LONG FIBER REINFORCED THERMOPLASTICS A LIGHTWEIGHT SOLUTION FOR ENGINEERING APPLICATIONS

SAMPE BRAZIL 2014

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Manufacturing Process – Pultrusion

- Polymer: PP, PA, TPU, etc. + additives
- Extruder
- Thermoplastic Melt
- Impregnation Die
- Puller
- Granulator
- LFRT Pellets: 0.5” / 11mm Length

Fiber Rovings:
- Fiberglass,
- Carbon,
- Aramid,
- Stainless Steel
Manufacturing Process – Technologies

**Step 1**
Short Fiber Granule
Fiber Length = 0.2 – 0.4 mm

**Step 2**
Wire-Coated Or Co-Mingled Fibers

**Step 3**
Fully Impregnated Long Fiber Granule
Fiber Length = 11-25 mm

**Step 4**
Fully Impregnated, Continuous Fiber Reinforced Tape (CFR-TP)
Fully melt impregnation technology

- Each fiber fully impregnated / Constant fiber dispersion
- Superior mechanical properties
- Better surface finish
- Easier to process

SEM picture of pellet cross section
Wire coating technology – loose fiber
Pellets are fragile and break*

Cestran® pultrusion technology
Fully fiber melt impregnation*

* LFT pellet pictures after mill test
### LFT properties by matrix

<table>
<thead>
<tr>
<th>Property</th>
<th>PP-GF40</th>
<th>PA66-GF40</th>
<th>PA6-GF40</th>
<th>PBT-GF40</th>
<th>TPU-GF40</th>
<th>PPS-GF40</th>
<th>HDPE-GF40</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tensile Stress @ Break (MPa)</td>
<td>140</td>
<td>215</td>
<td>205</td>
<td>180</td>
<td>210</td>
<td>170</td>
<td>80</td>
</tr>
<tr>
<td>Tensile Strain @ Break (%)</td>
<td>2,2</td>
<td>2,0</td>
<td>2,1</td>
<td>1,9</td>
<td>2,5</td>
<td>1,2</td>
<td>2,3</td>
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<tr>
<td>Tensile Modulus (MPa)</td>
<td>9.500</td>
<td>13.300</td>
<td>12.400</td>
<td>13.600</td>
<td>11.100</td>
<td>14.700</td>
<td>6.800</td>
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<tr>
<td>Charpy notched 23ºC (KJ/m²)</td>
<td>30</td>
<td>35</td>
<td>32</td>
<td>32</td>
<td>48</td>
<td>33</td>
<td>24</td>
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<tr>
<td>Density</td>
<td>1,22</td>
<td>1,45</td>
<td>1,45</td>
<td>1,61</td>
<td>1,52</td>
<td>1,49</td>
<td>1.27</td>
</tr>
</tbody>
</table>

### LFT with 40% glass fiber with different matrix materials

- **LFT with 40% glass fiber with different matrix materials**

  - PP
  - PA66
  - PA6
  - PBT
  - TPU
  - PPS

  - **PP 40% short fiber**
  - **PA66 40% short fiber**
Specific strength (tensile strength/density) of LFT materials (Celstran® from Celanese) in comparison with metals (typical values)

<table>
<thead>
<tr>
<th>Material</th>
<th>Density (g/cm³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PP-GF40</td>
<td>1,2</td>
</tr>
<tr>
<td>PA66-GF40</td>
<td>1,45</td>
</tr>
<tr>
<td>PA66-GF60</td>
<td>1,67</td>
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<tr>
<td>PA66-CF40</td>
<td>1,34</td>
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<tr>
<td>Stainless Steel</td>
<td>7,7</td>
</tr>
<tr>
<td>Aluminium</td>
<td>2,7</td>
</tr>
<tr>
<td>Zinc</td>
<td>6,0</td>
</tr>
<tr>
<td>Magnesium</td>
<td>1,8</td>
</tr>
</tbody>
</table>
LFT – Metal replacement

- **Weight reduction**: the use in vehicles leads to lower fuel consumption - energy savings
- **Lower production costs**: reduce assembly and secondary operations; lower scrap rates during standard processing; in-process recyclability potential; avoid painting thanks to in-mold color possibility
- **Flexibility of design**: easy to color; possibility of design in complex shapes; parts integration
- **Corrosion resistance**
- **Dimensional stability** – for high precision parts
Long fiber or short fiber?

Instrumented puncture test on LFT PP-GF40 (continuous line - Celstran® from Celanese) and a polypropylene with 40% short glass fibers (market reference – dotted line).
Long fiber or short fiber?

Creep curves for two LFT PP grades compared with short glass fiber reinforced PP and short glass fiber reinforced PA66

Tensile stress: 35MPa - According to ISO 899 part 1
Long fiber or short fiber?

Flexural creep modulus of LFT PP-GF40 as a function of time compared with a PP with 40% by weight short glass fiber flexural stress: 120MPa, temperature: 120º C)
Fiber Structure giving strong final parts

- Short fiber part shows no fiber integrity or structure
- Celstran long fiber part maintains shape due to fiber entanglement

Gear Wedge ‘Burn-off’ Results
Long fibers tend to orient less in the flow direction than comparable short fiber products, a fiber interlocking skeleton is formed in the molded part.

Lower warpage and shrinkage than with comparable short fiber reinforced molded parts.
Abrasion against steel - LFT PA66-GF40 and short fiber reinforced PA66 with 40% by weight glass fibers
Flow lengths of LFT PP-GF30 compared with PP with 30% by weight short glass fiber
Thank you!
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