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American Composites Manufacturers Association

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Composites Recycling Conference 2020 | Online

May 19 – 21, 2020

Enter Topic Here

Market Pull for Recycled Composites Products

Ed Pilpel

Sustainable Composites

Options for Marketing-Recycling Composite Bi-Product Streams

- **Repurpose an existing composite product or Bi-Product Stream for an alternate use**. *Spare parts Automotive and Aerospace, Bird House, Light Fixture*
- **Conversion of an End of Service Life product to a next generation material.** *Filler material incorporated into new composite products, Cement Kiln conversion of composite material to energy and incorporation of the glass fiber as a component.*
- **Energy Conversion and Harvest high strength and high stiffness fibers .** *Polymer as a synthetic fuel. Harvested fibers and bi-products for Automotive, Consumer Products Aerospace.*
- **Reclaim by a reverse chemical or combination of processes to return a composite back to its fiber, monomer and additive constituents.** *Harvest and condition the fibers . Repurpose as monomers and bi-products or components for new polymers .*
- **Market/sales case for a product that is branded with recycled content, at a cost premium.** *Sporting Goods, Consumer Products.*
- ***Market to customer companies that are committed to sustainability and recycling.***

Supply Chain Elements to Support End Markets

- **A consistent, reliable, cost effective source** of End of Service Life composites and manufacturing Bi-Product streams to meet demand.
- **Universal Standards** that supports and determines original composite properties, recycled material properties and overall performance.
- **A Universal LCA/LCI modeling tool** for comparative analysis of all key variables (e.g. environmental impact, embedded energy, cost analysis).
- **Supply Chain supported by standards** to provide recycled material credibility, consistency and quality assurance certification.
- **Infrastructure for the Supply Chain** that supports manufacturing processing, logistics, transportation and available inventory .
- **Alternative to simplify the overall Supply Chain** via a single source that internally handles the supply chain from End of Service Life Gate to providing a raw material or manufacture of a next generation product.

THANK YOU

QUESTIONS

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Composite Recycling Program

Chuck Ludwig

CHZ Technologies

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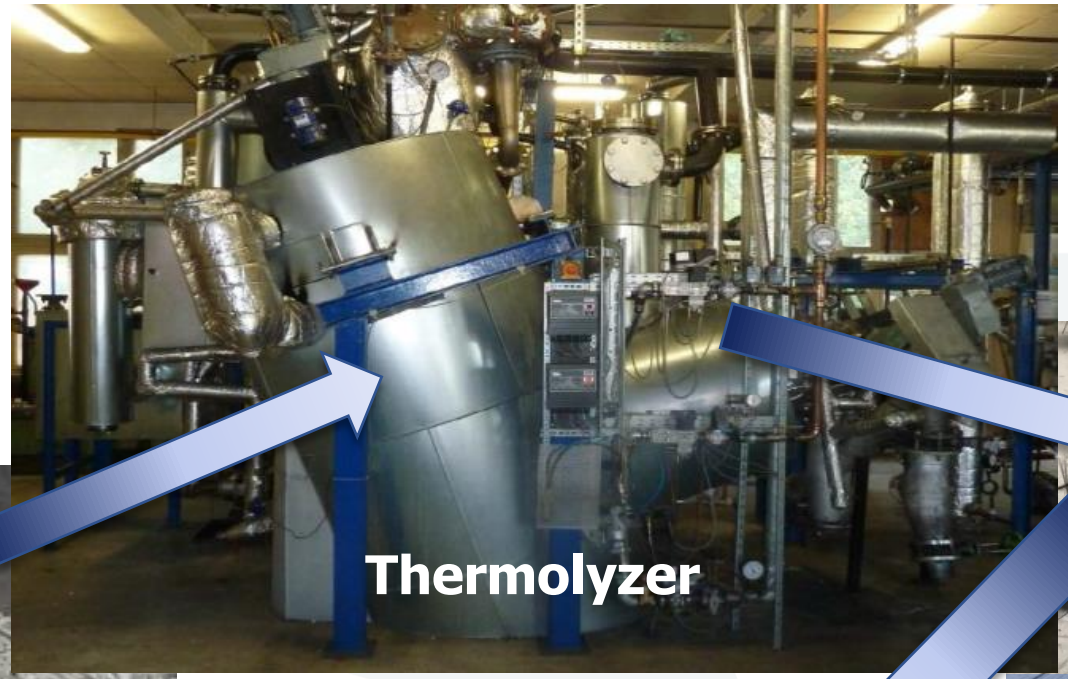
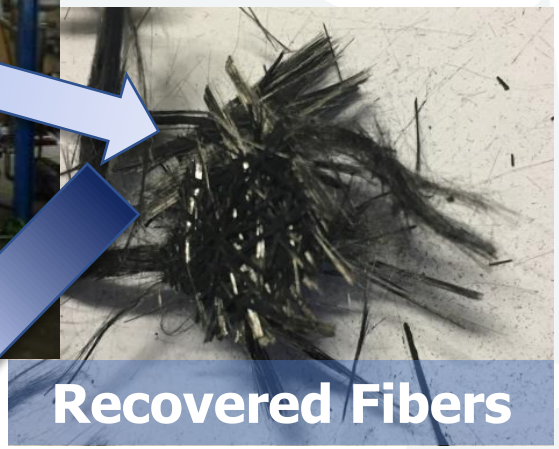
Bloomberg: Wind Turbine Blades can’t be Recycled 2-5-2020

Part 1: ACMA-IACMI-DOE Composite Program





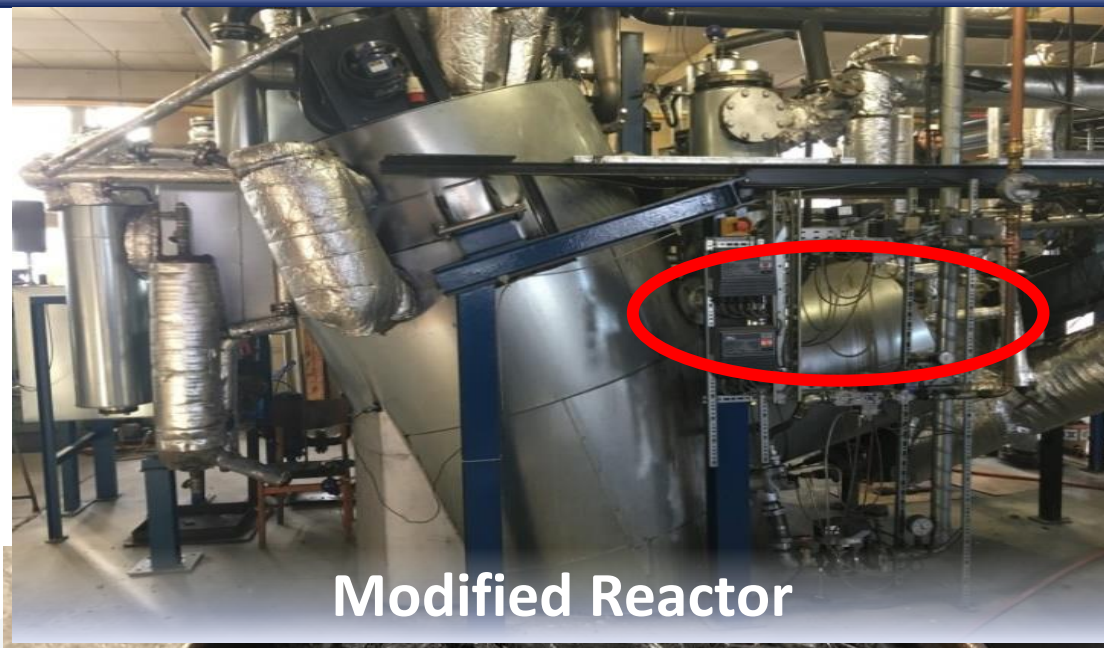
CHZ Phase 2—GE Wind Blade Fiber Recovery

CHZ TECHNOLOGIES

- Reactor modification complete & cleaned

- Phase A→ confirm process conditions for best recovered fibers.
- Phase B→ process balance of shreds. 120 lbs. of fibers
  - Process temp 400-450°C
  - Process "sweet spot" for composites

- Samples fibers and shreds sent to Ryan Ginder.
- Fibers testing in process



Modified Reactor

Recovered Glass Fibers

➢Process sweet spot for GF in the blades

CHZ Part of Phase 2 Complete

Next Step Objectives:

- **Industry** Goal→ find best fit applications
- **CHZ** Goal→ find process partners

Role in the Green/Circular Economy

- <u>Partnering</u> w/ Major association & markets needing EOL
  - EPRI Impact poles & wind blades
  - Non-recyclable Plastics (Ocean) + Electronic scrap + Vinyl Institute (PVC) + Polyurethane + EPS (packaging) + others
- CERMR→ 501 (c) (3) Non Profit
- Renewable SynGas → Energy, Liquid fuels, Building blocks, Green H_2, others
- Youngstown Thermal Plant + R&D Center-Ohio based
- ORNL Processing facility

➢IACMI-ACMA-DOE has opened the pathways

➢Jobs, investment, scalability and legacy

CHZ Technologies

Thanks & Questions

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Opportunities for Recycled Fibers in Thermoplastic Composites

David Salem
CNAM Center
South Dakota School of Mines and Technology

Panel: Market Pull for Recycled Composite Products

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Opportunities for Recycled Fibers in Thermoplastic Composites

- High cost of composites remains a significant impediment to their wider use in industrial and consumer applications
- One way to reduce composites cost is the utilization of recycled fibers
- To gain value from low fiber cost, the manufacturing cost must also be low - able to produce parts at high volume and short cycle times
- Thermoplastic composites offer high volume, low cost production processes, which can take advantage of low-cost carbon fibers, and can make economic sense for recycling of glass fibers

Suitable processes for low cost incorporation of recycled fibers in composite parts

Injection Molding

- Fast, high volume, low cost
- Limitation on part size and on directional control of mechanical properties

Molding of Fiber-Reinforced Thermoplastic Sheet

(CNAM's **DiFTS** process)

- Fast throughput, high volume sheet-forming process
- Discontinuous fibers have controlled orientation
- Lamination of sheets to any width and thickness
- Layup (with/without continuous-fiber thermoplastic tapes/sheets) can be engineered to meet specific cost/property requirements
- Can use as composite skins with lightweight moldable core
- Well-suited to low-cost vacuum thermoforming or pressure forming, with rapid cycle times
- Well-suited to compression molding for higher value products

3D Printing

- Thermoplastic filaments containing recycled fibers for fused deposition 3d printing

DiFTS laminate properties

DiFTS	Tensile		Flexure	
	Strength (MPa)	Modulus (GPa)	Strength (MPa)	Modulus (GPa)
PA6 / 30wt% RECYCLED, standard modulus ¼" carbon fiber from VARTEGA	212	23	342	22
PA6 / 30wt% VIRGIN, standard modulus, chopped ¼" carbon fiber from SGL (thermoplastic sizing)	249	24	377	24
PA6 / 30wt% RECYCLED, ¼" intermediate modulus carbon fiber from Barnet	283	30	438	27

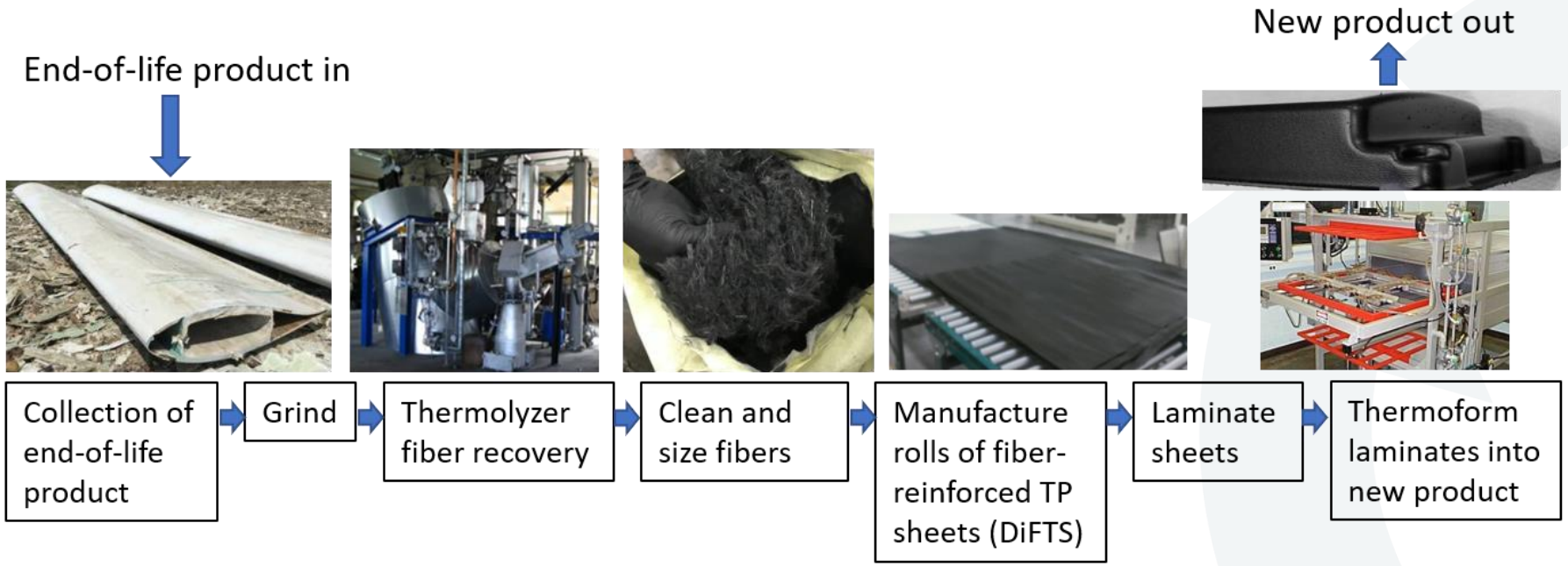
DiFTS sheets and tapes

DiFTS molded products

Market drivers and applications

Market Drivers

- Low cost composites for semi-structural and structural parts
- Property/cost design flexibility
- Meet corporate sustainability goals and reduce costs
- End-of-life product in, new products out, potentially in a single facility
- Multiple life products



Application Examples

- Light weight vehicles: Reduction of components, production steps, screws, bolts, seams: strong opportunities in EVs and self-driving vehicles
- Construction and furniture – shape flexibility for greater design freedom and light weight
- Consumer electronics: parts and casings
- Agricultural equipment – sustainability
- Musical instruments
- Sports equipment
- Overmolding substrates
- Composites that can be fused with 3D printed parts

Demonstration in a John Deere Part
(ACMA-IACMI Recycling Group Project, Phase 2)

Commercial Motivation
Recover fibers from an end-of-life John Deere product (e.g. an agricultural spray boom containing glass and carbon fibers in a thermoset resin) and re-use them in a John Deere thermoplastic composite part (e.g. agricultural vehicle component)

Materials
Polymer: HMWPE regrind (recycled), used in many John Deere parts
Fibers: (1) Barnett recycled carbon fibers, (2) Thermolyzer-recovered glass fibers, (3) Mixture of Thermolyzer-recovered glass fibers and Thermolyzer-recovered carbon fibers.

Process
- Thermolyzer fibers were cyclone-cleaned at SD Mines and some were densified by Vartega to permit feeding to extruder
- SD Mines produced fiber-reinforced sheet using its DiFTS technology
- Reinforced sheets were laminated into ~6mm thick, 4’ x 4’ panels
- Panels were vacuum thermoformed by a John Deere contractor into a door panel part

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OAK RIDGE National Laboratory

Enabling the Circular Economy

"Develop Value Added Recycled Feedstocks for Additive and Composite Manufacturing"

Soydan Ozcan- Senior R&D Scientist
Thrust lead: Composite Recycling
: Bio-Derived Materials & Additive Manufacturing
Oak Ridge National Laboratory

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Waste Stream for Composite and Additive Manufacturing

Waste Stream	Recovered Commodities	Value-added Recycled Products
Example Thermosets • Wind Turbine Blades • Aerospace Components • Automotive Paneling • Marine • Construction Industry • Sheet Molding Compound • Bicycle Industry • High End Sports Equipment (e.g. CF Kayak paddles)	Thermoset Composites → Energy & Chemicals Thermoset Composites → Reclaimed Valuables, e.g. fibers, carbon black	• Additively manufactured parts and industrial molds (e.g., precast concrete for construction) • Compression and/or injection molded components for vehicle lightweighting (e.g., automotive body paneling) • Composite extrusion for infrastructure components (e.g., composite decking)
Example Thermoplastics • Bottles • Packaging Materials • End of Life AM parts • Automotive Trim • Elastomers (Rubber) • Water Sports Equipment	Thermoplastic → High Value Plastics for AM Thermoplastic → Low value plastics for composite upcycling	

Recycling Process Flow Chart

- ✓ Repurpose high value plastics as AM and composites feedstock
- ✓ Reclaim high value products e.g., high performance fibers etc.
- ✓ Upcycle low value plastics
- ✓ Recovering energy from non-reusables

Waste Stream

Bulk Shredding

Sorting

Thermoplastics

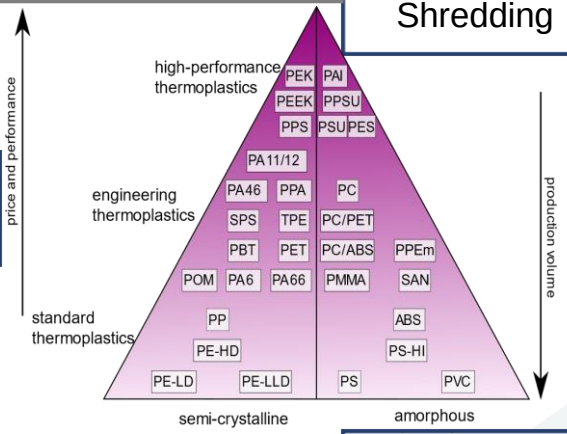
Classification /Separation

High Value

Fine Shredding

Low Value

Fine Shredding



Big Area Additive Manufacturing

Compounder

Thermoplastic Composite processing Compression injection molding etc..

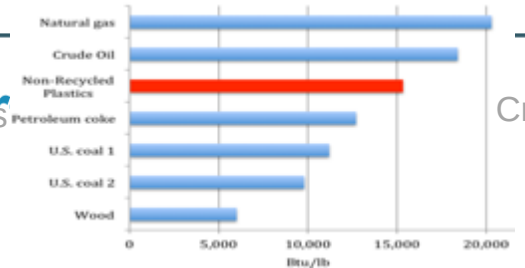
Thermoset

Pyrolysis-Chemical Recycling

Fiber Recovery

Thermoset Composite processing SMC/wet-layup etc..

Syngas



Crude oil

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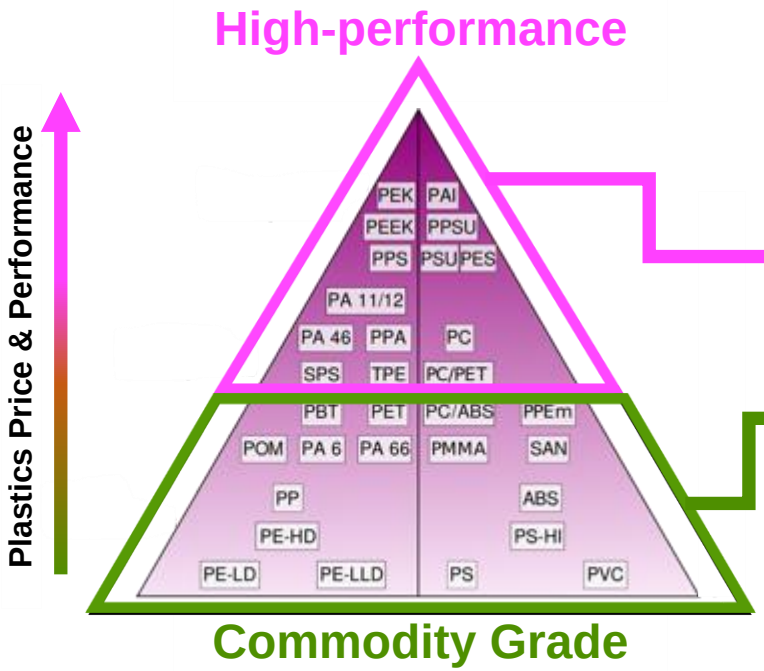
Proposed Signature Projects



Case Study I

Mechanical Recycling

Case Study II

Additive Manufacturing

Composite Upcycling
(Compounding with standard thermoplastics)

AM Mold Fabrication: precast concrete, marine molds

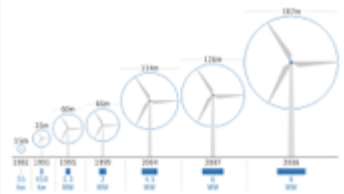
AM molds can also support composite manufacturing

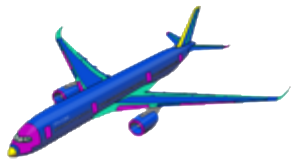
Compression & Injection Molded Automotive Parts

Fiber and Energy Recovery process (Pyrolysis)

Energy Production (from resin)

Reclaimed Carbon & Glass Fibers





Glass & Carbon Fiber Reinforced Thermoset Composite Waste

- Wind turbine blades
- Aerospace parts
- Agricultural & construction equipment

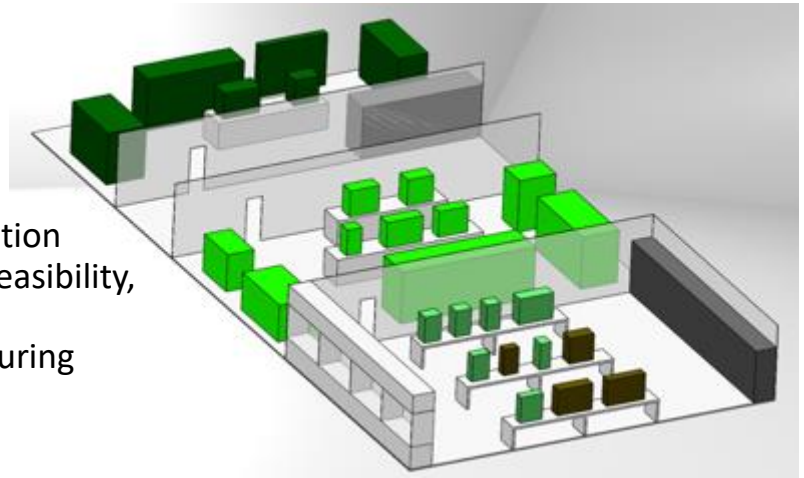
Extruded Infrastructure Materials: paneling, decking

Recycling- Rapid Innovation and Commercialization Lab Floor Plan

Open research facility with the combined capabilities

Rapid Innovation Capability

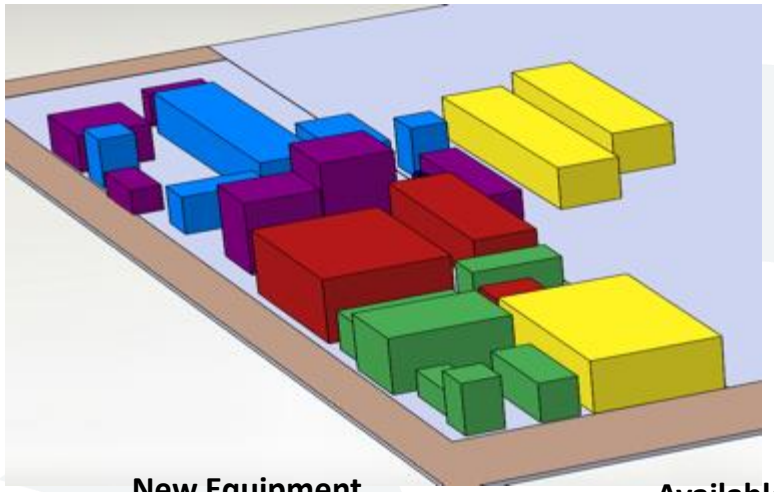
Low Bay
50’ x 100’
- Characterization
- Bench Top Feasibility, Recycling & Remanufacturing



New Equipment

- Lab-Scale Recycling & Recovery
- Manufacturing
- Characterization

Scale up Capability



High Bay
50’ x 200’
- Commercial Scale Manufacturing Systems
- Recycling & Recovery Equipment

New Equipment

- Recycling & Recovery

Available Equipment

- Thermosets
- Thermoplastics
- Additive Manufacturing
- Automation and Molding

Circular economy supporting capabilities:
- **Green** boxes are new equipment
- Other colors are MDF existing capabilities

Current Pilot Scale Capabilities

Demonstrate the Process Scalability

Thermoplastics

- Big Area AM

- Injection Molding

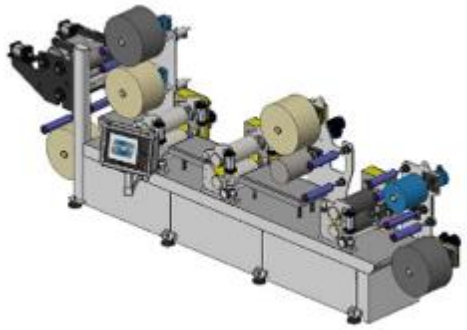
- Compression Molding

Thermosets

- Sheet Molding Compound (SMC) Line

- Thermoset Printing

- Prepreg Molding



Pilot Scale Recycling Capabilities

Fiber Reclamation

- Pyrolysis of resin for reclaiming of fiber – controlled atmosphere, mesh belt furnace

Cutting/Shredding/Granulation

- Physical breakdown of plastics for either immediate use or further processing

Compounder - Pelletizer

- Melt mixing to create new feedstock (pellets)
- Processing of material into immediately usable feedstock (pellets)

Future Capabilities

Pyrolysis/Gasification

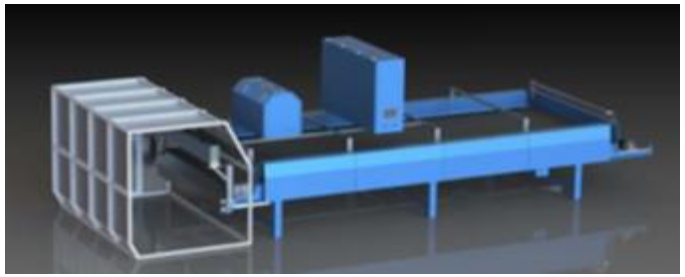
- Thermal breakdown to recover oils, syngas, fibers, and energy

Fischer–Tropsch process

- Further conversion of oils into higher grade fuels and lubricants

Sorting

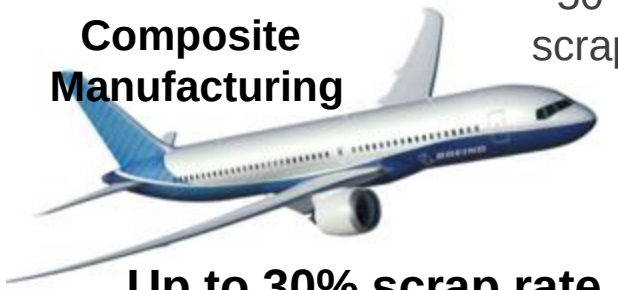
- Separation of different plastics for further processing



Example R&D Projects – Plastic & Composite Recycling

--There are many avenues for circular composites--

Carbon Fiber Plastic Composite Manufacturing



~50 million pounds of carbon fiber scrap is landfilled annually in the world

Up to 30% scrap rate

Closing the loop of recycled carbon fiber, converting to automotive panel

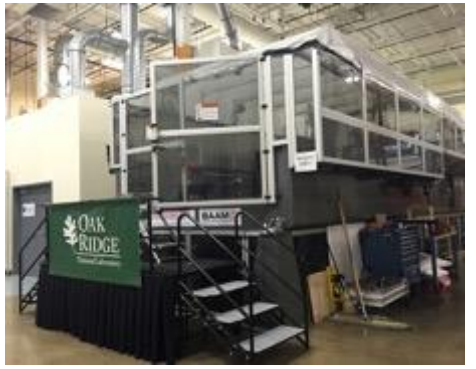
vartega

TECHMER PM POLYMER MODIFIERS

OAK RIDGE National Laboratory | MANUFACTURING DEMONSTRATION FACILITY

Source:
Reclaimed Polycarbonate waste

Process:
Big Area Additive Manufacturing



Application:
Printed Utility Pole

Material used:
Recycled Polycarbonate reinforced with bamboo

IACMI Outreach and Dissemination of Knowledge

- IACMI Composite Recycling and Remanufacturing Roadmapping Workshop, 2016
- Participate conference panels, support various CAMX, SAMPE, ACMA Sustainability Coalition 2017-2019
- 8 IACMI Recycling Projects with total of 30 industrial collaborators
- Published journal papers
- Selected for cover page of "*Recycling*" journal for June 2019
-

Current related industrial partners

Polynt, Dixie Chemical, Plastech Corporation, Techmer PM, Chomarat, NRG: The CMU Designed for Today, AvCarb, CHZ Technologies, BASF, Materials Innovation Technologies, John Deere, CRTC Composite Recycling Technology Center, GE Renewable Energy, Ford, eg, Eastman Chemical Company, BASF, sabic, Saint-Gobain, LM Wind Power, Continental Structural Plastics, Teijin, ACMA, UAM, Arkema, American Chemistry Council, ResourceFiber

June 2019 vol cover page

Thank you!