Development of a High Speed Nakajima Testing Device

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Subjects

- Motivation
- Experiments
- Results
- Summary and Outlook

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Motivation

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Motivation

Enhancement of Process Limits → Combination of Quasistatic & High Speed Forming

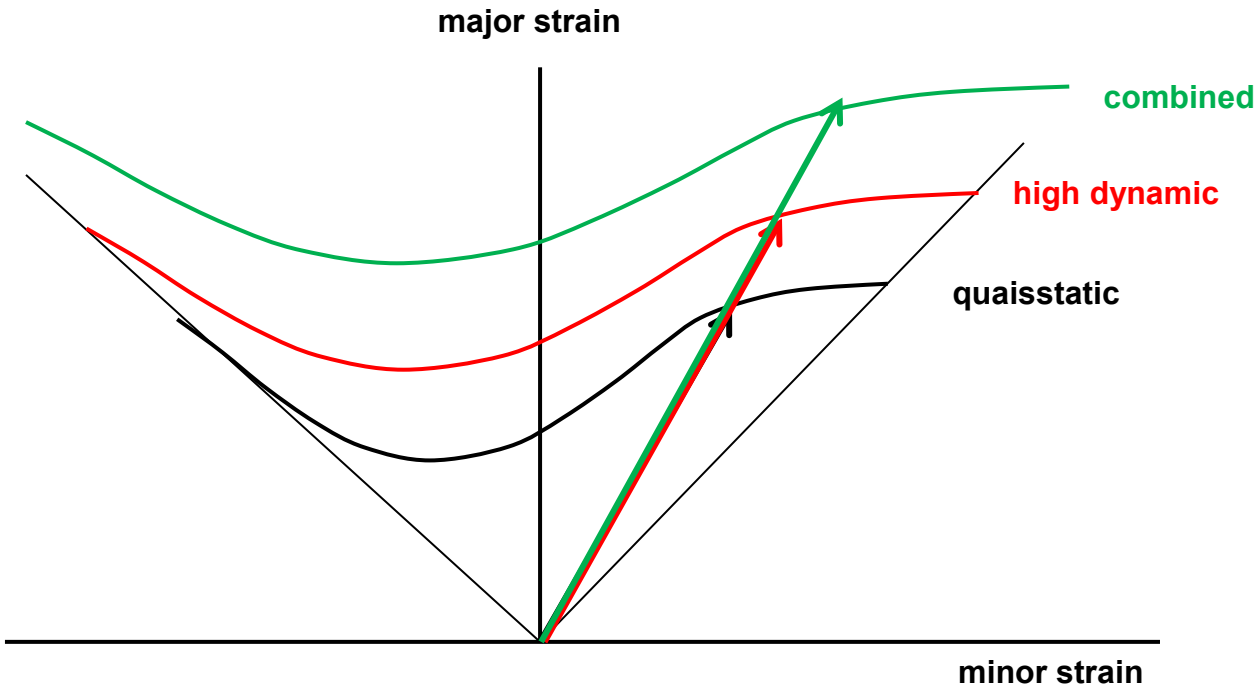
Prosesses

- Deep Drawing Process
- Electromagnetic Pulse Forming

Characterisation

- Forming Limit Diagram (FLD)
- Nakajima Test

→ Development of a High Speed Nakajima Testing Device



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Experiments

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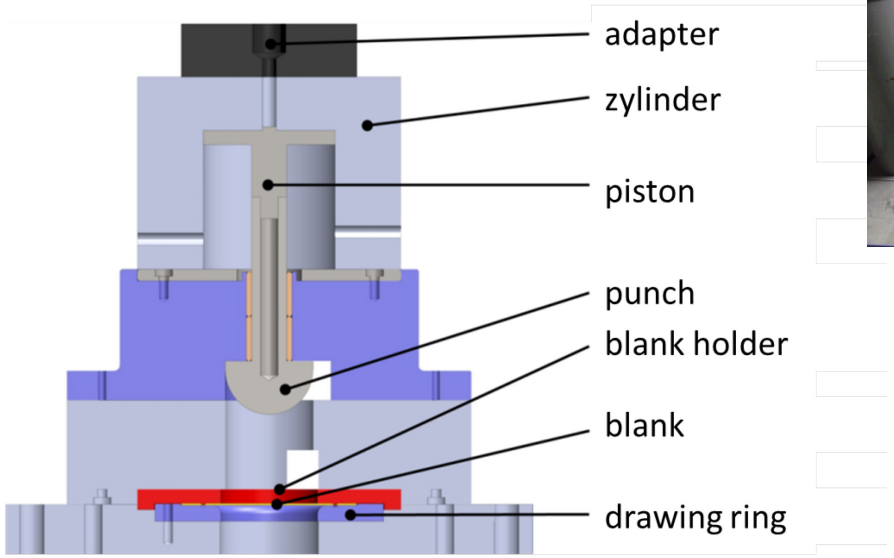
Testing Device

Characteristcs

- Pneumatic testing device
- Working pressure up to 300 bar
- Punch velocity max. 30 m/s
- Nakajima test according to DIN EN 12004

Nakajima test

- Tool of 50 mm diameter
- Blanks of 100 mm diameter
- 6 diffrent Geometries
- Lubication: oil + teflon foil



Testing Device, diagramm

Testing Device

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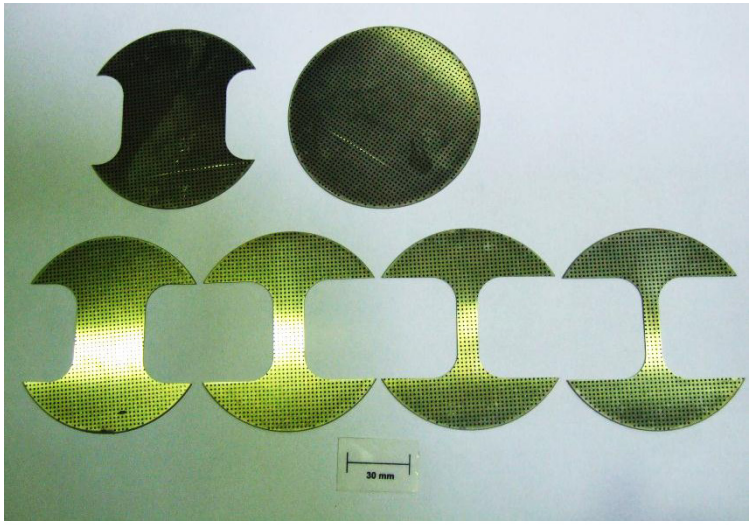
Experimental Setup

Specimens

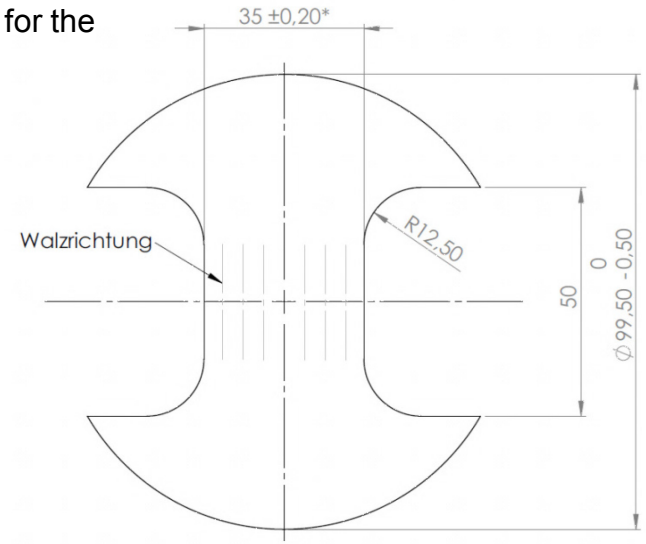
- according to DIN EN 12004
- EN AW 5083
- 7,5 mm; 10mm; 15 mm; 35 mm and 55 mm width or full diameter
- Thickness 1 mm

Evaluation

- GOM/ Argus- system



Specimens used for the Nakajima Test



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Experimental Setup

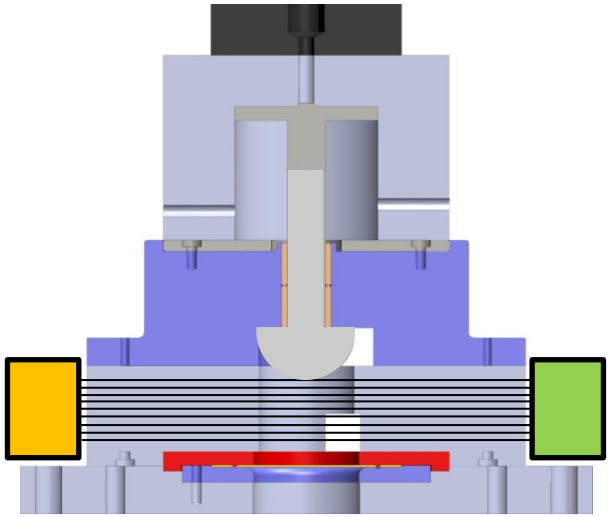
Optical sensors

- Typ mircoepsilon optoCONTROLL 1200
- 20 x 3 mm
- Resolution: 10 mm bzw. 100 kHz

Evaluation

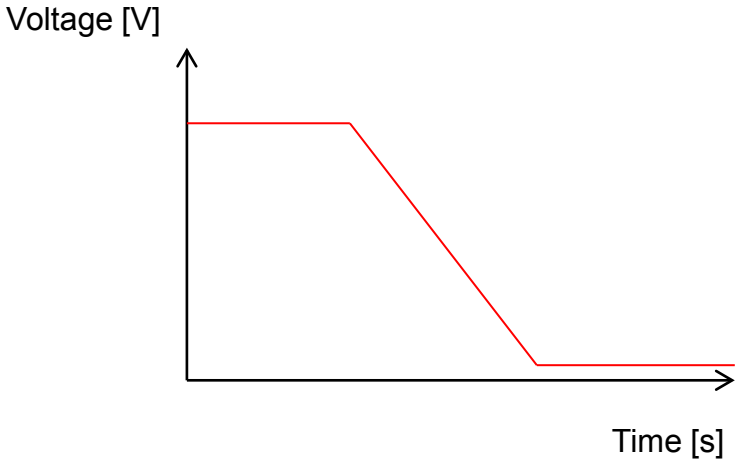
- Impact velocity
- Springback velocity
- Impact energy
- Springback energy

→ energy absorption of the blank



Sensor-position, diagramm

Sensor-position



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Results

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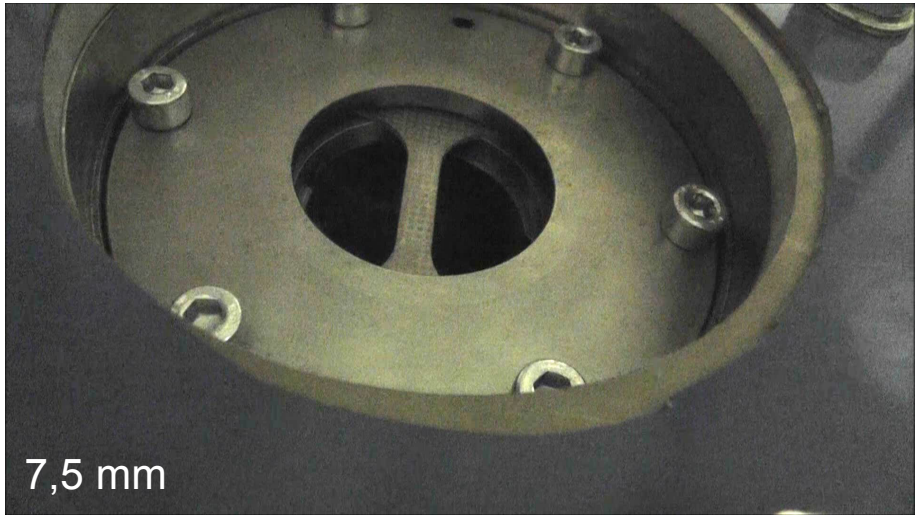
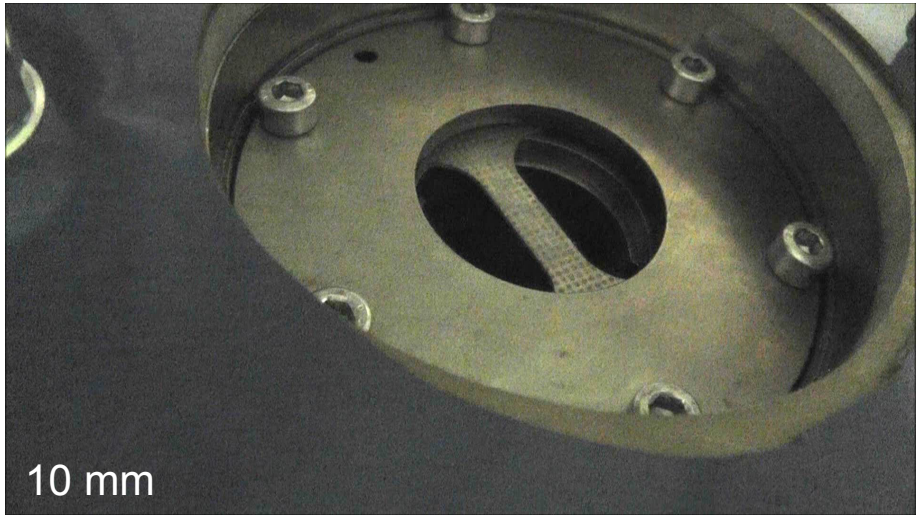
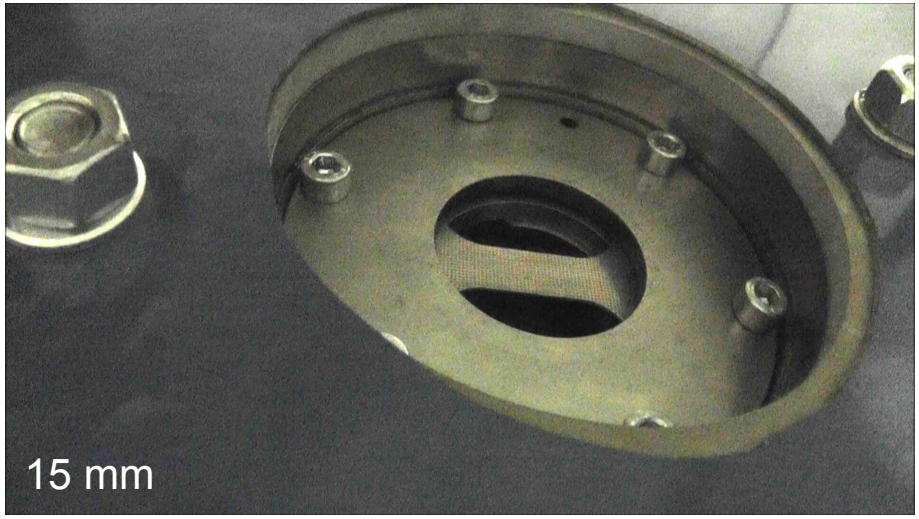
Function test

Videos of a Nakajima Text







Experimental parameters

Specimen width

- 7,5, 10 and 15 mm

Air Pressure

- 100bar

Punch speed ≈ 21 m/s

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Sepecimens after fracture

Fracture position

Width > 35 mm

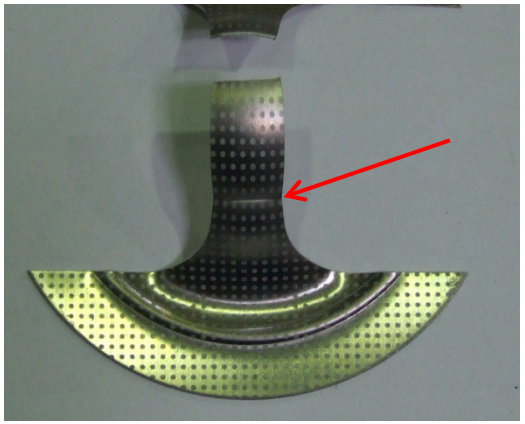
- Fracture in the center of the specimens

Width < 35 mm

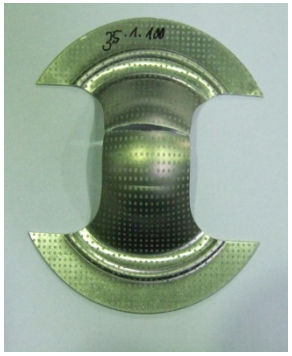
- Excentric fracture
- 2. fracture occurs

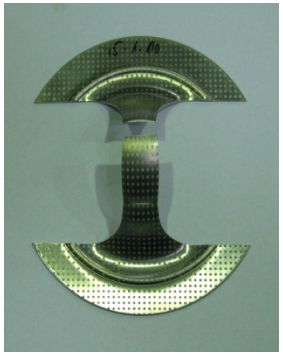
Full diameter

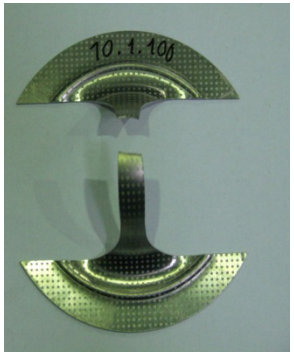
- High number of not fractures specimens



Position of the 2. fracture







EN AW 5083, 100 bar air pressure, 21 m/s punch speed

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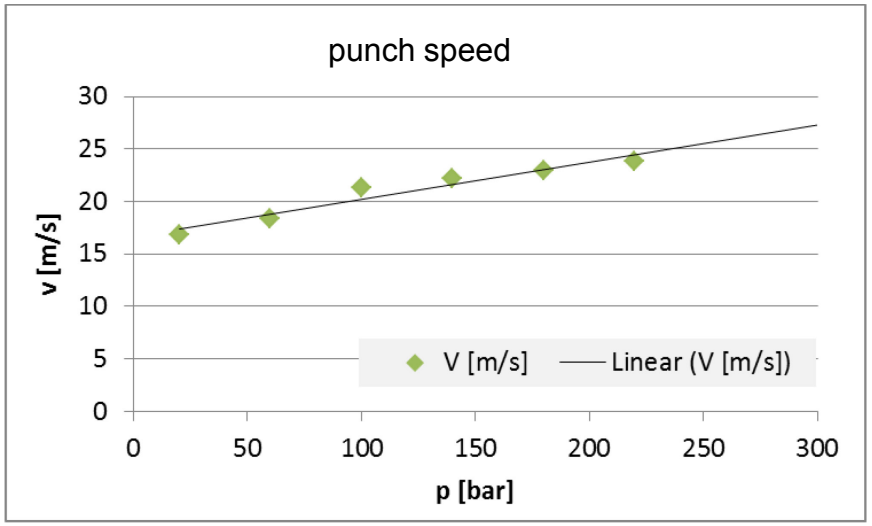
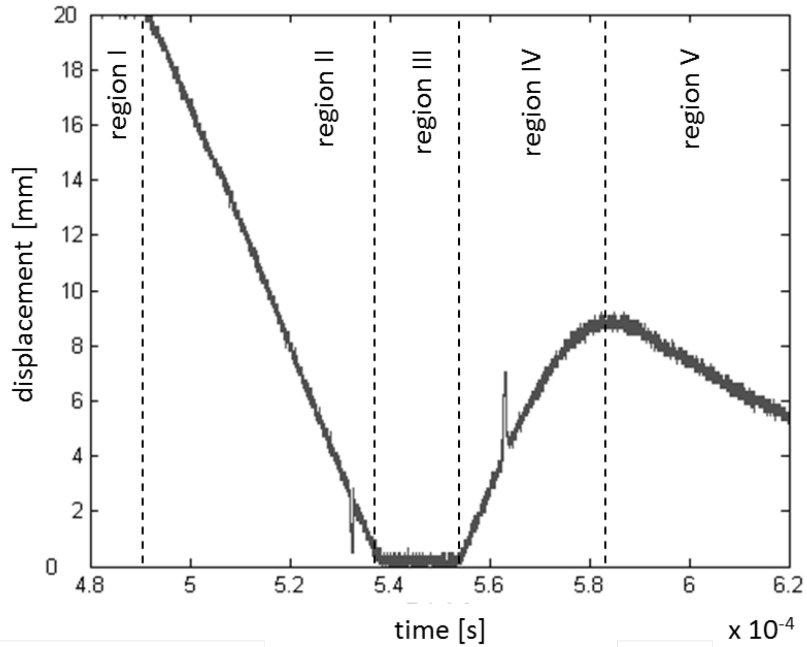
Punch speed

Speed and air pressure

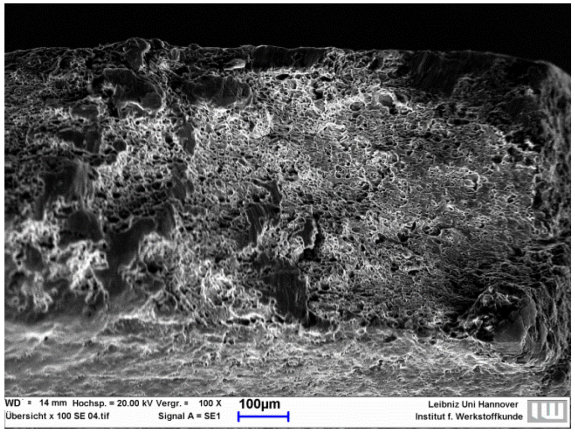
- Linear correlation of speed and pressure
- 17 m/s … 25 m/s
- Springback depends on specimen geometrie

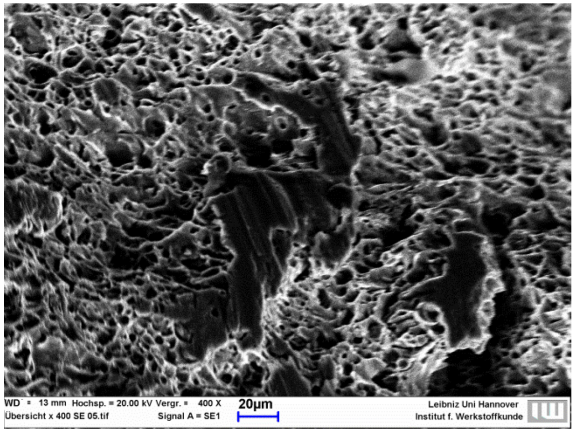


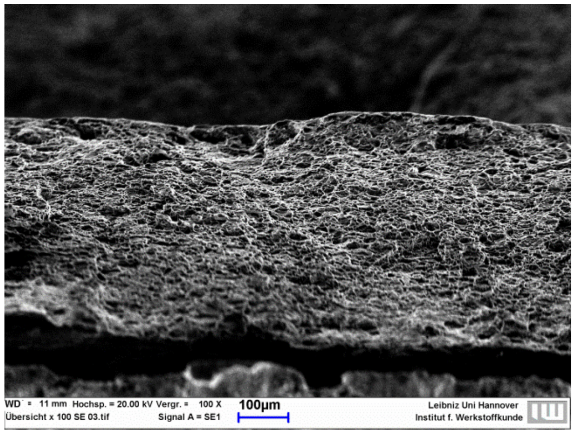


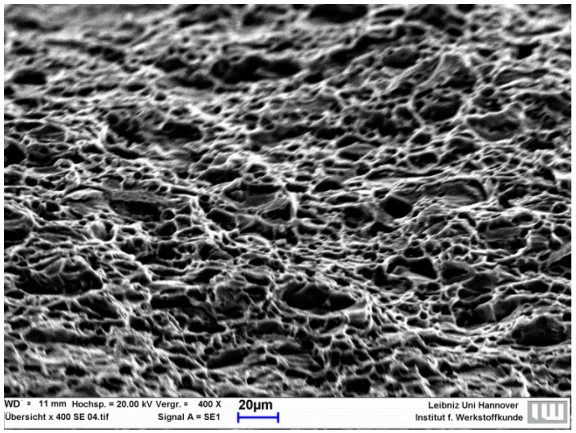
Fracture Characteristics

HS, 10 m/s, 35 mm width, EN AW 6082









QS, 0,001 m/s, 35 mm width, EN AW 6082

Fracture Surface

- Ductile fracture
- No clear influence of speed/ strain rate
- Deformation due to surface contact

Forming limit curves

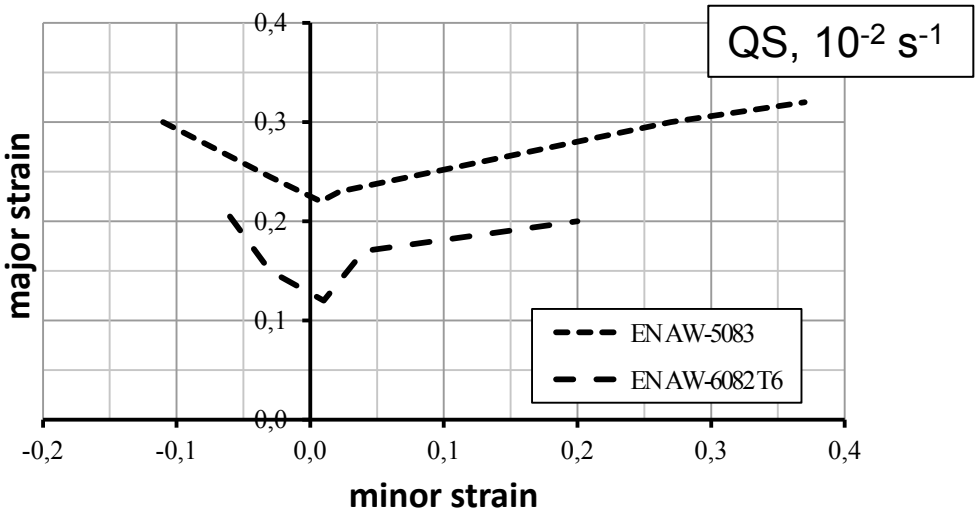
Punch speeds: 1 mm/s and 10 m/s

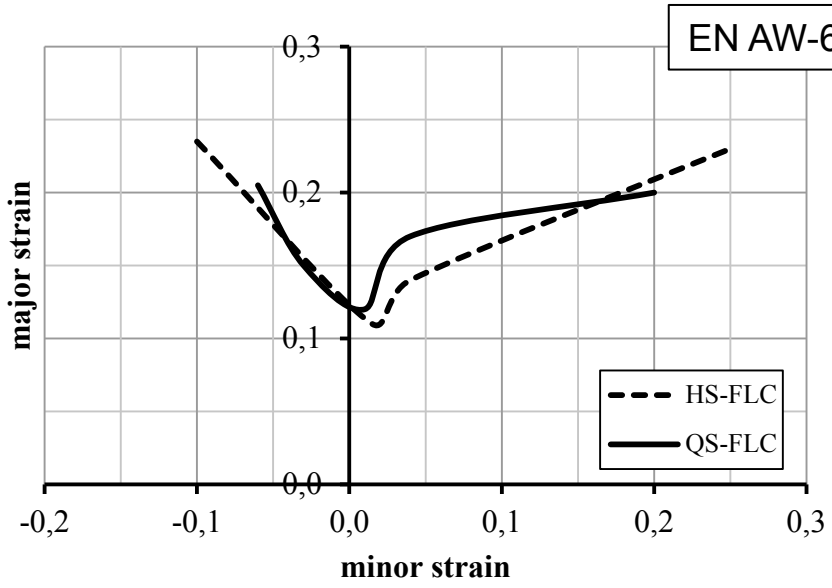
Approximate strain rates: 10^{-2} s^{-1} and 10^{2} s^{-1}

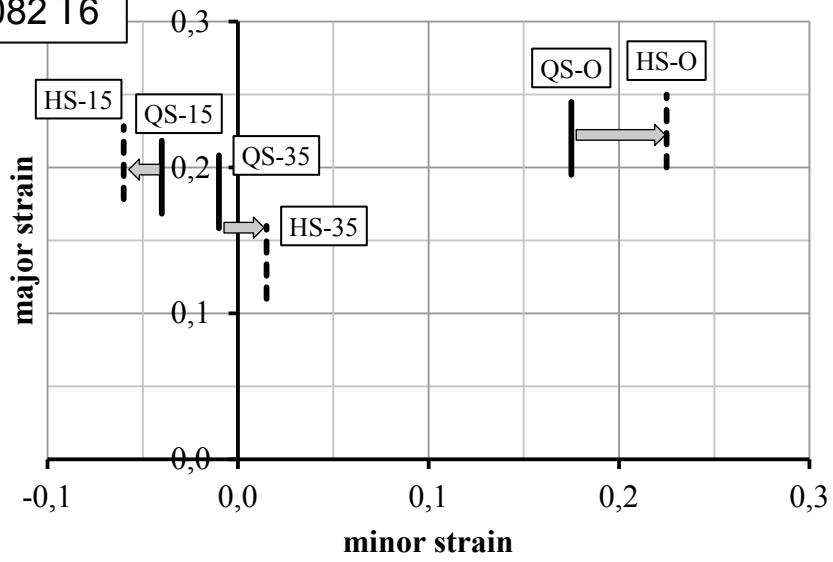
Strain rate change results in

- Drop of forming limit curve
- Shift to lower right side of FLD

Strain rate at 10 m/s is too low to increase deformability







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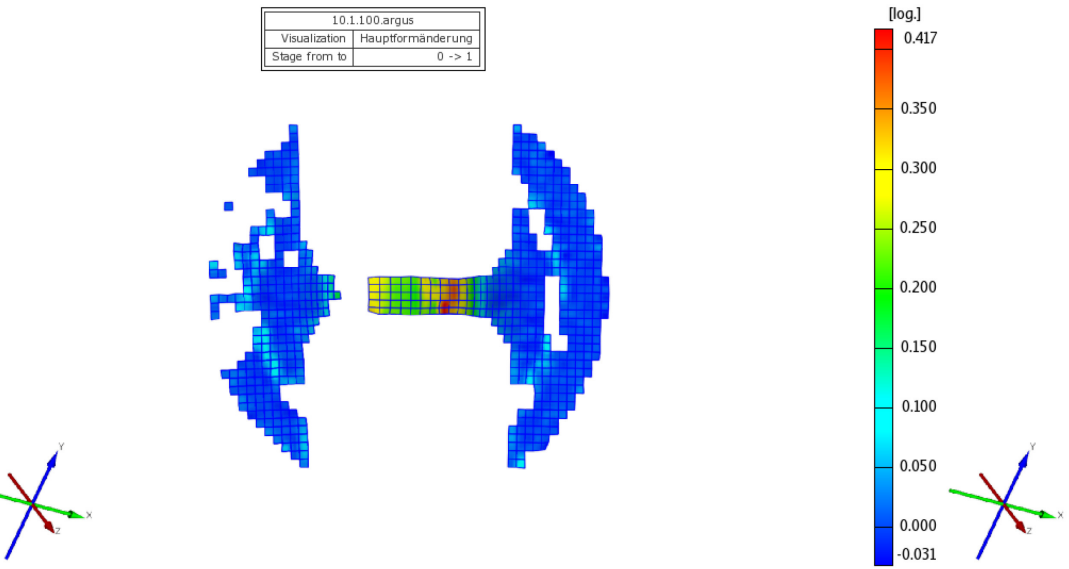
Forming limit curves

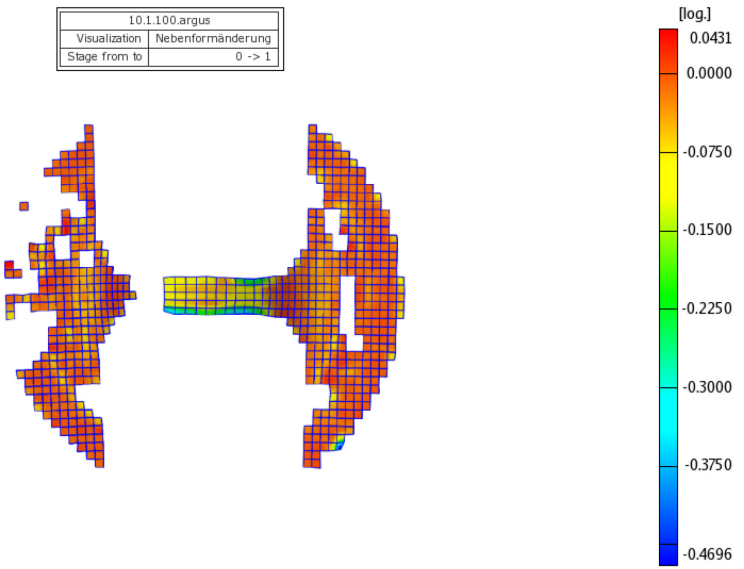
Punch speed: 21 m/s at 100 bar

Approximate strain rates: 10^2 s^{-1}

Strain maxima near 2. fracture



major strain, width = 10 mm



minor strain, width = 10 mm

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Forming limit curves

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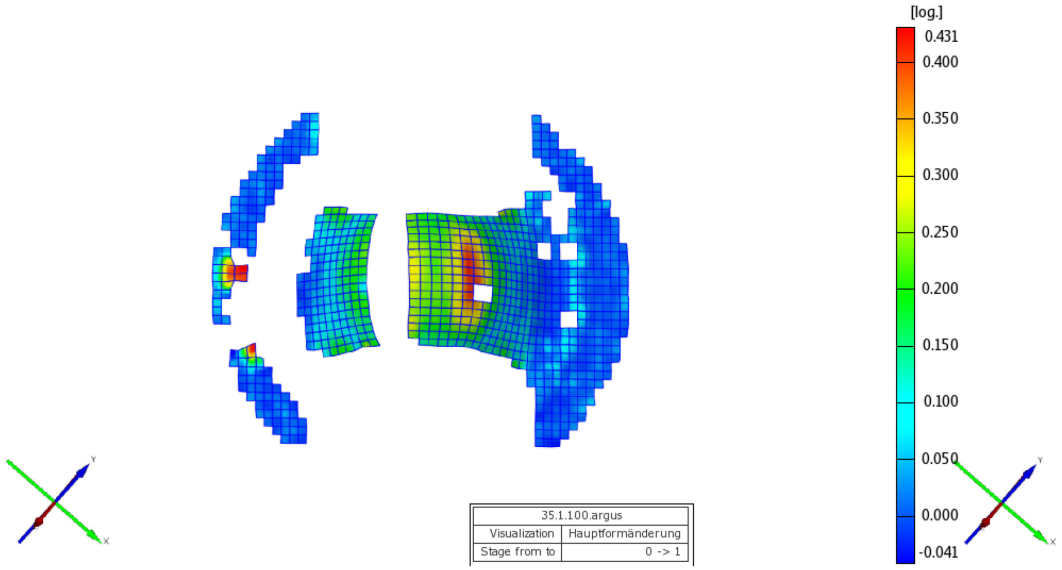
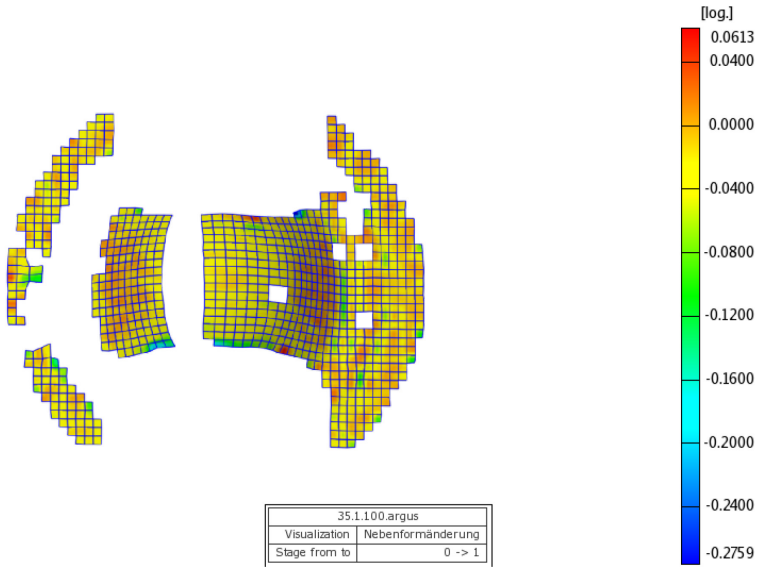


major strain, width = 35 mm



minor strain, width = 35 mm

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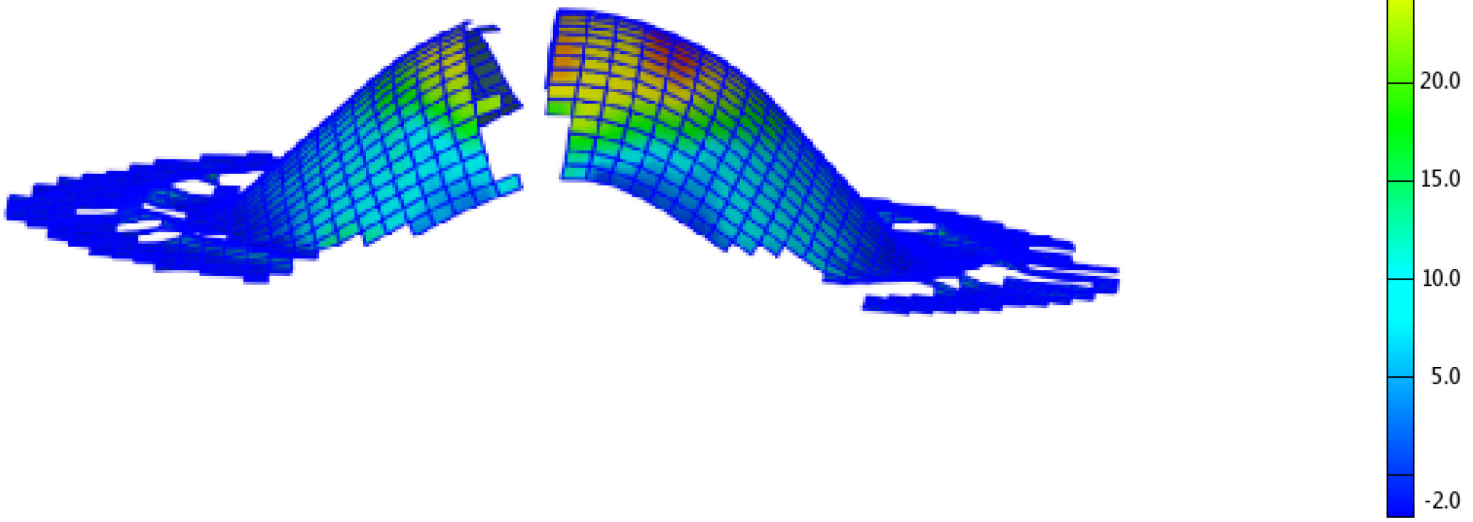

major strain, width = 35 mm

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Summary and Outlook

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Summary and Outlook

A pneumatic high speed nakajima testing device was developed and tested

Maximum punch speeds of 25 m/s are possible at 240 bar

Change in strain rate results in

- Drop of forming limit curve
- Shift to lower right side

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