Data-driven multiscale modeling and experimental framework to reveal the PSP linkage of filler reinforced polymer composites, PSED Cluster 2019-2020

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Academic Disciplines: **THEORETICAL AND APPLIED MECHANICS, MECHANICAL ENGINEERING**

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Objective

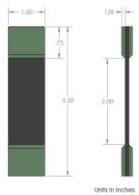
To develop a modeling framework for assessing and linking process to structure to property relationship in particle reinforced polymer composites.

Motivation

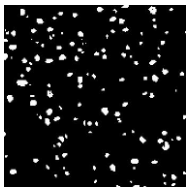
- Predictive numerical techniques are vital for increased design and implementation of composite materials.
- Implementation of curing process to modeling increases the design space and allows for more optimal composite structures.

Experimental Curing and Reconstruction

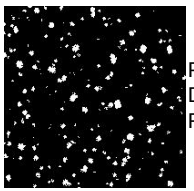
•Spherical Ti-6Al-4V metallic powder of different mass fractions were mixed with epoxy resin and cured.
•Images are inputted to Nanomine for a physical descriptor-based reconstruction.
•Tensile specimens are cured in a high-throughput experimental set up for model validation.



Tensile specimens manufactured using ASTM-D3039 standards.



Target Image



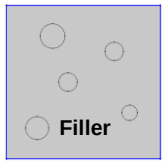
Physical Descriptor Reconstruction

Future works

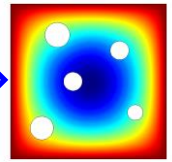
•3D cure model with experimental microstructures input
•Expand cure database with more microstructure and process cycles
•Tensile coupon preparation following optimized cure cycles and testing
•Optimization of curing time

Modeling and simulation of curing process

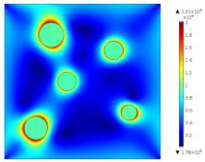
Physics considered
- Heat transfer
- Cure kinetics
- Viscoelasticity



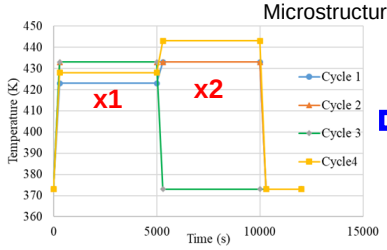
Microstructure



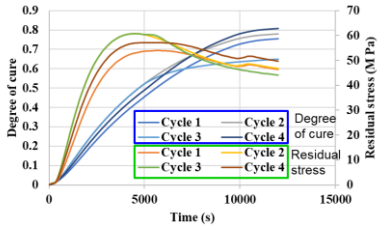
Curing conversion



Residual stress



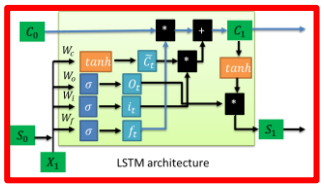
Curing process cycle



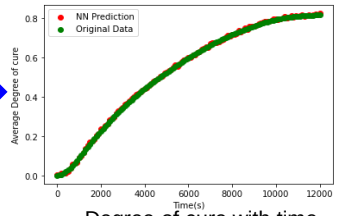
Cured properties

Predictive modeling and optimization

Curing database from simulation



Recurrent neural network

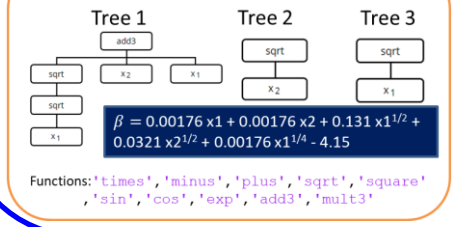


Degree of cure with time

Input data
Process variables, Holding temperature (x1, x2)

Output data
Properties (degree of cure, $\beta(x_1, x_2)$

Genetic programming



Multiobjective Optimization

$$\max f_1(x_1, x_2)$$
$$\min f2\,(x_1, x_2)$$
$$Subject\ to\ 410 \le x_1, x_2 \le 443$$

Pareto front of optimized cure cycle

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