Experimental and Computational Multiphase Flow
Vol. 3, No. 2, 2021, 124–130
https://doi.org/10.1007/s42757-020-0068-0

Slug length and frequency upstream a sudden expansion in gas–liquid intermittent flow

A. H. Zitouni[1], A. Arabi[2,3] (✉), Y. Salhi[3], Y. Zenati[3], E. K. Si-Ahmed[4], J. Legrand[4]

1. Research Center in Industrial Technologies CRTI P.O.BOX 64, Cheraga 16014 Algiers, Algeria
2. SONATRACH, Direction Centrale Recherche et Développement, Avenue 1er Novembre, 35000, Boumerdes, Algeria
3. University of Sciences and Technology Houari Boumediene USTHB, Physics' Faculty Laboratory of Theoretical and Applied Fluid Mechanics, LMFTA, BP 32 El Alia 16111 Bab Ezzouar, Algiers, Algeria
4. University of Nantes, ONIRIS, CNRS, GEPEA, CNRS, UMR-6144, 37 Bd de l'université BP406, 44602 Saint –Nazaire, France

Abstract

The purpose of this work is to analyze the influence of a sudden expansion on the upstream behavior of the horizontal gas–liquid slug flow. Measurements were made on a 40 mm ID pipe with and without a sudden enlargement of aspect ratio $\sigma = 0.444$. The experiments were carried out with two-phase air–water mixture. The slug lengths and frequencies were measured using a non-intrusive video technique. Upstream the sudden enlargement, it was observed that the mixture velocity has no influence on slug length. The variation of slug frequency is found proportional to the liquid superficial velocity for the two cases within this study. It was also observed that the behavior of the slug length and frequency was affected by the presence of the sudden enlargement. The comparison of the results obtained with various empirical correlations available in the literature showed that the latter are not worthwhile in the case where singularity is installed.

Keywords

slug flow
sudden expansion
slug length
slug frequency

Article History

Received: 5 December 2019
Revised: 2 April 2020
Accepted: 4 April 2020

Research Article

1 Introduction

Whether in nature or in many industrial sectors, such as petroleum engineering, chemical and biological industries, the simultaneous flow of gas and liquid represents a challenge for researchers. The complexity of this type of flow includes the various flow regimes that might be encountered. For instance, horizontal two-phase flows exhibit a multitude of flow regimes that can be classified into three main groups: separated flow, dispersed flow, and intermittent flow (Dukler and Hubbard, 1975). The intermittent flow or slug flow is the most complex one. It is characterized by the alternating passage of gas pockets and liquid slugs. The intermittent nature, in space and time, of such flow, generates several operational problems for manufacturers, including high pressure drop and liquid overflow in downstream installations (Arabi, 2019). Slug flow is the most critical flow regime for flow induced vibration (FIV) (Miwa and Hibiki, 2020).

Slug flow regime is characterized by some intrinsic parameters such as liquid slug frequency and length as well as the translation velocity of the slug unit (gaz pocket + liquid slug). These parameters, besides being included in the design of industrial installations, are used as input parameters in various slug flow models (Dukler and Hubbard, 1975; Taitel and Barnea, 1990; Cook and Behnia, 2000). One should note that a great number of empirical models, developed from data collected on straight pipe, are available in the literature for the prediction of above cited parameters. However, installations and devices in the industry involve singularities that will definitely disturb the flow (void fraction distribution, flow regime) in addition to a significant pressure loss. Therefore, models based on flow parameters gathered from uniform pipe data are not necessarily valid in the case of singularity (Bertola, 2002). Furthermore, most of the investigations involving singularities focused on the pressure drop and the average void fraction evolution, which used mainly as an input in the two-fluid model (Ishii and Hibiki, 2010; Hibiki, 2019).

Bertola and Moschella (2003) studied the influence of abrupt contraction on the upstream behavior of a horizontal

✉ arabi.abderraouf@sonatrach.dz