Abstract

Liquid-liquid flow finds a number of applications in chemical petrochemical, food and pharmaceutical industries. In addition, there is a growing interest to transport heavy crude by utilizing a particular distribution of oil and water known as core annular flow. Despite the increasing applications, the literature on liquid-liquid flow is relatively scarce and the present work attempts to investigate the physics of flow through extensive experimentation and numerical analysis.

The experiments have been performed on liquid-liquid downflow through a vertical tube as well as through pipe fittings namely expansion, contraction and return bend of different geometry in a horizontal tube. Two different fluid pairs namely kerosene-water and lube oil-water have been selected for the experiments. As the viscosities of the oils are widely different, it is expected that such a study will bring out the effect of oil viscosity on the hydrodynamics of flow. The experimental observations reveal that core flow is the dominating flow pattern in case of oil-water downflow. However, the interfacial wave characteristics of core flow are different for the two pairs of test liquids. In addition, some interesting phenomena like liquid rope coiling and film inversion have also been noticed during lube oil-water core flow through sudden expansion and U type return bend.

As core flow is the most desirable configuration to transport high viscous oil, further attempts have been made to develop CFD models for lube oil-water core flow through the above mentioned geometries. Commercial CFD software FLUENT 6.3 has been used for the simulation. Extensive investigations are made to understand the velocity, pressure and insitu phase distribution. However, the commercial software has its own limitation to track the complex liquid-liquid interface. Hence, a numerical algorithm has been developed based on Lattice Boltzmann method. To check the predictability of the numerical algorithm, one of the simplest two-phase flow situation viz a liquid Taylor drop (heavier liquid is falling through a stationary column of a lighter liquid) has been simulated and efforts have been made to understand the influence of drop volume, pipe diameter and thermo-physical properties of the drop on its shape and velocity.