

# Thermoplastic Pultrusion Process Using Commingled Glass/Polypropylene Twintex® Roving



**Raymond Wolff, Stratikore, Inc.**



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# Why Thermoplastic Pultrusion?

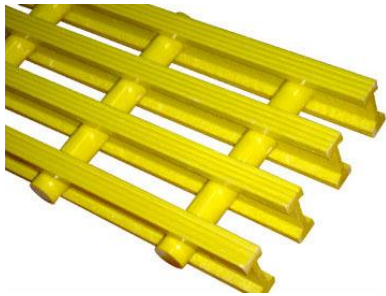
- **Thermoset pultrusions typically compete against metals in niche applications.**
- **Pultruded composites typically provides some additional performance alternative benefit over metal counterpart.**



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# Typical Benefits



- **Insulative Properties**  
(electrical, thermal)
- **Tensile Strength**
- **Corrosion Resistance**
- **Weight savings**
- **Flexural Properties**
- **Others**



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# Why Thermoplastic Pultrusion?

- Large market size difference between thermoset pultrusion market when compared to extrusion market
- Opens up new market opportunities by targeting products that elevate properties of extruded products.
- Breaking the Pultruder Mindset?



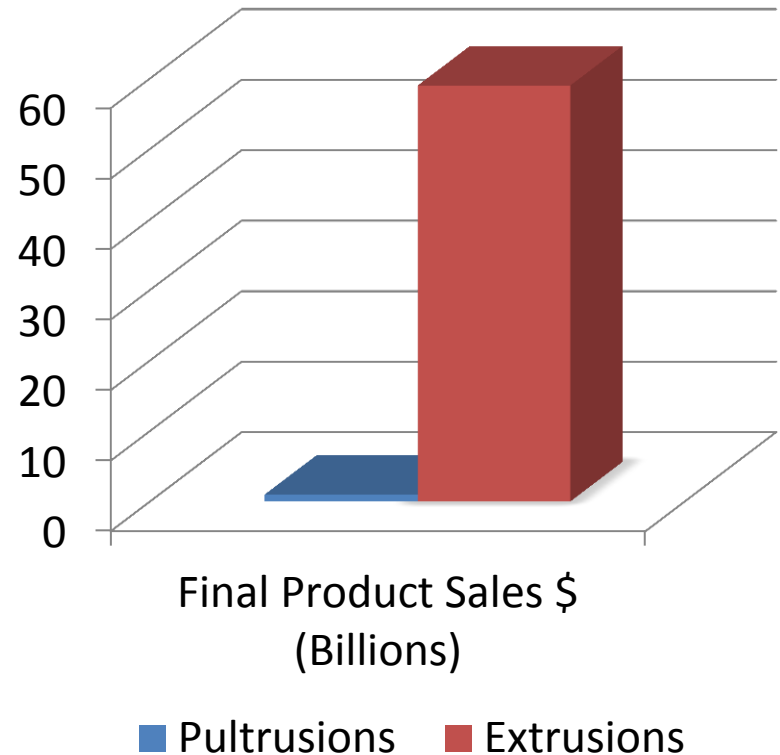
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# Market Size

## Pultrusion vs. Extrusion

- **Est. annual world pultrusion market size**
  - \$ 1 Billion in product
- **Est. annual US extrusion market size**
  - \$59 Billion in product



Sources:

<http://www.mmdnewswire.com/press-release-6849.html>

<http://www.frptoday.in/patel%20dec%20article.pdf>



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# History of Development

- **Development performed at Polygon Company, Walkerton, IN**
- **Offshoot of work initiated as licensee of Dow Fulcrum pultrusion technology.**
  - **Thermoplastic Polyurethane**
  - **Fulcrum technology attempted to take advantage of unique reversible polymerization reaction at elevated temperatures.**



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# History of Development

- **Initial development efforts started with unsuccessful attempt to commercialize Fulcrum pultrusion process.**
- **Led to evaluation of commingled glass/polypropylene fiber.**
- **Lead to process commercialization within 4-5 month period.**

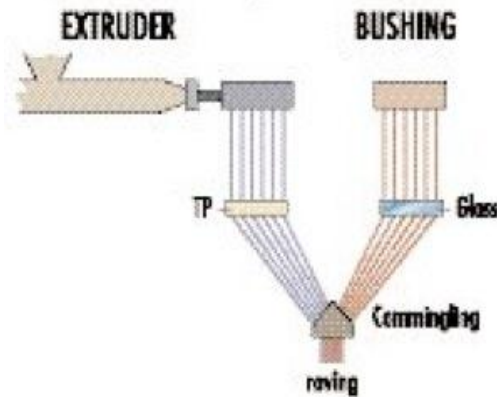


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# Commingled Fiber Process

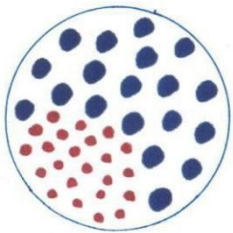
Twintex commingled fiber process



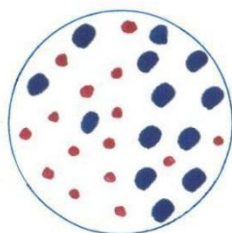
Combines glass fiber production techniques with filament extrusion process.

Ref: <http://machinedesign.com/article/long-glass-fiber-pp-hits-the-road-1024>

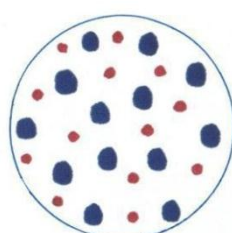
PUT TOGETHER



COMMINGLED



IDEAL



<http://www.comfil.biz/processing.php>

Commonly used in production of carpet yarns.



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# Challenges in Pultruding Thermoplastics

General Relationship:

$$\text{Wetout} \propto \frac{T_a w t}{u}$$

Where  $T_a$  = resin temperature when applied to fiber,  $w$  = work applied to fibers,  $t$  = immersion time, and  $u$  = resin viscosity.

Thermoset resin viscosities range from 100-5,000 CPS

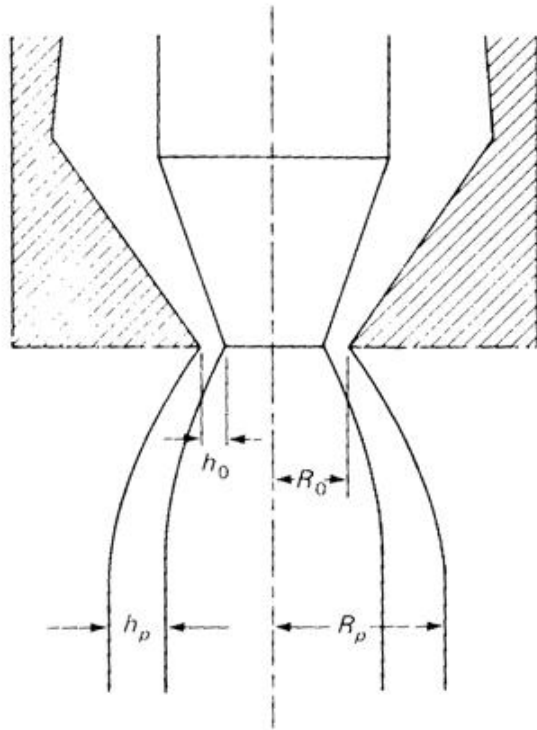
Thermoplastics melt viscosities up to 500,000 CPS



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# Die Swell



**Swell of thermoplastic resin upon exit of die.**

**Directly related to relaxation of polymer chains, entanglement and entropy.**

**Affected by tooling design and die lengths.**



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# Process Approach

- Increased wetout by increasing work into resin wetout utilizing impregnation pins.
- Utilized segmented tooling approach to accommodate die swell and control heat profile through process.
- Incorporation of extrusion calibration tooling and techniques to cool and set part.

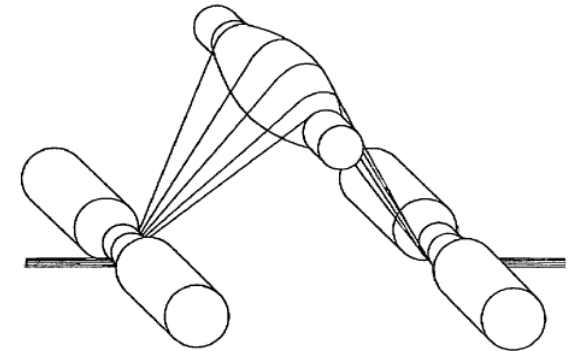


FIGURE 1. Schematic drawing of concave/convex filament spreading pin system.

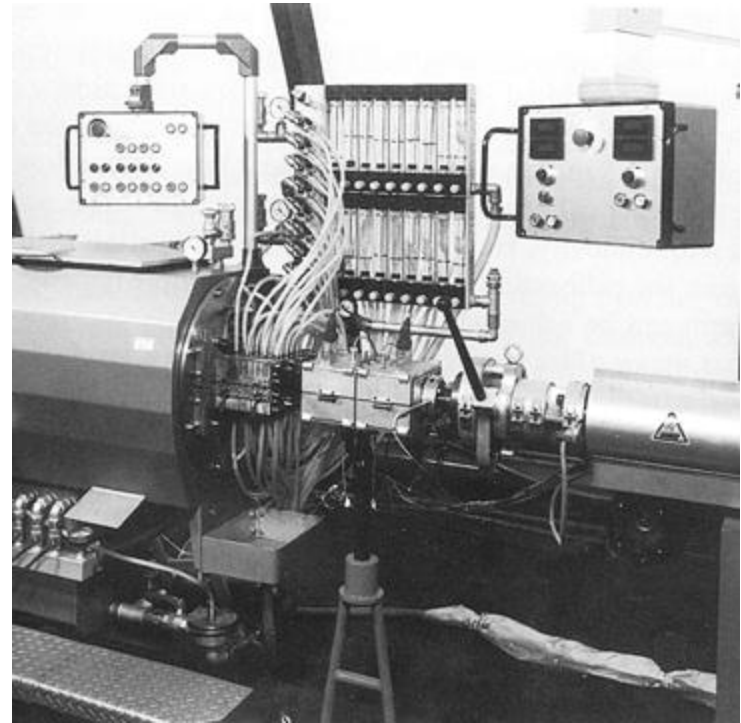
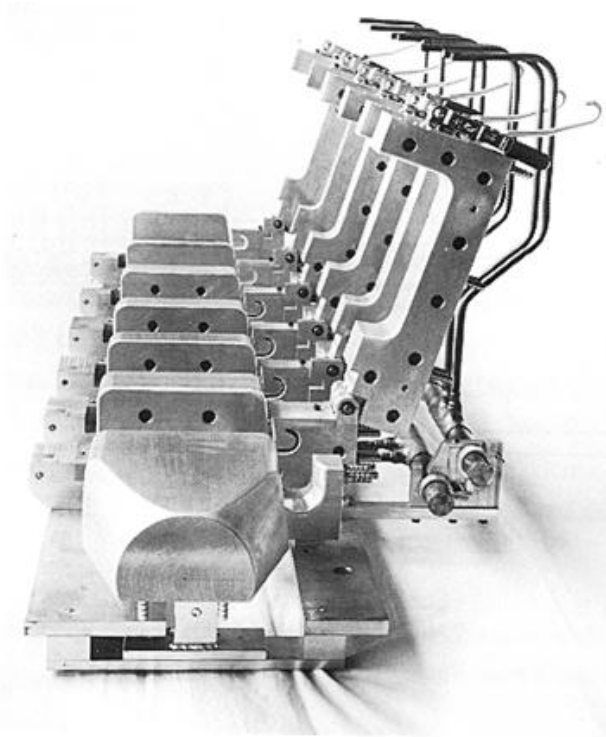
Ref: The Effect of Pin Shape on Spreading Roving Filaments for a Thermoplastic Pultrusion Resin, J.M Charrier, et al., 45<sup>th</sup> Annual Conference, Composites Inst., Feb 12-15, 1990



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# Extrusion Calibration



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# Line Schematic

Thermoplastic Pultrusion Line

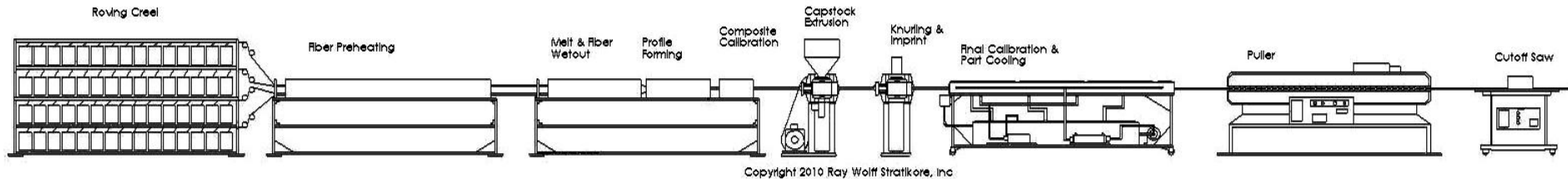


Figure 2: Thermoplastic Pultrusion Line Diagram

- Roving Creel
- Fiber Preheating
- Melt & Fiber Wetout
- Profile Forming
- Composite Calibration
- Capstock Extrusion
- Knurling & Imprint
- Calibration & Cooling
- Puller
- Cutoff Saw



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# Lessons Learned

- **Not based on reaction kinetics.**
- **Process more driven by heating & cooling management.**
- **Special considerations when processing.**
- **Less breakdowns. Many issues addressable during processing.**
- **New and different production issues.**



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# Capstocking Effects



- **Knurling**
- **Online Details**
- **Multiple Capstock Resins**
- **(sections or layers)**



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# Initial Applications

## Ornamental Fencing



## Tool Handles



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# Thermoplastic Pultrusions Fabrication Possibilities

## Part Welding



## Spin Welding



## Twisting



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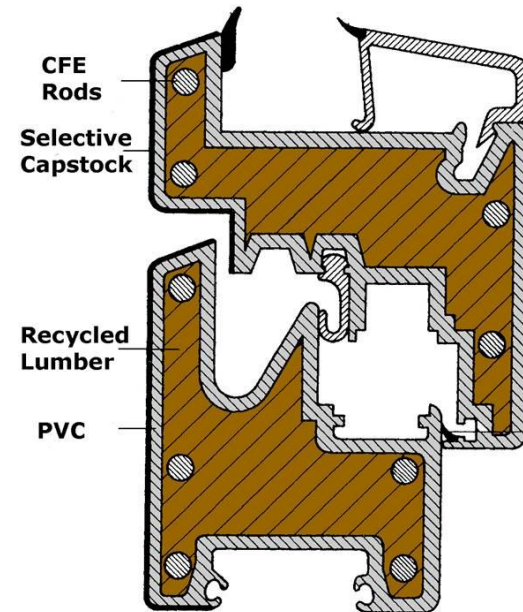
# Addition of Off Axis Fiber



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# Strategic Reinforcement



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