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Coining of micro Structures with an electromagnetically driven Tool

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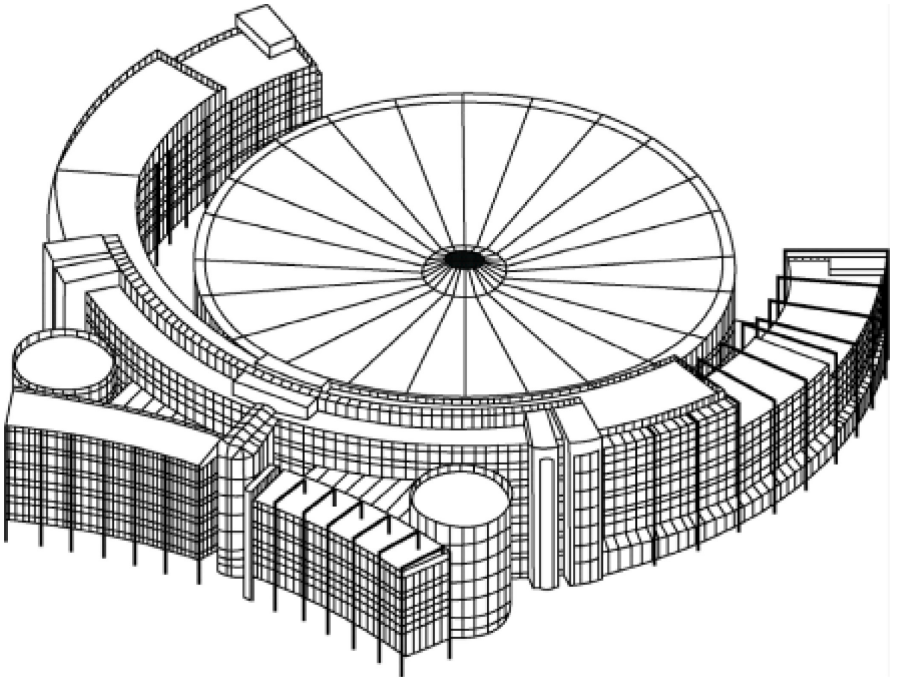


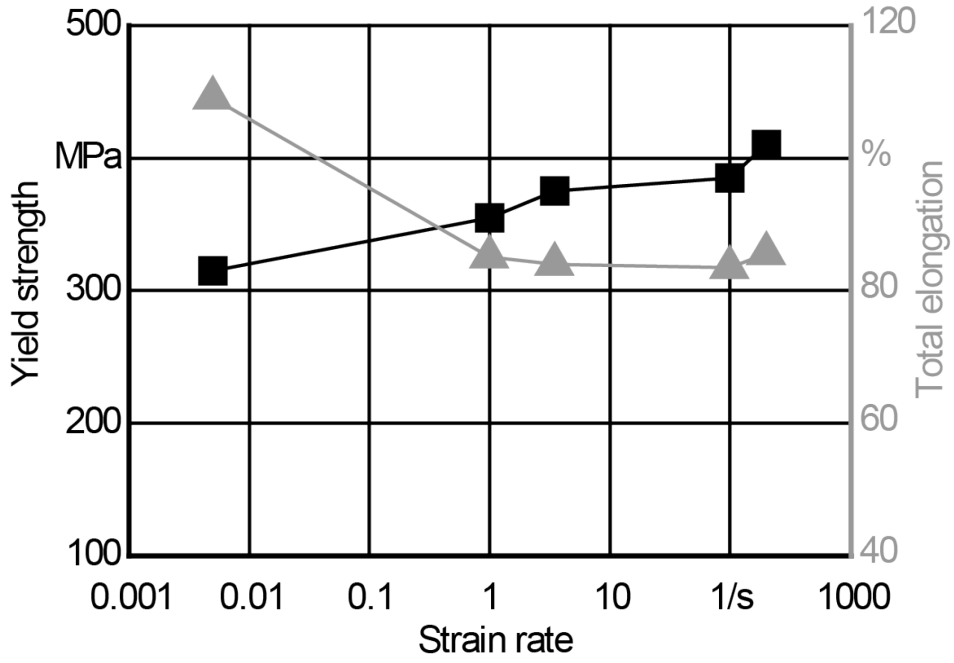
Content

- Introduction
- Experimental Setup
- Test Stand
- Experimental Results
- Conclusion
- Outlook

Introduction

Motivation

- Improvement of coining micro structures into high strength steels
- Investigation of energy needed at elevated tool velocities
- Forming behavior depends on forming velocity
  - Quasi-adiabatic forming
  - Change of ductility
  - Rise of yield strength
  - Change of friction characteristics at high tool speeds
- Investigations through coining strut structures into steel 1.4301 (AISI 304)



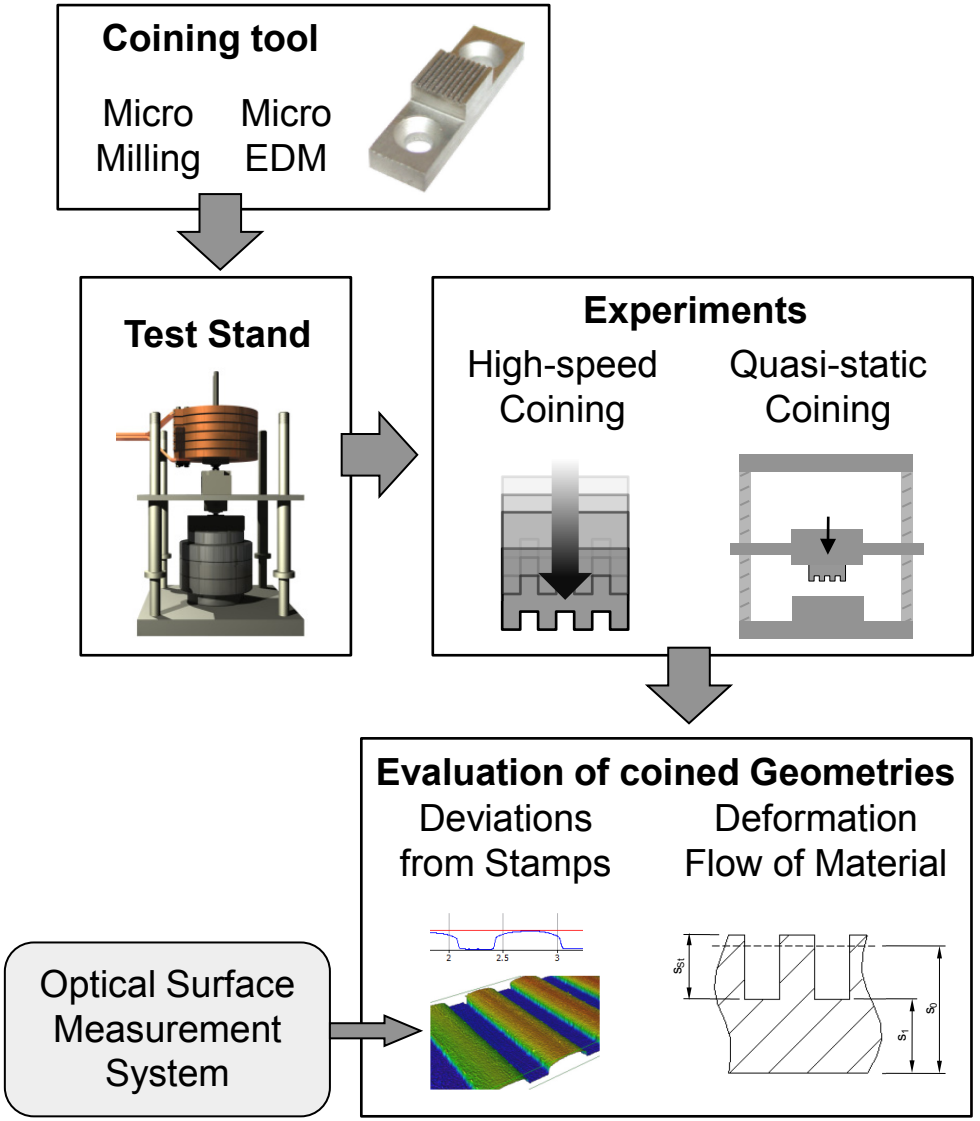
Strain-rate Sensitivity for high-grade Steel 1.4301 (AISI 304)

Picture: W. Bleck, I. Schael: “Determination of crash-relevant material parameters by dynamic tensile tests”, *Steel Research*, 2000, volume 71

Experimental Setup

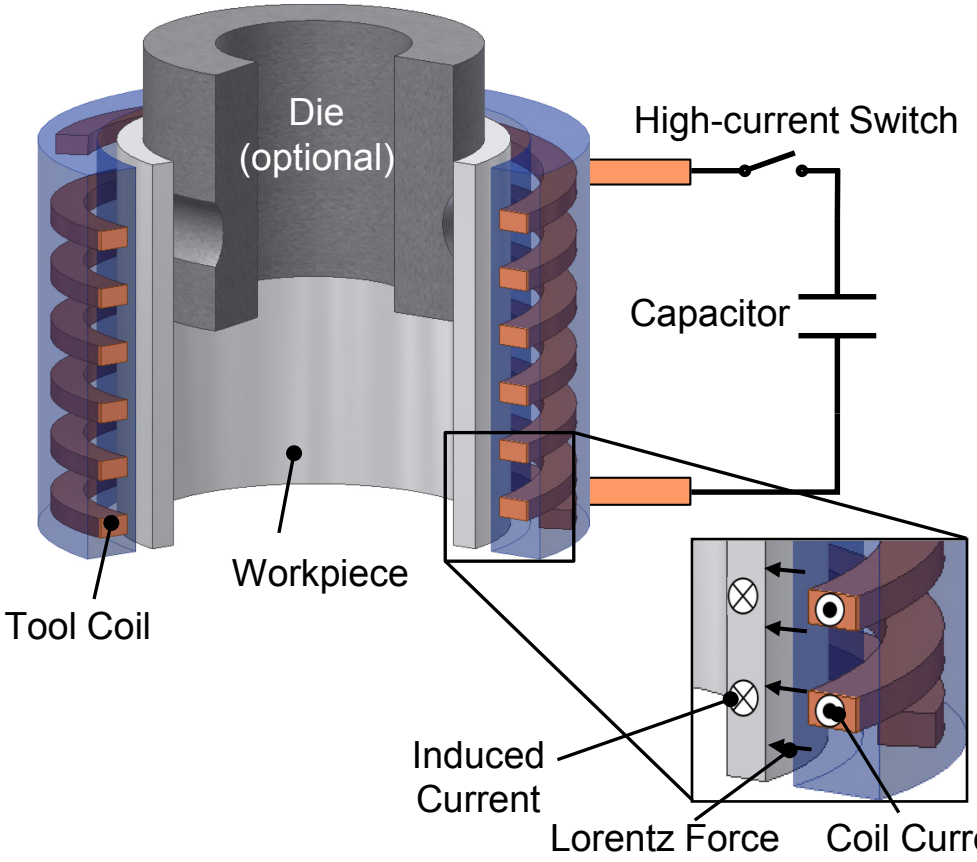
Approach

- Development of test stand for acceleration of coining tools
- Coining of high-grade steel at high velocities
- Coining at quasi-static tool velocity
- Evaluation of coined geometries
  - Evaluation of geometrical criteria
  - Evaluation of deformation and material flow

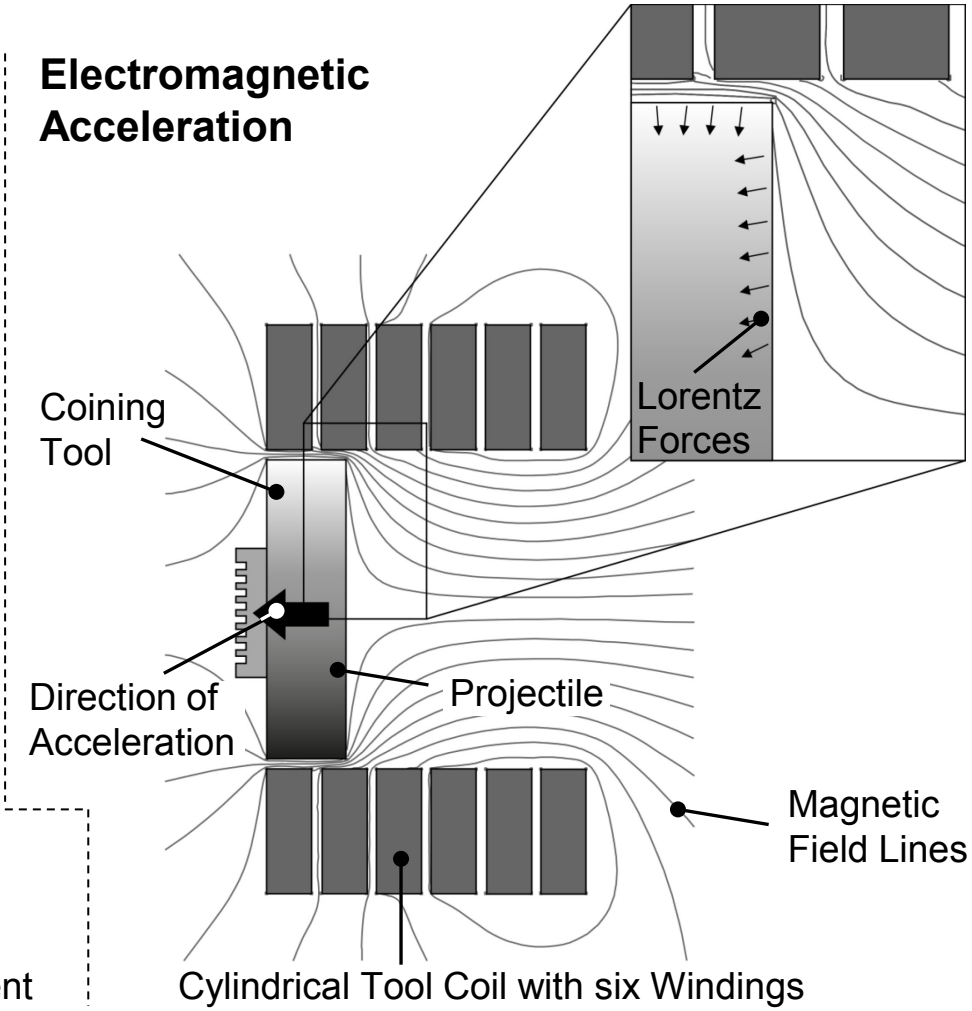


Experimental Setup

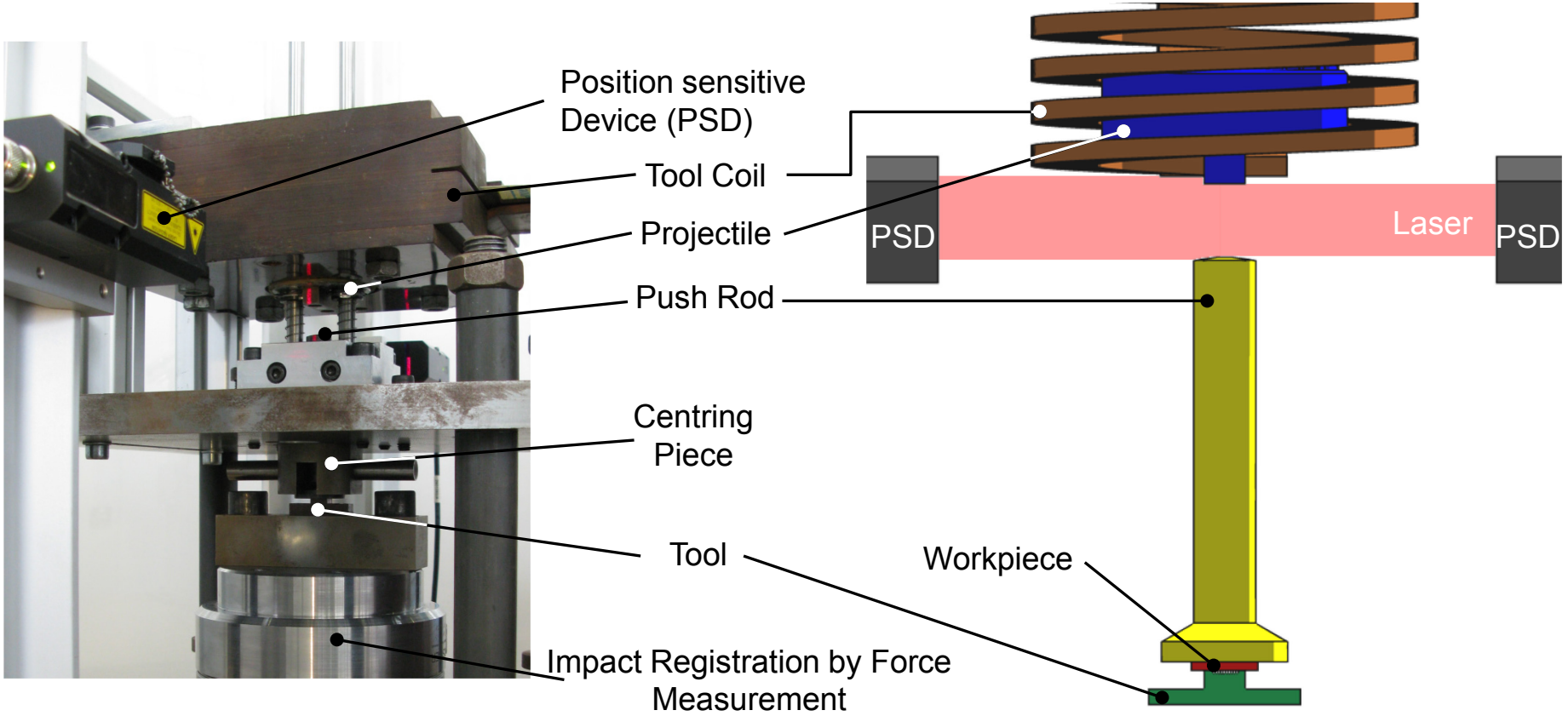
Electromagnetic Forming



Electromagnetic Acceleration

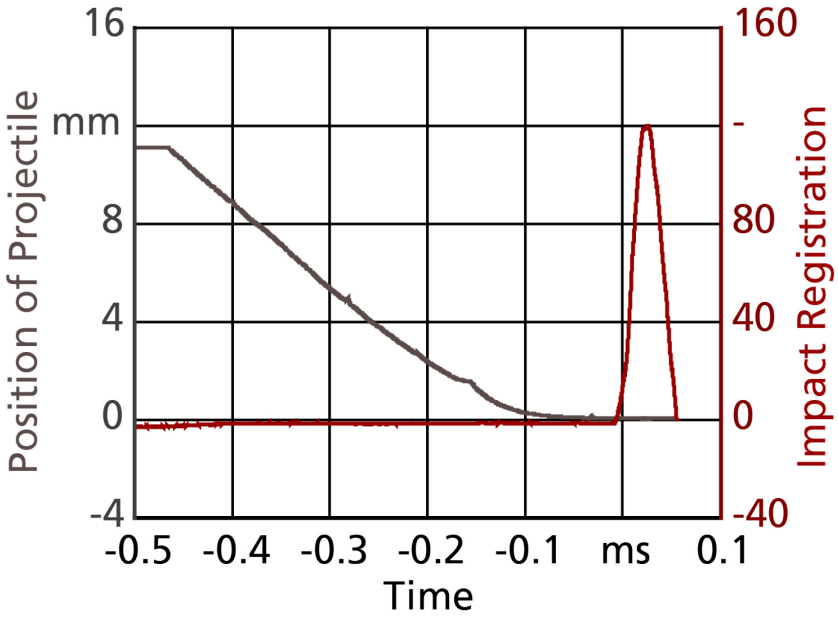


Test Stand


Position sensitive Device (PSD)
Tool Coil
Projectile
Push Rod
Centring Piece
Tool
Impact Registration by Force Measurement
PSD
Laser
PSD
Workpiece

Test Stand

- Velocities of up to v_P = 35 m/s, limitations due to stiffness
- Velocity measurement with laser shading
- Triggered by impact registration
- Variation of charging energy and therefore velocity of projectile
- Duration of impulse of about 60 µs



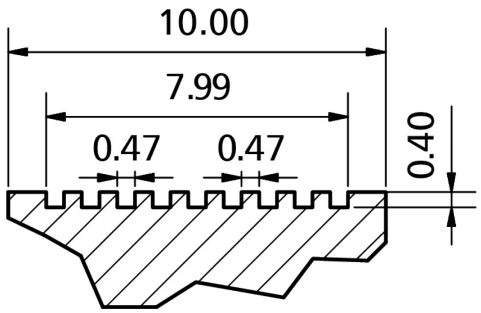
Velocity of Projectile
v_P = 29.7 m/s

Structure 2

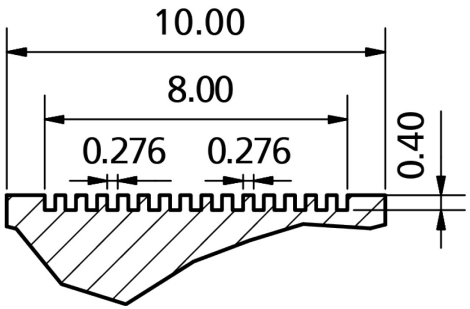
Test Stand

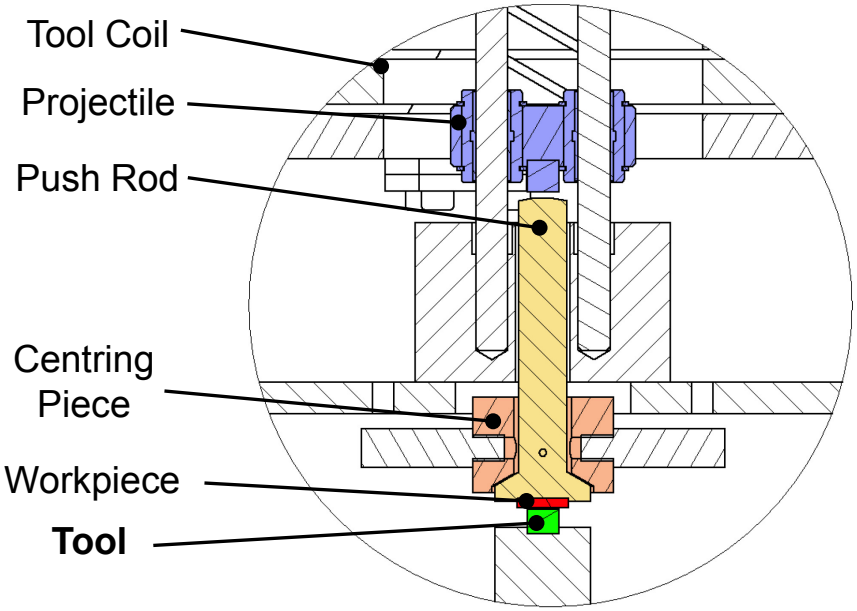
- Investigated structures

Structure 1, aspect ratio 0.85



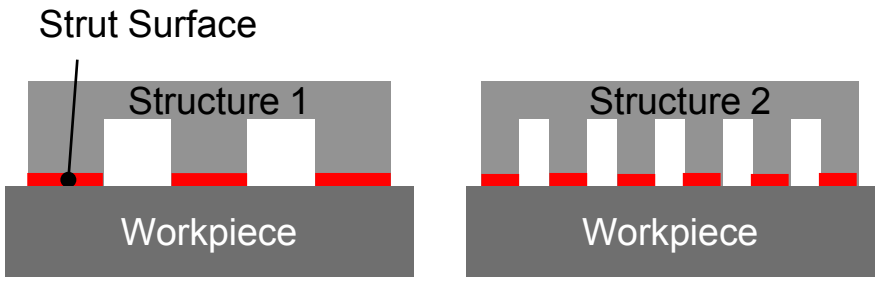
Structure 2, aspect ratio 1.45

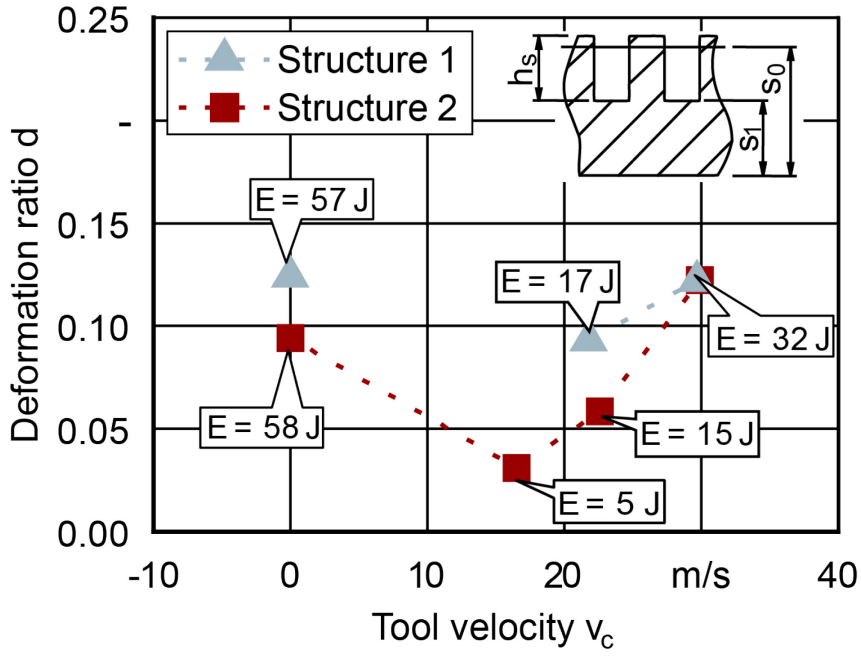




Experimental Results

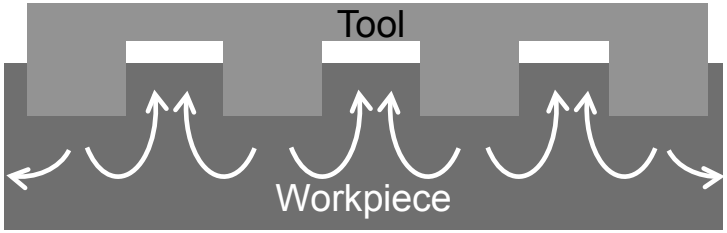
- Deformation ratio d = ln (s_1/s_0) of structure 1 higher due to lower friction at lower tool velocities
- Significant rise of deformation at tool velocity of v_c = 30 m/s

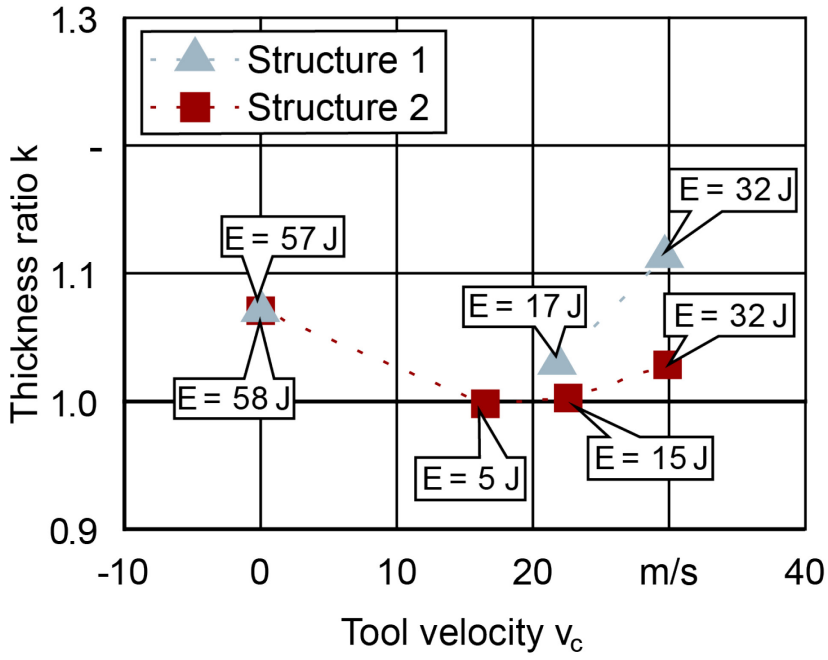




Experimental Results

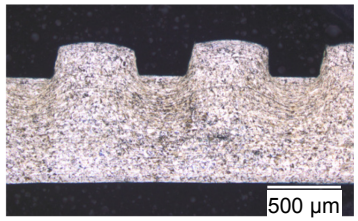
- Thickness ratio k is
  sheet thickness before coining /
  sheet thickness after coining
- Flow of material mainly into struts
- Thickness increases
  with rising tool velocity



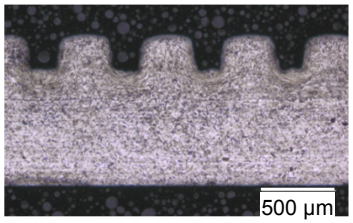


Experimental Results

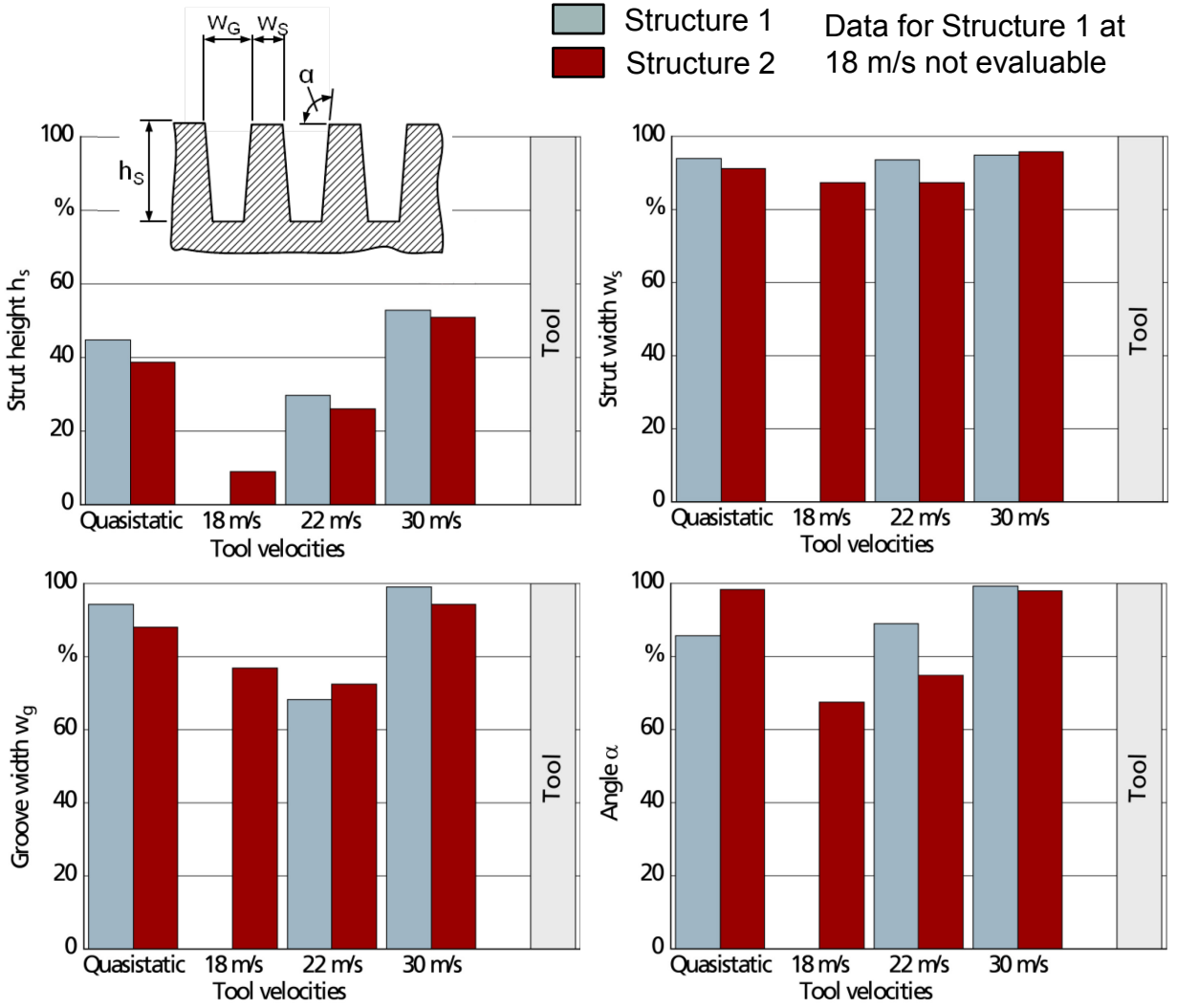
- Increasing strut height with rising tool velocity
- Higher deviation with structure 2 due to friction
- Elastic deformation
  - Struts are always wider than grooves of tools
  - Grooves are always more narrow than struts of tools



Structure 1 with 30 m/s



Structure 2 with 30 m/s

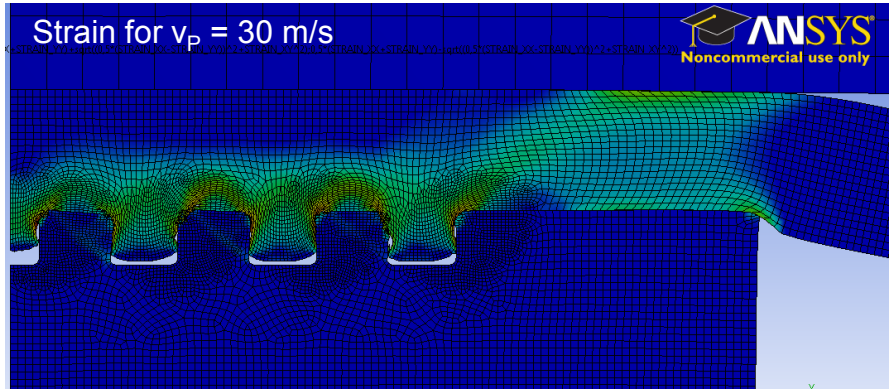


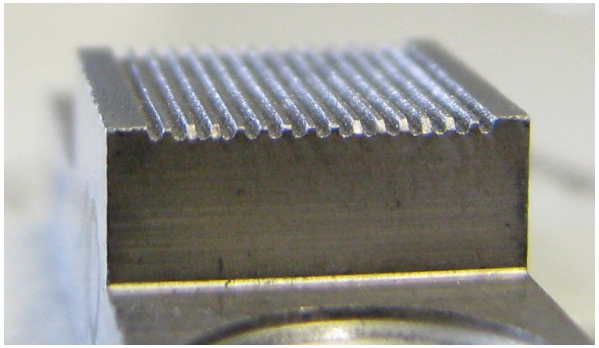
Conclusion

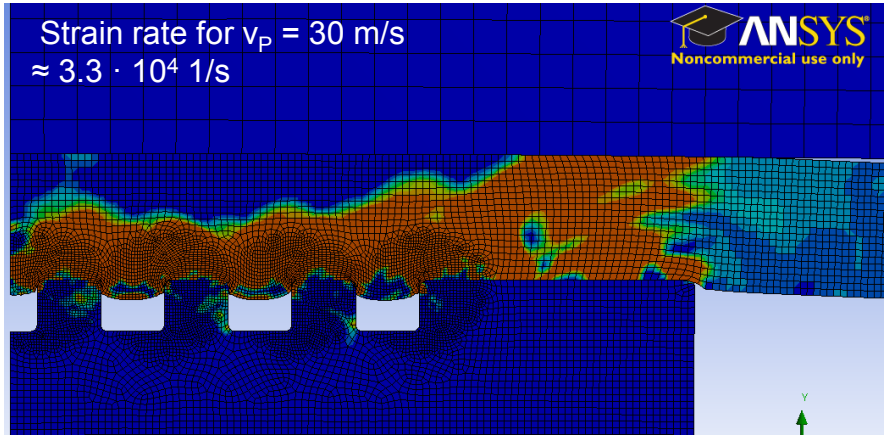
- Quality of coinings at high impacts could be increased compared to quasi-static coining
- Difference in deformation of structure 1 and structure 2 eases at higher tool velocities
- Flow of material into the struts is stronger at high energy input
  and stronger with structure 1
- Energy needed for same deformation is less for high impact forming

Outlook

- Simulation of the forming process to show
  - Stress dependence on tool geometry
  - Material flow dependence on tool velocity, strain and tool geometry
- Investigations at higher tool velocities
- Tool wear dependent on tool velocity
- Coining of workpiece material of higher strength







Thank you very much for your attention!

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