International Journal of Multiphase Flow 59 (2014) 186–205

Contents lists available at ScienceDirect

International Journal of Multiphase Flow

journal homepage: www.elsevier.com/locate/ijmulflow

# A flow pattern independent drift flux model based void fraction correlation for a wide range of gas–liquid two phase flow

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ARTICLE INFO

*Article history:*
Received 31 August 2013
Received in revised form 30 October 2013
Accepted 2 November 2013
Available online 15 November 2013

*Keywords:*
Distribution parameter
Drift velocity
Drift flux model
Void fraction
Gas–liquid two phase flow

ABSTRACT

The main objective of this study is to present new equations for a flow pattern independent drift flux model based void fraction correlation applicable to gas–liquid two phase flow covering a wide range of fluid combinations and pipe diameters. Two separate sets of equations are proposed for drift flux model parameters namely, the distribution parameter ($C_o$) and the drift velocity ($U_{gm}$). These equations for $C_o$ and $U_{gm}$ are defined as a function of several two phase flow variables and are shown to be in agreement with the two phase flow physics. The underlying data base used for the performance verification of the proposed correlation consists of experimentally measured 8255 data points collected from more than 60 sources that consists of air–water, argon–water, natural gas–water, air–kerosene, air–glycerin, argon–acetone, argon–ethanol, argon–alcohol, refrigerants (R11, R12, R22, R134a, R114, R410A, R290 and R1234yf), steam–water and air–oil fluid combinations. It is shown that the proposed correlation successfully predicts the void fraction with desired accuracy for hydraulic pipe diameters in a range of 0.5–305 mm (circular, annular and rectangular pipe geometries), pipe orientations in a range of $-90^\circ \leqslant \theta \leqslant 90^\circ$, liquid viscosity in a range of 0.0001–0.6 Pa-s, system pressure in a range of 0.1–18.1 MPa and two phase Reynolds number in a range of 10 to $5 \times 10^6$. Moreover, the accuracy of the proposed correlation is also compared with some of the existing top performing correlations based on drift flux and separated flow models. Based on this comparison, it is found that the proposed correlation consistently gives better performance over the entire range of the void fraction ($0 < \alpha < 1$) and is recommended to predict void fraction without any reference to flow regime maps.



## 1. Introduction

Two phase flow of gas and liquid is a widely observed phenomenon in several practical applications pertaining to chemical, nuclear, refrigeration and petroleum industries. For instance, the gas–liquid (two component two phase) flow exists in ozonification and desalination process in chemical industries and the simultaneous transportation of oil and gas in the petroleum industry. On the other hand, the existence of vapor–liquid (one component two phase) flow is inevitable in nuclear systems, steam generators and evaporators and condensers used in refrigeration systems. The knowledge of two phase flow parameters such as flow patterns, void fraction, pressure drop and heat transfer is crucial in design and optimization of all these industrial processes and equipment. Out of all these two phase flow parameters, void fraction is the most fundamental and crucial parameter as it is required as an input in almost every two phase flow calculation such as two phase mixture density, two phase mixture viscosity and actual velocities of each phase. In addition to this, the correct knowledge of void fraction is also decisive in determination of two phase pressure drop (hydrostatic and accelerational components), refrigerant charge inventory in evaporators and condensers and two phase heat transfer coefficient.

Due to its significance, the concept of void fraction has received significant attention by several investigators resulting into numerous void fraction measurement experiments and development of different models for its prediction. However, these experiments and modeling work has been confined mostly to the horizontal and vertical pipe orientations with very little attention paid to the two phase flow in inclined systems and with various fluid combinations. One of the major short comings of some of these models is that they are developed for a specific flow pattern or need additional information related to the flow pattern to be fed into the model beforehand which is in most of the cases is not known to the user. Although, there are few mathematical and graphical tools available in the literature for estimation of the flow pattern in a two phase flow system; these tools are developed based on limited experimental data and flow conditions with flow patterns often identified qualitatively merely by visual observations and hence

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http://dx.doi.org/10.1016/j.ijmultiphaseflow.2013.11.001