Project Title - Microgravity thermofluids analysis and propellant management

Host University - University of Canterbury

Industrial Partner - Dawn Aerospace

Academic Supervisor(s)

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Project Description

Satellite propulsion systems that rely on phase-changing propellants in microgravity present a significant thermofluid modelling challenge. In particular, accurately predicting heat transfer, phase change (evaporation and condensation), and resulting pressure dynamics in low-gravity environments remains an open research problem. The absence of buoyancy-driven flow and hydrostatic settling fundamentally alters fluid behaviour, limiting the applicability of Earth-based experimental validation and making high-fidelity numerical modelling essential.

This PhD project will address these challenges by developing and validating advanced thermofluids models for saturated propellant systems operating in microgravity. The research will focus on capturing the coupled effects of heat transfer, phase transitions, and transient fluid dynamics within propulsion systems. A key aim is to improve predictive capability for vapor quality, pressure evolution, and overall system response under realistic operational conditions.

The project will involve the development of computational fluid dynamics (CFD) models capable of resolving complex, multi-physics phenomena, including non-Earth gravity conditions, evaporation and condensation processes, and system-level transience. A particular emphasis will be placed on identifying efficient modelling approaches that balance computational cost with physical accuracy. The research will also explore sensitivity and optimisation of critical parameters such as surface roughness, slosh dynamics, and localised thermal effects.

A central challenge of this work is validation. Due to the difficulty and cost of replicating microgravity conditions on Earth, the project will investigate novel validation strategies that combine numerical results with available experimental and operational data. This includes leveraging in-orbit data and payload experiments to assess model predictions and refine simulation approaches.

The research is closely aligned with the needs of Dawn Aerospace, whose propulsion systems utilise saturated vapour propellants such as nitrous oxide and propene. These propellants enable pressure fed operation through thermal control, eliminating the need for separate pressurant systems and reducing hardware complexity. Improved modelling capability will directly support the design and optimisation of such systems by enhancing understanding of propellant behaviour, enabling more precise control of thrust and impulse, and reducing design uncertainty.

Ultimately, the outcomes of this project have the potential to advance both fundamental understanding of thermofluid behaviour in microgravity and practical propulsion system design. For Dawn Aerospace, this could translate into improved system performance, greater operational flexibility, and enhanced service offerings for satellite customers.

Objectives

1. Development of efficient thermofluid modelling frameworks for saturated propellant systems in microgravity

2. Improved predictive modelling of evaporation and condensation processes under low-gravity conditions

3. Validation of numerical models using experimental data, including in-orbit measurements or payload experiments

4. Sensitivity analysis and optimisation of key parameters influencing system performance

If successful, the framework developed in this research could be extended to actively optimise phase change processes within propulsion systems, enabling enhanced control of propellant delivery and overall system efficiency.

Student Time Split

University base for student (university, campus, department):

University of Canterbury, Department of Mechanical Engineering

Industry base for student (company, site, address):

Dawn Aerospace, 14 Birmingham Drive, Middleton, Christchurch

Expected Time Split Between University and Industry Partner (in months):

Time with Industrial Partner (months): 24 months; Time with Academic Partner (months): 12 months

Rationale for Time Split:

Dawn Aerospace and the University of Canterbury are both located within 10mins distance of each other, ensuring close contact and support of the PhD candidate, by supervisors from Dawn and UC. This project involves both theory and hands-on engineering. Dawn Aerospace provides extensive hardware, test capabilities, and leaders with strong field knowledge to support the student in validating the project findings. Leveraging UC's theory strength and analysis/validation capabilities is expected to be useful for the more generalized aspects.

We expect the project to begin with a primary start at UC, becoming more involved at Dawn's workplace, before giving the student space to write up their results at the end wherever suits them best. The close location makes it possible to spend time across both locations, seamlessly.

Application

To apply for this project please first read the guidance document and then complete the application form on the Applied Doctorates Scheme website.