DETERMINATION OF MATERIAL AND FRACTURE PARAMETERS FOR HIGH STRAIN RATE PROCESSES, ESPECIALLY CONSIDERING THE LOCAL ADIABATIC HEATING IN THE FRACTURE ZONE OF THE SAMPLE

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Keywords: Numerical Simulation, High-Speed Forming, DC06, EN AW-5754, Material Properties

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Formgebende Fertigungsverfahren

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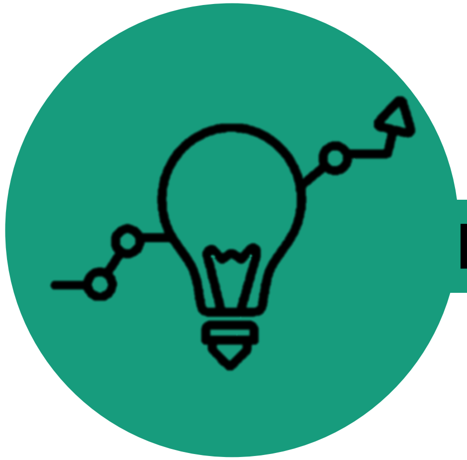
01 Objectives

Objectives



Motivation

- Accurate strain-rate dependent material parameters improve the numerical analysis of processes with high forming speeds
- Precise numerical modelling and process design is a key means for industrial implementation of technologies and enables the exploitation of process specific advantages

Objective

- Development of a method for determining **material** and **failure characteristics** for high rate forming processes
- Analysis of the influence of **adiabatic heating** and the associated local flow stress reduction

02 Inverse parameter identification

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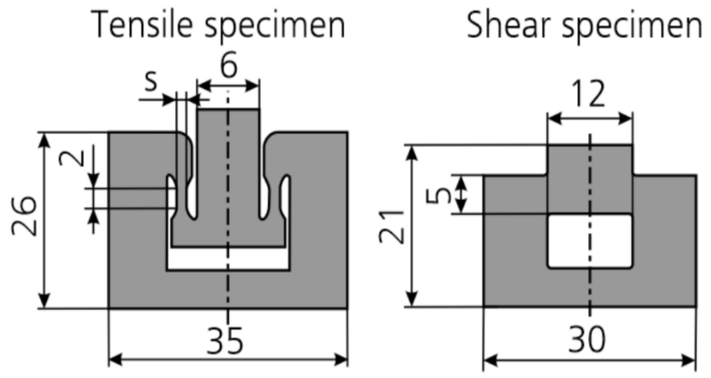
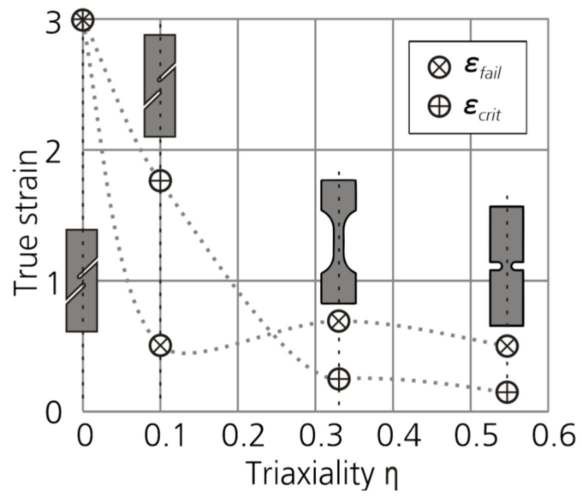
Inverse parameter Identification



Input data
- Hammer velocity (30 m/s)
- Quasistatic material parameters
- Strain rate sensitivity law (parameter c or m)
- Failure/Damage law (failure strains $\boldsymbol{\varepsilon_f}$, $\boldsymbol{\varepsilon_{crit}}$)



Experimental data
- Displacement vs. Time (Laser)
- Strain vs. Time (Strain gauge)

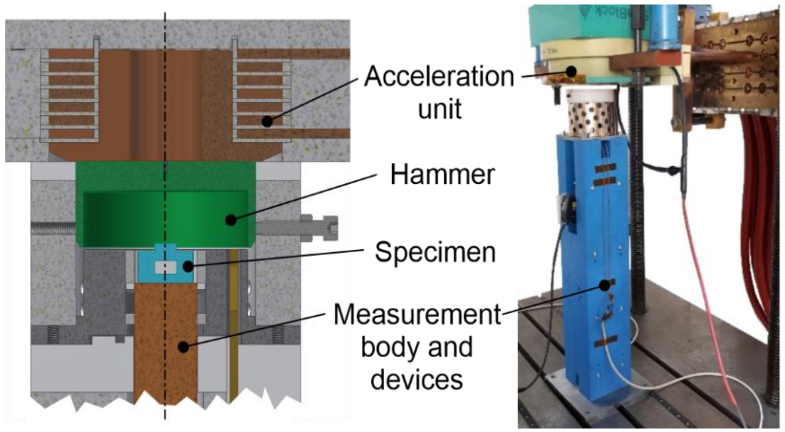
FE-Simulation (LS-DYNA)

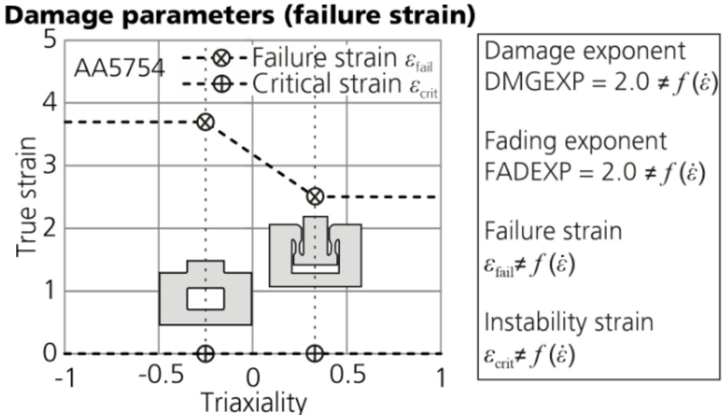
Comparison

Optimization (LS-OPT)

Identified parameters

c or **m** and $\boldsymbol{\varepsilon_f}$, $\boldsymbol{\varepsilon_{crit}}$





[1] Scheffler. C (2020) Electromagnetic Pulse Welding Process and Material Parameter Identification for High Speed Processes

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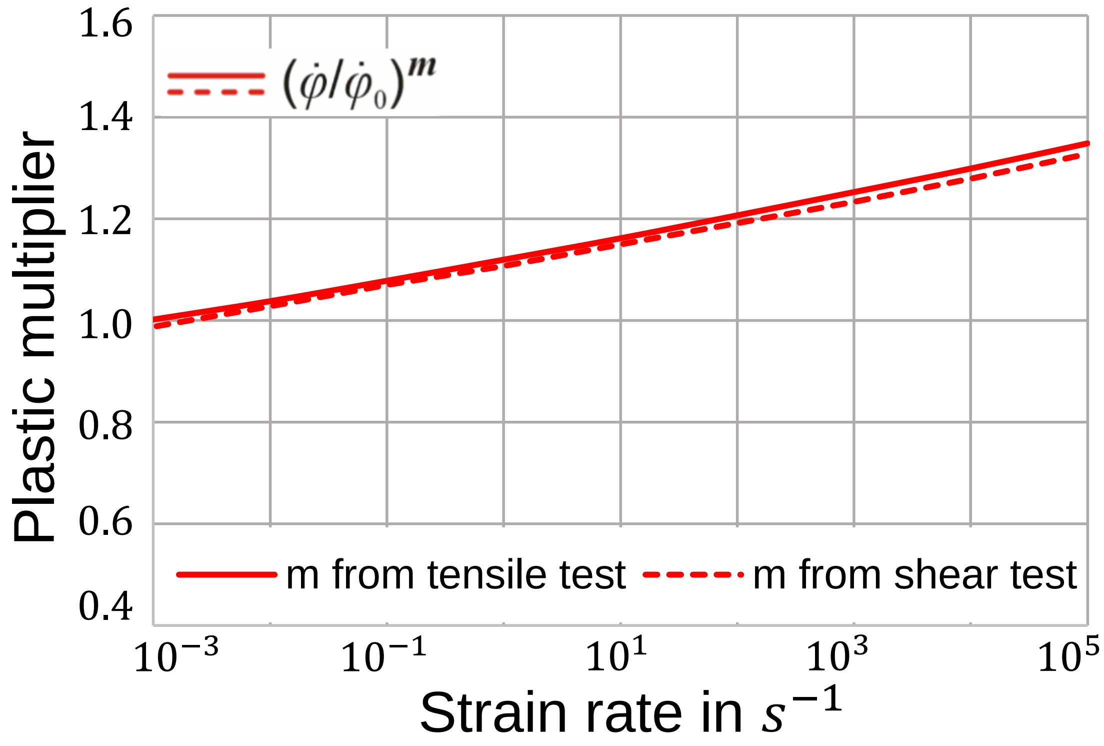
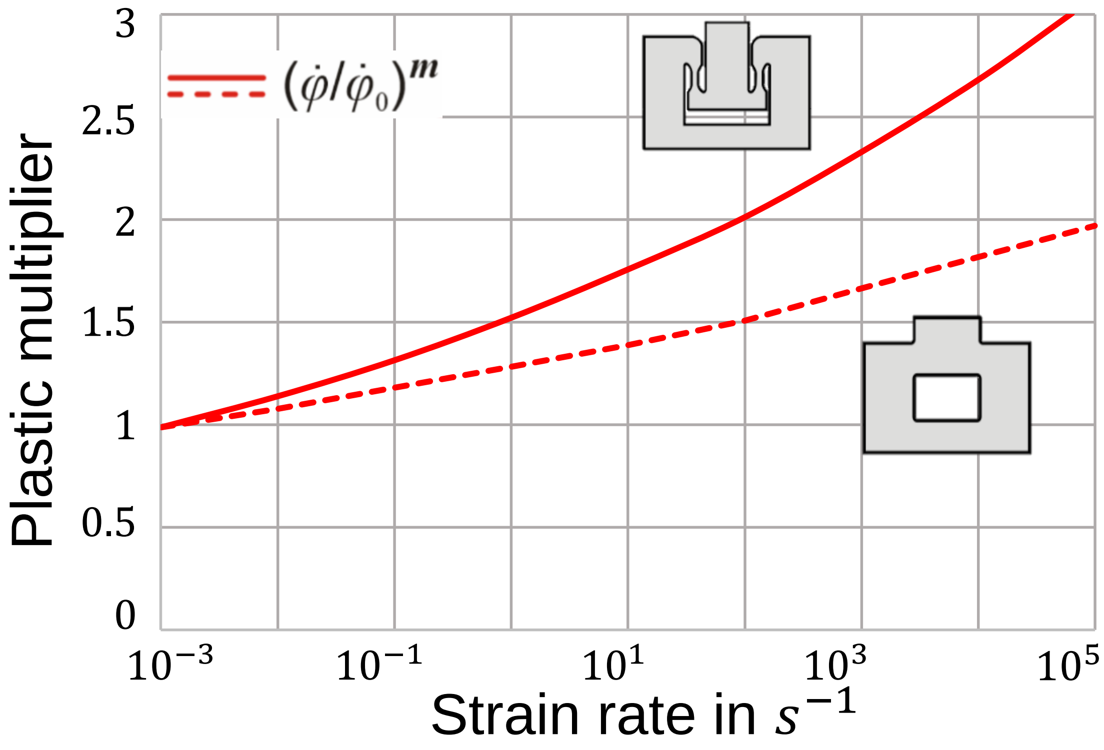
Inverse parameter Identification

High-speed material characterization

AA5754 H111



DC06



- **AA5754:** strain rate sensitivity is independent from the triaxiality
- **DC06:** strain rate sensitivity is higher for tensile specimens than for shear specimens

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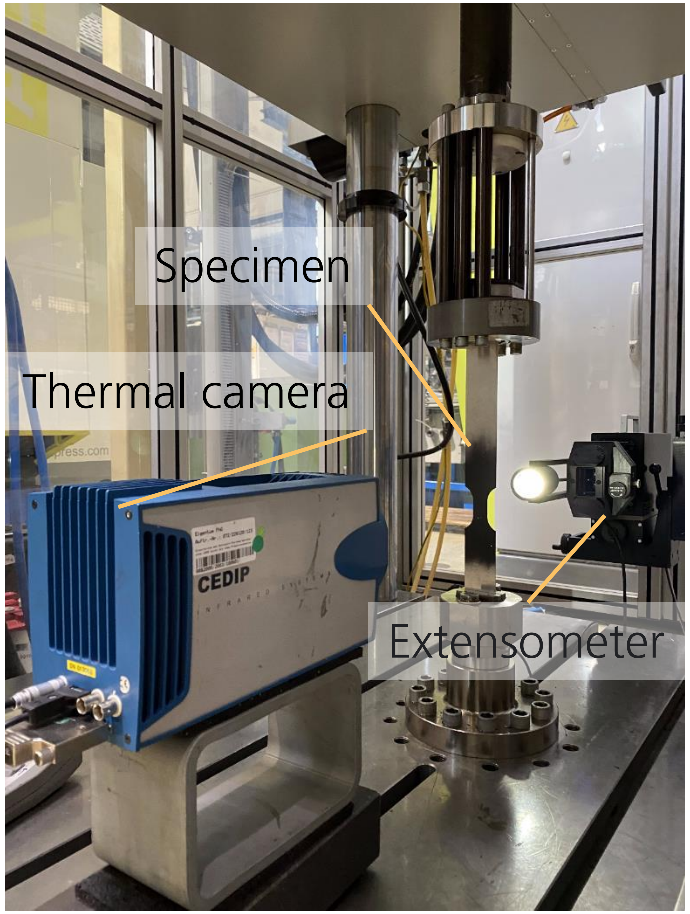
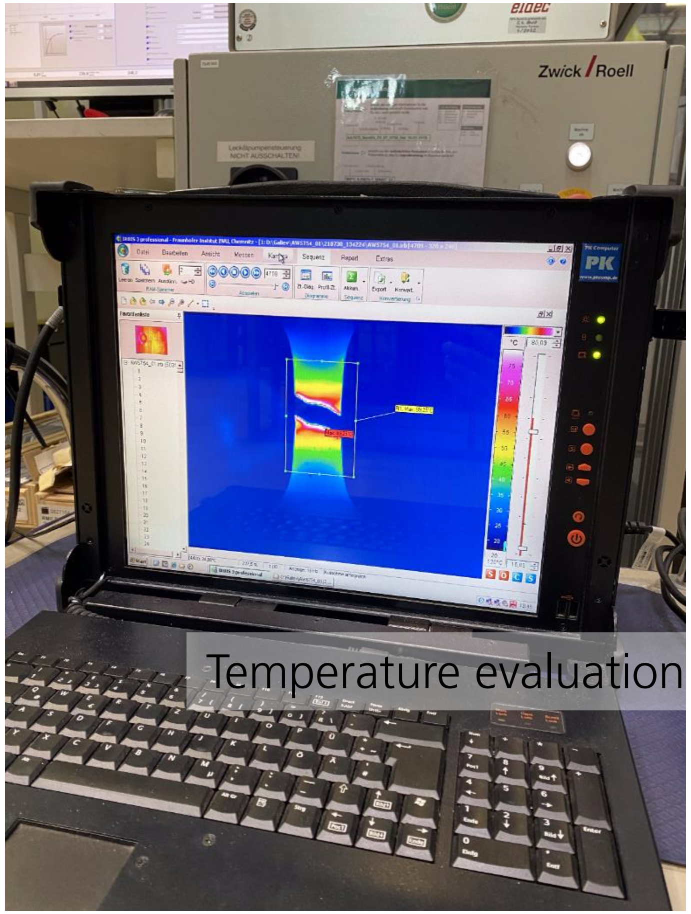
03 Experimental setup

Experimental setup

High-Speed tensile test machine Zwick – HTM 16020





- **Strain rates** of 50, 200 and 1000 /s were studied
- Maximum frame rate of the thermal camera: **1000 frames** per second
- Tests were conducted at room temperature in order to quantify the adiabatic heating in the **fracture** region of the sample

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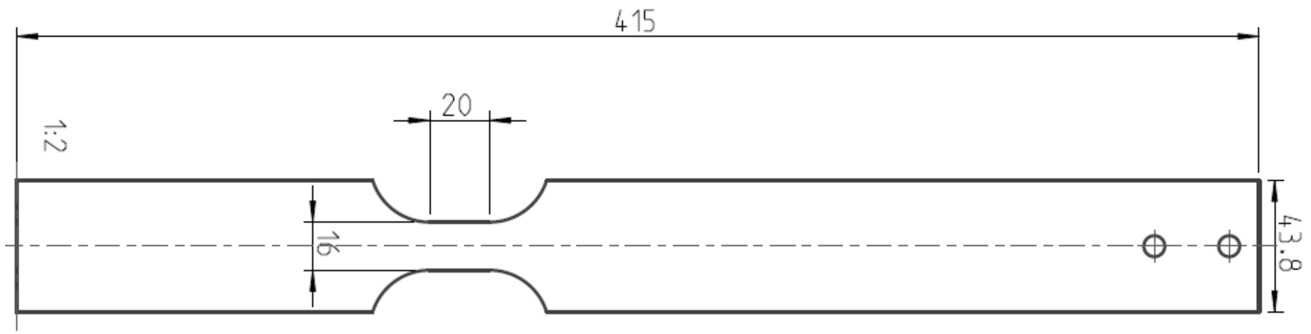
Experimental setup

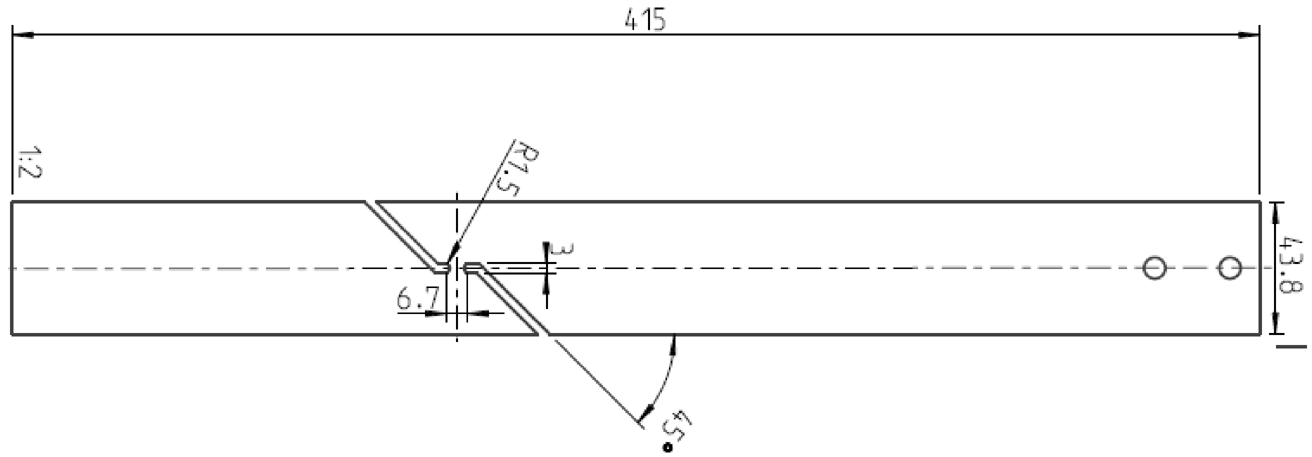
Dimensions of specimen

HTM Tensile specimen



- Standard tensile test specimen with a **16 mm** beam width, should then correspond to classic **uniaxial stress condition**

HTM Shear specimen



- Based on **triaxility** of investigated shear samples, the final geometry for further experiments was customized to the sample shape of HTM machine

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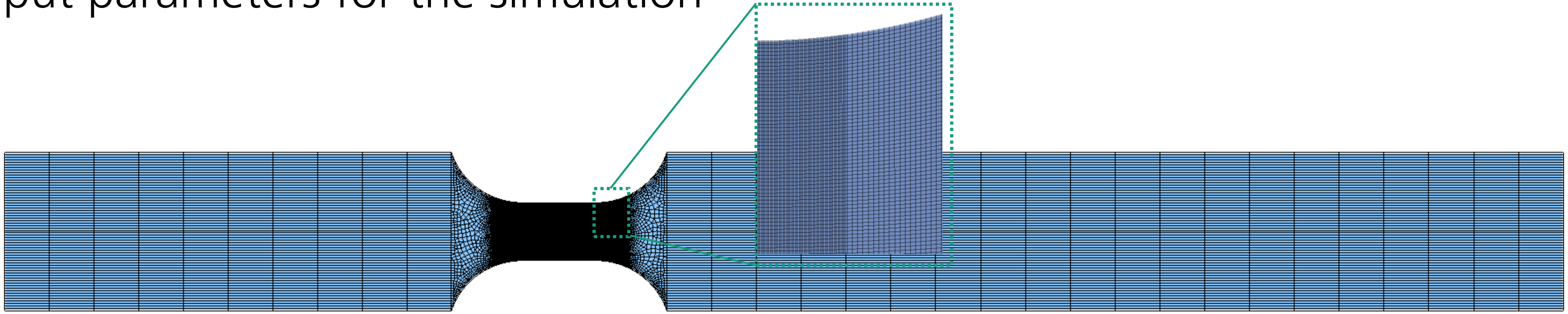
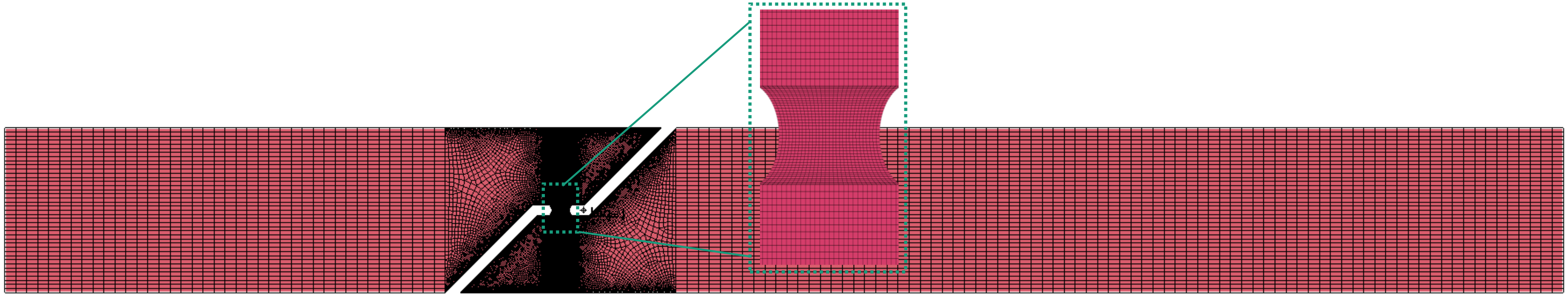
04 FE-Simulation

FE-Simulation LS DYNA

Input parameters for the simulation





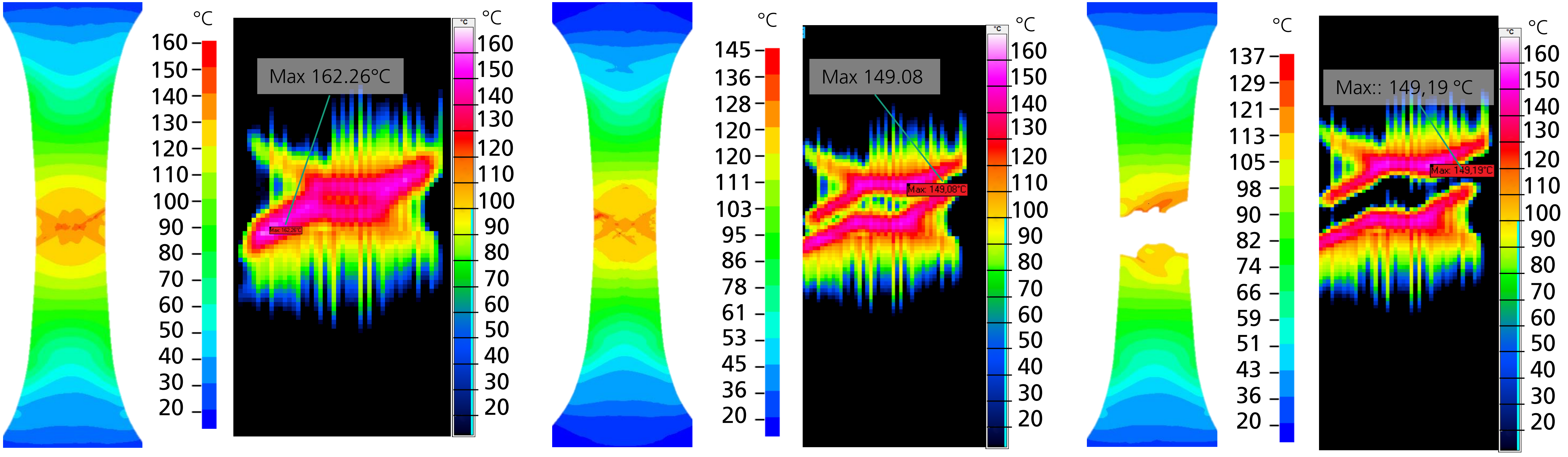
Tested materials	Material modell	Strain rate	Meshsize	Solver
DC06, AW5754	MAT 24 + GISSMO (Strain rate dependent)	50, 200,1000 s/1	0.05 mm	thermo-mechanical explicit

05

Results

Results

HTM fracture zone temperature DC06 tensile specimen (strain rate 50/s)



State 1
before failure

State 2
failure already initiated

State 3
failure already initiated

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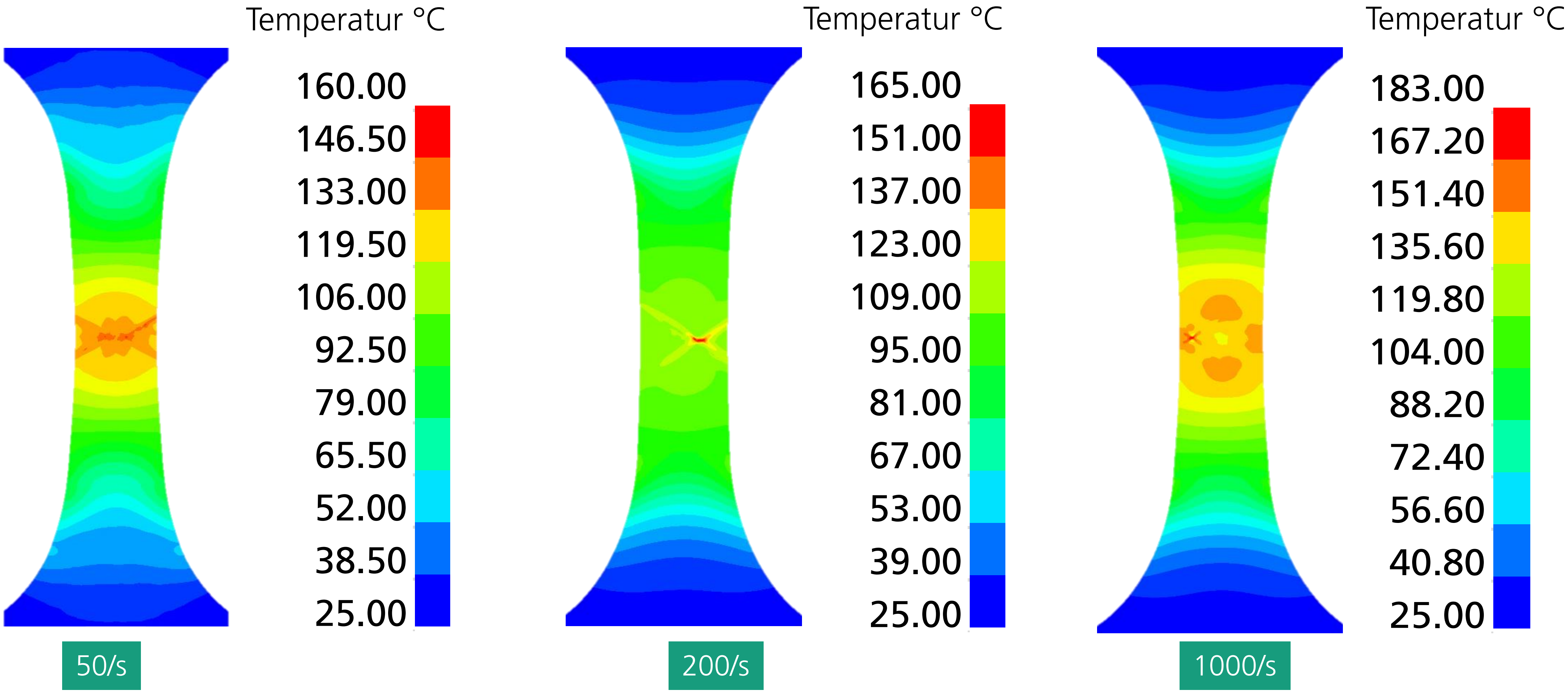
Results

HTM fracture zone temperature DC06 tensile specimen



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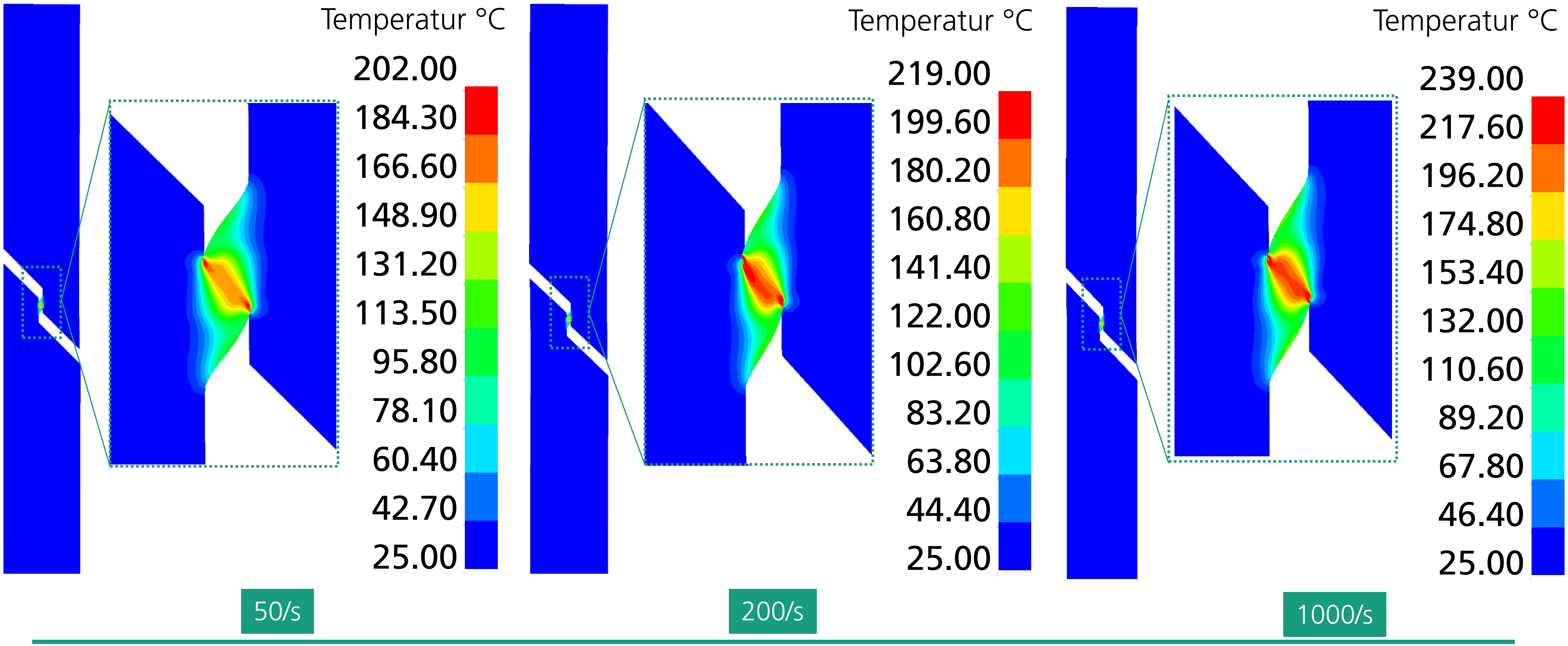
Results

HTM fracture zone temperature DC06 shear specimen



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06 Conclusion

Summary

- significantly higher **strain rate sensitivity** of tensile specimens compared to shear specimens observed for **DC06** steel → for **DC06** the strain rate sensitivity is a **function of the stress state**.

Thermo-mechanical analysis is necessary to study this effect

- Simulations results based on material model and the parameters identified for the **GISSMO damage model**, show good agreement with the experimental data for the other sample geometry
- good **agreement** of **temperature distribution** in the fracture zone for simulation and experiment
- it is extremely important to consider the influence of the element mesh size on the **fracture zone** of the sample and the distribution and localization of temperature

To do

- The agreement of the simulation/experiment fracture zone can be further improved by extending the optimized material model with temperature yield curves and subsequent inverse parameter optimization
- Based on this we expect further improvement in the simulation quality and we will hopefully be able to clarify if the different strain rate dependencies for tensile and shear load in case of DC06 can be fully explained by adiabatic heating effects or if this is a "true" dependency on the stress state.

Thank You

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