High Temperature Structural Products, Improved Performance at Elevated Temperatures and Harsh Environments

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1:00 p.m.
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Matt Torosian,
Product Manager, High Temperature Structural Products

What are Ultra Performance products?

Highlights

Review of competing materials

- Metals
- Conventional engineering thermoplastics
- VLF Products
  - Vs. Conventional reinforced TP compounds

Dictionary: "Ultra" - Very or extreme. (descriptive)

Ultra Performance Structural Compounds

Built upon RTP Company’s current standard product portfolio of industry-leading reinforced compounds by

- Optimizing reinforcement technology
- Optimizing process technology

Ultra Performance structural products are in addition to and do not replace our current high temperature structural products
1. 10-30% higher strength and modulus in the RTP Company high temperature portfolio.
   - Greatest gains in CF compounds
2. PPA and PPS w/CF demonstrate a 30-40% improvement in room temperature physical properties.
3. 40%CF PEEK with exceptional properties Vs. Victrex 90 HMF 40, the only other High Modulus PEEK available.
   - Targeted metal replacement in energy and D&A
4. VLF products have 3-4 times the impact of short glass products
   - Improved creep, fatigue and CLTE
5. Technology is transferable to other polymer systems

Competitive metals

- Die cast aluminum
- Heat treated T-6 aluminum
- Die cast zinc alloy (Zamak 3)

A-380 die cast aluminum and 6061 T-6 heat treated aluminum

- A-380 accounts for over 85% of the Al die cast market

**Pros**

- Excellent high temperature performance
- Very good thermal conductivity
- Very good EMI shielding capabilities
- Good corrosion resistance
- Light: good strength-to-weight ratio (specific strength)

**Cons**

- Poor chemical resistance
- Poor fatigue resistance
- Subject to attack by galvanic corrosion when in contact with carbon fiber, carbon fiber composites, and other metals
ZAMAK alloys are widely used in die casting

- **Pros**
  - Very good EMI shielding
  - Very good conductivity
  - Good strength

- **Cons**
  - Poor creep resistance under load
  - Poor strength-to-weight ratio
  - Difficult to process vs. injection moldable plastics

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**ISO Tensile Strength**

<table>
<thead>
<tr>
<th>Material</th>
<th>ISO Tensile Strength (MPa @ 23°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ZAMAK 3</td>
<td>283</td>
</tr>
<tr>
<td>Heat Treated AL</td>
<td>310</td>
</tr>
<tr>
<td>Die Cast AL</td>
<td>325</td>
</tr>
<tr>
<td>PEEK CF</td>
<td>305</td>
</tr>
<tr>
<td>PPA CF</td>
<td>360</td>
</tr>
</tbody>
</table>

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**Specific Tensile Strength**

<table>
<thead>
<tr>
<th>Material</th>
<th>Specific Strength</th>
<th>Specific Gravity</th>
</tr>
</thead>
<tbody>
<tr>
<td>RTP-2287 UP</td>
<td>143</td>
<td>0.94</td>
</tr>
<tr>
<td>RTP-1387 UP</td>
<td>125</td>
<td>0.94</td>
</tr>
<tr>
<td>RTP-2287 UP</td>
<td>143</td>
<td>0.94</td>
</tr>
<tr>
<td>RTP-2287 UP</td>
<td>125</td>
<td>0.94</td>
</tr>
<tr>
<td>Al 4-360</td>
<td>76</td>
<td>2.7</td>
</tr>
<tr>
<td>Al 6061 T6</td>
<td>82</td>
<td>2.7</td>
</tr>
<tr>
<td>Zamak 3</td>
<td>82</td>
<td>6.8</td>
</tr>
</tbody>
</table>

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**What about Tg and Tm**

- Tg or glass transition temperature is critical when comparing materials for High Temp applications
- Conventional semi-crystalline thermoplastics are usable above their Tg but physical properties begin to deteriorate quickly
- Amorphous materials have defined Tg but have a more gradual drop off in properties below the Tg
- Creep and fatigue have increased effects above the TG of thermoplastic materials
  - Crystallinity is critical and affects the Tg
  - End use testing is the best measure of performance
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**PPS 40%CF Relative Properties**

- **Tensile Strength**
- **Notched Izod Impact**
- **Tensile Modulus**
- **Flex Modulus**
- **Flex Strength**

![Graph showing properties comparison](image)

**Data Table of Ultra Performance PPS**

<table>
<thead>
<tr>
<th>Material</th>
<th>RTP 1387</th>
<th>RTP 1387 UP</th>
<th>Comp. PPS 40% CF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tensile Strength</td>
<td>215</td>
<td>260</td>
<td>207 MPa</td>
</tr>
<tr>
<td>Tensile Modulus</td>
<td>34000</td>
<td>40500</td>
<td>34500 MPa</td>
</tr>
<tr>
<td>Flexural Strength</td>
<td>295</td>
<td>405</td>
<td>209 MPa</td>
</tr>
<tr>
<td>Flexural Modulus</td>
<td>32500</td>
<td>32500</td>
<td>30000 MPa</td>
</tr>
<tr>
<td>Notched Izod Impact</td>
<td>5.0</td>
<td>7.5</td>
<td>9.0* KJ/m²</td>
</tr>
</tbody>
</table>

Note: Properties tested using ISO test methods

* Competitive material is a PPS alloy (no other 40% CF PPS competitive data available)

**PEEK 40%CF Relative Properties**

- **Tensile Strength**
- **Notched Izod Impact**
- **Tensile Modulus**
- **Flexural Modulus**
- **Flex Strength**

![Graph showing properties comparison](image)

**Data Table of Ultra Performance PEEK**

<table>
<thead>
<tr>
<th>Material</th>
<th>RTP 2287 HF</th>
<th>RTP 2287 UP</th>
<th>RTP 2299 X 133017</th>
<th>Comp. PEEK 40% CF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tensile Strength</td>
<td>270</td>
<td>275</td>
<td>310</td>
<td>330 MPa</td>
</tr>
<tr>
<td>Tensile Modulus</td>
<td>27500</td>
<td>36000</td>
<td>46200</td>
<td>45000 MPa</td>
</tr>
<tr>
<td>Flexural Strength</td>
<td>385</td>
<td>415</td>
<td>480</td>
<td>480 MPa</td>
</tr>
<tr>
<td>Flexural Modulus</td>
<td>24000</td>
<td>31000</td>
<td>39300</td>
<td>37000 MPa</td>
</tr>
<tr>
<td>Notched Izod Impact</td>
<td>6.5</td>
<td>6</td>
<td>10</td>
<td>11 KJ/m²</td>
</tr>
</tbody>
</table>

Note: Properties tested using ISO test methods
An Introduction to VLF – Very Long Fiber Composites in High Temperature Materials

Typical Long Fiber Pellets

Short Fiber & VERY LONG FIBER

Fibers: ~2 mm    12 mm

PA 66 + 60% VLF Seat Belt Tensioner Housings

The Structural Skeleton

YOUR GLOBAL COMPOUNDER OF CUSTOM ENGINEERED THERMOPLASTICS
Masterbatch VLF Technologies
YOUR GLOBAL COMPOUNDER OF CUSTOM ENGINEERED THERMOPLASTICS

Steel Carbon Glass

Polymers Additives “Long Cut” technology

PEEK Your color – Your way™ Flame retardants
PPS Wear & lubricity
PPS Heat stabilizers
PBT Nano particles
TPE UV resistance
TPU Conductivity
TPU Anti-stat

PEI 40%GF Relative Properties
YOUR GLOBAL COMPOUNDER OF CUSTOM ENGINEERED THERMOPLASTICS

Tensile Strength

Notched Izod Impact.

Tensile Modulus

Flex Modulus

Flex Strength

PEI 40% GF Comp. VLF B2107 RTP 2107 RTP 2107 UP

PPS 50%GF Relative Properties
YOUR GLOBAL COMPOUNDER OF CUSTOM ENGINEERED THERMOPLASTICS

Tensile Strength

Notched Izod Impact.

Tensile Modulus

Flex Modulus

Flex Strength

PPS 50% GF Comp. VLF B1309 RTP 1309 RTP 1309 UP

PPA 50%GF Relative Properties
YOUR GLOBAL COMPOUNDER OF CUSTOM ENGINEERED THERMOPLASTICS

Tensile Strength

Notched Izod Impact.

Tensile Modulus

Flex Modulus

Flex Strength

PPA 50% GF Comp. VLF 84009 RTP 4009 RTP 4009 UP

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### PPA 50%GF Actual Properties

<table>
<thead>
<tr>
<th>Property</th>
<th>PPA 50% GF Competitive</th>
<th>VLF 84009 50% VF GF</th>
<th>RTP 4009 50% GF</th>
<th>RTP 4009 UP 50% UP GF</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tensile Strength</td>
<td>270</td>
<td>275</td>
<td>250</td>
<td>285</td>
<td>MPa</td>
</tr>
<tr>
<td>Tensile Modulus</td>
<td>17,000</td>
<td>18,000</td>
<td>18,000</td>
<td>20,000</td>
<td>MPa</td>
</tr>
<tr>
<td>Flex Strength</td>
<td>390</td>
<td>400</td>
<td>370</td>
<td>440</td>
<td>MPa</td>
</tr>
<tr>
<td>Flex Modulus</td>
<td>17,000</td>
<td>18,000</td>
<td>17,000</td>
<td>18,500</td>
<td>MPa</td>
</tr>
<tr>
<td>Notched Izod Impact</td>
<td>10</td>
<td>35</td>
<td>10</td>
<td>15</td>
<td>KJ/m²</td>
</tr>
</tbody>
</table>

Note: Properties tested using ISO test methods.