Next Generation Structural Adhesives for Improved Processing Properties

Tyler J. Auvil
Dow Automotive Systems
• Lightweight Design Potential
• Diversity in Bonding Technologies
• Why Structural Adhesives?
• Improvements in Body Shop Adhesives
Regulations Driving Lightweight Design

Targeted CO$_2$ emissions for vehicle fleet

- Continuing specifications under elaboration
- Regulations differ significantly in dependence of the region

<table>
<thead>
<tr>
<th>Europe</th>
<th>USA CAFE-tr</th>
<th>Japan</th>
<th>China</th>
</tr>
</thead>
<tbody>
<tr>
<td>2015 130g CO$_2$/km</td>
<td>2016 160g CO$_2$/km</td>
<td>2016 139g CO$_2$/km</td>
<td>2020 5L/100km</td>
</tr>
<tr>
<td>2020 95g CO$_2$/km</td>
<td>2025 101g CO$_2$/km</td>
<td></td>
<td>&gt; 60 mpg small cars, &gt; 30 mpg trucks</td>
</tr>
</tbody>
</table>
Lightweighting Potential

- The car body contributes ~35-40% of vehicle’s entire mass
- The vehicle mass contributes ~25% of fuel consumption

### Forecasted Material Usage – McKinsey

<table>
<thead>
<tr>
<th>Material Type</th>
<th>2010</th>
<th>2030</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fiber-reinforced Plastics</td>
<td>19</td>
<td>13</td>
</tr>
<tr>
<td>Plastics</td>
<td>52</td>
<td>38</td>
</tr>
<tr>
<td>Magnesium</td>
<td>0</td>
<td>5</td>
</tr>
<tr>
<td>Aluminum</td>
<td>15</td>
<td>12</td>
</tr>
<tr>
<td>High Strength Steel (&gt;550 MPa)</td>
<td>0</td>
<td>0.5</td>
</tr>
<tr>
<td>Steel (&lt;550 MPa)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non Lightweighting</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Forecasted percentage usage:
- 29% in 2010
- 67% in 2030

Light Weight Materials
- Fiber-reinforced Plastics
- Plastics
- Magnesium
- Aluminum
- High Strength Steel (>550 MPa)
- Steel (<550 MPa)
- Non Lightweighting
Adhesives Supporting Structural Lightweighting

- Toughened Epoxy based structural adhesives for body shop application
- High elastic PU based structural adhesives for trim shop applications

<table>
<thead>
<tr>
<th>Toughened BETAMATE™ Structural EP</th>
<th>High Elastic BETAFORCE™ Structural PU</th>
</tr>
</thead>
<tbody>
<tr>
<td>A High modulus toughened adhesives</td>
<td>A High &amp; low modulus high elastic Adhesives</td>
</tr>
<tr>
<td>B Low modulus toughened &amp; thermal strain resistant adhesives</td>
<td>B Tailored curing speeds to adjust to the final application</td>
</tr>
</tbody>
</table>

™ Trademark of The Dow Chemical Company
Diversity in Bonding Technologies

- PU sealer
- PU adhesive & sealer
- Semi-structural PU
- BETAFORCE™
- Tougthened BETAMATE™

Epoxy Hybrid
Epoxy adhesive

Lap shear strength in MPa
Elongation in %
Advantages of Modern Joint Technologies

• Elimination of stress concentration resulting in enhanced fatigue and durability
• Increase in load transfer efficiency
• Reduction of sheet metal thickness
• Reduction of spot welds
Advantages of Modern Joint Technologies

- >300 % increase in joint strength at failure
- >300 % increase in displacement at failure

- High ductility at a broad range of temperatures
NEW SPECIALTY TOUGHENING TECHNOLOGY

- Increased adhesive modulus
- Maintains high fracture toughness
BETAMATE™ Improved Performance

- Significant increase in fatigue durability
- Consistent fatigue failure mode
BETAMATE™ Humidity Resistance

The global manufacturing and the shipment of closure panels and entire bodies requires adhesives which offer improved humidity resistance.

- Improved adhesive hydrophobicity by new components improves open time storage
- Innovative catalysis offers excellent bulk viscosity stability
BETAMATE™ Low Temperature Cure

- Consistent lap shear strength when cured at a broad range of temperatures
- Consistent performance on a variety of steel grades

Greater than three months of shelf stability at 23 °C
BETAMATE™ Low Temperature Cure

- Good impact strength when cured at a broad range of temperatures
- Good T-Peel strength at all bond line thicknesses
New Technology

- Improved wash-off resistance while maintaining pumpability
- Typical storage stability >6 months at room temperature
BETAMATE™ Improved Wash-Off Resistance

- Optimized rheology for superior wash-off resistance
- Wash-off tests on lubricant treated HDG steel

Rotational Wash-off – 140 rpm in a 60 °C bath

Spray Wash-Off
50 psi, 58 °C

Low Performance

New High Performance
Conclusions

- New Toughening Technology
  - Offers significant improvements in tensile modulus without affecting the adhesive ductility
  - Will provide improved stiffness/NVH and enable OEMs to downgauge high strength steels
- Improved vehicle longevity through improvements of
  - Fatigue durability
  - Environmental resistance
- Greener manufacturing processes offered without sacrificing performance
- Improved wash-off performance without sacrificing cold-pumpability through robotic applicators
For More Information

Dr. Tyler Auvil
Dow Automotive
+12483916377
tjauvil@dow.com

Dr. Daniel Sophiea
Dow Automotive
+12483916544
dosophiea@dow.com

Dr. Andreas Lutz
Dow Automotive
+41 447283559
alutz@dow.com

Thank you!