Hydroform Intensive Body Structures
Theory and Real World Applications
(Phase III)

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HIBS I Recap

Direct Replacement of Hydroform Tubes for Stampings

-11% Piece Cost
-14% Tooling Cost
-14.7 kg Mass
HIBS II Recap

Investigation Into Higher-Strength Materials, Variable Gage Tubes and Body Shop Provisions

Parallels of Constant Value
US$/9.00 Kg
Stamping History

Sheetmetal Stampings:

- Have Been Used Forever
- Are a Known Commodity
Stamping History

Sheetmetal Stampings:

- Offer Good Design Flexibility
- Body Shops Are Set Up To Weld Them
Stamping History

Stampings May Be Easy To:

- Design
- Manufacture
- Weld In The Body Shop

But Are They Structurally Efficient?
Direct (Axial) Compression

Forces/Stresses
Compression Due to Bending

Compression/Tension Stresses Resulting From Bending Forces
Examples of Bending Compression
Parts of B-Pillar In Compression
Inhibitors To Structural Performance

Holes/Features Are Introduced Which Further Compromises The Structure
Material Utilization

Higher-Strength Materials Can Compensate For Compromised Geometry, But Only To a Certain Extent
Critical Buckling Stress Formula

\[ \sigma_{cr} = \frac{\pi^2 k_c E}{12(1 - \nu_e^2)} \left( \frac{t}{b} \right)^2 \]

- \( k_c \) = buckling coefficient which depends on edge boundary conditions and sheet aspect ratio (a/b)
- \( E \) = modulus of elasticity
- \( \nu_e \) = elastic Poisson’s ratio
- \( b \) = short dimension of plate or loaded edge
- \( t \) = plate thickness
Critical Buckling Stress Chart

\[ \sigma_{cr} = \frac{\pi^2 k_c E}{12(1 - \nu^2)} \left( \frac{t}{b} \right)^2 \]

- **Geometry Limited**
- **Material Limited**

Materials:
- 22MnB5
- DP980
- DP780
- HSLA350
Geometry Driven Performance

Results (designs with similar performance):

- Single tube (baseline) weight (2.0mm wall) 7.4 kg
- Dual tube weight (1.4mm wall) 6.3 kg
- Delta 1.1 kg (15% reduction)
Material Strength vs. Roof Crush

Roof Crush Analysis

Marginal Gains > 980 MPa Yield

Gains Proportional To Yield < 980 MPa yield
Geometry Driven Performance

\[ \sigma_{cr} = \frac{\pi^2 k_c E}{12(1 - \nu^2)} \left(\frac{t}{b}\right)^2 \]

Unrealized Material Potential

Stress (MPa)

<table>
<thead>
<tr>
<th>Material</th>
<th>Stress (MPa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>22MnB5</td>
<td>1400</td>
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<tr>
<td>DP980</td>
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<td>DP780</td>
<td>600</td>
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<td>HSLA350</td>
<td>400</td>
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Geometry Driven Performance

As thickness decreases in a structure, the actual percentage of “useable” yield strength decreases.

At lower gages, higher strength materials lose efficiency more quickly.

Ref. Mazda Presentation at EuroCarBody 2014
Real World Examples – Ford Fusion

Ref. Ford Presentation at GDIS 2012
Real World Examples – Ford Mustang

- Initial studies yielded:
  - 25% Reduction in Variable Cost
  - 9% Reduction in Mass
  - 30mm reduction in functional section height

Ref. Ford Presentation at GDIS 2014
Real World Examples – Ford Edge

DP1000 Tube running from the base of the A-Pillar to the C-Pillar

Hydro-Formed tubes introduced in the D-Pillar to improve BIW Stiffness

Ref. Ford Information at FDIC 2015
Real World Examples – Jaguar XE

Roof Rail

- Compact Section
- High t/b Ratio
Real World Examples - Ford F-150

- Roof Rail
- Compact Section
- High t/b Ratio
Future Applications

- Focused Structure
- Efficient Closed Section Geometry
- Reduce/Eliminate Non-Structural Sheetmetal
- Part Count Reduction
- Driven By Weight/Cost Reduction New Impact Requirements
Summary

HIBS I
• Hydroform Tubes Demonstrate Their Value

HIBS II
• New steels, Variable-Wall Tubes and Body Shop Manufacturing Processes Further Reduce Mass

HIBS III
• Geometry Is Critical In Compression Members
• Structures May Not Fully Benefit From Higher-Strength Steels
• Hydroform Tube Designs Can Efficiently Use Geometry To Maximize Material Performance
• Many Current Vehicles Have Hydroform Tubes As Structural Solutions and Future Vehicles Will Have More
Thank You