Advanced Thermofluids Optimization, Modelling, and Simulation (ATOMS) Laboratory

Master of Engineering (MEng) Research Project

Title: Developing digital twins for battery thermal management systems

Motivation:

Electric vehicles (EVs) are expanding rapidly, enabled by significant technological advances in lithium-ion batteries (LIBs) and charging infrastructure. However, current LIB technology still falls behind consumer expectations due to concerns over battery lifetime, charging speeds, driving range, and safety. Further breakthrough advances in LIB performance and lifetime require ground-breaking thermo-electrical management strategies and the hierarchical integration of complex sub-systems during modelling, design, and operation of EVs, with intimate knowledge of the thermo-electrical phenomena occurring across multiple scales in the vehicle, to maximize their performance, minimize battery degradation, and enable fast-charging protocols under a wide range of environmental conditions.

Electric vehicle batteries must overcome thermal management challenges at multiple levels in the vehicle, from individual components (battery cells), to sub-systems (battery modules and packs), to systems (vehicle). This MEng research project will advance cell-to-vehicle hierarchical modelling methodologies that systematically integrate multiphysics computational simulations across multiple physical domains and length scales.

Objective:

Develop battery pack digital twins of industry-relevant battery systems using advanced battery modelling and simulation tools. Digital twin development activities will include embedded control algorithms custom designed to safely operate and manage heat removal from beginning-of-life (BOL), and degraded batteries, with context-dependent temperature set points that can be adjusted on-demand based on the battery state-of-charge (SOC), charge/discharge C-rate, and state-of-health (SOH).

Required Experience/Skills:

In-depth understanding of thermal transport phenomena and strong foundation in multiphysics computational modelling, simulation, model validation, and control algorithms. Experience with battery systems and battery testing equipment would be an asset.

To Apply:

Submit CV, unofficial transcripts, and one paragraph describing your interest in the project to Prof. Cristina Amon (cristina.amon@utoronto.ca)