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Thermocapillary flow in small rectangular cavity

Objective

The objective of this test is to test the surface tension force in both the normal and tangential direction. This test will also test the static contact angle model.

Definition

We consider a small aspect ratio (A=h/L=0.2 between the liquid height h and the cavity length L) cavity in 2D for which Sen and Davis [1] have obtained accurate steady-state solutions using asymptotic theory. The characteristic nondimensional numbers are:

the Reynolds number $\mathrm{Re} = \left(\rho|\gamma|\Delta T\,\mathrm{h}\right)/\mu^2$,

the Prandtl number $\mathrm{Pr} = \mu/\left(\rho\alpha\right)$,

the Marangoni number $\mathrm{Ma} = \left(|\gamma|\Delta T\,\mathrm{h}\right)/\left(\mu\alpha\right) = \mathrm{Re}\cdot\mathrm{Pr}$,

the Capillary number: $\mathrm{Ca} = \left(|\gamma|\Delta T\right)/\sigma_{ref}$,

where α is the thermal diffusivity and ΔT=(T_H - T_C).

The nondimensional numbers are for this case Ca=0.008, Ma=0.2, Re=1, and Pr=0.2.We assume a Neumann (insulated) condition for temperature at the free surface. We assume the static contact angle is 90°. The computational domain is [0,1] x [0,0.3] x [0,0.02] and the mesh is 50x16x1. The interface is initially flat at y=0.2.

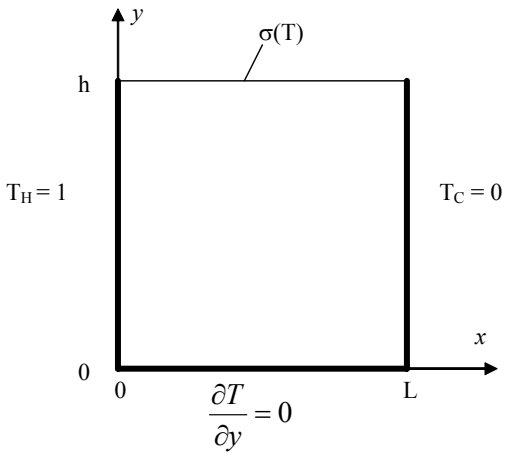

Figure 1. Thermocapillary cavity flow geometry and temperature boundary conditions.

We will run the simulations for a few time cycles from a restart file (that is close to steady state) in order to verify the results with the steady state asymptotic solution.

Metrics

We will compare the interface position with the results of Sen and Davis (Eq.5.3 of their paper). In particular we will check the interface position on the cold and hot wall. This will require to find the vof=1/2 contour or output the interface planes.

We will also verify the maximum and minimum velocity in the domain against the golden outputs.

Truchas Model

We will consider different static contact angle conditions (60° and 100°).

Results

This section will contain a description of the results of Truchas simulations, and evaluation of the metrics described above. Any description of the computational resources needed for the simulation (including parallel issues) should be included here.

Critique

This section will discuss the conclusions from the results section above. It will contain recommendations for further development (if needed), comparisons with other tools (if available), and any general discussion of what was learned from performing the simulations.

References

[1] Sen A.K., Davis S.H., Steady thermocapillary flows in two-dimensional slots, *Journal of Fluid Mechanics*, Vol. 121, pp. 163-186, 1982.