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Numerical Study on the Effect of Liquid Viscosity on Gas Wall and Interfacial Shear Stress in a Horizontal Two-Phase Pipe Flow

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Abstract : In this study, the calculation methods for interfacial and gas wall shear stress in two-phase flow over a stationary liquid surface with dissimilar liquid viscosities within a horizontal pipe are explored. The research focuses on understanding the behavior of gas and liquid phases as they interact in confined pipe geometries, with liquid-water and kerosene serving as the stationary surfaces. To achieve accurate modelling of flow variables such as pressure drop, liquid holdup, and shear stresses in such flow configurations, a 3D pipe model is developed for Computational Fluid Dynamics (CFD) simulation. This model simulates fully developed gas flow over a stationary liquid surface within a 2.2-liter reservoir of 6.25 meters length and 0.05 meters pipe diameter. The pipe geometry is specifically configured based on the experimental setup used by Newton et al [23]. The simulations employ the Volume of Fluid (VOF) model to track the gas-liquid interface in the two-phase domain. Additionally, the k-ω Shear Stress Transport (SST) turbulence model is used to address turbulence effects in the flow field. The governing equations are solved using the Pressure-Implicit with Splitting of Operators (PISO) algorithm. The model is validated by calculating liquid heights, gas wall, and interfacial shear stresses and comparing them against experimental data for both water and kerosene. Notably, the proposed interfacial friction factor correlation based on the employed pipe model aligns excellently with experimental data using the conventional two-phase flow calculation method. However, it is observed that the interfacial and gas wall shear stresses calculated from mathematical formulations involving hydrostatic force exhibit poor correlation with the experimental data.

Keywords : Two-Phase Flow, Horizontal Pipe, VOF Model, k-ω SST Model, Stationary Liquid Surface, Gas Wall and Interfacial Shear Stresses and Hydrostatic Force.
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