Prediction of Failure in the Hemming Process of Aluminium Sheet Metal Alloy

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LS-DYNA User Forum

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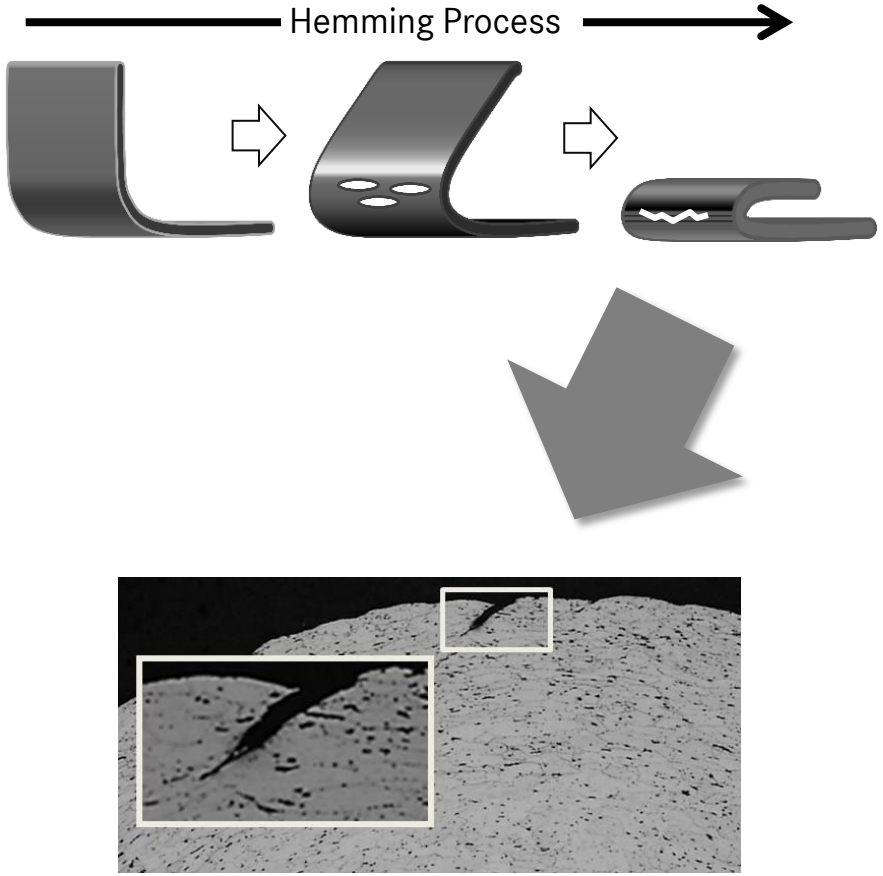
Agenda

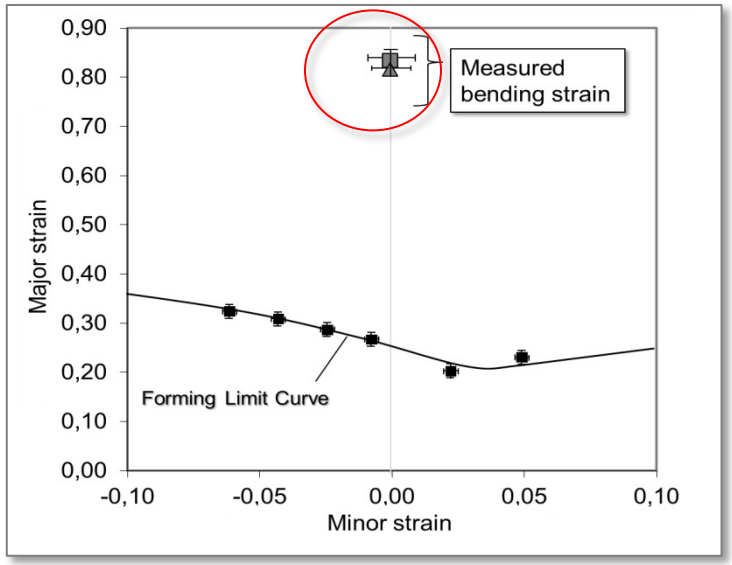
1. Motivation
2. Investigation of Bending Process
3. Investigation of Hemming Process
4. Summary

Why is Failure Prediction needed ?

Failure in the bending area

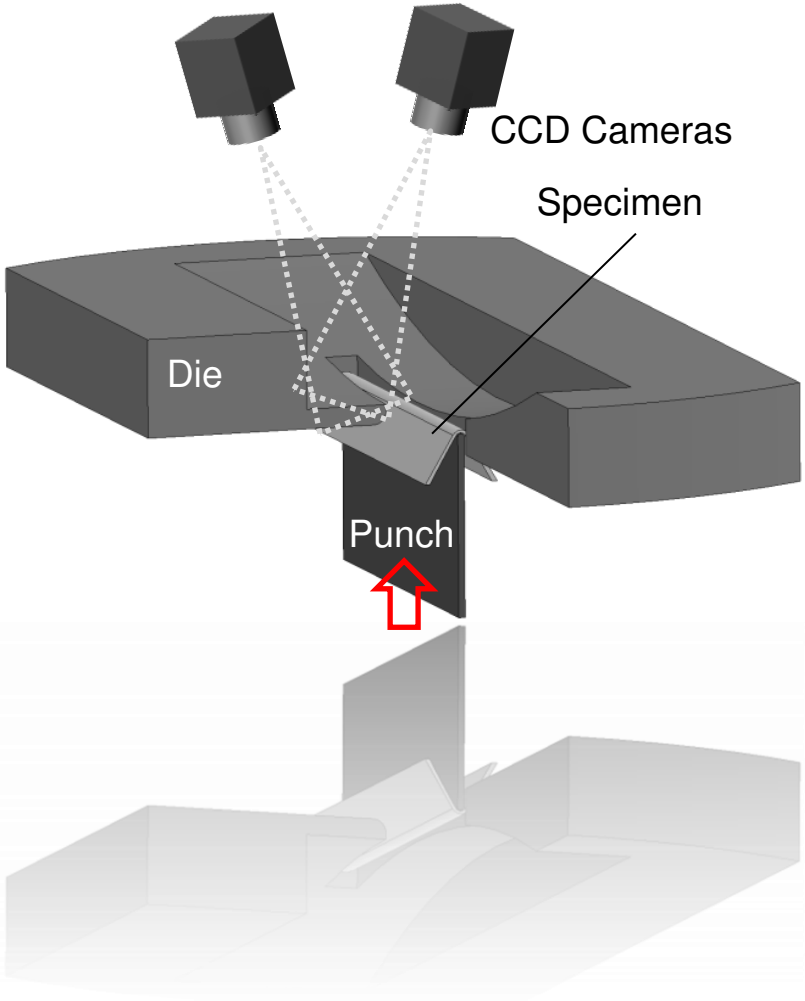


Failure Criterion



No reasonable criterion to identify failure in bending areas available.

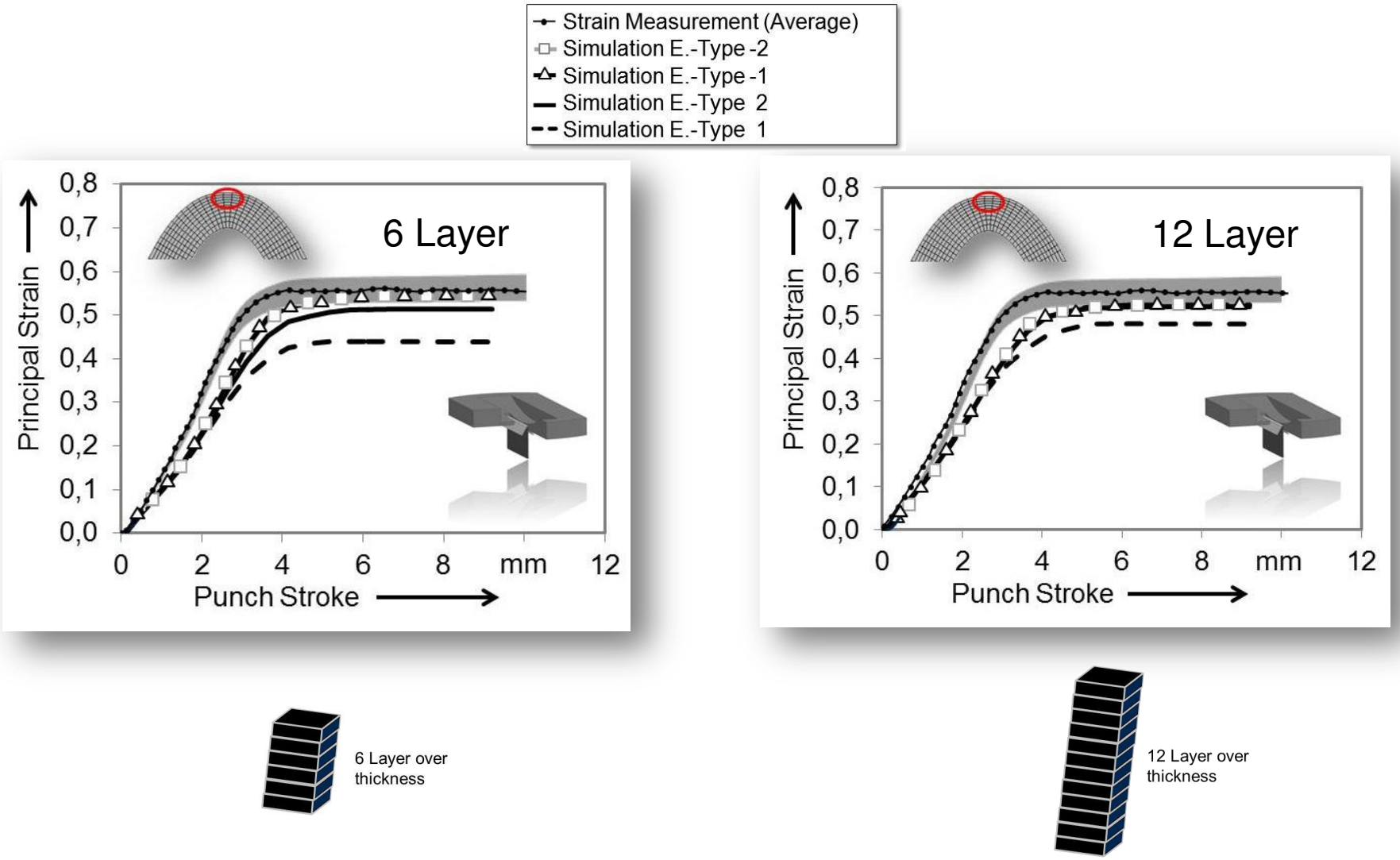
Simulation of 3-Point-Bending-Device



- **Material**
  - 6000 Series Aluminium Alloy
  - **Thickness:** 1,0 mm
  - **Material Model:** Barlat 91
    (***MAT_BARLAT_ANISOTROPIC_PLASTICITY** | **MAT_033**)
- **Simulation Model**
  - **Element:** Solid (Typ -1 / -2 / 1 / 2)
  - **Mesh Size:** 0,4 – 0,16 mm width
  - **Damage Model:** GISSMO
- **Verification**
  - Optical Strain Measurement GOM Aramis
  - Punch Force

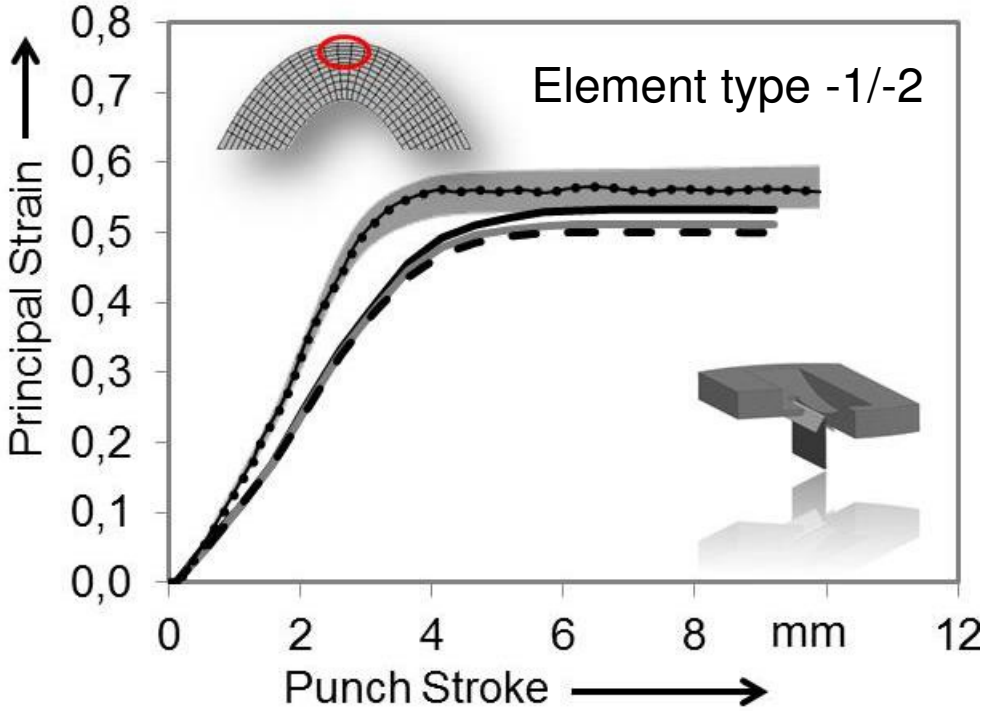
Simulation of 3-Point-Bending-Device

→ Verification of bending strain evolution with focus on **element type**

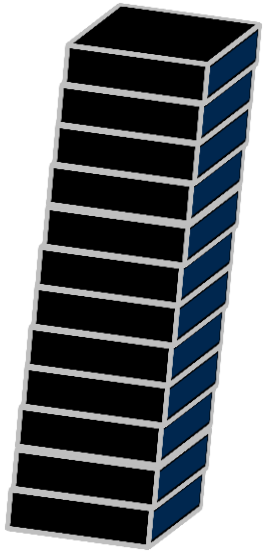


Simulation of 3-Point-Bending-Device

→ Verification of bending strain evolution with focus on **mesh size**

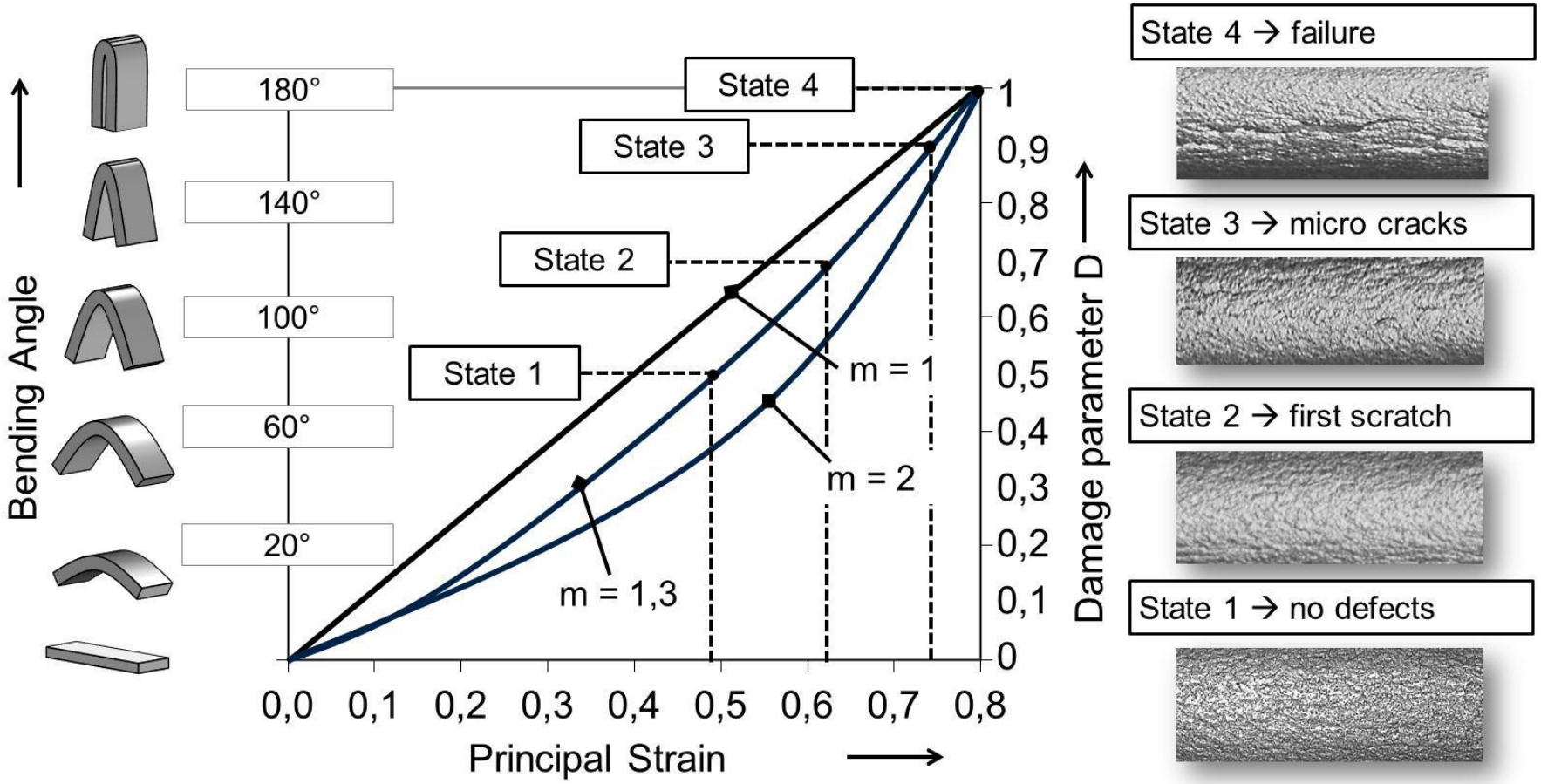


- Strain Measurement (Average)
- Sim. Element width = 0,04 mm
- Sim. Element width = 0,08 mm
- Sim. Element width = 0,16 mm



12 Layer over thickness

Identification of Failure States during Bending



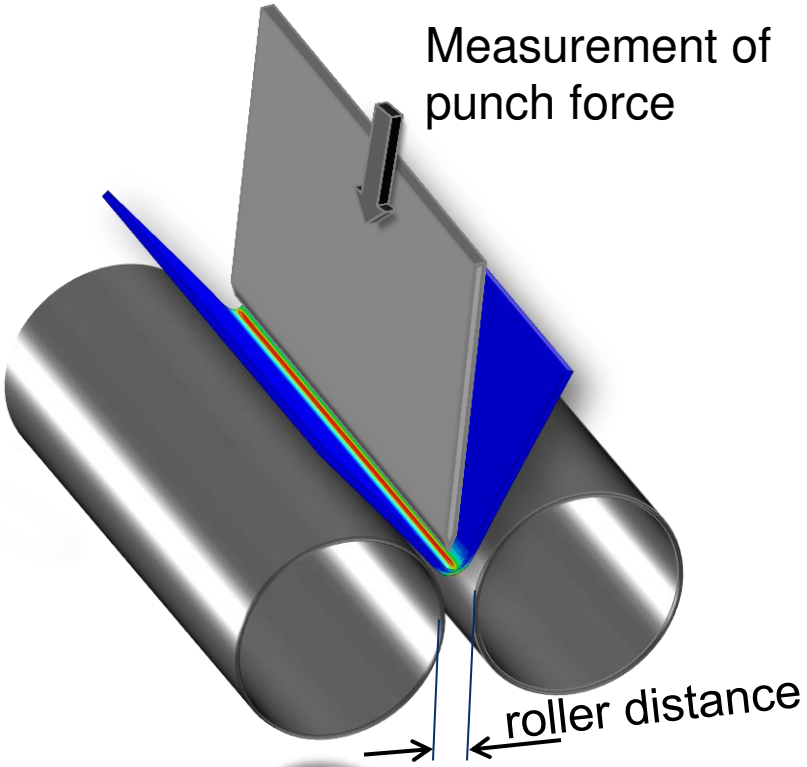
→ Calibration of damage model GISSMO

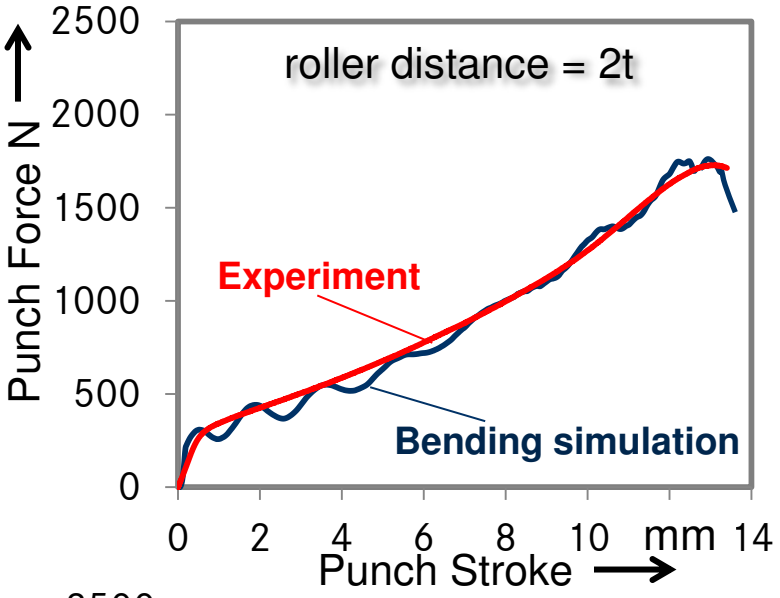
$$\Delta D = \frac{m}{\varepsilon_f} D^{(1-\frac{1}{m})\Delta\varepsilon_p}$$

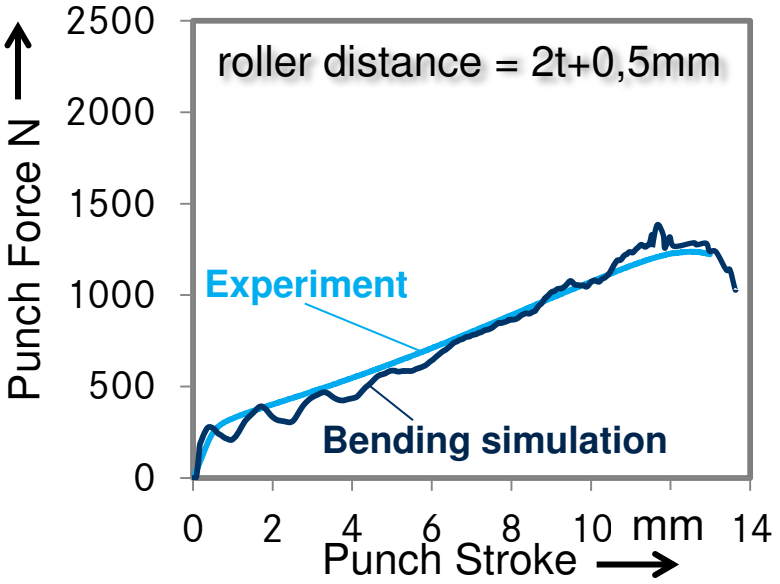
Verification of Failure Behaviour

→ Bending simulation with GISSMO (m = 1,3)

DIN EN ISO 7438:2012-03

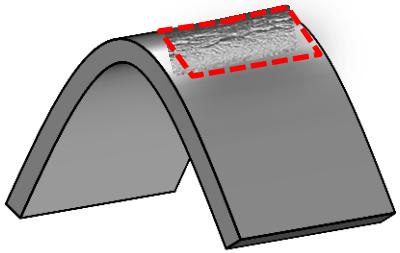




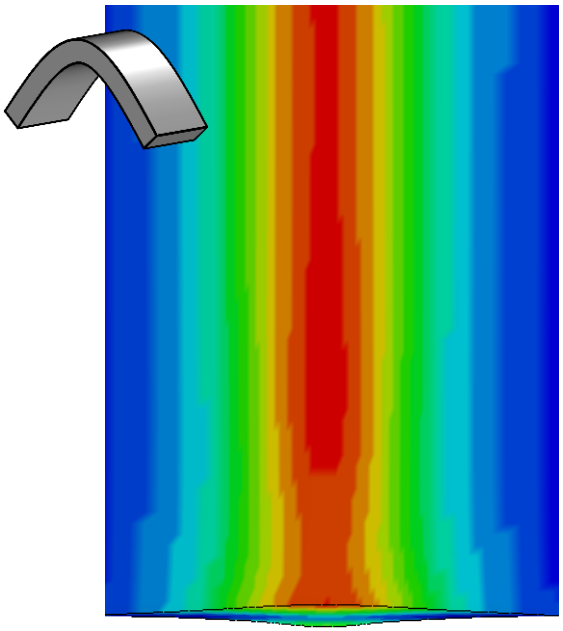


Verification of Failure Behaviour

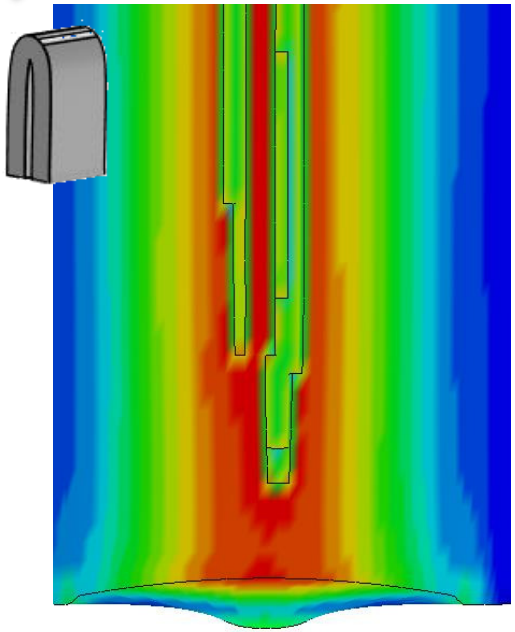
→ Bending simulation with damage model

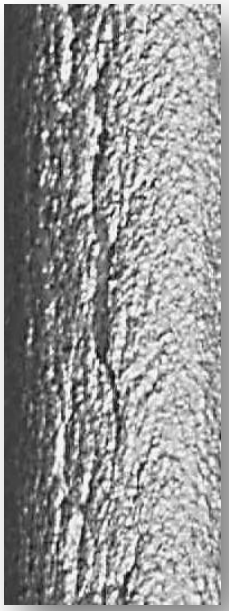


Pre-stage of bending process → no damage



Erosion of elements caused by the damage model



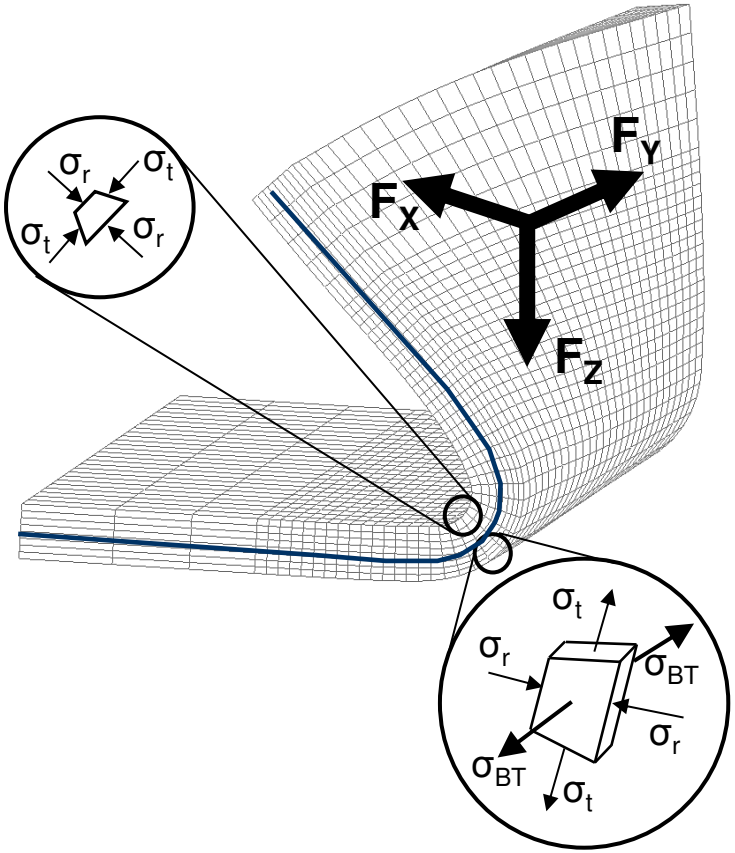


→ Good correlation between real surface defect and calculated damage value

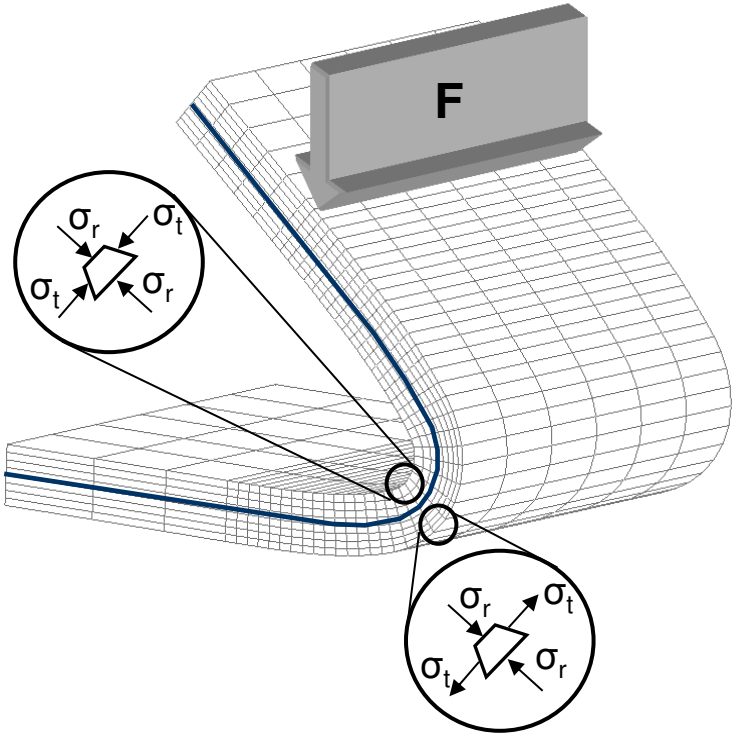
Use of the Failure Criterion based on 3P-Bending for Hemming

→ Stress state during roller hemming and tabletop hemming

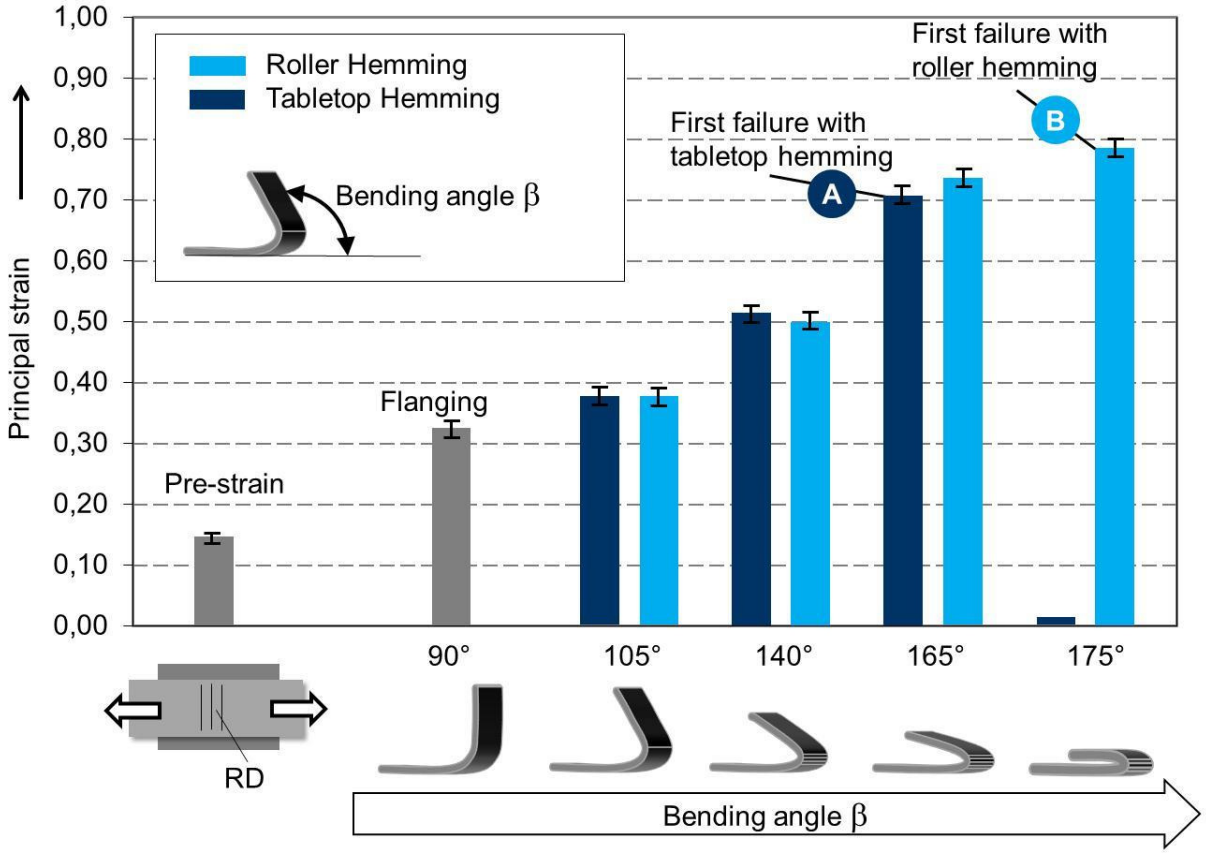
Roller Hemming



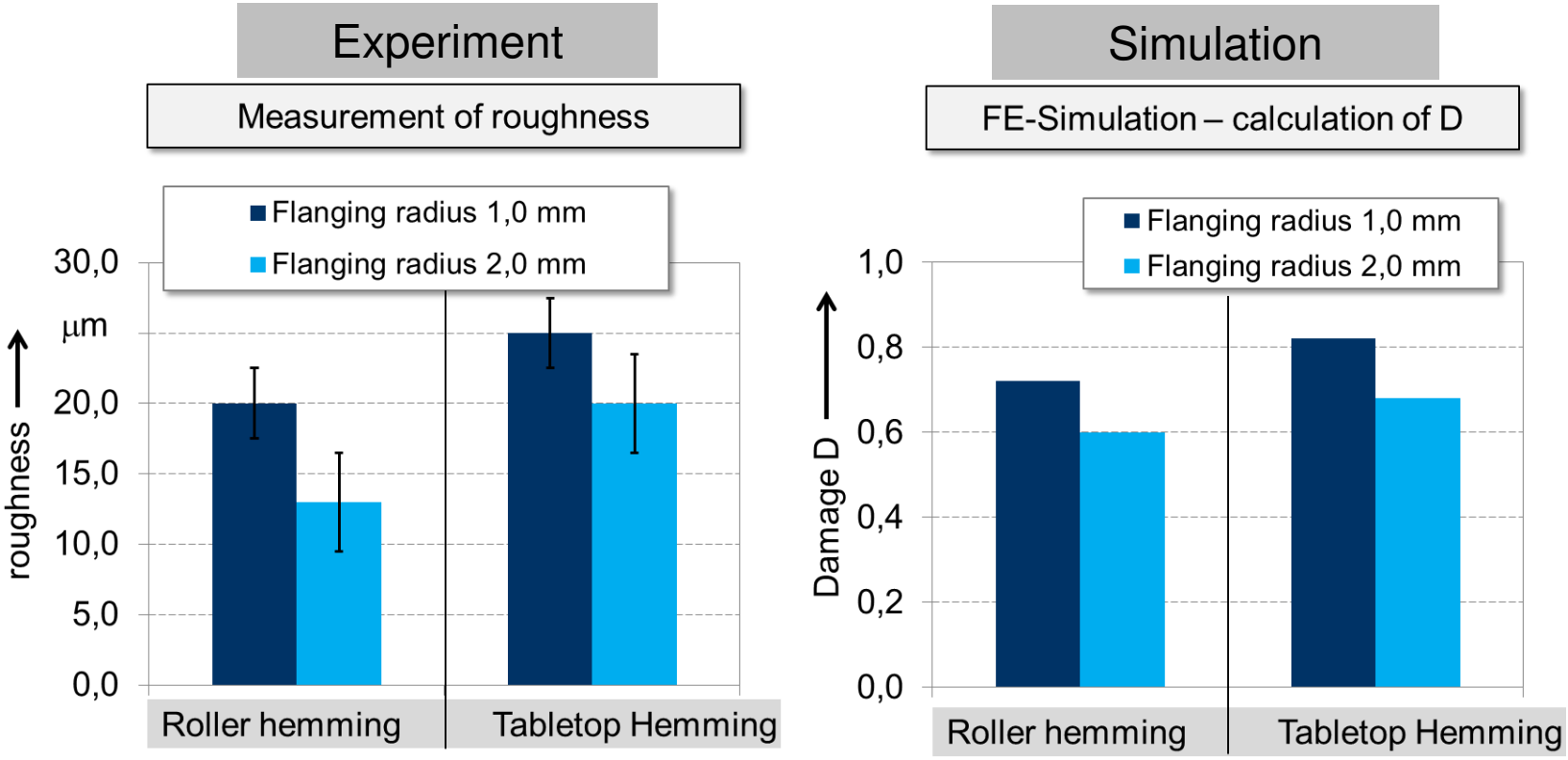
Tabletop Hemming



Investigation of the Failure Behaviour at Roller Hemming and Tabletop Hemming



Comparison of Damage Accumulation between Hemming Experiment and Simulation



→ Difference of damage accumulation between roller hemming and tabletop hemming is producible.

→ Good correlation between measured roughness and calculated damage value.

Summary

- Applicability of FE-Simulation with solid elements was investigated.
- Element types -1/-2 lead to good correlation between simulation and optical strain measurement.
- The use of GISSMO to calculate damage in bending is possible.
- A transfer of the modelling concept based on bending to the hemming process is possible.
- The difference of stress states between roller hemming and tabletop hemming was indicated by simulation with solid elements.
- A specific failure criterion for hemming was developed and showed good correlation to the measurement.