Innovative High and Ultra High Strength Steel Concepts for Cold Forming Applications

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BILSTEIN North America, Inc.
1. The BILSTEIN GROUP
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6. Summary
The BILSTEIN GROUP

BILSTEIN NORTH AMERICA, Inc., Chicago

ARMCO do Brasil s. a.

BILSTEIN GmbH & Co. KG, Germany, Hagen

BILSTEIN Trading Shanghai Co., Ltd.

BILSTEIN global

privately owned company
~ 1,300 employee
~ 600,000 mt per annum
~ 580,000,000 € annual turnover in 2011
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6. Summary
Motivation

- **Recovery annealed HSLA**
- **Elongation** $A_{80}$ [%]
- **Yield strength** [MPa]

Legend:
- **DDQ**: Deep Drawing quality
- **BH**: Bake Hardening quality
- **HSLA**: High Strength Low Alloy
- **TRIP**: Transformation Induced Plasticity
- **DP**: Dual Phase
- **B**: Bainitic
- **CP**: Complex Phase
- **MS**: Martensitic

Press hardened

Recovery annealed HSLA

Gap
Motivation

hot shaping area

surface / volume ratio [1/m] vs. blank thickness [mm]

- Blue line: surface / volume ratio
- Red line: max. transfer time

max. transfer time [s]
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The new BILSTEIN ZE-Grades

- **DDQ**: Deep Drawing quality
- **BH**: Bake Hardening quality
- **HSLA**: High Strength Low Alloy
- **TRIP**: Transformation Induced Plasticity
- **DP**: Dual Phase
- **B**: Bainitic
- **CP**: Complex Phase
- **MS**: Martensitic

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**Press hardened**

**Recovery annealed HSLA**

**The new BILSTEIN ZE-Grades**

**yield strength [MPa]**

**elongation A₈₀ [%]**
The new BILSTEIN ZE-Grades

Recovery annealed HSLA

- Available:
  - Width [mm]: 300, 400, 500, 600
  - Thickness [mm]: 1, 2, 3, 4, 5

- On request:
  - Width [mm]: 100, 200, 300, 400, 500, 600
  - Thickness [mm]: 3, 4, 5

The new BILSTEIN ZE-Grades

- Available:
  - Width [mm]: 300, 400, 500, 600
  - Thickness [mm]: 3, 4, 5
The new BILSTEIN ZE-Grades

1. Single phase steels:
   DDQ, BH, HSLA, Recovery annealed HSLA

2. Multi phase steels
   DP, TRIP, B, CP, MS

- Carbide
- Ferrite
- TiN

HNO₃, 1000 : 1

- Restaustenit
- Martensit
- Ferrit

Klemm/HNO₃, 1000 : 1
## The new BILSTEIN ZE-Grades

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Single phase concept</th>
<th>Multi phase concept</th>
</tr>
</thead>
<tbody>
<tr>
<td>hot band chemistry</td>
<td>- commonly available HSLA chemistry for different grades</td>
<td>- special chemistry per grade</td>
</tr>
<tr>
<td></td>
<td>- excellent weldability due to the low C-equivalent</td>
<td>- higher C-equivalent</td>
</tr>
<tr>
<td></td>
<td>- small lot sizes available</td>
<td>- min. lot size = heat size</td>
</tr>
<tr>
<td>work hardening (cold rolling)</td>
<td>- continuously variable concept</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- high yield ratio</td>
<td></td>
</tr>
<tr>
<td>annealing (t-T curve)</td>
<td>- batch annealing process</td>
<td>- Continuous annealing process</td>
</tr>
<tr>
<td></td>
<td>- high consistency in mechanics</td>
<td>- small process windows</td>
</tr>
</tbody>
</table>
The continuously variable concept

EN 10268

BILSTEIN ZE-Grades

The new BILSTEIN ZE-Grades
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5. BILTIC®: BILSTEIN Tailor Improved Coil

6. Summary
<table>
<thead>
<tr>
<th>Material</th>
<th>Thickness</th>
<th>Direction</th>
<th>Rp0,2 [MPa]</th>
<th>Rm [MPa]</th>
<th>A80 [%]</th>
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</thead>
<tbody>
<tr>
<td>ZE950</td>
<td>1,2</td>
<td>L</td>
<td>973</td>
<td>1008</td>
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<td>1075</td>
<td>1107</td>
<td>6,3</td>
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<td></td>
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<td>1157</td>
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<tr>
<td></td>
<td></td>
<td>D</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>
Support distance: \( l = 400 \text{ mm} \)
Die diameter: \( D = 250 \text{ mm} \)
Support diameter: \( D = 50 \text{ mm} \)
Testing machine: Zwick Roell Z250
Testing speed: \( 0.008 \text{ m/s} \)
Initial force: \( 100 \text{ N} \)
Limits: \( 100 \text{ N} \) or \( 100 \text{ mm stroke} \)
Evaluation

comparison of force-stroke-curves

about 15 %
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5. BILTIC®: BILSTEIN Tailor Improved Coil

6. Summary
Based on the new BILSTEIN ZE-Grades with yield strength values of up to 1200 MPa the new product line BILTiC® was developed at the BILSTEIN GmbH & Co. KG. This is not only a new product line but also a totally new developed process allowing:

- to adjust different mechanicals in one ultra high strength steel strip coil.
- in application specific areas, where critical forming applies.
- to recover the strength in these areas by work hardening close to the original strip values.
part 1:
similar to a B-pillar segment to evaluate the forming behaviour of the new BILSTEIN ZE-Grades

part 2:
identical with part 1. In the flat area a hard to form structure similar to a side impact beam was added to evaluate the partial heat treatment, PHT
blank preparation by Partial Heat Treatment

PHT

PHT-zone
ZE600

basis
ZE1050
hardness profile over strip width

- Heat Transition Zone (HTZ)
- PHT-ZONE
- Heat Transition Zone (HTZ)

hardness HV 10 vs. strip width [mm]
FEM-simulation of the "customer relevant part"

simulation 1

grade: ZE 1050 – without PHT
thickness: 1.2 mm

simulation 2

grade: ZE 1050 – with PHT
thickness: 1.2 mm
FEM-simulation shows cracking in the SIB area on part without PHT.
**Rp ≈ 450 MPa**
**Rm ≈ 600 MPa**
**A₈₀ ≈ 20 %**

**Rp ≈ 1100 MPa**
**Rm ≈ 1150 MPa**
**A₈₀ ≈ 6 %**

= Partial Heat Treatment Zone (PHT-zone)
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1. With the new BILSTEIN ZE-Grades a significant decrease of the gap in minimum yield strength between available UHSS and hot shaped parts could be achieved.

2. The thickness range of the BILSTEIN ZE-Grades could be shifted to significant lower thicknesses allowing massive weight reductions and the manufacturing of small and thin ultra high strength parts, where the hot shaping technology reaches its limits.

3. The evaluation of the new BILSTEIN ZE-Grades on a side impact beam shows a 15% better performance compared to similar multi phase grades.

4. Based on the new BILSTEIN ZE-Grades the totally new product line BILTIC® was developed, showing areas with higher elongations where critical forming applies.
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