



Quelle: Danieli

Aachener Ofenbau -und Thermoprozess Kolloquium 2021

„Kühlung bewegter Metallplatten mit Flachstrahl- und Vollstrahldüse“

“Quenching of Moving Metal Plates with Flatsprays and Single Full Jet Nozzle“

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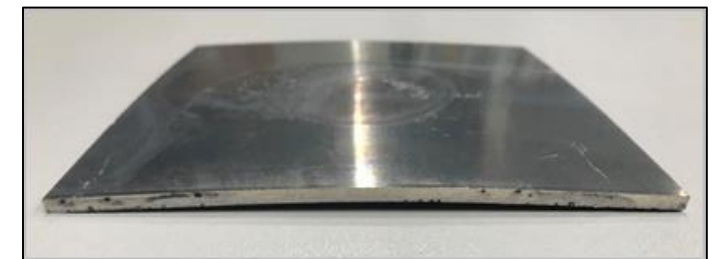
08. Oktober 2021

- Bedarf an hochwertigen metallischen Werkstoffen
 - Verbesserung der Abschrecktechnik
 - Vermeidung von Deformationen und Rissen
 - Anlagen- und Energieeffizienz
 - Einstellung optimaler Prozessparameter
-
- Untersuchung von Vollstrahl-, Flachstrahl- und Vollkegeldüsen zur Abschreckung bei $T > T_{\text{Leid}}$
 - Entwicklung eines 2D-inversen Modells
 - Ausbau eines 3D-zweiphasigen Simulationsmodells der Abschreckung
 - Validierung der numerischen Simulation
 - Einfluss der Prozessparameter auf Kühlverlauf



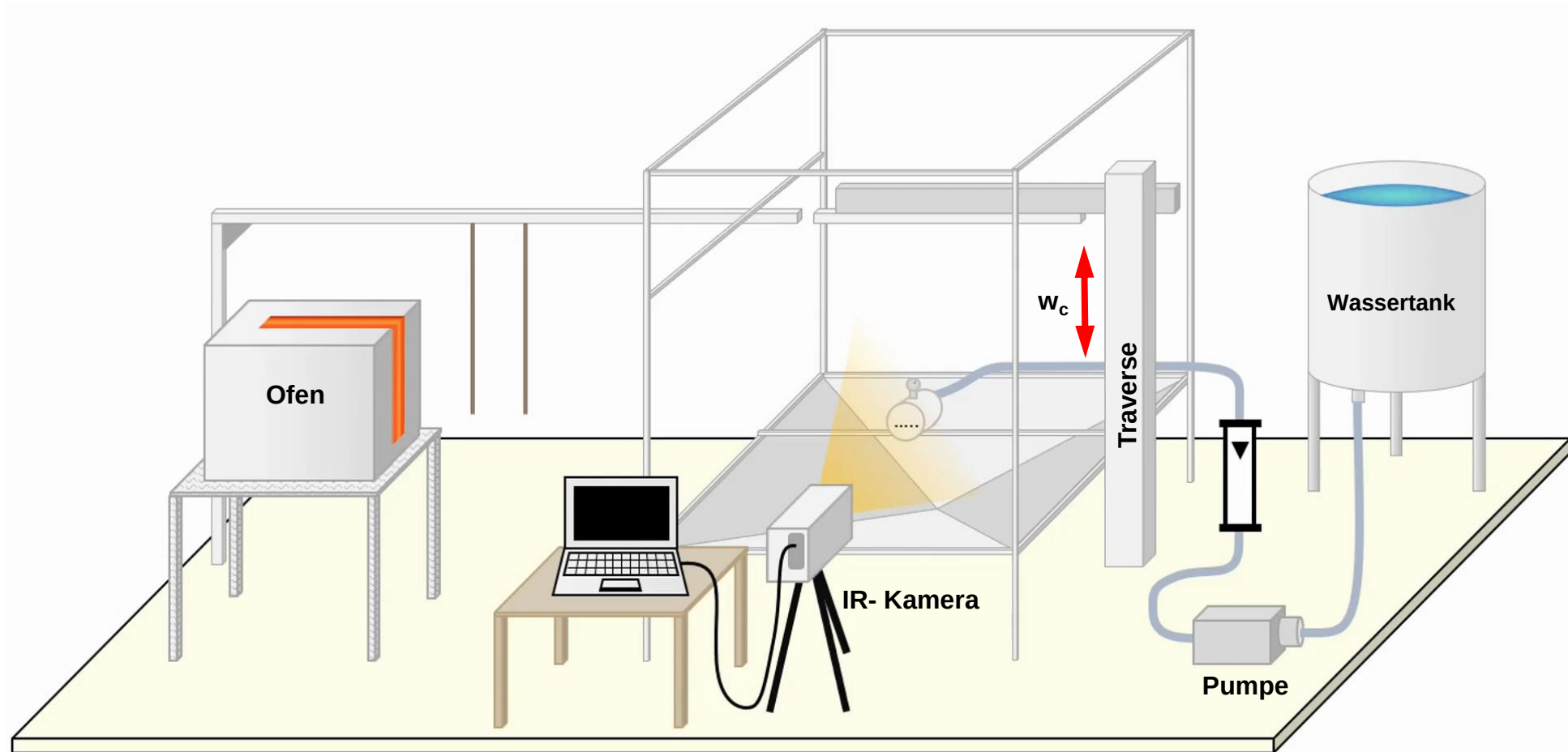
Abschrecken

[<http://siemens.com>]

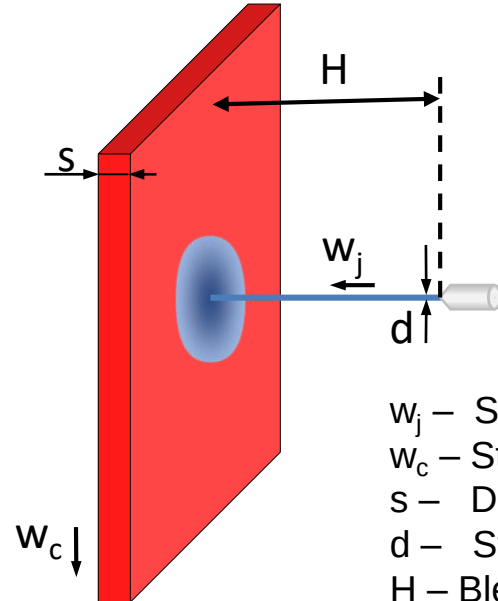


Deformation eines Alu-Blech

Prinzipieller Aufbau der Versuchsanlage

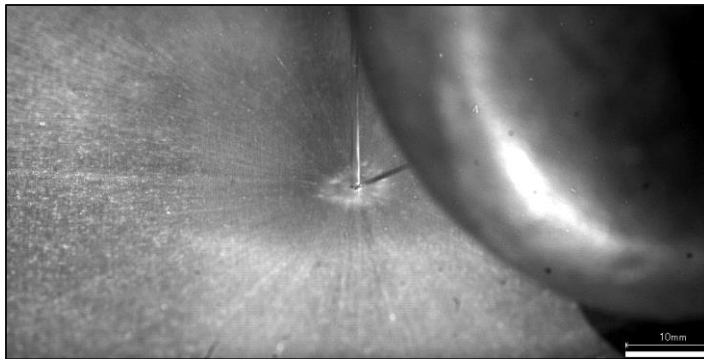


Einzel-Vollstrahldüse

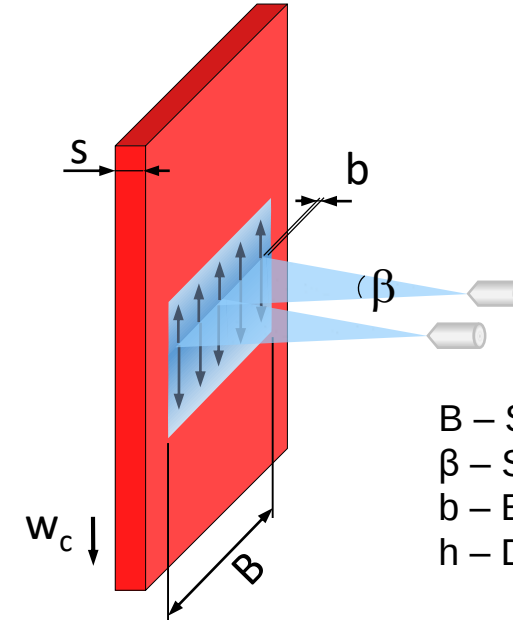


w_j – Strahlgeschwindigkeit
 w_c – Stranggeschwindigkeit
 s – Dicke
 d – Strahldurchmesser
 H – Blech-Düsen Abstand

$d = 1,05 \text{ mm}$



2 x Flachstrahldüsen

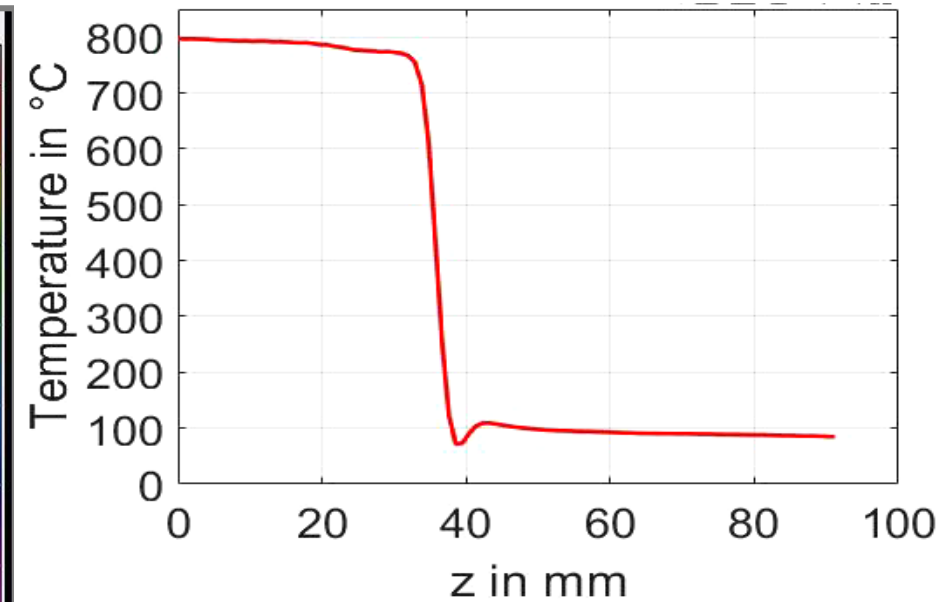
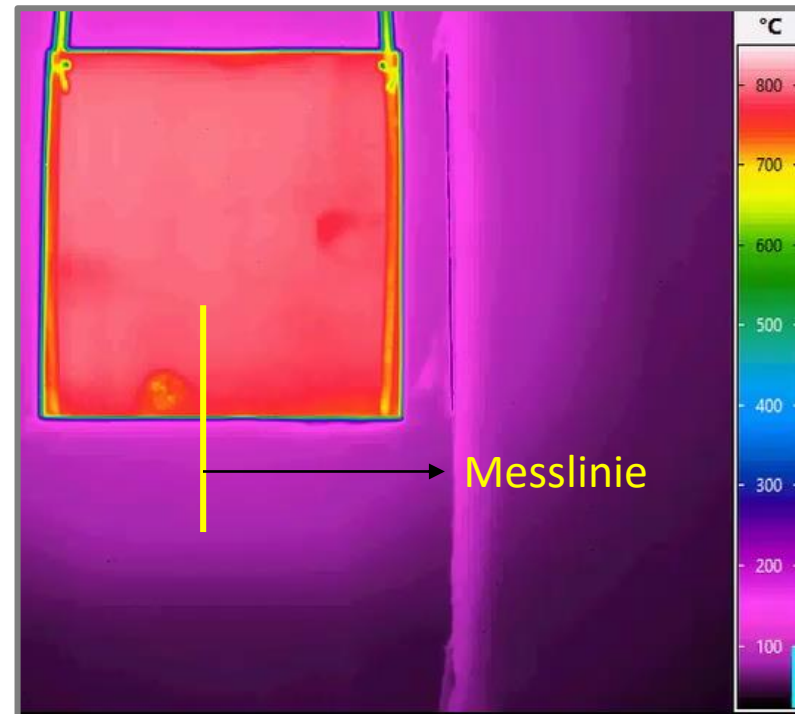
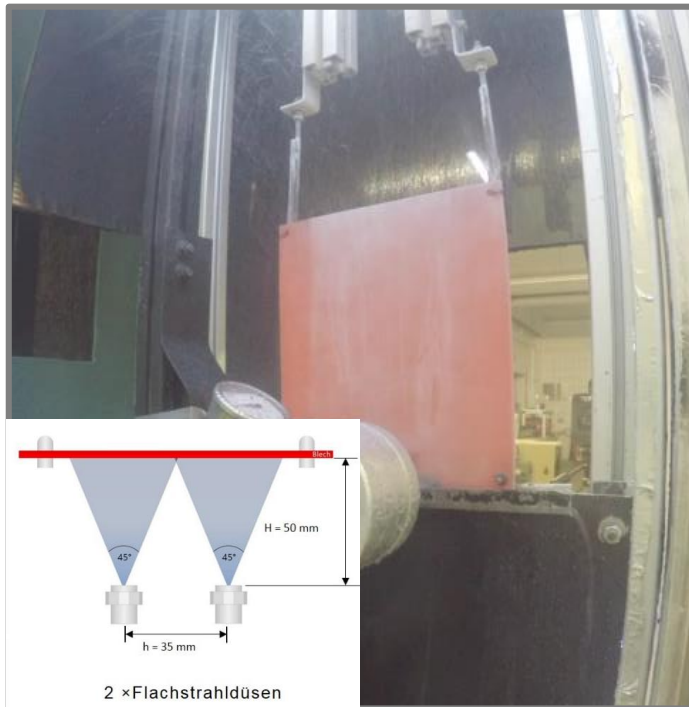


B – Strahlbreite
 β – Spritzwinkel
 b – Breite des Flachstrahls
 h – Düsen Abstand

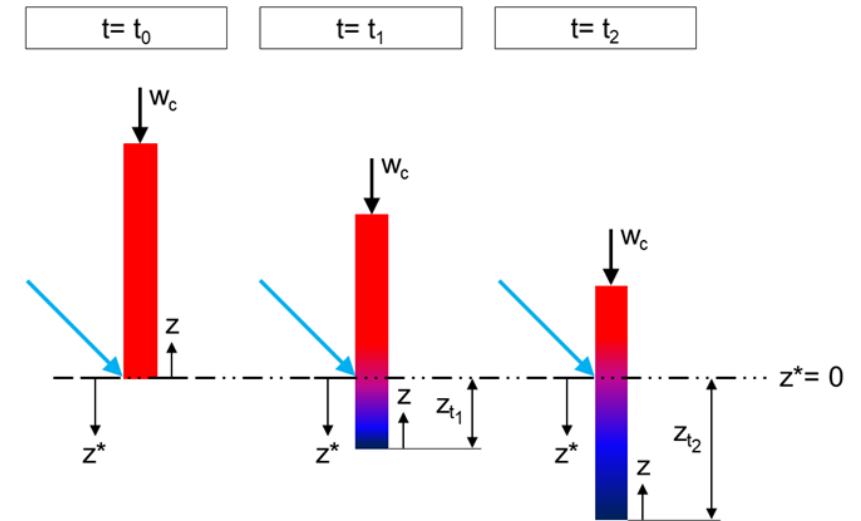
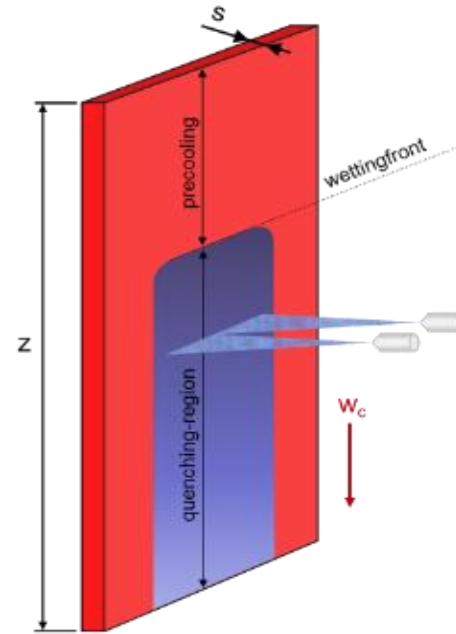
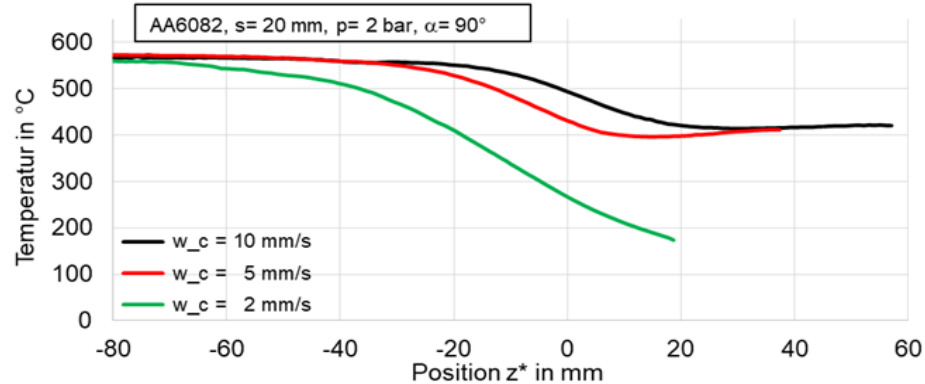
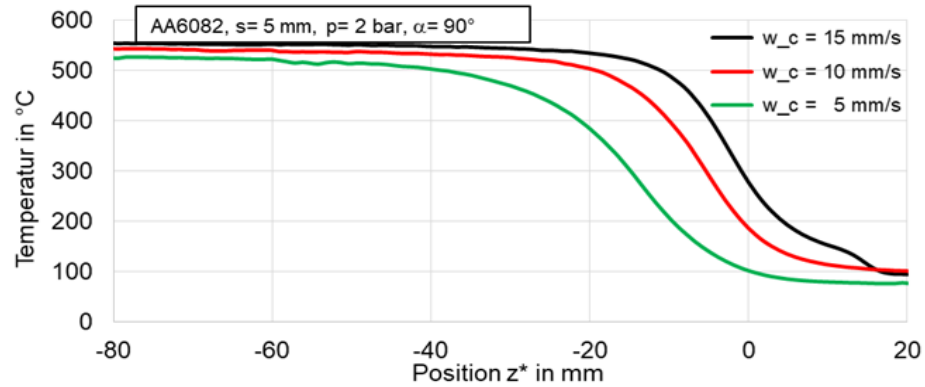
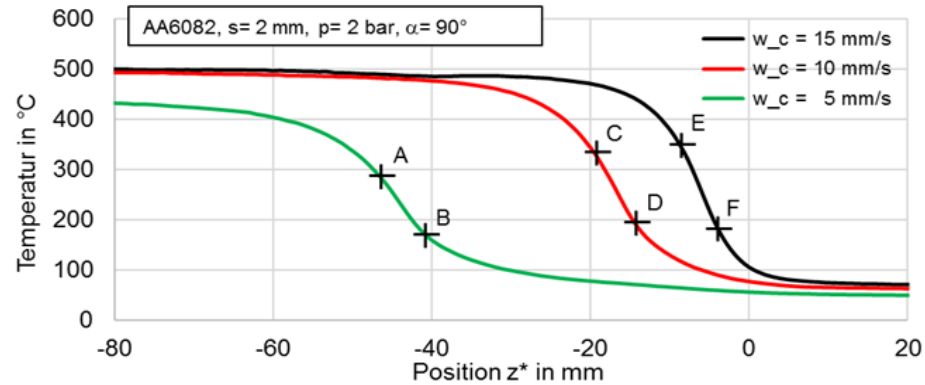
$\beta = 45^\circ$



Nickel, $s = 5 \text{ mm}$, $T_{\text{start}} = 800 \text{ }^{\circ}\text{C}$, $T_w = 21 \text{ }^{\circ}\text{C}$, $h = 35 \text{ mm}$, $\beta = 45^{\circ}$, $p = 2 \text{ bar}$, $H = 50 \text{ mm}$



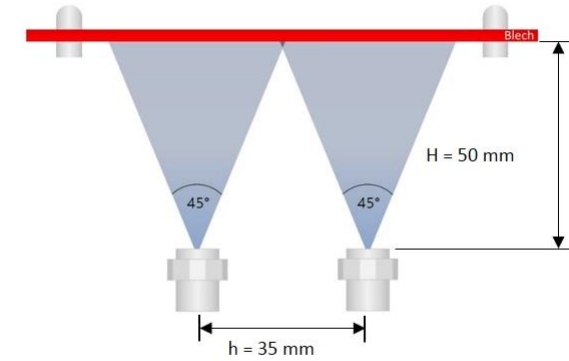
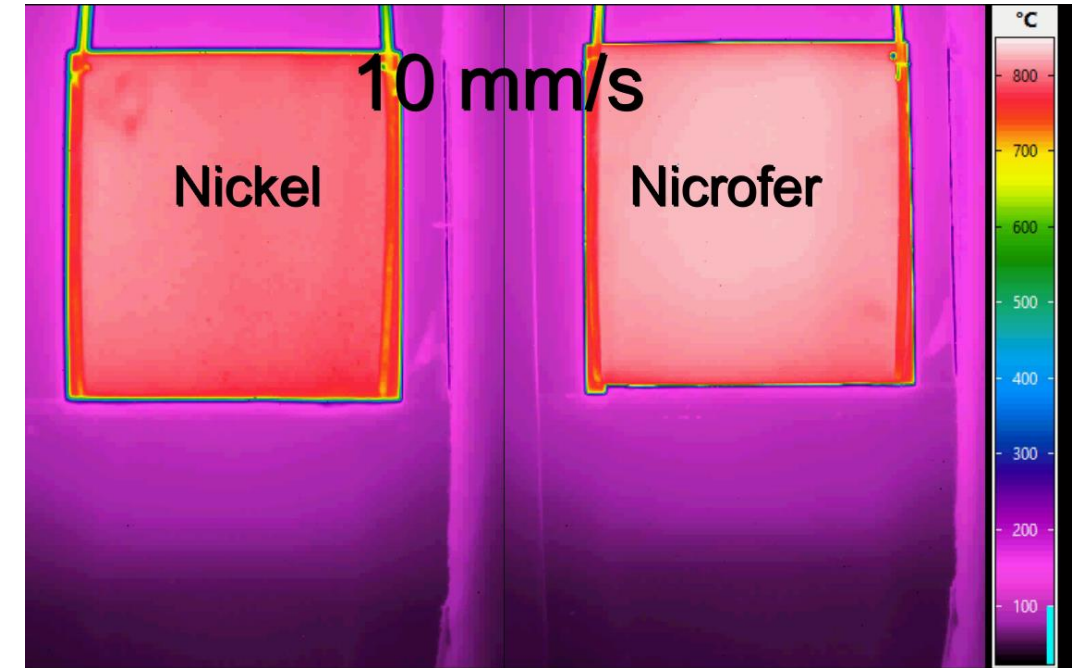
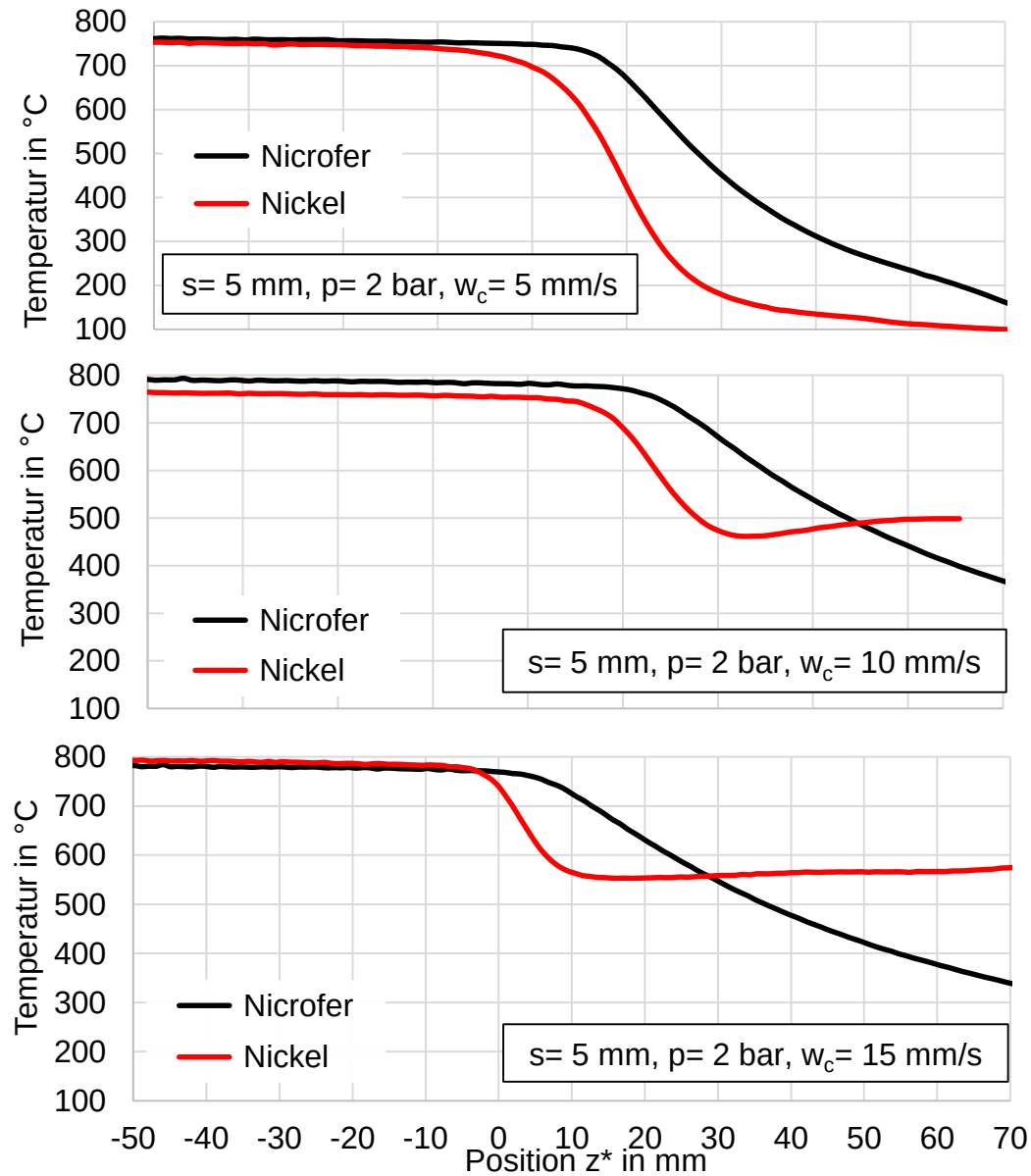
Einfluss der Stranggeschwindigkeit



$$z^* = z_{tn} - z = w_c \cdot t_n - z$$

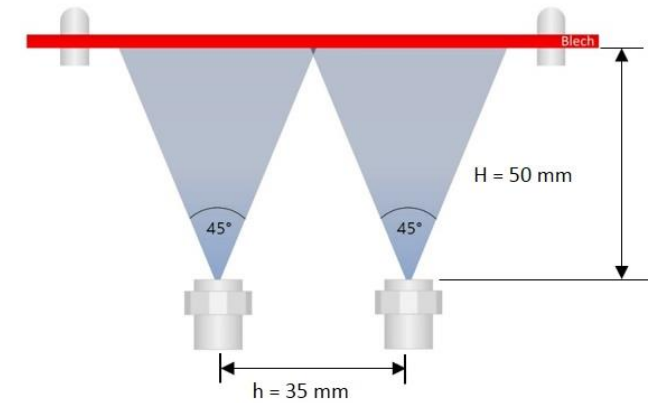
$z^* = 0$ ist die Position der Düsen

Einfluss der Stranggeschwindigkeit und Werkstoffe

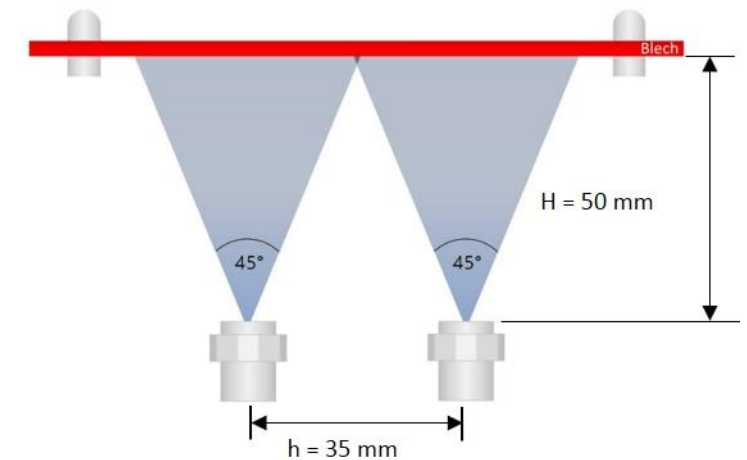
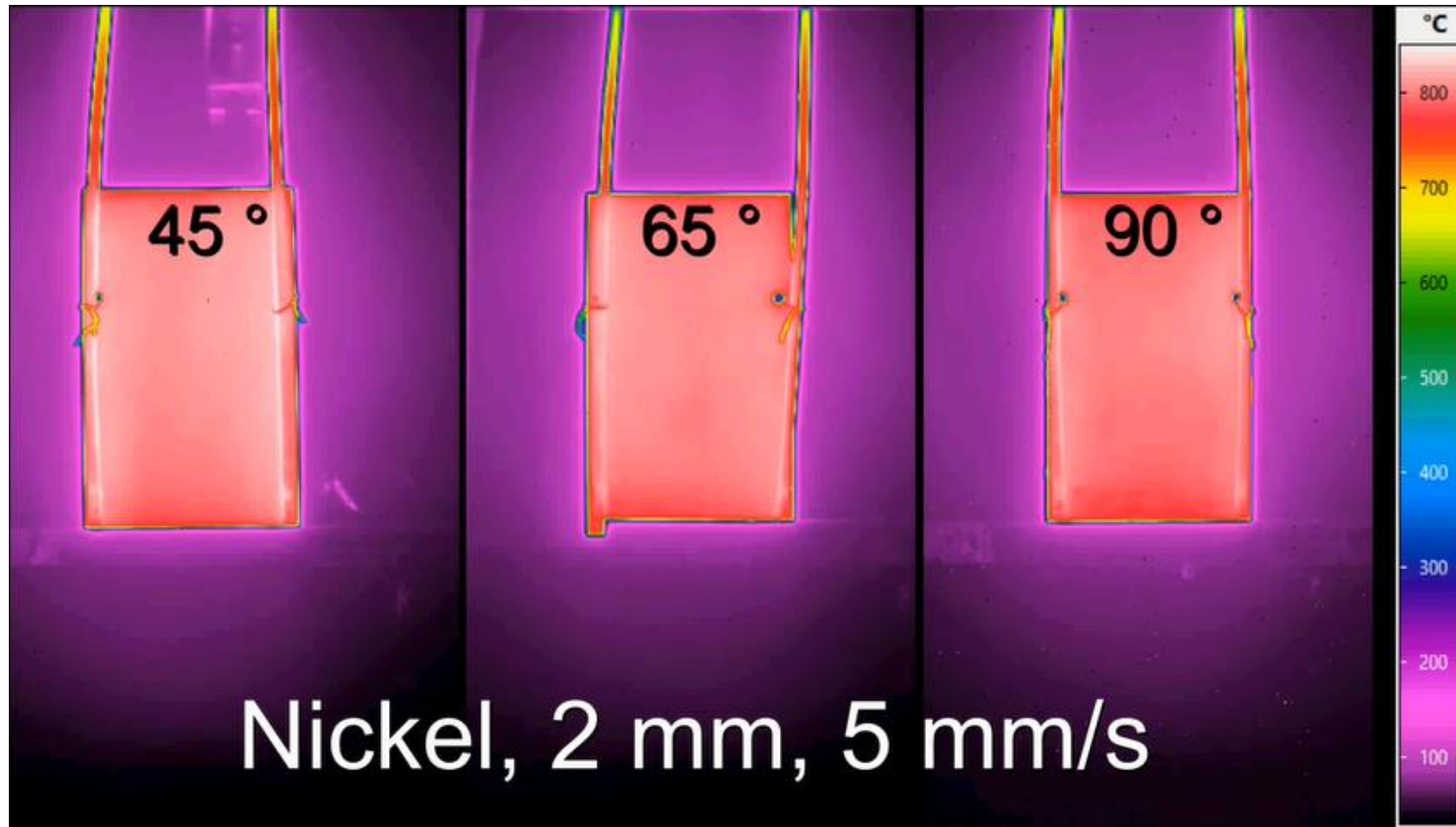


2 x Flachstrahldüsen

Nickel, $s = 5 \text{ mm}$, $T_{\text{start}} = 800^\circ\text{C}$, $T_w = 21^\circ\text{C}$, $h = 35 \text{ mm}$, $\beta = 45^\circ$, $p = 2 \text{ bar}$ und $H = 50 \text{ mm}$.

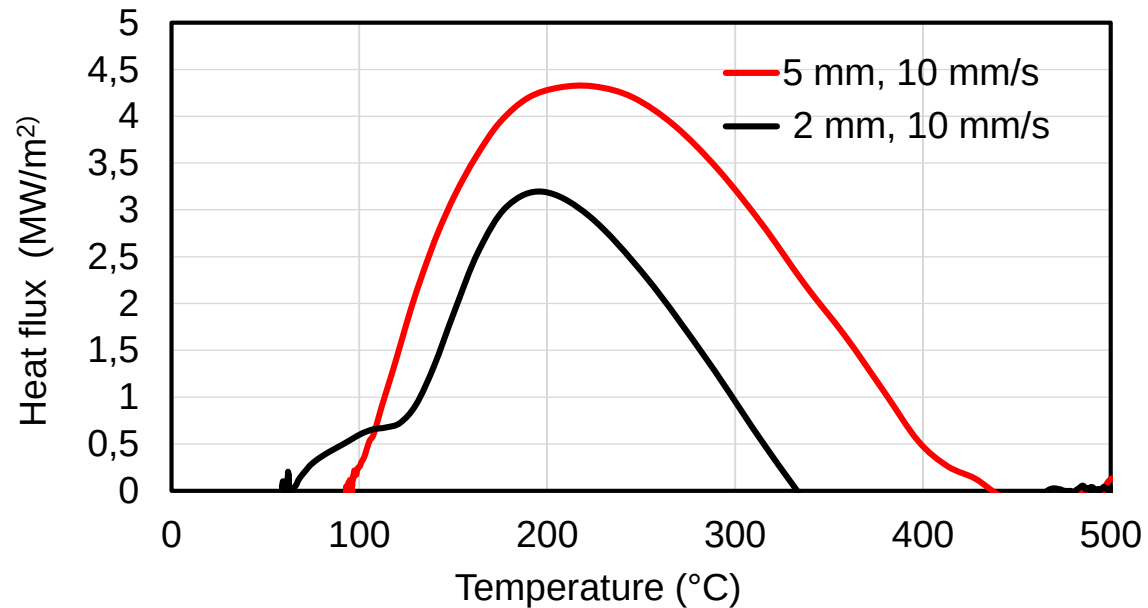


2 x Flachstrahldüsen



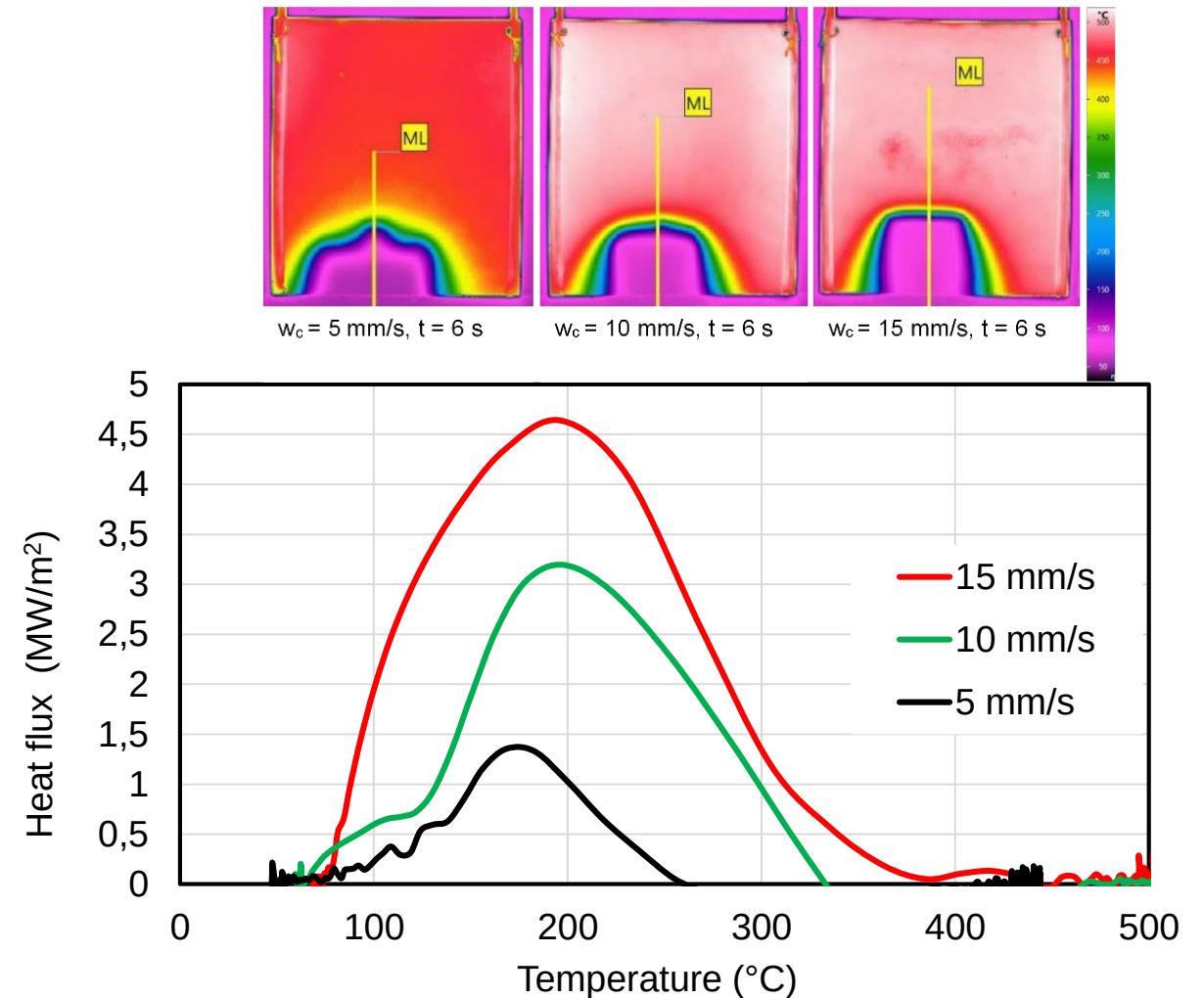
2 × Flachstrahldüsen

Einfluss der Werkstoffdicke

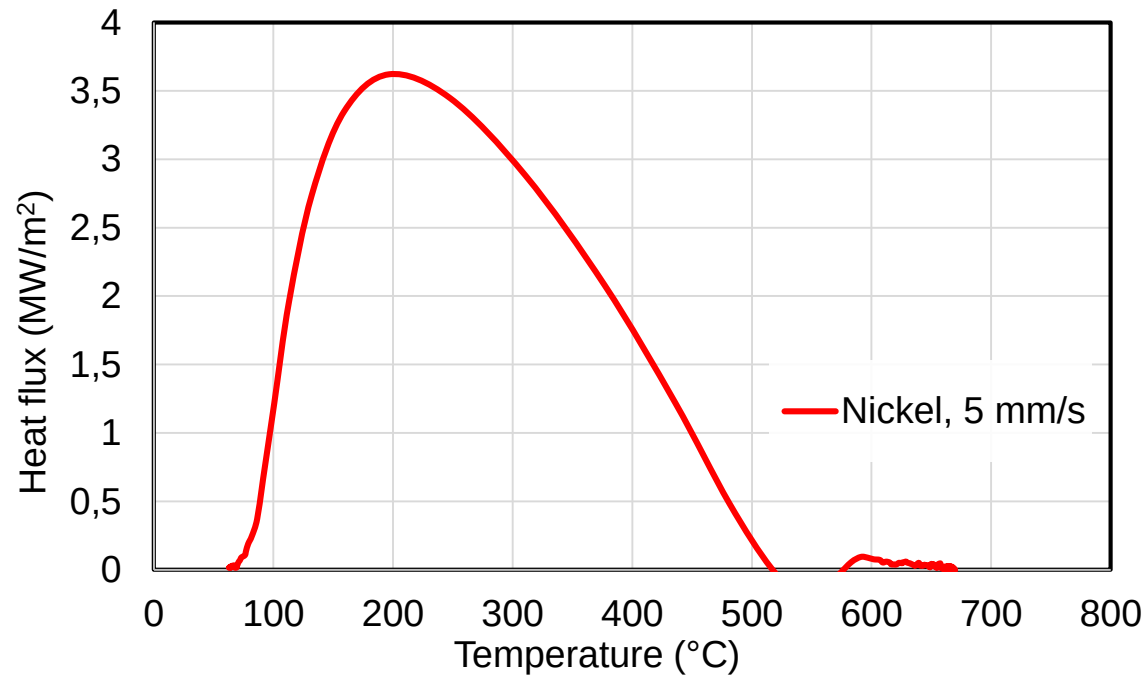


AA6082, 2 x Flachstrahldüsen, $p = 2$ bar, $T_{\text{start}} = 500$ °C

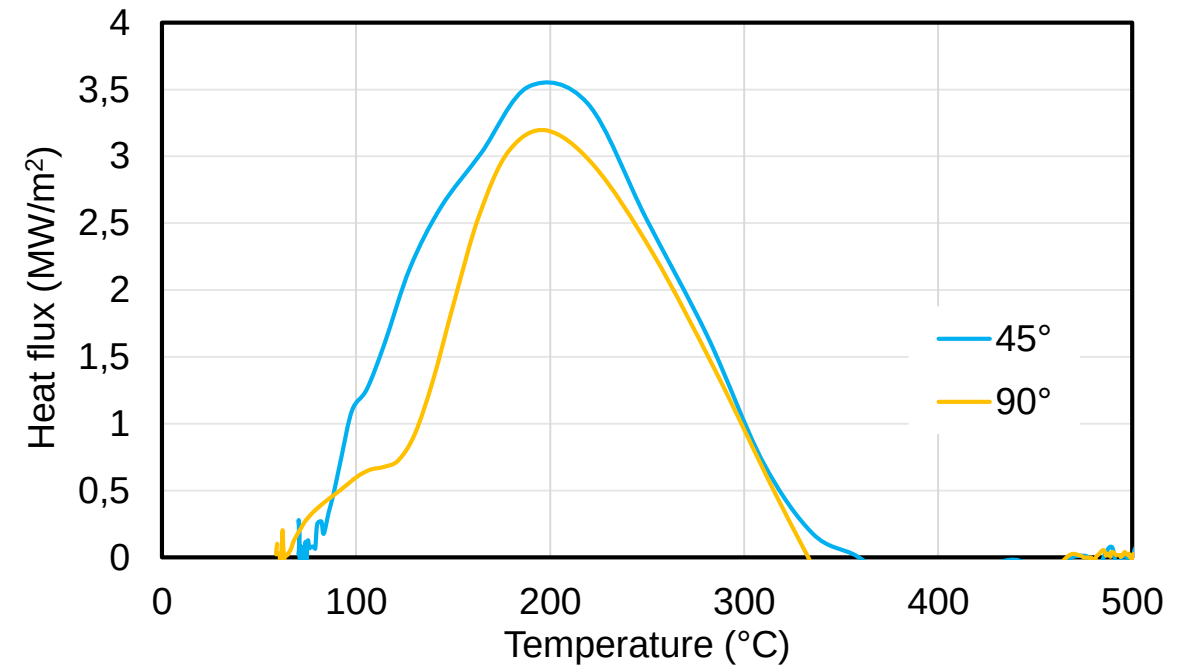
Einfluss der Stranggeschwindigkeit



Nickel, $s = 2 \text{ mm}$, $T_{\text{start}} = 800 \text{ °C}$

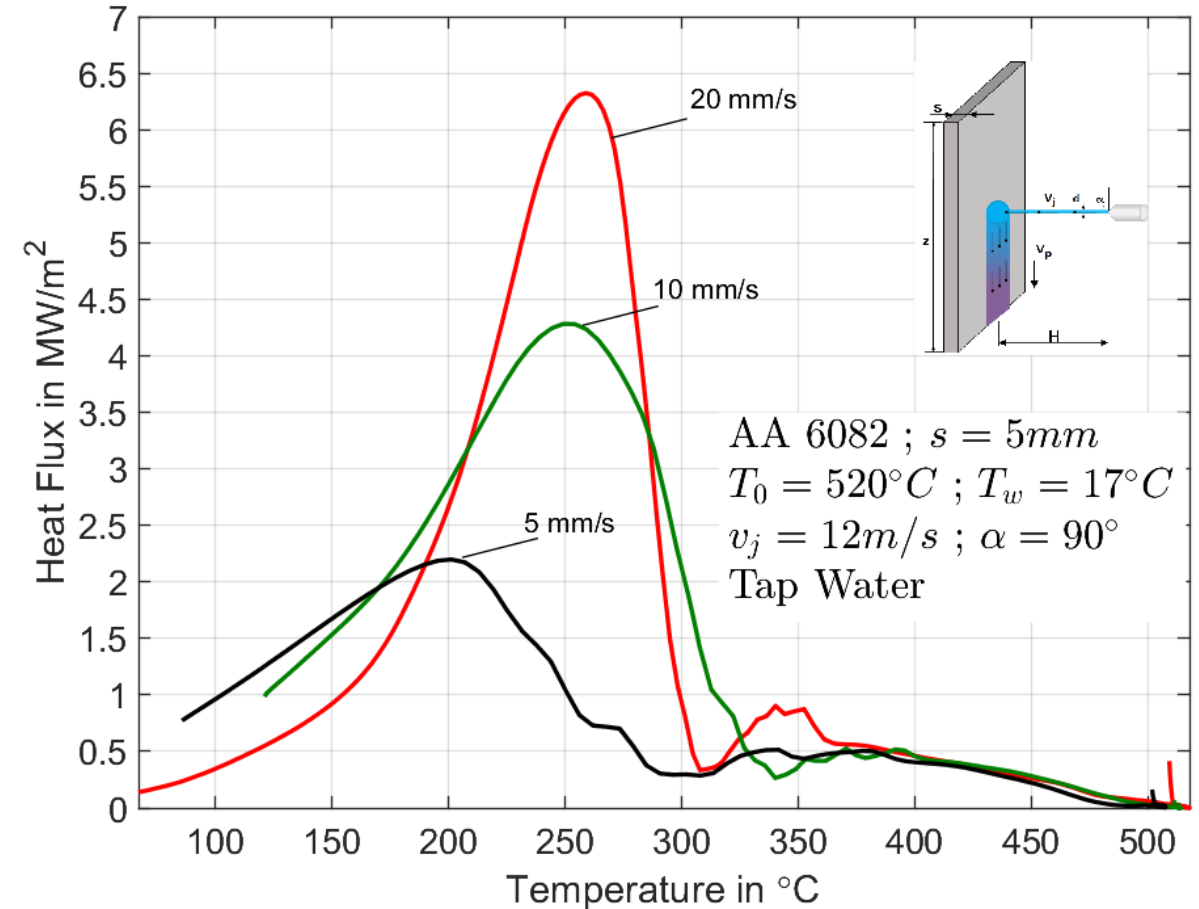
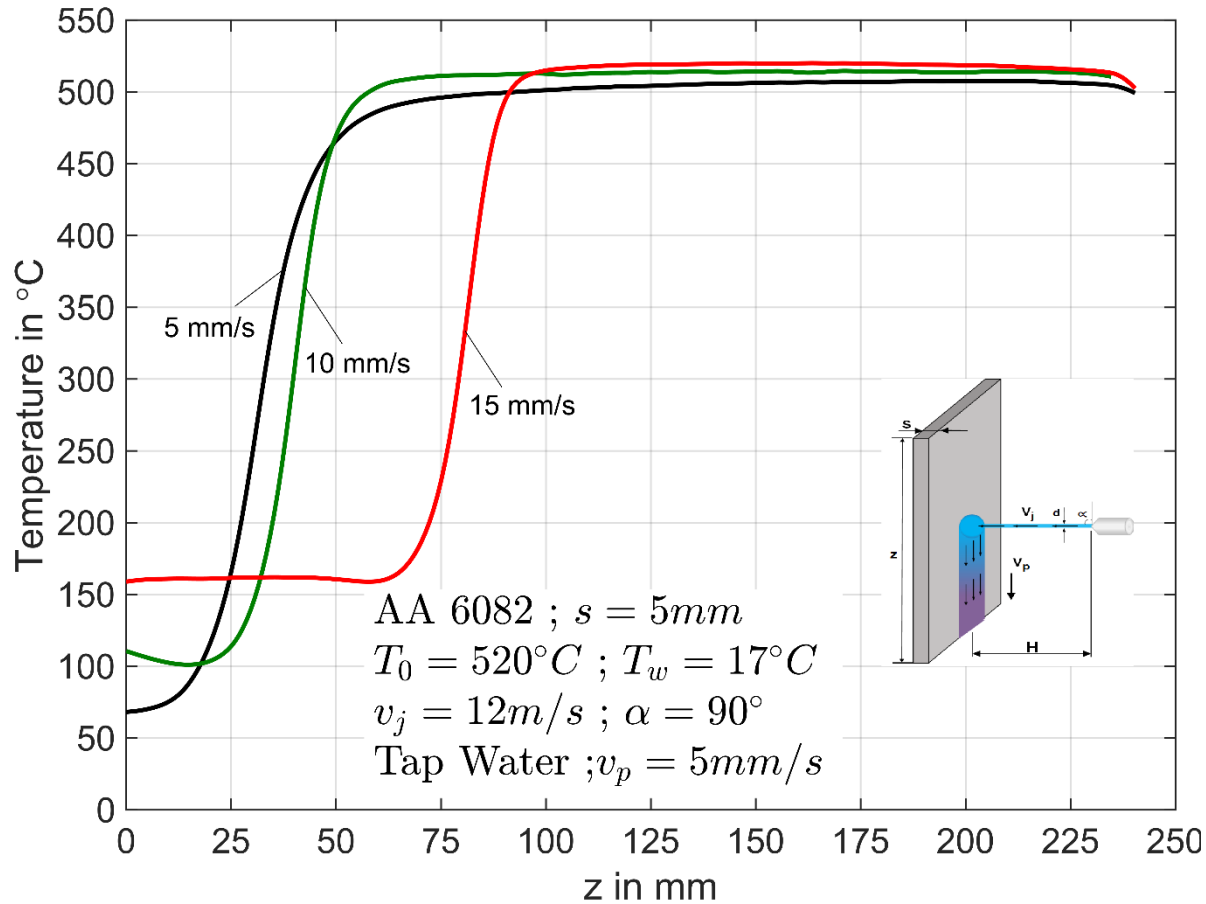


AA6082, $s = 2 \text{ mm}$, $w_c = 10 \text{ mm/s}$, $T_{\text{start}} = 500 \text{ °C}$

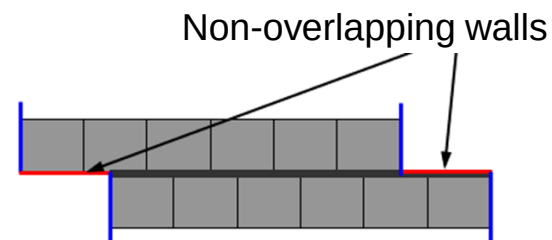
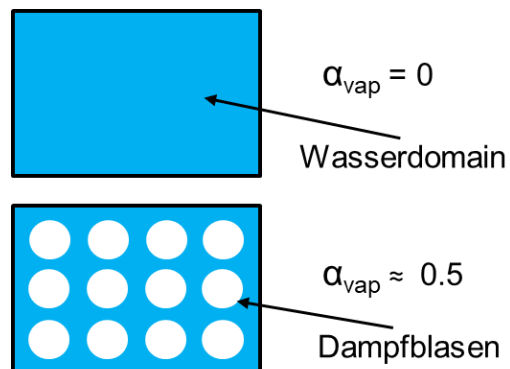


Neu!

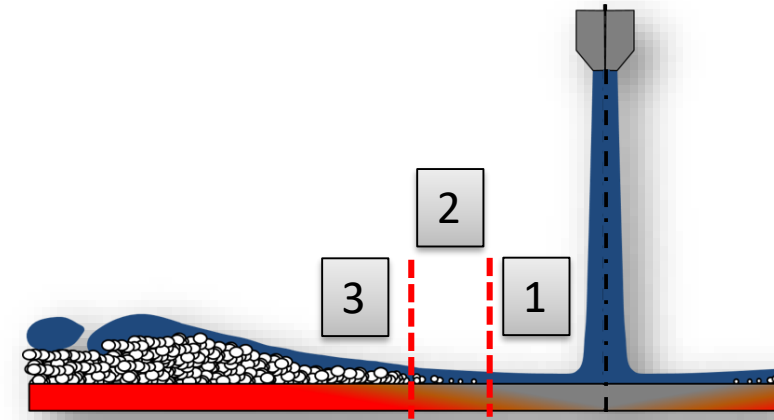
AA6082, 1 x Vollstrahldüse, $p = 2 \text{ bar}$, $T_{\text{start}} = 525 \text{ °C}$



- Ein Ansatz für den gesamten Abschreckprozess
- Modifiziertes Euler-Mehrphasenmodell
- Bubble Crowd mixture Modell
- Dampf als disperse Phase
- Phasenwechselwirkung, gekoppelt durch Quellen- und Senken Terme
- Zonenidentifikation mit Hilfe des Volumenanteils
- Plattenbewegung mittels Sliding Mesh Ansatz



[N.M.Narayan et al., 2nd International Conference on Quenching and Distortion Engineering, 2021]

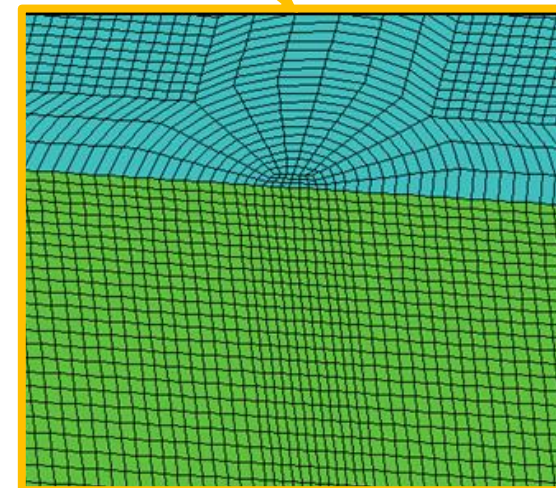
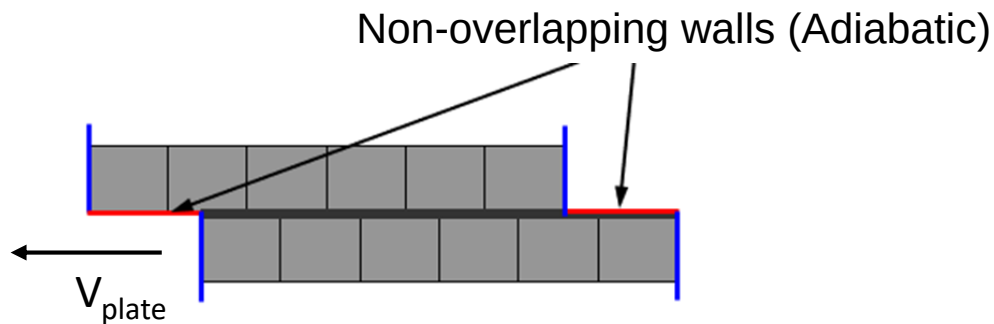
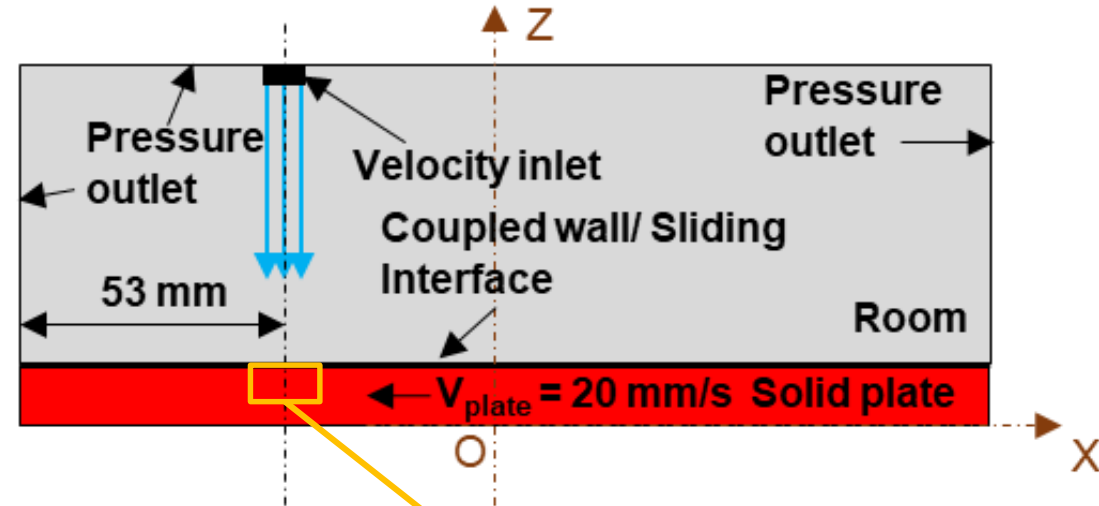


[S.Waldeck, Evaluation of heat transfer in quenching process with impinging liquid jets, Journal of Thermal Sciences 134 (2018)]

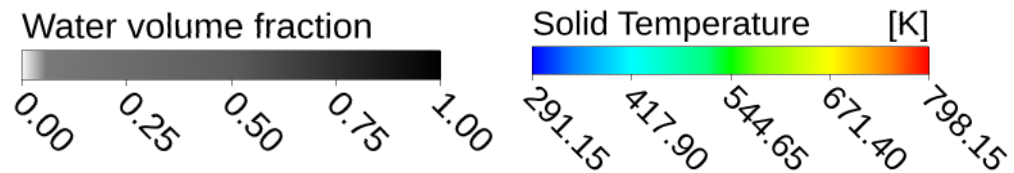
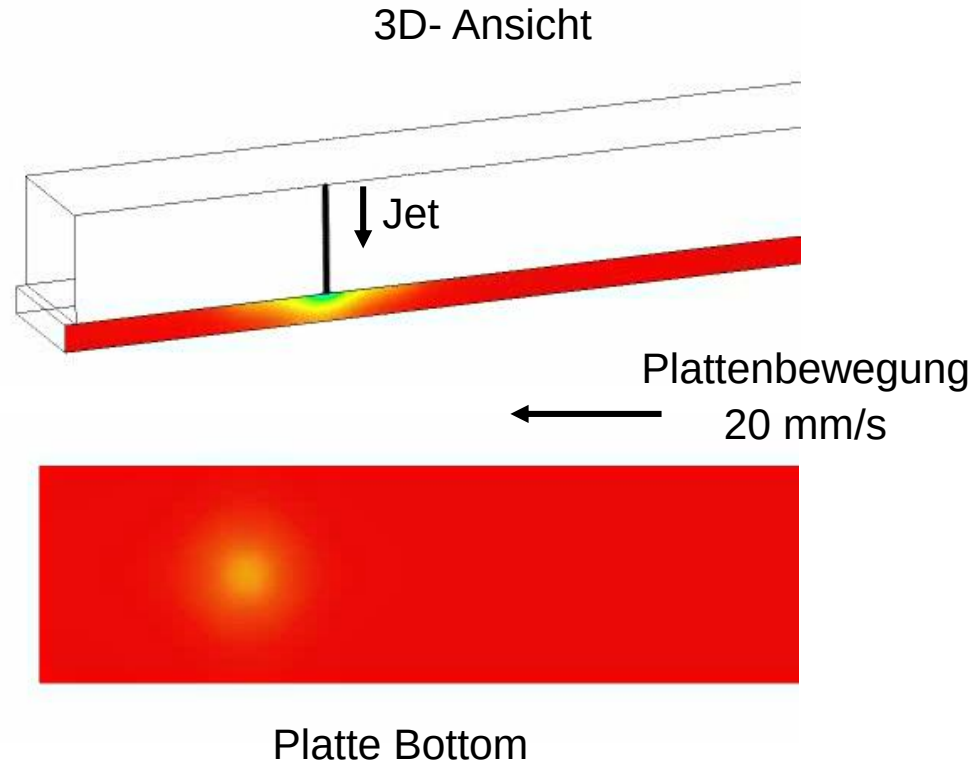
1. Konvektion : $\alpha_{vap} \rightarrow 0$
2. Transientes/ Blasensieden : $0 < \alpha_{vap} < 1$
3. Filmsieden : $\alpha_{vap} \rightarrow 1$

[P.Stark., Dissertation, Universität Bremen, 2013]

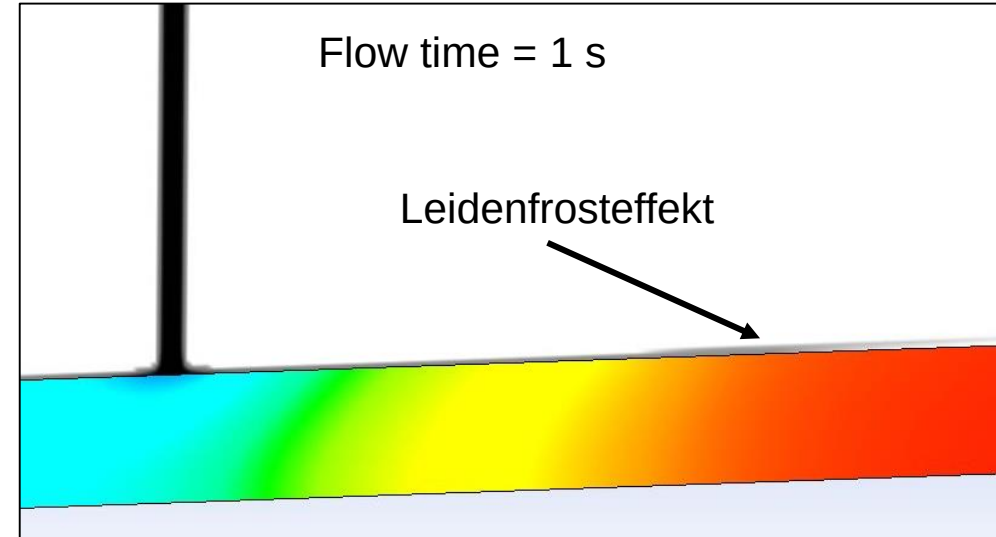
- 200 × 50 × 5 mm AA6082 Platte
- 1,05 mm Vollstrahldüse
- ANSYS ICEM 19.2
- Blocked Meshing mit O-Grid
- Ca. 5 Mio. Zellen
- Separates Interface für Raum und Solidplatte



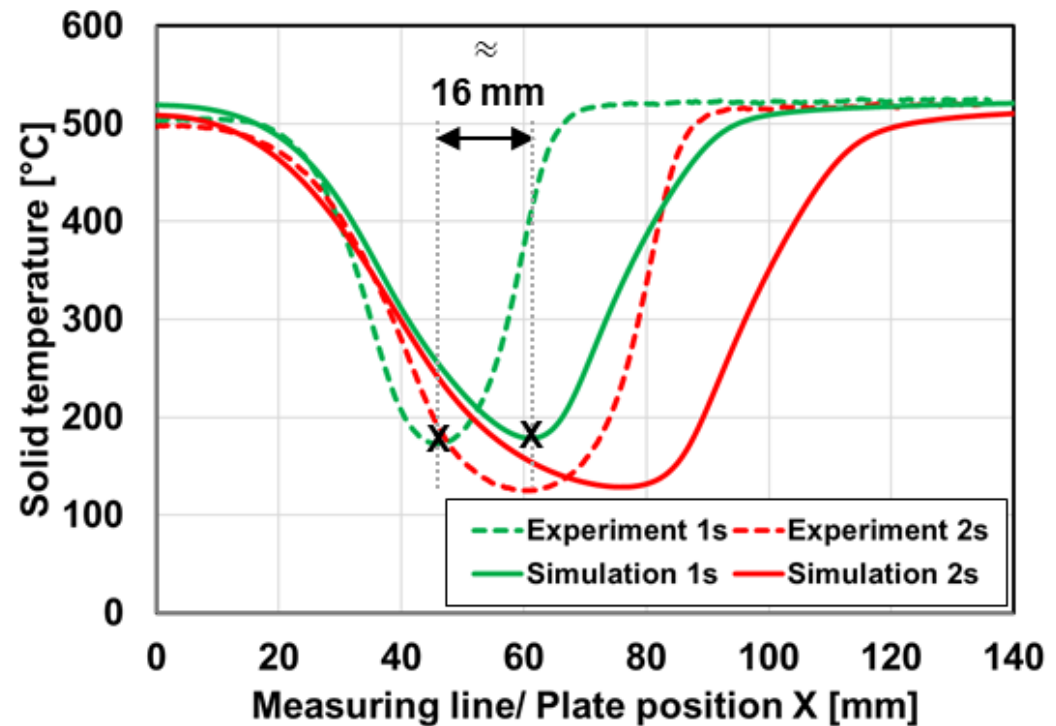
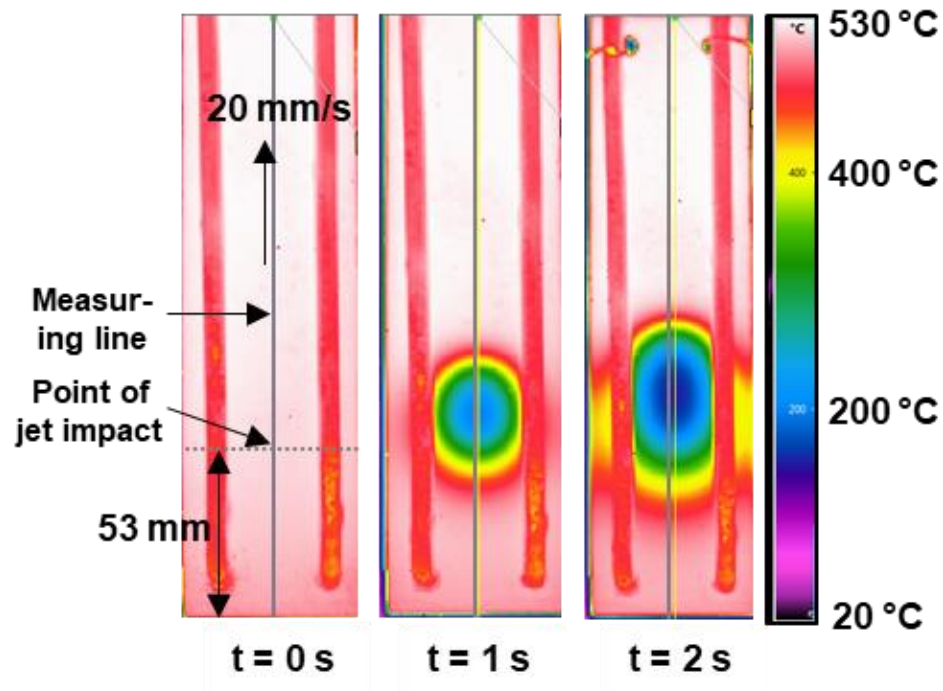
Flow time = 0.1 [s]



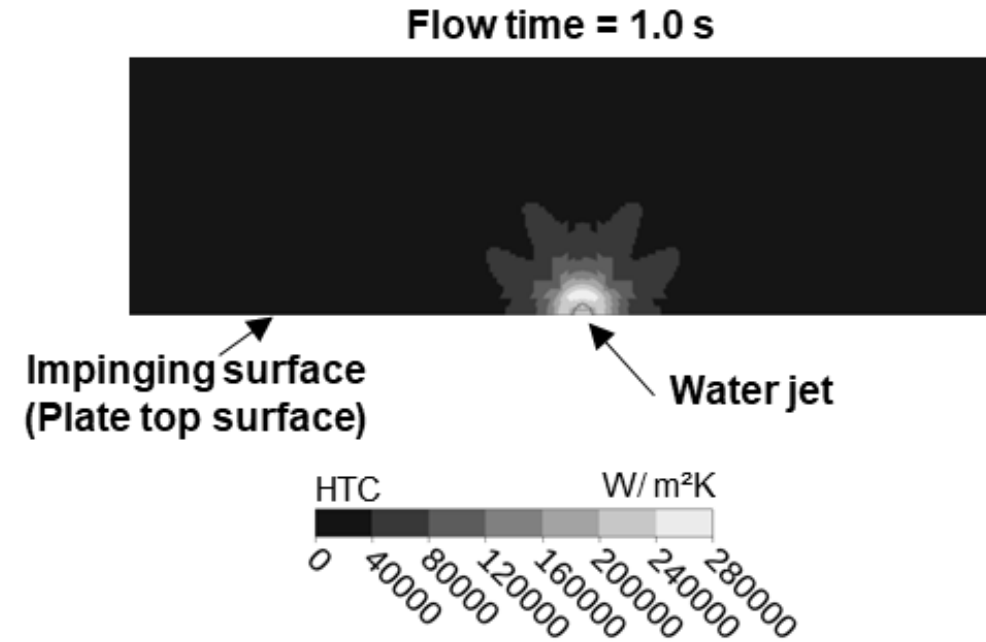
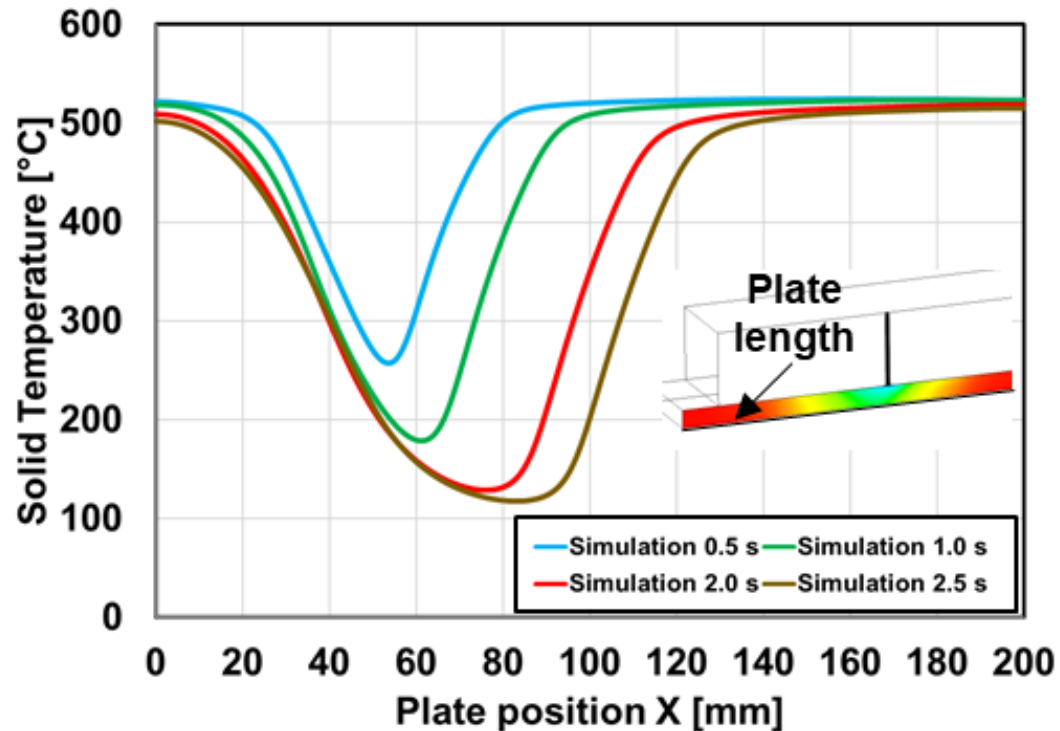
Flow time = 1 s



- 200 × 50 × 5 mm AA6082 Platte
- $d = 1,05$ mm
- $T_s = 798,15$ K (525 °C)
- $T_w = 291,15$ K (18 °C)
- $w_j = 19,25$ m/s
- $w_c = 20$ mm/s
- $H = 20$ mm (Düse/ Platte Abstand)



- $200 \times 50 \times 5$ mm AA6082 Platte
- $d = 1,05$ mm
- $T_s = 798,15$ K (525 °C)
- $T_w = 291,15$ K (18 °C)
- $w_j = 19,25$ m/s
- $w_c = 20$ mm/s
- $H = 20$ mm
- Simulation schneller
- Kohärenter Jet in Simulation
- Synchronisierung schwierig
- Auswertung des Jet-impakt Punkts

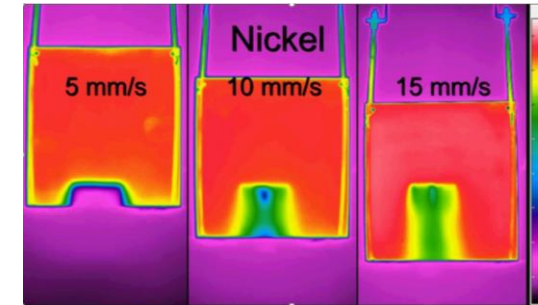


- 200 × 50 × 5 mm AA6082 Platte
- $w_j = 19,25 \text{ m/s}$
- $d = 1,05 \text{ mm}$
- $w_c = 20 \text{ mm/s}$
- $T_s = 798,15 \text{ K (525 °C)}$
- $H = 20 \text{ mm}$
- $T_w = 291,15 \text{ K (18 °C)}$

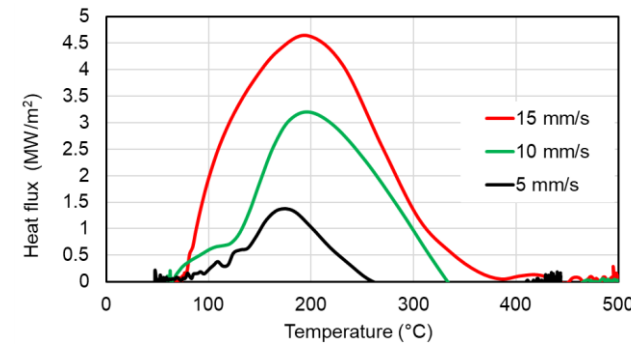
- Axiale und radiale Übertragung
- Geeignete Geschwindigkeit
(Kombination von Plattendicke
und Werkstoff Eigenschaften)

W_c ↓ = ↑ Temperaturhomogenität

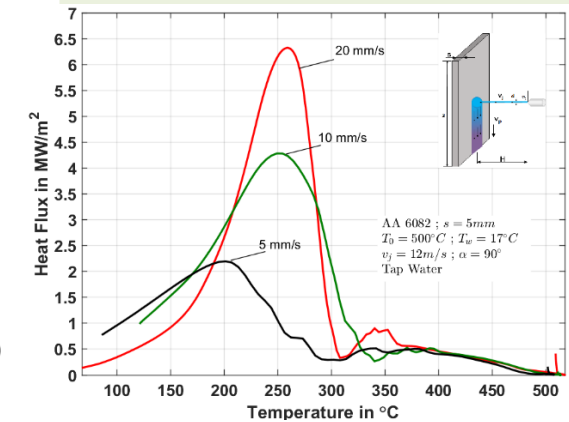
W_c ↑ = ↑ $q_{\max}$



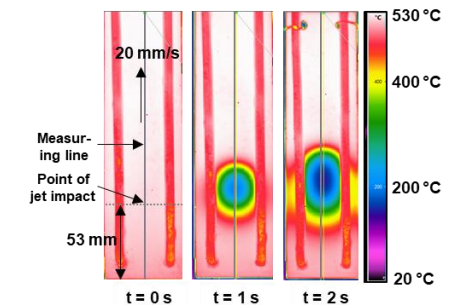
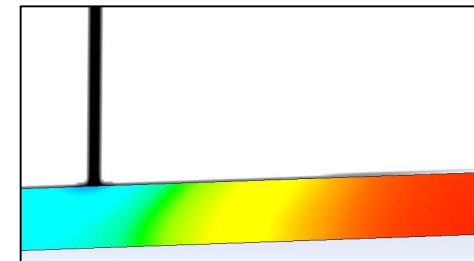
1D – 2xFlachstrahldüsen



2D – Vollstrahldüse



- 2D-inverses Modell erfolgreich entwickelt
- 3D-Simulations Quenching Modell entwickelt und validiert



Dieses Projekt wird von der Arbeitsgemeinschaft industrieller Forschungsvereinigungen "Otto von Guericke" e.V. (AIF) und der Forschungsgemeinschaft Industrieofenbau e.V. (FOGI) gefördert .



Die Arbeiten wurden durch den Norddeutschen Verbund für Hoch- und Höchstleistungsrechnen (HLRN) gefördert.



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