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Weakly Nonlinear Computational Analysis on Viscous Fingering in Tapered Hele-Shaw Cells DAIHUI LU, IVAN CHRISTOV, Purdue Univ — We present a theoretical and numerical study on the stability of immiscible viscous fingering in tapered Hele-Shaw cells across a range of capillary numbers (Ca), which measure the relative significance of the fluid's viscous forces to the interface's surface tension. The simulations are carried out using the InterFoam solver in the OpenFOAM, which solves the incompressible Navier-Stokes equations in each fluid, and couples the two through interfacial boundary conditions. We consider two cells: a diverging cell with a depth gradient $\alpha = 3 \times 10^{-3}$ and a converging cell with $\alpha = -1.5 \times 10^{-3}$. We find in the diverging case the finger's growth rate is always positive. However, in the converging case there are three regimes depending on Ca. For small Ca, the growth rate is negative, which stabilizes the finger; for moderate Ca, the growth rate is negative first and then positive; for large Ca, the growth rate is positive. We explain this change through a local Ca, which is increasing along the flow direction in a converging cell. We also find in the high-Ca regimes, the interface is relatively destabilized in the converging cell and stabilized in the diverging cell. We compare our simulations to recent experiments in the literature.

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