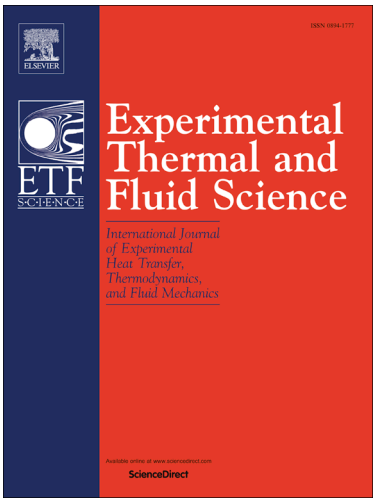

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Similarities and Differences in Churn and Annular Flow Regimes in Steady-State and Oscillatory Flows in a Long Vertical Tube

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1. Introduction

Pressure and flow oscillations (or instabilities) are often encountered in two-phase flow in pipes. These oscillations may have high frequency (with frequencies higher than 1 Hz – for instance, created by Kelvin-Helmholtz instabilities), or low frequency oscillations (with frequencies lower than 1 Hz – associated by the action of valves and pumps). This study is investigating primarily low frequency oscillations.

Induced-low-frequency oscillations of pressure and flow are often found in the oil and gas industry in gas-lifted vertical wells. During gas-lift operations, gas-lift valves placed at the bottom of the well can create periodic oscillations of gas injection, which creates pressure and flow oscillations on gas-liquid flows (Hu, 2004). Unstable production in oil and gas systems has also been identified as an undesired phenomenon (Hu et al., 2010; Lozada et al. 2011). Oil wells that are under unstable flow are difficult to operate efficiently. Therefore, the characterization of multiphase flow in long vertical pipes under low-frequency flow oscillations is essential on the evaluation of oil and gas production, in petroleum engineering. The characterization of such flows include experimental studies to obtain laboratory data to determine if current theoretical models can appropriately capture the effects of oscillations of pressure and flow in flow regimes, liquid holdup and pressure gradient. The current models available in the literature have been extensively validated for steady-state flow (Shoham, 2005). However, more studies are needed to better describe the accuracy of such models to predict upward gas-liquid two-phase flow in vertical pipes under induced-low-frequency oscillations of pressure and flow. Oscillatory flows are also important in other industrial applications in nuclear engineering such as in heat exchangers, boiling water reactors, fuel channels and refrigeration systems. However, there is a lack of studies in the literature on the experimental characterization of two-phase flows under induced-low-frequency oscillations and its differences with two-phase flow in steady-state for long vertical tubes.

The study of low frequency oscillations have been previously investigated in nuclear engineering (Fukuda and Kobori, 1978; March-Leuba, 1992; Okawa et al., 2010). Okawa et al. (2010) investigated the effect of forced-low-frequency oscillations in two-phase flow in pipes for