Press-Hardened and Roll-Formed Lightweight Bumpers in Steels with Enhanced Strength

Johan Nilsson

Gestamp
Abstract

-Bumpers protect the BIW and external attributes in low speed collisions and contribute to crash safety in high speed collisions (transfer loads to the BIW).

-They are continuously improved through implementation of materials with enhanced strength, new design features, new manufacturing processes, reduction of number of components and reduction of package space.
### Press-Hardened Three-Layered Material for Deformation Elements

<table>
<thead>
<tr>
<th>Layer</th>
<th>Percentage</th>
<th>Tensile Strength</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ductile outer layer</td>
<td>20%</td>
<td>500 MPa</td>
</tr>
<tr>
<td>High strength core</td>
<td>60%</td>
<td>1500 MPa</td>
</tr>
<tr>
<td>Ductile outer layer</td>
<td>20%</td>
<td>500 MPa</td>
</tr>
</tbody>
</table>

*Simulation - Test*

![Image of press-hardened three-layered material](image-url)

![Graph showing force vs. displacement](image-url)
Press-Hardened Uncoated 2000 MPa Material for Cross Beams

Front bumper:
- Cross beam PH 1500 MPa 1.5 mm.
- Crash boxes 800 MPa 1.5 mm.
- Weight 4.36 kg.

Front bumper next generation:
- Cross beam PH 2000 MPa 1.25 mm.
- Crash boxes PH 1200 MPa 1.2 mm.
- Weight 3.67 kg = -15%.

Cross beam
PH 2000 MPa 1.5 mm

OK!
Roll-Formed M-Profile, Optimization Process

Objectives:
- Reduce weight of bumpers with roll-formed beams.
- Manage high speed crash w/o rupture of materials or welds.
- Fulfill world wide low speed crash requirements.
- Investigate new materials with higher strength.

Solution:
- Beam section with modularity possibility and press-hardened crash boxes.

Simulation set-up
- Three point bending.

Variables
- Dimensional variations.
- Automatic optimization.

M-profile
- 10.4% higher energy absorption / mass unit than benchmark beam.
Front Bumper, Roll-Formed M-Profile, Press-Hardened Crash Boxes

Front bumper:
- Cross beam 1200 MPa 1.2 mm.
- Crash boxes PH 1200 MPa 1.2 mm.
- Weight 6.37 kg = -13% (compared to benchmark bumper).

Modularized:
Section depth increased by 10 mm.
Front Bumper, Roll-Formed M-Profile, Press-Hardened Crash Boxes

IIHS 0/U 10.5 km/h

Center pole, Intrusion 460 mm

AZT 16.0 km/h, 40% Offset Barrier

-12% lower barrier intrusion and 15% lower beam deflection, with modularized beam, compared to the benchmark front bumper
Compact Rear Bumper with Improved High Speed Performance

Objectives:
- Reduce the necessary package space for rear bumpers.
- Manage high speed crash without rupture of materials or welds.
- Fulfill world wide low speed crash requirements.
- Investigate new press hardening materials with higher strength.

Solution:
- Implement patch technology on press hardened beam with deformable section.

Innovation:
- Patch technology – additional material only where needed.
- For improved high speed crash performance.
Bumpers with Deformable Beam Section

Ford Focus

Range Rover

BMW 1-series

Opel Adam
Compact Rear Bumper, Design Concept

Rear bumper:
- Cover plate 800 MPa 0.7 mm.
- Cross beam PH 2000 MPa 1.4 mm.
- Patch PH 2000 MPa 2.0 mm.
- Weight 5.235 kg.
- Mounting brackets 700 MPa 2.8 mm.
- Towing bracket 700 MPa 2.8 mm.
- Tow tube 200 MPa.

Crash requirements:
AZT 10°, RCAR/IIHS O/U, ECER42, FMVSS581, Towing, Center Pole, FMVSS301.
Compact Rear Bumper, Low Speed Performance

AZT RH-Side 16.0 km/h (1400 kg barrier, 40% offset)

Energy absorption: 5.150 kJ at 57.5 mm
Compact Rear Bumper, High Speed Performance

FMVSS301 LH-Side

- No material failure in patch or HAZ.
- However, some fracturing of the main bumper beam.
Summary

Front bumper, press-hardened beam and crash boxes
A beam in press-hardened un-coated quality with ~2000 MPa tensile strength is good for crash applications, as are crash boxes in press-hardened three-layered 1200 MPa material.

Using these materials can reduce the weight of a present front bumper by ~15%.

Front bumper, roll-formed beam, press-hardened crash boxes
A beam with roll-formed M-profile in 1200 MPa is 10.4% lighter than benchmark roll-formed beam.

The M-profile is possible to modularize, in order to increase the bending stiffness and/or adapt to fit with the package requirement.

A beam with M-profile in 1200 MPa material and crash boxes in press-hardened 1200 MPa material is 13% lighter than benchmark bumper and still deliver superior crash performance.

Rear bumper, press-hardened beam with patch

The bumper fulfills world-wide low speed crash requirements.

The bumper beam only experiences minor material failure in high speed impacts. The patch, including heat-affected zones, remain completely intact.
Johan Nilsson
Gestamp
+46 (0)920 474216
jonilsson@se.gestamp.com