Light Weight Class ‘A’ SMC Body Panels – TCA Lite®

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Continental Structural Plastics
Technical Objectives

Initial/Current Goals for MD Class ‘A’ SMC

- SpG 1.6 (Standard Class ‘A’ SMC is 1.92 SpG)
  - Bonded to 1.3 SpG inner (Standard Inner is 1.92 SpG)
- Surface appearance same or better than current production parts
- Maintain pop resistance of TCA®
- Mechanical properties comparable to standard TCA®
- Processable viscosity
- No special handling required
Reducing Weight

Typical Class 'A' SMC Formulation

<table>
<thead>
<tr>
<th>Component</th>
<th>Weight %</th>
<th>Typical SpG</th>
</tr>
</thead>
<tbody>
<tr>
<td>PE Resin / LPA Package</td>
<td>20-25%</td>
<td>1.10</td>
</tr>
<tr>
<td>Additives (catalyst, inhibitor, thickener, pigment, mold release)</td>
<td>1-2%</td>
<td>0.85-1.50</td>
</tr>
<tr>
<td><strong>Filler (calcium carbonate)</strong></td>
<td><strong>45-50%</strong></td>
<td><strong>2.71</strong></td>
</tr>
<tr>
<td>Glass Fibers</td>
<td>25-30%</td>
<td>2.60</td>
</tr>
</tbody>
</table>
Potential Alternate Fillers

- Nanoclays
- Mineral Fillers
- Ceramic Microspheres
- Polymeric/Thermoplastic Microspheres
- Recycled Polymeric Materials
- Natural Fillers
- Hollow Glass Microspheres
Challenges

Nanoclays
Mineral Fillers
Ceramic Microspheres
Polymeric Microspheres
Recycled Polymeric Materials
Natural Fillers

Hollow Glass Microspheres
Hollow Glass Microspheres

Traditional glass microspheres used in SMC

- 0.37 g/cm$^3$
- 3000psi isostatic crush strength
- Structural low density (1.3 SpG) SMC
  - Production capable – several years of experience
- Class ‘A’ SMC$^1$
  - In-mold coating
  - Low-density sandwich structure

High Crush Strength Hollow Glass Microspheres

- **3M™ iM30K Glass Microspheres**
  - 0.6 g/cm³
  - 28,000 psi isostatic crush strength
  - Withstand compounding and molding process
  - Help provide excellent dimensional control
  - Help provide superior surface smoothness to alternative low density fillers
Substrate Sanding Study

- Spheres not affected by sanding of SMC
  - Multiple standard abrasive products
    - 3M™ 210U P400
    - 3M™ 360L P400
    - 3M™ 268L 30 micron
    - 3M™ 268L 40 micron
  - Orbital sander
    - Multiple passes across unpainted lab plaques
    - Panels evaluated for surface finish and evidence of ruptured spheres
Substrate Sanding Study

Raw SMC Panel - Unsanded
Substrate Sanding Study – Sample Results
Surface Improvement

Normalized Diffracto Data (vs. Standard TCA)
Paint Pop Flex Test

- 2” x 18” x 0.1” test strips
- 8.25” diameter cylindrical mandrel
- 125% of ultimate stress
- Primer-sealer with E-coat bake simulation
  - 380°F for 30 min.

MD TCA performed comparably to standard density TCA
Property Testing
# Mechanical Property Testing

<table>
<thead>
<tr>
<th>Property</th>
<th>Unit</th>
<th>Values</th>
<th>Specification Values</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Mean (X)</td>
<td>Std. Dev.</td>
</tr>
<tr>
<td>Glass Content</td>
<td>%</td>
<td>31.5</td>
<td>1.2</td>
</tr>
<tr>
<td>LOI</td>
<td>%</td>
<td>29</td>
<td>0.4</td>
</tr>
<tr>
<td>Filler</td>
<td>%</td>
<td>39.6</td>
<td>1</td>
</tr>
<tr>
<td>Water Absorption</td>
<td>%</td>
<td>0.66</td>
<td>0.12</td>
</tr>
<tr>
<td>Specific Gravity</td>
<td></td>
<td>1.58</td>
<td>0.01</td>
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<tr>
<td>Flexural Modulus@22°C</td>
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<td></td>
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<tr>
<td><a href="mailto:-@0.5mm">-@0.5mm</a> deflection</td>
<td>MPa</td>
<td>7948</td>
<td>966</td>
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<tr>
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<td>MPa</td>
<td>5630</td>
<td>287</td>
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<tr>
<td>Flexural Strength</td>
<td>MPa</td>
<td>149</td>
<td>6</td>
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<tr>
<td>Tensile Strength</td>
<td>MPa</td>
<td>60</td>
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<tr>
<td>Tensile Chord Modulus</td>
<td>MPa</td>
<td>8764</td>
<td>535</td>
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<tr>
<td>Elongation</td>
<td>%</td>
<td>1.1</td>
<td>0.08</td>
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<tr>
<td>Izod Impact, Unnotched</td>
<td>J/m</td>
<td>1041</td>
<td>93</td>
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<tr>
<td>Izod Impact, Unnotched</td>
<td>kJ/m²</td>
<td>82</td>
<td>7</td>
</tr>
<tr>
<td>Izod Impact, Notched</td>
<td>J/m</td>
<td>760</td>
<td>84</td>
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<tr>
<td>Izod Impact, Notched</td>
<td>kJ/m²</td>
<td>75</td>
<td>9</td>
</tr>
</tbody>
</table>

| Property                             | Unit | Values | Specification Values |
|                                      |      |        |                      |
| GMP.UP.010                           |      | 25-30  | 26-31               |
| WSS-M3D184-A                         |      | 50 max | 1.85-1.95           |

*September 15, 2010*
# Paint Adhesion Results

<table>
<thead>
<tr>
<th>Substrate</th>
<th>Primer</th>
<th>Initial Adhesion</th>
<th>240 Hr. Water Imm. (100F)</th>
<th>240 Hr. Humidity (100%@100F)</th>
</tr>
</thead>
<tbody>
<tr>
<td>850A1</td>
<td>Red Spot BP9471</td>
<td>Pass 100%</td>
<td>Pass 100%</td>
<td>Pass 100%</td>
</tr>
<tr>
<td>Red Spot BP9471</td>
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<td>Pass 100%</td>
</tr>
</tbody>
</table>
# Paint Adhesion Testing

<table>
<thead>
<tr>
<th>Record Date</th>
<th>Mold Date</th>
<th>Part</th>
<th>Substrate</th>
<th>Coating</th>
<th>Initial Adhesion</th>
<th>240 Hr. Water Immersion (100°F)</th>
<th>240 Hr. Humidity (100%@100°F)</th>
</tr>
</thead>
<tbody>
<tr>
<td>6/25/2010</td>
<td>May-10</td>
<td>OEM Decklid</td>
<td>MD TCA</td>
<td>RS 9471BC</td>
<td>Pass</td>
<td>Pass</td>
<td>Pass</td>
</tr>
<tr>
<td>6/25/2010</td>
<td>May-10</td>
<td>OEM Decklid</td>
<td>MD TCA</td>
<td>RS 9471BC</td>
<td>Pass</td>
<td>Pass</td>
<td>Pass</td>
</tr>
</tbody>
</table>
Production Trials
April 2009

- **Lab Roll Trial**
  - Improved surface (based on DOE results)
  - Standard production parameters
  - No molding issues

- **Current Production Decklid**
  - 1.6 outer / 1.3 inner
  - Topcoated (manual paint) at OEM Assembly Plant
### Paint Adhesion Testing

**Black OEM Topcoat**

<table>
<thead>
<tr>
<th>System</th>
<th>Initial Adhesion</th>
<th>Water Immersion</th>
<th>Humidity</th>
</tr>
</thead>
<tbody>
<tr>
<td>TCA Control</td>
<td>Pass - 100%</td>
<td>Pass - 99%</td>
<td>Pass - 99%</td>
</tr>
<tr>
<td>MD TCA</td>
<td>Pass - 100%</td>
<td>Pass - 99%</td>
<td>Pass - 99%</td>
</tr>
</tbody>
</table>
Lab Roll Trial

Current Production Decklid – OEM Assembly Plant
- 1.6 / 1.3 assembly subjected to production paint process
  - Standard E-coat
  - Topcoated

OEM R&D reported successful trial
- No defects
- No surface difference control vs. 850MD
- Weight savings well-received
May 2010

➢ Production Compounding Trial – CSP Van Wert Plant
   ▪ 5000 lbs produced
     • Standard production process
     • Good fiber wet out
     • Processable / Predictable viscosity
     • No manufacturing issues

➢ Production Molding Trial – CSP Carey Plant
   ▪ All panels molded using standard production parameters
   ▪ No press-side molding issues
   ▪ Standard material handling procedures (no special processing necessary)
May 2010 – Production Decklid

- **Outer Panels**
  - 32 outers molded
  - Outer panel weight 11.1 lbs (13.1 lbs standard)

- **Inner Panels**
  - 32 Inners molded from production low density (1.3) SMC
  - Inner panel weight 7.9 lbs (11.5 lbs standard)

- **Decklid Assembly**
  - Standard – 24.7 lbs
  - Mid-Density / Low-Density Assembly – 19 lbs

- **Total Weight Reduction – 5.7 lbs (23%)**

- **16 Assemblies Primed**
  - Similar defect rate to production
  - Paint adhesion and bond teardown both passed
Outer Panels
- 20 outers molded
- Outer panel weight 13.1 lbs (15 lbs standard)

Inner Panels
- 20 Inners molded from production low density (1.3) SMC
- Inner panel weight 5.5 lbs (8 lbs standard)

Hood Assembly
- Standard – 23 lbs
- Mid-Density / Low-Density Assembly – 18.6 lbs

**Total Weight Reduction – 4.4 lbs (19%)**

14 Assemblies Primed
- Similar defect rate to production
- Paint adhesion, bond teardown, and dimension checks all passed

2 Assemblies sent to OEM Plant for Topcoat evaluation
Results – TCA Lite® SMC

- Development of Viable 1.6 SpG Class ‘A’ SMC
  - Transparent to standard compounding process
  - Transparent to standard molding process
  - Transparent to standard finishing process
  - Excellent surface smoothness
  - Excellent paintability
  - 20-25% weight reduction (total assemblies)

- Patent Issued April 20, 2010
Next Steps

➢ Additional production trials
  - Compounding
    • Gain Experience
    • Collect Production data for approval process
  - Molding
    • Capability studies
    • Additional parts
    • OEM Topcoat

➢ Develop specifications with OEMs
➢ Gain material approvals for new business
Questions / Comments