

Products from Post-Consumer Carpet

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CARE Conference

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Callaway Gardens



Outline

- Georgia Tech and Georgia Composites
- Glass Fiber Composites
- Wood Fiber Composites
- Bracket Demonstration Product
- Additional Products
- Conclusions
- Catalytic pyrolysis/depolymerization

Georgia Tech's Role

- CCACTI project:
 - Products from Post-consumer carpet
 - Focus on reinforced composites
 - Determine properties and processing routes
 - Identify and assess applications
 - Use processing and testing facilities in the Center for Polymer Processing

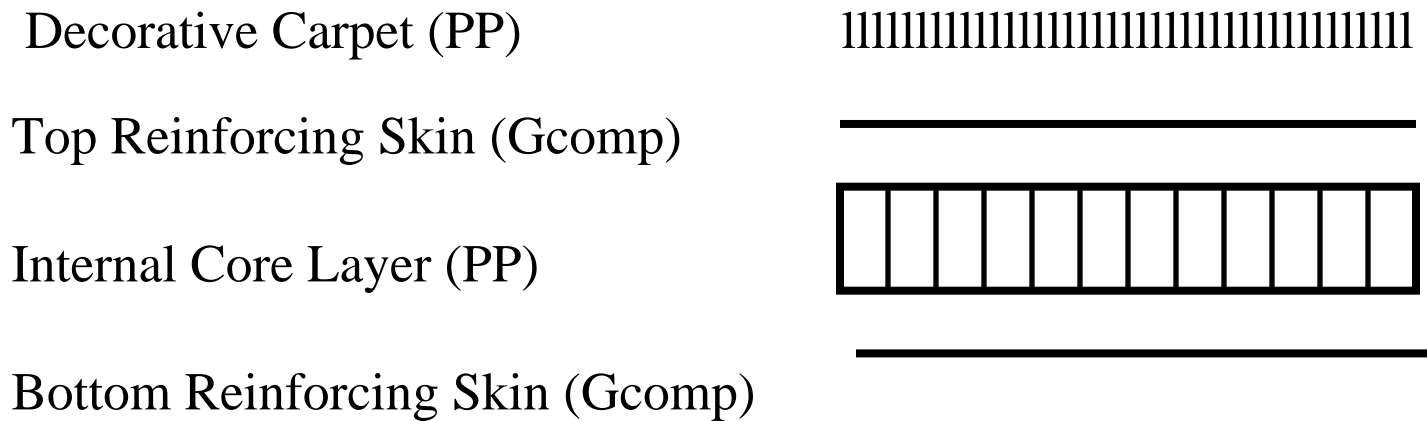
Georgia Composite's Role

- CARE Project:
 - Molded Products containing Post-Consumer Carpet
 - Screen applications
 - Demonstrate molding of viable candidates
 - Commercialize molded products

Georgia Composites Background

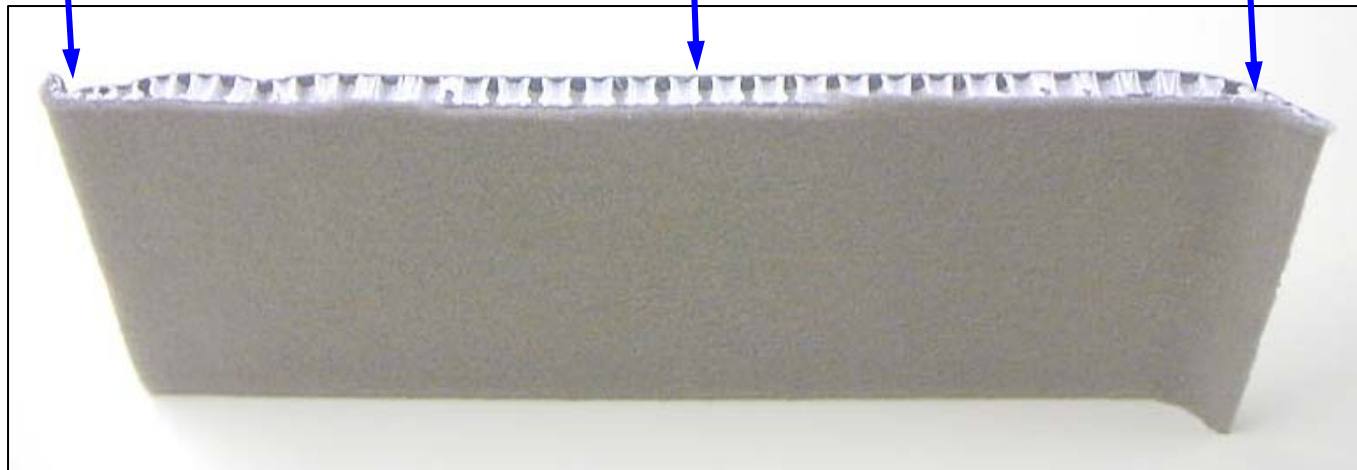
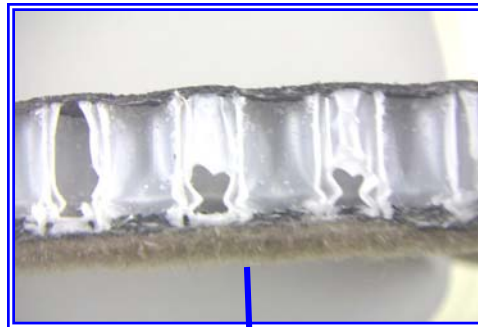
- Georgia Tech start-up
 - Initial technology from Muzzy in 1997
- Eleison Composites, Inc has majority stake
 - As of April, 2006
- Primary product is Gcomp^R
 - Mostly glass mat reinforced recycled polypropylene

SUV Load Floor



Molded by Cadence-USA
(previously Venture Industries)

SUV Load Floor



Load Floor in SUV Jeep Grand Cherokee



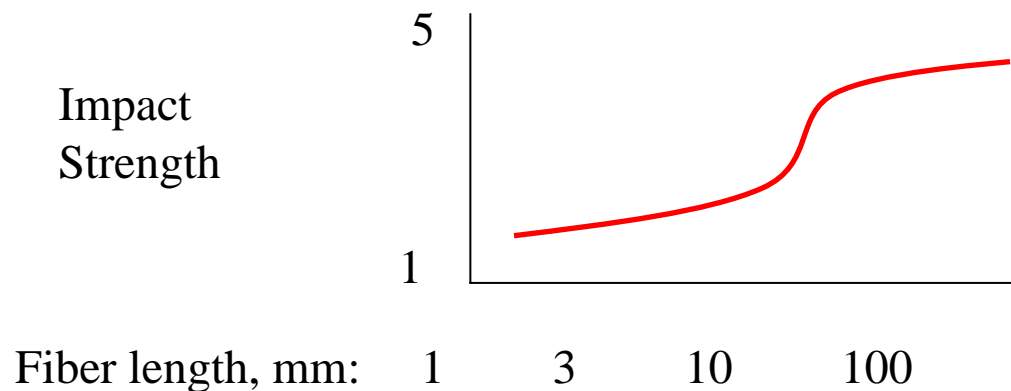
Why Reinforce PCC?

Fibers dominate properties (99 %) (GPa)

	Thermoplastic	Glass Fiber	Composite 60 vol %, unidirectional
Tensile Strength	0.05	3.5	2
Modulus	2	70	40

Why Long Fiber?

- Impact Strength increases with fiber length
- Avoid fiber breakage
 - Requires use of low shear extruders



Approach: Do only easy separation

- Sort carpet by face fiber
 - => process entire carpet
 - => pellets with mixed polymers
 - Suitable for low cost, high volume processing
 - Low properties due to incompatibility between nylon & PP ?
 - May improve properties by using compatibilizers **AND/OR** fiber reinforcement

Glass Fiber Reinforced PCC status

- Glass mat reinforced PCC has good mechanical properties
- Evaluating extrusion compounding
- Demonstrating coupling extrusion compounding with compression molding

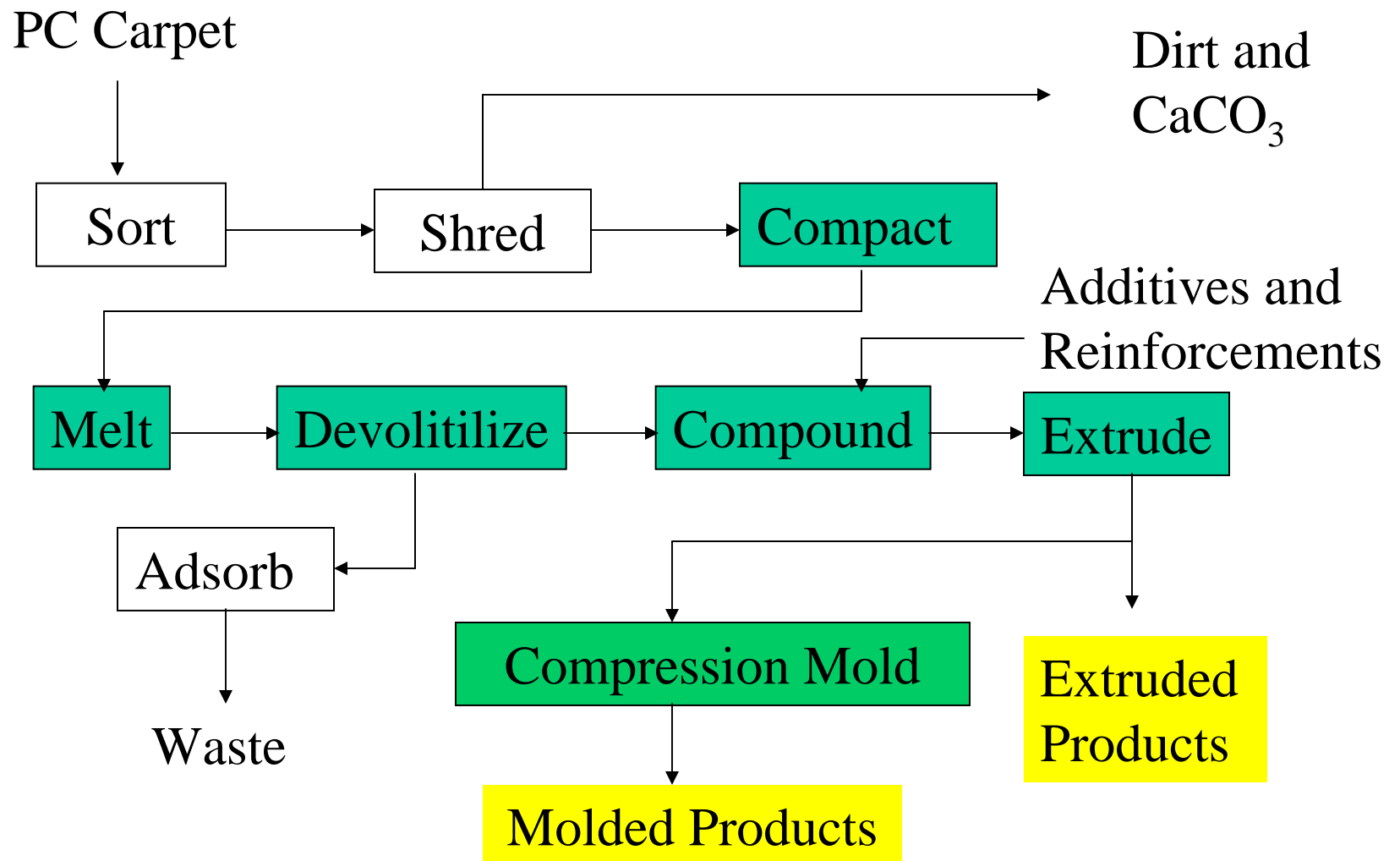
Wood Fiber vs Glass Fiber Composites

- Advantages
 - Cheaper
 - Renewable
 - Lower density
 - Less abrasive
 - More durable
- Disadvantages
 - Lower strength
 - Lower modulus
 - Hard to disperse
 - Low aspect ratio
 - Degradation

Wood Pulp Composite Status/Plans

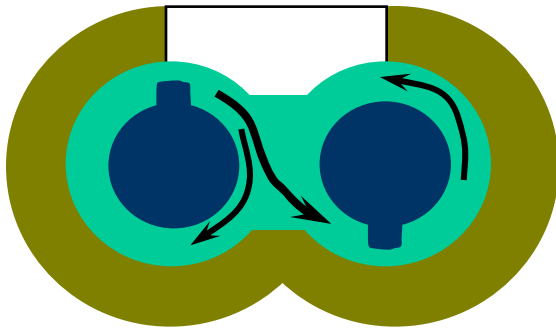
- PP and N6 composites promising
- N66 needs work (less time at high temp.)
- Couple extrusion and molding (less time at high temp.)
- Find feeders for pulps and shredded carpets

Integrated Process Scheme



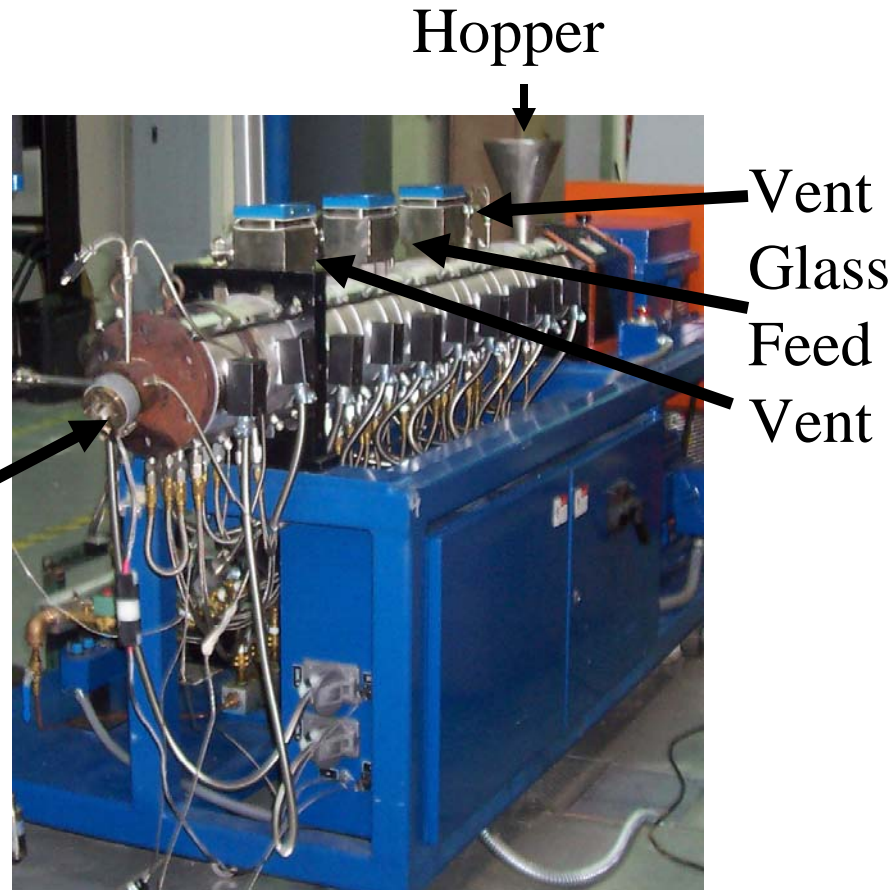
Lab Demonstration

Cross - section
of twin screw



25 mm rod die

NFM Welding Engineers
30 mm twin screw design



Glass Feeding

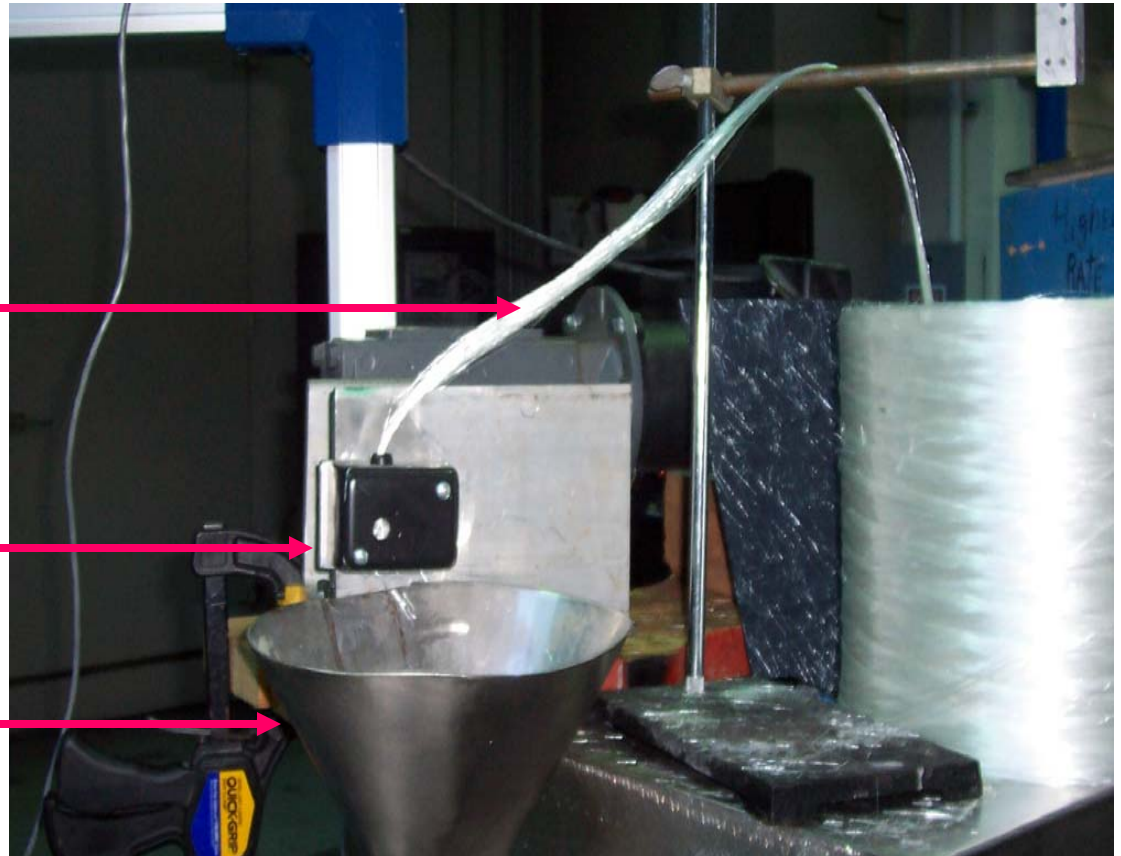


Chopper Feed

Glass Roving

Chopper Gun
(motorized)

Hopper

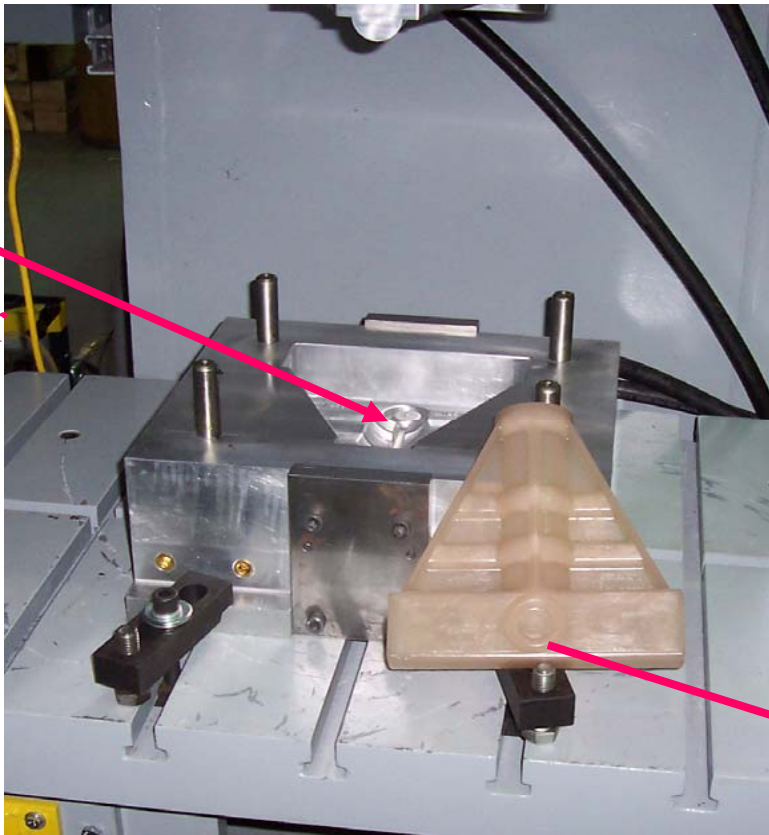


Extruded Charge (RPET)



Molding Z Base Bracket

Hot Log
from
Extruder



Brackets from PCC / Chopped Glass

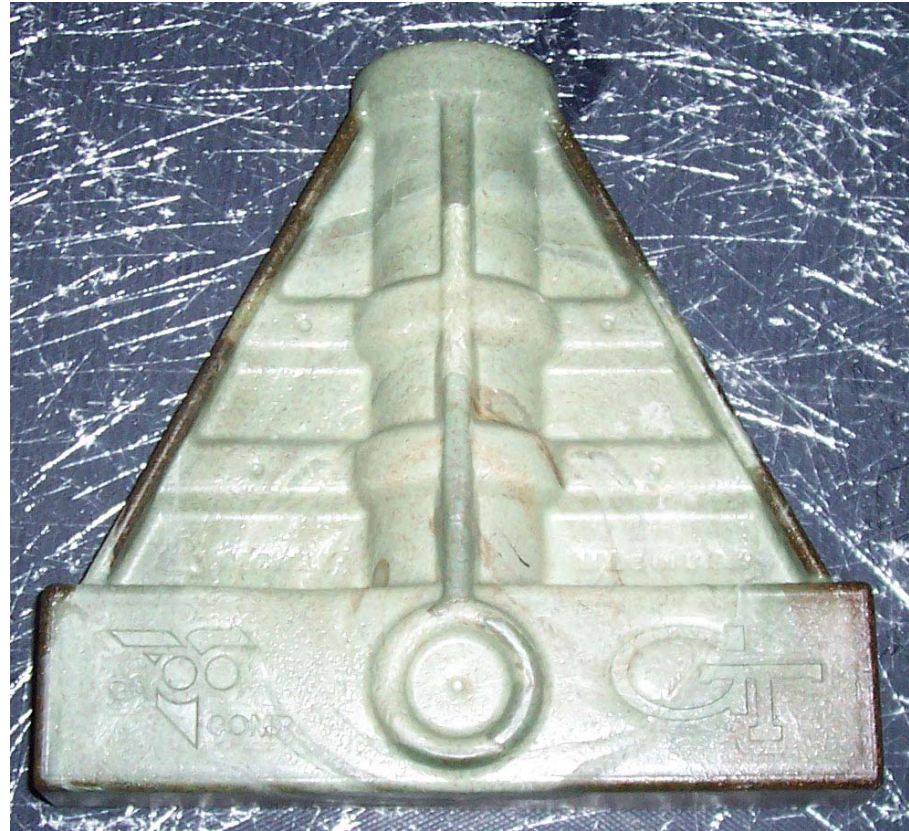


PP PCC + 20 wt % 1/2" GF



N6 PCC + 20 wt % 1" GF

Bracket Outside, RPET/Wood Flour



Bracket Economics

- Raw materials: \$ 0.30/lb or \$ 0.50/bracket set
- Need 4 presses and molds for one 30 mm extruder
- Make 450,000 bracket sets/yr (760,000 lb/yr)
- Break-even selling price \$ 2.10 / bracket set
- Assessment:
 - Feasible
 - Try wood fibers instead of glass fibers
 - Look for bigger products
 - Better for larger extruders and larger parts

Composite applications

- Brackets (just covered)
- **Everything that follows is > than 10 lbs/part**
- Truck accessories
 - Tool boxes
- Manhole covers
- Car components
 - Bumpers
- Shipping
 - Pallets
 - Containers
- Building Elements
 - Structural lumber
 - Ramps

Conclusions

- PP, N6 and N66 PCC successfully reprocessed and tested
 - Shredded carpet repelletized
 - Pellets injection molded with good properties
 - Glass mat composites compression molded with commercially attractive properties
- Wood fiber reinforcement feasible for PP and N6 PCC
 - Need better equipment to gain benefits of fiber length, improve dispersion and to process N66 PCC

Conclusions

- Integrated extrusion-molding demonstrated with Z base garment rack bracket
- High volume applications identified
 - Pallets, structural lumber, bumpers, truck accessories
 - Large parts preferable for integrated process
- Commercialization feasible

Work in progress

- Further demonstration of bracket molding
 - Field testing of brackets
- Integrated extrusion-compression molding of test plaques
 - Wood and glass fibers
 - Fiber lengths and distributions
 - Properties
- Candidate Products
- Exploring Commercialization

Catalytic Pyrolysis of PCC

Objectives

- Recover monomers from carpet
 - first: caprolactam from nylon 6
 - Catalytic depolymerization
- Recover liquid mixtures for refining and fuel use
 - first: low molecular weight hydrocarbons from polypropylene
 - Catalytic pyrolysis

Approach

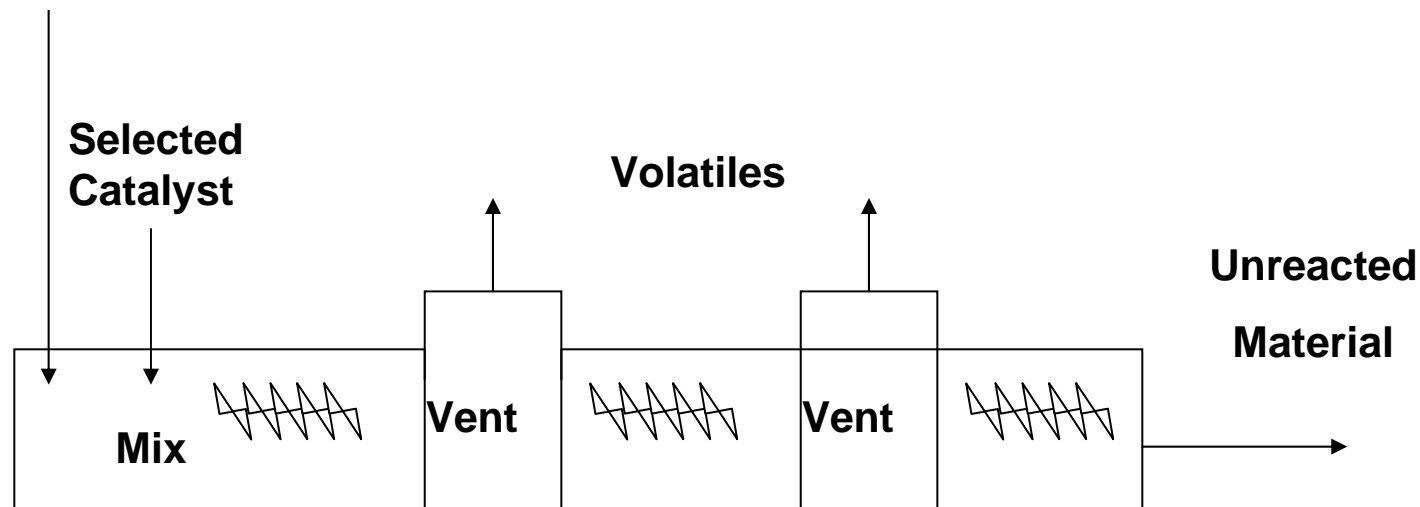
- Catalytic depolymerization/pyrolysis
 - Faster reactions
 - More selective
 - Lower temperature operation
- Extruder/Reactor
 - Multi-purpose
 - Compounding → Composite products from post consumer carpet
 - Compounding (plus catalyst, co-reactant) → Monomers and chemicals

Approach (cont.)

- Extruder/Reactor
 - Potentially low cost
 - High volume extrusion compounding around 10 cents per pound
 - Suitable for low or high volumes
 - Operate close to recycled carpet sources
 - Ship crude products to refiners
 - Minimize transportation costs
 - Well suited for intended application

Extruder Design for Depolymerization/Pyrolysis

Polymer



- Volatiles are the desired products
- Recover volatiles quickly to avoid further degradation
- Volatiles also recovered from extrudate stream

Nylon 6 summary

- Caprolactam yields not known
 - Expect > 90 %
- KOH and K_2CO_3 catalysts are effective at 1 %
 - Don't need catalyst recovery system
- Can operate below 400 °C
- Can depolymerize in < 10 minutes
- Process looks economically attractive
- Pilot extrusion runs this summer

Polyolefin summary

- Waste zeolite catalysts from petroleum refining work well for PE and PP
 - Very inexpensive catalysts
- Post-consumer carpet appears to be inherently catalyzed for pyrolysis
- Polyolefins still require temperatures above 400 C for fast pyrolysis
- Expected products are gas and liquid hydrocarbons suitable for a refinery
- May not be profitable (whereas nylon 6 to caprolactam looks profitable)

Acknowledgements

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 - Funding from Georgia TIP - CCACTI program and GT IPST Exploratory Grant
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