Machine learning based modeling of impregnation and curing stages of resin transfer molding process

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Machine learning (ML) based modeling of physical processes is emerging as a fast and accurate alternative to physics based modeling such as by using finite element method.

Convolutional neural networks are commonly used for predicting the microscale flow behavior and macroscale mold filling behavior in resin transfer molding (RTM) process, however they remain limited in dealing with non-square domains as encountered in both microscale analysis and modeling of flow and cure phenomena at macroscale in complex molds.

To address these limitations, we leverage Graph Neural Networks (GNNs) to simulate the RTM process across multiple scales. By transforming numerical mesh data—where nodes and connectivity naturally map to graph vertices and edges—into a graph-based representation, we enable the model to handle variable domain sizes and complex topologies.

During the talk, we will detail the mesh-to-graph transformation, the GNN architecture, and performance benchmarks against conventional numerical solvers. We will then present the recent progress of our framework in terms of modeling the microscale flow behavior, as well as our latent models to accelerate these predictions, macroscale mold filling behavior, and the macroscale curing behavior with applications towards process optimization.