Modelling and Numerical Simulation of Thermosyphon with LBM with focus on Phase Change Phenomena

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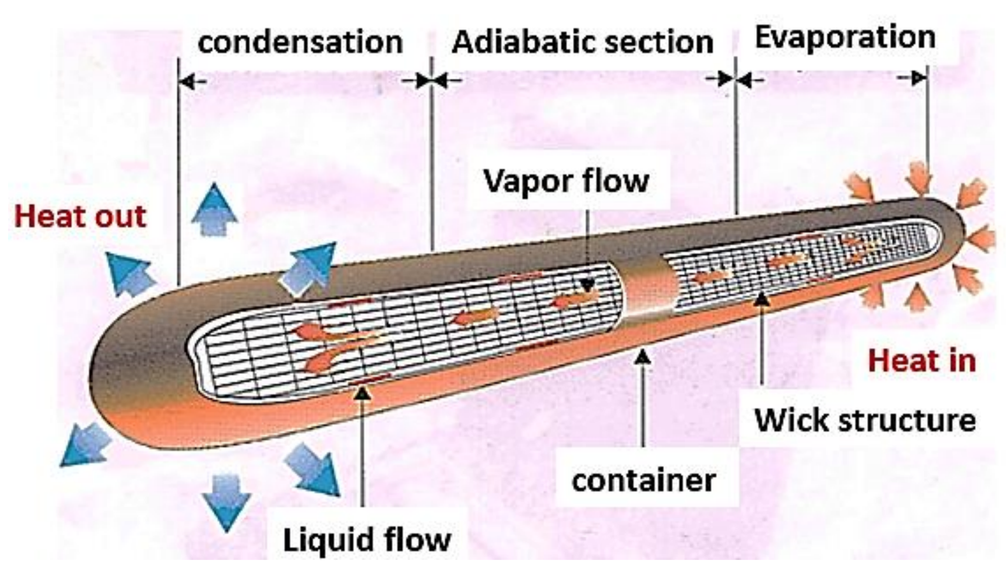
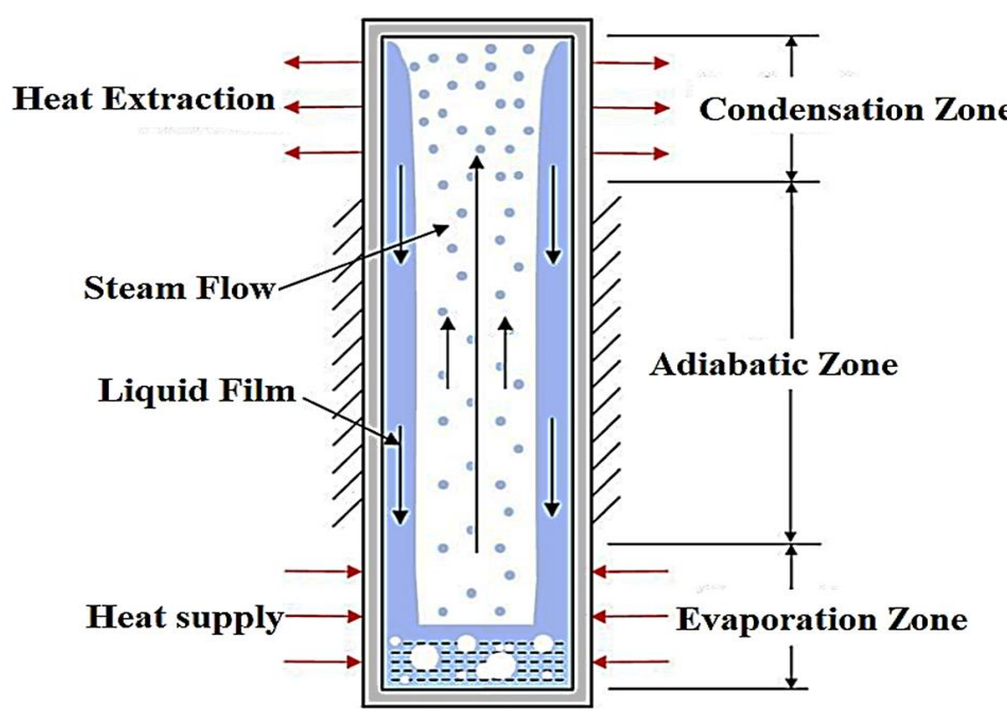
Introduction

Heat loss and recovery limit the development of energy systems, and today's industry needs systems with more heat capacity in a volume. Heat pipes are heat transfer devices with high thermal conductivity and the capacity to carry a substantial quantity of heat over long distances.



Thermosyphon

These tools consist of an evaporator, an adiabatic section, and a condenser section. In the evaporation section, heat is absorbed, so the fluid boils and converts to vapor and then moves to another part of the pipe. Heat exits from the condenser section of the cylinder due to condensation. The vapor converts to the liquid phase. Because of gravity, this liquid returns to the evaporation part and continues this cycle.

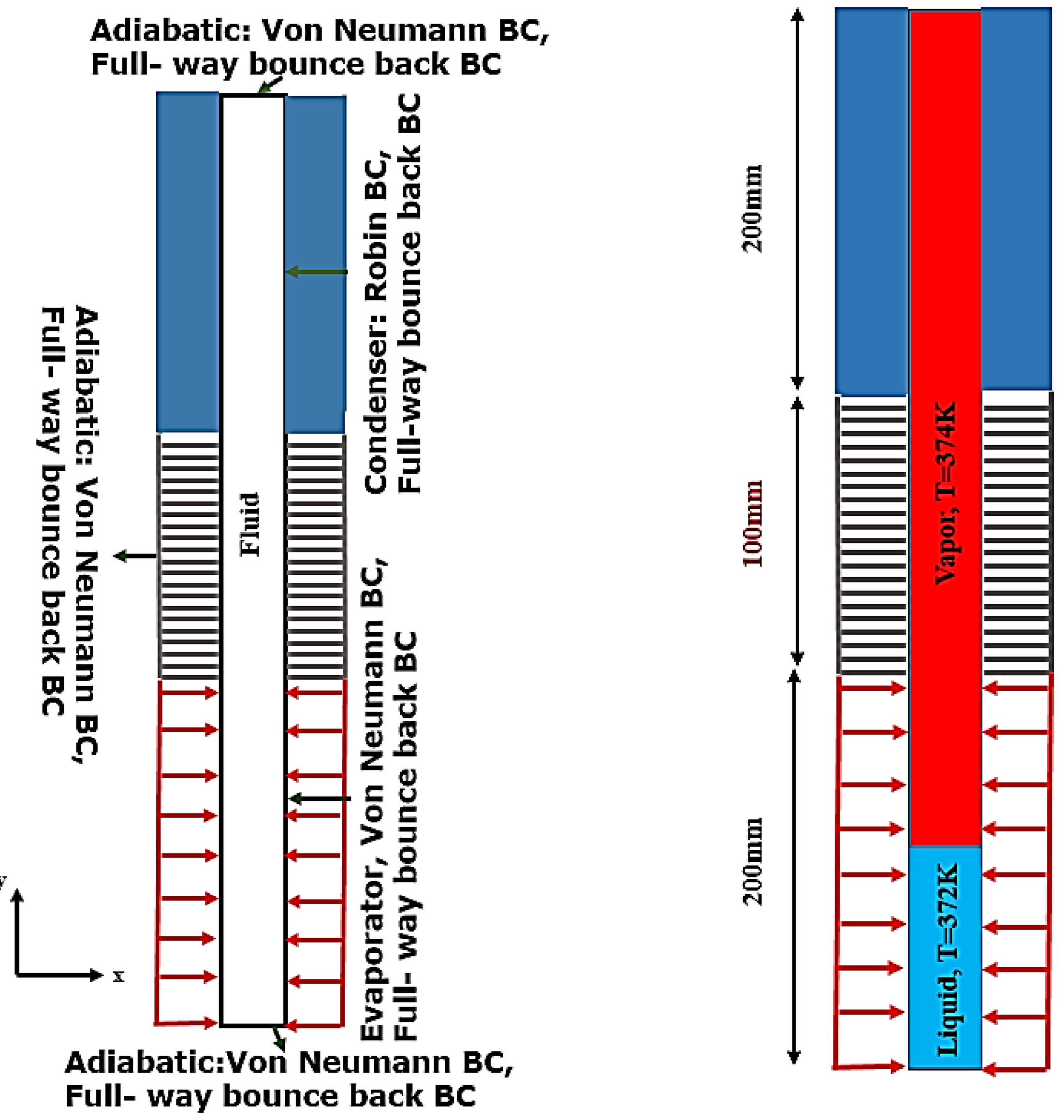


Objectives

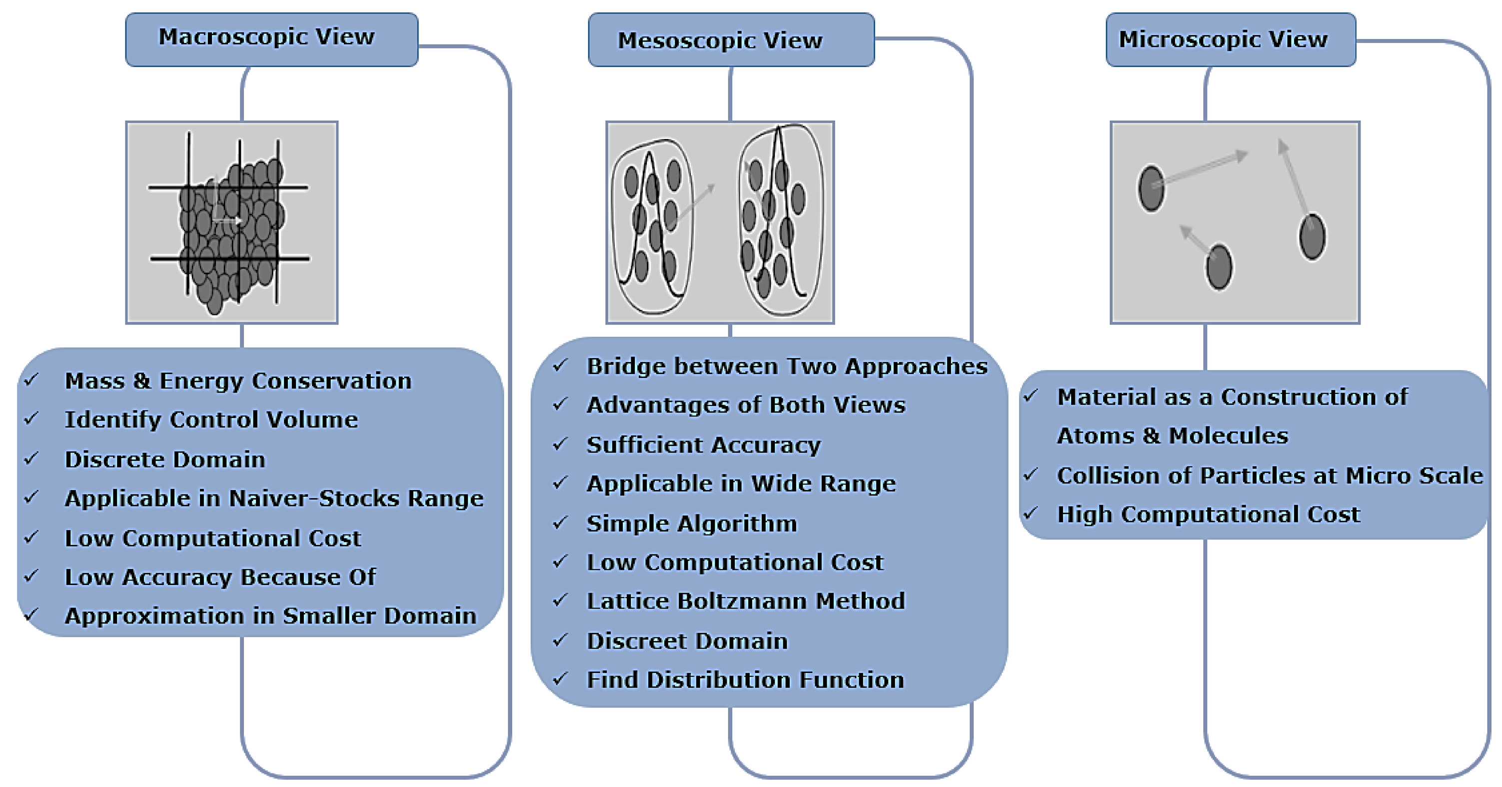
The most significant part is the numerical simulation of the evaporator and condenser phase change. Then the effect of these parameters on the thermal resistance will be investigated:

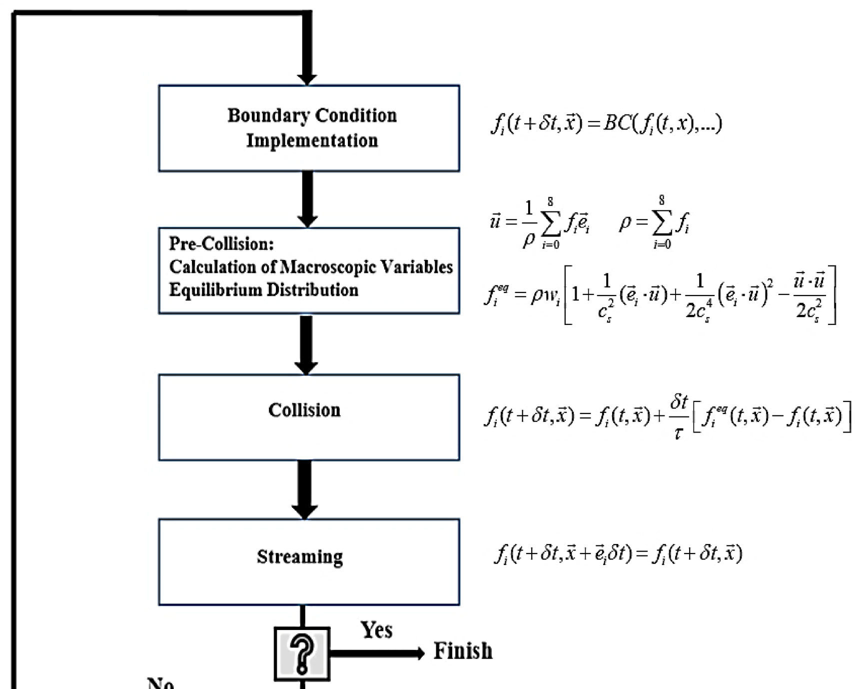
- ✓ Heat input
- ✓ Fill ratio
- ✓ Aspect ratio
- ✓ Working fluid

Simplified mathematical model



Methodology

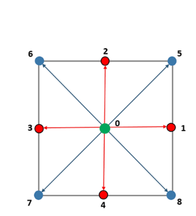




The implementation:

Basic LBM + Lee's Method + Energy Equation + Safari's Method

Lee Method	Two distribution functions: h_i → to calculate composition factor; g_i → to calculate pressure and velocity
Energy equation	One distribution function s_i to calculate temperature.
Safari Method	Phase change source term: $\dot{m}''' = \frac{K\Delta T}{h_{fg}} \cdot \nabla C$



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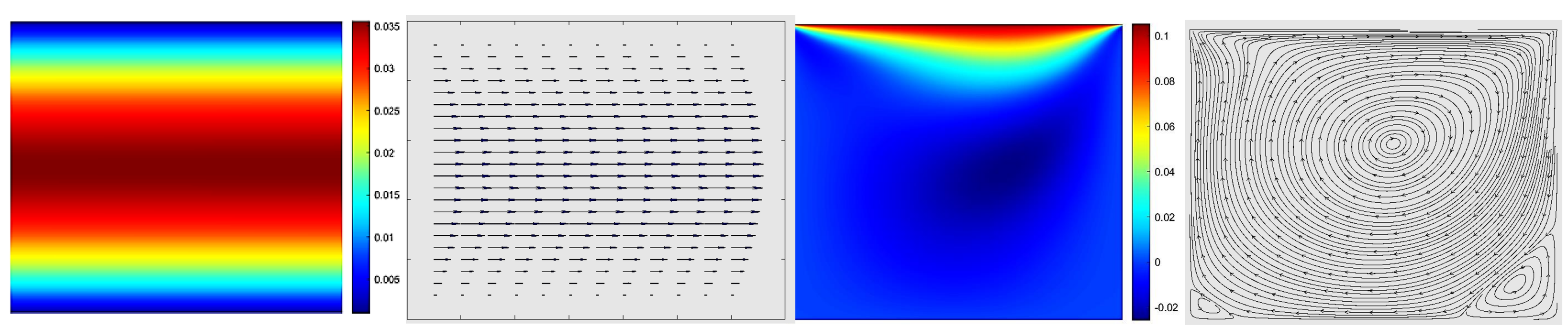
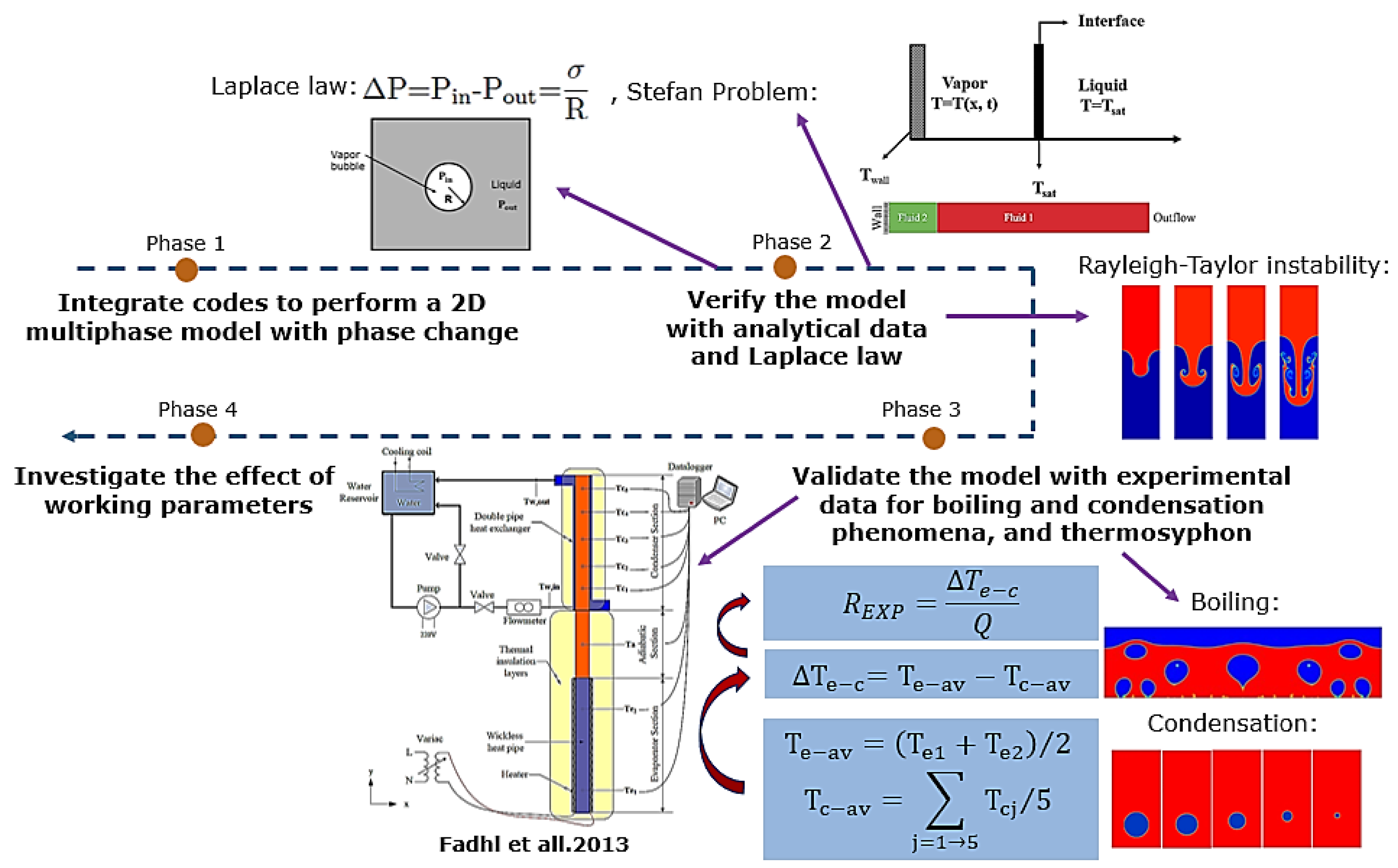
Preliminary Tests

Poiseuille Channel Flow — Lid-driven Cavity Flow



Future Works



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Nomenclature

- f_i: distribution function
- t: Time
- δt: discrete time step
- $\vec{x}$: position
- $\vec{u}$: macroscopic fluid velocity
- ρ: macroscopic fluid density
- $\vec{e_i}$: microscopic velocity
- f_i^{eq}: equilibrium distribution function
- w_i: weighting factors
- c_s: lattice speed of sound
- τ: relaxation time
- T: temperature

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CRSNG NSERC — FONCER — compute • calcul CANADA — Calcul Québec