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Chemical Papers 67 (3) 313–325 (2013)
DOI: 10.2478/s11696-012-0277-5

ORIGINAL PAPER

Experimental investigation of bubble and drop formation at submerged orifices

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Received 4 November 2011; Revised 6 July 2012; Accepted 6 July 2012

The aim of this study was to investigate bubble/drop formation at a single submerged orifice in stagnant Newtonian fluids and to gain qualitative understanding of the formation mechanism. The effects of various governing parameters were studied. Formation behavior of bubbles and drops in Newtonian aqueous solutions were investigated experimentally under different operating conditions with various orifices. The results show that the volume of the detached dispersed phase (bubble or drop) increases with the viscosity of the continuous phase (or dispersion medium), surface tension, orifice diameter, and dispersed phase flow rate. A PIV system was employed to measure the velocity flow field quantitatively during the bubble/drop formation, giving interesting information useful for the elucidation of the fundamental formation process at the orifice. It was revealed that the orifice shape strongly influences the size of the bubble formed. Furthermore, based on a simple mass balance, a general correlation successfully predicting both bubble and drop sizes has been proposed.

Keywords: bubble, drop, formation, PIV measurements

Introduction

Formation of gas bubbles or liquid drops is an important fundamental phenomenon that significantly influences hydrodynamics in gas–liquid and liquid–liquid reactors commonly used in chemical and petrochemical processes, manufacture of cosmetics, mineral processing, etc. The contact between phases is generally achieved either by bubbling gas into the liquid or by making droplets of one liquid in another one for various applications such as absorption, distillation, emulsification, froth flotation, etc.

In most multiphase equipments, understanding of the transport and transfer processes across the gas–liquid or liquid–liquid interface is useful for the estimation of interfacial area, mass transfer coefficient, and dispersed holdup. Furthermore, physicochemical properties of the liquid phase (viscosity, surface tension, density, etc.) as well as characteristics of the dispersed phase (bubble/drop size, bubble/drop rise velocity, etc.) govern the hydrodynamics and flow pattern in the system. The formation mechanism determines the primitive bubble or drop size in the system which has important consequences for the hydrodynamics.

The earliest reports on the formation of single bubbles and drops were published by Tate (1864) and Bashforth and Adams (1883). Bashforth and Adams (1883) computed the shape of liquid menisci under equilibrium conditions and published their results in

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