Lightweight Chassis Cradles

Dr. Lothar Hein & Ken Weise
Benteler Automotive
Why Benteler Light Weight Steels?

- Benteler light weight steels can provide significant mass reductions, approaching that of aluminum, at significantly lower cost.
- Benteler’s steel making expertise allows for formulations tailored to the needs of the automotive industry.
- Benteler uses different types of materials and processes depending upon the vehicle and component needs.
- Heat treatment during the component manufacturing process allows the engineer to optimize yield, tensile and elongation, thus saving weight.
Benefits of BTR165 and BAS100

**BTR 165 (for hot forming)**
- Ultra high strength with good ductility
- High crash resistance and fatigue strength
- Good weldability with conventional techniques
- Exact part shape; no springback-effect
- Forming of complex parts possible

**BAS 100 (for post forming heat treatment)**
- Ultra high strength with excellent ductility
- High crash resistance and fatigue strength
- Good weldability (high strength over weldseam)
- Different material conditions adjustable
- High tempering resistance up to 600°C
- Batch galvanizing without losing strength

High Potential combinations of material and process
Chassis Materials

Dr. A. Frehn

BTR165 Water Quenched
BAS100 Tool Quenched
Air-quenched/Air Hardened
Complex-Phase-Steel (CP)
Ferritic-bainitic Steel
BAS100 Soft
BTR165 Delivery Behavior
HSLA
High strength Steel (P, BH, IFHS)
(Ultra-)Deep Drawing Quality (DDQ, UDDQ)

Tensile Strength, MPa
Elongation, %
Bending Fatigue Properties

Bending fatigue test
R=−1
Speed: 25Hz

TRIP800 (Hot rolled material)
BAS100 (Air QT)
BTR165 (Water QT)
440-Grade
590-Grade
780-Grade
780-Grade (Kobe steel**)

Dr. A. Frehn
BTR 165:

- A steel grade developed by Benteler
- successfully used for structural and chassis components
- Manganese-Boron-alloyed QT-steel
- Optimised for the hot forming process
- Good formability in the soft annealed condition and ultra high strength in hot formed components
- A steel with good weldability (with conventional welding techniques)
- Free of spring back effects in hot formed components
- Has sufficient ductility for chassis components
- Available as cold and hot rolled strip, ERW- and seamless tubes
- Available worldwide including also Asia-Pacific

Typical microstructure after hot forming: 100% martensite
Material Properties – BTR165

<table>
<thead>
<tr>
<th>BTR165</th>
<th>Condition of delivery</th>
<th>( R_e ), MPa</th>
<th>( R_m ), MPa</th>
<th>( A_5 ), %</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Water quenched, annealed at ~250°C</td>
<td>min. 1100</td>
<td>1400-1850</td>
<td>min. 8</td>
</tr>
<tr>
<td></td>
<td>Water quenched, annealed at ~630°C</td>
<td>min. 900</td>
<td>1000-1300</td>
<td>min. 10</td>
</tr>
<tr>
<td></td>
<td>Normalised</td>
<td>min. 320</td>
<td>520-640</td>
<td>min. 20</td>
</tr>
<tr>
<td></td>
<td>Soft annealed</td>
<td>min. 250</td>
<td>min. 400</td>
<td>min. 20</td>
</tr>
<tr>
<td></td>
<td>BKS</td>
<td>min. 500</td>
<td>min. 650</td>
<td>min. 15</td>
</tr>
</tbody>
</table>
Bending Performance of BTR165
BTR165 TYE Properties

Coupon TYE Testing 04-008

Stress [ksi]

Strain [%]

1ksi=6.9MPa
150ksi=1035MPa
BAS100:
• A steel grade developed by Benteler
• An air-hardening steel mainly alloyed with Mn-Cr-Mo-V
• Combines good formability in the soft annealed condition and high strength in the post forming heat treatment condition
• A steel with excellent weldability due to the low Carbon content
• Showing no hardness decrease over weldseams due to self-QT-effects
• Has good ductility and crash resistance for chassis components
• Stable regarding heat treatments up to 600°C (e.g.: tempering, batch galvanising, etc.)
• Available as cold and hot rolled strip, ERW- and seamless tubes
• Currently used for the front subframe of the Mercedes C-class

Typical microstructure after air-QT:
Ferrite, Bainite, precipitations
Material Properties – BAS100

<table>
<thead>
<tr>
<th>BAS100</th>
<th>Condition of delivery</th>
<th>$R_e$, MPa</th>
<th>$R_m$, MPa</th>
<th>$A_5$, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air quenched</td>
<td>min. 700</td>
<td>950-1100</td>
<td>min. 14</td>
<td></td>
</tr>
<tr>
<td>Air quenched,</td>
<td>min. 700</td>
<td>850-1000</td>
<td>min. 15</td>
<td></td>
</tr>
<tr>
<td>annealed at ~</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>600°C</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Soft annealed</td>
<td>max. 650</td>
<td>max. 750</td>
<td>min. 18</td>
<td></td>
</tr>
</tbody>
</table>
TYE Properties of BAS100

BAS100, QT: 720 MPa (Rp0.2), 935 MPa (Rm), 6% (Ag), 9% (A80)
BAS100, soft annealed: 463 MPa (Rp0.2), 575 MPa (Rm), 15% (Ag), 24% (A80)
S420MC: 467 MPa (Rp0.2), 527 MPa (Rm), 16% (Ag), 26% (A80)
S355MC: 385 MPa (Rp0.2), 441 MPa (Rm), 18% (Ag), 30% (A80)
Temperature Effects on BAS100

- **Re (Yield)** & **Rm (Ultimate)**, MPa
- **A5 (Total Elongation)**, %

Tempering Temperature, °C

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Heat Affected Zones – BAS100

Homogenous range of hardness

High fatigue performance

HV392 ~ 40 Rc
HV310 ~ 30 Rc

Typical HSLA

Hardness HV0,2

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Heating Options

Possibilities of heating

• Inductive Heating
• Gas Oven
• Electric Resistance Heating
• Salt Bath Heating
• Radiating Heating
• Contact Heating
Inductive Heating

• What is it?
  – A process where specialized Benteler steels are inductively heated and water quenched to locally increase the yield strength of the steel.

• What materials are used?
  – Post form heat treatment is accomplished with one of two specialized Benteler steels; BTR165 and BAS100.
  – Both can obtain high yield strengths while maintaining good elongation.
  – Both have excellent welding capability.
  – BAS100 is air quenched, minimizing heat affected zones in welding areas.

• Useful for any area needing light weight and high strength.
Gas fired furnace heats the part to working temperature.
• Suitable for single components or fully welded assemblies.
• Can be configured for heating, tempering, annealing, or any combination thereof.
Hot Stamping

...of blanks
- Coil
- Blank
- Furnace
- Robot

...with pre formed parts
- Coil
- Blank
- Press (Pre-forming / Cutting)
- Furnace
- Robot

Press
Cooling
Benteler Hot Stamping Locations

Total: 30 Lines in production
- 1 Lines under construction
- 2 Lines planned (w/production orders)

First hot stamp line launched in 1991

Benteler Automotive
- Paderborn 10 Hot stamp lines
  - 1 under construction
  - 1 prototype line
- Migennes 3 Hot stamp lines
- Burgos 2 Hot stamp lines
- Vigo 1 Hot stamp line
- Chrastava 3 Hot stamp lines
- Rumburk 1 Hot stamp line
- Changchun 1 Hot stamp line
- Shanghai 1 Hot stamp line planning

Aisin Takaoka
- Japan 3 Hot stamp lines
Current Hot Forming Applications

- Front Bumper
- Door Beam
- Roof Reinforcement
- Window Shaft Reinforcement
- Rear Bumper
- B-Pillar Reinforcement
- Side Beam Reinforcement
- Crossmember Reinforcement
- A-Pillar Reinforcement
- Rear Bumper Reinforcement
- Window Shaft
- Roof Reinforcement
Hot Stamping Portfolio

45,000,000 Hot Formed Parts in 2006

www.autosteel.org
Mercedes W204 (C-Class) Engine Cradle

Prior (W203) Design:
- Die cast aluminum cradle.
- Added parts to manage crash.

W204 Design Objectives:
- Crash Energy Absorption
- Reduced Mass
- Reduced Cost
Case Study – Aluminum Replacement

Design Constraints

- Mass – Thin Gage BAS100
  - 1.3mm min
- Corrosion – Hot Dip Galvanizing after Welding
- Crash – Sidemember Geometry

www.autosteel.org
Manufacturing Constraints and Solutions

To ensure proper fit between the thin walled tubes and mating components, trim edges are plasma cut under a water fog.
Manufacturing Constraints and Solutions

Fully welded frames are hardened and tempered in a gas fired oven. Only materials compatible with this process are included in the design.
Dimensional integrity is maintained by post heat treatment machining and punching.
Case Study – Aluminum Replacement

Results

Mercedes W203 Front Cradle
Aluminum Die Casting – 14kg
- Weight Reduced 14% (2kg)
- Cost Reduced 45%
- Crash Energy Managed

Mercedes W204 Front Cradle
Benteler BAS100 – 12kg
- 1.3mm
- 1.5mm
- 1.65mm
Benteler materials and processes make it possible to reduce weight without the high cost of aluminum.
Questions?
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