A New Approach to SMC Weight Reduction
Prior approaches to weight reduction using SMC

• Conventional SMC—circa 1.8 specific gravity (sg), weight reduction vs other materials by taking advantage of design flexibility using ribs, gussets.

• Low filler SMC—replacement of calcium carbonate with high-resin demand clays, including nano-clay. Lower feasibility limit circa 1.4 sg with good mechanicals and fair surface quality.

• Glass microsphere SMC—use of hollow glass microspheres to achieve sg of 1.1 or lower. Original approach resulted in non-sandable, non-paintable SMC but recent advances have enabled class A surfaces paintable surfaces.

• Carbon fiber and Carbon/glass hybrid SMC: achieve weight reduction through lower sg reinforcement fiber and through design flexibility for thinner structures due to advantageous stiffness of carbon fiber.
Soy Filler: a new option for weight reduction using SMC

- Used as a direct replacement for calcium carbonate at similar volume fraction loadings.
- Soy filler has 1.1 sg vs 2.7 sg for calcium carbonate.
  - Similar resin demand permits same loading as calcium carbonate
- For a typical semi-structural SMC at 25-30% glass, the soy filler product with comparable volume fraction of filler and glass achieves approximately 1.4 sg.
- Soy filler is not applicable in SMC’s with high-volume-fraction of fiber since those SMC’s use little filler.
- Soy filler can be used in conjunction with glass microspheres to achieve 1.1 sg or lower.
Why Soy Filler?

- Primary driver is cost per cubic inch
- Once economies of scale are achieved, soy filler is expected to be cost per cubic inch neutral with typical grades of calcium carbonate.
- Net effect is to achieve lower specific gravity with little or no premium.

Relative cost per cubic inch comparison:
Environmental benefits

CO2 Sequestration
Support farm economy
Reduce foreign petroleum

Weight Reduction—fuel savings in service
Durable components
Design flexibility

Filler treatment, compounding and molding
Soy Filler: Renewable, plentiful resource

- Soy filler is derived from the hull, a low-value component which has low feed value.
- Primary value is the soy oil, used for food and cooking oil, feedstock for bio-diesel, and for polymers and printing inks.
- The soy meal is also a highly valued component used for high protein component of animal feed and human consumption
- The soy hull is readily available, used mostly as an animal feed extender
- As demand for soy oil and soy meal continue to rise, soy hulls are expected to be plentiful
- For use as soy filler, the soy hulls are ground, heat treated to reduce water absorption in the end product.
PROPERTIES OF SMC WITH SOY FILLER
# Mechanical Properties of SMC using various low density approaches

<table>
<thead>
<tr>
<th>Property</th>
<th>Units</th>
<th>Soy+ microsphere</th>
<th>Microsphere</th>
<th>Soy filler</th>
<th>Low filler</th>
<th>Standard SMC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tensile strength</td>
<td>MPa</td>
<td>66.8</td>
<td>65</td>
<td>57</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Tensile Mod</td>
<td>MPa</td>
<td>7342</td>
<td>8000</td>
<td>10000</td>
<td>8500</td>
<td>15000</td>
</tr>
<tr>
<td>Flex strength</td>
<td>MPa</td>
<td>139</td>
<td>160</td>
<td>160</td>
<td>220</td>
<td>210</td>
</tr>
<tr>
<td>Flex Mod</td>
<td>MPa</td>
<td>6367</td>
<td>7000</td>
<td>9300</td>
<td>8000</td>
<td>10000</td>
</tr>
<tr>
<td>Unnotched Izod</td>
<td>J/m</td>
<td>1048</td>
<td>1100</td>
<td></td>
<td>1500</td>
<td>1500</td>
</tr>
<tr>
<td>Notched Izod</td>
<td>J/m</td>
<td>820</td>
<td>700</td>
<td>1190</td>
<td>1100</td>
<td>950</td>
</tr>
<tr>
<td>Specific gravity</td>
<td>(NA)</td>
<td>1.1</td>
<td>1.2</td>
<td>1.4</td>
<td>1.4</td>
<td>1.9</td>
</tr>
<tr>
<td>Wt % glass</td>
<td>%</td>
<td>39</td>
<td>41</td>
<td>38</td>
<td>38</td>
<td>28</td>
</tr>
<tr>
<td>Volume % glass</td>
<td></td>
<td>15.9</td>
<td>18.2</td>
<td>19.7</td>
<td>19.7</td>
<td>19.7</td>
</tr>
</tbody>
</table>
Tensile and Flexural Strength of LD SMC's

- Soy+ microsphere
- Microsphere
- Soy filler
- Low filler LD SMC
- Standard R-30

- Tensile strength MPa
- Flex strength MPa
Impact Properties of LD SMC's

Unnotched Izod J/m  Notched Izod J/m

Soy+ microsphere  Microsphere  Soy filler  Low filler LD SMC  Standard R-30
Stiffness Characteristics of LD SMC's

- Soy+ microsphere
- Microsphere
- Soy filler
- Low filler LD SMC
- Standard R-30

Tensile Mod MPa vs Flex Mod MPa
Observations from Mechanical Data

• The soy filler SMC has properties in the same range as the glass microsphere SMC that has seen commercial acceptance in the market for semi-structural applications.

• Use of a low filler loading, high resin demand filler approach yields the better retention of strength values among LD solutions, but the soy filler may be a bit better in modulii retention.

• It is noted that the formulations herein are each optimized to some degree for their applications, they are not structured in strict academic comparisons.
HIGH SPEED INSTRUMENTED IMPACT
High Speed Instrumented Impact

• Since modulus generally has some trade-off with toughness, high speed instrumented impact was used to investigate overall impact characteristics.
# High Speed Impact

<table>
<thead>
<tr>
<th>Property</th>
<th>Soy+ microsphere</th>
<th>Microsphere</th>
<th>Soy filler</th>
<th>Low filler</th>
<th>Standard SMC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peak load, lbs</td>
<td>370</td>
<td>418</td>
<td>272</td>
<td>453</td>
<td>416</td>
</tr>
<tr>
<td>Deflection at max load, in</td>
<td>0.193</td>
<td>0.180</td>
<td>0.160</td>
<td>0.194</td>
<td>0.163</td>
</tr>
<tr>
<td>Deflection at failure, in</td>
<td>0.307</td>
<td>0.366</td>
<td>0.388</td>
<td>0.406</td>
<td>0.414</td>
</tr>
<tr>
<td>Energy to max load, ft-lbf</td>
<td>2.87</td>
<td>3.22</td>
<td>1.90</td>
<td>3.99</td>
<td>3.61</td>
</tr>
<tr>
<td>Total energy, ft-lbf</td>
<td>5.19</td>
<td>7.21</td>
<td>5.28</td>
<td>9.43</td>
<td>9.55</td>
</tr>
<tr>
<td>Specific gravity</td>
<td>1.1</td>
<td>1.2</td>
<td>1.4</td>
<td>1.4</td>
<td>1.9</td>
</tr>
</tbody>
</table>
High Speed Instrumented Impact

- Soy+ microsphere
- Microsphere
- Soy filler
- Low filler
- Standard SMC

Deflection at max load, in
Deflection at failure, in
High Speed Instrumented Impact

- Energy to max load, ft-lbf
- Total energy, ft-lbf

Soy+ microsphere
Microsphere
Soy filler
Low filler
Standard SMC

Suc·cess [sək' ses]
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Summary

• Soy Filler offers a new avenue for SMC weight reduction, with potential economic advantage once economies of scale are achieved with the soy filler.

• Soy Filler offers the added benefit of sequestering carbon, and supporting the US farm economy.

• Replacement of conventional SMC with each of the low density approaches requires a balance between part design and specific material properties.

• The low filler SMC approach yields properties most in line with conventional SMC but has a floor around 1.4 SG for a 20% volume fraction of glass fiber.

• Glass microsphere SMC and soy filler SMC in combination with glass microspheres offer the greater weight reduction opportunities where design allowables fit.
Acknowledgements

Our Soy Checkoff
Project #2456 & 1340-512-5275

Ohio Soybean Council

University of Akron

success [səkˈses]
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