Overmolding with Continuous Fiber Reinforced Thermoplastic Composites for Selective Reinforcement

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PolyOne Advanced Composites

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AGENDA

• Materials – Comparison and Contrast

• Injection Overmolding with CFRTP

• Performance Comparison

• Applications

• About PolyOne Advanced Composites
PERFORMANCE VS. DESIGN FLEXIBILITY

- **Continuous Fiber Thermoset Composites**
- **Continuous Fiber Thermoplastic Composites**
- **Long Glass Fiber Thermoplastics**
- **Short Glass Fiber Thermoplastics**

### PERFORMANCE

#### Flexural Strength
- **PLASTICOMP COMPLÉT™** Long Fiber Thermoplastics:
  - 53,500 psi (at ~50% Wf)
- **POLYSTRAND™** Continuous Fiber Thermoplastic Composites:
  - 85,000 psi (at ~65% Wf)

#### Flexural Modulus
- **PLASTICOMP COMPLÉT™** Long Fiber Thermoplastics:
  - 2,400,000 psi (at ~50% Wf)
- **POLYSTRAND™** Continuous Fiber Thermoplastic Composites:
  - 4,200,000 psi (at ~65% Wf)
LONG FIBER REINFORCED THERMOPLASTIC COMPOSITES

Creels
Fiber Alignment
Pelletizer
Impregnation Die

PLASTICOMP COMPLÊT™
CONTINUOUS FIBER REINFORCED THERMOPLASTIC (CFRTP) COMPOSITES

Creels

Fiber Management

Impregnation Die

Accumulator

POLYSTRAND™ CFRTP
INJECTION OVERMOLDING WITH CFRTP

1. Solid resin infeed
2. Material heating, melting, and conveying
3. CFRTP is preheated and inserted into tool
4. Mold to compress and cool into shape
5. Overmolded finished part
LAMINATE PREPARATION - Preheating

- Preheating is essential for optimal interfacial bonding
- Insufficient preheating can result in a depressed ultimate failure strength
- Preheating also allows for forming of laminates into complex curvatures

<table>
<thead>
<tr>
<th>OVERMOLD LAMINATE PREHEATING</th>
<th>Uni &amp; X</th>
<th>Tri &amp; Quad</th>
<th>S-Ply and Above</th>
</tr>
</thead>
<tbody>
<tr>
<td>Polypropylene</td>
<td>160°C</td>
<td>180°C</td>
<td>190°C</td>
</tr>
<tr>
<td>Polyamide 6 (Nylon 6)</td>
<td>170°C</td>
<td>190°C</td>
<td>200°C</td>
</tr>
<tr>
<td>Polyethylene</td>
<td>150°C</td>
<td>160°C</td>
<td>180°C</td>
</tr>
</tbody>
</table>

Peel test samples

Adequate preheat
Substrate Failure

Low preheat
Interface failure
LAMINATE APPLICATION - Geometry

- Targeted laminate placement is governed by part geometry
  - Injection flow path
  - Part / application thickness
  - Laminate thickness
  - Radius of curvature for 2D and 3D shapes
# PERFORMANCE COMPARISON

## TEST MATRIX

<table>
<thead>
<tr>
<th>Base Resins – PlastiComp™ LFT</th>
</tr>
</thead>
<tbody>
<tr>
<td>LCF40-PA66</td>
</tr>
<tr>
<td>Long Carbon Fiber 40%, Nylon 6,6</td>
</tr>
<tr>
<td>LCF40-PA66</td>
</tr>
<tr>
<td>LGF50-PA66</td>
</tr>
<tr>
<td>Long Glass Fiber 50%, Nylon 6,6</td>
</tr>
<tr>
<td>LGF50-PA66</td>
</tr>
<tr>
<td>LCGF50-PA66</td>
</tr>
<tr>
<td>Long Carbon &amp; Glass Fiber 50%, Nylon 6,6</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Laminates – Polystrand™ CFRTP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Uni-Ply</td>
</tr>
<tr>
<td>X-Ply</td>
</tr>
<tr>
<td>Tri-Ply</td>
</tr>
<tr>
<td>Quad-Ply</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Standardized Testing</th>
</tr>
</thead>
<tbody>
<tr>
<td>D7264 4-Point Flex</td>
</tr>
<tr>
<td>D3763 Dynatup Impact</td>
</tr>
<tr>
<td>D790 Elevated Temp. Flex</td>
</tr>
</tbody>
</table>
PERFORMANCE – FLEX

D7264: Modulus of LCF40 + XX Laminate

- Glass tape onto Carbon fiber resin
- 

Modulus (MPa)

<table>
<thead>
<tr>
<th>LAMINATE</th>
<th>None</th>
<th>Uni</th>
<th>X</th>
<th>Tri</th>
<th>Quad</th>
</tr>
</thead>
<tbody>
<tr>
<td>LCF40</td>
<td>19715.7</td>
<td>24870.4</td>
<td>27164.6</td>
<td>27422.7</td>
<td>27800.2</td>
</tr>
</tbody>
</table>

~26%
PERFORMANCE – TEMPERATURE

D7264: Modulus of LCF40 + XX Laminate versus Temperature

Modulus (MPa)

Room Temperature

100°C

150°C

200°C

~64%

~68%

LCF40 Only

LCF40 + Uni-Ply

LCF40 + Tri-Ply
PERFORMANCE – TEMPERATURE

D7264: Strength of LCF40 + XX Laminate versus Temperature

<table>
<thead>
<tr>
<th>Temperature</th>
<th>LCF40 Only</th>
<th>LCF40 + Uni-Ply</th>
<th>LCF40 + Tri-Ply</th>
</tr>
</thead>
<tbody>
<tr>
<td>Room Temp</td>
<td>247.7</td>
<td>379.7</td>
<td>385.1</td>
</tr>
<tr>
<td>100°C</td>
<td>132.0</td>
<td>233.0</td>
<td>230.7</td>
</tr>
<tr>
<td>150°C</td>
<td>120.4</td>
<td>180.9</td>
<td>175.0</td>
</tr>
<tr>
<td>200°C</td>
<td>101.4</td>
<td>101.7</td>
<td>109.9</td>
</tr>
</tbody>
</table>
PERFORMANCE - IMPACT

D3763 Dynatup Impact Test: LGF50

<table>
<thead>
<tr>
<th>Force at Peak (kN/mm)</th>
<th>Energy at Peak (J/mm)</th>
<th>Energy at Puncture (J/mm)</th>
<th>Energy at Total (J/mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.505</td>
<td>3.83</td>
<td>5.79</td>
<td>6.32</td>
</tr>
<tr>
<td>1.120</td>
<td>3.07</td>
<td>5.43</td>
<td>5.79</td>
</tr>
<tr>
<td>1.311</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

LGF50 Only

LGF50 + Tri-Ply

LGF50 + Quad-Ply

~+180%

~+313%
PERFORMANCE - IMPACT

D3763 Dynatup Impact Test: LCGF50

- **Force at Peak (kN/mm):**
  - LCGF50 Only: 0.944
  - LCGF50 + X-Ply: 1.061
  - LCGF50 + Tri-Ply: 1.230
  - LCGF50 + Quad-Ply: 1.176

- **Energy at Peak (J/mm):**
  - LCGF50 Only: 3.13
  - LCGF50 + X-Ply: 3.29
  - LCGF50 + Tri-Ply: 2.95
  - LCGF50 + Quad-Ply: 3.17

- **Energy at Puncture (J/mm):**
  - LCGF50 Only: 4.29
  - LCGF50 + X-Ply: 5.22
  - LCGF50 + Tri-Ply: 5.58
  - LCGF50 + Quad-Ply: 5.58

- **Energy at Total (J/mm):**
  - LCGF50 Only: ~+46%
  - LCGF50 + X-Ply: ~+50%
  - LCGF50 + Tri-Ply: ~+50%
  - LCGF50 + Quad-Ply: 7.17

**Legend:**
- LCGF50 Only
- LCGF50 + X-Ply
- LCGF50 + Tri-Ply
- LCGF50 + Quad-Ply
For low weight penalty, significant mechanical increases in flex, mechanical retention, and impact.
APPLICATIONS

SNOWBOARD BINDING

OIL PAN

AUTOMOTIVE HATCH COVER

STRUCTURAL DEMONSTRATOR
POLYONE ADVANCED COMPOSITES

GLASFOMS
Thermoset Composite Pultrusions
Continuous Filament Wound Poles & Tubes

GORDON COMPOSITES
Unidirectional Thermoset Composite Laminates & Barstock

POLYSTRAND
Continuous Fiber Reinforced Thermoplastic (CFRTP) Tapes, Laminates & Sandwich Panels
QUESTIONS?

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