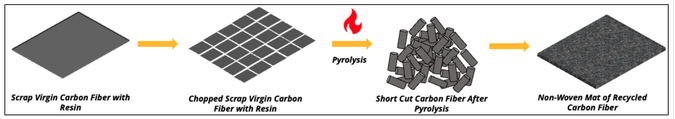
Recycled Thermoplastic Composites

Cecilia Bailey, Jonny Harrigan, Melike Portakal, Areesa Trevino, Hung Wang

Background/Motivation

- There has been an increasing amount of carbon fiber demand as well as waste generation.
- Recycling the composites offers the opportunity to recycle carbon fiber and mitigate waste.



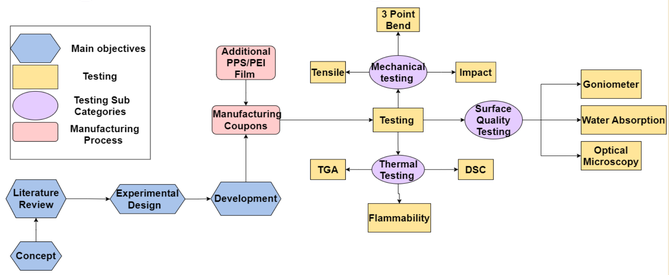
Objectives

- To characterize recycled carbon fiber comingled with PPS (rCF/PPS).
- To develop a technique for improving surface quality.

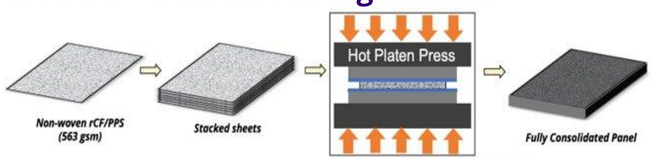
Scope

- Manufacture composite panels
- Test surface energy, flammability, impact, flexural, and tensile strength
- Provide data for application development

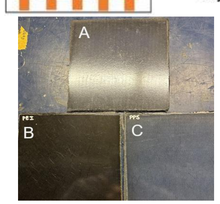
Design Process Flow Diagram



Method – Manufacturing Process

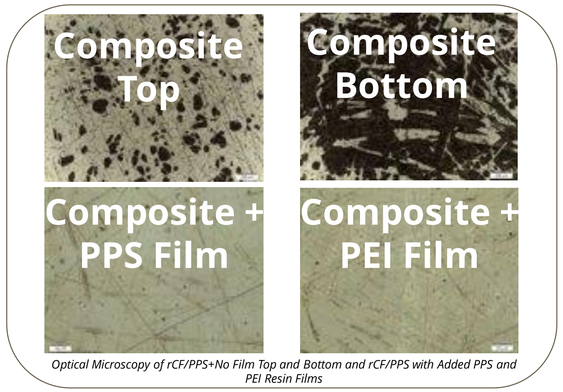


Hot Press Cycle	
Time (min)	60
Clamp Force (tons)	5
Set Temperature (°F)	553
Cooling Cycle	
Time (min)	30
Clamp Force (tons)	5
Set Temperature (°F)	77



Hot Pressed Consolidated Panels A) Recycled Carbon Fiber with PPS + No film, B) Recycled Carbon Fiber with PPS + PEI film, C) Recycled Carbon Fiber with PPS + PPS film

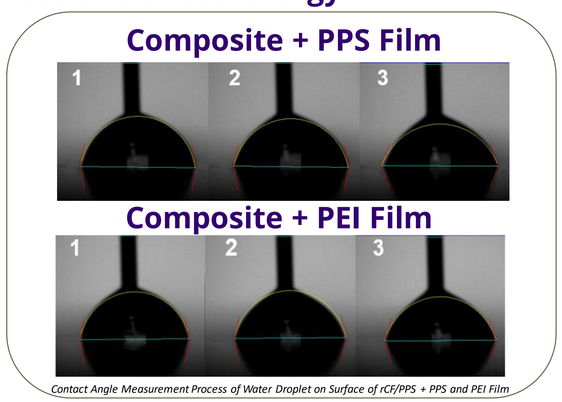
Result – Surface Quality



Optical Microscopy of rCF/PPS+No Film Top and Bottom and rCF/PPS with Added PPS and PEI Resin Films

- The rCF/PPS+No Film top exhibited higher thermoplastic content than the rCF/PPS+No Film bottom.
- The addition of the PPS and PEI films decreased the surface porosity.

Result – Surface Energy



Contact Angle Measurement Process of Water Droplet on Surface of rCF/PPS + PPS and PEI Film

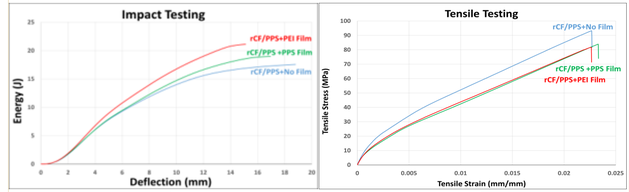
Specimen ID	Time (min)	Contact Angle (deg)
rCF/PPS+ 3 PPS Film	0.00	81.4
	2.00	78.7
	4.00	69.8

Specimen ID	Time (min)	Contact Angle (deg)
rCF/PPS+ 3 PEI Film	0.00	78.2
	2.00	78.0
	4.00	73.0

Tables 1-2: Contact Angle Measurement for rCF/PPS+PPS and rCF/PPS+PEI Film (3 Layers of Resin Film)

- The contact angle of rCF/PPS+No Film is higher than samples with added film.
- The addition of the film layers showed improved surface energy due to lower contact angle.

Results – Mechanical Characterization



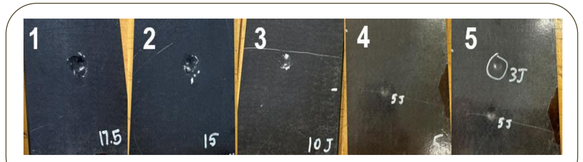
Mechanical Testing Graphs: Averages of each material in Impact, Tensile and Flexural Testing

- The rCF/PPS+No Film performed the strongest in the flexural and tensile tests
- The rCF/PPS+PEI absorbed the most energy in the impact test, meaning it performed the best

Parameters:

- Impact: ASTM D7136, Sample Size: 6" x 4"
- Flexural: ASTM D7264, Sample Size: 6" x 0.5"
- Tensile: ASTM D3039, Sample Size: 10" x 0.95"

Measuring Impact Strength Threshold



Visual Impact Damage on rCF/PPS+No Film Samples at varying total energy

Specimen rCF/PPS+No Film	Total Energy (J)	Maximum Load (kN)	Total Deflection (mm)
Sample 1	17.67	2.88	12.03
Sample 2	15.50	2.55	9.95
Sample 3	10.40	2.54	6.02
Sample 4	5.30	2.77	3.22
Sample 5	3.40	2.03	2.87

Tables 3: Results from impact strength threshold testing

- Samples were no longer punctured at a drop height of 0.1346m (10.40 J)

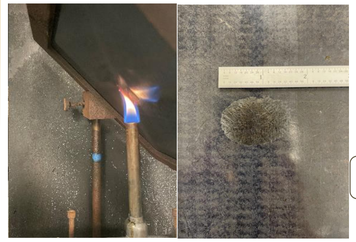
Results – Flammability

Vertical Burn rCF/PPS + No Film

- 1.2" for burn length (<6")
- 0 seconds extinguishing time (<15 sec)
- 0 second drip flame time (<3 sec)
- 3 samples tested

Passes FAA requirement

30 Second 45 Degree Burn rCF/PPS+No Film



- 0 seconds extinguishing time (<15 sec)
- No flame penetration
- 2 samples tested

Passes FAA requirement

Results – Water Absorption

Specimen rCF/PPS+No Film	Dry Weight (g)	Wet Weight (g)	Increased Weight (%)
Sample 1	6.79	7.16	5.45
Sample 2	6.47	6.89	6.49
Sample 3	6.92	7.33	5.92

Table 4: Results of the water absorption testing

- ASTM D570
- The samples were dried in an oven for 1 hour at 105 degrees Celsius for conditioning.
- The dry and wet weight were measured before and after a 24-hour submersion in water.

Future Work

- Conduct tests on virgin carbon fiber as control group to assess post-recycling properties.
- Conduct characterization tests using the same parameters as those used for rCF/PEI by Boeing company to compare the results with the data obtained from this material.
- Vary thicknesses using the same amount of plies in manufacturing process utilizing metal shims.

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