Analysis of process limits for partial hot stamping with controlled pre-cooling by radiation exchange

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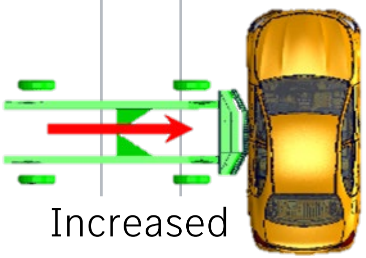
Mercedes-Benz

Analysis of process limits for partial hot stamping with controlled pre-cooling by radiation exchange

Introduction and motivation

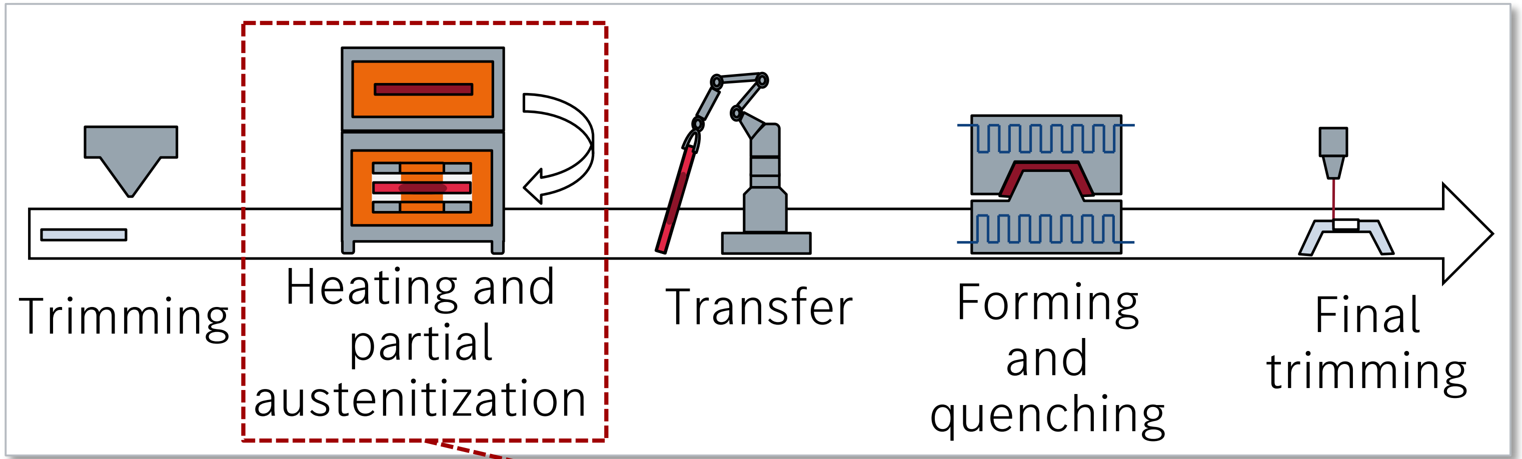
Higher safety requirements for the car body

*IIHS old!: 50 km/h;1500 kg

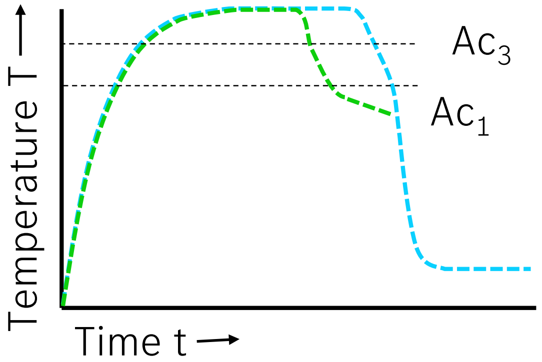


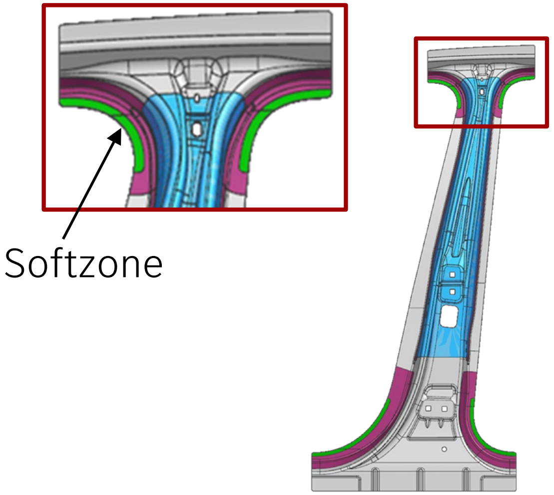
Increased requirements

*IIHS new since 2022: 60 km/h;1900 kg



Targeted austenite decomposition





*Insurance Institute for Highway Safety

Investigation methods and materials

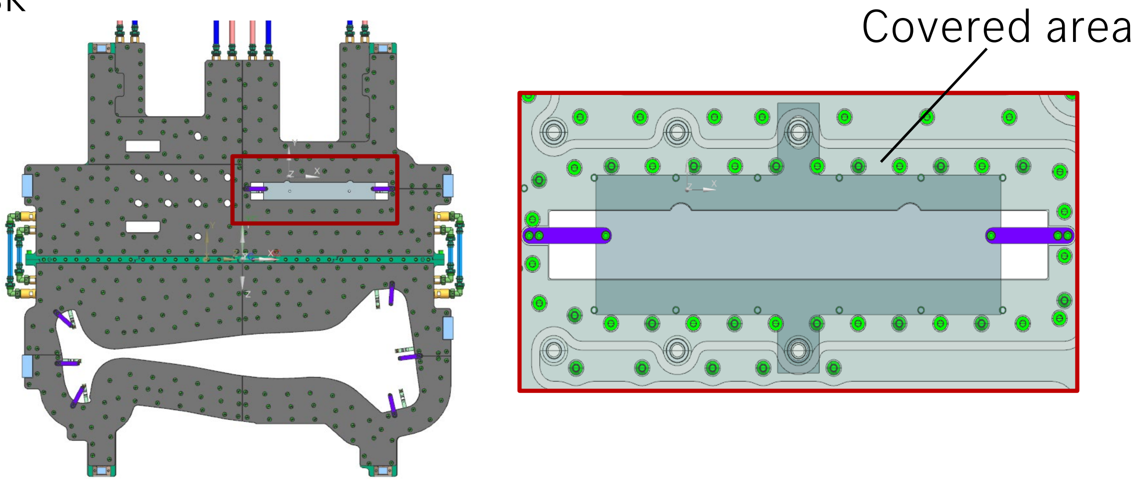
Investigation methods
- Experimental trials
- FE-simulation with AutoForm®R10

Materials
- 22MnB5 AS150
- 8MnB7 AS150
- Blank 8MnB7 and patch 22MnB5

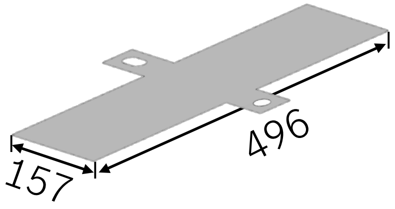
Parameter
- Sheet tickness t_0
- Partial pre-cooling time $t_{pre\text{-}cooling}$

Objectice
Simulative and experimental analysis of **phase transformation** and **hardness** using different **sheet thicknesses and materials**
⇨ Elaboration of possible process limits

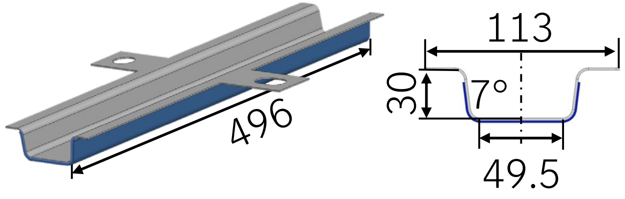
Mask



Blank

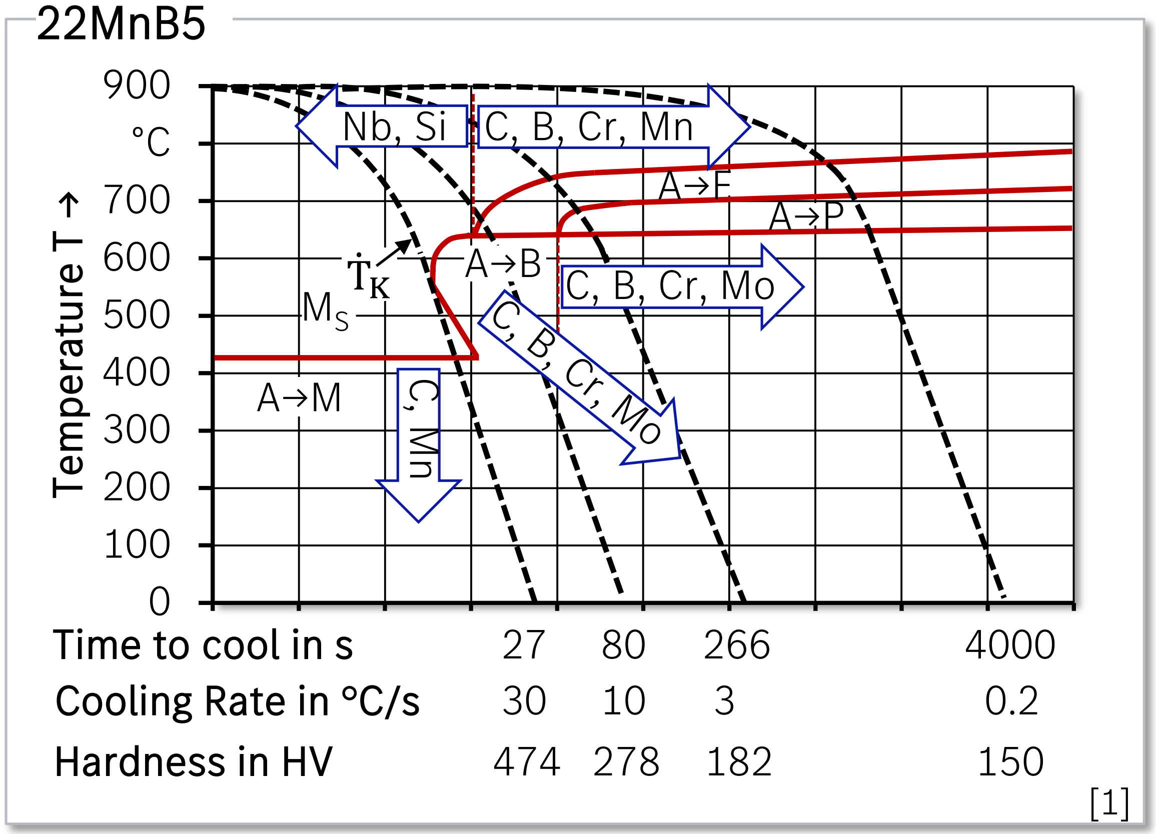


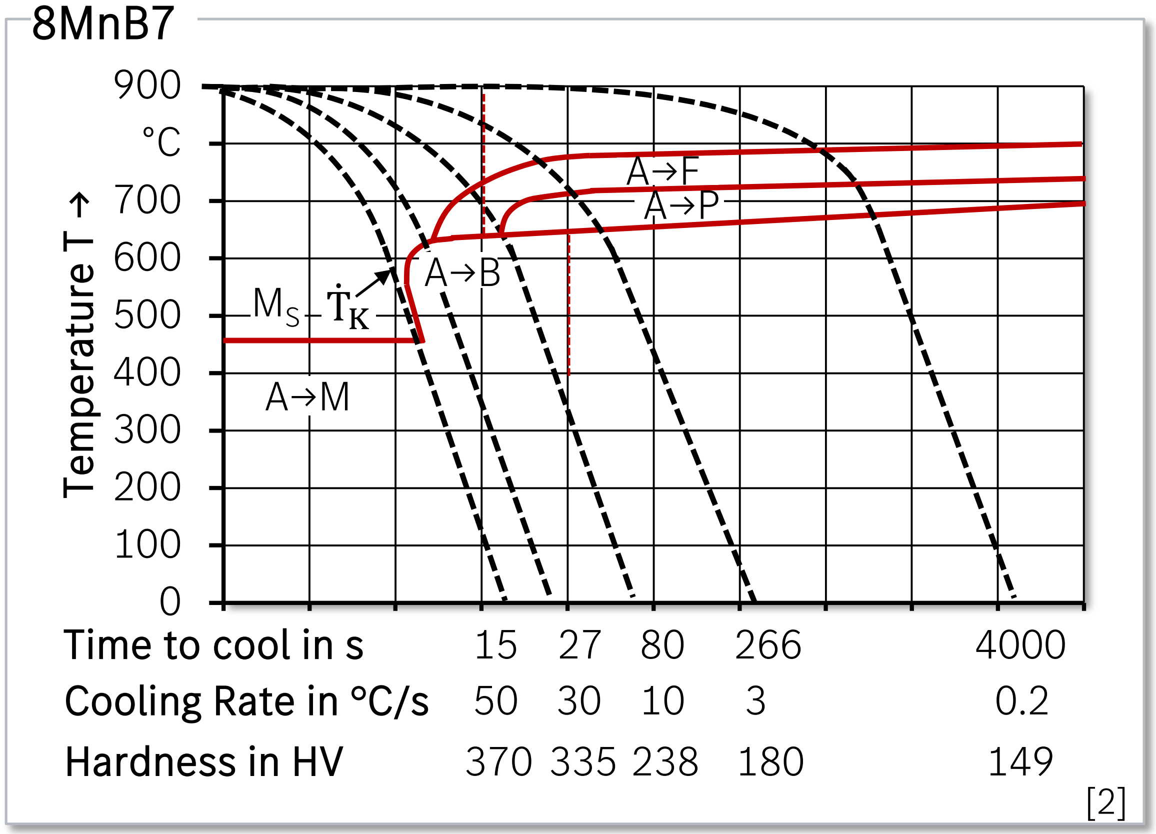
Patched-hat profile



CCT-Diagram of 8MnB7 and 22MnB5

Shifting phase transformation areas due to chemical composition

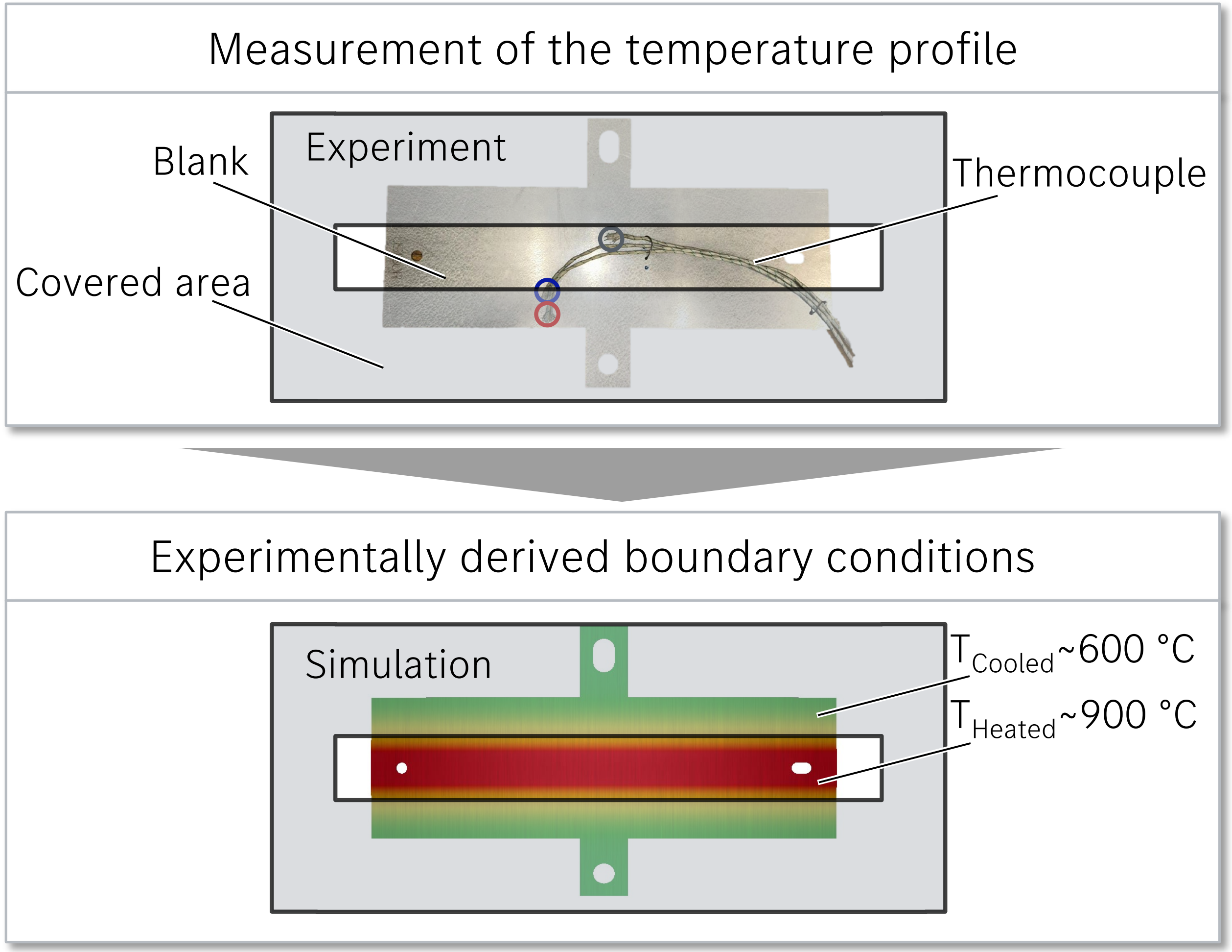


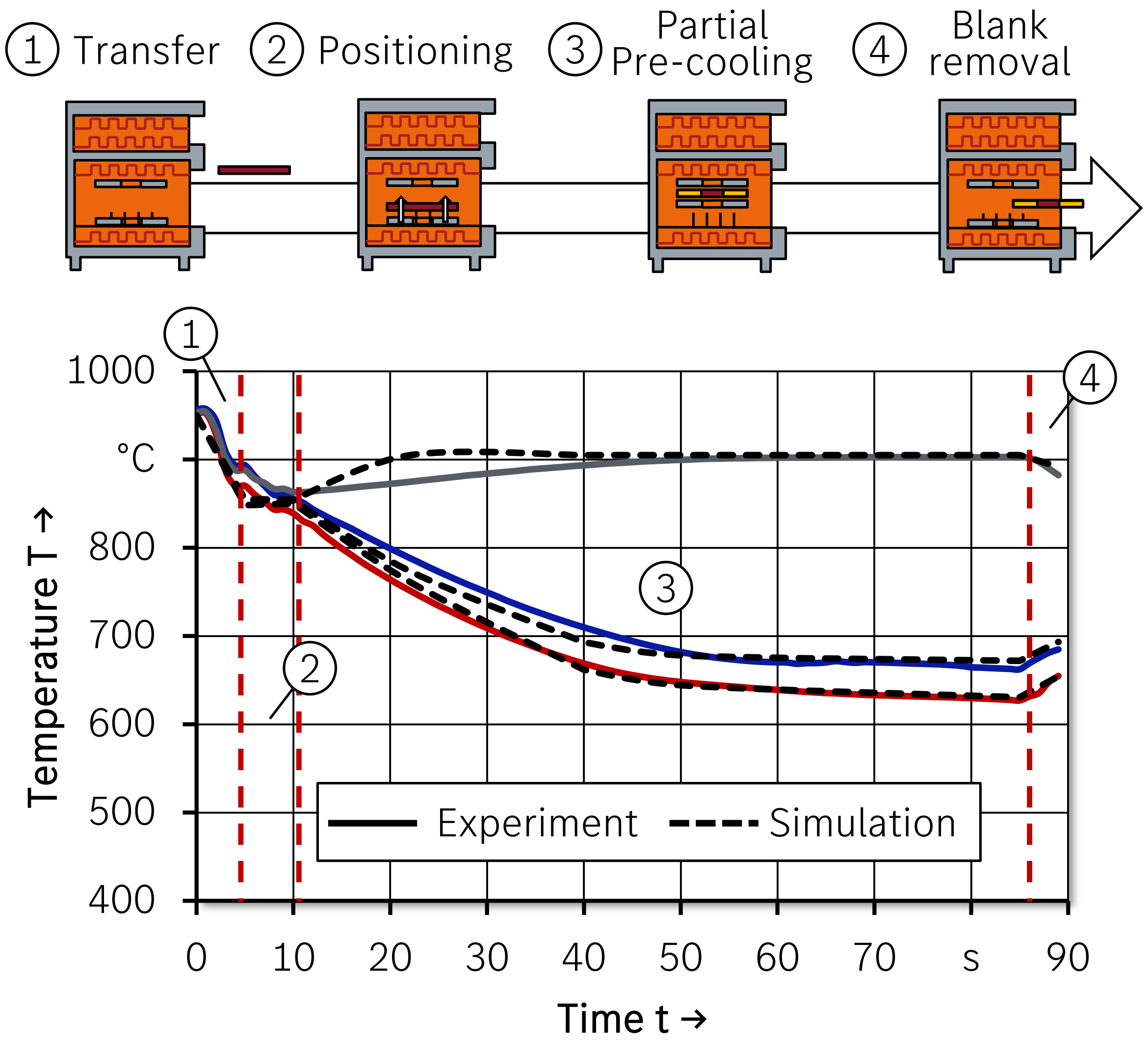


A: Austenite B: Bainite F: Ferrite P: Perlite M: Martensite M_S = Martensite Start Temp.

Temperature measurements and simulation of partial pre-cooling

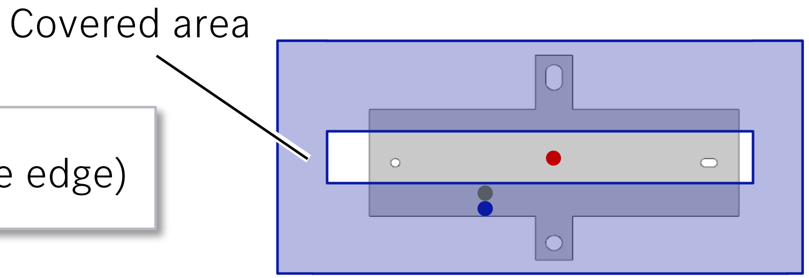
Temperature-input for the simulation is derived from experimental measurements



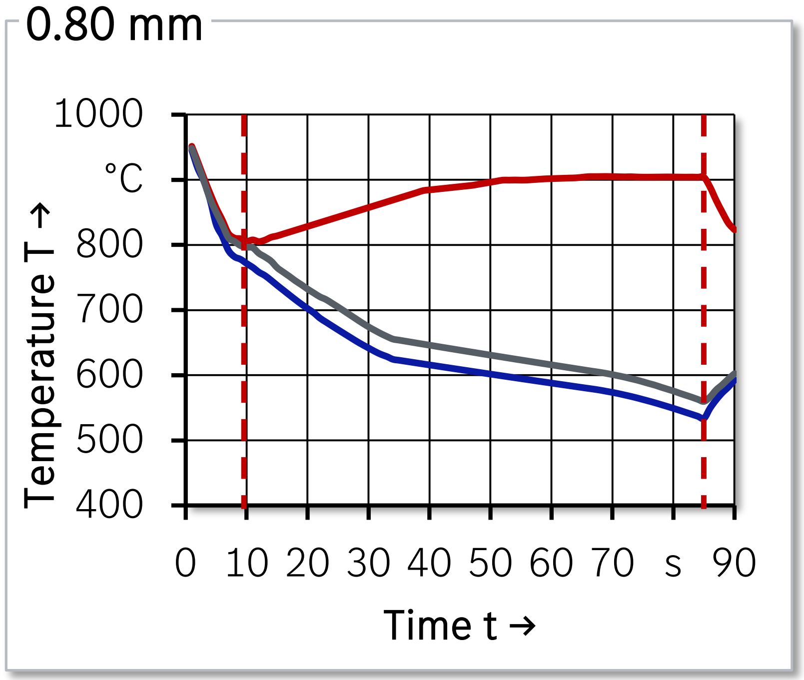


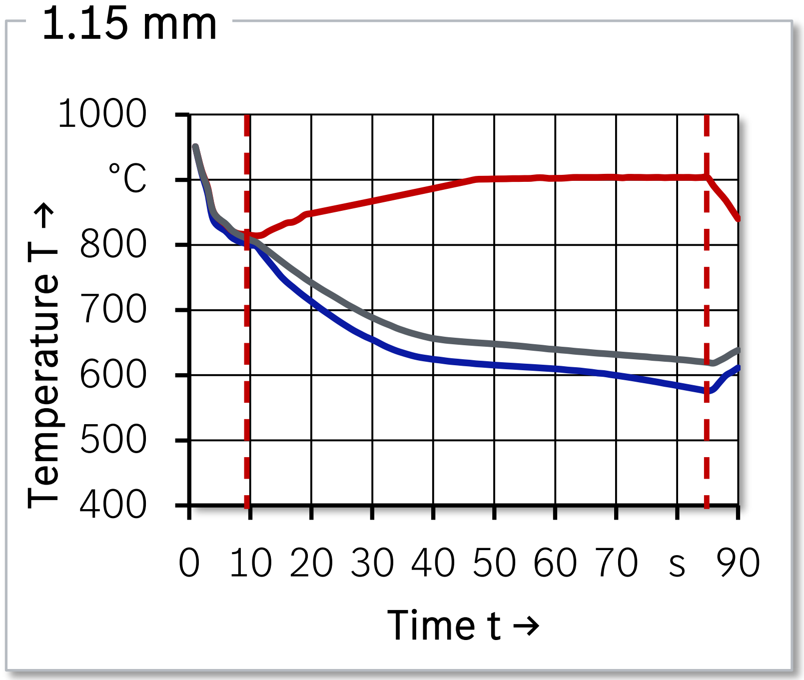
Influence of the sheet thickness

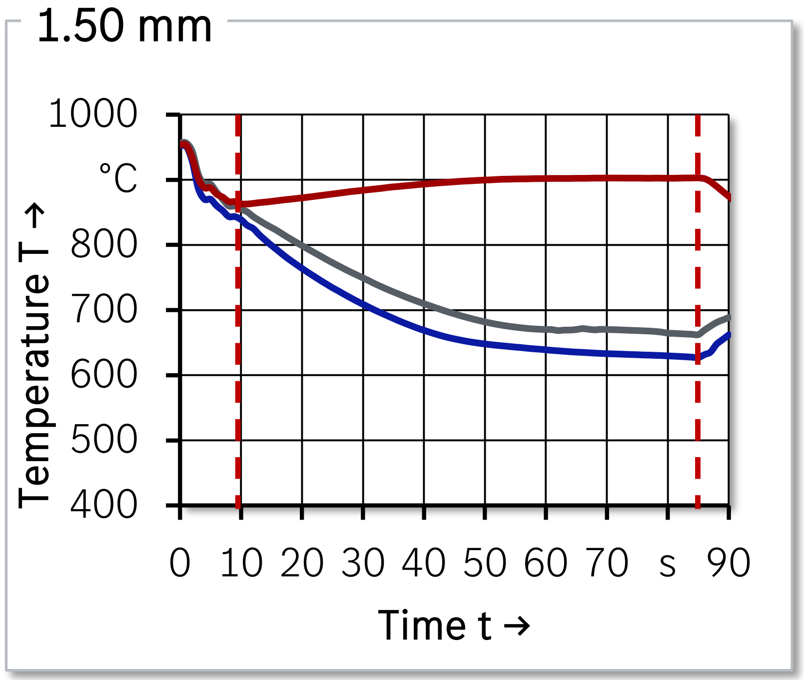
Significant influence on temperature profile, cooling rate and phase transformation



Heated — Cooled (20 mm from the edge) — Cooled (5 mm from the edge)



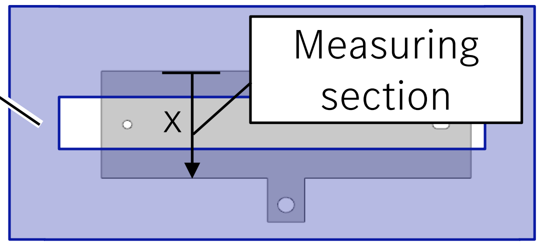




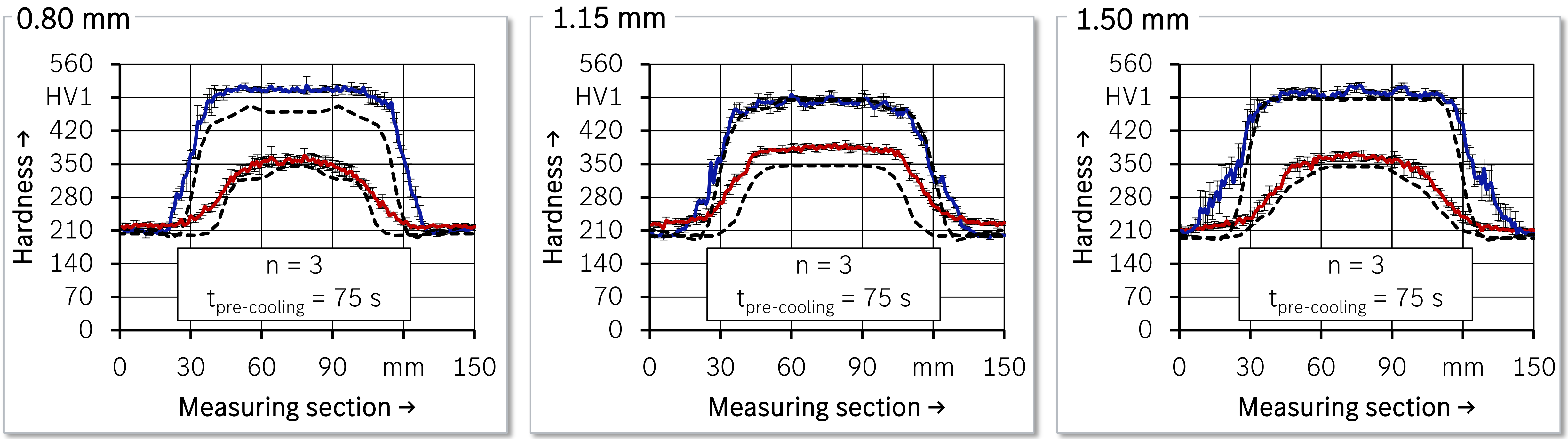
Hardness - 8MnB7 and 22MnB5

Sheet thickness influences the formation of soft, transition and hard areas

Covered area



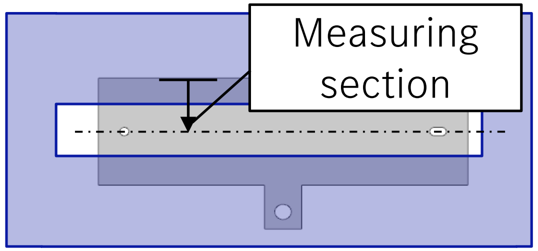
Simulation | Experiment (8MnB7) | Experiment (22MnB5)

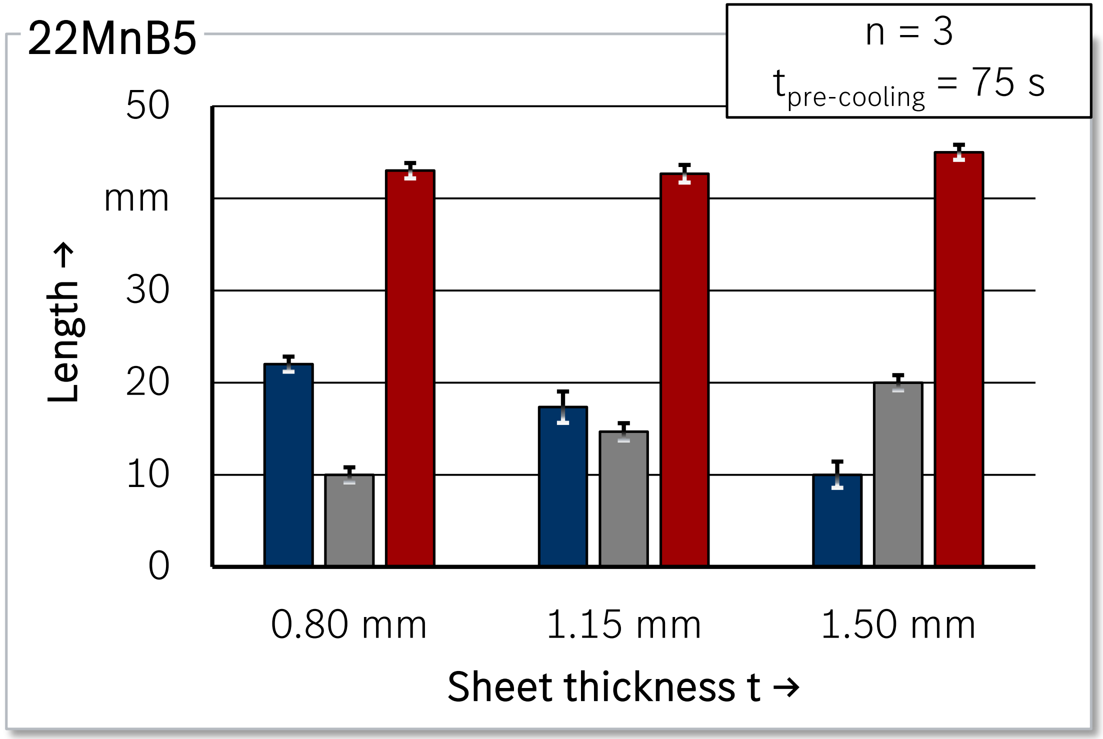


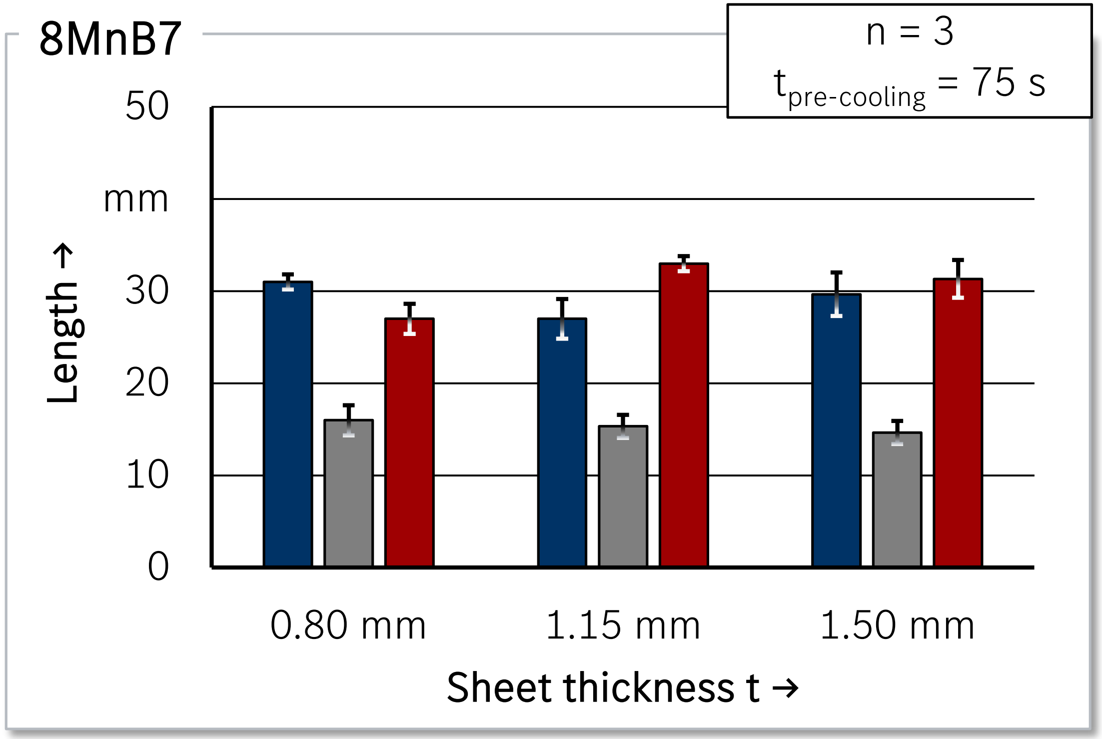
Hardness - 8MnB7 and 22MnB5

Sheet thickness influences the formation of soft, transition and hard areas

Soft zone (< 240 HV) | Transition zone | Hard zone (> 420 HV 22MNB5) (> 330 HV 8MnB7)

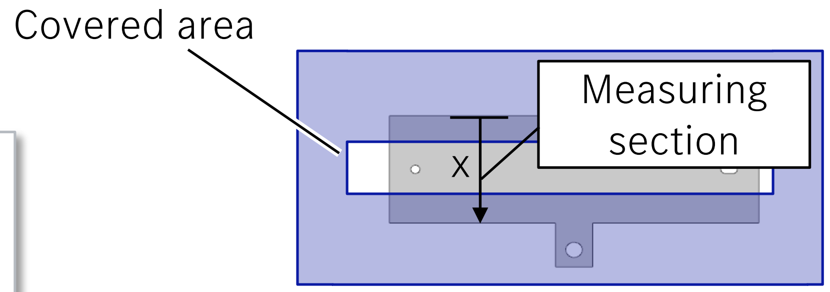


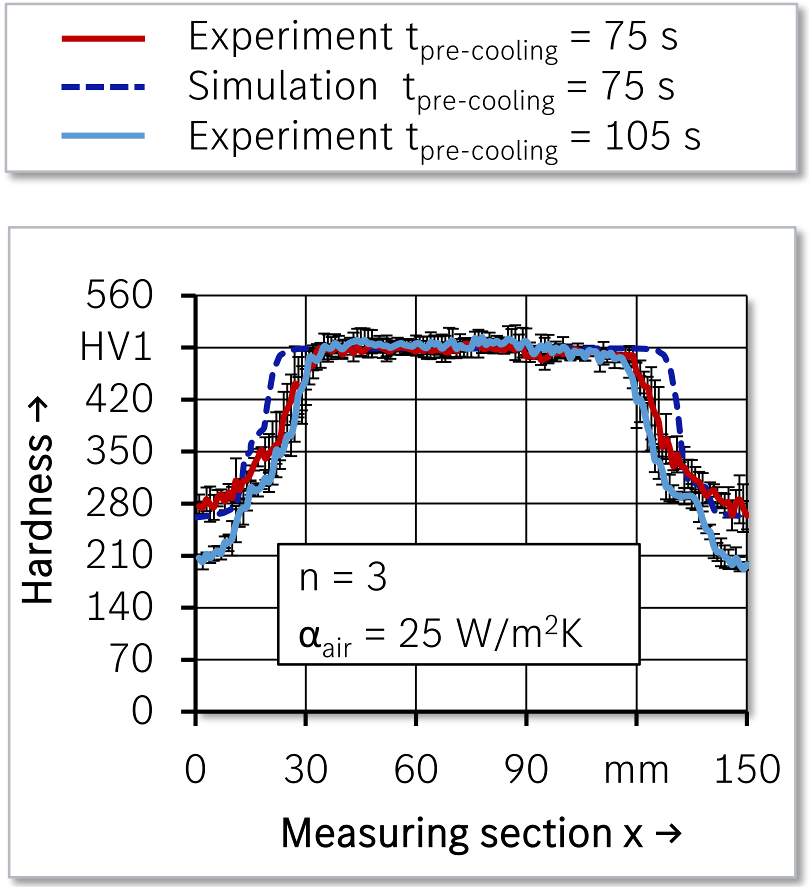


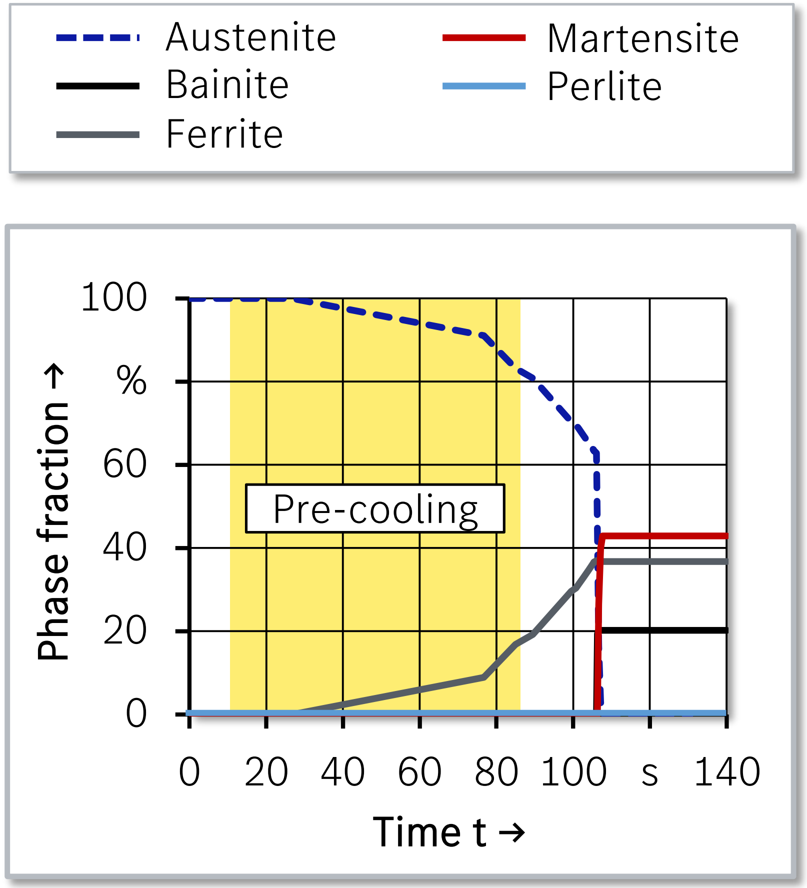


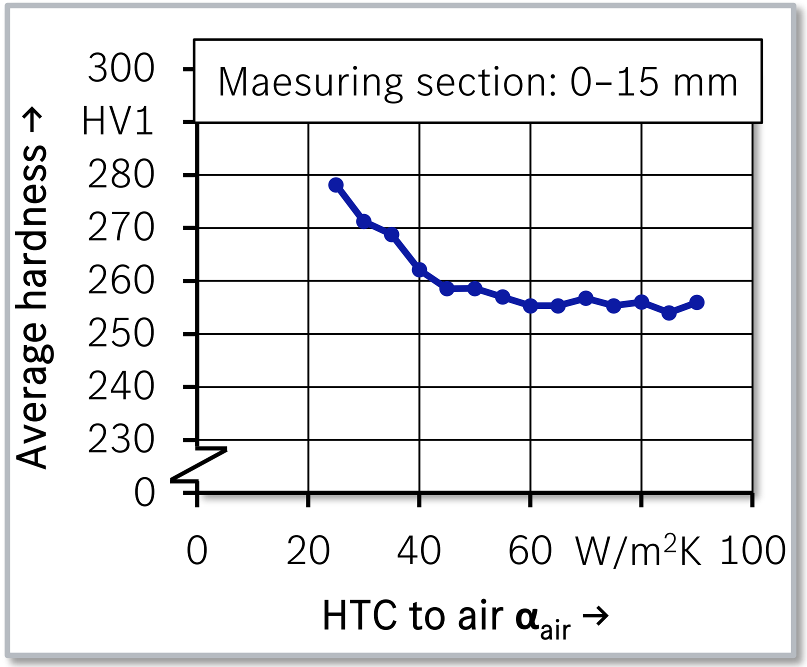
Hardness - Sheet thickness of 2.25 mm - 22MnB5

Extended pre-cooling times are required for the formation of soft areas





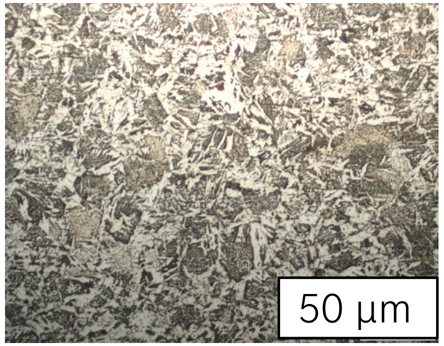




Microstructure analysis - 22MnB5

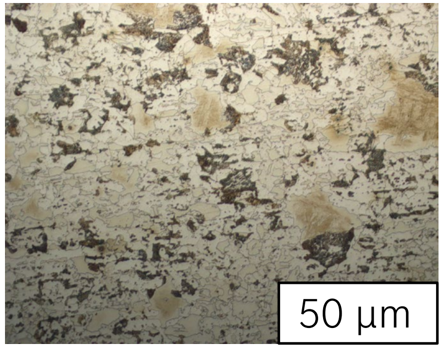
Higher proportion of hard phases in the overall microstructure at 2.25 mm

0.80 mm

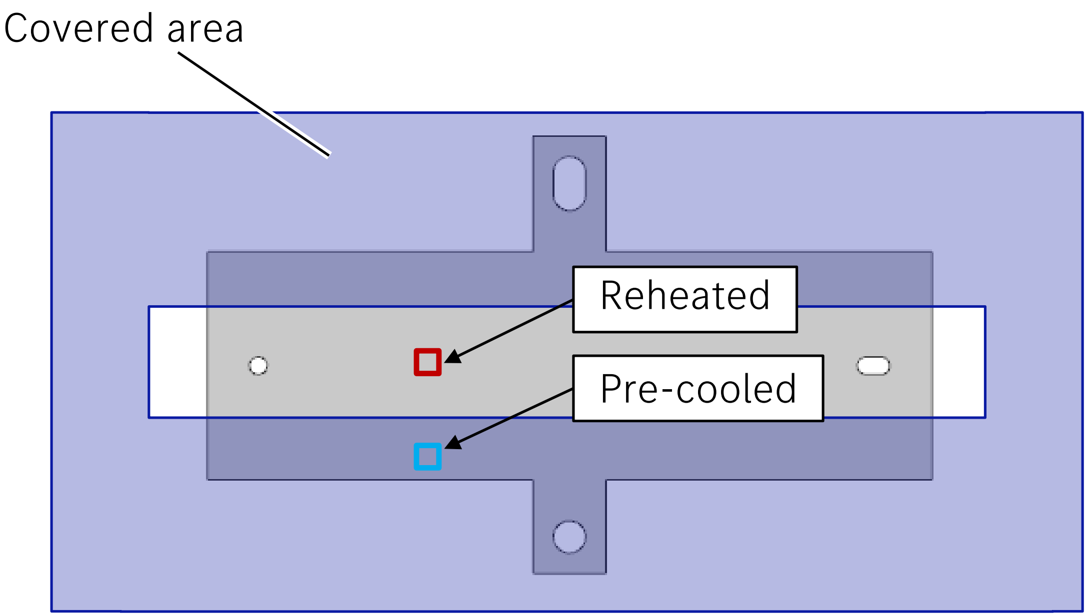


Ferrite and Perlite

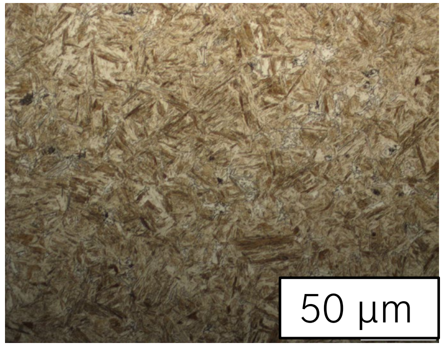
2.25 mm



Ferrite, Perlite and Bainite/Martensite

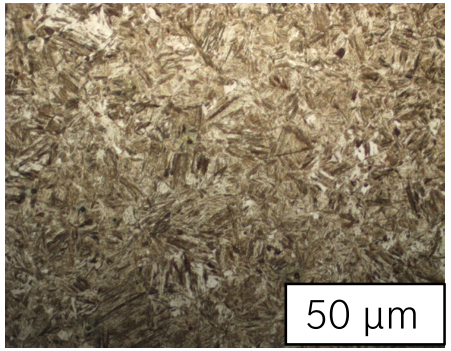


0.80 mm



Martensite

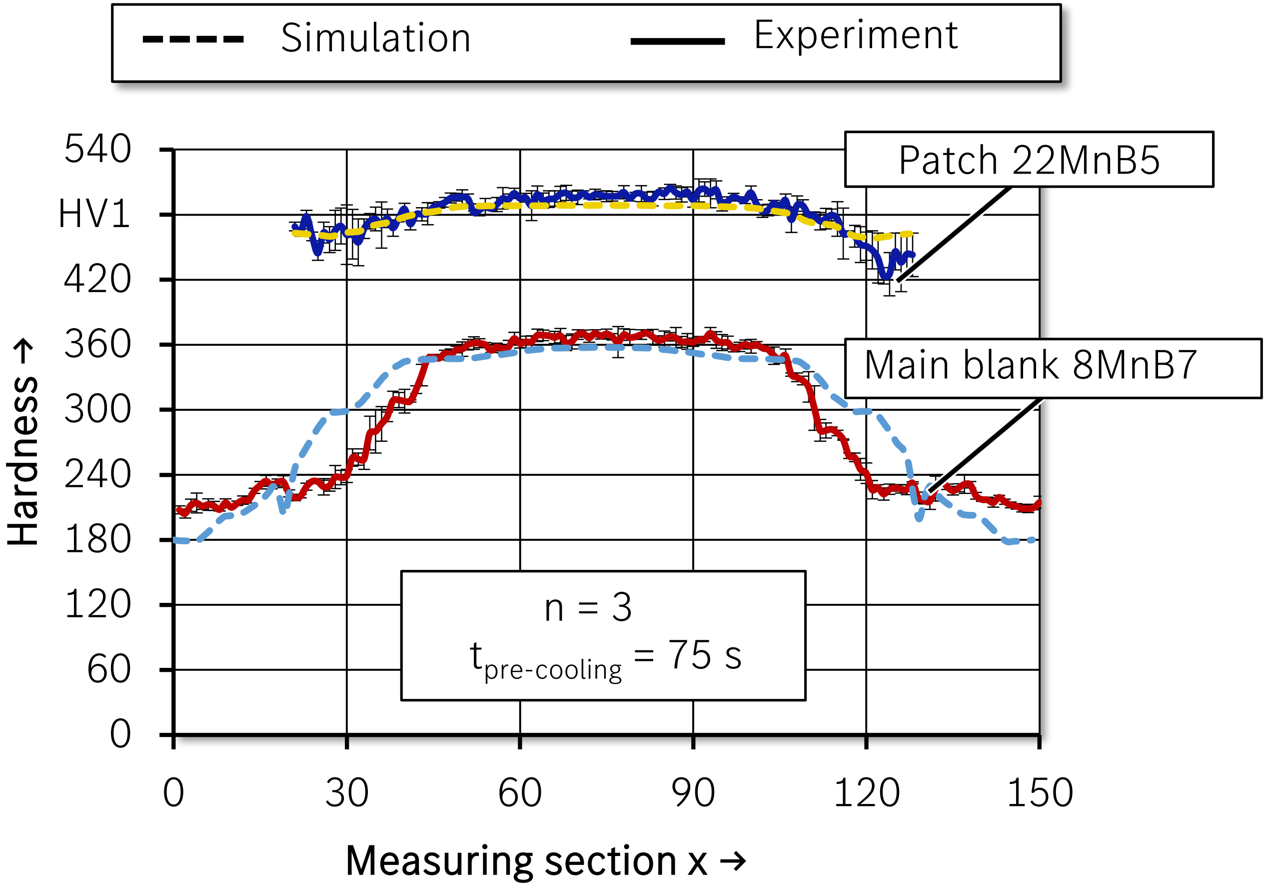
2.25 mm

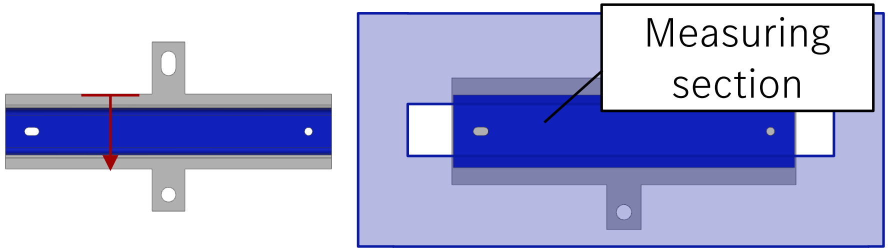


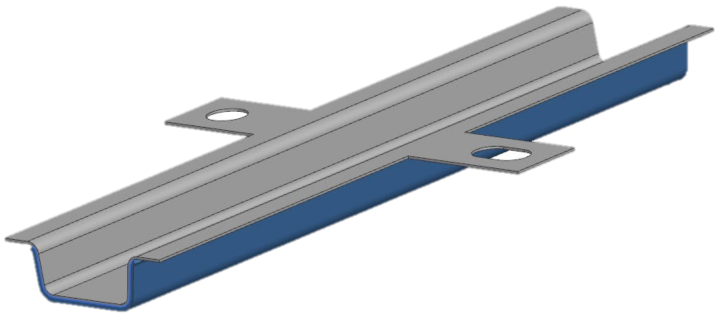
Martensite

Patched-hat profile

TemperBox® process affects hardness of the patch

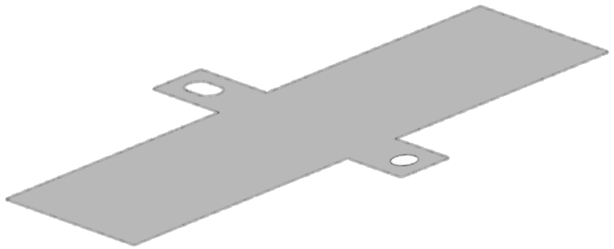






Summary

Flat blank



t_0 = 0.8 mm, 1.15 mm and 1.50 mm

- The carbon content influences the final hardness profile significantly
- Good correlation of simulation and experiment

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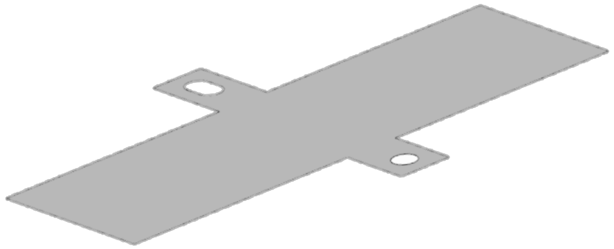
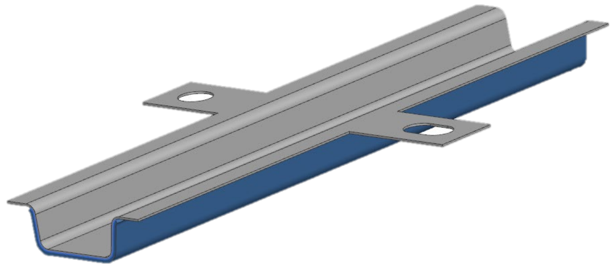


t_0 = 2.25 mm

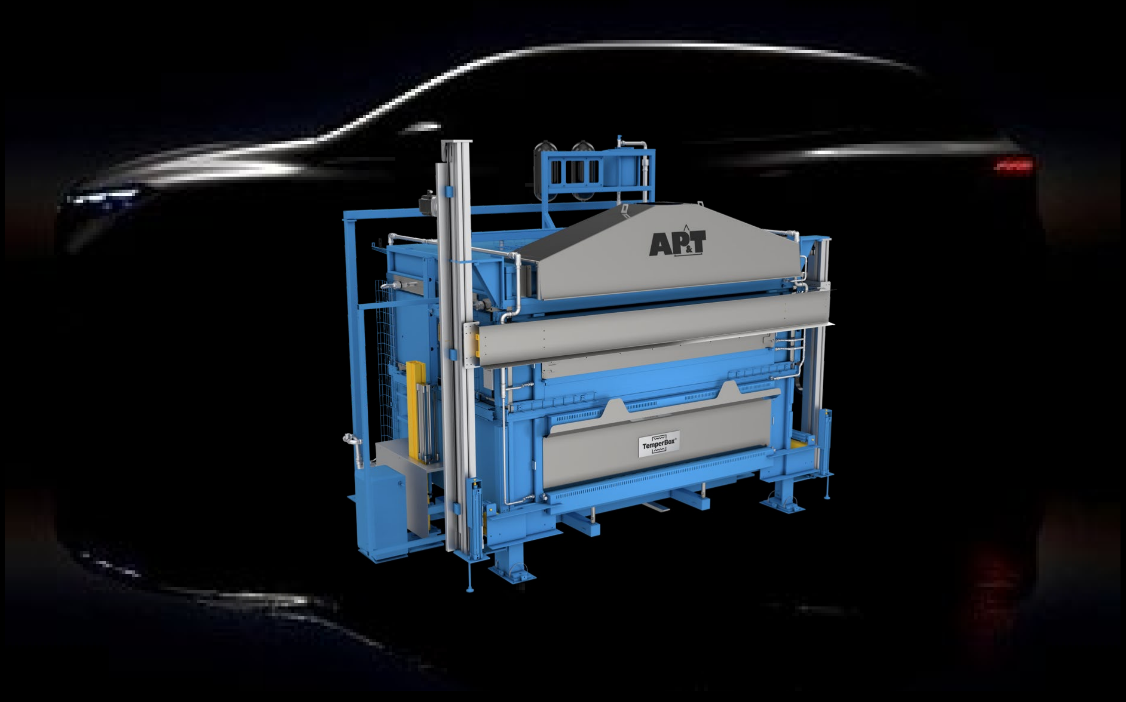
- 75 s pre-cooling time is not sufficient to form homogeneous soft areas
- Simulatively the heat transfer coefficient to air is of importance

Patched-hat profile



t_{patch} = 1.25 mm and t_{blank} = 1.50 mm

- Partial pre-cooling slightly affects hardness of the patch
- Deviation between simulation and experiment in the transition area



Thank you
for your attention.

References

[1] Mohrbacher H 2014 Martensitic Automotive Steel Sheet - Fundamentals and Metallurgical Optimization Strategies *Advanced Materials Research* **1063** 130–42.

[2] Güner A, Sonntag M, Philippot C, Bittendiebel J, Sarre B, Dormegny L, Reihani A and Heibel S2022 Experimental and numerical investigation of final product properties of Ductibor® 1000 AS underdifferent process conditions, 8th *Int. Conf. Hot Sheet Metal Forming of High-Performance Steel,* May30th–June 2nd, Barcelona, Spain.