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Studies on low viscous oil–water flow through return bends

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ABSTRACT

In the present work, investigations have been carried out on the hydrodynamics of kerosene–water flow through return bends connecting two horizontal conduits. Extensive experiments are performed on two bend geometry (U and rectangular) and three flow directions through the bend (up, down and horizontal flow). It is observed that bend geometry has a strong influence on the downstream phase distribution while the direction of flow through the bend does not significantly affect the same. The pressure drop has been observed to be higher in the rectangular as compared to the U bend. The loss coefficients have been estimated for each of the cases. They have been found to be independent of flow patterns for all cases. Two different pressure drop correlations have also been proposed for each bend geometry to estimate liquid–liquid pressure drop across bend.

1. Introduction

Flow of liquid–liquid mixtures is frequently encountered in chemical, petrochemical, food and pharmaceutical industries. As a result, there has been a growing interest to study liquid–liquid flow during the last decade. Most of these studies are confined to the hydrodynamics of liquid–liquid flow through straight conduits namely vertical pipes [1–10], horizontal pipes [11–20] and inclined tubes [21–26]. These studies have explored flow regimes as well as pressure drop characteristics [1,2,13–20,26]. Different measurement techniques have also been proposed to identify flow patterns for low viscous oil–water flow [6–9].

On the other hand, not much is known about the hydrodynamics when such flow encounters a pipe fitting such as sudden expansion/contraction, Tee junction, valves or return bends in its flow path. Only a few limited studies have reported the hydrodynamics of liquid–liquid flow through contraction/ expansion and Tee junction. Hwang and Pal [27] have obtained the pressure profiles and loss coefficients during the flow of low viscous oil–water emulsion across sudden expansion and contraction of different area ratios. Subsequently, Balakhrisna et al. [28] have performed experiments to study the effect of sudden contraction and expansion on the hydrodynamics of low viscous and high viscous oil–water flow. They have used lube oil (μ = 0.22 Pa s and ρ = 960 kg/m^3) and kerosene (μ = 0.0012 Pa s and ρ = 787 kg/m^3) as the oil phase and observed several types of core annular flow. They have noted that sudden changes in cross-section have a significant influence on the downstream phase distribution of lube oil–water flow.

One of the earliest studies on liquid–liquid flow through T-junctions have been reported by Pandey et al. [29] who have investigated kerosene (μ = 0.0012 Pa s and ρ = 787 kg/m^3) and water flow at a horizontal dividing T-junction. Their results show that an increase in kerosene superficial velocity and a decrease in water superficial velocity increases the water take off in the stratified smooth and stratified wavy flow regimes. However they could not find any definite trend of pressure drop on flow split. Yang et al. [30] have reported liquid–liquid phase separation in a horizontal main pipe with a vertically upward side arm. They have observed that the maldistribution at the T-junction is higher when the inlet flow is stratified and low when it is dispersed. Yang and Azzopardi [31] have reported kerosene (μ = 0.0021 Pa s and ρ = 796 kg/m^3)–water flow through a horizontal T-junction made from a pipe of diameter 0.0674 m. They have noticed slight maldistribution of phases in this arrangement and suggested such a T configuration to be a convenient partial separator. Wang et al. [32] have preformed experiments with oil (μ = 0.031 Pa s and ρ = 836 kg/m^3) water flow through a T-junction. They have observed that the performance of a T-junction as a separator largely depends on the inlet volumetric composition and flow pattern. Further they numerically simulated flow inside the T-junction using a 3D two-fluid model. Their simulation results were in close agreement with the experiments.

Although return bends are a common occurrence in process industries, till date no literature is available on oil–water flow

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