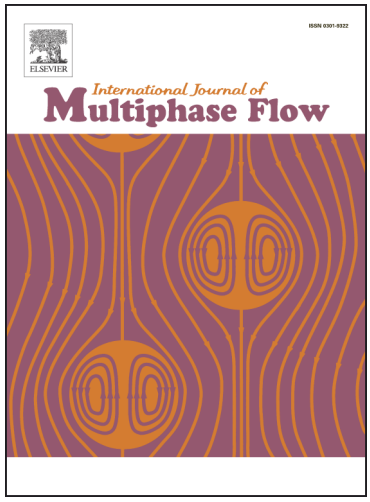

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PII: S0301-9322(14)00147-5
DOI: http://dx.doi.org/10.1016/j.ijmultiphaseflow.2014.08.005
Reference: IJMF 2087

To appear in: *International Journal of Multiphase Flow*

Received Date: 4 May 2014
Revised Date: 13 August 2014
Accepted Date: 17 August 2014

Please cite this article as: Zhou, Y., Huang, Z., Wang, B., Ji, H., Li, H., A New Method for Void Fraction Measurement of Gas-liquid Two-phase Flow in Millimeter-scale Pipe, *International Journal of Multiphase Flow* (2014), doi: http://dx.doi.org/10.1016/j.ijmultiphaseflow.2014.08.005

A New Method for Void Fraction Measurement of Gas-liquid Two-phase Flow in Millimeter-scale Pipe

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Abstract. This work attempts to investigate the feasibility and potential of Capacitively Coupled Contactless Conductivity Detection (C^4D) technique in the void fraction measurement of gas-liquid two-phase flow in millimeter-scale pipe and hence to propose a new void fraction measurement method based on C^4D technique. A new C^4D sensor is developed and a void fraction measurement system is constructed. As a preliminary study, the research work is focused on the void fraction measurement of two typical flow patterns (bubble flow and slug flow) in millimeter-scale horizontal pipe. The relationship between the conductance value and the void fraction is investigated. It is found that there is obvious linear relationship between the conductance value and the void fraction and flow pattern has significant influence on void fraction measurement. To overcome the influence of flow pattern, different void fraction measurement models are developed for different flow patterns. In the practical void measurement process, flow pattern is firstly identified, then a corresponding void fraction measurement model is selected, and finally the void fraction measurement is implemented with the selected model and the conductance measurement obtained by the new C^4D sensor. Void fraction measurement experiments are carried out (the inner diameters of the pipes are 2.8mm, 3.9mm, 5.3mm and 7.0mm, respectively). The experiment results show that the application of C^4D technique to the void fraction measurement of gas-liquid two-phase flow in millimeter-scale pipe is feasible. The proposed void fraction measurement method is effective and the measurement performance is satisfactory (the maximum absolute error of void fraction measurement is less than 7%). The research results also indicate that C^4D technique may have a broad application prospective and potential in the research field of two-phase flow.

Keywords: Gas-liquid two-phase flow; Void fraction; Measurement; Millimeter-scale pipe; Capacitively Coupled Contactless Conductivity Detection

1. Introduction

Gas-liquid two-phase flow is an important research field due to the increasing number of industrial applications (Hewitt, 1978; Hetsroni, 1982; Li, 1991; Crowe, 2006). As an important indicator of the flow mechanism, void fraction is fundamental for describing the basic behavior of gas-liquid two-phase flow during diabatic and adiabatic flow conditions and to develop physical models able to predict mass, momentum and energy transfers (Fossa, 1998; Devia and Fossa, 2003). Thus, the determination of void fraction in gas-liquid two-phase flow is very important. Currently, with the development of modern technologies, the industrial devices/equipments of gas-liquid two-phase flow present a trend of miniaturization. More and more millimeter-scale devices/equipments appear (Bergles, 2003; Kandlikar, 2006). There is an urgent need of research works on void fraction measurement of gas-liquid two-phase flow in millimeter-scale pipe.

Conductance detection method is a classic and traditional approach for analyzing the void fraction of gas-liquid two-phase flow. The conductance detection technique has been widely used to measure void fraction for many decades (Hewitt, 1978; Hetsroni, 1982; Tsochatzidis, 1992; Ceccio and George, 1996; Costigan and Whalley, 1997; Fossa, 1998; Lucas et al., 2004; Jin et al., 2008; Zheng et al., 2008; Hasan et al., 2011). Unfortunately, the