

**Joint PhD position** at Université de Sherbrooke\* and INSA Lyon\*\*

*CFD modeling of the thermal energy storage for the transport of frozen food products*

Context: Food transport, including motive power and refrigeration, is estimated to be responsible for around 2% of total greenhouse gas emissions in developed countries [1]. Road transport refrigeration equipments need to operate reliably in harsher environments compared to stationary equipments. Legislations exist and provide common standards for temperature-controlled transport vehicles and tests to be done on such equipments for certification purposes [2]. Constraints due to available space, noise and weight make also them less efficient than stationary systems. For road transport vehicles, different types of refrigeration units exist depending mainly on the size of the vehicle and its load: vapour compression systems with a vehicle or an auxiliary alternator unit, a direct belt drive or an auxiliary diesel unit. The majority of medium to large vehicles use refrigeration units that include a self-contained diesel engine. Running at full capacity to guarantee  $-20^{\circ}\text{C}$  within the trailer, the fuel consumption of this unit is up to 5 liters per hour. To overcome that, eutectic systems have been developed and used in prototype vehicles in Canada. They consist of tubes, beams or plates filled with a phase change material to store energy and produce a cooling effect. They are charged at night and they operate silently during the day for a specific duration of time. Such systems may be suitable for small deliveries where the heat loss through frequent door openings can be a major concern. The heat and mass transfers inside a refrigerated chamber exhibit some similarities with the truck trailer configuration [3-5]. To the best of our knowledge, only Tso et al. [6], and more recently Lafaye de Micheaux et al. [7], investigated the velocity and temperature distributions in a truck trailer with different door openings but without any refrigeration system. The model developed by Benchikh Lehocine et al. [8,9] was the first to include eutectic plates and fans within the trailer.

Objectives: A reliable refrigeration system based on eutectic material integrated in truck trailers for food transport does not exist yet. The major problem stems from the multiple door openings that occur for loading or unloading during a typical working day. In humid countries (like in Québec during summer), humid air enters the trailer. It induces condensation, creating ice on the plates' surface, which then blocks heat transfer between the eutectic plates and the air within the trailer. The main objective of this project is to design a reliable refrigeration system based on eutectic materials able to operate under different loads and for different transport temperature requirements. The specific objective is the extension of the CFD model developed by Benchikh Lehocine et al. [8,9] to test different technical solutions (design and location of the plates, fans, addition of an air curtain) for realistic operating conditions (heat losses, loads, ambient conditions). The choice of both the appropriate eutectic mixture and the design of the plates (addition of a metal foam, specific coating to prevent ice formation) depending on the required transport temperature is still an open question in the literature, as well as the influence of different loads on the temperature distribution within the trailer. These two parameters will be considered to propose a system applicable for a multi-compartment trailer.

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**Methodology:** An advanced 3D numerical model has already been developed and validated using ANSYS Fluent [8,9]. It accounts for the conjugated heat and mass transfer inside a refrigerated truck trailer with an innovative way to model fans by imposing a source term in the momentum equations. Some numerical developments are however still required: addition of thermal losses through the trailer walls, temperature- and humidity-dependent properties of air, simulation of different loads, integration of an air curtain at the opening back door. The main development will concern the modeling of the eutectic mixture fusion within the plates. This is indeed of prime importance to obtain realistic unsteady results over an entire working day. The model will be developed using OpenFOAM, a free access software, to make the technological transfer to the partners easier and the calculations will be performed using the Compute Canada facilities.

**Required skills:** Master in mechanical engineering or in a related field. A good knowledge in fluid mechanics and heat transfer is required. Knowledge in numerical methods and a first significant experience in Computational Fluid Dynamics using one of the following softwares, ANSYS Fluent/CFX or ideally OpenFOAM, would be appreciated. **Canadians, Frenchs and permanent residents of Canada will be given priority. Applications must meet diversity and equity objectives.**

**Institution:** This is a joint PhD position. Thus the two workplaces are (i) the faculty of mechanical engineering at Université de Sherbrooke (Québec, Canada) with a strong collaboration with Laboratoire des Technologies de l'Énergie (Hydro-Québec, Shawinigan) and Emerson Canada and (ii) CETHIL (UMR 5008, INSA Lyon). Good salary (**net funding of 23000\$ per year**) and working conditions are offered. The suitable starting date for this position is winter 2020. Interested candidates are encouraged to contact: Professors Sébastien Poncet ([sebastien.poncet@USherbrooke.ca](mailto:sebastien.poncet@USherbrooke.ca)) and Jocelyn Bonjour ([jocelyn.bonjour@insa-lyon.fr](mailto:jocelyn.bonjour@insa-lyon.fr)).

## References

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