Abstract

The slug flow pattern is a frequent occurrence during gas-liquid two-phase flow. It is characterized by the periodic appearance of large bullet-shaped bubbles termed as Taylor bubbles and liquid slugs occupying the space between two successive Taylor bubbles. Under normal circumstances, this pattern is not observed during liquid-liquid two-phase flow. An interest is felt in the present study to investigate whether the slug flow pattern exists under conditions known for excessive slugging in gas-liquid cases. For example, it is known that slight undulations in a horizontal pipeline induces slugging during gas-liquid flows. This flow pattern is also observed for a wider range of flow conditions in small diameter pipes. The present study is, therefore, directed to the study of liquid-liquid flow through small diameter pipes and undulated horizontal pipelines commonly referred to as hilly terrain pipelines in literature.

Since the hydrodynamics of slug flow is governed by rise of Taylor bubbles, the initial studies are directed to the rise of Taylor bubbles through stationary liquid columns in vertical and inclined orientations. The study comprises of extensive experimentation to understand the behavior of Taylor bubbles for different tube diameters and liquid pairs. Some studies have also been directed to the fall of Taylor drops (heavier liquid falling through a stationary column of a lighter liquid) in different pipe diameters and orientations.

Attempts have next been made to investigate air-water and oil-water flows in an undulating pipeline. The undulation comprises of an uphill and a downhill section between two horizontal portions. Studies have been focused to both a peak and a valley configuration of the undulation.

Further attempts have been made to observe the distribution of the two liquids in small diameter pipes. The flow patterns in all the cases have been identified by the optical probe technique for oil-water flows and the conductivity probe method for air water systems. The probe signals have been analyzed by Probability Density Function (PDF) analysis, Fast Fourier Transform (FFT), auto correlation function and cross correlation function for a better appraisal of the flow

phenomenon. The flow patterns thus obtained have been compared with the flow pattern maps available in literature to show the influence of the orientation of pipeline and conduit diameter on the flow phenomena. Existing mechanistic models have been used to predict the transitions in small diameter pipes.

A new flow pattern namely rivulet flow has been observed in the horizontal conduit. The reason behind its existence is attributed to the effect of liquid-liquid contact angle with the Perspex pipe. Studies have been made to understand the characteristics and range of existence of slug and rivulet flow patterns as well as estimation of the insitu composition and pressure drop under such conditions.

Thus it has been concluded that undulation enhances the slugging during two-phase flow and small diameter pipe induces the slug flow in both vertical and horizontal orientations.