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Prandtl Number Influence Analysis on Droplet Migration in Natural Convection Flow Using the Level Set Method

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Abstract : Multiphase flows have currently been placed as a key solution for technological advances in energy and thermal sciences. The comprehension of droplet motion and behavior on non-isothermal flows is, however, rather limited. The present work consists of an investigation of a 2D droplet migration on natural convection inside a square enclosure with differentially heated walls. The investigation in question concerns the effects on drop motion of imposing different combinations of Prandtl and Rayleigh numbers while defining the drop on distinct initial positions. The finite differences method was used to compute the Navier-Stokes and energy equations for a laminar flow, considering the Boussinesq approximation. Also, a high order level set method was applied to simulate the two-phase flow. A previous analysis developed by the authors had shown that for fixed values of Rayleigh and Prandtl, the variation of the droplet initial position at the beginning of the simulation delivered different patterns of motion, in which for $Ra \geq 10^4$ the droplet presents two very specific behaviors: it can travel through a helical path towards the center or define cyclic circular paths resulting in closed paths when reaching the stationary regime. Now, when varying the Prandtl number for different Rayleigh regimes, it was observed that this particular parameter also affects the migration of the droplet, altering the motion patterns as its value is increased. On higher Prandtl values, the drop performs wider paths with larger amplitudes, traveling closer to the walls and taking longer time periods to finally reach the stationary regime. It is important to highlight that drastic drop behavior changes on the stationary regime were not yet observed, but the path traveled from the begging of the simulation until the stationary regime was significantly altered, resulting in distinct turning over frequencies. The flow's unsteady Nusselt number is also registered for each case studied, enabling a discussion on the overall effects on heat transfer variations.

Keywords : droplet migration, level set method, multiphase flow, natural convection in enclosure, Prandtl number
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