GREAT DESIGNS IN STEEL

Presentations will be available for download on SMDI's website on Wednesday, May 22

GREAT DESIGNS IN STEEL

BENTELER AUTOMOBILTECHNIK

BUSINESS UNIT STRUCTURES

BENTELER makes it happen

AGENDA

TOPIC	SPEAKER
BENTELER IN GENERAL Structure Figures	Paul Deller
NEW HOT FORM MATERIAL BTR 2000	Paul Deller
AVOID LASER CUTTING OF HF PARTS Adiabatic punching	Paul Deller
HOT FORMING PROCESS Closed HF Structure	Franz Schaefers
COLD FORMED GEN III MATERIAL OUTLOOK Material Simulations Tool trials Next steps	Franz Schaefers

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BENTELER IN GENERAL

BENTELER HISTORY

COURAGE. AMBITION. RESPECT. SINCE 1876.

1876
Carl Benteler opens an ironmongery store in Bielefeld, Germany

1916
Purchase of an engineering plant, two years later start of tube production

1935
First major order for the automotive industry

1980
First plant of BENTELER Automotive in the US

2002
First plant of BENTELER Automotive in China

2010
Foundation of BENTELER International AG, Salzburg, Austria

2015
BENTELER Steel/ Tube opens its first US-based tube plant in Shreveport, Louisiana

2015
BENTELER Distribution opens a central warehouse in Duisburg, Germany, with Europe's biggest high-rack storage for tubes

2017
BENTELER Automotive founds Business Unit "E-Mobility"

BENTELER makes it happen

BENTELER IN NUMBERS

	BENTELER Group	BENTELER Automotive
EMPLOYEES	about 30,000	about 26,000
LOCATIONS	141 in 38 countries	74 plants in 24 countries
SALES	8,072 € bn.	6,304 € bn.
	IN DIVISIONS	
	Automotive 76 %	
	Steel/Tube 15 %	
	Distribution 9 %	
INVESTMENT	429 € million	370 € million
R&D	87 € million	
PATENT APPLICATIONS	81	
NEW PLANTS IN 2017	5 in China 1 in Czech Republic 1 in Brazil	

BENTELER makes it happen

BENTELER AUTOMOTIVE PORTFOLIO

As a competent development partner we create individual solutions together with our customers.

STRUCTURES
Lightweight solutions for vehicle structures

CHASSIS & MODULES
Lightweight optimized suspension components as well as the development and assembly of highly complex modules

ENGINE & EXHAUST SYSTEMS
Powertrain systems and components to reduce emissions

ELECTRO-MOBILITY
Complete and lightweight optimized system solutions for new electric vehicles

MECHANICAL ENGINEERING
Innovative machines, systems and tools for the automotive industry

LIGHTWEIGHT PROTECTION
Development and production of protective solutions for various customers and market segments

BENTELER makes it happen

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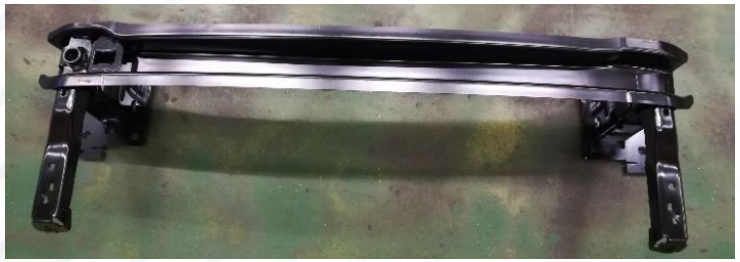
NEW HOT FORM MATERIAL
BTR 2000 TARGET / MOTIVATION

Target	Solution
▪ Light weight structural solutions ▪ Increased crash requirements for BEV ▪ Best Weight/Cost Ratio	Higher-strength hot forming steel



Process

- Austenitization of BTR2000 in a continuous furnace with decarburization of the surface layer
- Hot forming and press hardening to the required product

Customer Benefit / Motivation

- Weight savings compared to regular BTR165
- Increased crash requirements can be met with BTR2000
- BENTELER standard hot forming lines can be used with only slight adjustments

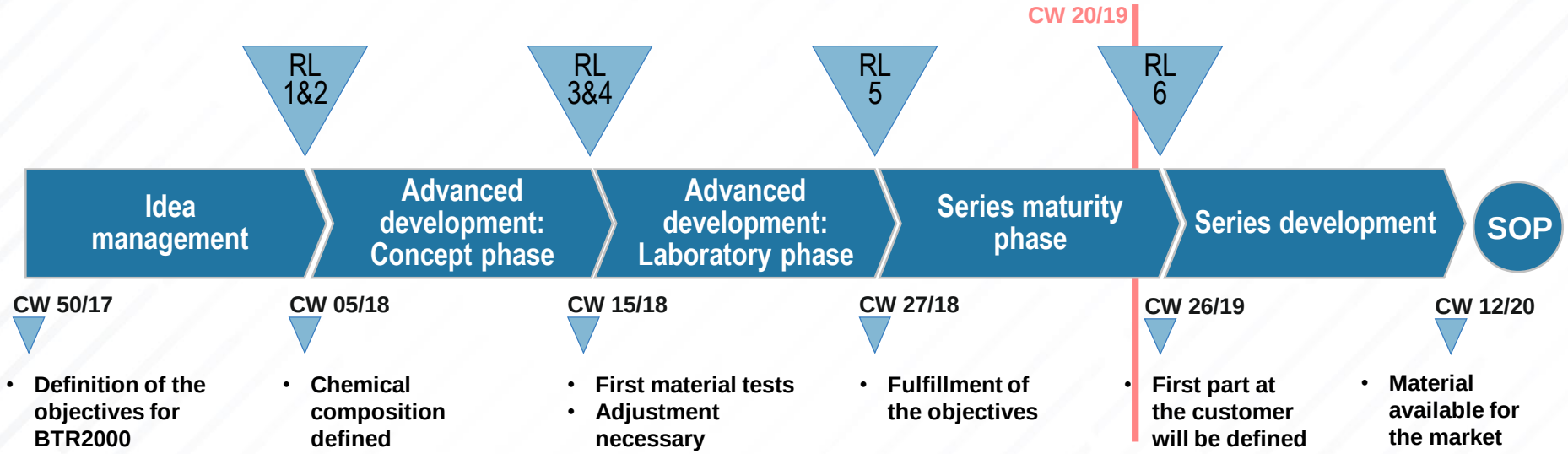
Milestones

▪ Project Start	IV.QRT 2017
▪ Project End (RL6)	I.QRT 2020
▪ Current	RL 5

BTR Explanation = BENTELER TUERVERSTAERKUNGS ROHR
BENTELER DOOR REINFORCEMENT TUBE

NEW HOT FORM MATERIAL

BTR 2000 TIMING



NEW HOT FORM MATERIAL
BTR 2000 TECHNICAL INFORMATION

	BTR165 t=1.8mm press-hardened	BTR165 t=1.8mm press-hardened + KTL	BTR2000 t=1.8mm press-hardened	BTR2000 t=1.8mm press-hardened + KTL
$R_{p0,2}$ [MPa] > 1200/1300	1020	1140	1360	1540
R_m [MPa] > 2000/1800	1600	1520	2040	1850
A_{30} [%] > 6	8.7	9.0	8.6	8.8

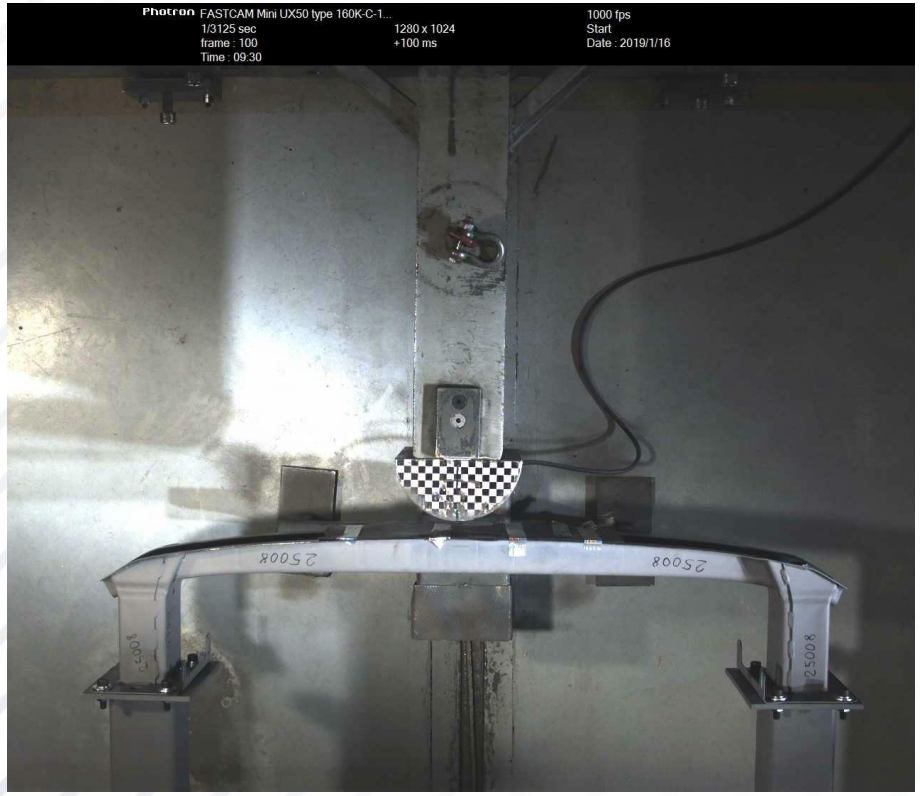
KTL = Cathodic dip painting

NEW HOT FORM MATERIAL
BTR 2000 TECHNICAL INFORMATION

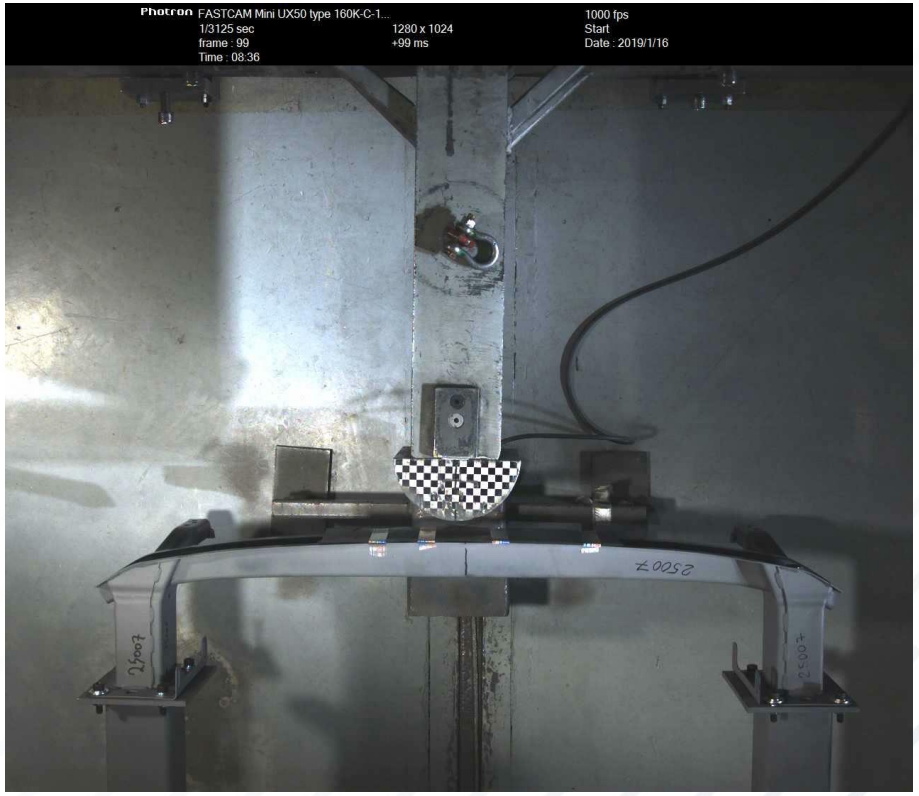
CMS front Pole Test

Velocity: 15km/h / Mass: 1200kg / Pole-diameter: 178mm / t=1,8mm

BTR165



BTR2000

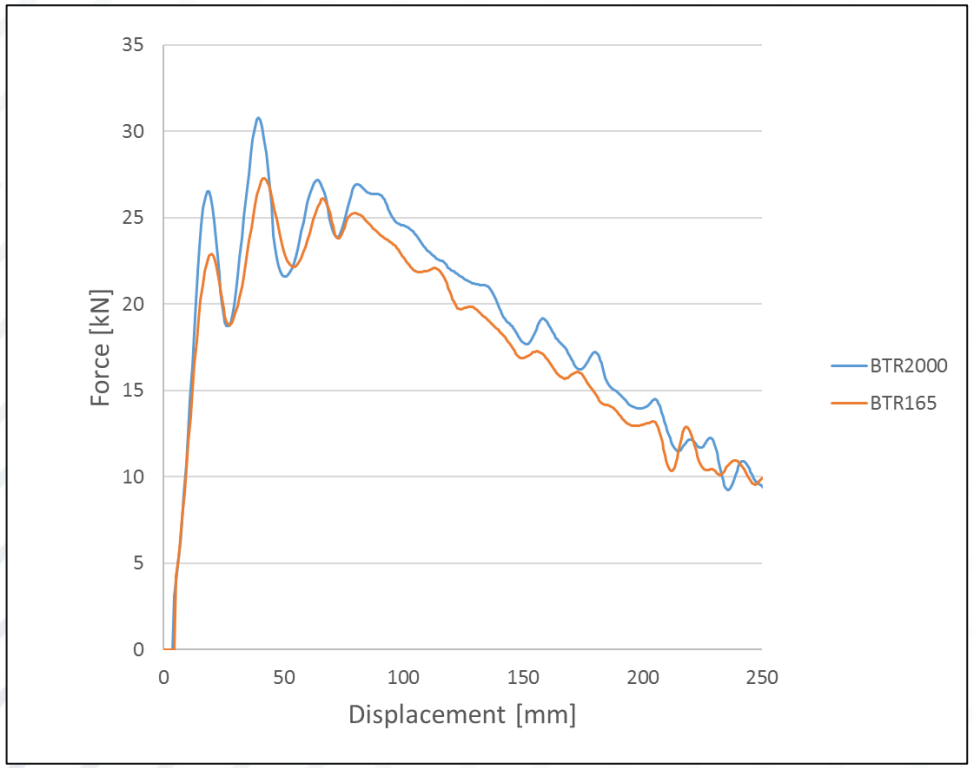


NEW HOT FORM MATERIAL
BTR 2000 TECHNICAL INFORMATION

CMS front Pole Test

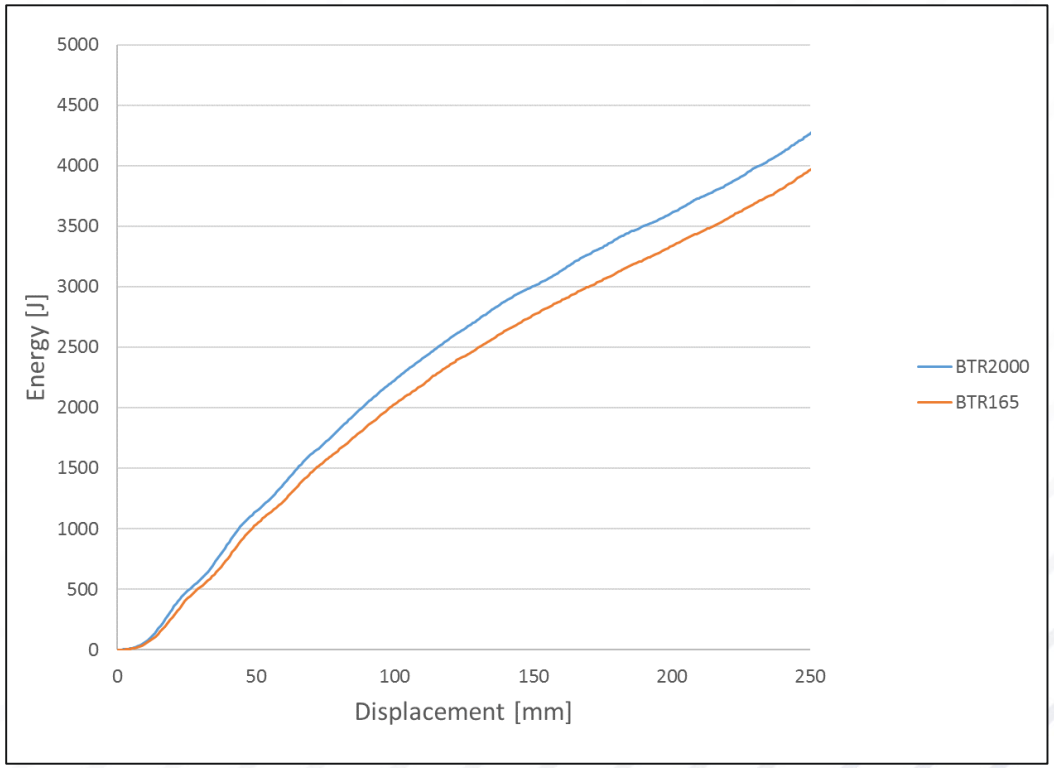
Velocity: 15km/h / Mass: 1200kg / Pole-diameter: 178mm / t=1,8mm

Force - Displacement



- Force absorption is increased by 13%

Energy - Displacement



- Energy absorption is increased by 9%

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AVOID LASER CUTTING OF HF PARTS

TARGET / MOTIVATION

Target

- Reducing/Eliminate Laser cutting
- Reducing Investment
- Reducing part cost

Solution

Adiabatic punching for hot formed coated boron steel

Process

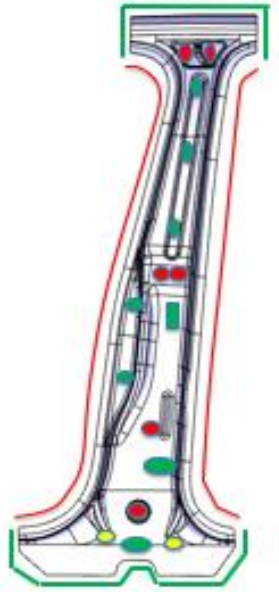
- Using the BENTELER Impact Actuator (BIA)
- Accelerating the punch to a minimum impact speed > 6 m/s

Milestones

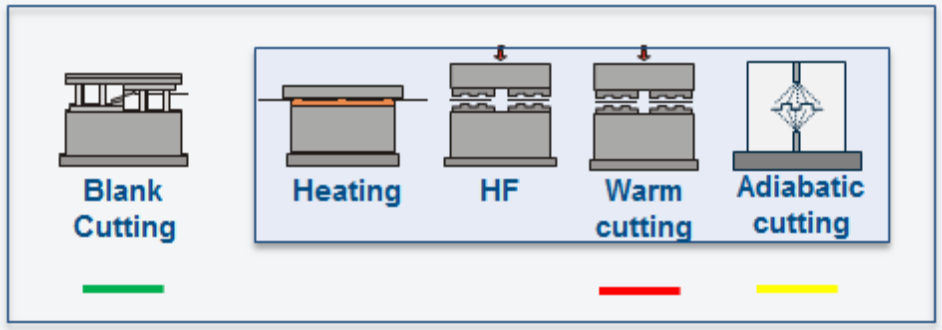
Project Start	III. QRT 2016
Project End (RL6)	II. QRT 2019
Current	RL 5

Customer Benefit / Motivation

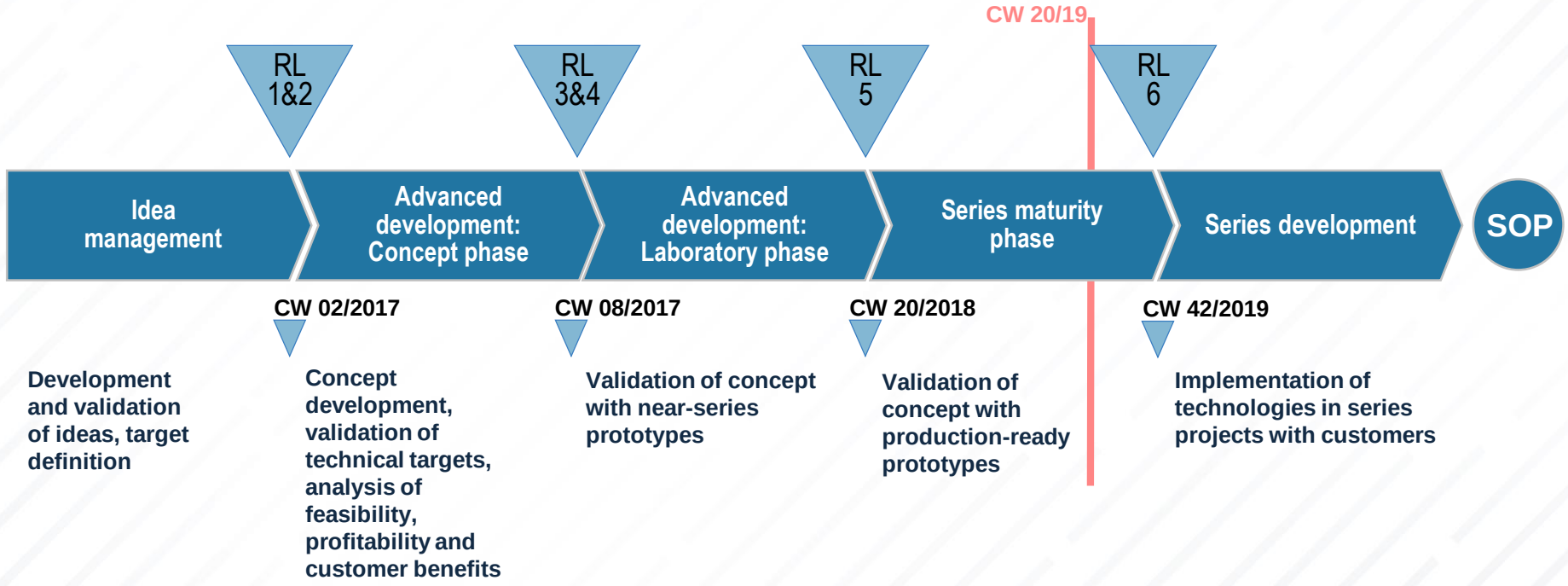
- Hardened sheet-metal-parts, finished without Lasering
- Applicable on hot formed parts from boron steel, in particular from pre-coated steel sheets
- Substitute for small-area Laser cutting



Process Flow

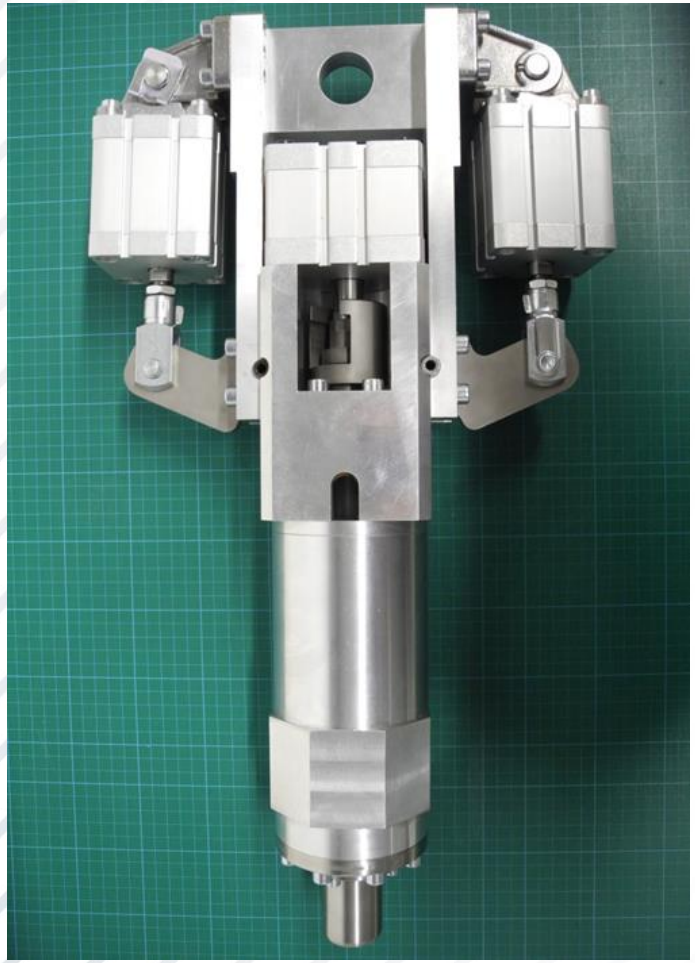


AVOID LASER CUTTING OF HF PARTS
TIMING



AVOID LASER CUTTING OF HF PARTS
CONCEPT

Demonstration Device



Prototype Test Rig

Pre-serial Machine

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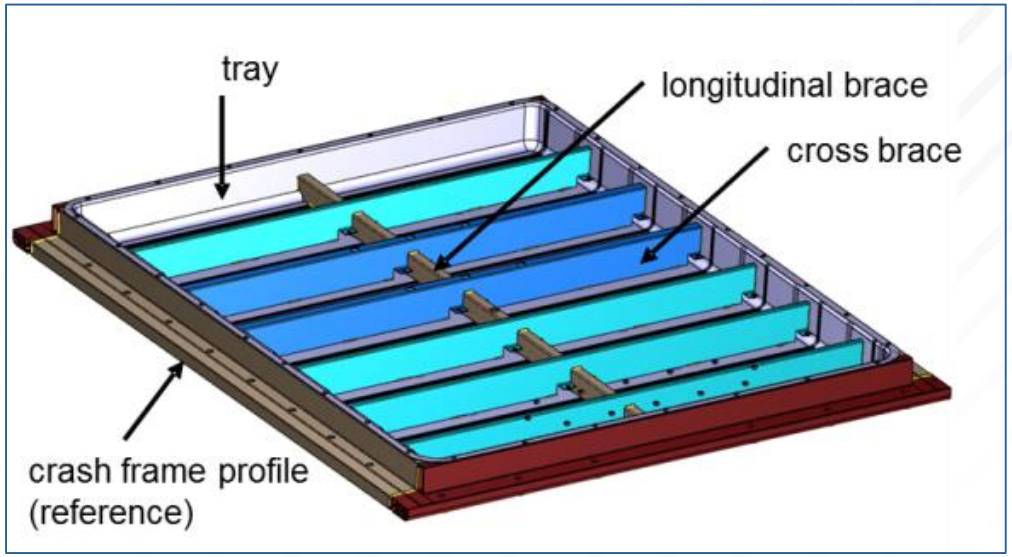
HOT FORMING PROCESS
CLOSED HOT FORMING STRUCTURE

Substitution of crash frame profile with

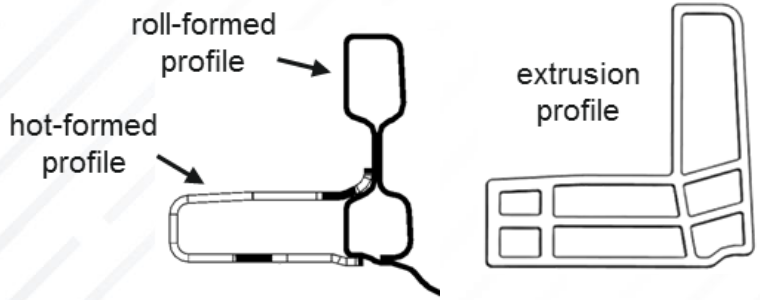
closed hot-formed steel profile in outer frame.

Targets:

- ⇨ Comparable weight
- ⇨ Cost reduction
- ⇨ Same crash performance
- ⇨ Improved life cycle assessment

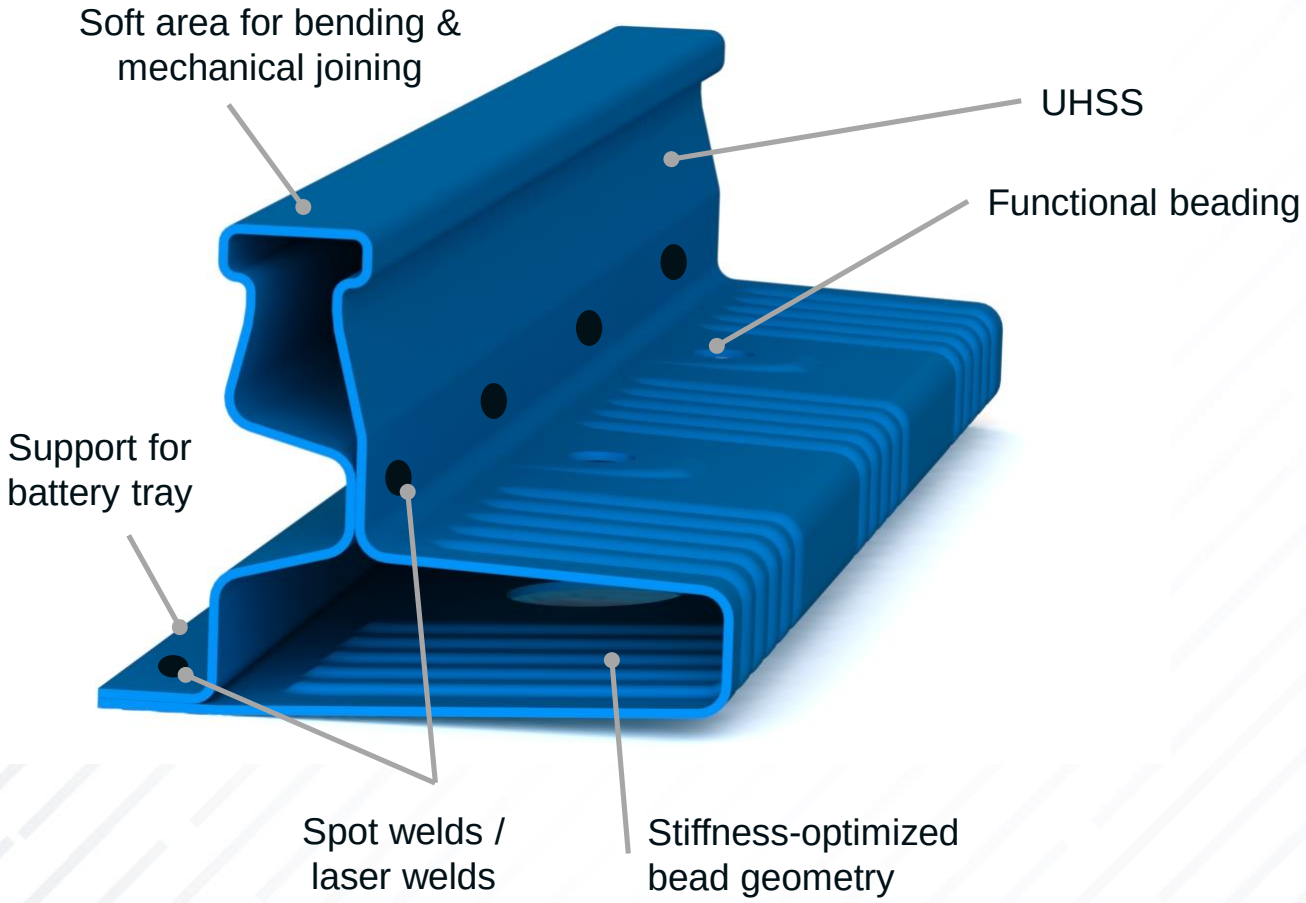


Reference geometries



First closed hot-forming design

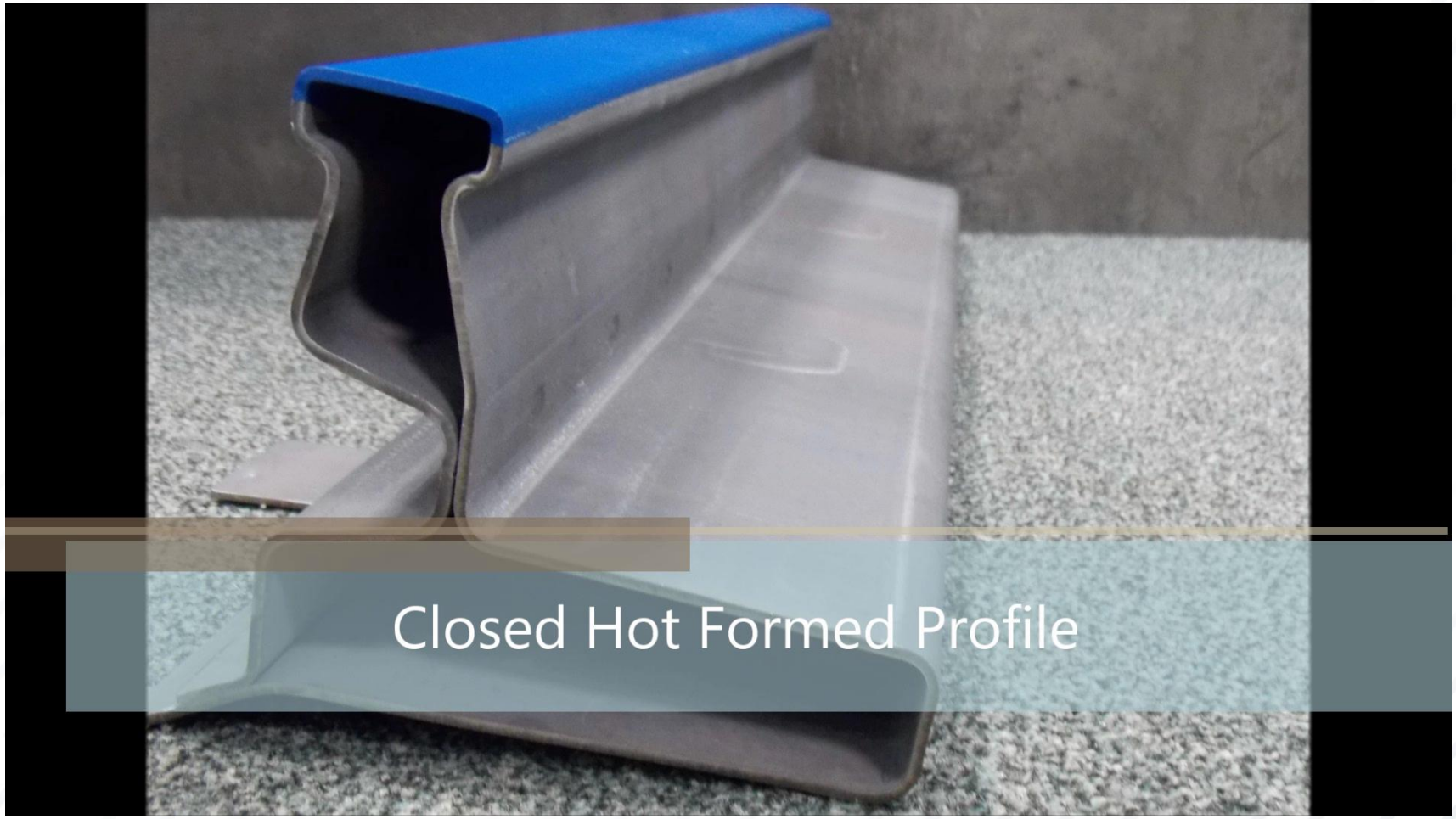
HOT FORMING PROCESS
CLOSED HOT FORMING STRUCTURE



Advantages
- Reduced material cost
- Cost efficient lightweight
- Global material availability
- Standardized hot form process
- Technology for high volume production
- Variable cross sections
- Function integration
- Crash optimization

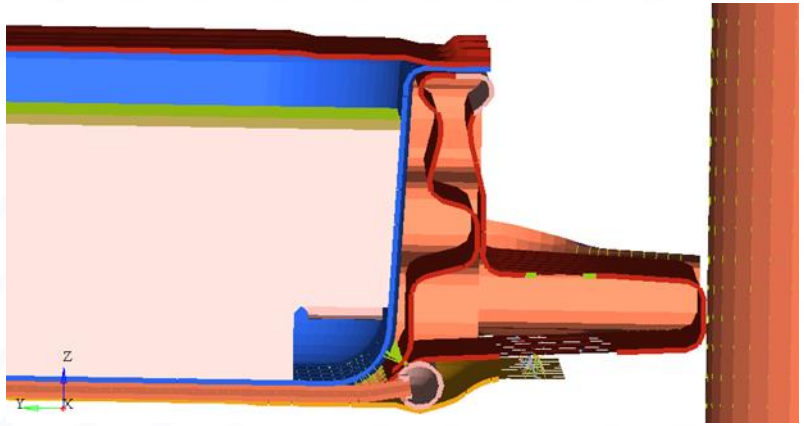
HOT FORMING PROCESS

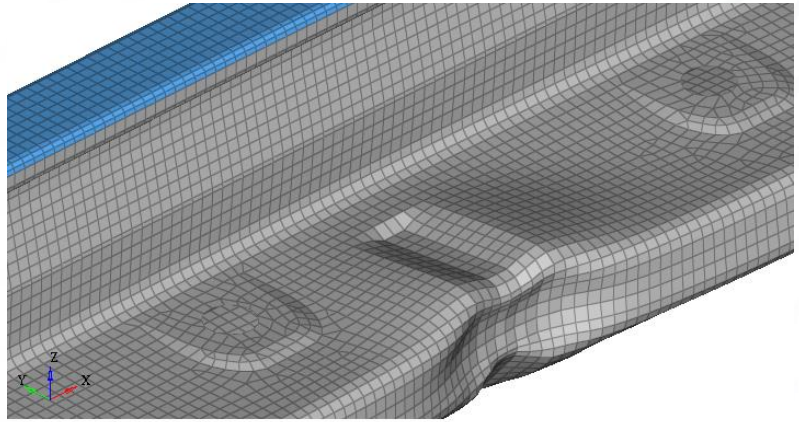
CLOSED HOT FORMING STRUCTURE



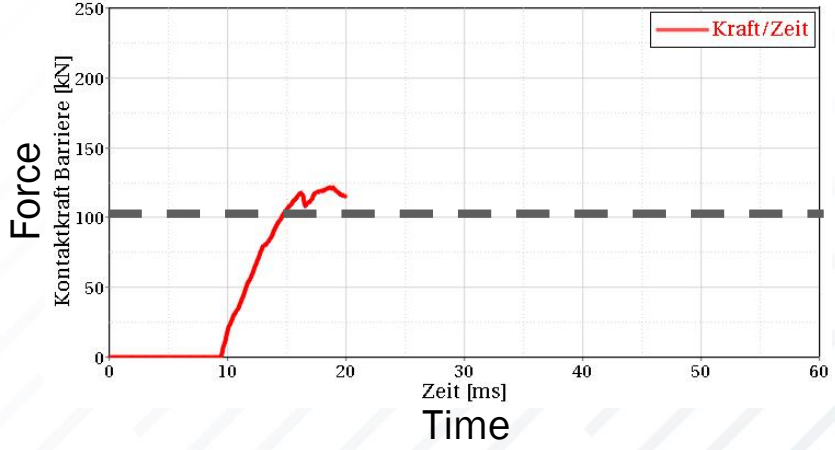
HOT FORMING PROCESS

CLOSED HOT FORMING STRUCTURE SIMULATIONS



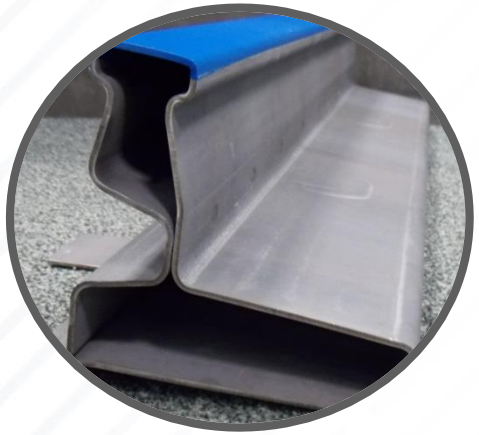


No intrusion in battery at 100 kN crush test with simple beading design.



HOT FORMING PROCESS

CLOSED HOT FORMING STRUCTURE
STATUS OF DEVELPMENT



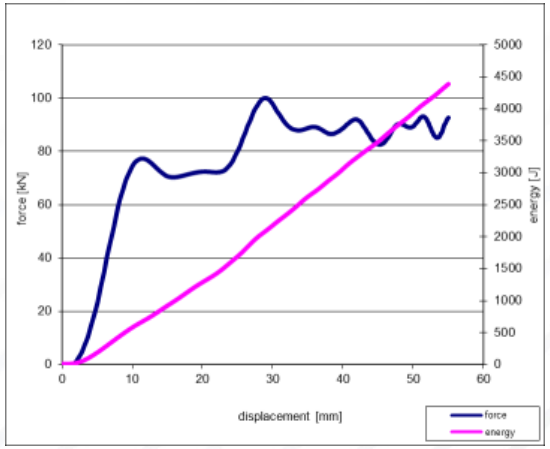
Prototyping

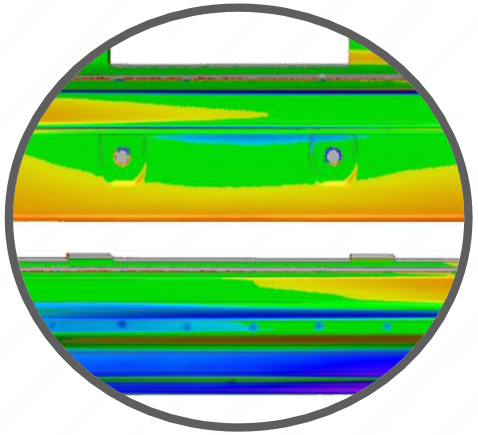
Successful prototyping of closed hot-formed profile

- AlSi-coated press hardening steel (> 1400 MPa)

Performance Tests

Successful performance tests for quasi-static loads and crash loads

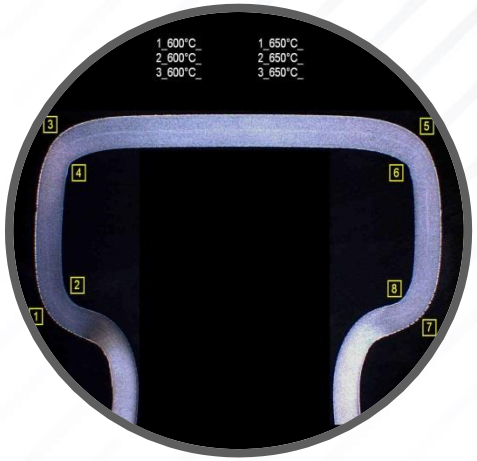




3D Geometry

Possible difficulties with close tolerances for long profile geometries due to warping after hot forming

- Warping simulation ongoing



Material Testing

Investigation of hardness, material strength and micro structure

- Fulfilment of prototype targets

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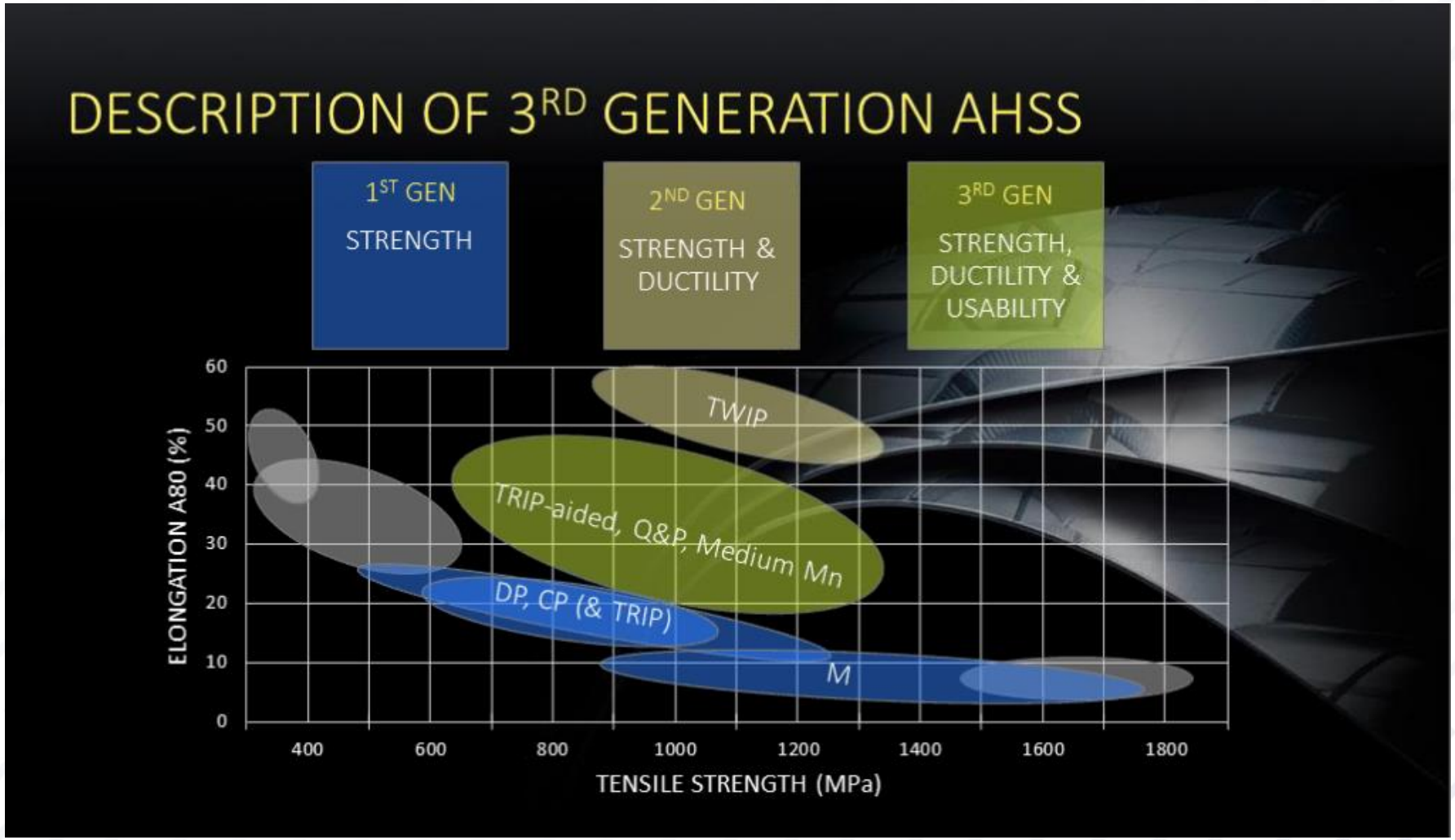
CF GEN III MATERIAL OUTLOOK

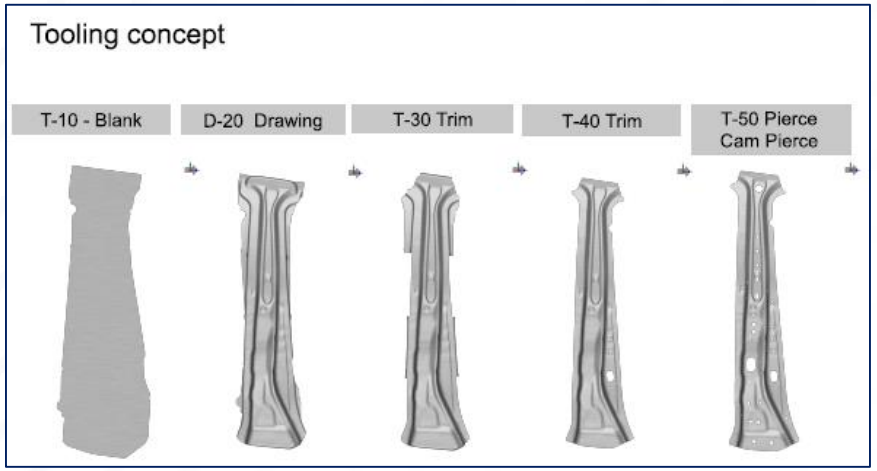
Overview

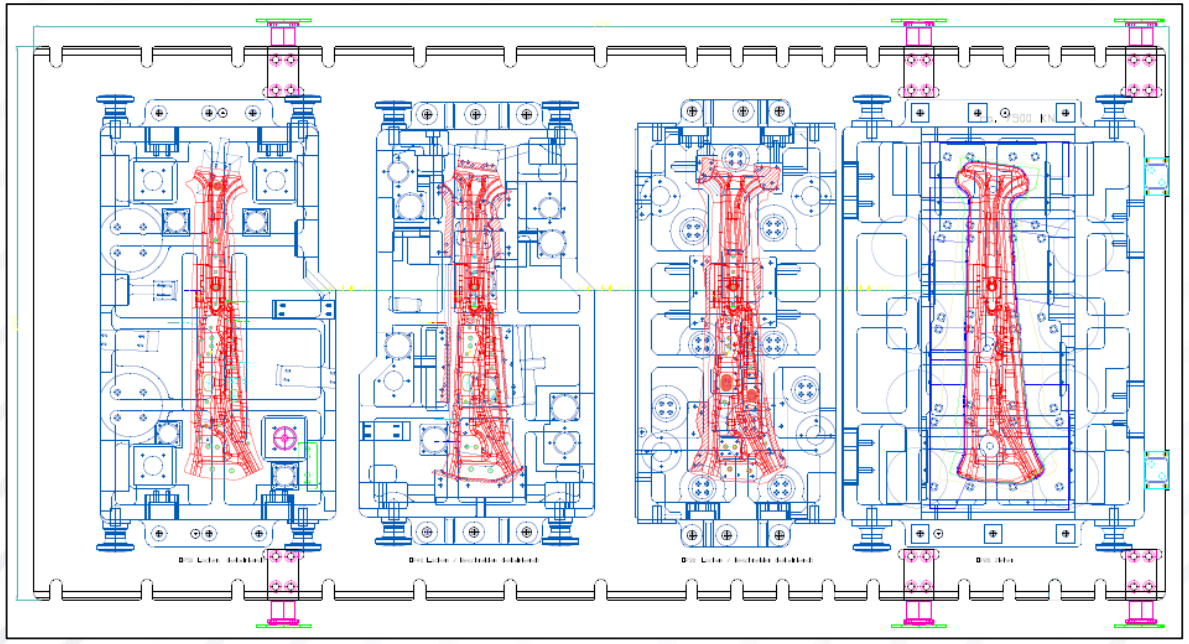


Source: SSAB

CF GEN III MATERIAL OUTLOOK

Tooling concept:





CF GEN III MATERIAL OUTLOOK

Overview / results of material simulations

MATERIAL	MATERIAL TYPE	SIMULATION OK / NOK	TOOL TRIAL OK / NOK
Mat. 01: YS 700 - / TS 1050 -	DH	OK	OK
Mat. 02: YS 850 - / TS 1180 -	DH	NOK	OK
Mat. 03: YS 700 - / TS 1020 – (GI60/60)	CP	OK	OK
Mat. 04: YS 450 - / TS 950 -	TWIP	OK	OK
Mat. 05: YS 600 - / TS 980 -	DH	OK	OK
Mat. 06: YS 850- / TS 1180 -	TRIP	NOK	OK
Mat. 07: YS 600 - / TS 980 -	TRIP	OK	OK
Mat. 08: YS 850 - / TS 1180 -	TRIP	NOK	OK
Mat. 09: YS 1130 - / TS 1470 -	DP	NOK	NOK
Mat. 10: YS 850 - / TS 1180 -	DH	OK	NOK
Mat. 11: YS 700 - / TS 980	DH	OK	OK
Mat. 12: YS 780 - / TS 980 -	CP	NOK	OK
Mat. 13: YS 900 - / TS 1180	CP	NOK	OK
Mat. 14: YS 590 - / TS 980 – (GI70/70)	DP	OK	OK

Simulations based on a current B-Pillar design.
NOK simulations = Part geometry changes needed to achieve OK results (NOK = cracks, NOK = risk of cracks)

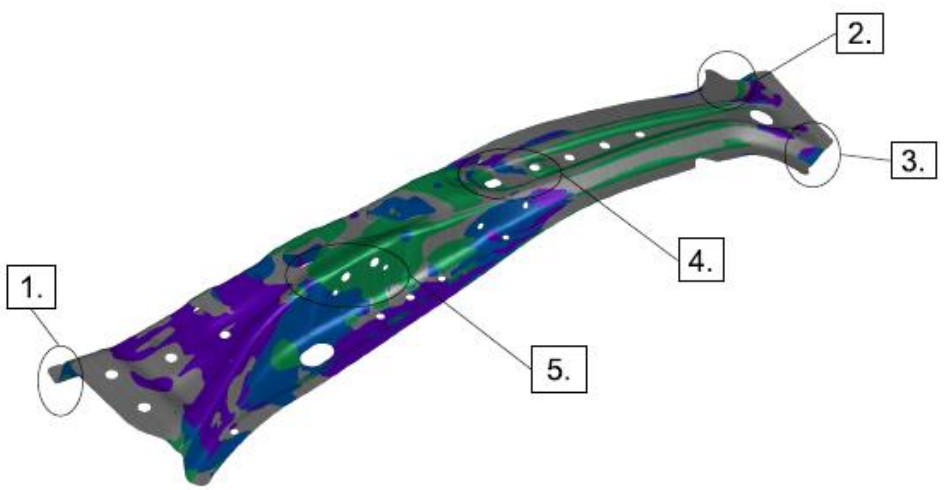
CF GEN III MATERIAL OUTLOOK

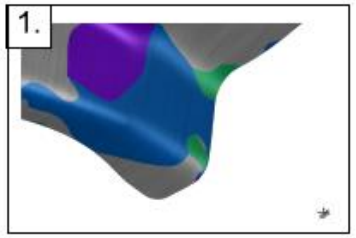
Simulation result shown based on one material:

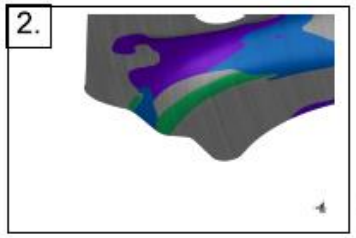
FLD / Formability

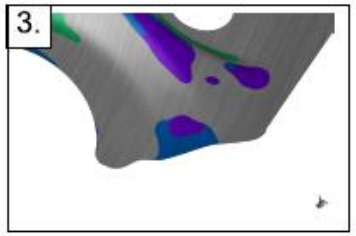
Final Part

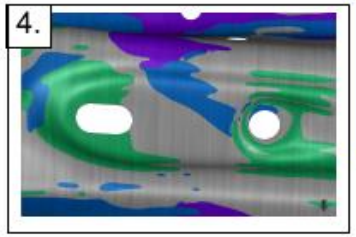
RH

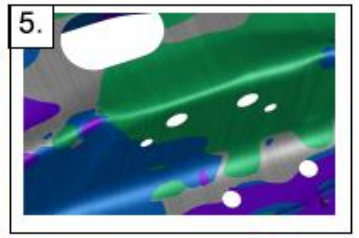


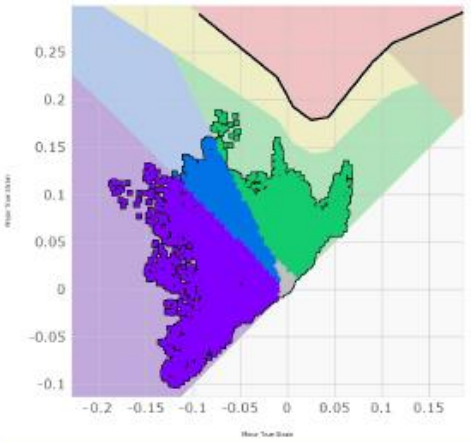








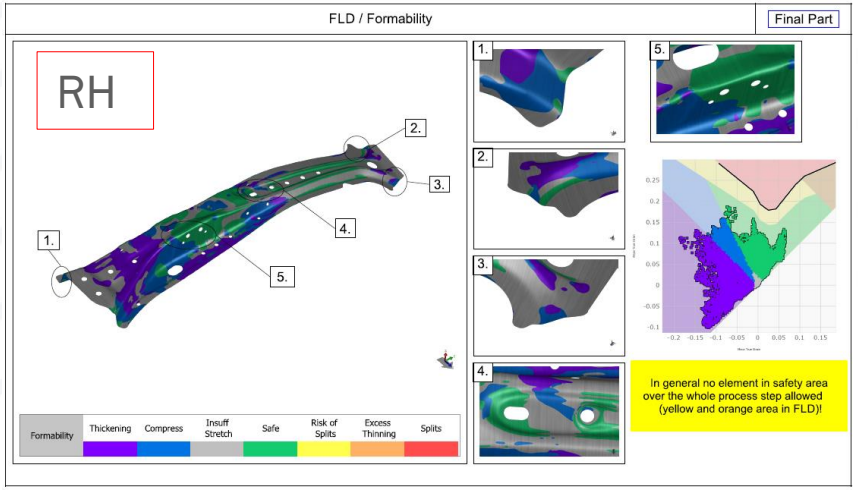


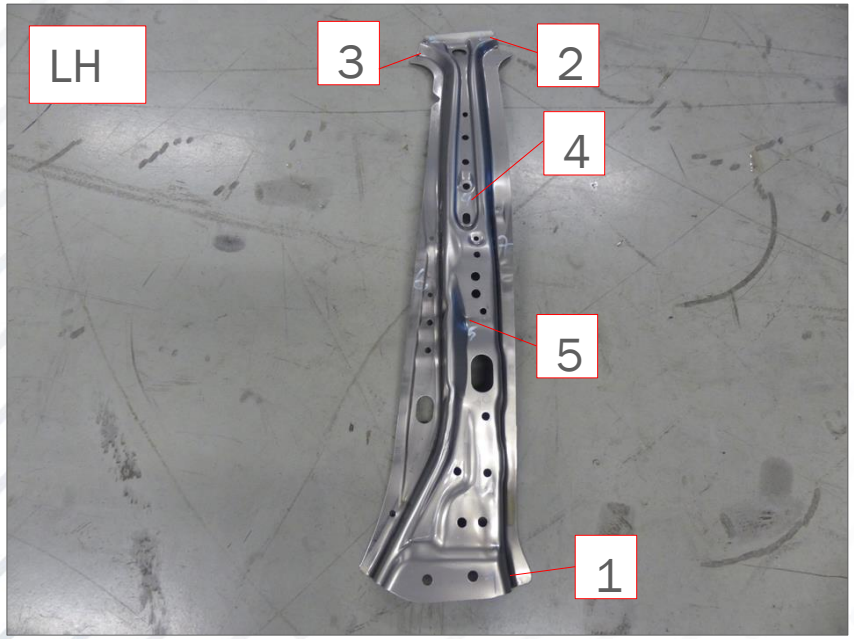


In general no element in safety area over the whole process step allowed (yellow and orange area in FLD)!

CF GEN III MATERIAL OUTLOOK

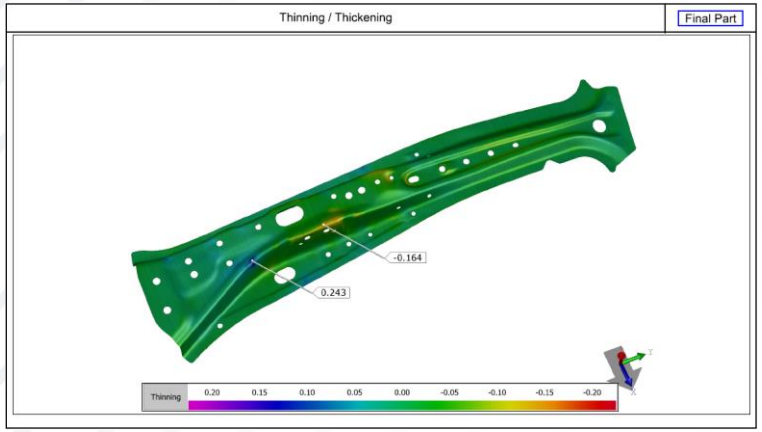
Simulation result shown based on one material:

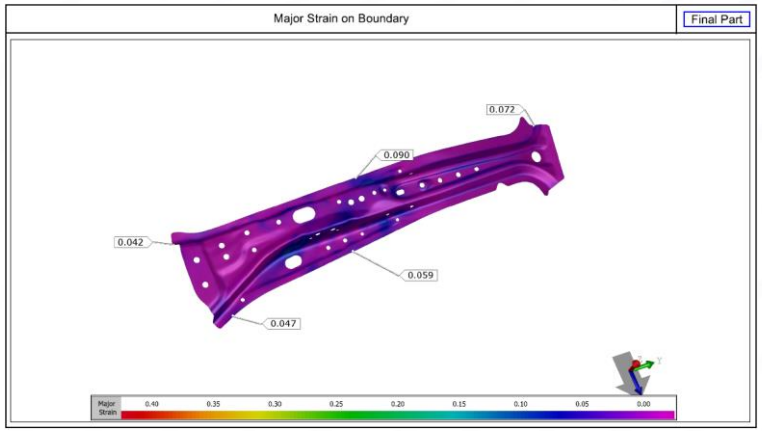


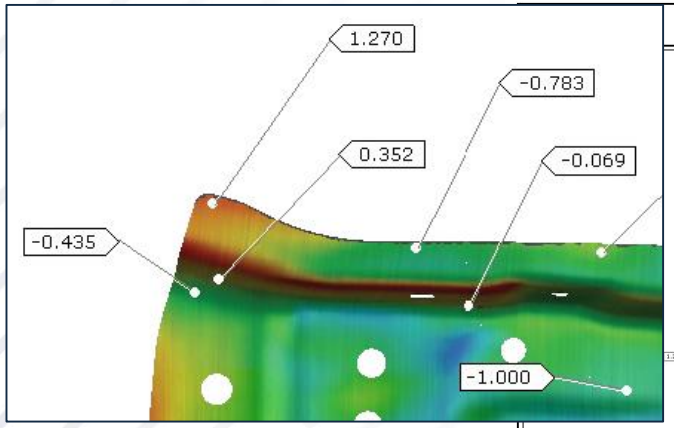


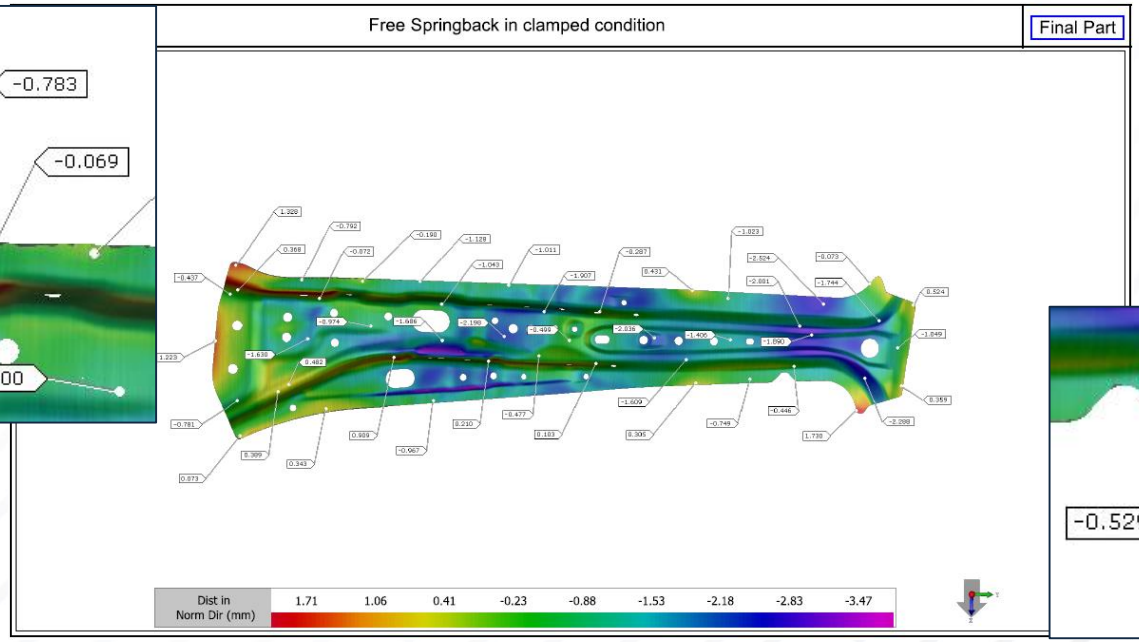
CF GEN III MATERIAL OUTLOOK

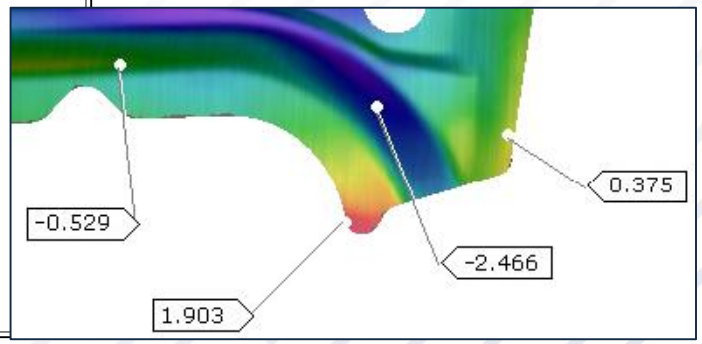
Simulation result shown based on one material:





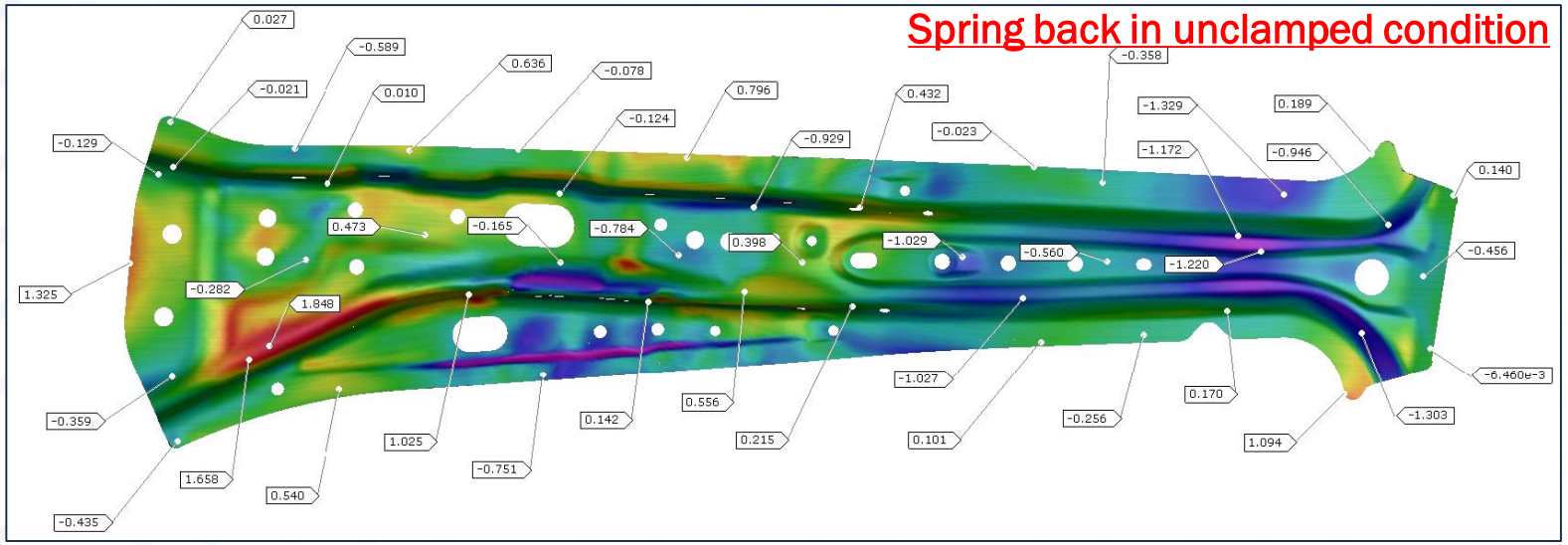


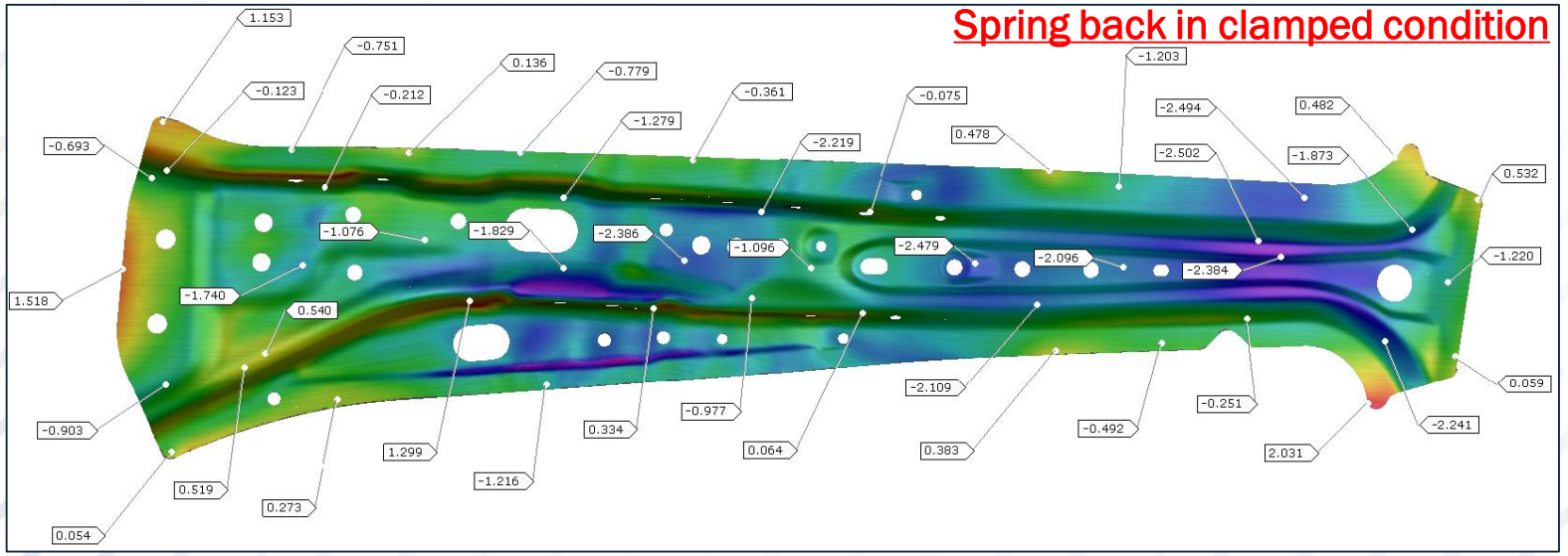




CF GEN III MATERIAL OUTLOOK

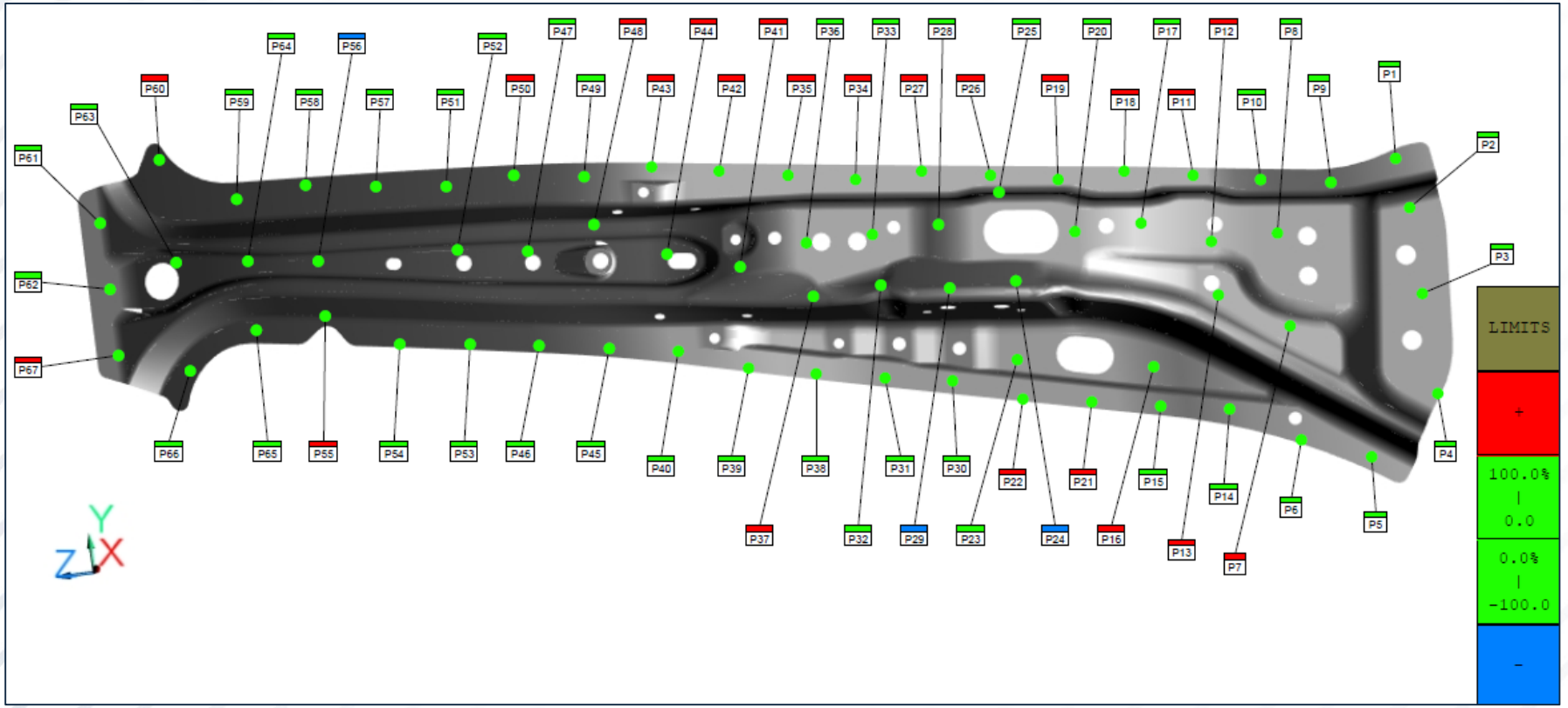
Simulation result (spring back) shown based on one material:

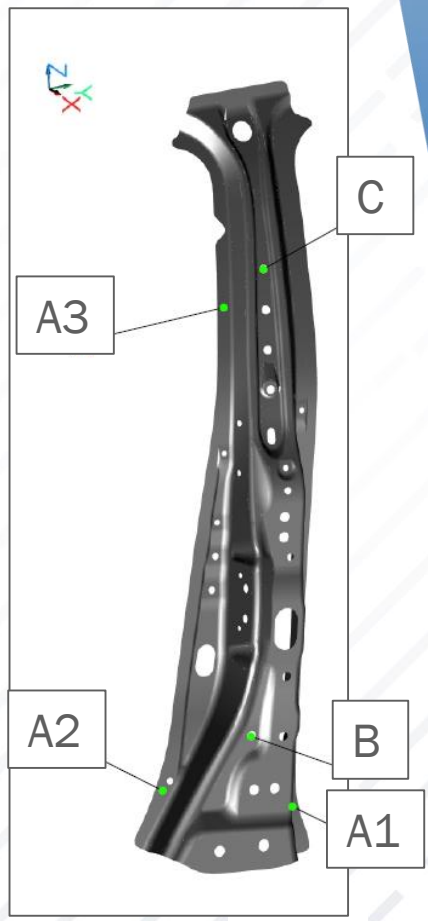


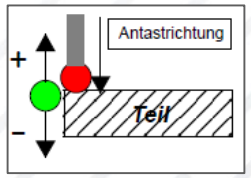


CF GEN III MATERIAL OUTLOOK

Measurement result shown based on one material:







Tolerances:	+/- 0.50 mm
3D:	Hole A1; A2; A3
2D:	Hole B; C
Zero:	Hole B

CF GEN III MATERIAL OUTLOOK

Tool trial results:

Material 1

Material 3

Material 7

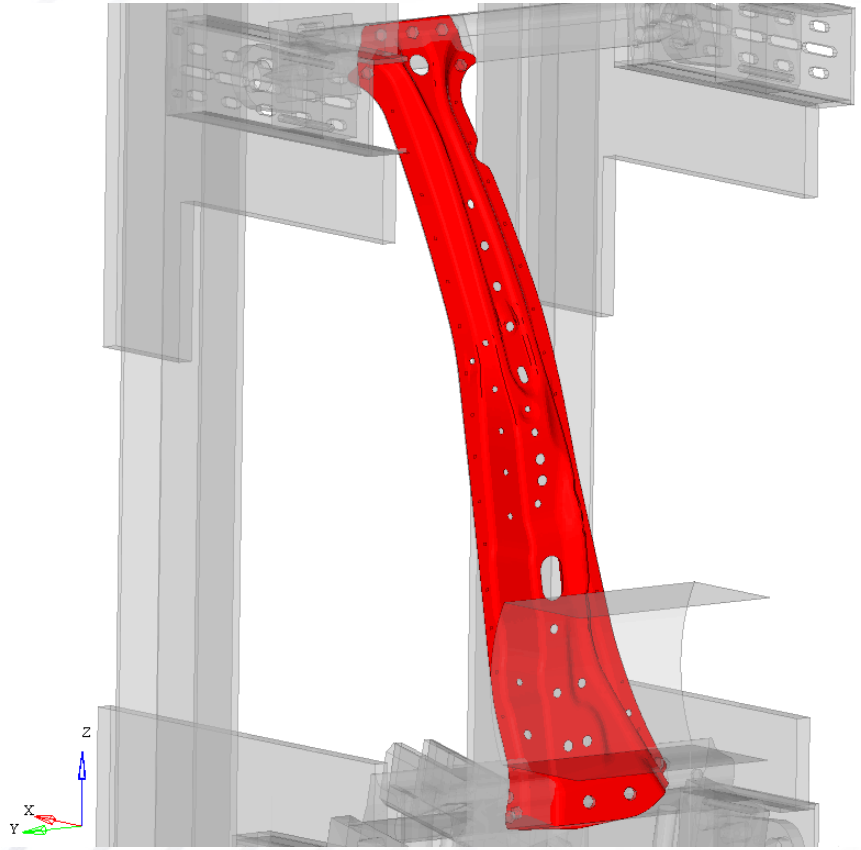
Material 10

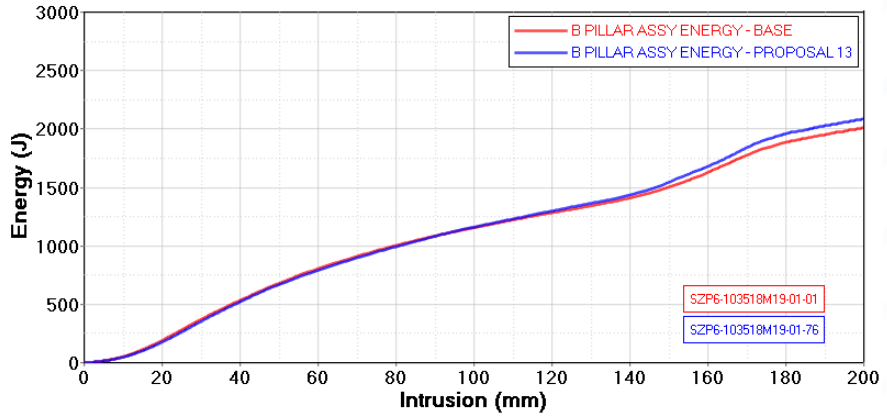
CF GEN III MATERIAL OUTLOOK

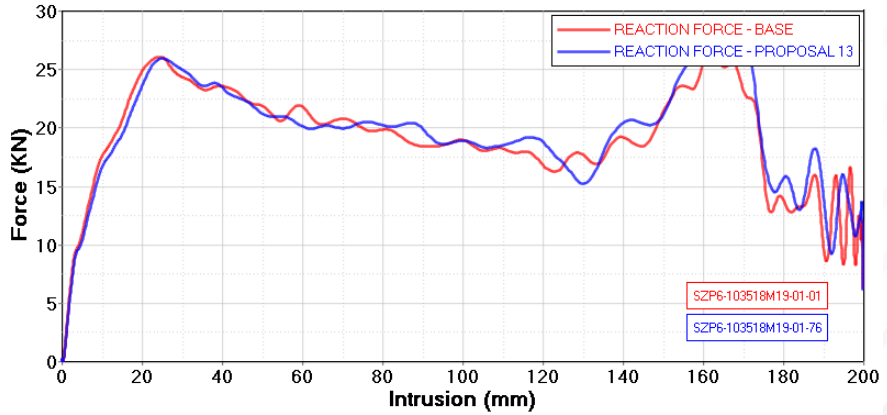
Potential weight reduction:

RESULT COMPARISON

BASE DP980 VS MATERIAL 2







	Thickness (mm)	Mass (kg)
Base - CR590Y980T-DP (ArcelorMittal)	1.40	2.466
Material 2 (Dual phase steel, YS 850, TS 1180)	1.30	2.290

Potential weight reduction = - 0.176 kg

CF GEN III MATERIAL OUTLOOK

Next steps / Validation process at BENTELER:

- Measuring of all produced parts at BENTELER plant Talle, Paderborn in regards to:
  - Part geometry
  - Spring back
  - …
- Tool design modifications to reduce / avoid spring back
- Welding trials
  - First welding trials with material 2 & 10 (Due to highest potential weight reduction)
  - Planned closing plate: DP600, 1mm thickness
  - SEP1220-2 (spot welding) information from steel supplier needed
  - Planned start: Week 25/2019
- ..

MANY THANKS FOR YOUR ATTENTION!

ANY ADDITIONAL QUESTION / TOPIC COULD BE DISCUSSED IN THE BOOTH!

CONTACT

Paul Deller
Customer Engineering Manager NAO
Division Automotive
Business Unit Structures

BENTELER Auburn Hills
2650 N. Opdyke Rd, Auburn Hills
MI 48326
USA

Phone: +1 248 364-7297
Mobile: +1 248 4107877
E-Mail: paul.deller@benteler.com
www.benteler.com

CONTACT

Franz Schaefers
Customer Engineering Manager Global
Division Automotive
Business Unit Structures

BENTELER Automobiltechnik GmbH
An der Talle 27-31
33102 Paderborn
Germany

Phone: +49 5254 81 303646
Mobile: +49 172 6377813
E-Mail: franz.schaefers@benteler.com
www.benteler.com

GREAT DESIGNS IN STEEL

Presentations will be available for download on SMDI's website on Wednesday, May 22