POLYMER AND CARBON FIBER RECLAMATION OF ELIUM 188 O INFUSED TUFF COMPOSITES

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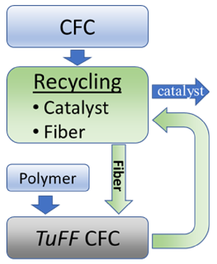
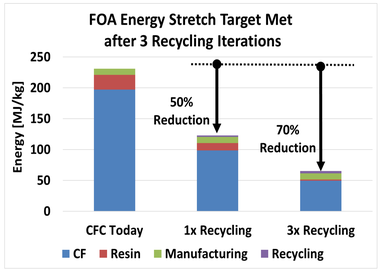
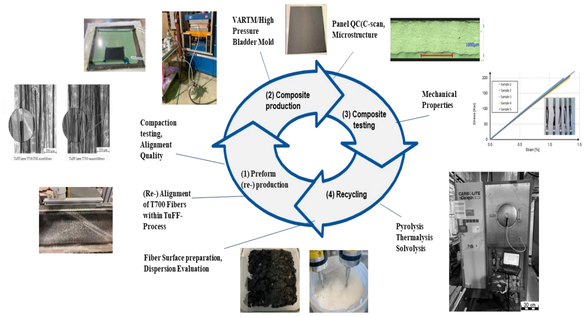
Motivation

- CFC recycling approach allows multiple iterations with fiber and catalyst recovery 50% energy saving after first recycling and ~70% after 3 recycling steps



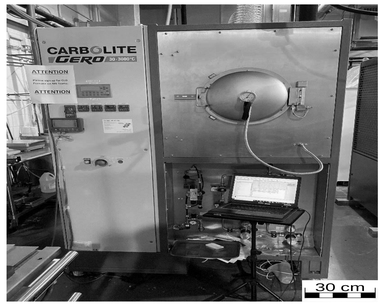


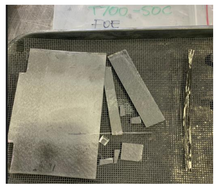
Recycling Approach

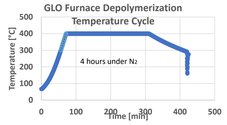


- *TuFF* process aligns discontinuous fibers to produce high FVF composites (Patents “Aligned Short Fiber Preforms and Composite and Method of Manufacture”, US16054405 & US11047078
- Recycled carbon fibers (*r*CF) recovered after depolymerization can be used with *TuFF*
- *r*CF *TuFF* has the potential of full property translation compared to virgin carbon fiber (*v*CF) composites
- Key is to maintain *r*CF fiber properties (strength/stiffness), resin / fiber adhesion, control of fiber length and the ability to disperse *r*CF fibers in water

Depolymerization

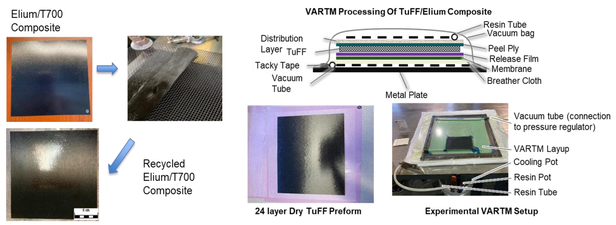






- *v*CF *TuFF* coupons made with Arkema Elium 188 O resin were processed per process cycle above
- 500 mL/hour flow rate under N2
- 0.31 g of residue (by-products of Elium resin) was leftover on fibers (~1.5%)
- Resulting *r*CFs were not fully dispersible in water, so additional steps needed to improve fiber dispersion and aligned *TuFF* sheet quality

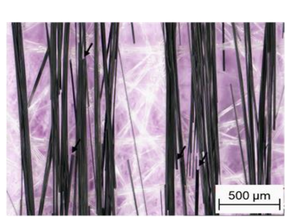
TuFF Composites via VARTM



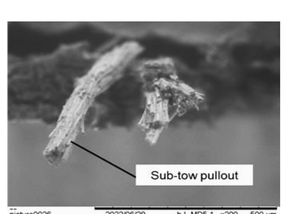
- Composite tensile strength retention of 55 % and tensile modulus retention of 100 %

	FVF [%]	Tensile Strength [MPa]	Modulus [GPa]	Strain [%]
vT700S	27	814 ± 51	60.91 ± 3.13	1.34 ± 0.06
rT700S	24	484 ± 12	60.71 ± 0.93	0.93 ± 0.05

- Failure mode fiber pull-out and matrix failure

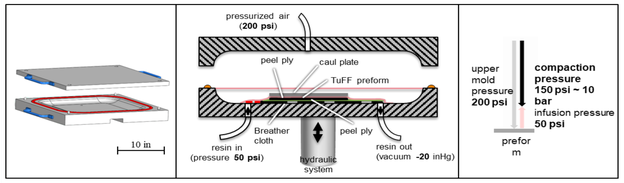


TuFF T700 F0E sized layer with bundles



Composite failure mode SEM image

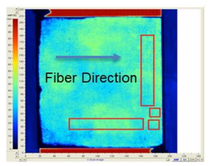
TuFF Composites via Bladder Mold

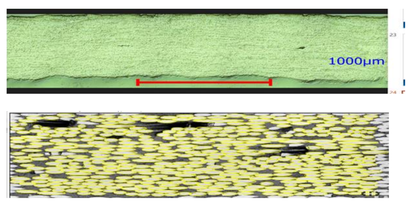


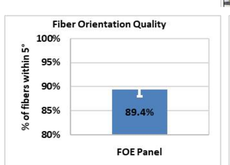
- Enables infusion of High FVF TuFF preforms while maintaining 200 PSI consolidation pressure
- Applicable to Elium/acrylic resin system
- Infusion of a 114-layer TuFF material resulted in a ~1 mm thick composite with a 54.4 % FVF

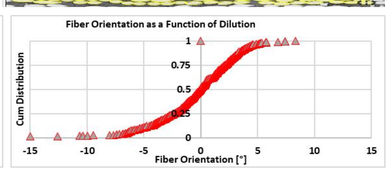
Material	Mass (g)	Density (g/cm^3)	Volume (cm^3)
T700 FOE	29.89	1.80	16.6
Elium 188	16.29	1.17	13.9
Total	46.18		30.5
		FVF %	54.4

- C-scan shows resin infusion is good with no porosity issues
- Fiber orientation is good with 89.4% in 5 degree of orientation direction









- Modulus measured as 108.6 GPa, and strain at failure as 1.33
- For ~50% FvF, expected Modulus is 115 GPa and Strain at failure ~2 %

Sample ID	Width (mm)	Thickness (mm)	Area (mm²)	P^{MAX} (kgf)	Strength (MPa)	Modulus (GPa)	%Strain
THICK	12.38	1.03	12.75	1900	1460	108.6	1.33
THIN	13.38	0.19	2.54	364	1405 (STD+-78)	110.5 (STD+-2.7)	1.32 (STD+-0.08)

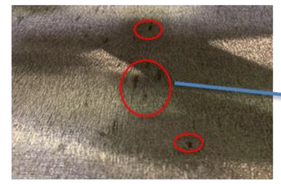
rT700-FOE Fiber Surface Cleaning

- Recycled fibers washed in 1/200 ratio Bluesil/Water solution.
- Recycled TuFF material showed a few defects (10-14 defects per sq. ft.)

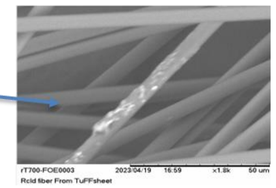
Before Bluesil Wash

After Bluesil Wash

Recycled fiber TuFF sheet



TuFF clump SEM image



Summary and Future Work

- GLO depolymerization of Elium is successful with >95% fiber reclamation with minimal property degradation and residue on fibers
- Development of cleaning process for recycled fibers in progress (solvent wash, dispersant wash, low temperature oxidation via Ozone)
- Property translation of ~100% modulus and 55% tensile strength *r*CF compared to *v*CF *TuFF* parts has been demonstrated
- *TuFF* Composites via Bladder Molding is currently being developed to increase FVF to 50%

Acknowledgements

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