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Investigating the Motion of a Viscous Droplet in Natural Convection Using the Level Set Method

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Abstract : Binary fluids and emulsions, in general, are present in a vast range of industrial, medical, and scientific applications, showing complex behaviors responsible for defining the flow dynamics and the system operation. However, the literature describing those highlighted fluids in non-isothermal models is currently still limited. The present work brings a detailed investigation on droplet migration due to natural convection in square enclosure, aiming to clarify the effects of drop viscosity on the flow dynamics by showing how distinct viscosity ratios (droplet/ambient fluid) influence the drop motion and the final movement pattern kept on stationary regimes. The analysis was taken by observing distinct combinations of Rayleigh number, drop initial position, and viscosity ratios. The Navier-Stokes and Energy equations were solved considering the Boussinesq approximation in a laminar flow using the finite differences method combined with the Level Set method for binary flow solution. Previous results collected by the authors showed that the Rayleigh number and the drop initial position affect drastically the motion pattern of the droplet. For $Ra \geq 10^4$, two very marked behaviors were observed accordingly with the initial position: the drop can travel either a helical path towards the center or a cyclic circular path resulting in a closed cycle on the stationary regime. The variation of viscosity ratio showed a significant alteration of pattern, exposing a large influence on the droplet path, capable of modifying the flow's behavior. Analyses on viscosity effects on the flow's unsteady Nusselt number were also performed. Among the relevant contributions proposed in this work is the potential use of the flow initial conditions as a mechanism to control the droplet migration inside the enclosure.

Keywords : binary fluids, droplet motion, level set method, natural convection, viscosity
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