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RESEARCH PAPER

A facile pressure drop measurement system and its applications to gas–liquid microflows

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Abstract A system for measuring the pressure drop of a fluid in a microchannel was developed in this study with measurements ranging from 0 to 7 kPa and an accuracy of 1 Pa for constant pressure drop. This system utilizes commercial pressure sensors, self-made amplifiers and a vibration insulation platform to insure accuracy and reproducibility of the results. Pressure calibrations can be conveniently computed using the manufacturers' datasheet. This measuring system was firstly tested with the pressure drop measurement of single-phase flow in microchannels and the results showed good agreement with theoretical computations. Oscillating pressure drops in the generation of bubbles in T-junction microchannel were studied using the pressure measurement system and their amplitude relatively to the change of working systems is carefully discussed with the comparison of theoretical models from literatures.

Keywords Pressure drop · Measurement · Microflow · Microchannel · Gas–liquid two-phase flow

1 Introduction

The abundant use of microchannels and their widespread applications in recent years have demonstrated the growing importance of microfluidic devices in key research areas including microelectronics, analysis biology and chemical processes (Atencia and Beebe 2004; Meijer 2010; Morin et al. 2012). Droplets and bubbles are the cores of microfluidics theory, and numerous researchers investigated how to predict the droplet/bubble size (van Steijn et al. 2010; Xu et al. 2008) and the flow patterns in microchannels. For example, most correlations make the difference between two asymptotic flow regimes, called squeezing flow (the interface is always at the equilibrium) and dripping flow (interfacial tension is in competition with shear stress). However, this transition is hard to define solely based on the droplet/bubble size. In 2008, De Menech et al. used numerical simulations to show that the formation of droplets or bubbles in T-junction microchannels induced pressure fluctuations at the inlet of the continuous phase, that these fluctuations amplitude was almost constant under squeezing and that the transition from squeezing to dripping was coupled with a dramatic reduction in these pressure fluctuations. Recently this study was experimentally confirmed by Abate et al. (2012). Beyond the need to know what is the flow regime, current microfluidic studies suffer from another limitation: to know what the droplet/bubble size is, most researchers use image analysis to measure the droplet/bubble diameter so that the channel walls must be transparent. This complicates the studies of micromixers and microreactors when using surface catalyst, in corrosive media or under high temperature/pressure, where no supervision of the flow regime is available. In this case, another advantage in using pressure sensors to monitor the channel would be the ability to control it in blind. According to these two cases, the pressure measurement is an important issue for fluid dynamic studies of microflows.

Although numerous publications deal with pressure measurements in microchannels (Abate et al. 2012; Fuerstman et al. 2007; Kohl et al. 2005; Pfund et al. 2000), to the best of our knowledge only Abate and coworkers (2012) have performed experiments involving measurements of very low pressures (below 50 Pa), using their own

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