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Universality in Viscous Fluid Spreading and Leveling

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ABSTRACT

Multiphase fluid flows, or flows where the dynamics of an interface between unlike fluids can be observed, require study to further understand the fundamental relationships of the fluids' properties and their dynamics in multiple applications. The scope of this research project pertains to low Reynolds number flow, a dense fluid spreading through a less dense ambient fluid, with the spreading fluid movement being driven by gravitational buoyancy forces and density differences. The primary investigation involves studying the spreading and leveling of such fluids in shaped geometries, such as subsurface fractures. The objective is to determine the effect of a wide variety of crack geometries on these flows, both in its spreading and leveling phases, or pre and post "closure," respectively. The methods involve understanding the basic governing partial differential equation, the transformation to an ordinary differential equation with the use of a self-similarity variable and requisite, rescaling, and verification of these mathematical predictions through direct simulation of the PDE in MATLAB. Self-similar behavior physically means "universality" holds across all fluid types and fracture geometries, and such behavior can be observed for a variety of crack widths and geometries. We verify the spreading and leveling relationships of viscous fluid flows (determined mathematically using the theory of self-similarity), and further compare these to previous experiments. Future research interests include study of particulate viscous flow in its spreading and leveling phases, the final distribution of particles in the flow, and the effect of varying crack geometries on these flows.

KEYWORDS

Modelling & simulation, environment, flow analysis & processing