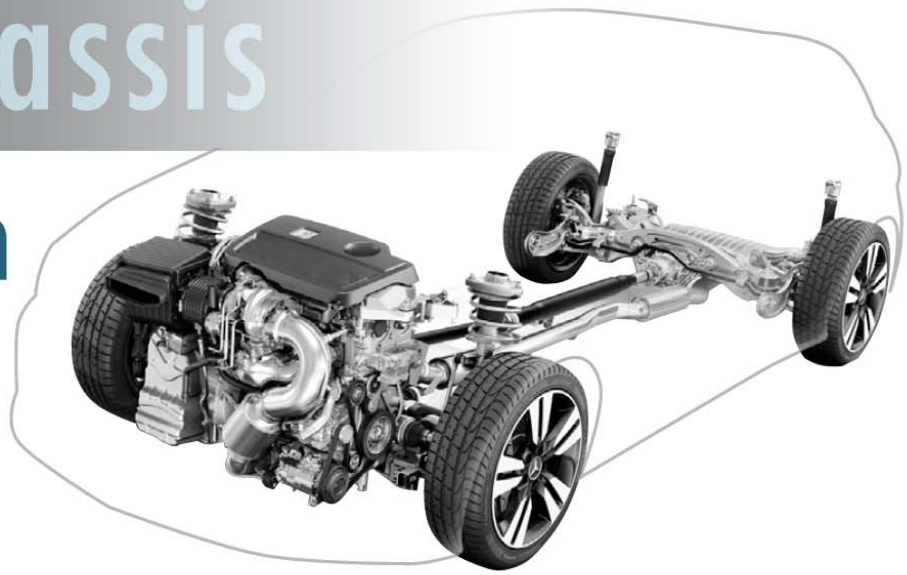
HMGF – HOT METAL GAS FORMING

Innovative Forming Technology for Lightweight Chassis & Frame Design

International Conference

Lightweight Chassis & Frame Design

Minimize weight – maximize profit!
Current use, developments and challenges of existing and future lightweight technologies for automotive chassis and frame design.



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CONTENT

- Motivation / approaches for lightweight designs
- Benefits of sheet and tube hydroforming
- HMGF of lightweight metals
- HMGF of steel grades
  - HMGF of stainless steels
  - HMGF of manganese boron alloyed steels
- HMGF – potential applications and market

Motivation / Approaches for Lightweight Designs

Lightweight materials

⇨ Low density materials

- Aluminium
- Magnesium
- Titanium
- Metal Foams
- Plastics / Composites

magnesium convertible door

High performance metals

⇨ Lightweight “steels”

- High strength steels
- Manganese boron steels for form- and press hardening

press hardened crash box

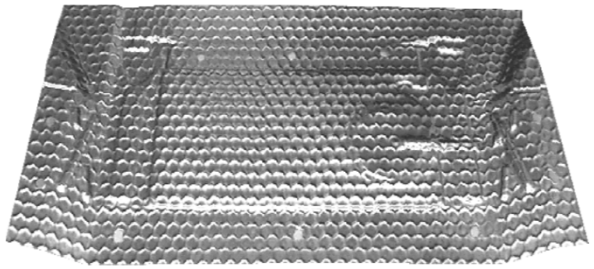
Structure optimization

⇨ Reduce masses

- Material, just where it is necessary

⇨ Innovative semi-finished products

- Structured sheets



honey comb structured panel

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Benefits of Sheet and Tube Hydroforming

- **Hydroformed cam shafts**

cast or forge camshaft

[2,4 kg, 0 %]

Formed and joined via TK-PCH method

[1,5 kg, -38 %]

State of the art

developed in 1993

Formed and joined via hydroforming

[1,2 kg, -50 %]

1. generation

developed in 2003

2. generation

developed in 2010

Assembled camshafts (with separate cams)

Hydroforming and carbide metal coating

[1,4 kg, - 42 %]

1. generation

developed in 2007

Hydroforming and additional nitration

[1,2 kg, - 50 %]

2. generation

developed in 2009

Hydroforming with press hardening

[1,0 kg, - 59 %]

3. generation

currently in development

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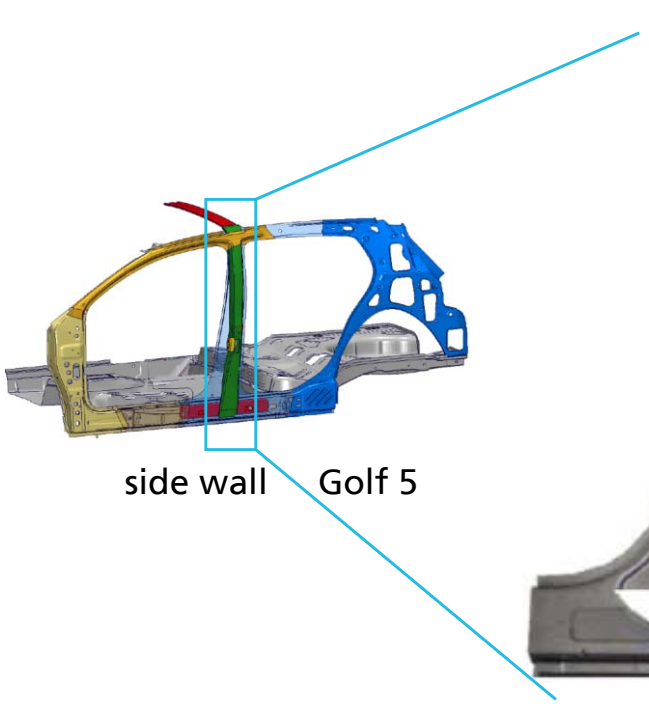
Benefits of Sheet and Tube Hydroforming

- **Benchmark: B-pillar part and assembly**



deep drawing

double blank hydroforming

flangeless tube hydroforming

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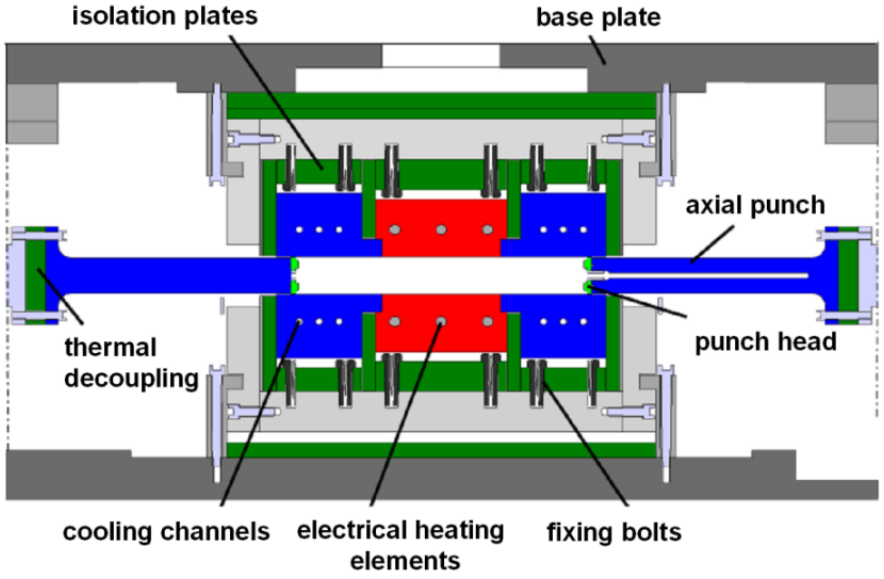
Benefits of Sheet and Tube Hydroforming

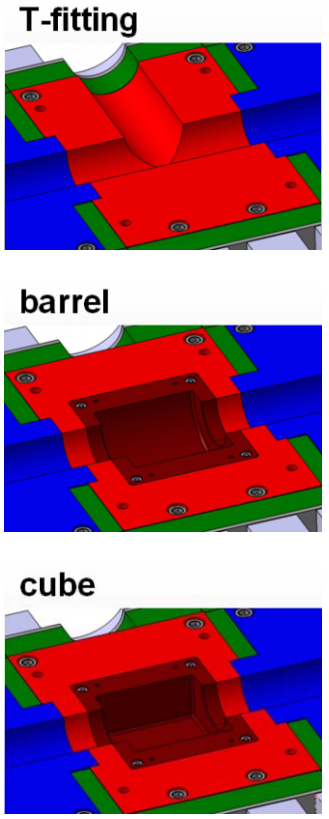
- **Benefits of hydroforming compared to deep drawing**

Double blank hydroforming	Tube hydroforming
two parts per stroke	alternative flangeless B-pillar
increased form accuracy	highest form accuracy
7 instead of 12 dies	integration of 10 into 4 parts
production costs minus 15 %	Cost reduction, less logistics
Material usage of 60 %	Material usage of 85 %
component rigidity enhanced by 20 %	weight reduction of 2,3 kg per car
less spring-back	optimized stiffness, no spring-back

HMGF of lightweight metals

- **Fundamental research of HMGF for aluminum and magnesium**
  - Process planning and die design
  - Temperature depending material behavior
  - Optimal process conditions and forming limits





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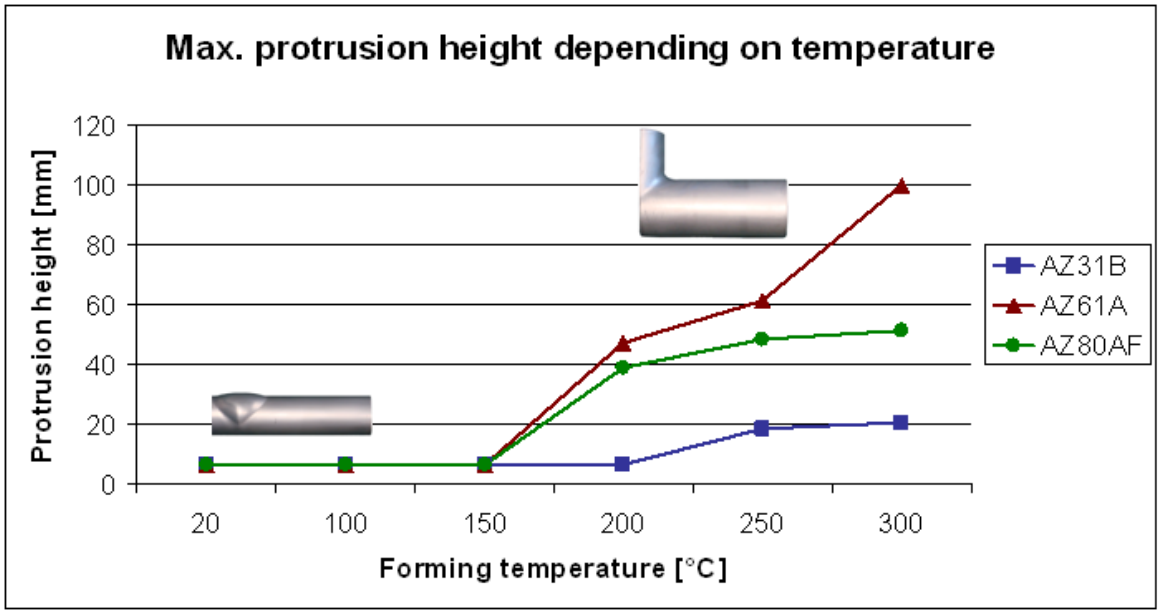
HMGF of lightweight metals

- **Increased formability by using temperature as process parameter**



Forming limit of AZ61 at 280°C

Forming limit of AZ61 at room temperature

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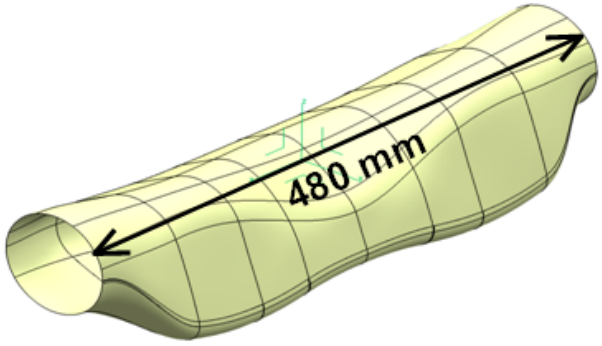
HMGF of lightweight metals

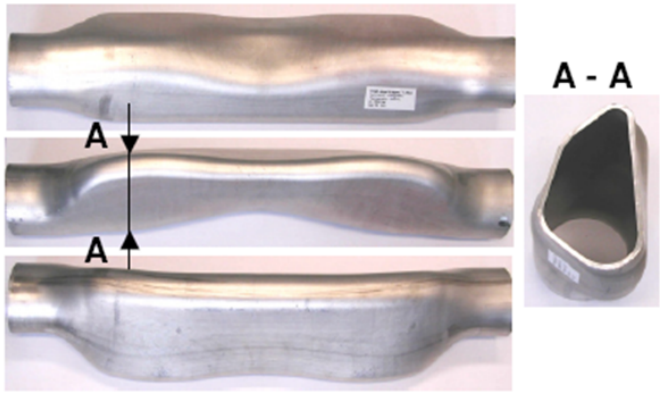
- **Near-series application**

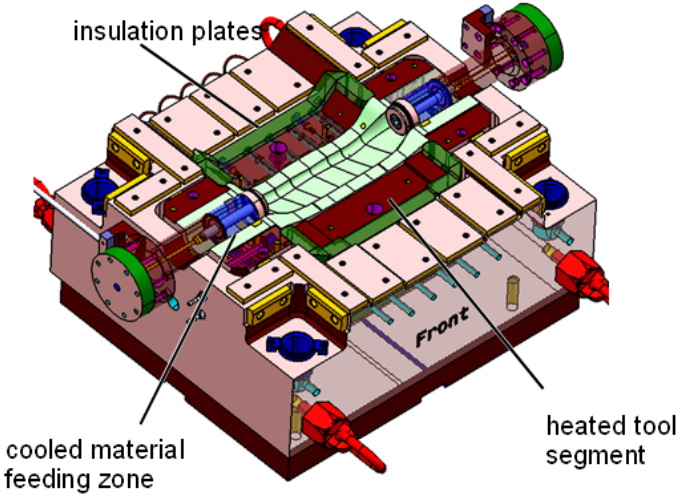
  „rear axel beam“

  - Tested magnesium alloys
    - AZ 31 B / AZ 61 A / AZ 80 A-F
  - Tested aluminum alloys
    - AlMgSi0,5 / AlMg3Mn



Δu_{max} = 42 %





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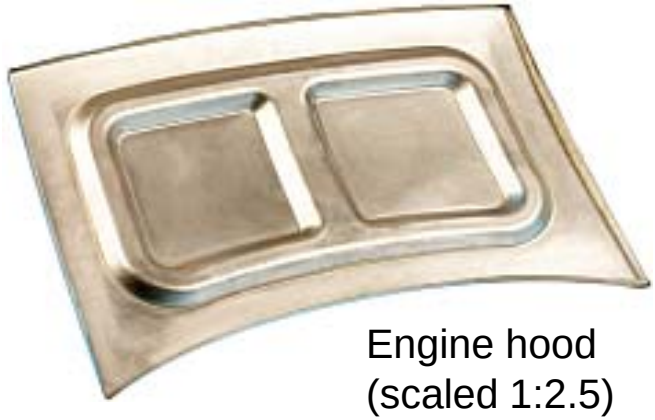
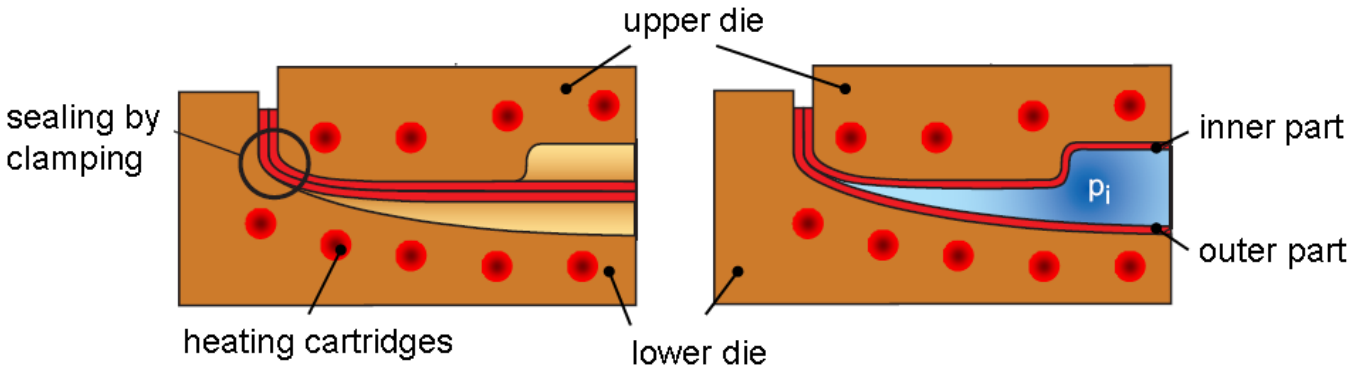
HMGF of lightweight metals

- **Process combination of deep drawing and thermal hydroforming**
  - Deep drawing of double blanks for a suitable material distribution
  - Hydroforming of outer and inner part at bottom dead center
  - Tested materials:
    - steel, aluminum, magnesium



Engine hood
(scaled 1:2.5)



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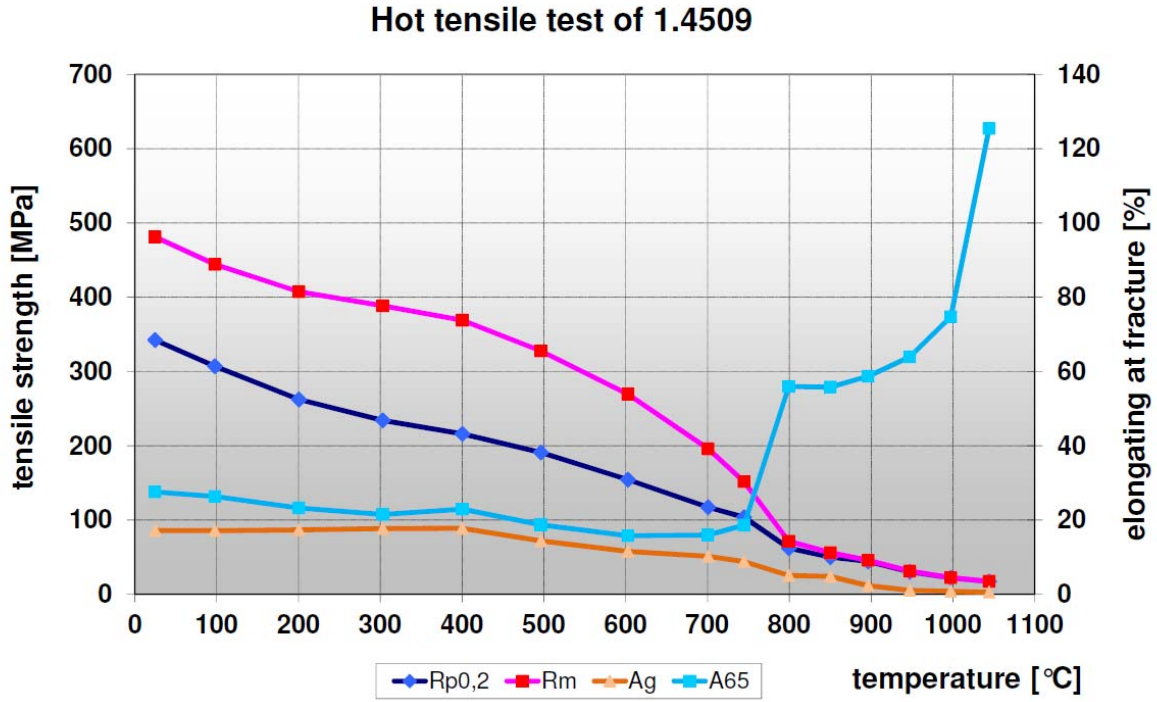
HMGF of stainless steels

- **Investigation of forming behavior at high forming temperatures**
  - Material testing at temperatures up to 1000 °C
  - Detection of suitable process condition for different stainless steels



Exhaust part

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Ein Unternehmen der Salzgitter Gruppe

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HMGF of stainless steels

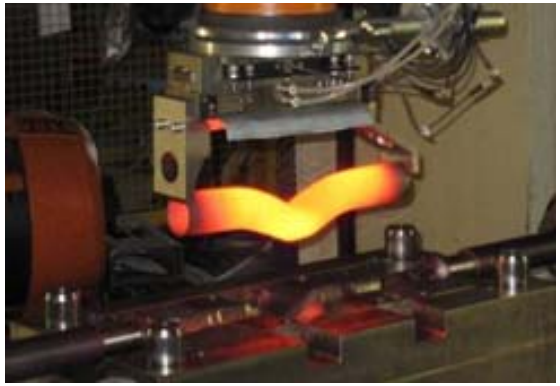
- **Significant shortening of process chains**

Conventional tube hydroforming	HMGF "best case"	Economic benefits
1 Preforming	1 Preforming	Up to 3 annealing steps less
2 Embossing I	2 HMGF	2 hydroforming steps less
3 Annealing I	3 Finishing	Less heat treatment logistics
4 Tube hydroforming I		Better handling in the box (collecting) and out of the box (separating)
5 Embossing II		
6 Annealing II		
7 Tube Hydroforming II		Easier tool change setting
8 Annealing III		Lower scrap rate
9 Tube Hydroforming III		
10 Finishing		

HMGF of stainless steels

- **Approaches and results**
  - Proved concepts for:
    - die integrated tube heating for straight part geometries
    - external heating by induction for bended exhaust components
  - Usage of improved formability at high forming temperatures
    - 3 times increased formability for ferritic stainless steels compared to cold hydroforming
  - Ready for serial production

Straight test geometry



External heated preform

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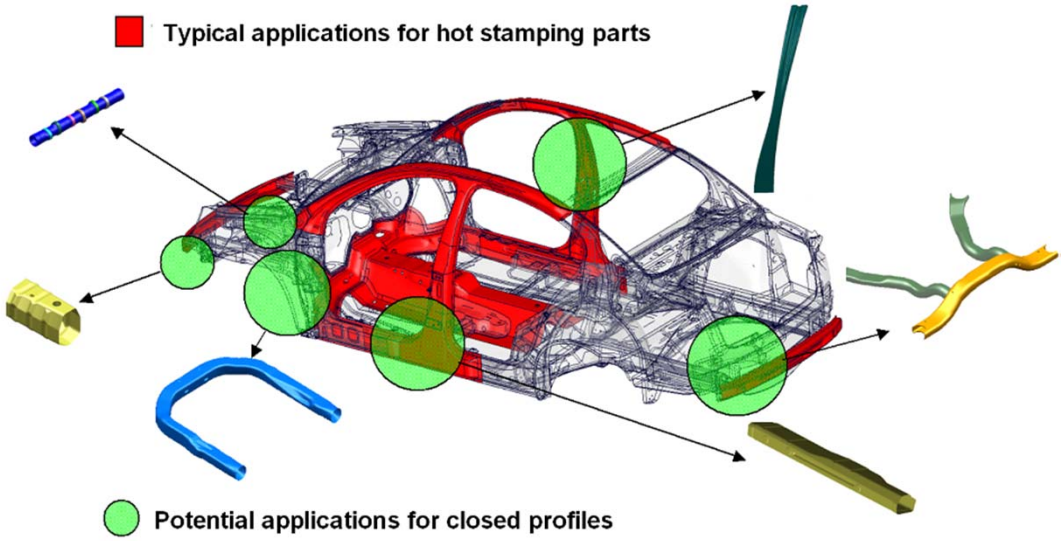
HMGF of manganese boron alloyed steels

- **Integration of the hardening procedure into the hydroforming process**
- Press hardening of closed profiles (22MnB5, 34MnB5, MW1000L, LH800®)
  - increase of strength by a factor of 3
  - high dimensional accuracy
  - low deflection and spring-back

testing part
„Crashbox“



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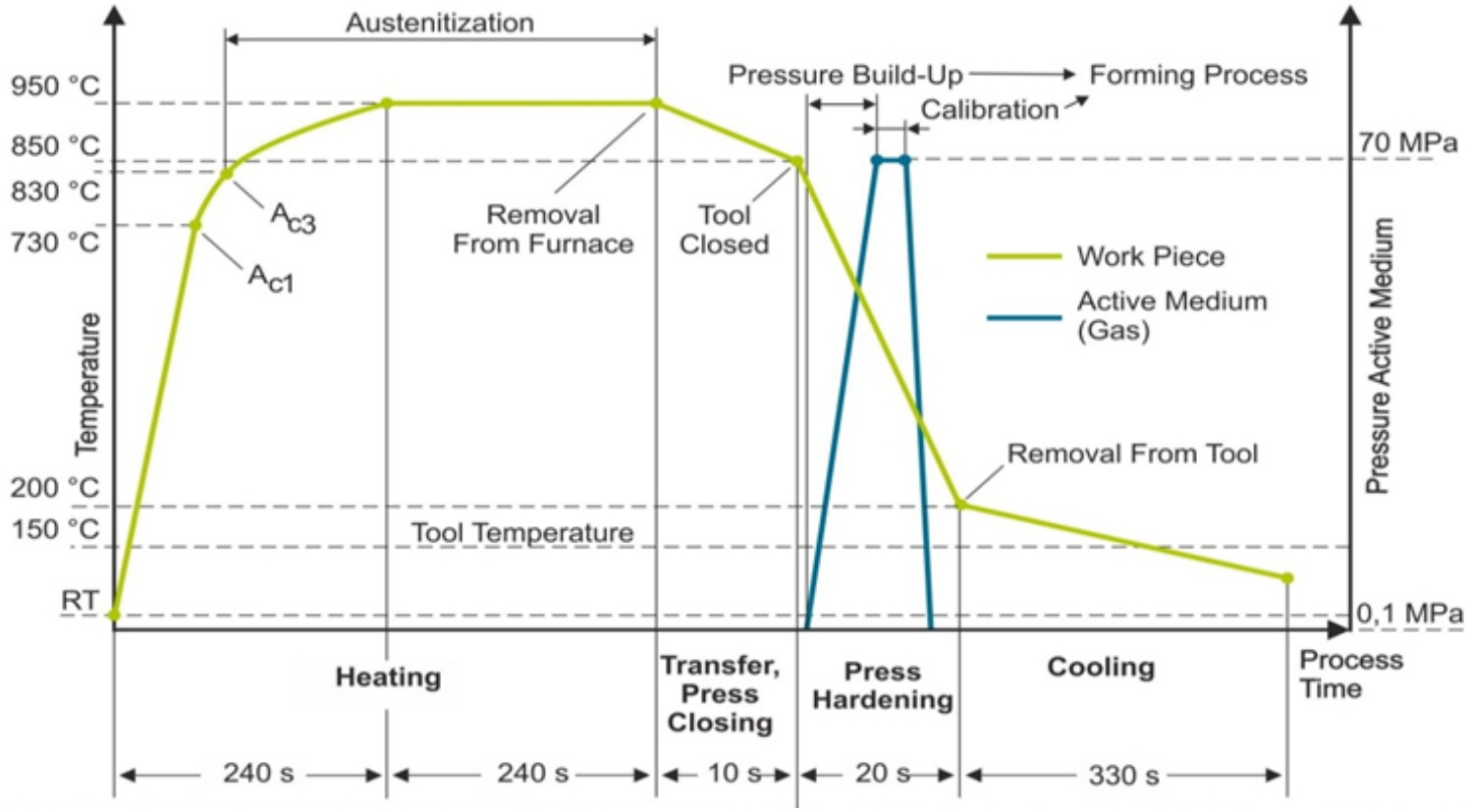
HMGF of manganese boron alloyed steels

- **Thermo-mechanical principle**



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HMGF of manganese boron alloyed steels

Production sequence

material: 22MnB5,
dimension: ∅70 x 2 mm, 400mm
coating: x-tecR CO 4020

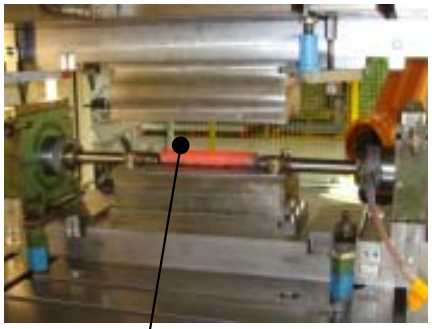
Inductive heating

$\vartheta \approx 950$ °C, 50 sec

Transfer by robot

$\Delta\vartheta \approx 120$ K, 12 sec

Tool Closing



$\vartheta \approx 830$ °C

Formed and hardened part

$\vartheta \approx 60 - 90$ °C

increasing pressure:	4 sec	→ 0 – 100 MPa
calibration:	3 sec	→ 100 MPa
decreasing pressure:	3 sec	→ 100 – 0 MPa
cooling:	4-8 sec	

HMGF of manganese boron alloyed steels

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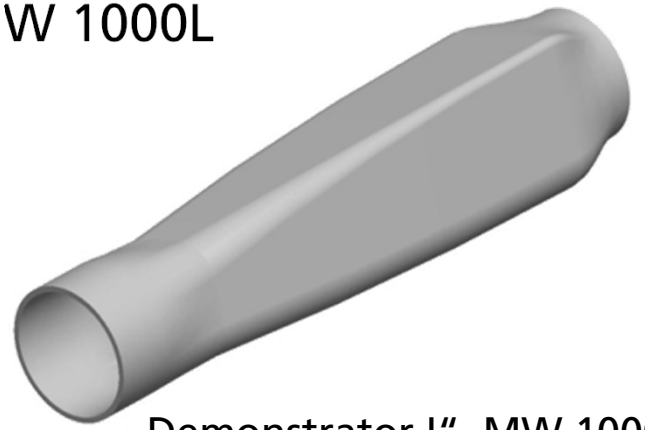
HMGF of manganese boron alloyed steels

- **Investigated materials and part geometries**
  - 22MnB5
  - 34MnB5
  - LH 800®
  - MW 1000L

„Crashbox“, 22MnB5
ø70 x 2 mm, 400 mm lang
R_m = 1400 ... 1600 MPa

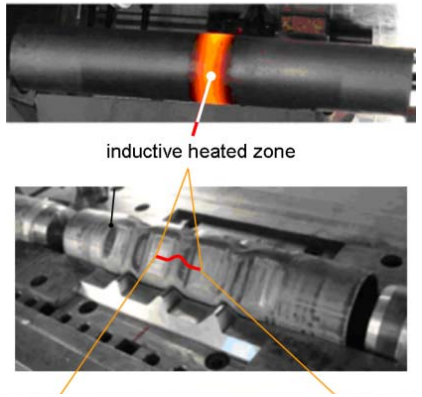


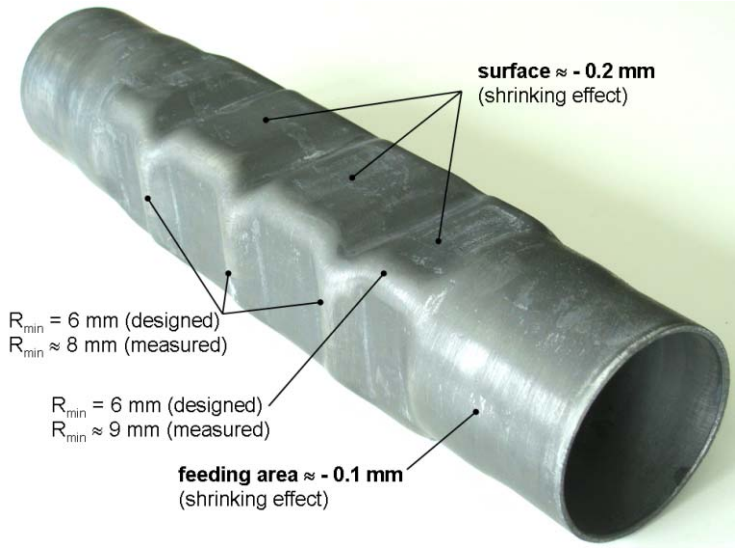
„Demonstrator I“, MW 1000L
ø45 x 1,35 / 2,05 mm
R_m = 1600 ... 1400 MPa

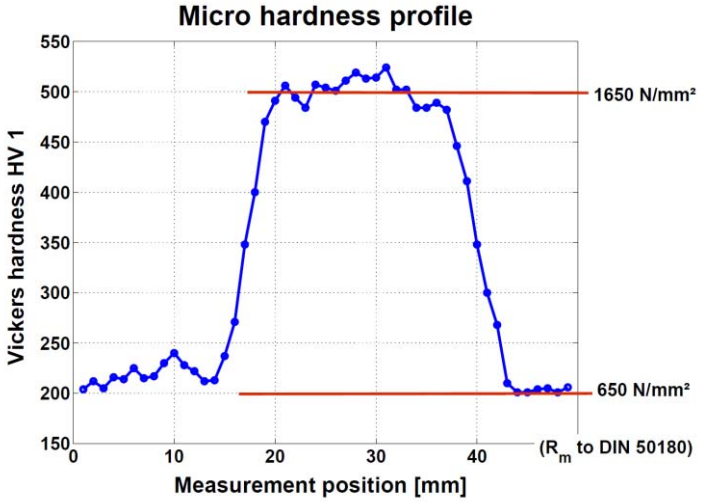
„Demonstrator II“, LH 800®
ø58,5 x 1,35 / 2,05 mm
R_m = 1250 ... 1400 MPa

HMGF of manganese boron alloyed steels

- **Approaches and results**
  - High dimensional accuracy
  - Equal distribution of microstructure and mechanical properties or
  - Tailored properties



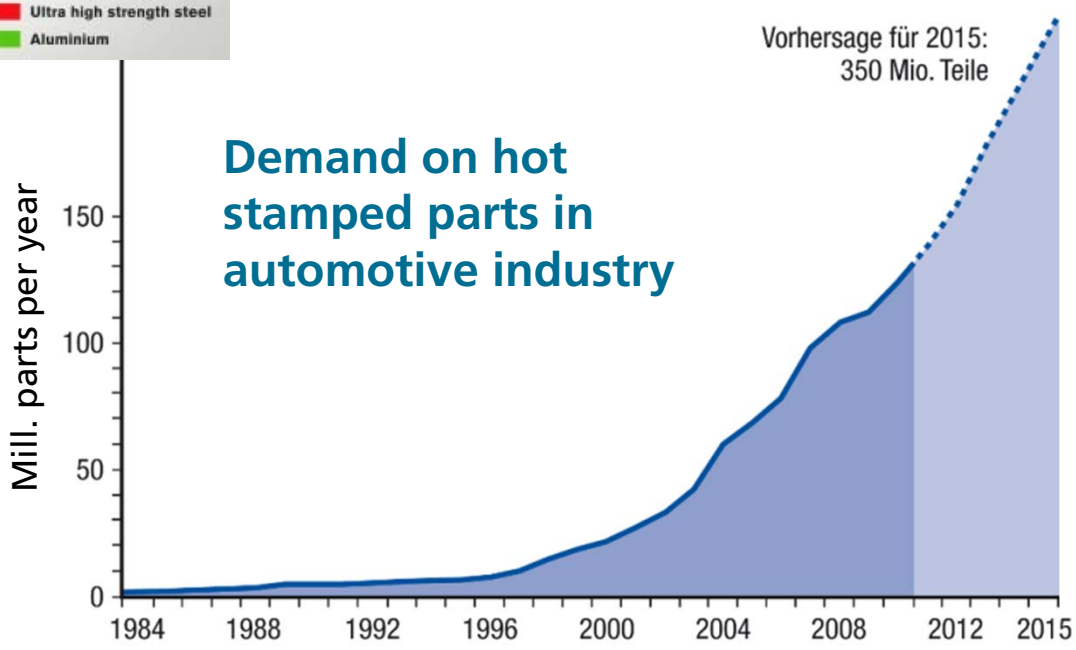




HMGF – potential applications and market

- **Growing market**

Body in White of new Volvo XC90
app. 40% hot stamping parts (red colored)



Market for hot stamping parts (Source: Bleche-Rohre-Profile, 06-2011)

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