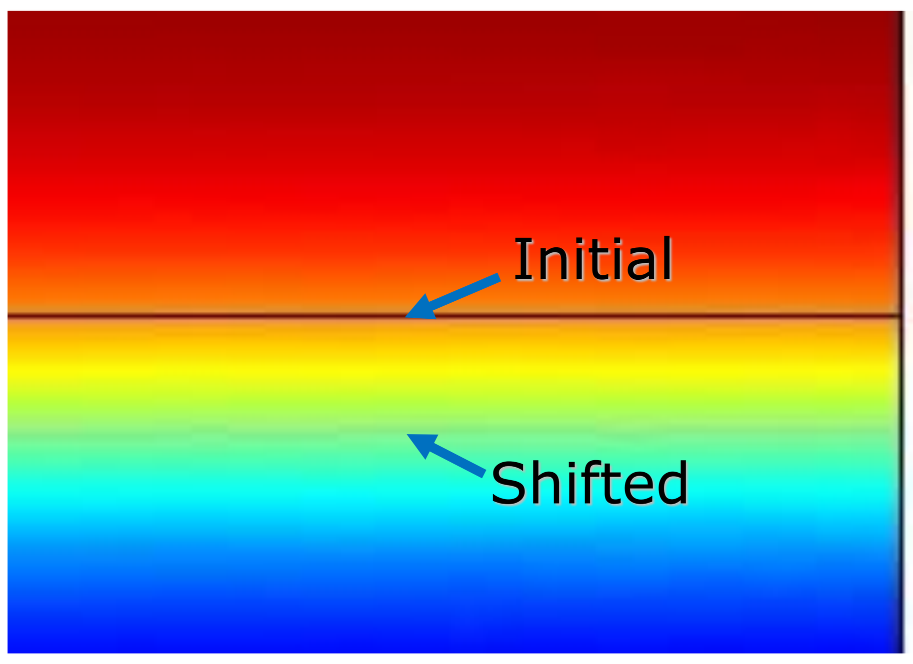
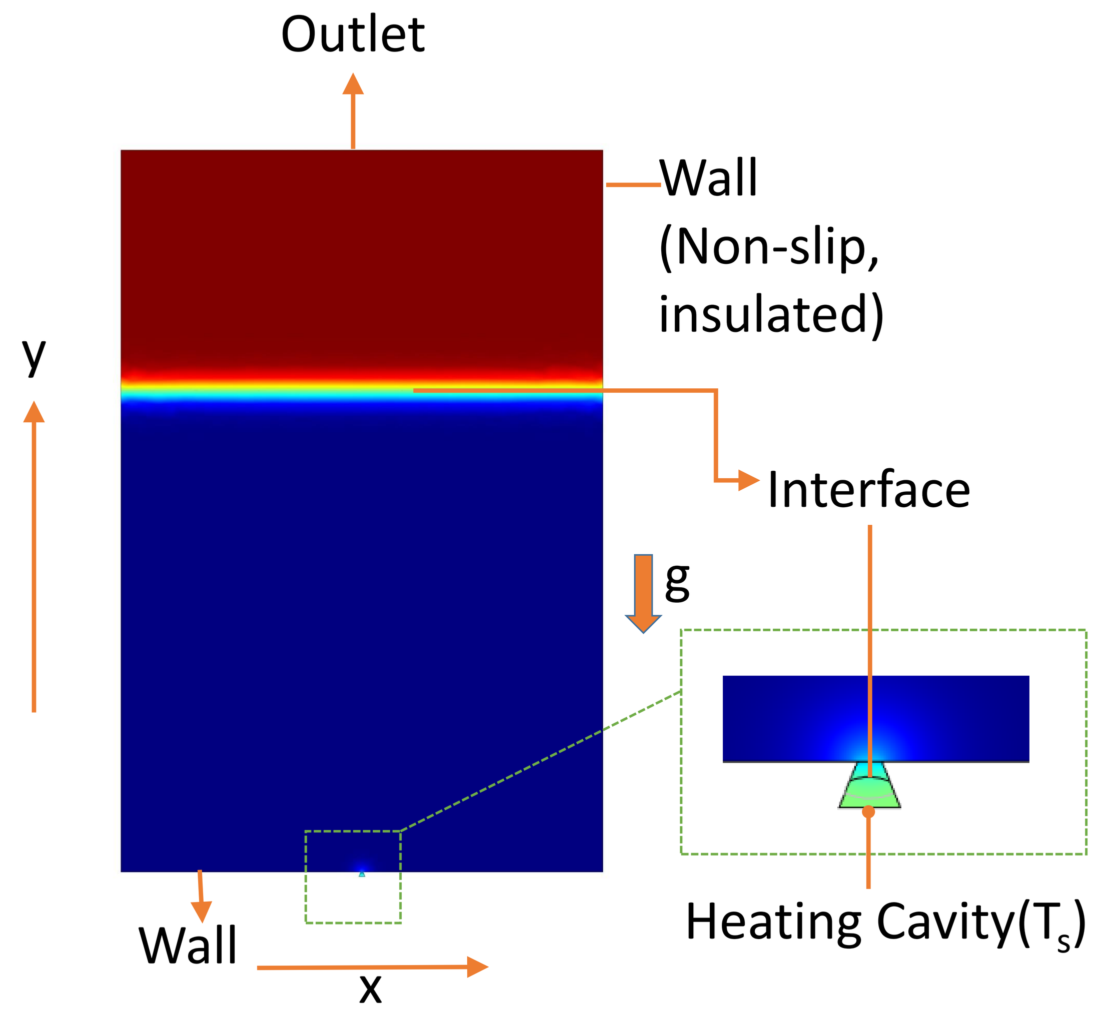
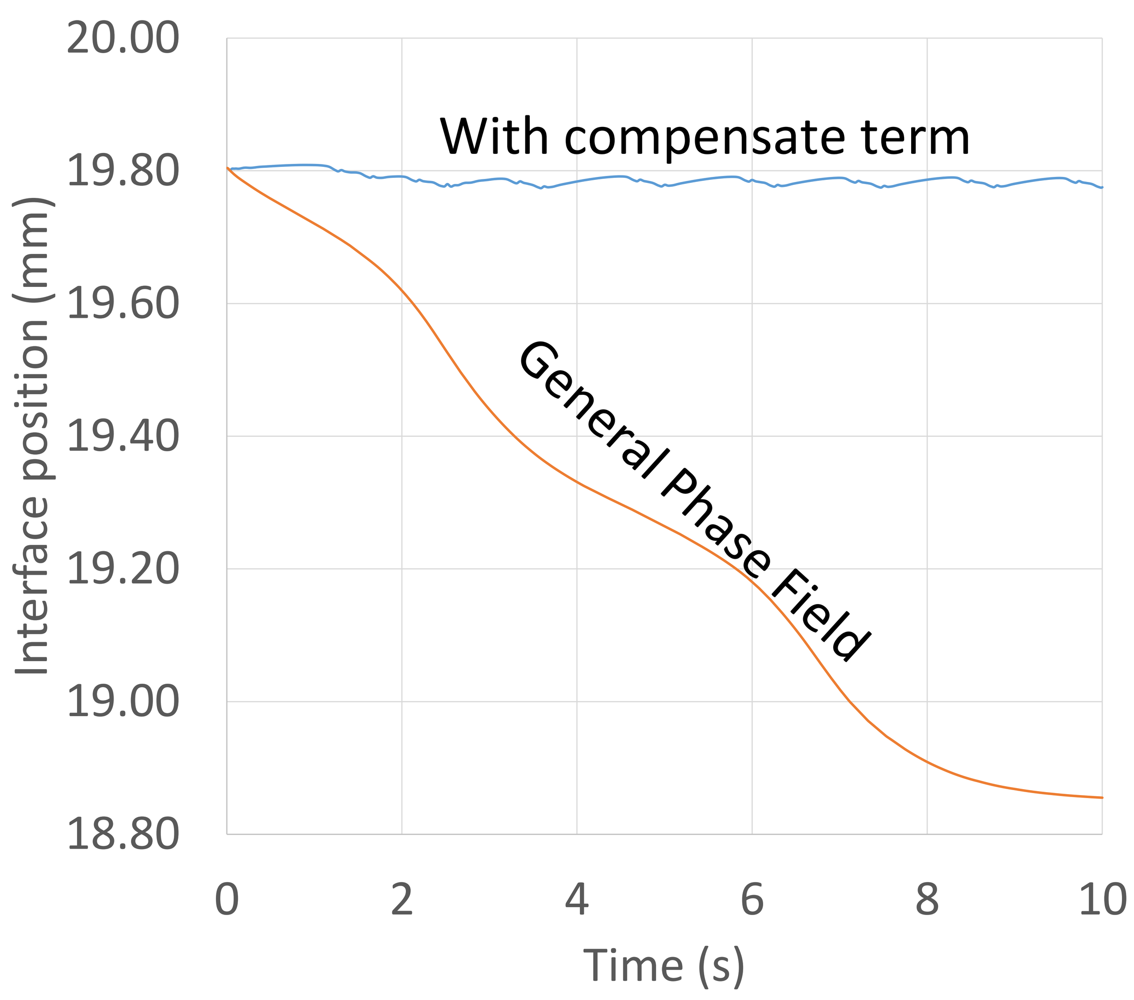
MODIFIED MODEL OF HEAT & MASS TRANSFER PHASE CHANGE WITH HIGH DENSITY RATIO



Initial (black line) & shifted (light grey) interface even without phase change (Figure 1)



Physical model (Figure 2)



Interface position comparison over 10s (Figure 3)

Background:

In **two phase fluid problem** which involve **phase change**, the **location of interface** is **over-shifted** if the two immiscible fluid have **high density ratio**. By using general phase field model, the issue emerged with inaccurate location of moving interface with time (Figure 1).

Objectives:

Recover interface position & stabilize numerical estimation

Methodology:

Laminar Two phase flow, phase field is used in the simulation model. Governing equation of phase field model is based on Cahn-Hilliard equation [1]:

$$\frac{\partial \emptyset}{\partial t} + u \cdot \nabla \emptyset = \nabla \cdot \frac{\gamma \lambda}{\varepsilon^2} \nabla \varphi$$

$$\varphi = -\nabla \cdot \varepsilon^2 \nabla \emptyset + (\emptyset^2 - 1)\emptyset + \underbrace{\frac{\varepsilon^2}{\lambda} \frac{\partial f_{ext}}{\partial \emptyset}}_{\text{External free energy}}$$

In this work, condition of **no phase change** is first be investigated. Phase field model is modified to limit the free energy to compensate the large properties variation by introducing a derived **Compensate term**:

$$\frac{\partial f_{ext}}{\partial \emptyset} = -C \frac{u_y \emptyset}{\gamma}$$

Where C is a constant; u_y is the y-direction velocity; $\emptyset$ is phase field variable; γ is mobility.

Findings & Achievements:

The shifting is investigated to be due to **over estimation of velocity field** whenever there's large density gradient at the interface. This error is then translated to the change of phase field variable and result in change in interface position. Figure 3 shows that derived **compensate term is able to negate this effect** and recover the interface position for **density ratio of 50,000**.

Initial temperature, T_o	Tsat [K]
Inward temperature, T_s	Tsat + 10 [K]
Density ratio, ρ_1/ρ_2	50,000

Parameter used in model (Table 1)

Conclusions:

When density ratio of two phase fluid is high, velocity field is over-estimated in general phase field model which result in instable interface position captured over time. This effect can be negated by introducing compensate term derived in this study. The future work is to **incorporate this term into phase change study** that **involve high density ratio**.

Reference:

[1] Cahn, J. W. & Hilliard, J. E. 1958 Free energy of a nonuniform system. I. Interfacial free energy. J. Chem. Phys. 28, 258–267.

[2] P. Yue, J.J. Feng, C. Liu, J. Shen, A diffuse-interface method for simulating two-phase flows of complex fluids, J. Fluid Mech. 515. (2004) 293–317.

[3] COMSOL CFD User Guide

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Project Partners:

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