SCREENING OF NATURAL LIGHTWEIGHT FILLERS FOR SHEET MOULDING COMPOUND IN NORTH AMERICA

Alia Pierce, Tobias Potyra
Fraunhofer Project Centre @ Western
Western University
2520 Advanced Ave
London, ON, N6M 0E1, Canada

Frank Henning
Fraunhofer ICT
Joseph-von-Fraunhofer-Str. 7
76327 Pfinztal
Germany

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Outline
1. Introduction and Motivation
2. Selection of alternative fillers
3. Particle shape
4. Viscosity measurements
5. Summary and outlook
1. Motivation

Motivation for Light-weight design

- Weight increase of typical medium-class vehicle since 1970.
- Implementation of CAFE regulation.
- Reduction of consumption and emissions through lighter structures.
- Improvement of passive and active safety and product attractiveness through functional design.
- For commercial vehicles: increased payload.
- Lightweight design requires quality controlled, high-volume manufacturing processes for composites.
1. Motivation

SMC Technology

- Multiple processing steps
- Quality issues
- Application in diverse products

[Images of trucks, passenger cars, and logistics]

[Links to Daimler, Autoblog, and Fitpallet websites]
1. Motivation

Breakdown of SMC Formulation

- Resin/LPA: 32%
- Glass fibre: 21%
- Filler: 41%
- Additives: 6%
3. Alternative Fillers

Investigated Fillers

• Canola
• Corn Stover
• Wheat
• Pecan shell
• Walnut shell
• Hollow microspheres
### 3. Alternative Fillers

#### Investigated Fillers

<table>
<thead>
<tr>
<th>Biomass</th>
<th>Density [g/cm³]</th>
<th>Moisture (weight %)**</th>
<th>HHV (kJ/kg, dry basis)**</th>
<th>Grindability (kJ/kg) *</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glass Microspheres</td>
<td>0.46</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Wheat straw</td>
<td>1.2-1.35</td>
<td>3.8</td>
<td>18116</td>
<td>1745</td>
</tr>
<tr>
<td>Corn stover</td>
<td>0.7</td>
<td>5.4</td>
<td>16272</td>
<td>898</td>
</tr>
<tr>
<td>Canola</td>
<td>0.5</td>
<td>6.8</td>
<td>16871</td>
<td>1586</td>
</tr>
<tr>
<td>Pecan shell</td>
<td>1.2-1.35</td>
<td>6.6</td>
<td>18874</td>
<td>-</td>
</tr>
<tr>
<td>Walnut shell</td>
<td>1.2-1.4</td>
<td>6.4</td>
<td>19001</td>
<td>-</td>
</tr>
</tbody>
</table>
3. Alternative Fillers

Setup for Processing Filler from Raw Biomass

- Hammer Mill
- Stop clock
- Scales
- Container for transporting material
- Shredding device
3. Alternative Fillers

Corn Stover, Wheat Stover, Canola

Biomass Processed with Hammer Mill
3. Alternative Fillers

Corn Stover, Wheat Stover, Canola

Biomass Processed with Hammer Mill and Shredding Device
3. Alternative Fillers

Canola

Canola ground using a hammer mill and then further processed for 600 seconds in a shredding device (left) and zoomed in (right)

Canola processed for 900 seconds in a shredding device (left) and zoomed in (right)
### 3. Alternative Fillers

Particle Sizes Measured for Canola

<table>
<thead>
<tr>
<th>Name of Material</th>
<th>Average Mean Diameter of Particles (µm)</th>
<th>Min. Size Range of Particles (µm)</th>
<th>Max. Size Range of Particles (µm)</th>
<th>Equipment Used for Testing</th>
</tr>
</thead>
<tbody>
<tr>
<td>ICFAR ground canola</td>
<td>676.11</td>
<td>180</td>
<td>1400</td>
<td>ASTM sieves 1mm, 850, 710, 500, 355, 212, 180µm</td>
</tr>
<tr>
<td>ICFAR+ FPC ground canola</td>
<td>427.50</td>
<td>90</td>
<td>1400</td>
<td>ASTM sieves 1mm, 850, 710, 500, 355, 212, 180, 90µm</td>
</tr>
<tr>
<td>FPC ground canola 900secs</td>
<td>209.29</td>
<td>90</td>
<td>710</td>
<td>ASTM sieves 1mm, 850, 710, 500, 355, 212, 180, 106, 90µm</td>
</tr>
</tbody>
</table>
3. Alternative Fillers

Canola, Viscosity Measurement

Graph to show the loading of hammer mill processed canola filler in the SMC resin formulation

Graph to show the loading of hammer mill and 600second shredding device processed canola filler in the SMC resin formulation
3. Alternative Fillers

Corn Stover

Corn stover ground using a hammer mill and then further processed for 600 seconds in a shredding device (left) and zoomed in (right)

Corn stover processed for 900 seconds in a shredding device (left) and zoomed in (right)
## 3. Alternative Fillers

### Particle Sizes Measured for Corn Stover

<table>
<thead>
<tr>
<th>Name of Material</th>
<th>Average Mean Diameter of Particles (µm)</th>
<th>Min. Size Range of Particles (µm)</th>
<th>Max. Size Range of Particles (µm)</th>
<th>Equipment Used for Testing</th>
</tr>
</thead>
<tbody>
<tr>
<td>ICFAR ground corn stover</td>
<td>755.07</td>
<td>212</td>
<td>500</td>
<td>ASTM sieves 1mm, 850, 710, 500, 355, 212µm</td>
</tr>
<tr>
<td>ICFAR+ FPC ground corn stover</td>
<td>306.33</td>
<td>106</td>
<td>500</td>
<td>ASTM sieves 1mm, 850, 710, 500, 355, 212, 180, 106µm</td>
</tr>
<tr>
<td>FPC ground corn stover 900secs</td>
<td>314.67</td>
<td>106</td>
<td>500</td>
<td>ASTM sieves 1mm, 850, 710, 500, 355, 212, 180, 106µm</td>
</tr>
</tbody>
</table>
3. Alternative Fillers

Corn Stover

Graph to show the loading of hammer mill processed corn stover filler in the SMC resin formulation

Graph to show the loading of hammer mill and 600second shredding device processed corn stover filler in the SMC resin formulation
3. Alternative Fillers

Wheat ground using a hammer mill and then further processed for 600 seconds in a shredding device (left) and zoomed in (right).

Wheat processed for 900 seconds in a shredding device (left) and zoomed in (right).
### 3. Alternative Fillers

Particle Sizes Measured for Wheat

<table>
<thead>
<tr>
<th>Name of Material</th>
<th>Average Mean Diameter of Particles (µm)</th>
<th>Min. Size Range of Particles (µm)</th>
<th>Max. Size Range of Particles (µm)</th>
<th>Equipment Used for Testing</th>
</tr>
</thead>
<tbody>
<tr>
<td>ICFAR ground wheat</td>
<td>847.50</td>
<td>180</td>
<td>1400</td>
<td>ASTM sieves 1mm, 850, 710, 500, 355, 212, 180µm</td>
</tr>
<tr>
<td>ICFAR+ FPC ground wheat</td>
<td>404.88</td>
<td>106</td>
<td>500</td>
<td>ASTM sieves 1mm, 850, 710, 500, 355, 212, 180, 106µm</td>
</tr>
<tr>
<td>FPC ground wheat 900secs</td>
<td>494.46</td>
<td>106</td>
<td>500</td>
<td>ASTM sieves 1mm, 850, 710, 500, 355, 212, 180, 106µm</td>
</tr>
</tbody>
</table>
3. Alternative Fillers

Wheat

Graph to show the loading of hammer mill processed wheat filler in the SMC resin formulation

Graph to show the loading of hammer mill and 600second shredding device processed wheat filler in the SMC resin formulation
3. Alternative Fillers

Walnut/ Pecan Nut Shell
3. Alternative Fillers

Pecan Nut Shell

#200 pecan shell (above) and #325 pecan shell (below), left at 500x magnification, right at 1.5k magnification
3. Alternative Fillers

Particle Sizes Measured for Pecan Shell

<table>
<thead>
<tr>
<th>Name of Material</th>
<th>Average Mean Diameter of Particles (µm)</th>
<th>Min. Size Range of Particles (µm)</th>
<th>Max. Size Range of Particles (µm)</th>
<th>Equipment Used for Testing</th>
</tr>
</thead>
<tbody>
<tr>
<td>#200 pecan shell</td>
<td>11.26</td>
<td>-</td>
<td>215</td>
<td>HELOS (H2316) Particle Size Analyser</td>
</tr>
<tr>
<td>#325 pecan shell</td>
<td>14.45</td>
<td>-</td>
<td>250</td>
<td>HELOS (H2316) Particle Size Analyser</td>
</tr>
</tbody>
</table>
3. Alternative Fillers

Pecan Nut Shell

Graph to show the loading of #325 pecan shell filler in the SMC resin formulation

Graph to show the loading of #200 pecan shell filler in the SMC resin formulation
3. Alternative Fillers

Walnut Shell

#200 walnut shell (left) and #325 walnut shell (right) above at 500x magnification, below at 1.5k magnification
3. Alternative Fillers

Particle Sizes Measured for Walnut Shell

<table>
<thead>
<tr>
<th>Name of Material</th>
<th>Average Mean Diameter of particles (µm)</th>
<th>Min. Size Range of Particles (µm)</th>
<th>Max. Size Range of Particles (µm)</th>
<th>Equipment Used for Testing</th>
</tr>
</thead>
<tbody>
<tr>
<td>#200 walnut shell</td>
<td>8.91</td>
<td>-</td>
<td>90</td>
<td>HELOS (H2316) Particle Size Analyser</td>
</tr>
<tr>
<td>#325 walnut shell</td>
<td>14.90</td>
<td>-</td>
<td>255</td>
<td>HELOS (H2316) Particle Size Analyser</td>
</tr>
</tbody>
</table>
3. Alternative Fillers

Walnut Shell

Graph to show the loading of #325 walnut shell filler in the SMC resin formulation

Graph to show the loading of #200 walnut shell filler in the SMC resin formulation
3. Alternative Fillers

Hollow Glass Microspheres

Source: www.3m.com

3M iM16k
3. Alternative Fillers

Hollow Glass Microspheres

Graph to show the loading of glass bubble filler in the SMC resin formulation
3. Alternative Fillers

Summary

• Bulk density of Corn Stover very promising
• Viscosity increase due to corn stover, wheat and canola is very high

• Pecan nut shell seems to be the most promising alternative bearing a combination of mid density range at moderate viscosity increase
• Particle shape of pecan shell is rather spherical

Outlook

• Viscosity increase through alternative fillers should be overcome by use of alternative mixing technique
• Use of Direct SMC process with twin screw mixing extruder
Fraunhofer Project Centre for Composites Research at Western University

FPC @ Western

A joint venture between:

Western University, London, Ontario, Canada
And
Fraunhofer Gesellschaft, Munich, Germany & Institute for Chemical Technology (ICT), Pfinztal, Germany

Contact: tobias.potyra@ict.fraunhofer.de
www.eng.uwo.ca/fraunhofer
Twin Regions

Joint Expertise for Local Demands

Both entities, being situated in the heart of automotive areas will jointly work on composite technologies adapted to the local demands of each region’s industry. The activities of both research entities will utilize and increase the expertise to accelerate composite innovations as lightweight solutions.
Mission

- To reduce the consumption and the emissions within the field of transportation by implementing lightweight design.

- Improvement of passive and active safety as well as product attractiveness through functional structures.

- Realisation of innovative technologies, production processes and products in economically viable small, medium and large-scale volumes.

Design  Process and Material  Demonstrator Part
Applied Research with Industry

Bridging the gap in the knowledge chain.

- Realization of industrial processes
- Application of developed innovative processes
- Optimization of existing processes and materials

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- Application of developed innovative processes
- Optimization of existing processes and materials

- Basic research on fiber matrix phenomena
- Simulation and Design
- Investigation of fundamental interests

Collaboration with industry

Collaboration with FPC@Western

Collaboration with universities

in cooperation with

Western

Fraunhofer
Set of Principles

- The FPC is a neutral, not-for-profit, University-linked applied research facility
- The FPC is open to all potential users (no exclusive relationships)
- The FPC focuses on industry-led and industrially relevant needs
- The FPC takes a holistic approach to problem-solving
- The FPC collaborates with academic institutions and leverages industry funding with grants from research agencies (the ICRC takes the lead at UWO for developing and managing research grants and works closely with the FPC)
- The FPC acts with the aim of being self sustaining
Fields of Technologies

- Compression Moulding
- Sheet Moulding Compound
- Long-fiber Reinforced Thermoplastics
- Preforming Technology
- High Pressure Resin transfer Moulding
Thank you very much for your attention!