COMPOSITE MANUFACTURING WITH ELIUM 188 O RESIN AND T700SC F0E SIZED CARBON FIBERS IN BLADDER MOLDING PROCESS

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Introduction

- Recycling of high-performance fiber composites reduces waste, improves the energy balance and is becoming an important aspect to meet future regulations
- The objective of the project is to demonstrate that fiber recovery and reuse is possible without a significant loss of mechanical properties.

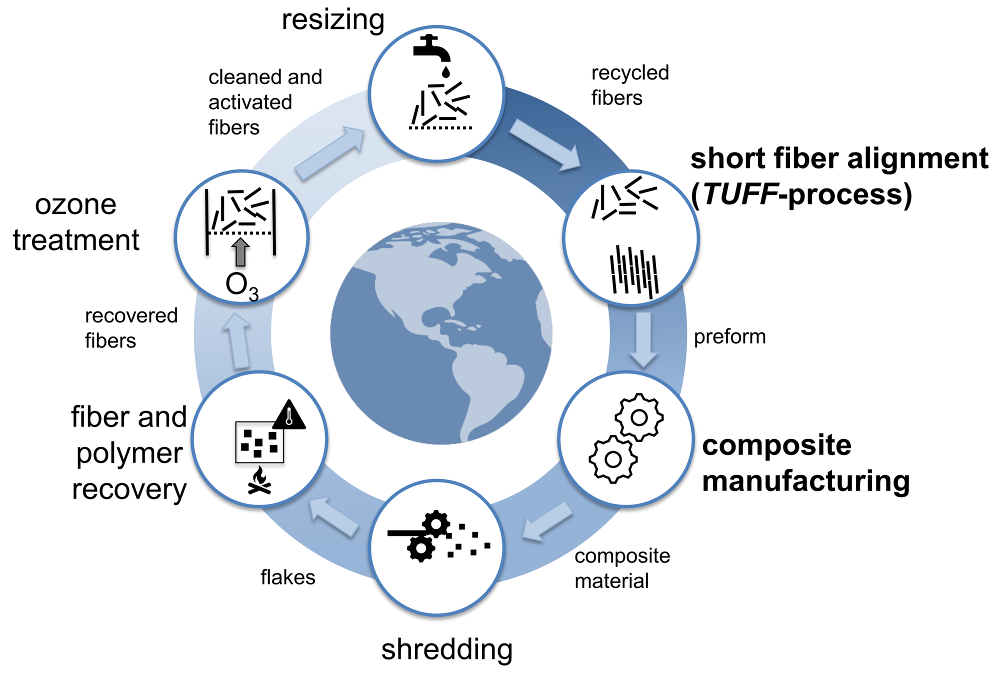


Fig. 1: Hypothesis process of the fiber recycling

- The TuFF process aligns discontinuous fibers at high packing efficiency and 100% property translation
- The recyclable Arkema Elium 188 O resin allows monomer recovery

Previous work

- Fiber volume fraction (FVF) of ~ 30 % has been demonstrated with a VARTM process
- Full composite strength translation was not achieved with 3mm T700SC 50C carbon fibers and Elium 188 O resin
- Continuous Fiber data from Arkema shows that F0E sizing allows full mechanical property translation with Elium resin

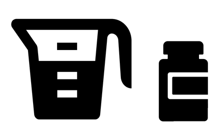
Objectives

- Increase the FVF to >50 % with the increased compaction pressure process
- Achieve 100% property translation with proper fiber-resin adhesion.

Material

T700SC F0E 3 mm virgin carbon fibers
TuFF preform 24 layers

Elium 188 0 resin (PMMA)
with 3wt% Luperox AFR 40 (peroxide, initiator free radical polymerization)



Bladder molding process

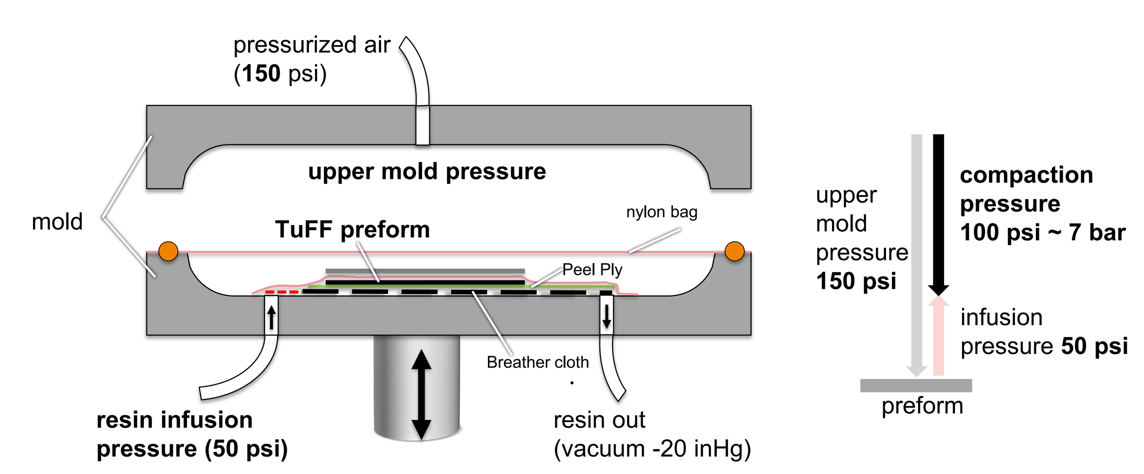


Fig. 2: Bladder molding infusion setup

- Bladder molding process allows impregnation to be combined with higher compaction pressure to produce a higher FVF part

Results

- Approximately 50 % FVF was achieved with 100 psi compaction pressure

$$FVF = \frac{\text{weight preform / density fiber}}{\text{weight preform / density fiber + weight matrix / density matrix}}$$

$$= \frac{5.61\,g / 1.8\,\frac{g}{cm^3}}{5.61\,g / 1.8\,\frac{g}{cm^3} + 3.37\,g / 1.17\,\frac{g}{cm^3}} \approx 52\,\%$$

- The FVF matches with the expected values based on the infusion pressures and TuFF compaction behavior

- The F0E-sized fibers are difficult to disperse. The fibers have a tendency to adhere together. Fiber bundles are visible in the dispersion and fiber sheets

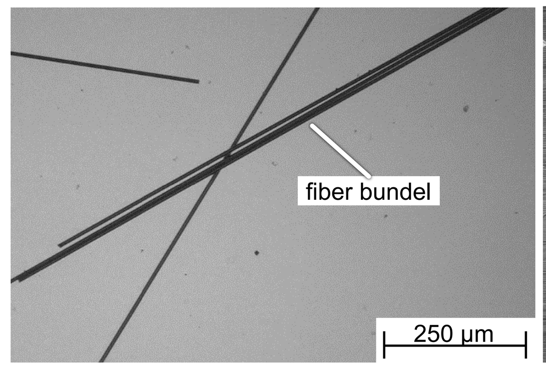


Fig. 4: Dispersed vT700 F0E sized fibers in water

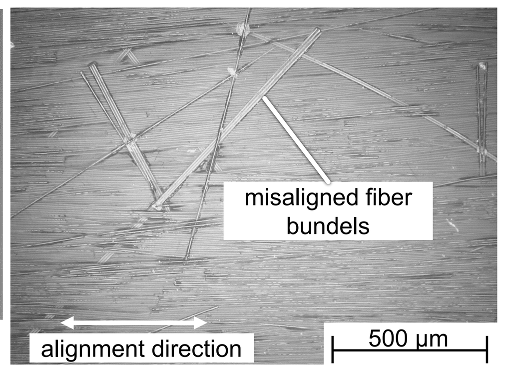


Fig. 5: Composite surface image with fiber bundels

- Due to the infusion layup, the peel ply side of the composite is rough and has a resin rich area

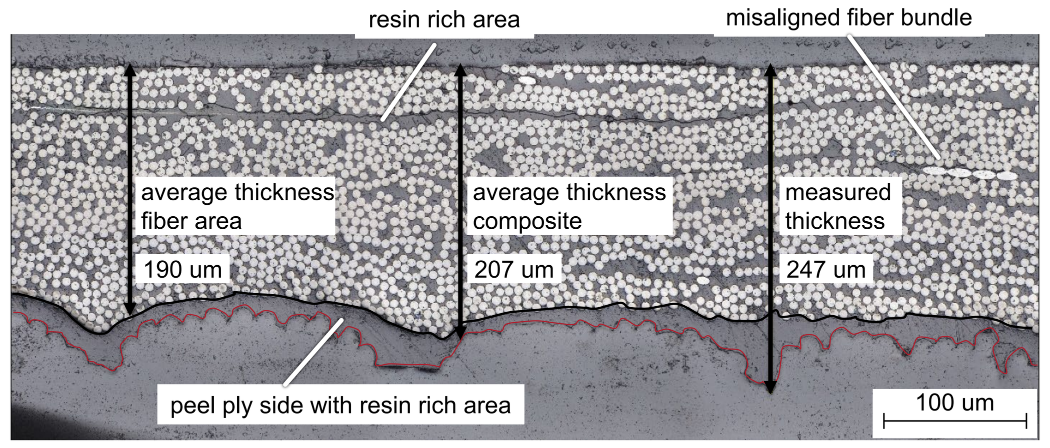


Fig. 6: Microscopy image cross section composite

- A representative thickness measurement for the exact calculation of the stress values is challenging

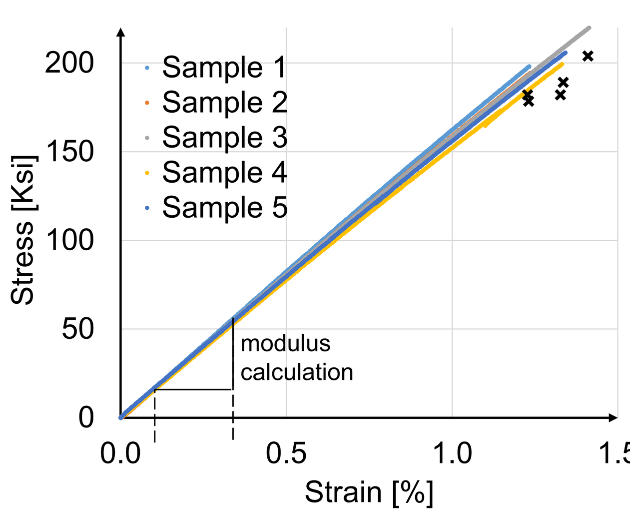


Fig. 7: Stress-Strain results mechanical testing calculated with 190 µm effective thickness

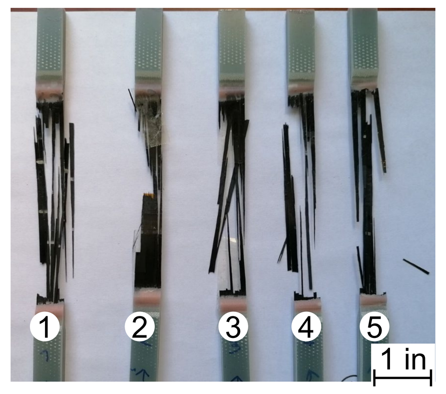


Fig. 8: Broken testing samples

- The average failure strain of 1.32 % is about 20 % lower than specified by the manufacturer (1.7 %).

Conclusion

- The low strain to failure properties are due to fiber bundles creating stress concentrations and/or poor resin-fiber adhesion
- A FVF of ~ 50 % was achieved

Future work

- Separation of all filaments prior to alignment
    - Pre-treatment of the FOE sized fibers in a sonicator
    - Fiber surface treatment of unsized fibers (recovered fibers)
- Manufacturing of a thicker panel with 115 layers, where the proportion of resin rich areas is less than 5 % of the measured thickness

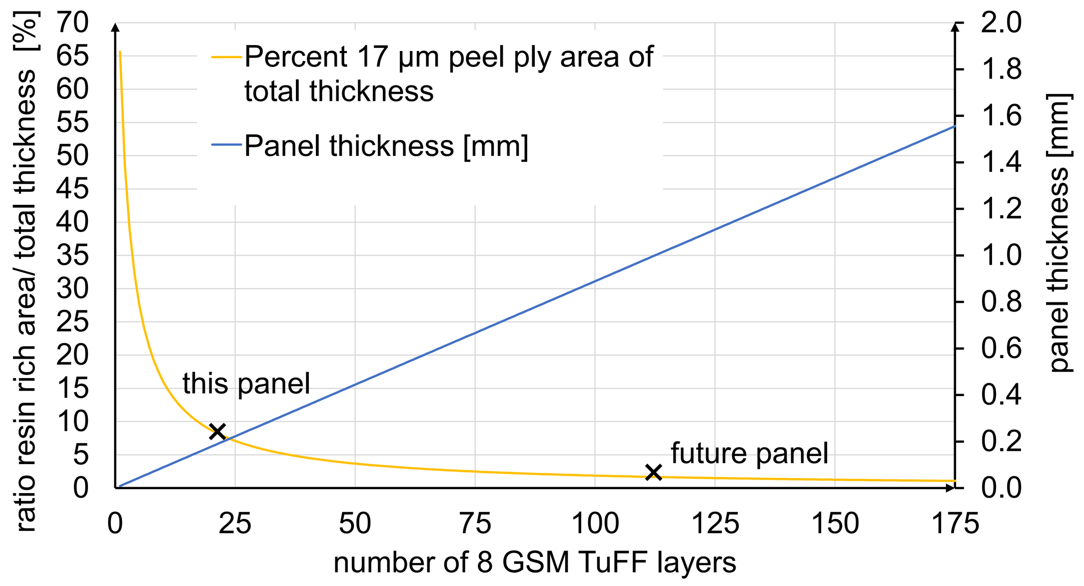


Fig. 9: Total thickness calculation composite with 50 % FVF of T700 carbon fibers and percentage of 17µm thick resin-rich peel ply area to total thickness

- Demonstrate full recycling process with fiber recovery and reuse

Acknowledgements

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