Adhesives and Sealants as an Enabling Technology for Lightweight, Safe, and High Performing Steel Vehicles

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Adhesive & Sealant Council
• Types & Applications of Adhesives and Sealants in Automobile Body

• Automotive Industry Trends & Implications to Adhesives
  – Global Designs
  – Fuel Economy (& weight reduction)
  – Auto / Electronic Convergence
  – Sustainability

• Multi Material bonding applications

• Summary & Long-Term Outlook
Benefits of Adhesives

Adhesives help manufacturers:

• Build structures that are stronger, stiffer, lighter and better performing

• Make products quieter and more comfortable

• Solve difficult joining problems

Source: General Motors
Adhesives in the Automobile Body

Application | Type
--- | ---
Front & rear fixed glass | 1K U
Body-in-White | 1K E
Panel inners / outers
   Metals | 1K E
   Composite | 2K E, U, A
   Anti-flutter | 1K sealants
Cavity filling foams | E, U

A = Acrylic  
E = Epoxy  
U = Urethane
Light Vehicle Trends & Implications

Trends
- Global designs, local production
- Auto/Electronic Convergence
- Increasing regulatory hurdles
- Sustainable manufacturing

Implications
- Suppliers with global capabilities
- Ability to provide material properties and predict static and dynamic performance
- Efficient powertrain and lightweight materials
- Low lifetime environmental footprint
- Changing user needs and priorities
Improvements in Powertrain, Aerodynamics, Rolling Resistance, and Weight will be required

EPA Fuel Economy Sticker Improvements for Light Vehicles

Source: US EPA, NHSTA
### Conflicting Regulatory & Consumer Demands

<table>
<thead>
<tr>
<th>Comfort, Convenience, Capability</th>
<th>Handling &amp; Performance</th>
<th>Safety</th>
<th>Fuel Economy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Larger vehicles, more features &amp; electronics</td>
<td>Faster, sportier. Stiffer, more power/weight</td>
<td>More energy absorbing capabilities</td>
<td>Lighter, more efficient (34.1 MPG...54.3 MPG)</td>
</tr>
</tbody>
</table>

**Impact to vehicle weight**

- Comfort, Convenience, Capability: Increasing
- Handling & Performance: Increasing
- Safety: Increasing
- Fuel Economy: Decreasing
Steel will remain the material of choice for high volume production.
Body Material Trends

- Mild steel losing share
- HSS gaining favor
- Aluminum making inroads

Industrial Market Insight Analysis based on sampling of passenger cars as reported by OEM
ASC Whitepaper: Adhesive Opportunities & Outlook in Light Vehicles

High strength steel has gained the most share of lightweight materials
Automotive Lightweight Material Trends

Source: ASC Grow the Vertical Report (Ground Transportation), Ducker Worldwide
ASC Whitepaper: Adhesive Opportunities & Outlook in Light Vehicles
Multi-Material Construction: BMW 7 Series

Production volume: 60,000 units
Retail price: $90,000 – 120,000 USD

145m of adhesives
Multi-Material Construction: Audi A8

Production volume: 45,000 units
Retail price: $82,500 – 115,000 USD

Photo: Compositesworld.com
Managing “Delta Alpha”

Source: Dow Automotive
Managing “Delta Alpha”

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1. Mixed part is assembled at RT
2. Metal expands in oven, CFRP ‘not’
3. Adhesive cures at that stage
4. Metal shrinks when cooling down
5. a) Adhesive fails, adhesively or cohesively
   b) Substrate fails / cracks, break or top layer delamination
   c) Substrate bends / deforms or/and high residual tension

Source: Sika
CAE modeling: roof example

Undesired roof vertical deformation baseline > 11 mm over 100 mm span

Optimized design With correction adhesive solution

Source: Dow Automotive
“Down-gauging” & Weld bonding

Challenge: stiffness & dynamic performance

- Stiffness $\sim E_t$ (shapes)
- $\sim E_t^3$ (flat panels)

Lower stiffness = degraded handling & performance

Solution: WELD BONDING

- Increases stiffness & crash energy absorption
- Decreases required spot welds or rivets

Source: Industrial Market Insight
Strength of Adhesives vs Other Joining Methods

Lap shear testing Structural Adhesive bonding vs. other joining techniques

Source: Sika, Daimler
Shock Tower

Al casting replaces multi-piece stamped assembly

Adhesive reduces stress on fastener and improves fatigue life

Adhesive prevents galvanic corrosion in mixed material assembly

Source: Steel Market Development Institute, Great Designs in Steel

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Why are Structural Adhesives Effective?

- Reduce stresses in joints, which improves durability
- Enable gauge reduction of steel, which reduces weight
- Higher loads can be sustained, which improves crash and safety performance

Source: Dow Automotive
Structural Adhesive Growth Trend

Source: ASC Grow the vertical report (Ground Transportation)
Structural Adhesive Usage Trend

Structural adhesives growing most rapidly in premium vehicles

Source: Industrial Market Insight
“...the difference in ride quality was comparable to the variation between a luxury automobile and an entry-level compact,” GM wrote.

-On GM evaluation of the ATS tested with and without structural adhesive.

<table>
<thead>
<tr>
<th>Vehicle</th>
<th>Chevy Spark</th>
<th>Chevy Malibu</th>
<th>Cadillac ATS</th>
<th>Cadillac CTS</th>
<th>Cadillac CT6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Materials</td>
<td>Steel Intensive</td>
<td>Steel Intensive</td>
<td>Steel Intensive with Al</td>
<td>Steel Intensive with Al</td>
<td>60% Aluminum 40% Steel</td>
</tr>
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</table>

Source: Industrial Market Insight
Adhesives help manufacturers:

• Build steel structures that are stronger, stiffer, lighter and better performing

• Combine steel with other materials

• Make products quieter and more comfortable

Source: General Motors
For More Information:  www.Adhesives.org

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