GREAT DESIGNS IN STEEL

EFFICIENT STEEL BUMPER BEAM DESIGN

Stu Brown
Technical Consultant – Bumper Systems
Former System Architect – Bumper Systems – General Motors Company
EFFICIENT STEEL BUMPER BEAM DESIGN

AGENDA

1. Identify Requirements
2. Material Selection – Start with Steel
3. Case Study – Roll Form Steel vs. Aluminum
EFFICIENT STEEL BUMPER BEAM DESIGN

1. Identify Requirements
   A. Low Speed Impacts
   B. High Speed Crashworthiness
   C. Pedestrian Protection
1. Identify Requirements

A. Low Speed Impacts
   1. Regulatory – must meet – 2 regulations globally
      a. FMVSR 581 – US/Canada
      b. ECE R42 – China/Korea/Gulf States/Canada
   2. Consumer Metrics – competitive decision
      a. RCAR Bumper Test – Override/underride – 10 kph
      b. RCAR Structure Test (Danner) – 40% offset – 15 kph

Main Focus – Design
Geometry to meet requirements efficiently
EFFICIENT STEEL BUMPER BEAM DESIGN

1. Identify Requirements

B. High Speed Impacts – Dependent on country of sale
   1. Regulatory
      Note: US – 70% offset rear barrier – 80 kph
   2. Consumer Metrics
      a. IIHS - US
         1. 40% Offset Barrier – 65 kph
         2. 25% Small Overlap Frontal – 65 kph
      b. EuroNCAP
         • Mobile Progressive Deformable Barrier
         • 50% overlap – 50 kph

Higher loads in high speed crash and additional mass of BEV creating need for stronger Bumper Beams.
EFFICIENT STEEL BUMPER BEAM DESIGN

Requirements Drive Bumper Beam Design

Center Reinforcement for RCAR Override Test

Crush cans and Brackets for IIHS SOF Test

Examples of design geometry to meet Low and High Speed Requirements.
EFFICIENT STEEL BUMPER BEAM DESIGN

1. Identify Requirements
   A. Low Speed Impacts
   B. High Speed Crashworthiness
   C. Pedestrian Protection

Result: Initial design for vehicle packaging and CAE analysis.
EFFICIENT STEEL BUMPER BEAM DESIGN

AGENDA
1. Identify Requirements
2. Material Selection – Start with Steel
3. Case Study – Roll Form Steel vs. Aluminum
2. Material Selection – Reasons to Start with Steel
   • Availability of Ultra High-Strength Steel – globally
   • High Strength to weight capability
   • UHS Steel ability to withstand high loads in high speed crash
EFFICIENT STEEL BUMPER BEAM DESIGN

Increase Mass

Aluminum
Steel

Increase Strength

Al
?
Steel
2. Material Selection – Start with Steel
   • Availability of Ultra High-Strength Steel – globally
   • High Strength to weight capability
   • UHS Steel ability to withstand high loads in high speed crash
   • Lowest Cost versus aluminum or plastic
   • Preferred material selection in industry globally
     o Study of mid-size car bumper beams – front and rear
EFFICIENT STEEL BUMPER BEAM DESIGN

Steel is the material of choice for bumpers – approx. 70% market.
EFFICIENT STEEL BUMPER BEAM DESIGN

AGENDA
1. Identify Requirements
2. Material Selection – Start with Steel
3. Case Study – Roll Form Steel vs. Aluminum
EFFICIENT STEEL BUMPER BEAM DESIGN

3. Case Study – Roll Form Steel vs. Aluminum

Comparison of Engineered Cost and Mass of:

1. Extruded Aluminum – Production Part
2. Hot Form Steel Design – optimized by computer FEA
3. Roll Form Steel Design – optimized by computer FEA
3. Case Study – Roll Form Steel vs. Aluminum

Requirements

1. Low Speed - RCAR Bumper Test – 100% overlap @ 10 kph
2. High Speed - IIHS Small Overlap Frontal – 25% overlap @ 64 kph
3. Case Study – Roll Form Steel vs. Aluminum
Beam Mass Comparison

<table>
<thead>
<tr>
<th></th>
<th>Beam Mass (kg)</th>
<th>Difference (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>#1 Aluminum</td>
<td>4.0</td>
<td></td>
</tr>
<tr>
<td>#2 Steel Hot Form</td>
<td>4.3</td>
<td>+0.3</td>
</tr>
<tr>
<td>#3 Steel Roll Form</td>
<td>4.2</td>
<td>+0.2</td>
</tr>
</tbody>
</table>

Goal: Reduce the mass of Steel Beams
EFFICIENT STEEL BUMPER BEAM DESIGN

Case Study

Proposal

10% reduction in Beam mass
### EFFICIENT STEEL BUMPER BEAM DESIGN

#### 3. Case Study – Roll Form Steel vs. Aluminum

Proposed Section Mass Comparison – 10% reduction

<table>
<thead>
<tr>
<th>#</th>
<th>Beam Mass (kg)</th>
<th>Reduce Beam by 10% (kg)</th>
<th>Diff (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>#1 Aluminum</td>
<td>4.0</td>
<td>Base</td>
<td></td>
</tr>
<tr>
<td>#2 Steel Hot Form</td>
<td>4.3</td>
<td>3.9</td>
<td>-0.4</td>
</tr>
<tr>
<td>#3 Steel Roll Form</td>
<td>4.2</td>
<td>3.8</td>
<td>-0.4</td>
</tr>
</tbody>
</table>

Steel has technology to save mass over Al on Beams.
EFFICIENT STEEL BUMPER BEAM DESIGN

Conclusions

• Increasing High Speed Crash requirements creates a need for higher strength Bumper Beams.

• Higher mass Battery Electric Vehicles are creating additional performance requirements for bumper beams in high speed crash.

• Ultra-high strength steel enables stronger Bumper Beams at lower mass and lower cost.
FOR MORE INFORMATION

Stu Brown
Brown Technical Consulting
scsmbrown@ameritech.net

Michael White
American Iron & Steel Institute
mwhite@steel.org