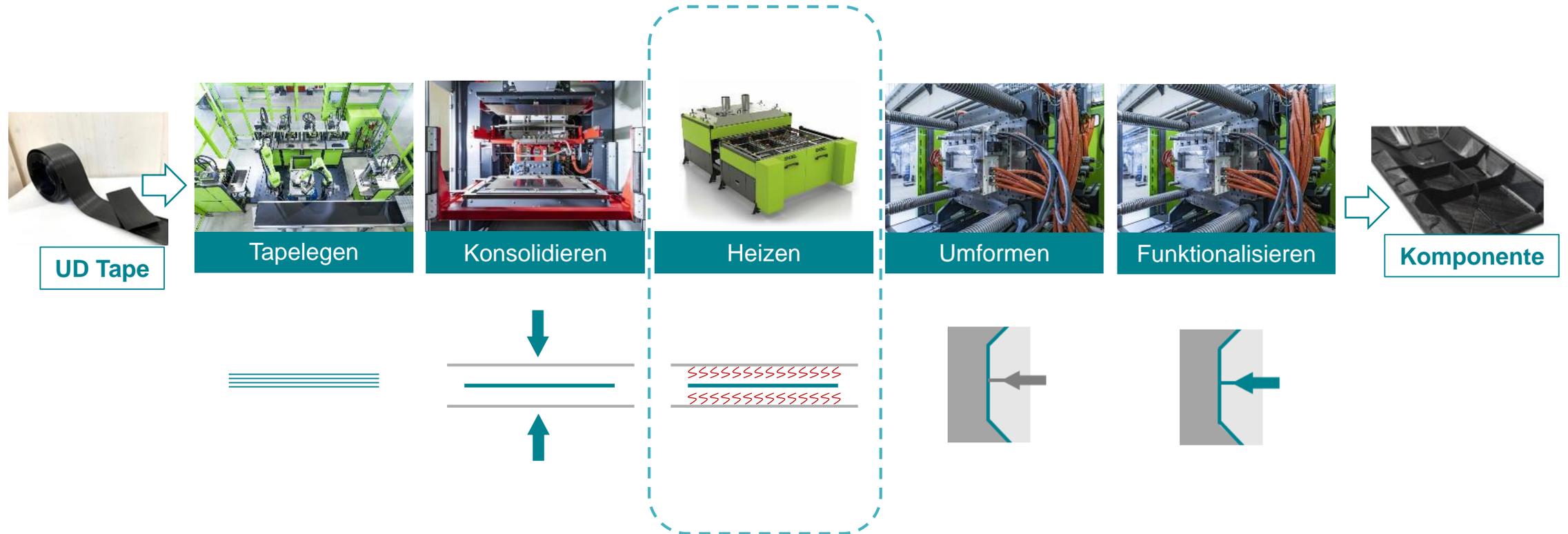


Konsolidieren – Verbundhaftung

PC-CF



Verarbeitung thermoplastischer Composites



Heizen



Quelle: ENGEL

Thermodynamisches Verhalten:

$$\frac{\partial T}{\partial t} - \nabla \cdot (a \nabla T) = S$$

Dickenänderung:

$$E_{voi} + E_{sur} + E_{net} + E_{vis} + E_{cry} + E_{com} + E_{moi} + E_{die} = 0$$

Einschlüsse Oberfläche Faser-
netzwerk Viskosität Kristallinität Ausdehnung Feuchtig-
keit Äußere Kräfte

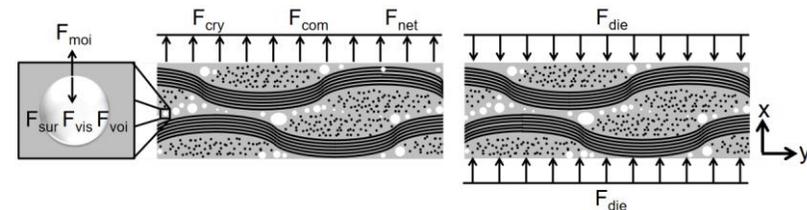


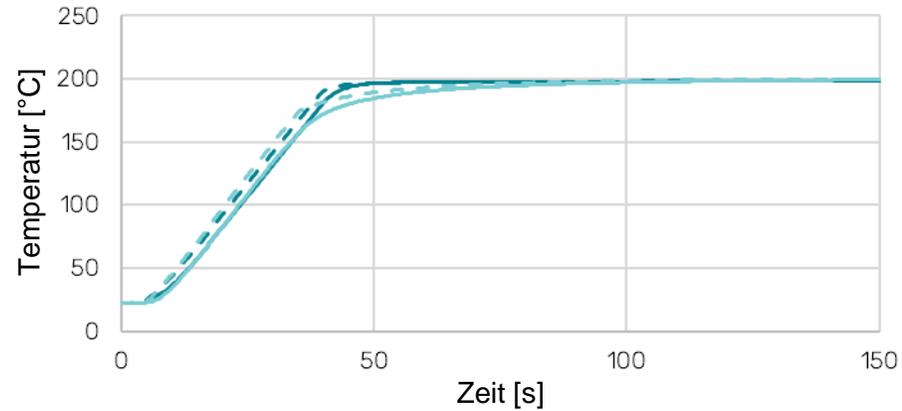
Figure 4.1: Illustration of the model including the corresponding forces of the energy and their effective direction

Quelle: Brzeksi, M., „Experimental and Analytical Investigation of Deconsolidation for Fiber Reinforced Thermoplastic Composites“, Dissertation, TU Kaiserslautern, 2014

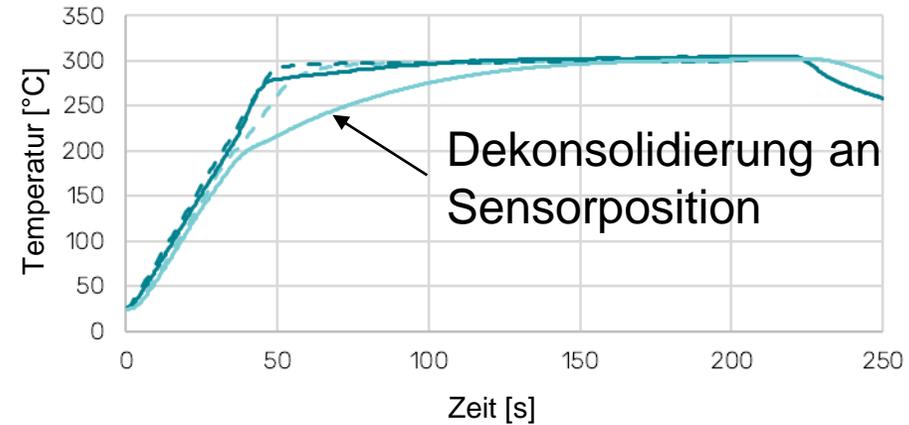
Heizen - Temperatur

PC-CF

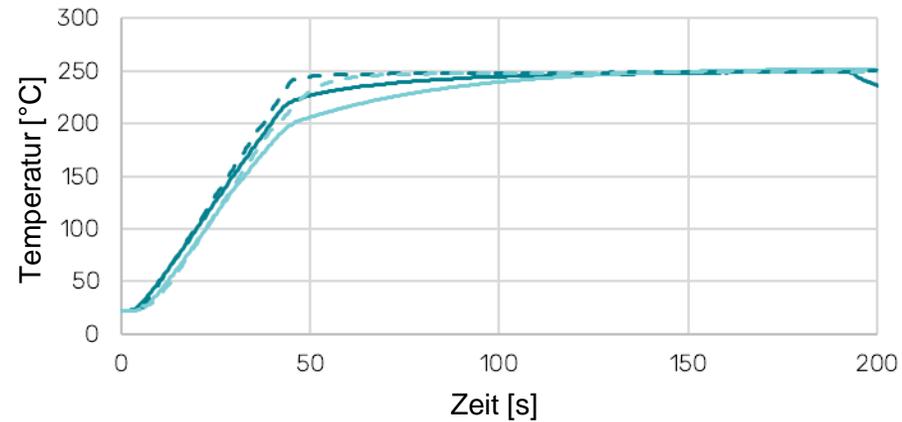
Zieltemperatur 200 °C



Zieltemperatur 300 °C

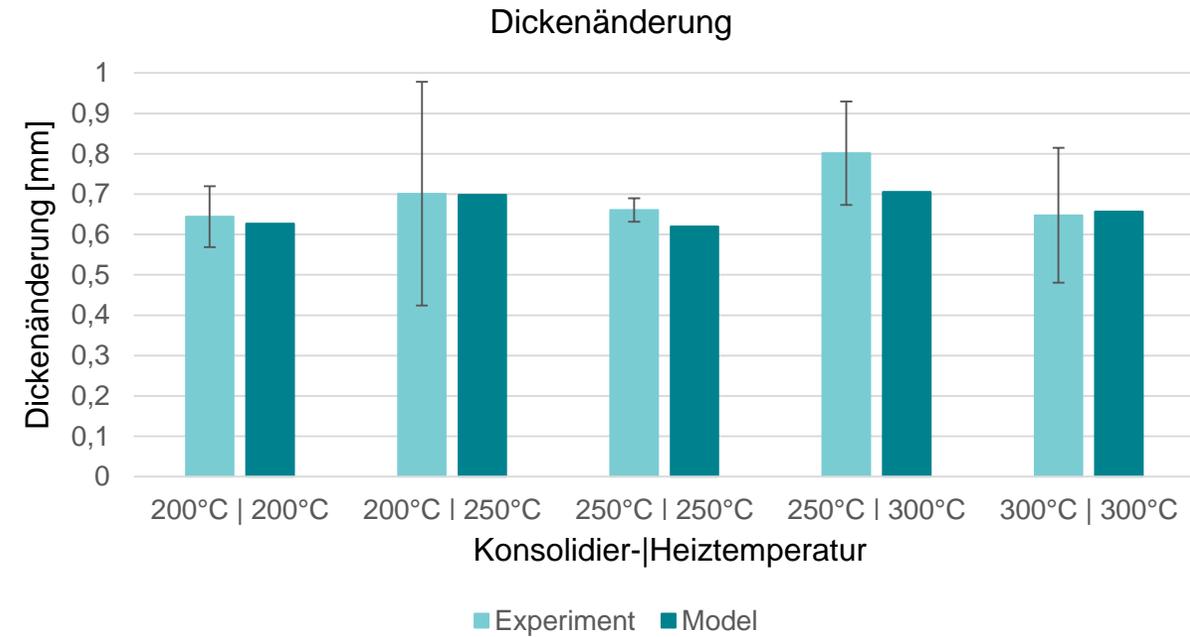
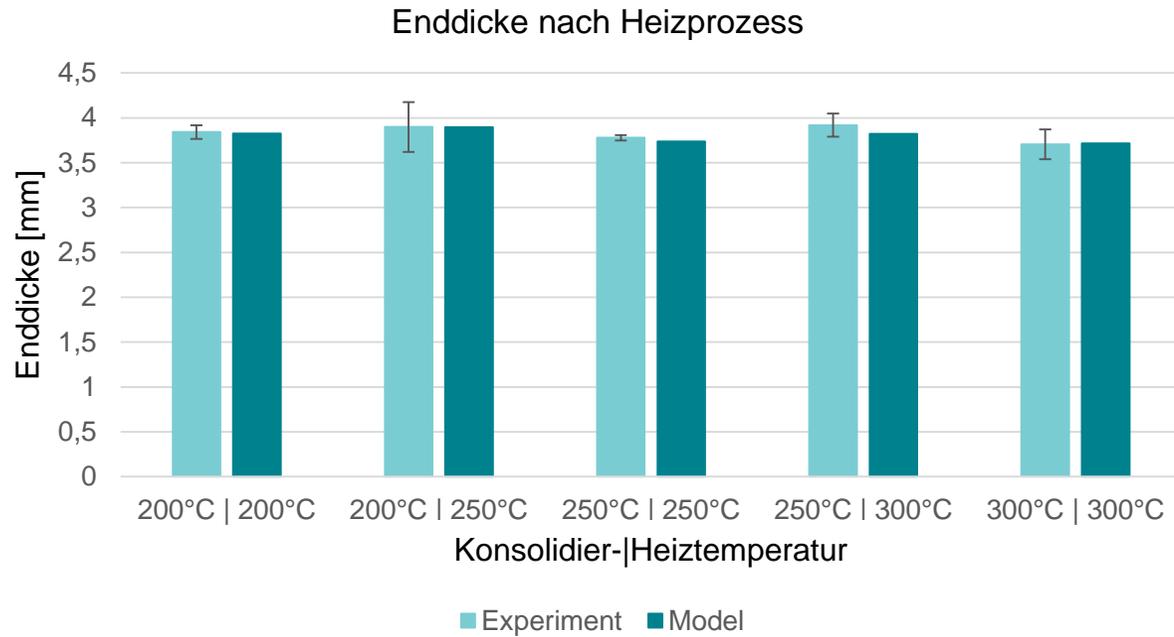


Zieltemperatur 250 °C

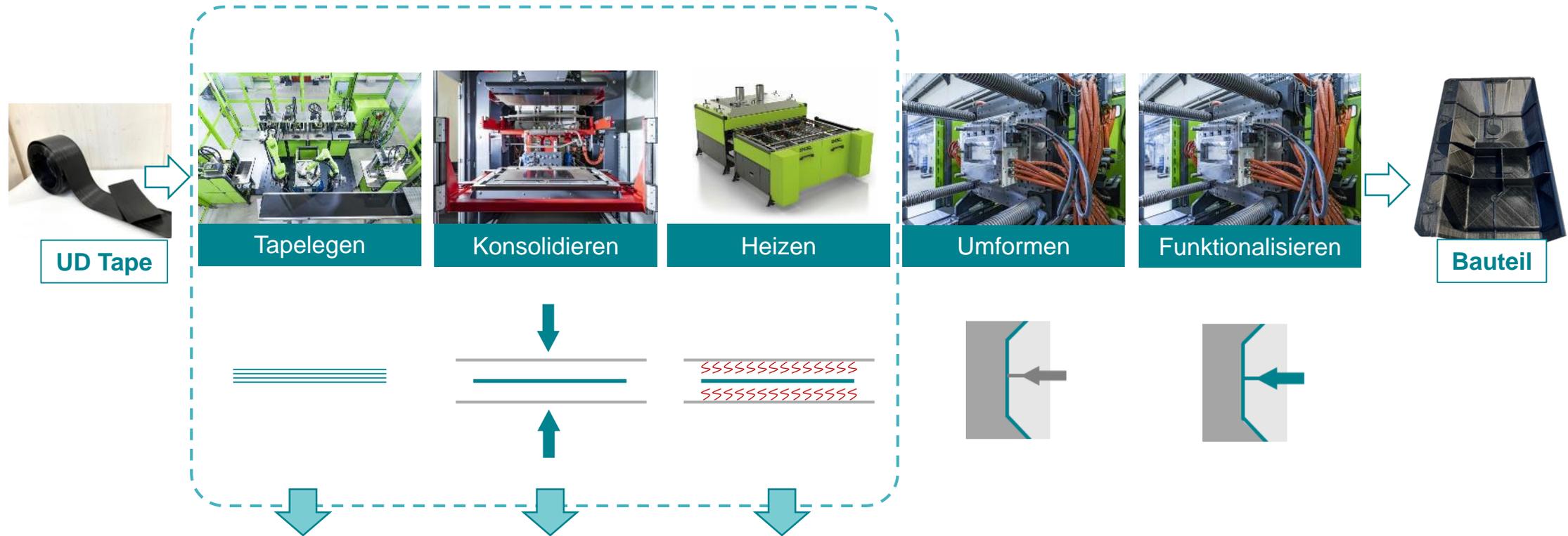


Heizen - Dekonsolidieren

PC-CF



Verarbeitung thermoplastischer Composites



Wie sehen die **optimalen Prozessparameter** für
Tapelegen | Konsolidieren | Heizen
aus, um eine **hohe Qualität bei kurzer Zykluszeit**
zu garantieren?

In Kooperation mit



Danke!



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