SINGLE FIBER TENSILE TESTING (SFTT) TO EVALUATE STRENGTH DEGRADATION LEVELS OF ORIGINAL AND 14-MINUTE OXIDIZED T700-FOE CONTINOUS CARBON FIBERS

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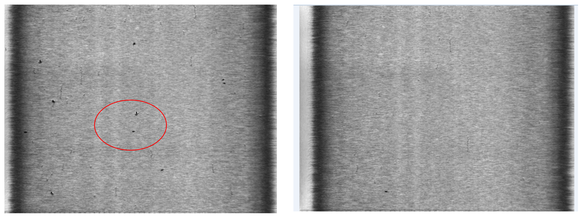
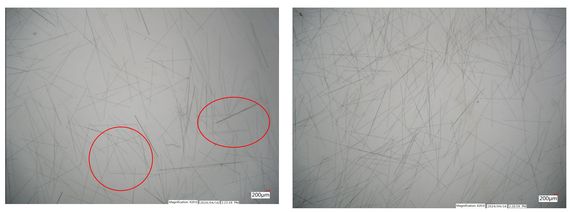
Research Motivation

- TuFF is a unique process that uses short (3-5 mm) carbon fibers to produce well-aligned short fiber preforms and composites with strengths equal to continuous fibers
- Recycled short carbon fibers tend to have groupings of fibers stuck together (“clumps”) because of the residue leftover after recycling processes such as depolymerization



- Clumps degrade composite strength
  - Disrupt fiber alignment
  - Create stress concentrations
- Optimized oxidation of recycled carbon fibers
  - Clean fibers with good dispersion
  - Minimal strength degradation
  - Higher oxidation time=Strength reduction

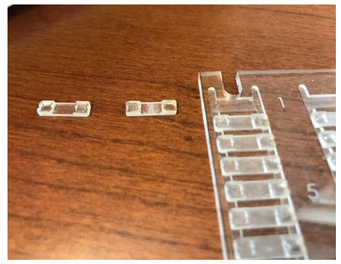


As-polymerized 14 minute oxidation

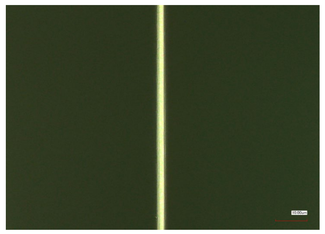
- TGA experiments show 14 minutes of oxidation give acceptable dispersion quality
- Single fiber tensile tests (SFTT) are performed to follow up the property degradation level after oxidation process

Single Fiber Tensile Test (SFTT)

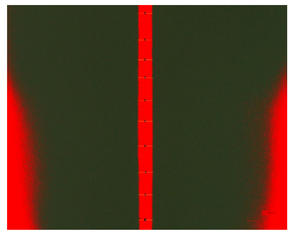
- SFTT testing is carried out to evaluate the effect of oxidation time on fiber strength
- 2x20 samples in 12 mm gauge length trays were prepared for 14-minutes oxidized and virgin T700-F0E fibers
- Single fibers are loaded into test tabs, and resin is used to firmly hold the ends in place



- A confocal microscope is used to determine fiber diameter (Average of 10 measurements)



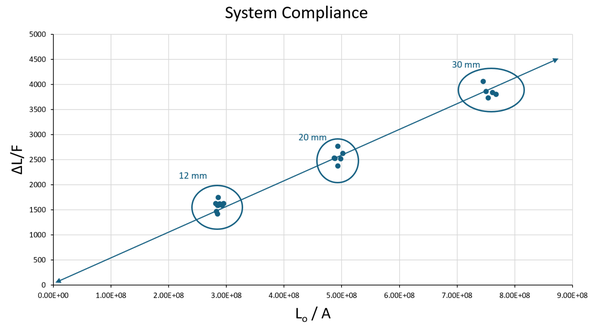
Laser Confocal image



Threshold image

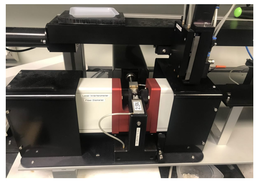
Compliance Testing

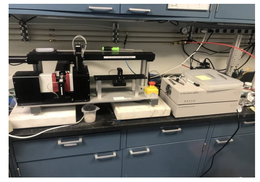
- Compliance tests are performed in accordance with ASTM C1557-20 test method by using at least 5 samples for each gage length of 12, 20 and 30 mm



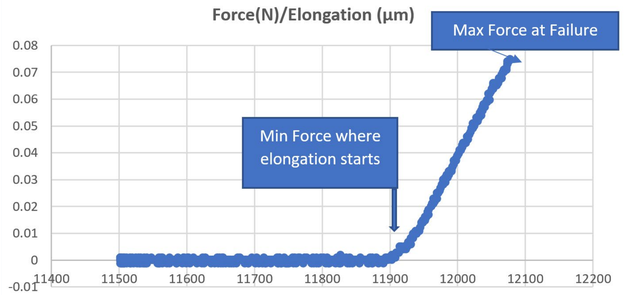
Conducting SFTT using Dia-Stron

- After sample preparation and diameter measurement is completed, test tray is loaded into the Dia-Stron SFTT machine
- Load is measured using a 2.5 Newton load cell with a resolution of 0.5 mN

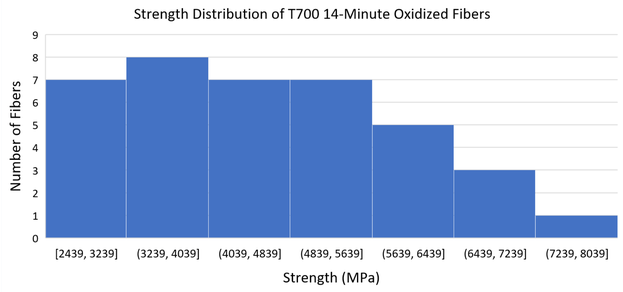




- The raw testing data is the measurement of position and force, which can be used to generate force/elongation diagrams

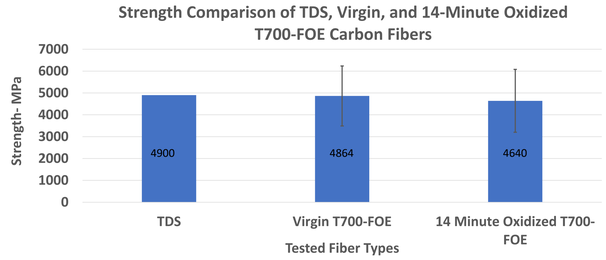


- Average fiber strengths are calculated by using 60 fibers for 12 mm gauge length



- Strength distribution for the 14-min oxidized fibers
- Diameter distribution is reasonable for the 14-minute oxidized fibers with 2.7% STD

Results and Discussion



- Toray Composites website reports T700S fiber strength as 4900 MPa
- Virgin T700-FOE fiber strength measured as 4864 MPa with an STD of 1372 MPa
- Depolymerized and 14-minute oxidized T700-FOE fiber strength measured as 4640 MPa with an STD of 1437 MPa
- Depolymerized and 14-min oxidized T700-F0E fiber property retention of 94.7% within on standard deviation of the virgin fiber strength
- The 14-min oxidized fiber strength test data has also comparable variation to the virgin fiber strength data
- The 14-minute oxidized Fiber diameter distribution is reasonable with 2.7% STD
- 14-minute oxidation after depolymerizing fibers at temperature results in reasonable degradation of fiber mechanical properties

Future work

- 1st iteration recycled T700-FOE fibers will be re-infused and depolymerized for multiple iteration of recycling
- SFTT tests will be replicated after each iteration of recycling to follow the strength degradation per second and third iteration of recycling

Acknowledgements

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