MSc Thesis proposal Volvo Group Truck Technology:

Modelling cooling systems and thermal management of heavy vehicles in Modelica

About us

Advanced Engineering & Vehicle Concepts is organized within Vehicle Engineering at Volvo Group Trucks Technology. We are responsible of preparing future trucks and transport solutions for all Volvo Group's brands and markets by managing and driving Advanced Engineering at Vehicle Engineering & Vehicle Technology. We develop the future competitive trucks to ensure the transport and energy efficiency for our customers and the society. We are open-minded and performance-oriented and honour to deliver tangible results.

Thesis Background

Environmental issues, consumers' expectations and the growing demand for freight transport have created a competitive environment in providing better transportation solutions. Conceptual and optimization-based vehicle design using mathematical models help finding cost- and energy-efficient solutions and eventually faster market adaptation. Therefore, mathematical models with acceptable levels of fidelity must be developed to facilitate the conceptual design and performing optimization for the given application, for example, to understand what vehicle components are suitable for US transport fleet market and how they are different from Asia and Europe applications.

Modelica language offers modular physical modelling. It is tool-independent and there are many open-source libraries which make building models with different levels of fidelity possible. In addition, models are open, so that the mathematical equations are visible to users, providing a good autonomy for updating the existing libraries and developing new models.

Problem motivating the project

Most of the existing mathematical models of cooling systems are not modular and the level of fidelity of the models cannot be changed in a straightforward way. However, those properties of the mathematical model (modularity and flexible change of fidelity) are necessary for vehicle conceptual design and optimization for different design targets, applications, optimization cost and constraints. The developed cooling system models should be easily replaceable within the overall vehicle model so that their performance and cost can be assessed and compared. In an optimization framework for sizing the components, the fidelity of models must be as lowest as possible and yet maintain the important physical behaviour, which is validated using high fidelity models or/and experimental data.

Envisioned solution

The envision solution is mathematical models in Modelica that can be used to simulate and compare the performance of overall vehicle cooling systems and thermal management, their control and their energy usage. The models should be modular, i.e., it should be possible to change a low fidelity cooling system model with a high fidelity one within the complete vehicle model to capture the physical phenomena needed for the given application. Developing the complete vehicle model is not part of the thesis.

Objective or Research Question

How to model the different cooling systems and thermal management for, e.g., cabin, batteries, engine, etc, in Modelica with the purpose of component sizing and cost and energy usage evaluation?

What are the important phenomena and physical behaviours that change or cannot be captured by altering the model fidelity?

Deliverables (flexible)

- Mathematical models with different levels of fidelity of heavy vehicle cooling systems in Modelica, and if possible, using available open-source libraries. The types of vehicles include diesel, battery-electric and fuel-cell-electric.
- The Modelica model should be automatically parameterized reading a model-independent vehicle parameter file.
- Making the comparison of the simulation results with other available tools as well as the available real-world test data, both in terms of energy consumption and performance.
- Some of the models should be exported as functional mock-up units to another environment (such as Matlab or Python) and re-parametrization and change of model fidelity should be tested in the new environment.

Requirement on student background:

Talented master students in Automotive, Mechanics, Mechatronics or Engineering Physics, with some knowledge of Modelica and programming. Please submit your CV and transcripts.

Supervision and examination:

Volvo Group Truck Technology, Advanced Vehicle Engineering.

Chalmers University of Technology

Thesis Level: Master

Language: English

Starting date: January 2022

Number of students: 1 or 2

Physical location:

Mainly a university in Sweden, but students are welcome to sit also at VGTT occasionally.

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