The Role of Metal Forming in Next Generation Manufacturing

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www.cpforming.org
www.ercnsm.org

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CPF is supported by NSF and several companies interested in metal forming.

HONDA

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Scientific Forming Technologies Corporation

IMRA

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EWI® THE MATERIALS JOINING EXPERTS

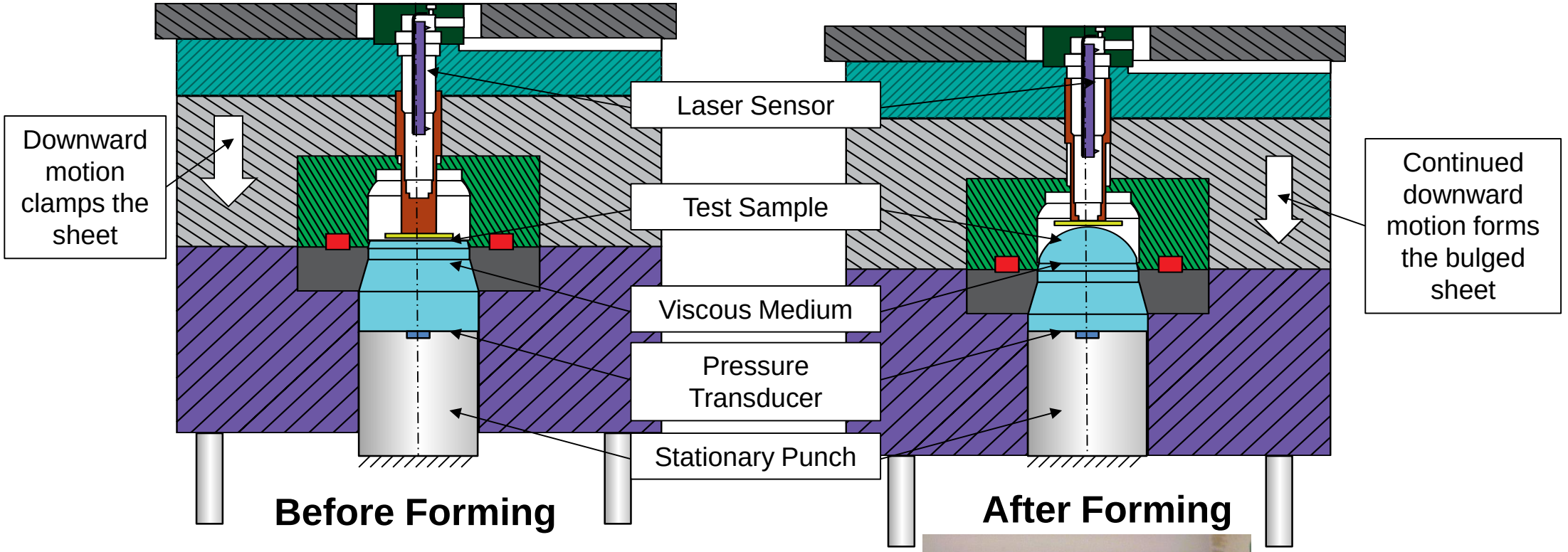
National Manufacturing Co., Inc.
Specialists in Deep and Shallow Drawn Enclosures

Outline

- Introduction-Materials in Automotive Engineering
- Material Characterization
- Friction / Lubrication
- Process Simulation / Forming Al & AHSS-Software:
    - •DEFORM-forging, PAMSTAMP/LS-DYNA-stamping
- Servo Drive Presses and Hydraulic Cushions
    - •Project experiments are conducted in cooperation with CPF members
- •Hot Stamping of UHSS
- •Summary

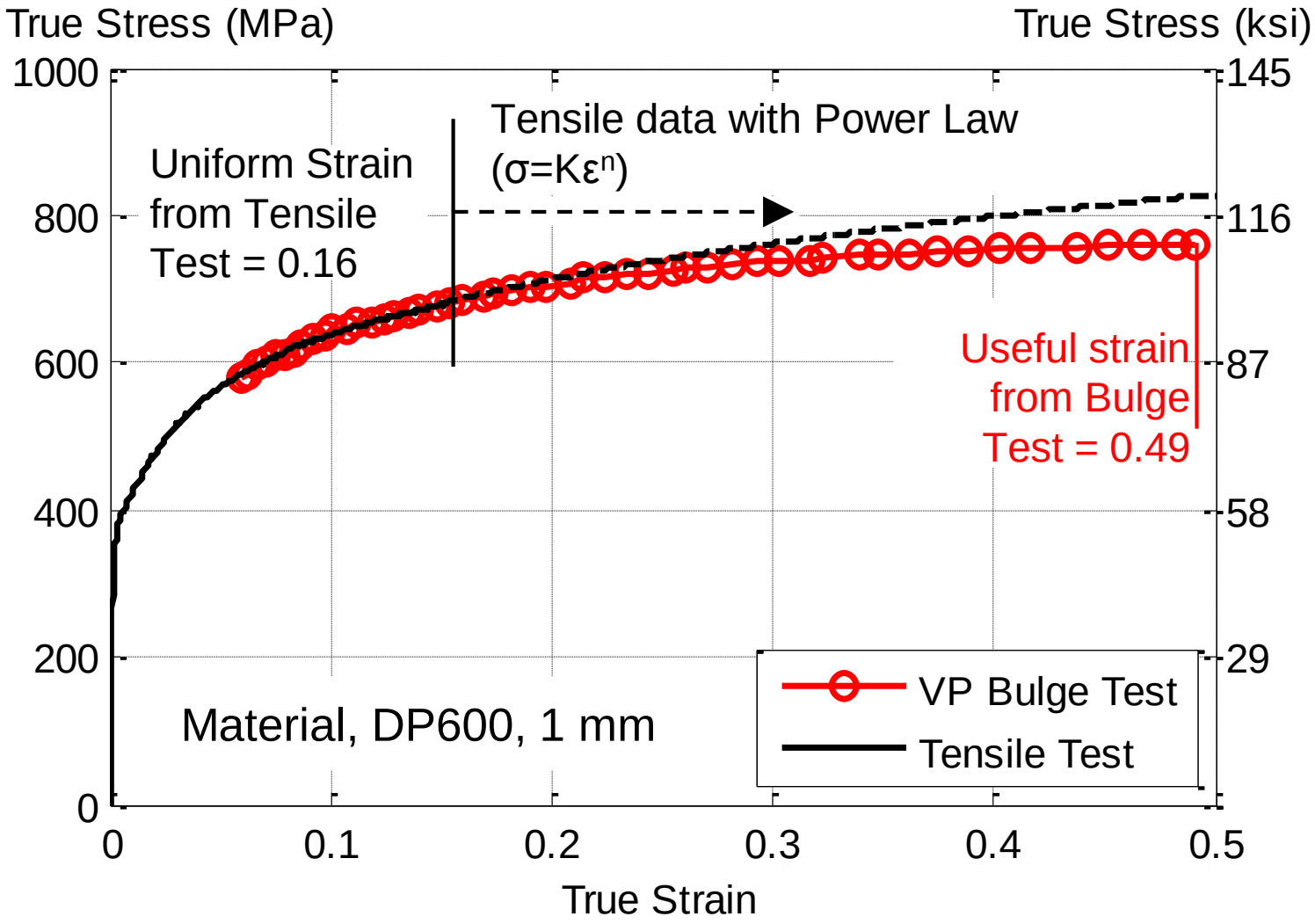
Material Characterization, Viscous Pressure Bulge (VPB) test

The flow stress data is determined from the pressure and dome height



Material Characterization – Flow Stress

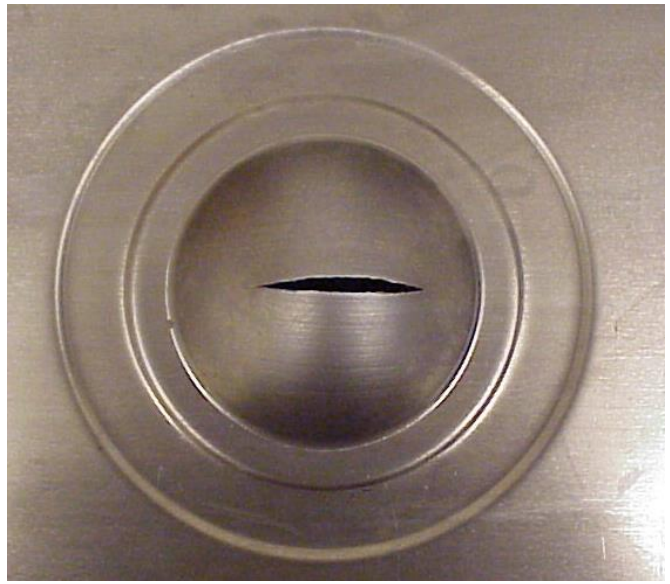
Viscous Pressure Bulge (VPB) Test



Material Characterization – VPB Test

Test sample

Before bursting

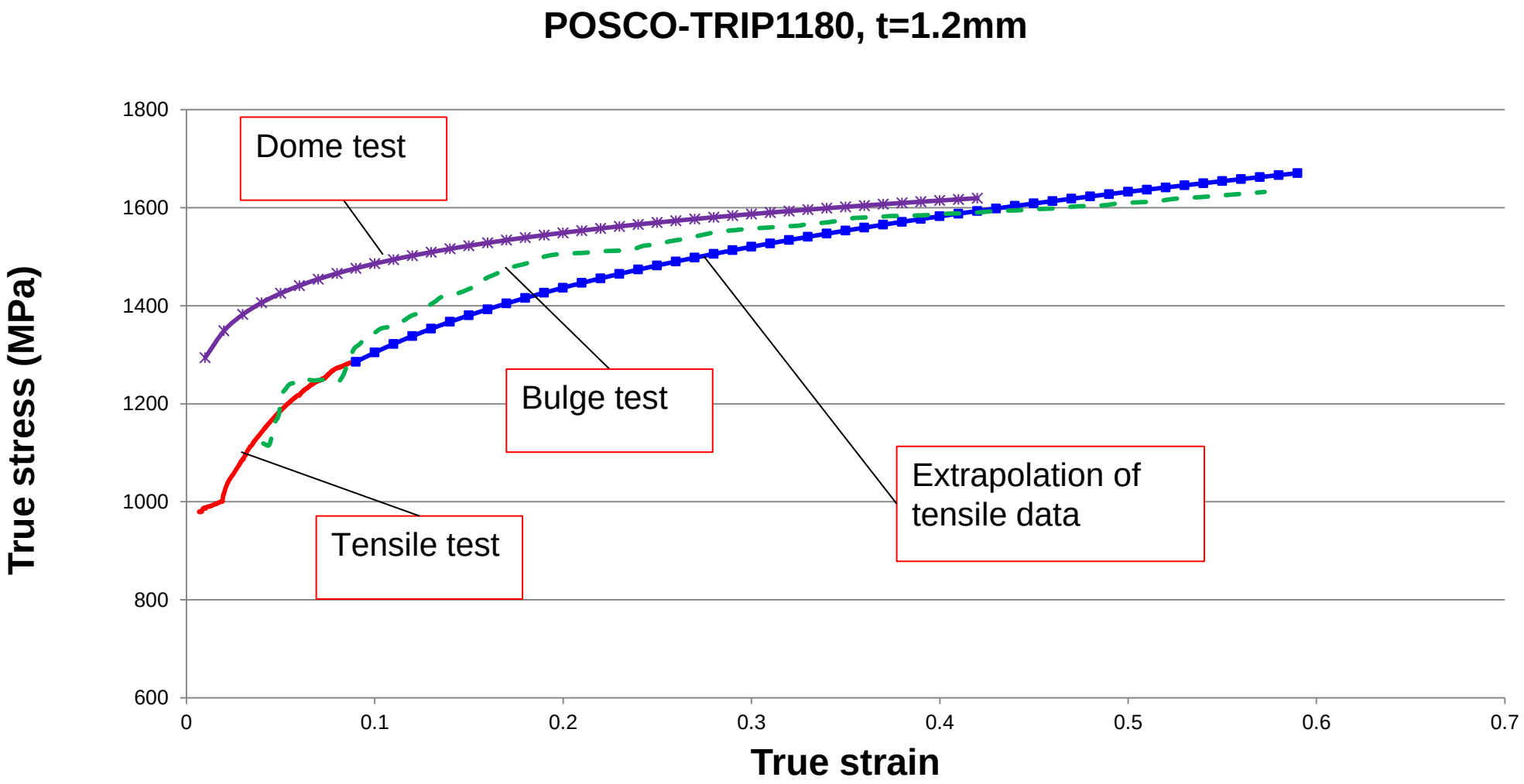


After bursting

AHSSs Tested with VPB, Tensile and Frictionless Dome Tests in cooperation with HONDA R&D and EWI

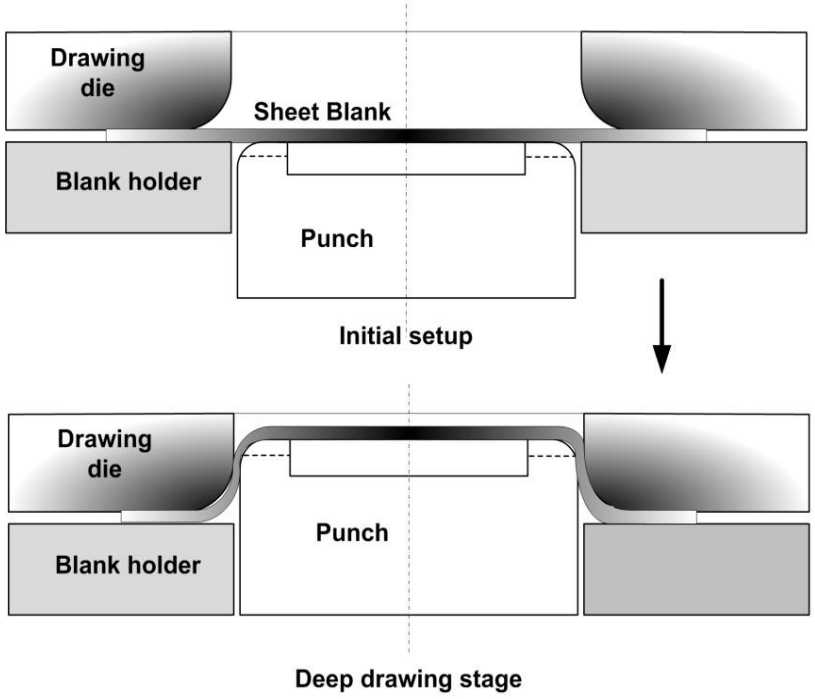
Material	Thickness (mm)
CP 800	1.4
DP 590	1.3
DP 980	1, 1.2,and 1.4
TWIP 900	1.1
TWIP 980	1.3
TRIP 1180	1.2

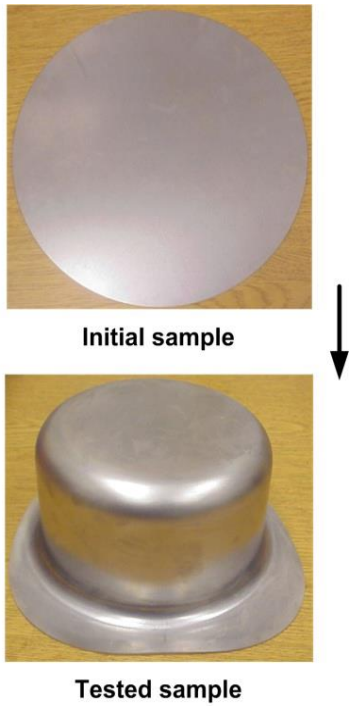
Example Flow Stress data obtained from VPB test, Tensile test, and Frictionless dome test



Friction/Lubrication – Cup Draw Test

Evaluation of Lubricants





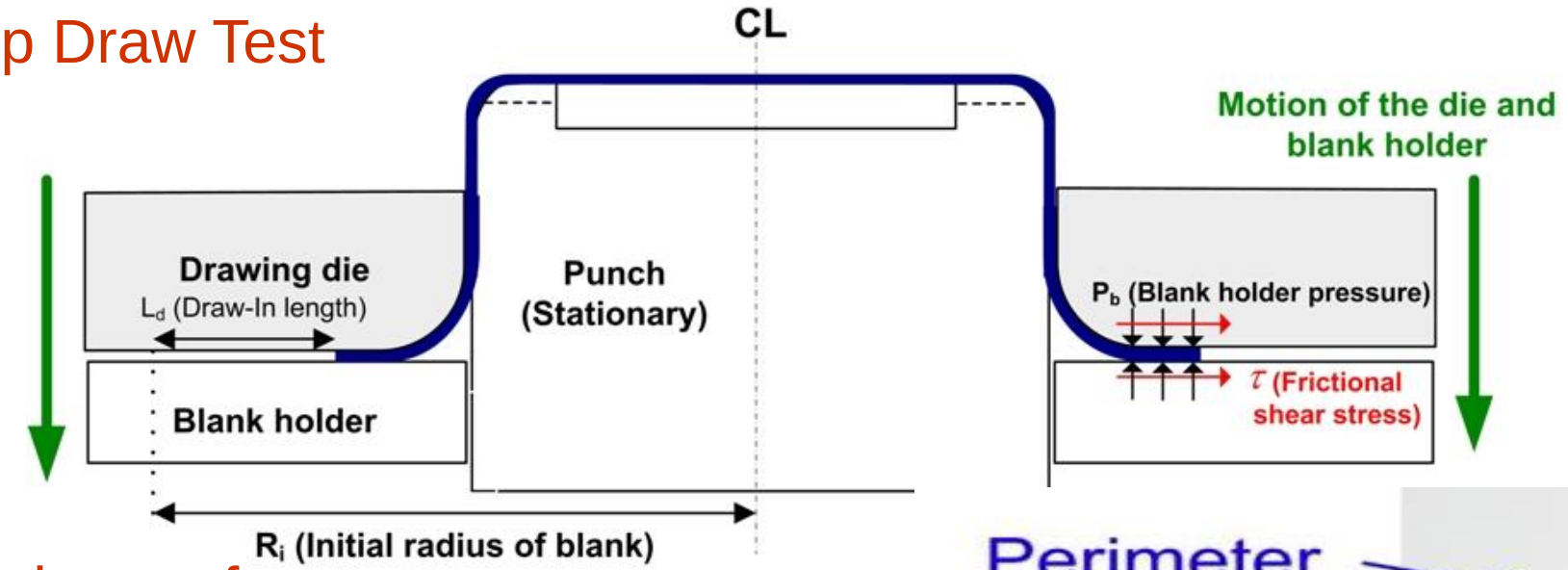
Performance evaluation criteria (cups drawn to same depth):

i. Higher the Blank Holder Force (BHF) that can be applied without fracture in the drawn cup, better the lubrication condition

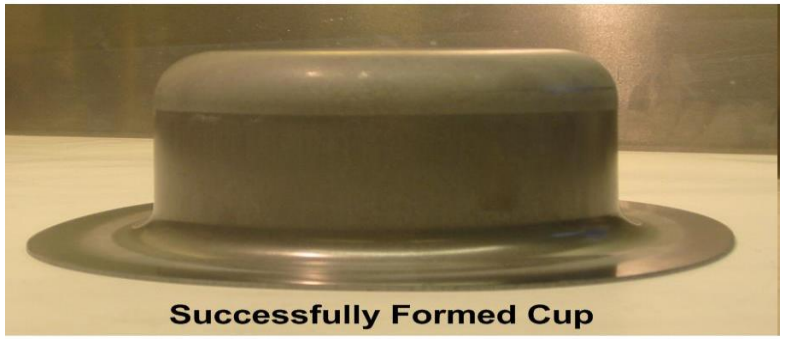
ii. Smaller the flange perimeter, better the lubrication condition (lower coefficient of friction)

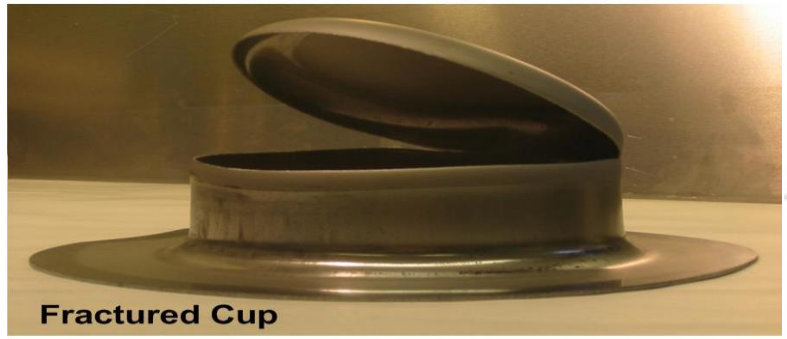
Friction – Cup Draw Test

Cup Draw Test



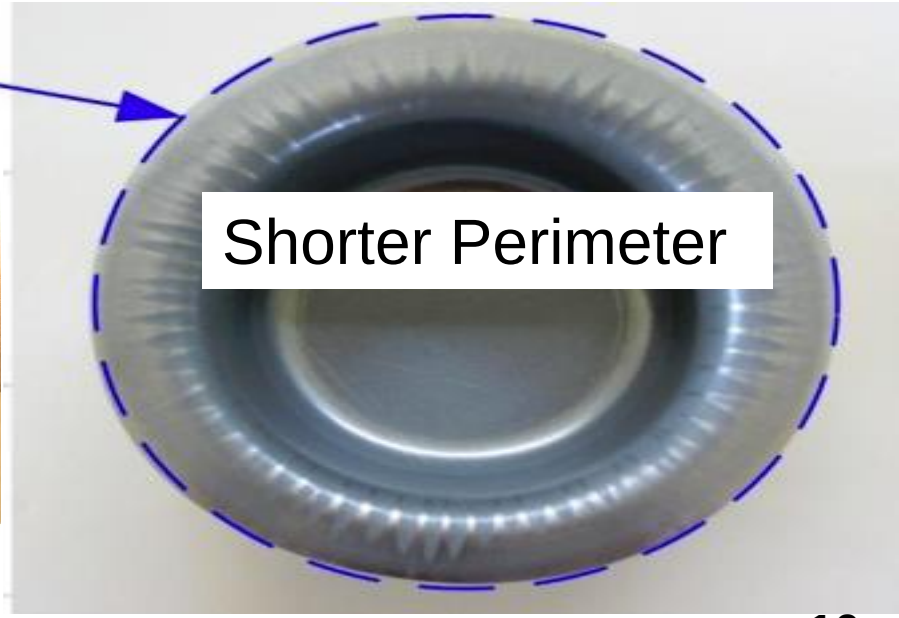
Lubrication performance:





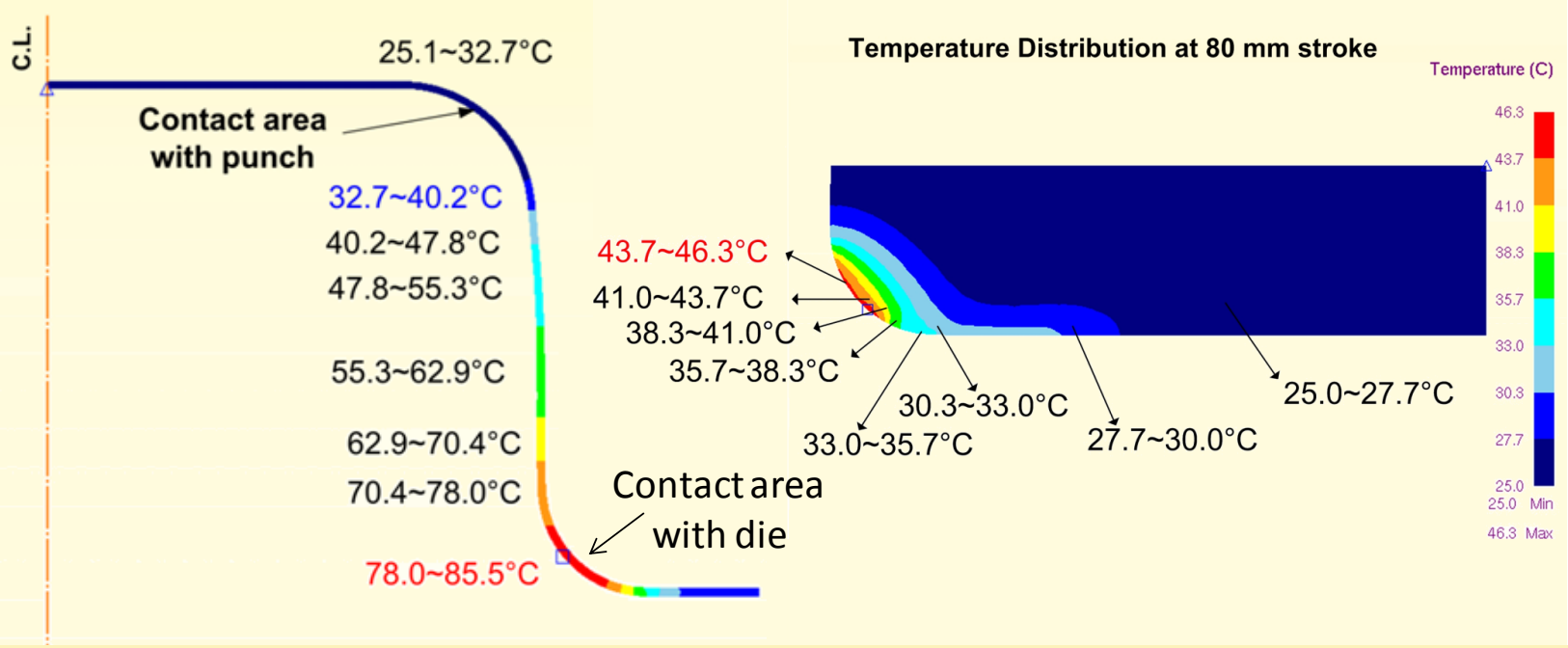
Higher BHF before fracture

Perimeter



Friction / Tribology

Temperatures in Cup Draw Test – DP 600

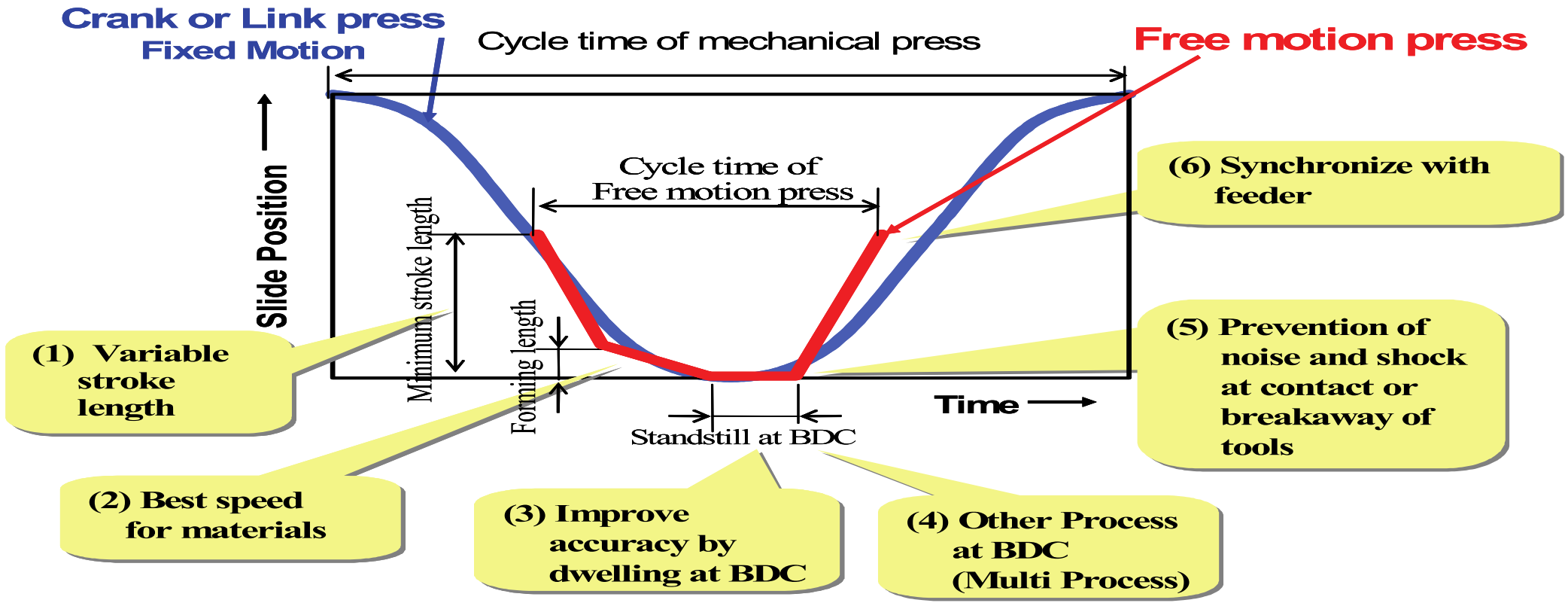


Challenges:

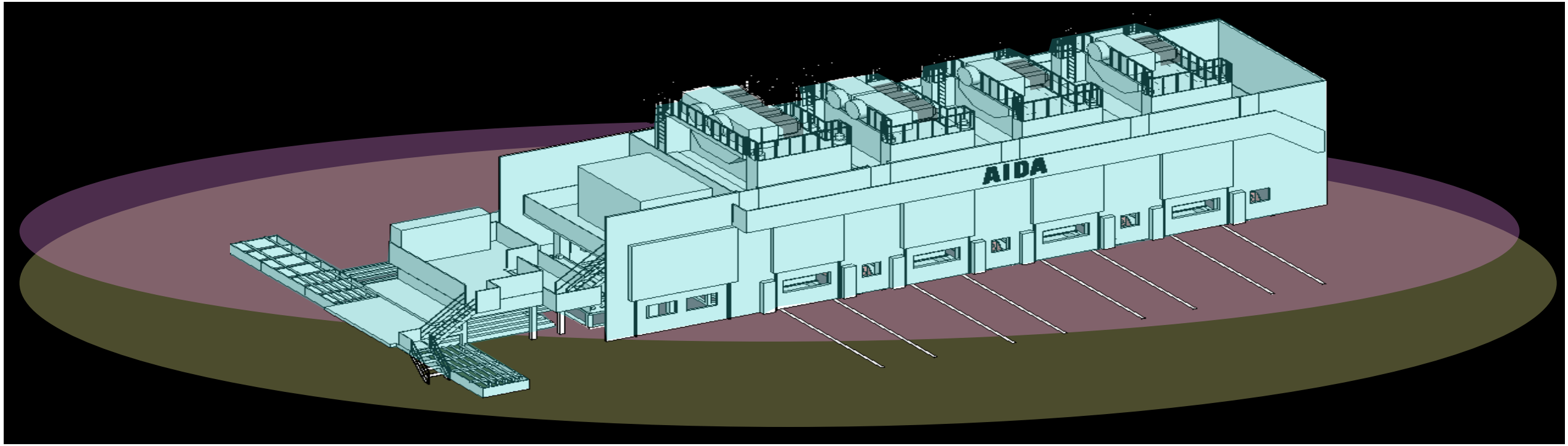
1) Higher contact pressure and higher temperature are detrimental for lubricants,
2) Temperature and pressure additives are needed

Ref: Kim et al 2009

Servo press characteristics

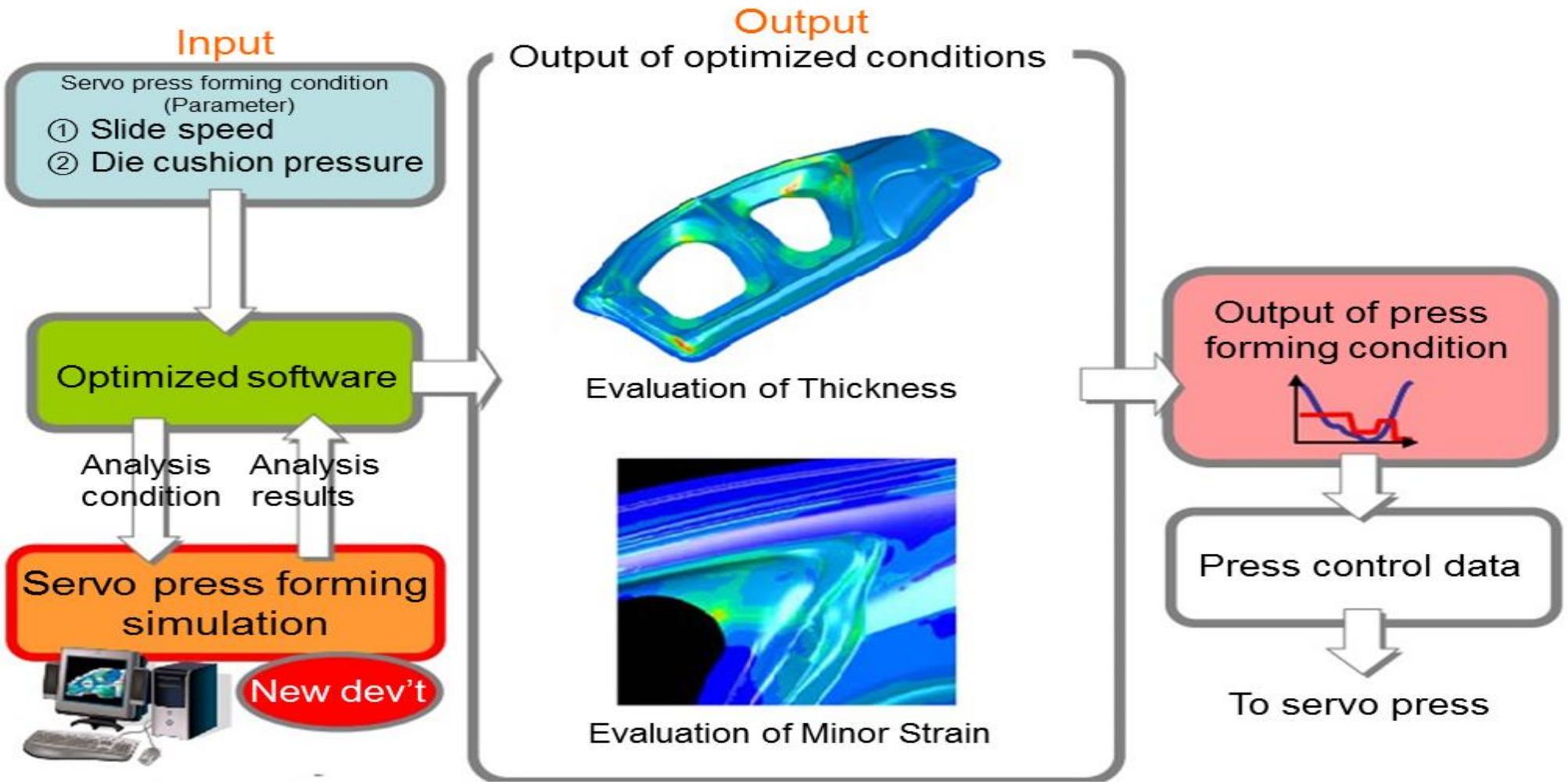


Schematic of Servo-press tandem line (Aida/Honda) 2500 ton/ 18 SPM (2009)



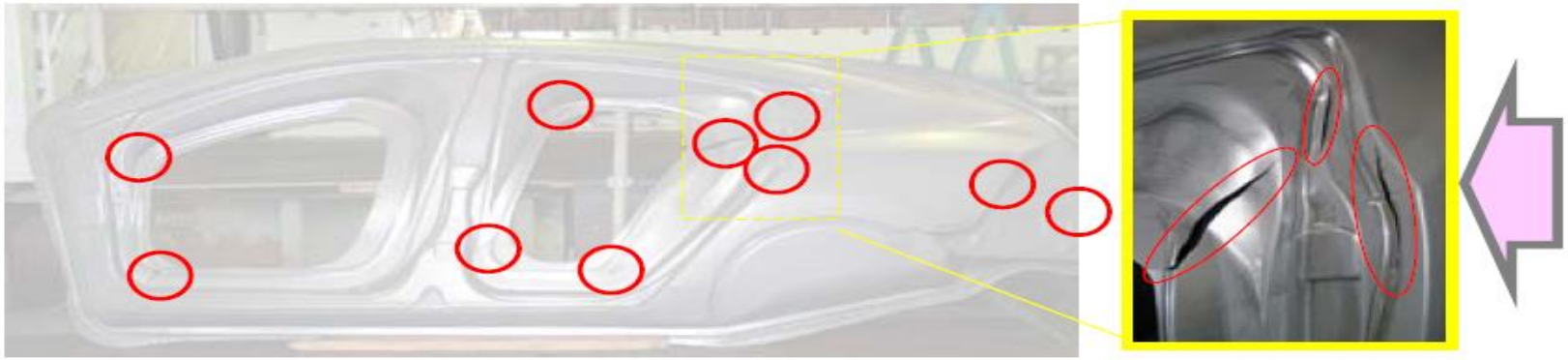
Improved Formability	Improved Productivity	Energy-Saving
• System with optimized press forming requirements for each product	• Press-to-Press Loading Motion: System is optimized for each product.	• Die cushions have an energy regeneration system

Optimized Press Forming Conditions through CAE- courtesy Honda



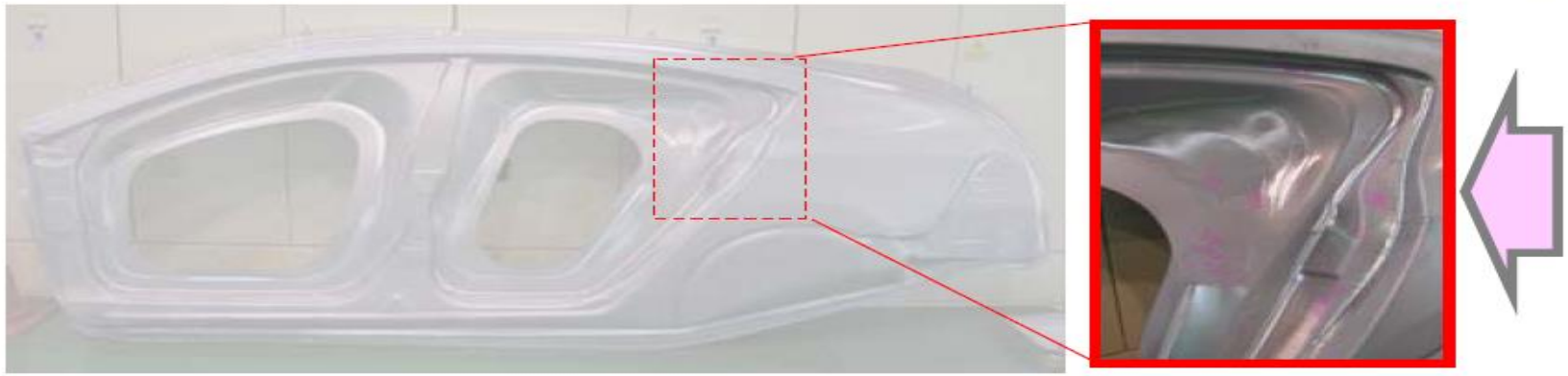
Side Panel Outer Deep Drawing Case Example (Honda)

- Existing manufacturing process (Mechanical press)



Crack occurrence
10 locations

- This development mfg process (Servo press + Optimized forming condition setting system)



Crack occurrence
None

15

Servo-press tandem line (Schuler/BMW) 2500 ton/ 17 SPM (2009)

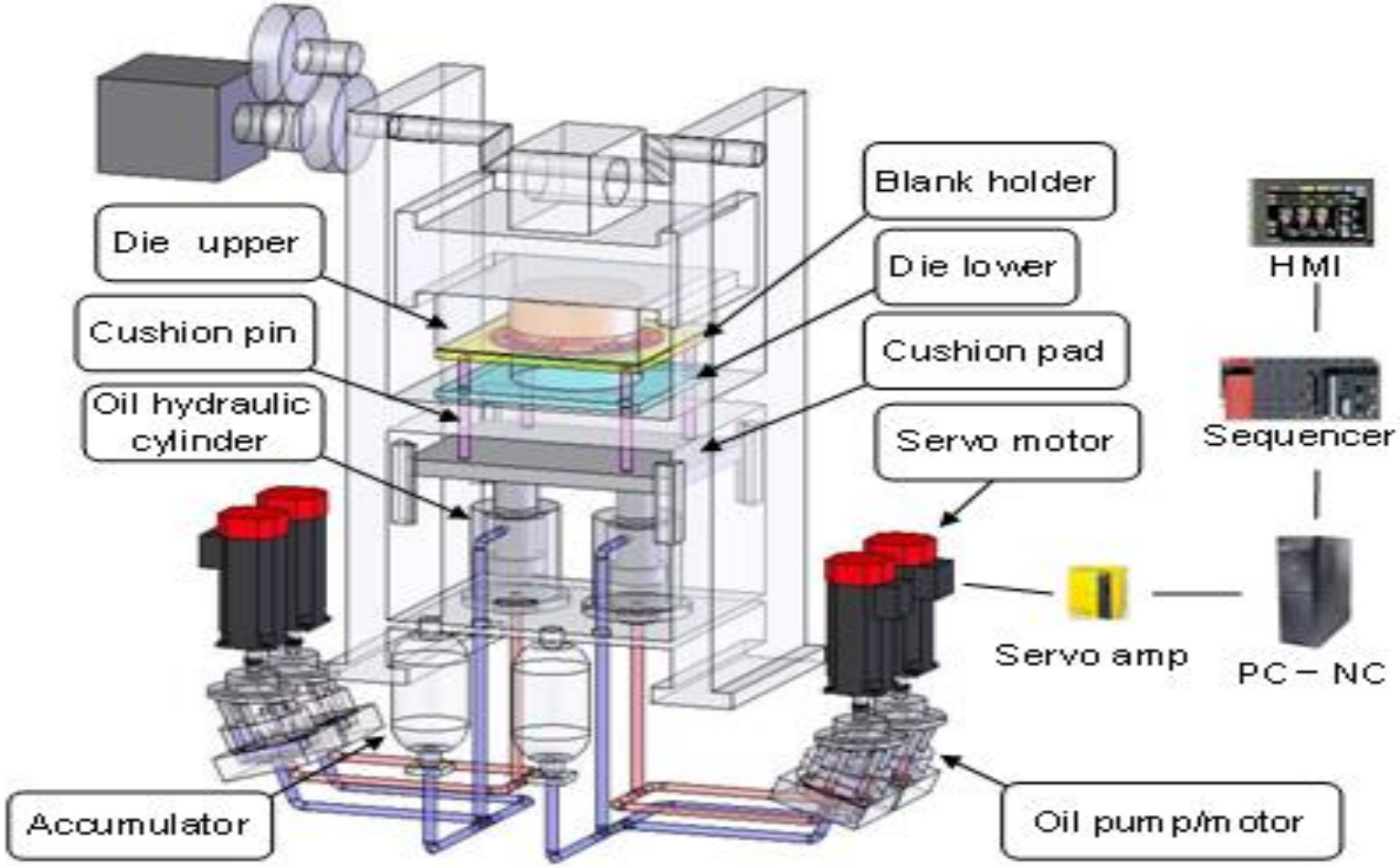
- One drawing press + 5 presses for follow-up operations

Technical Data:	
Total press force:	10,300 tons
Drawing press force:	2,500 tons
Total length of press line:	98 meters
Length o press:	34 meters
Strokes per minute:	17

Source:BMWarchive.de

Source:Schulergroup.com

Servo-Hydraulic Cushion (Courtesy-Aida)



Elimination of Pressure Surge in the Die Cushion

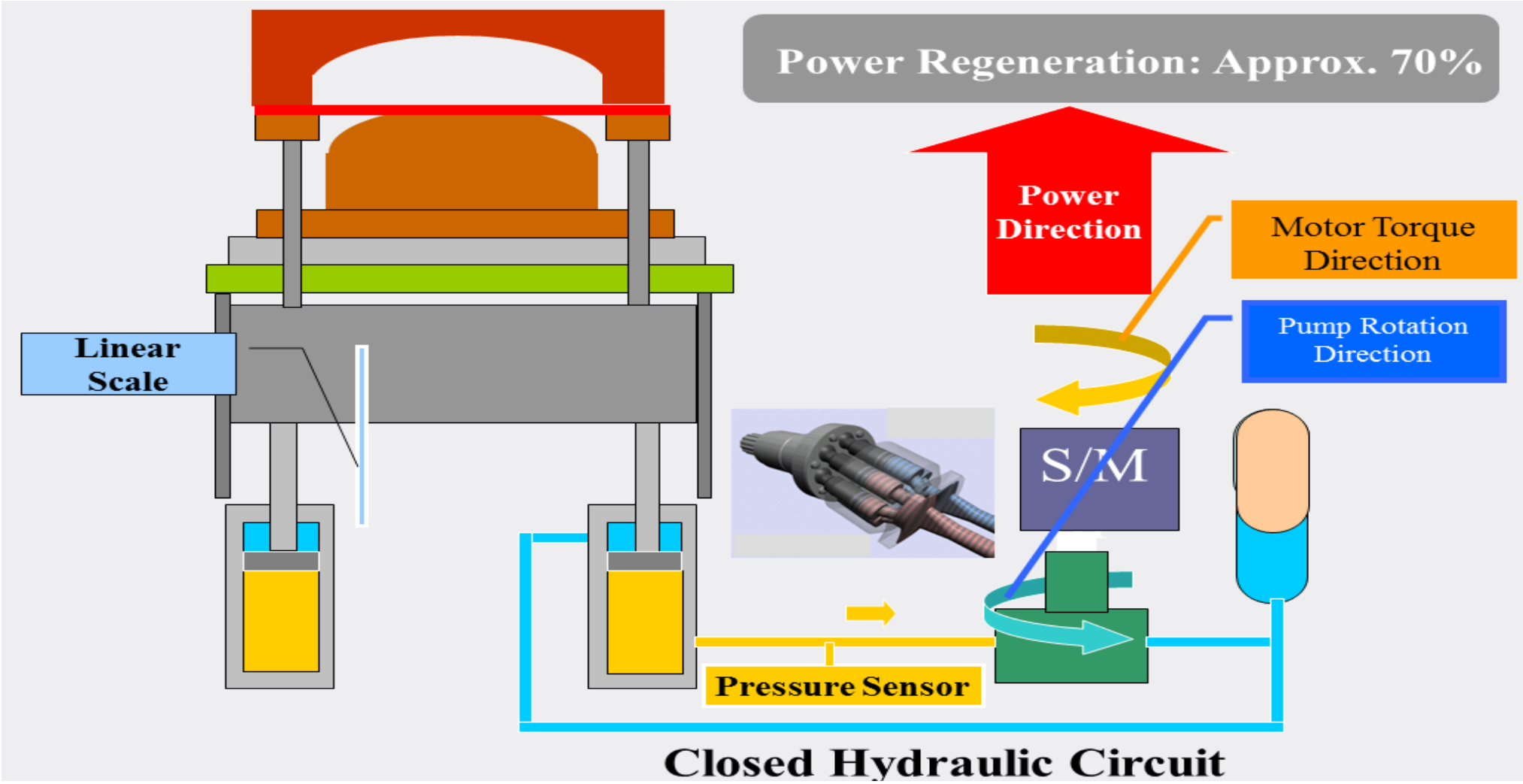
Capabilities of the Self-Driven Hydraulic Servo Cushion

- Pre-acceleration to reduce the impact speed between the die and blank holder

- Variable pressure / force capability to control blank holder force/pressure during stroke

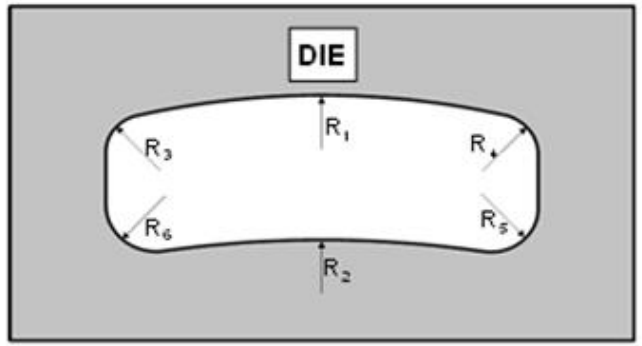
- Prevention of momentary return of the cushion after BDC to avoid pressure on the top of the part

Servo-Hydraulic Cushion - Courtesy AIDA

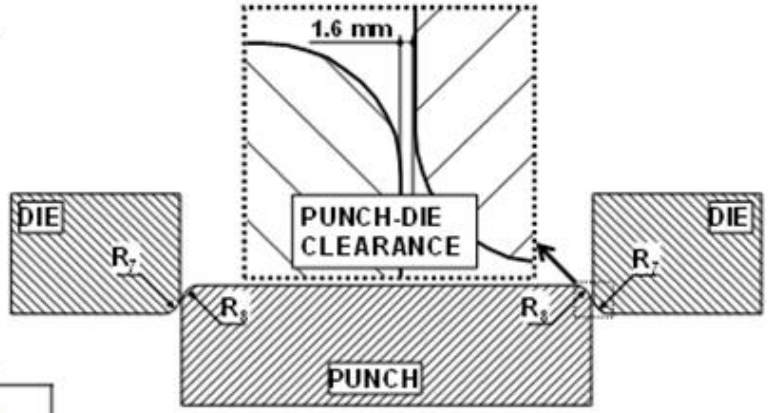


During Down Stroke, Cushion Pressure Generates Power

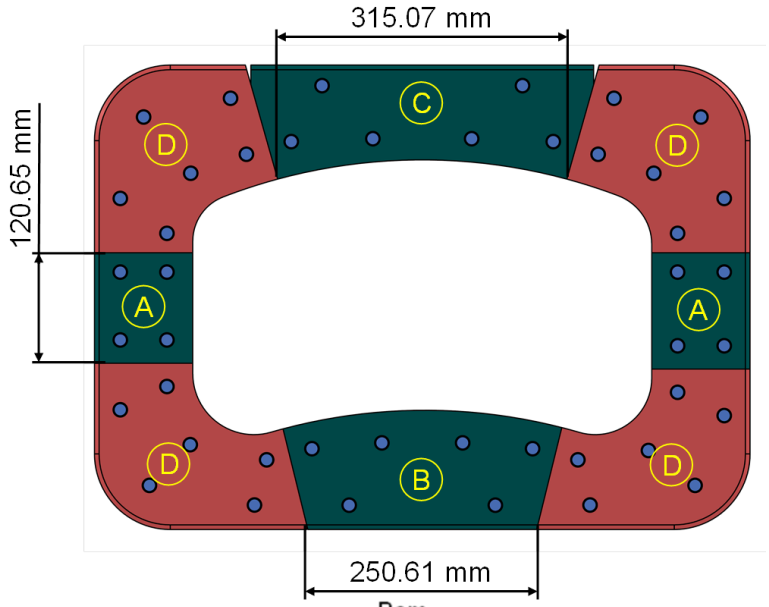
Forming of AHSS and Al5182-O in servo press

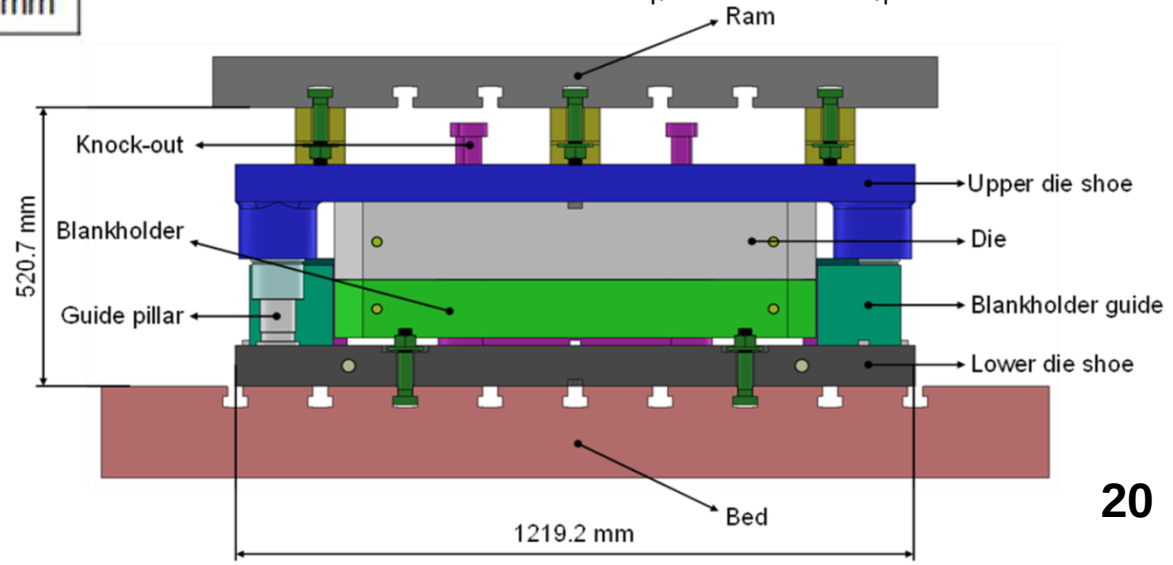


Parameter	Notation	Value
Concave side radius	R_1	1501.6 mm
Convex side radius	R_2	1998.4 mm
Cavity corner radii	R_3	51.6 mm
	R_4	55.6 mm
	R_5	61.6 mm
	R_6	66.6 mm



Parameter	Notation	Value
Die-corner radius	R_7	20 mm
Punch-corner radius	R_8	10 mm

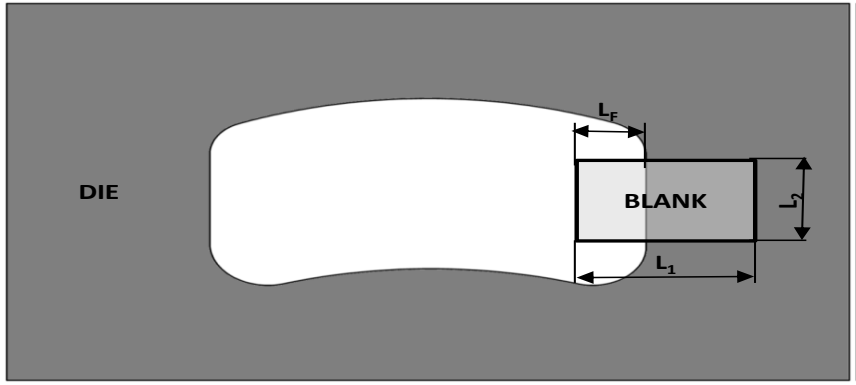




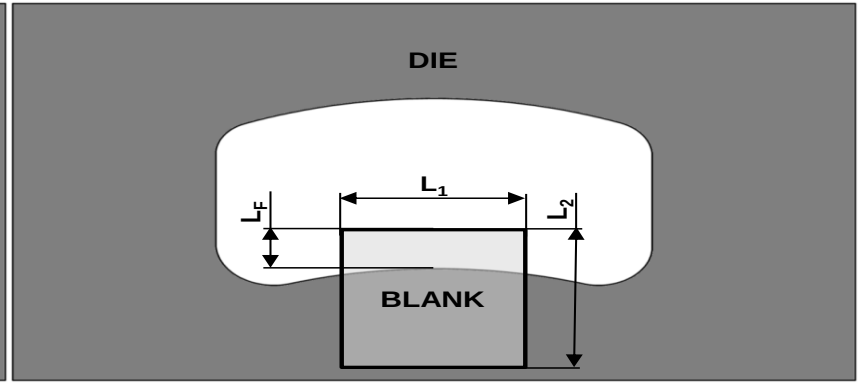
The Die is designed and manufactured by Shiloh

Forming of AHSS in a Servo press

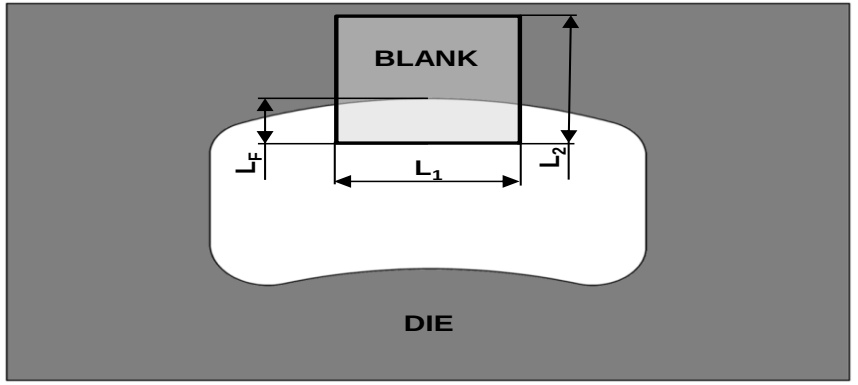
1-Wipe bending



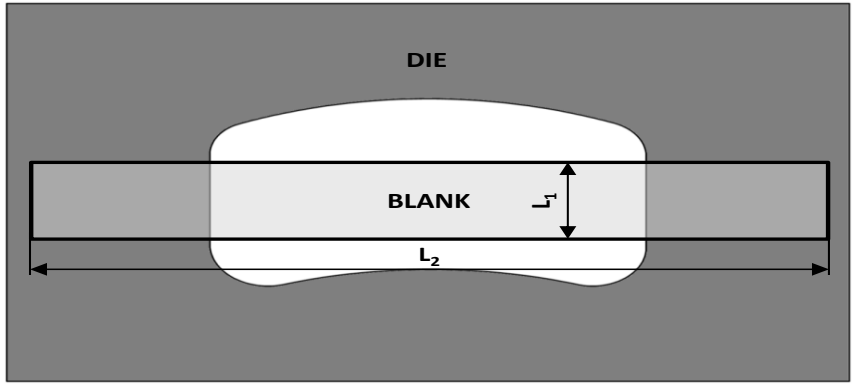
2-Shrink flanging



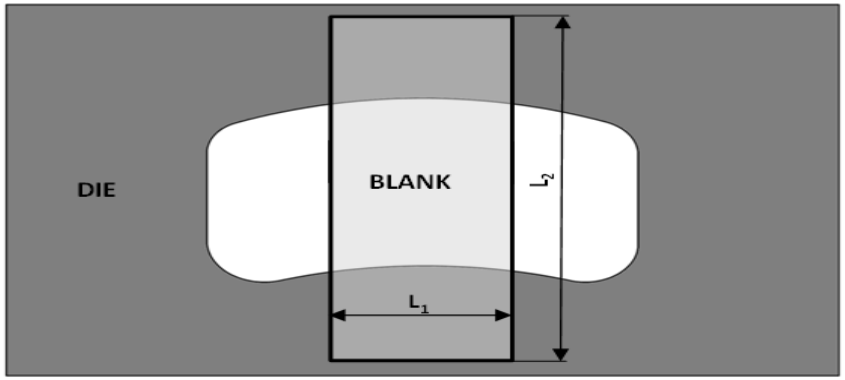
3-Stretch flanging



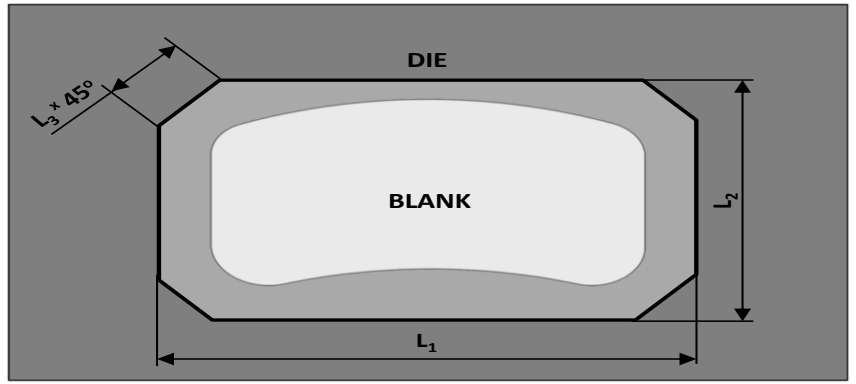
4-Hat and U-channel drawing



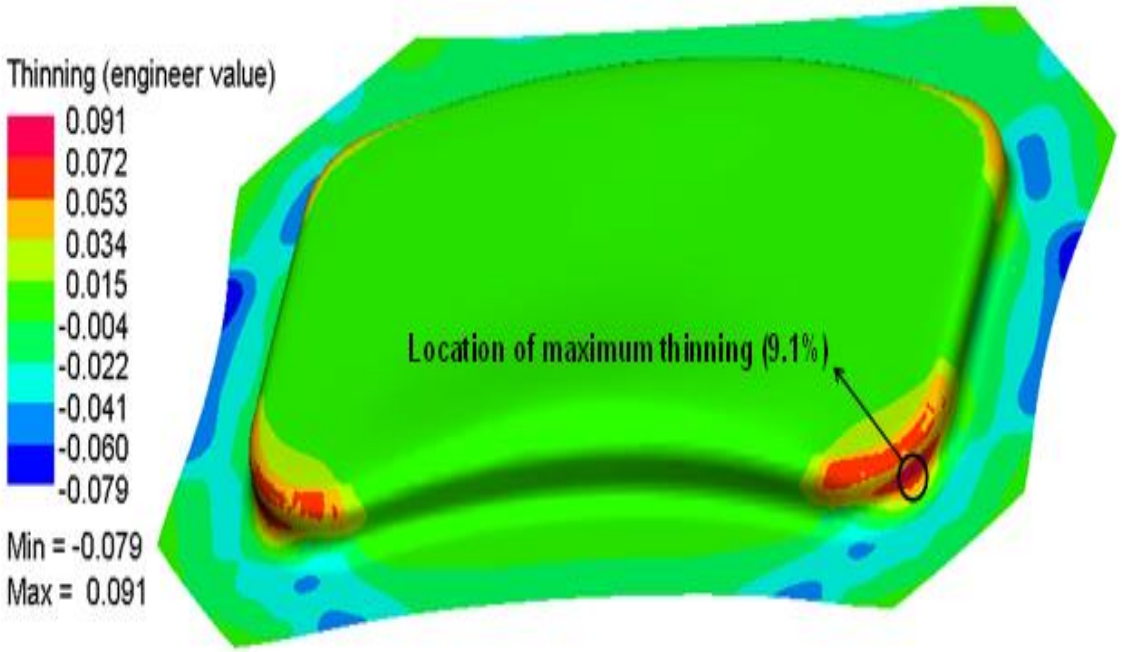
5- U-Flanging

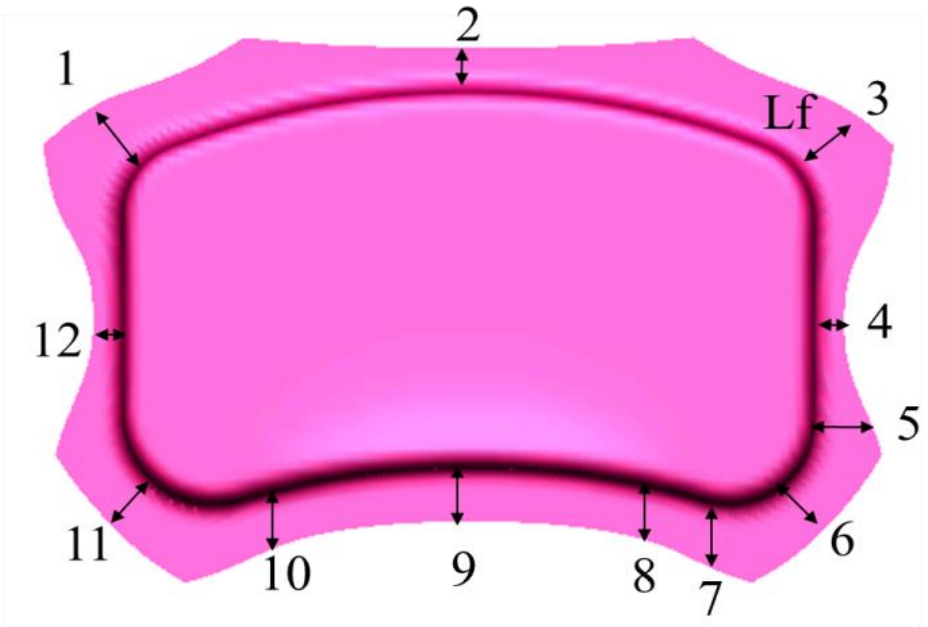


6-Deep drawing



Forming of AHSS in a Servo press



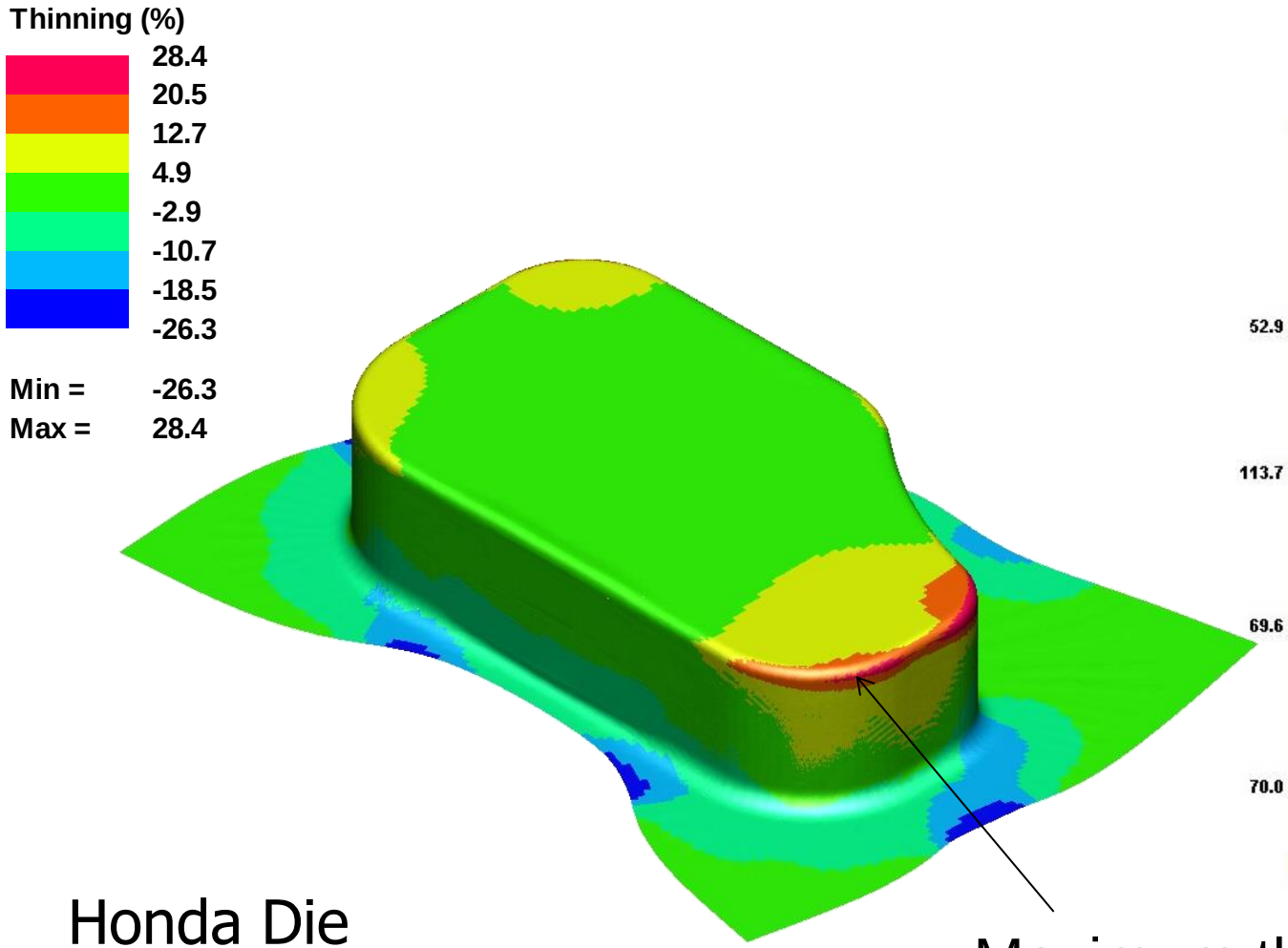


DP980 with 1.4mm thickness

Shiloh Die

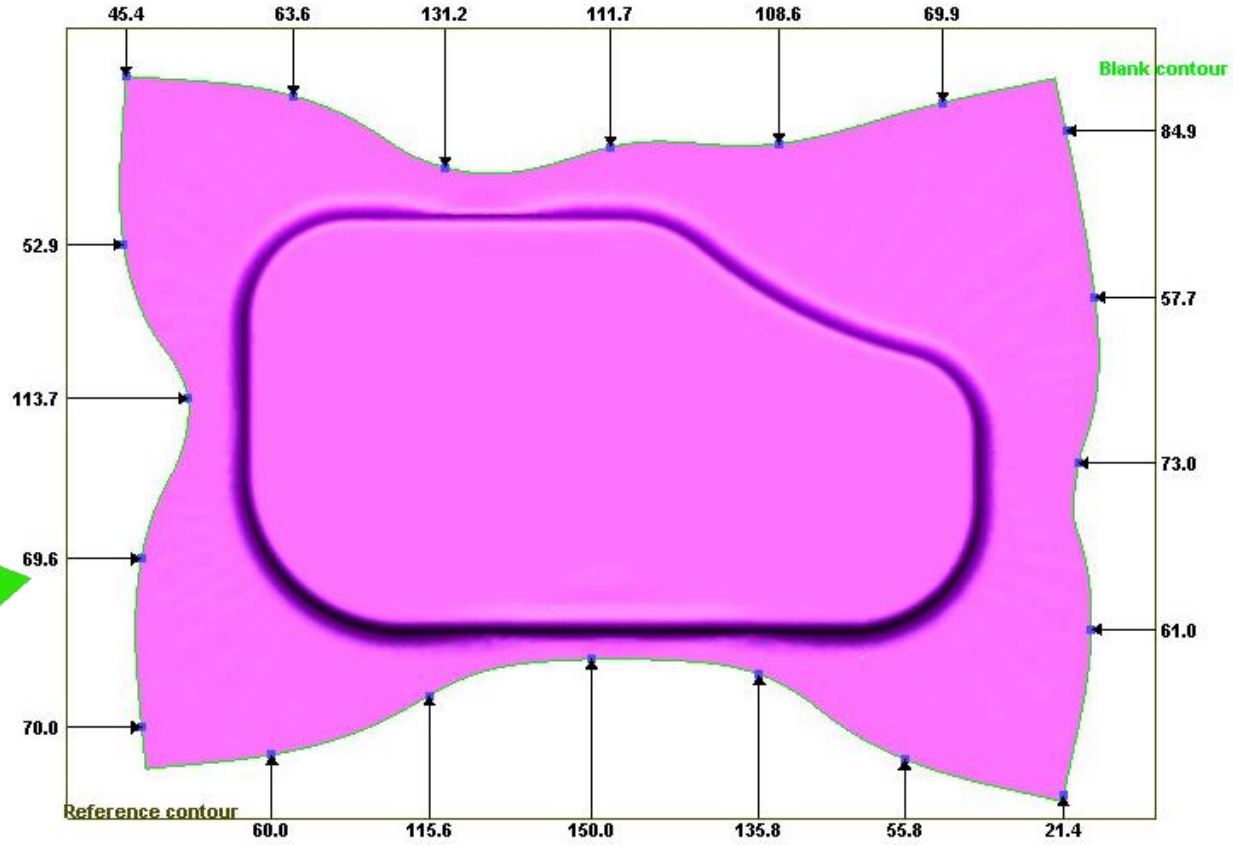
Flange length at different locations is measure from experimental samples and compared with simulation results

Forming of Al Alloys in a Servo Drive Press



Honda Die

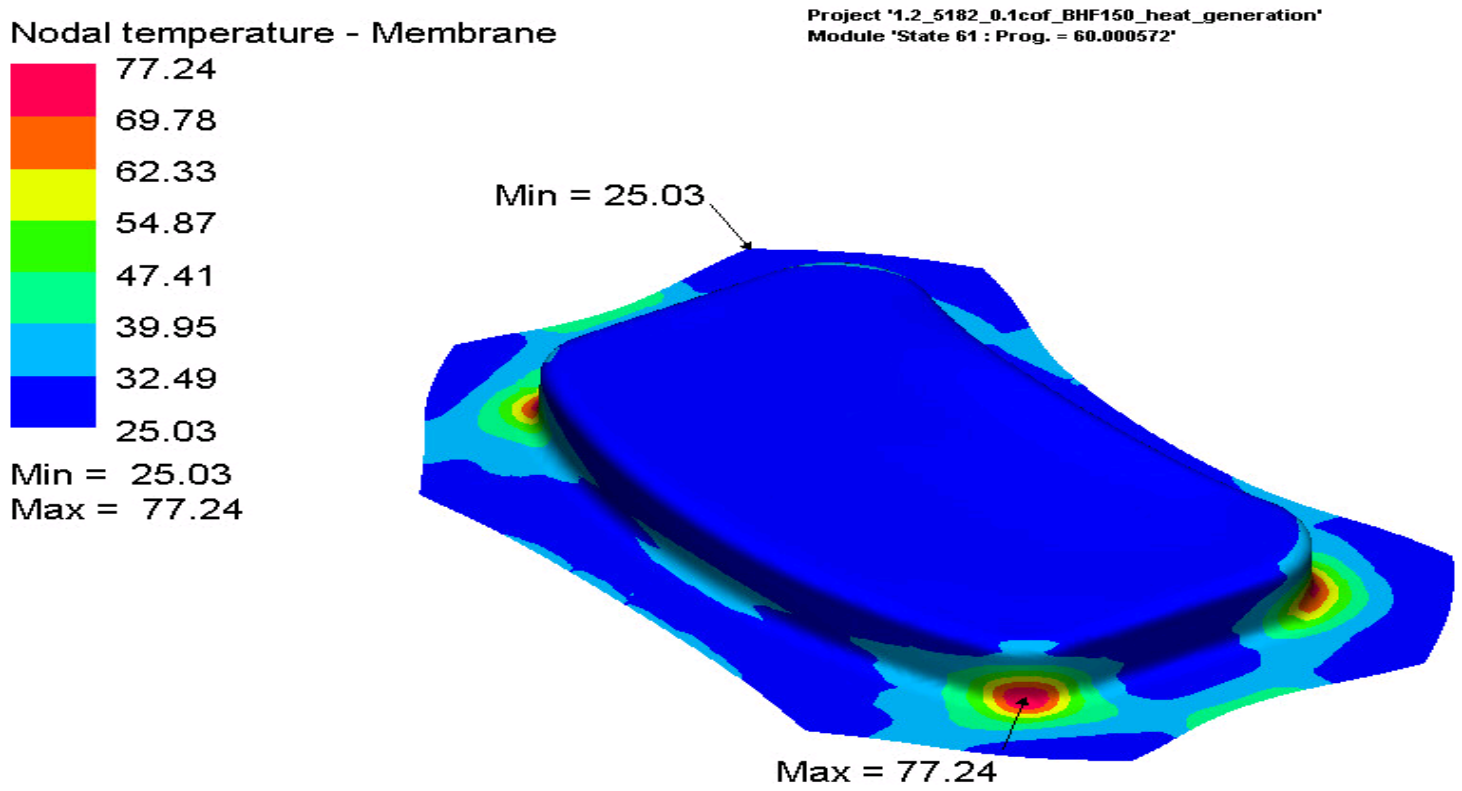
Material draw-in



Maximum thinning ~28%
Draw depth = 155 mm

Non-isothermal simulation of deep drawing for Al 5182-O

Deep drawing of Al5182-O shows the maximum temperature observed on blank is about 77 °C for 60mm stroke

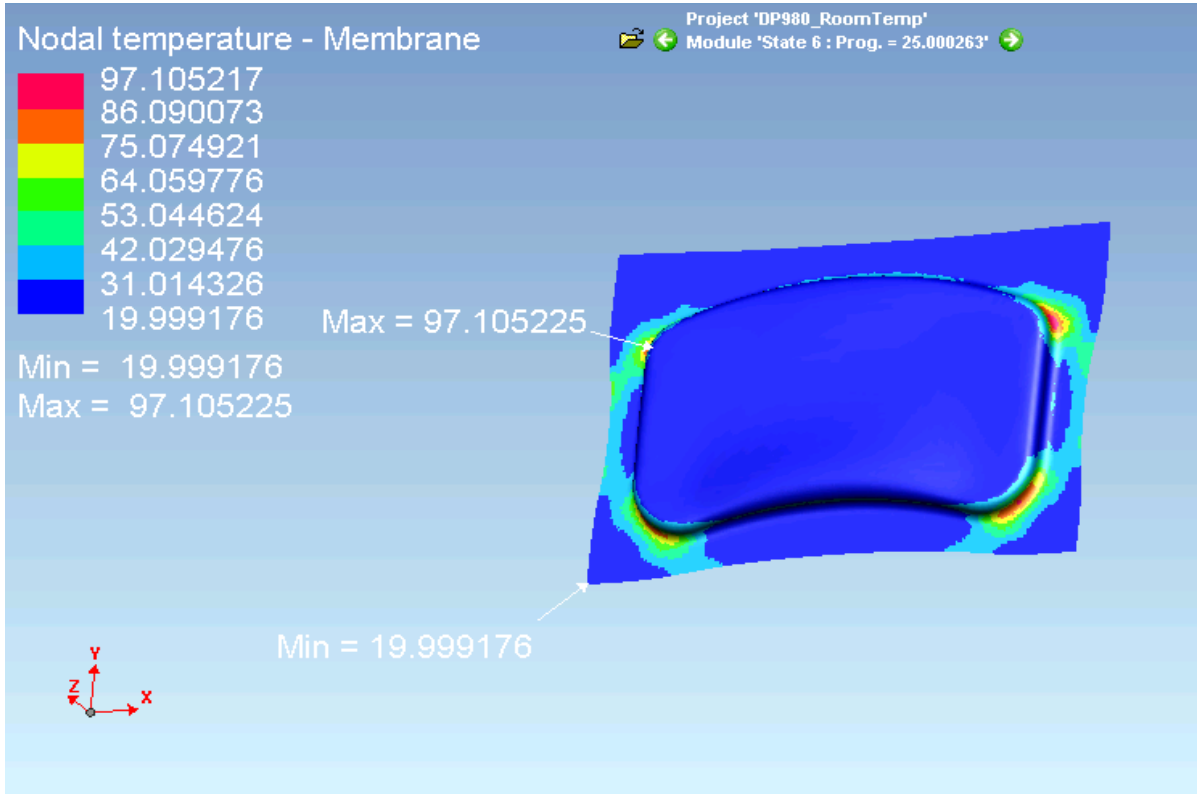


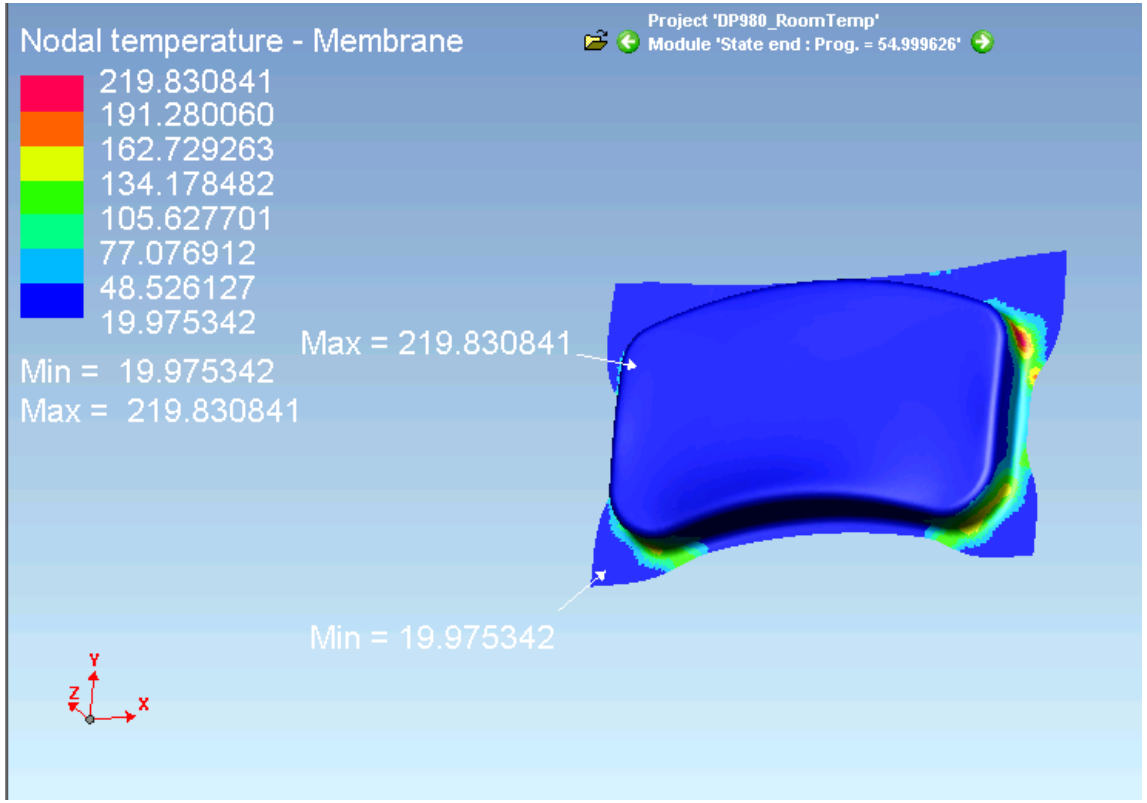
Surface heat transfer is between blank and tooling is not considered

Room temperature is 20 °C

Non-isothermal simulation of deep drawing for AHSS

Deep drawing of DP980 shows the maximum temperature observed on blank is about 97 °C for 25mm stroke and 219 °C for 55mm stroke.



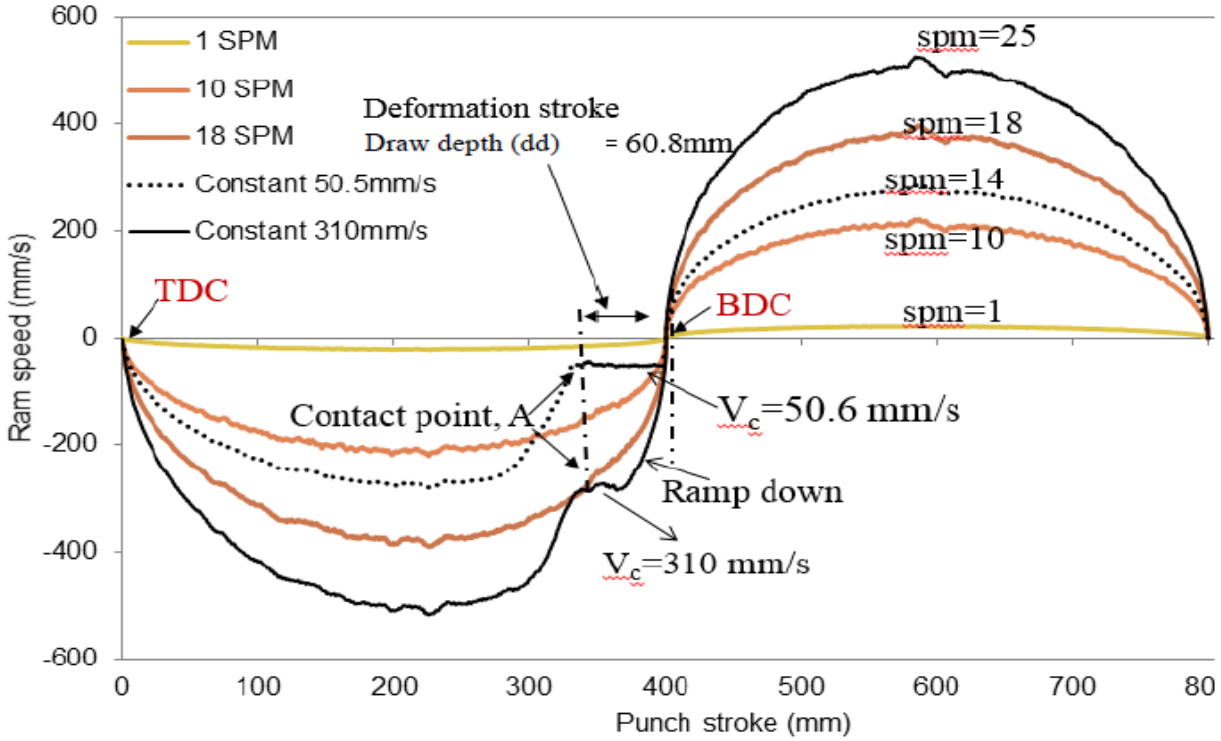


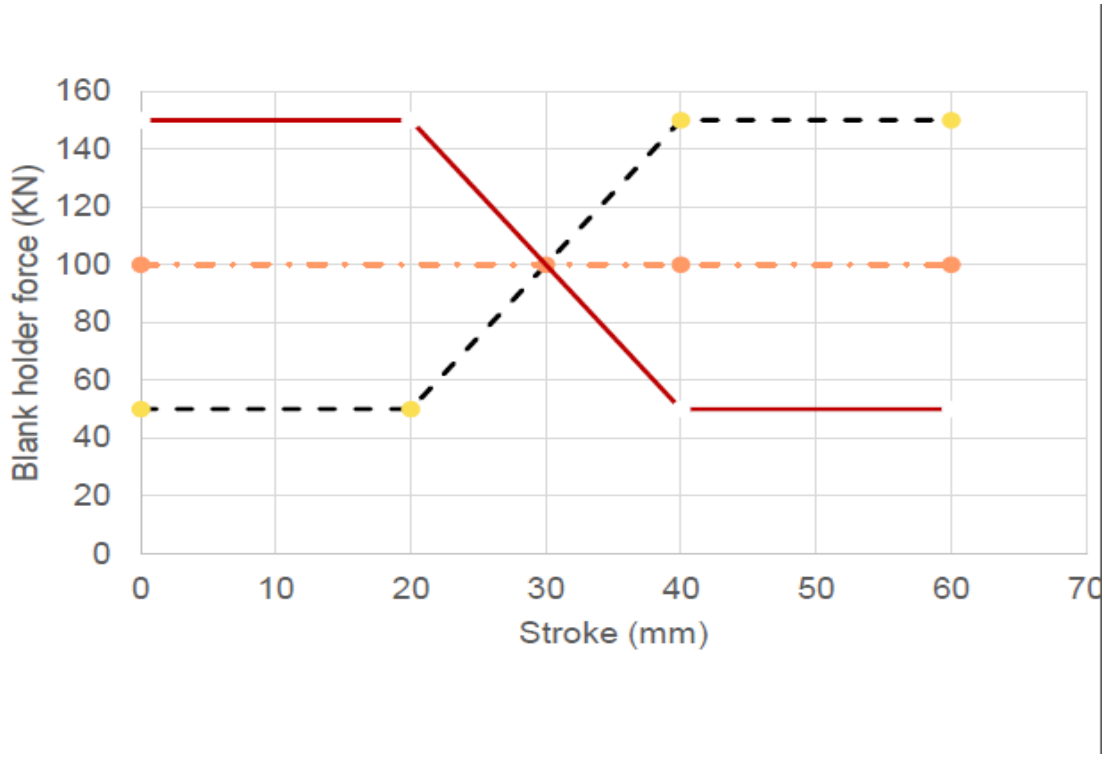
Surface heat transfer is between blank and tooling is not considered

Room temperature is 20 °C

Ram speed and blank holder force profiles used in tryouts (Aida servo press)

Different ram speed and BHF profiles were used in the tryouts.





Note: 1) These speed vs stroke curves were obtained from press.

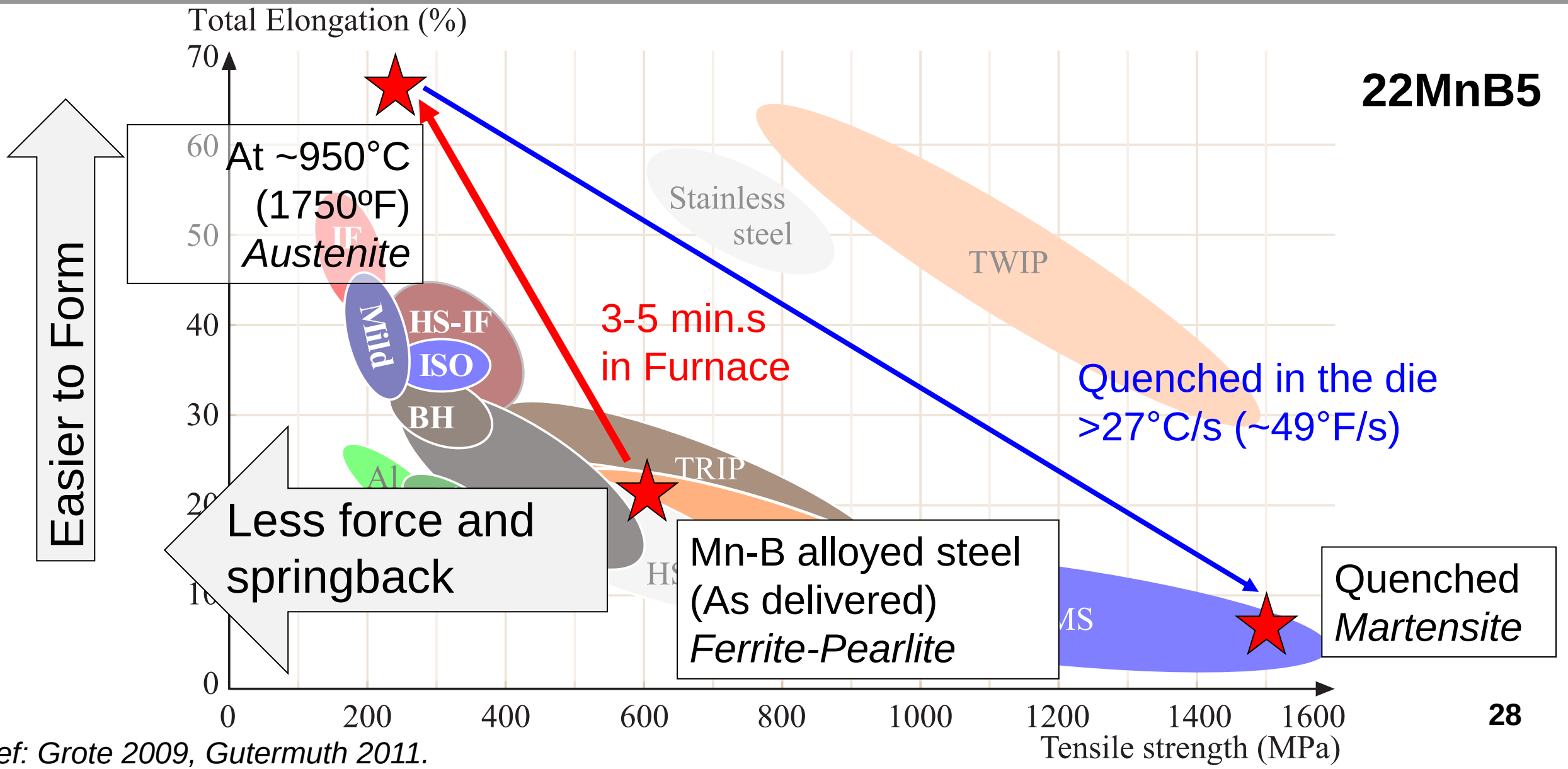
2) These blank holder force curves are input to the press.

Deep drawn part using AIDA servo press (Al5182-O)

Blank holder force: 250KN

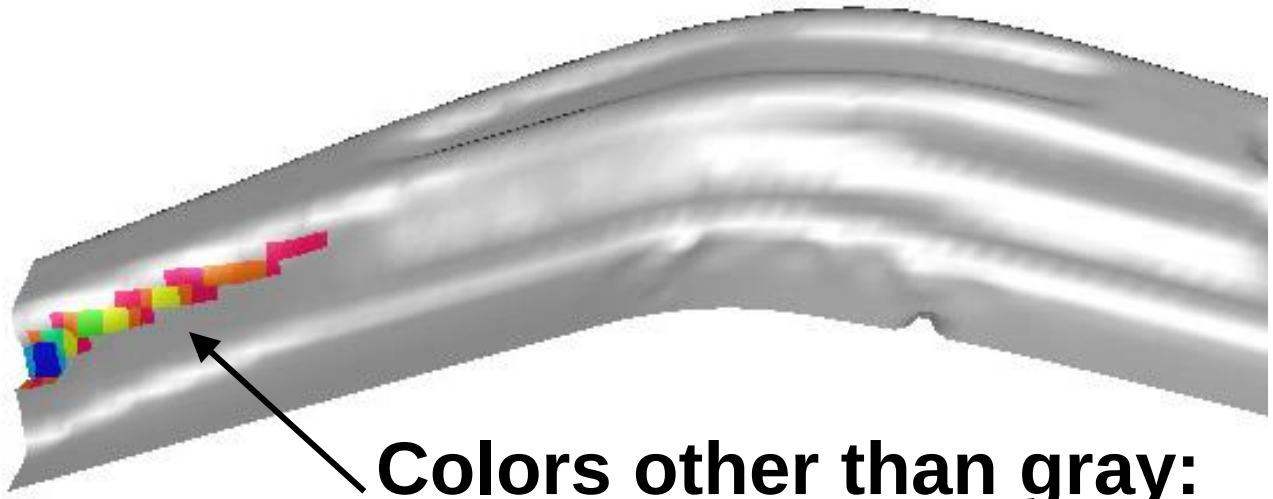
Draw depth: 75.8mm

Hot Stamping

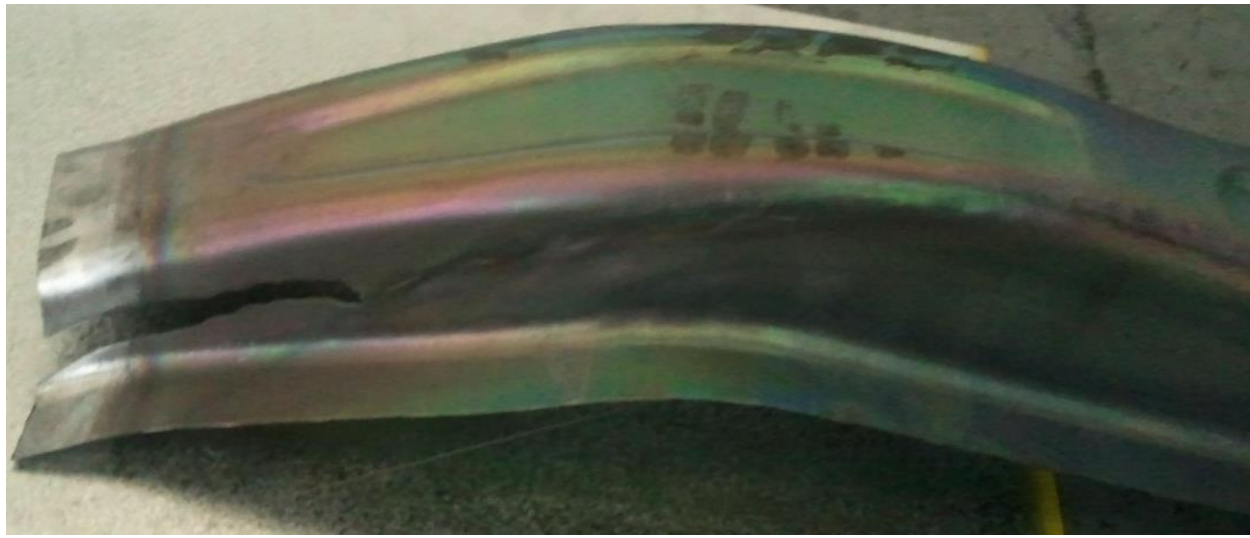


Ref: Grote 2009, Gutermuth 2011.

FE Simulation of parts with uniform properties

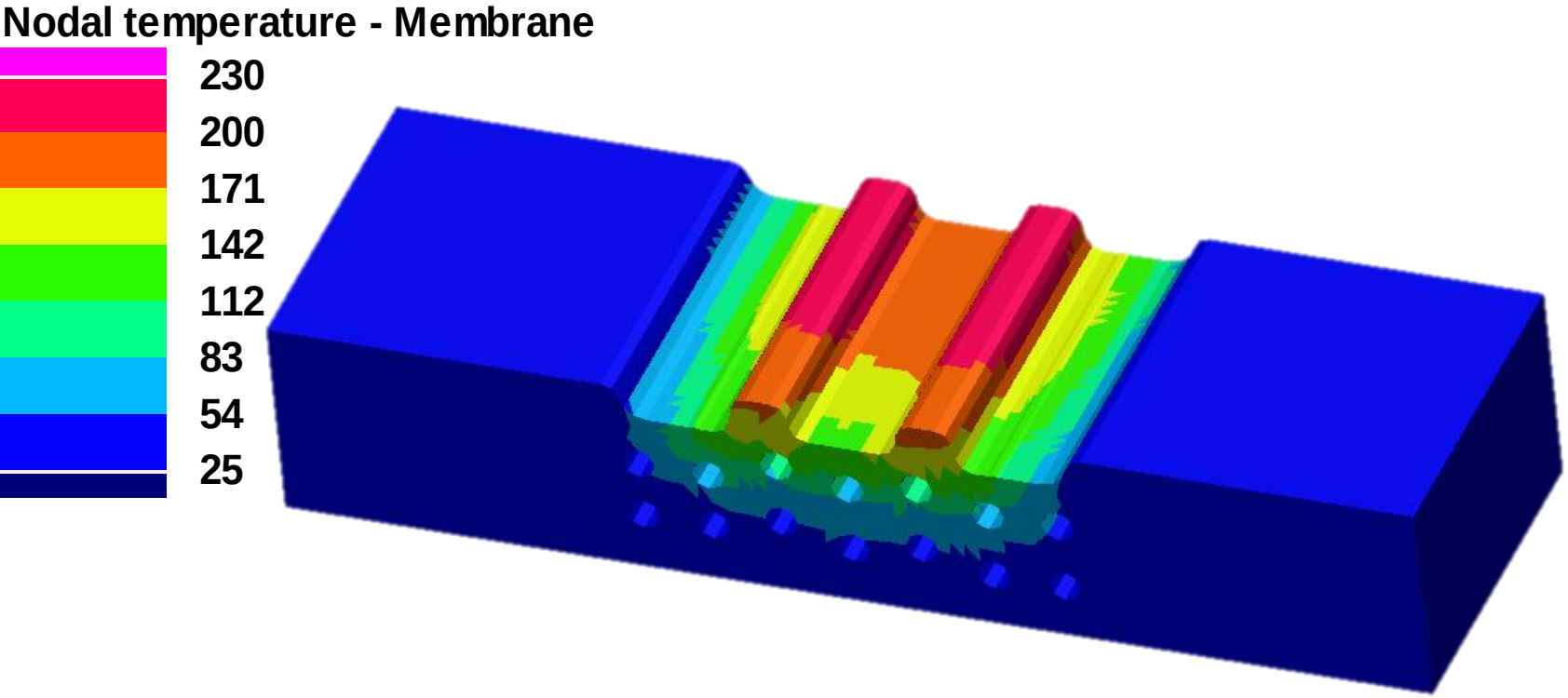


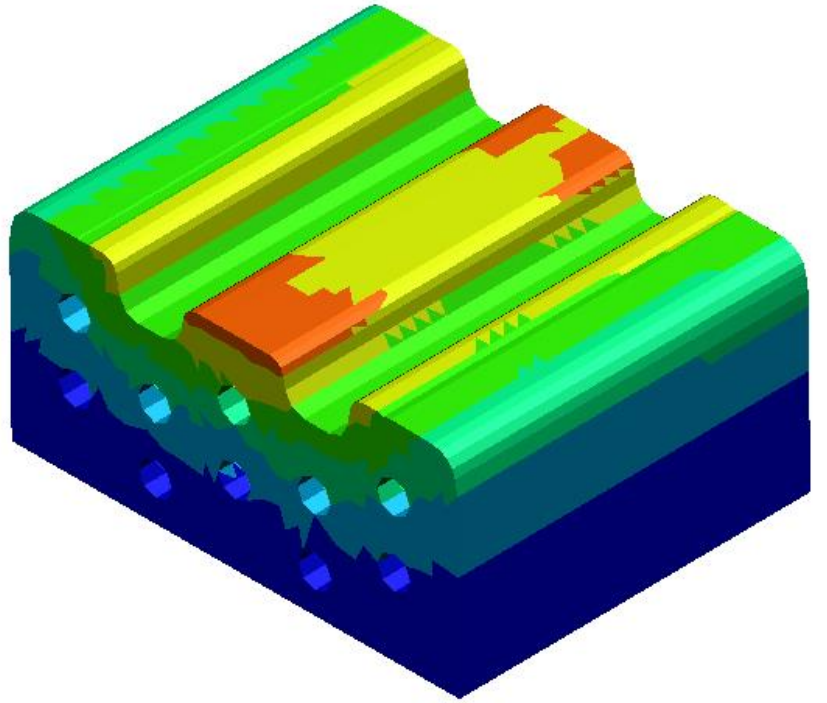
Colors other than gray: Thinning >20%.



Part stamped at the participating company

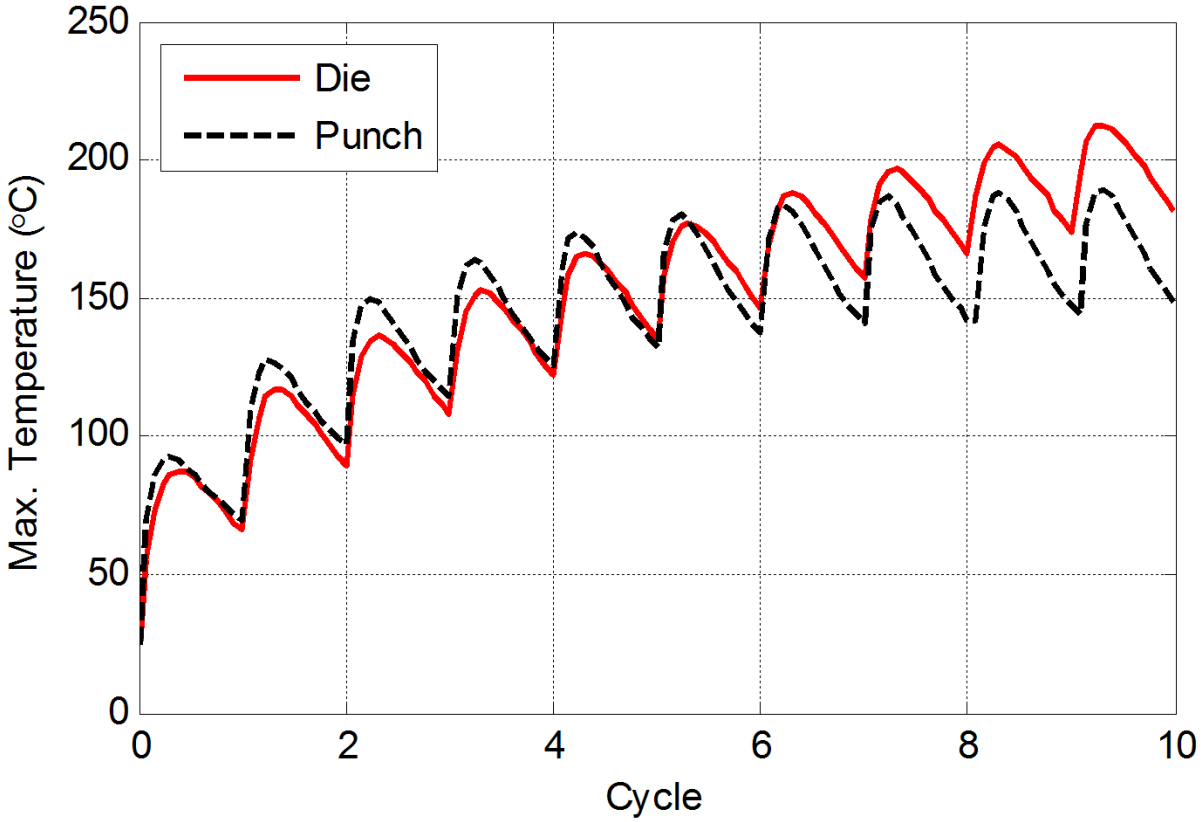
FE Simulation of cooling channel analysis

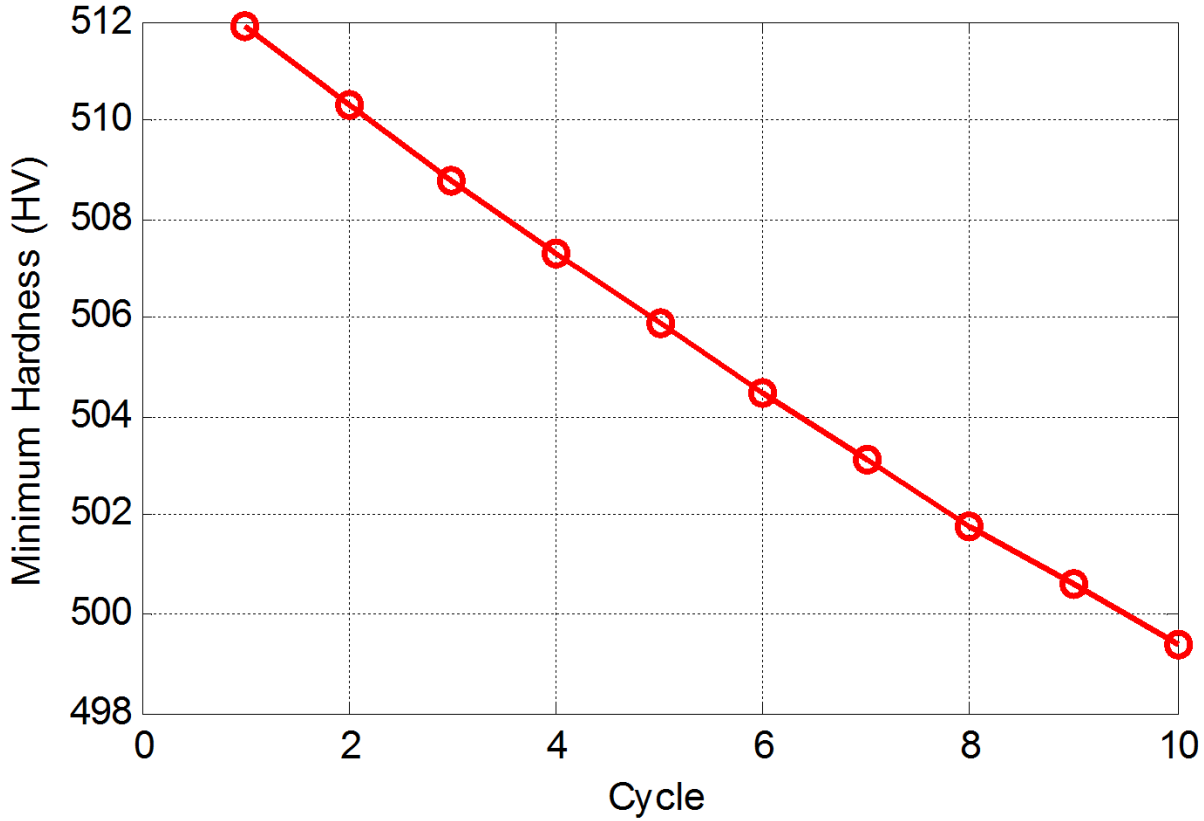




1.3 mm roof rail die,
After 10 stampings.

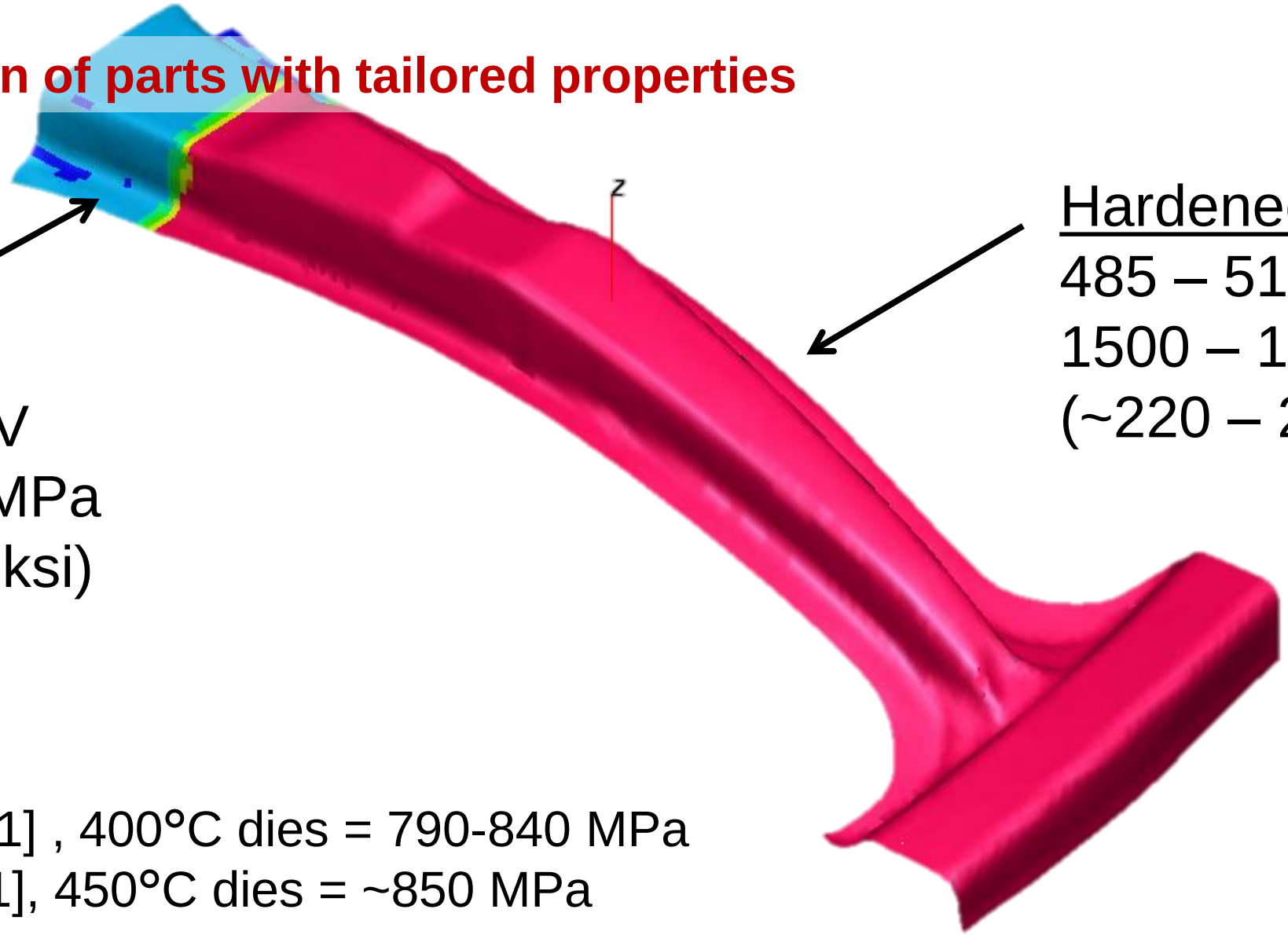
FE Simulation of cooling channel analysis





After 10 stampings.

FE Simulation of parts with tailored properties



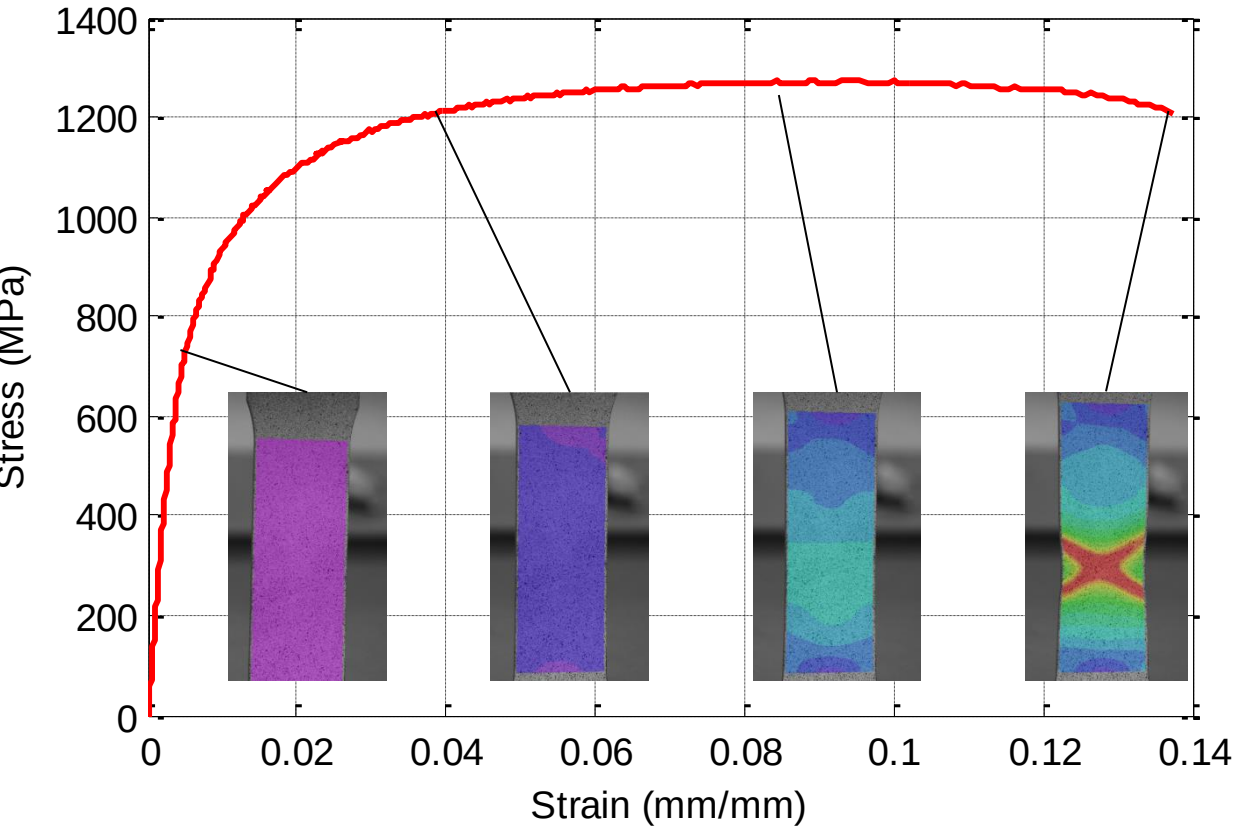
Soft zone:
310 – 330 HV
920 – 1020 MPa
(~135 – 150 ksi)

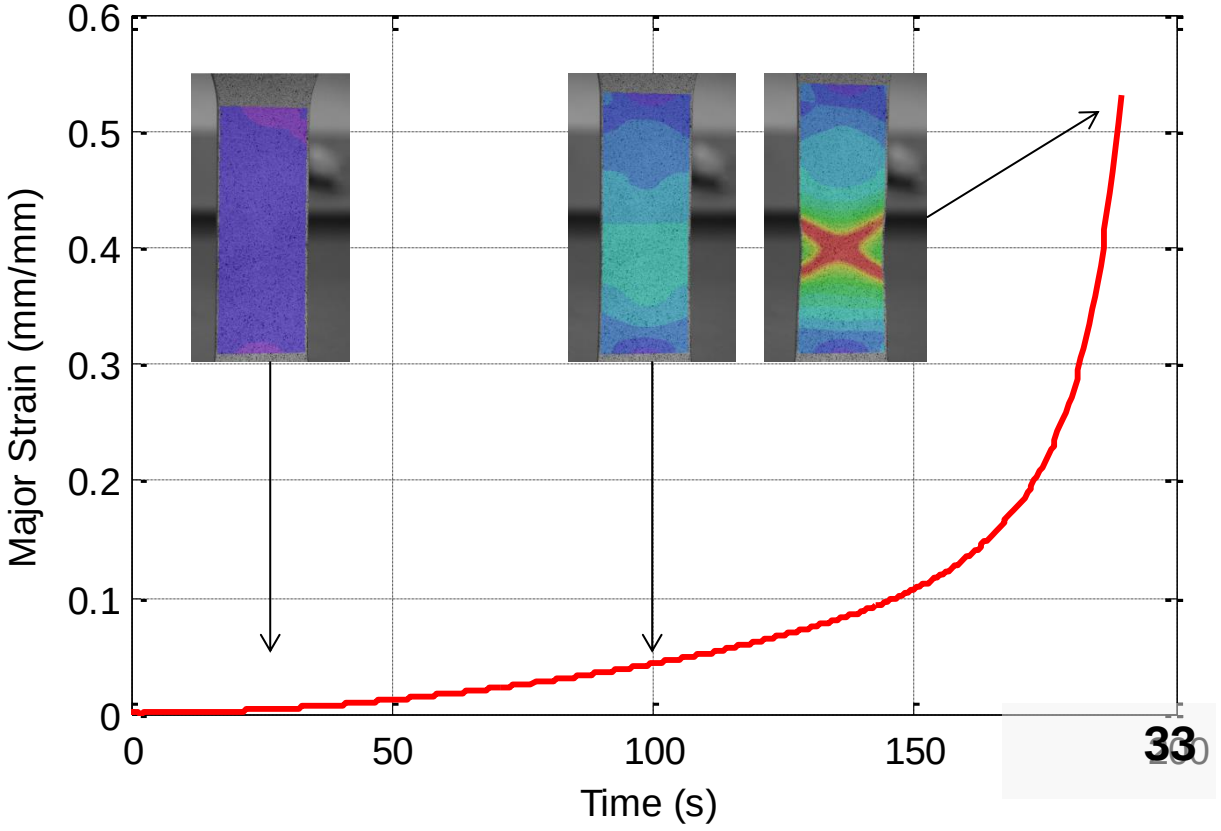
Hardened zone:
485 – 515 HV
1500 – 1590 MPa
(~220 – 230 ksi)

Literature:
[George 2011] , 400°C dies = 790-840 MPa
[Feuser 2011], 450°C dies = ~850 MPa

New Project: Prediction of Fracture

Prediction of fracture/necking from strain or thickness variations (tensile data from Jim Dykeman-Honda HRA)





Summary/ Outlook

1. Major Challenges in Forming AHSS (DP, TRIP, TWIP) include:

- lower formability (ductility) and higher probability of fracture
- variations in mechanical properties form batch to batch
- higher forming forces and high sheet/die interface pressures & temperatures
- Excessive tool wear, rapid increase in forming force and large reverse tonnage
- large springback due to large tensile strength

Summary/ Outlook

2. Forming of Al Alloys

- Becoming popular because of considerable weight savings
- Presents challenges in formability and tendency to fracture
- Presents opportunities for weight savings by using high strength Al alloys (thru warm forming)

3. Use of Servo Presses

- Increase productivity
- Offers flexibility in improving formability and effectiveness of lubricant by changing forming speed
- Have the potential to improve formability of AHSS and high strength Al alloys (possible competition to Hot Stamping Technology)

Questions/Comments

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