Mechanical & Industrial Engineering
UNIVERSITY OF TORONTO

MIE498H1: Research Thesis 2023-2024

Supervisor	Patrick Lee
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Number of Positions	1
Open to	Mechanical Engineering Students
Term Offered	Full-Year (Y)
Research Area	Applied Machine Learning
Research Topic	Polymer Microstructure Design and Foaming Optimization via Machine Learning (ML)

Project Description

Lightweight polymeric foams with desirable densities and mechanical properties are in great demand for numerous applications, such as food packaging, automotive, and construction. This study aims to achieve two primary objectives: (i) to establish structure-process-property relationships of next-generation foam resins using ML, specifically focusing on static batch foaming for preliminary study, and (ii) to explore the feasibility of the Foam Injection Molding (FIM) process using the same ML algorithm for industrial continuous process with more complex materials and process conditions. To begin with, a systematic approach based on the principles of design of experiments will be employed. This will involve conducting multi-stage characterizations, process optimizations, and structural analyses on a significant number of resin samples. Through this screening process, a selection of promising resin candidates will be identified. Subsequently, a combined theoretical and data-driven approach will be implemented, incorporating an analytical multi-bubble foam model method. This method will facilitate the prediction of bubble nucleation density and growth responses of foams for representative resin samples. To enhance the accuracy of the predictions, a transfer learning technique will be utilized. Initially, a deep neural network (DNN) will be trained using a large dataset of nucleation/growth curves generated by the analytical model. The pre-trained DNN will then be fine-tuned using a relatively smaller dataset derived from screening experiments. This step aims to achieve a target accuracy of 95% in predicting foaming behaviors. The successful completion of this research project will contribute to the development of lightweight polymeric foams with tailored properties for various applications. Furthermore, the utilization of machine learning techniques in foam resin design will enhance the efficiency and accuracy of the design process, potentially leading to significant advancements in the field.

Additional Information	N/A
Application Instructions	Please submit CV, unofficial transcript, to Prof. Patrick Lee (patricklee@mie.utoronto.ca)