New glass solutions for pultrusion

*World Pultrusion Conference, April 8th and 9th, Barcelona*

*Eric Dallies, Owens Corning Reinforcements*
Owens Corning in Composites

- Commercialized glass fibers in 1939
- Pioneered the use of glass as a reinforcement in composites
- Instrumental in developing composite applications
  - Roofing, Marine, Tub/Shower, Underground Storage Tanks, Auto & Truck Body Panels, Muffler Packing Systems
- Continues our legacy of innovation and transformation today
  - High Performance Armor, Pressure Vessels, Cable Stiffeners, Rubber Reinforcements.

Owens Corning is the leading global supplier of glass reinforcements to the composites industry
Owens Corning businesses provides a comprehensive range of reinforcement products for pultrusion.

**SINGLE-END ROVINGS**

- Single-End rovings are generally used in all pultruded products, usually as principal reinforcement.
- Provide axial strength and stiffness.
- High reinforcement content (typically 55 vol.%).
- Rovings available in a range of tex values (300 to 9600 tex).
- Specifically sized for different resin systems for optimum performance.

**BULKY ROVINGS**

- Being filamentised to a greater or lesser extent, producing loops or filaments misaligned from the axial direction.
- Provides some reinforcement in the transverse direction to improve shear properties.
- Produces a scouring action to clean the die and prevent lost edges in tight radii.
- Easy to wet out.

**UNIFILÔ® MATS**

- Unifilo® mats are also widely used in pultrusion process for better transverse mechanical properties.
- High mat tensile strength, also at elevated temperatures and when wetted with resin.
- Low density.
- Easy processing both faces well bound and easy to splice.
- Good compatibility with UP, UP(V), EP and acrylic resins.
- Available in a full range of weights from 300g/m² up to 900 g/m².
- Full width rolls and slit widths from 9 cm to 50 cm available.

**NON-WOVENS**

- Veils are designed to create a high quality surface layer on the pultruded part.

**COMPLEXES, FABRICS, STITCHED AND NEEDLED MATS**

- Fabrics, complexes and mats - with sufficient tensile strength for processing through a die, and which can be impregnated with resin under operating conditions - may all be used.

For more information: www.Owens Corningreinforcements.com/library.asp
Twintex® products for pultrusion

**TWINTEX® THERMOPLASTIC/GLASS ROVING**

Twintex® Roving is a unique and ready to use thermoplastic/glass reinforcement, made of commingled E-Glass and thermoplastic filaments, designed for high mechanical properties. Twintex® Roving also provides for an efficient process, high freedom of design, and can be recycled.

Twintex® Pul-extrusion concept: A Cost effective Technology

For more information: www.OwensCorningreinforcements.com/library.asp
High Performance Reinforcements

Delivering Performance, Enabling Possibilities

INNOVATIONS FOR LIVING™
Innovations in Glass Melting Technologies

- **1939**: Owens Corning invented E-glass
  - Boron added to glass for electrical properties

- **1968**: Owens Corning developed S-2 Glass®
  - High Performance Glass (high melting power needed)
  - Small capacity furnaces due to limits in melting technologies

- **1980**: Owens Corning developed ECR Glass
  - Corrosion resistant glass.

- **1997**: Owens Corning developed Advantex® Glass and Technology
  - Boron free E-glass (higher melting power than traditional E-Glass)
  - ECR-glass (Superior corrosion resistance to traditional E-glass)
  - Breakthrough in melting technology for large capacity furnaces

- **2006**: Owens Corning developed High Performance Glass (HPG) Technology
  - Boron free glass formulation that meets standards for R glass
    - ISO 2078 & DIN 1259-1
  - Combines High-Performance Glass and Melting Technology
  - Production of High-Performance Glass in large capacity furnaces

- **2009**: Owens Corning developed new S-glass formulation based on HPG technology
  - Boron-free glass formulation that meets all international standards for S-glass
  - Resulting in Lower Cost, Increased Capacity, Higher Fiber Homogeneity
Owens Corning High Performance Reinforcements, several glasses for delivering high value for composites.

Owens Corning HPR available at two levels of performance and value:
• made with H-glass for optimized performance/economical solutions,
• made with S-glass for even higher levels of performance.
Owens Corning HPR: Enabling Technologies for Markets

**Market** | **Glass Composition** | **Advantex® Glass** | **H - Glass** | **S - Glass**
---|---|---|---|---
Wind Energy | ☑ | ☑ | ☑
Defense | ☑ | ☑ | ☑
Industrial Infrastructure & Leisure | ☑ | ☑ | ☑
Aerospace | | ☑ | ☑

- **Owens Corning HPR Product Brands:**
- FliteStrand® Reinforcements - Aerospace
- ShieldStrand® Reinforcements - Defense
- XStrand® Reinforcements - Industrial
- WindStrand® Reinforcements – Wind Energy

**End Use Applications**

www.Owens Corningreinforcements.com/hp
XStrand® S and XStrand ® H
High Performance Reinforcements

Delivering Performance, Enabling Possibilities
Industrial, Infrastructure, Sports and Leisure Markets
XStrand® S and XStrand® H Glass offer superior mechanical properties compared to E-Glass

**XStrand® H versus E-Glass:**
- Up to 20% stronger, 15% stiffer
- Provides significantly improved corrosion resistance
- Potential to save up to 20% in weight

**XStrand® S versus E-Glass:**
- Up to 50% stronger, 20% stiffer
- Up to 80% tougher
- Up to 30% lower coefficient of linear thermal expansion
- Improved impact strength
- Provides significantly improve corrosion resistance
- Potential to save up to 30% in weight
XStrand® S and XStrand® H Glass offer superior mechanical properties compared to E-Glass

<table>
<thead>
<tr>
<th>Property</th>
<th>Test Method</th>
<th>Units</th>
<th>E-Glass</th>
<th>XStrand® H</th>
<th>XStrand® S</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pristine Fiber Tensile Strength</td>
<td>ASTM D2101</td>
<td>Gpa</td>
<td>3.4-3.8</td>
<td>4.1</td>
<td>5.1-5.3</td>
</tr>
<tr>
<td>Impregnated Fiber Tensile Strength</td>
<td>ASTM D2343</td>
<td>Gpa</td>
<td>2-2.5</td>
<td>2.6-3.1</td>
<td>3.4-3.8</td>
</tr>
<tr>
<td>Young’s Modulus</td>
<td>Sonic Resonance @ 20°C</td>
<td>Gpa</td>
<td>68.9-72.4</td>
<td>87</td>
<td>88</td>
</tr>
<tr>
<td>Density</td>
<td>ASTM C693</td>
<td>g/cc</td>
<td>2.55-2.58</td>
<td>2.61</td>
<td>2.45</td>
</tr>
<tr>
<td>Coefficient of Thermal Expansion, 23-300°C</td>
<td>ASTMD696</td>
<td>x10^6cm/cm. °C</td>
<td>5.4</td>
<td>5.3</td>
<td>3.4</td>
</tr>
<tr>
<td>Fiber weight loss at 96°C, 24 hours (acidic solution 10% HCl)</td>
<td>internal method</td>
<td>%</td>
<td>31.7</td>
<td>7.6</td>
<td>2.8</td>
</tr>
</tbody>
</table>
XStrand® S and XStrand® H Glass offer superior corrosion resistance compared to E-Glass

versus E-Glass:
- XStrand S Glass is 20 times more resistant in strong acids
- XStrand H Glass is as resistant as an E-CR glass in strong acids

XStrand S versus E-Glass:
- retains more than 90% of its initial strength in acids, even at low pH
- retains most of its strength after ageing in water
- provides the same strength in alkali media
**XStrand® S Reinforcements offer superior mechanical properties compared to other materials**

<table>
<thead>
<tr>
<th>Property</th>
<th>Test Method</th>
<th>Units</th>
<th>XStrand® S</th>
<th>Aramid K49</th>
<th>Carbon AS4</th>
<th>Aluminum 5083</th>
</tr>
</thead>
<tbody>
<tr>
<td>Density</td>
<td>ASTM C693</td>
<td>g/cm³</td>
<td>2,45</td>
<td>1,44</td>
<td>1,79</td>
<td>2,66</td>
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<tr>
<td>Conductivity</td>
<td>ASTM C177</td>
<td>watts/m.K</td>
<td>1,34</td>
<td>0,4</td>
<td>6,83</td>
<td>117</td>
</tr>
<tr>
<td>Pristine Fiber Tensile Strength</td>
<td>ASTM D2101</td>
<td>Mpa</td>
<td>4800-5100</td>
<td>3000</td>
<td>4400</td>
<td>320</td>
</tr>
<tr>
<td>Young’s Modulus</td>
<td></td>
<td>Gpa</td>
<td>88</td>
<td>112</td>
<td>230</td>
<td>70</td>
</tr>
<tr>
<td>Elongation at Break</td>
<td></td>
<td>%</td>
<td>5,5</td>
<td>2,4</td>
<td>1,8</td>
<td>13</td>
</tr>
<tr>
<td>Coefficient of Thermal Expansion, 23-300°C</td>
<td>ASTM D696</td>
<td>$10^{-6}$ cm/cm.°C</td>
<td>3,4</td>
<td>-4,9</td>
<td>-0,6</td>
<td>26</td>
</tr>
</tbody>
</table>

**XStrand® S versus Steel, Aluminum & Carbon Fiber**
- Up to 1/2 the weight of steel and up to 40% lighter than aluminum
- Superior corrosion resistance compared to metals
- Superior impact resistance compared with carbon fiber solutions
- Up to one half the cost of carbon fiber solutions
- Provides opportunities for part consolidation, reducing weight and assembly
Enhanced glass mechanical properties translate in stronger and stiffer pultruded part

2 mm diameter rods, Vinylester resin
84% glass weight content

Expected part properties with XStrand H and XStrand S
- up to 13% higher stiffness provided by XStrand H and up to 16% with XStrand S
- up to 20% more strength with XStrand H and up to 40% with XStrand S
XStrand® Glass Product Forms

- Single End Rovings and Fabrics.
- Multi-compatible & epoxy compatible sizings.
- Filament size ranges from 9 micron to 24 micron.
- Tex Range: 300 to 4800 tex depending on roving style selected.

**XStrand S**
- 9 µm → 24 µm
- 300 tex → 2400 tex

**XStrand H**
- 14 µm → 33 µm
- 300 tex → 4800 tex
XStrand® Reinforcement: An Enabling Technology for Pultrusion

Features and benefits

• Higher part stiffness:
  – provides lower deformation for a given load
  – allows weight and cost savings (reduced amount of reinforcement and resin)

• Longer resistance to corrosion and cyclic loadings
  – Improves sustainability for long life structures

• Higher fiber toughness
  – Provides very good impact properties and damage tolerant behavior

Potential applications

• Long span such as ladder rail, telescopic poles,
• Structural beams
• Lighting poles

• Rebars for infrastructure and bridge decks,
• Earthquake protection flooring
• Building repair, seismic retrofit

• Ballistics parts
• Door and window frames
XStrand® Reinforcement, an enabling technology:
- improving the cost performance ratio of existing composite solutions
- making new to market applications possible

- Offers opportunity for improved strength, stiffness and fatigue resistance
- Enables lighter weight, better corrosion resistance and durability.
- Enables better impact, improved wear resistance and increased toughness
Thanks for your attention