Making Carbon Fiber Composites Circular: CRTC Approach to Composites Recycling

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Background

• In North America: estimated 29 M lbs. (~13,200 MT) of carbon fiber landfilled per year
• In Washington: estimated 2 M lbs. (~900 MT) of carbon fiber landfilled per year
• Majority (in WA) is pre-preg, primarily aerospace production scrap
  – Secondary amount is cured production trim
  – Some pre-preg scrap has to be oven cured prior to landfill
  – Regulations vary based on constituents in resin system
  – Adds cost/time burden on composite manufacturers
Carbon Fiber Recycling Landscape

- Few players globally
- Capacities limited
- Reclamation process include pyrolysis & solvolysis

Renamed: Carbon Conversions

CRTC’s Vision, Mission, Principles

Vision:
- Pioneering product development to realize the full potential of composite recycling

Mission:
- To lead and grow a composite recycling industry that fully diverts Washington State’s carbon fiber scrap into value-added products

The following Guiding Principles shape CRTC’s decisions:
- **Economic**: Enable the expansion of the advanced manufacturing industry through research and development for conversion of carbon fiber scrap into value-added products.
- **Environment**: Reduce the amount of composite scrap being landfilled through re-use in new applications with reduced energy and environmental footprints
- **Education**: Support the training of a workforce prepared for and accomplished in the skills required by the composite recycling industry
Location – Space to Start-up and Room to Grow
Status/Scale of Effort

• Interim R&D facility: moved in presses and tooling/prototyping equipment to start development in January 2106

• New 25,000 s.f. facility under construction
  – Built-in ovens, freezers, finishing booths, etc.
  – 75,000 pound pre-preg freezer capacity
  – High temperature ovens (800°F capable)
  – High-speed compression molding presses
  – Complete steel 4-axis CNC tooling capability in-house
  – Design/analysis capabilities, collaborative testing with WSU
  – Pursuing UW collaboration for expanding capabilities; offering research & training opportunities at CRTC

• Co-location with Peninsula College’s Advanced Manufacturing - Composites Technology Program

• Separate production space and multiple laboratory spaces
CRTC Approach

- Create demand for reclaimed materials via market pull from high-value products
- Select products to match availability of scrap, achievable properties, and quantity of materials
- Develop process science for converting autoclave cure cycles to press-based rapid cure cycles
- Explore additive manufacturing
  - Chopping to the format planned and building net preforms for compression molding as a form of "bulk" additive manufacturing
- Develop design property data to reflect “combined” materials properties and new cure cycles
- Work with companies to advance market-based applications and support these with product demonstration, materials, and process technologies
Value Proposition for Recycled Carbon Fiber (rCF)

• CRTC will develop manufacturing and product sales and create confidence in using recycled pre-preg
• CRTC’s early rCF manufacturing and development efforts will generate property databases and process knowledge that feeds new applications
• CRTC success will attract increased R&D for new materials and processing technologies, such as Materials Genome Initiative
• Composite recycling needs “market pull” to improve reclamation business case
• CRTC will initiate with uncured carbon pre-preg Phase II will incorporate “recovered” dry fiber from Recyclers
Transforming “Waste” Streams into Value Streams

• Examining the Manufacturing Opportunity with Pre-preg Scrap
  – Selected applications in Paddlesports, Snow-sports, Fishing, and Cycling
    • Only considered applications that can use the recovered form of materials
  – Range of as-manufactured costing examined on a unit weight basis
  – Looked at cost within manufacturing operations
    • Backed out all mark-ups and distribution costs plus SG&A and profit
• Range is $75/pound to $192/pound. Average across the selected applications was $139/pound
  – This figure represents labor, materials, consumables, amortization & production management expenses
• 2M lbs. total carbon fiber scrap currently in WA:
  – Estimate 60% useful materials from landfilled scrap or ~1.2 M lbs/year
  – $166.8 M in direct manufacturing opportunity (converted to consumer goods)
  – Or approximately 1,100 direct jobs; plus 1,400 indirect jobs = Total 2,500 jobs
  – Equal to $670 M retail sales volume
Recycled Carbon Fiber Case Study  
(Actual Project)

**Large Radio Telescope Mount Support Components**

- Is virgin, continuous fiber required?  
  - What are the design drivers?
- What process should be used?  
  - What are the molding requirements?  
  - What are the masses/sizes?  
  - Can process/tooling accommodate cure induced dimension changes?

**Decision:**

- Dish rim connectors utilize hybrid of recycled discontinuous carbon fiber (spool ends), and virgin BimaX™ surface braid (for hole drilling stability)  
  - Fabric construction would have been 168 plies and ~84 ply drops – on 4 faces
- Metered infusion epoxy (low-exotherm), compression molded at ~300 psi, 160°F
Carbon Fiber: Applications and Innovation

Automotive
Recreational
Clean Energy
Non-structural
Aerospace
Seeking Partners to Realize CRTC Vision

• **Industry Partnerships**: Product design, development and sales
  – Direct sales transitioning into private label products for established market players
  – Enter supply chain:
    • Partnerships enable continued growth in CF industries into mainstream, high-volume manufacturing applications
  – Bridging the gap between lab scale and large production

• **R&D/D Partnerships**
  – Innovation tech center for cutting edge research
  – Interested in teaming with partners that have complementary needs and goals
    • Explore potential of low cost rCF feedstocks for new materials
    • Process improvements for scale up
  – Engineer in Residence Program

• **Educational Partnerships**
  – Peninsula College space for classes, offices and laboratories
    • Recycling certification program first in state
  – Collaboration with WSU and other universities
  – Hands on research and production training for Graduate Students
Conclusions

• Carbon fiber is a small business segment relative to other structural materials, and recycling is one barrier to achieving commodity scale.
• Addressing recycling as part of high-volume production development will lower overall costs, and increase demand for CF materials.
• CRTC is leading the way in closing the circle for composite recycling.
• High performance characteristics of CF can be applied in new applications through use of low cost rCF.
• CRTC focus on product development optimizes value of rCF material stream.
• CRTC wants to partner and collaborate to grow the recycled carbon fiber industry.
• rCF is part of the paradigm shift called for in the Materials Genome Initiative.
Join Us:

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