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Stability of the interface between two immiscible liquids during injection into a tapered Hele-Shaw cell

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ABSTRACT

In the early twentieth century, petroleum and mining engineers noticed that water does not displace oil uniformly. This phenomenon, when water penetrates through oil, is now known as viscous fingering. This discovery and the following extensive research have contributed to enhancing oil recovery. In this paper, we describe a numerical study conducted on the stability of the interface between two immiscible liquids in converging and diverging Hele-Shaw cells with varying gradients. Hele-Shaw cells are narrow flow geometries that mimic the properties of a porous medium with fixed permeability. By using computational tools built on the OpenFOAM platform, the multiphase flow dynamics can be accurately resolved and observed at small scales. The flow is computed in several designed tapered cell, which emulate natural heterogeneity in an actual porous medium. By analyzing the finger length under the same time period in both parallel cells and tapered cells, we found that the diverging cell relatively decreases the growth compared with the converging cell. Our primary conclusion, confirming previous theoretical predictions, is that the gradient of the tapered geometry variation has an effect on the sign of interfacial growth rate, which means the interface could be destabilized or stabilized depending on the absolute value of the gradient.

KEYWORDS

Viscous fingering, multiphase flow, Hele-Shaw cell, interfacial instabilities, variable flow geometry