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SCIENCE DIRECT•
Nuclear Engineering and Design 235 (2005) 1163–1178
Nuclear Engineering and Design
www.elsevier.com/locate/nucengdes

Gas–liquid phase distribution and void fraction measurements using MRI

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Received 13 January 2005; received in revised form 14 January 2005; accepted 16 February 2005

Abstract

We used a permanent-magnet magnetic resonance imaging (MRI) system to estimate the integral, spatially- and temporally-resolved void fraction distributions and flow patterns in vertical gas–liquid two-phase flow. Air was introduced at the bottom of the stagnant liquid column using an accurate and programmable syringe pump. The air flow rate was in upward vertical direction against the gravity vector. Air flow rates were varied between 1 and 200 ml/min. Bubble formation and detachment at the inlet of the vertical column was non-uniform. The cylindrical non-conducting test tube in which two-phase flow is characterized was placed in a 0.26 T permanent-magnet MRI unit. A roughly linear relationship has been observed for the integral void fraction versus volume flow rate of air through vertical stagnant liquid column. Integral or sample-averaged void fraction was obtained by volume-averaging of the spatially-resolved signals. Spatial averaging was performed in a radial or longitudinal axis of the column. The time-averaged spatially-resolved void fraction has also been obtained for the quasi-steady flow of air in a stagnant liquid column. No great accuracy is claimed as this was an exploratory proof-of-concept type of experiment. Preliminary results show that MRI can indeed provide qualitative and quantitative data and is especially well suited for characterization of averaged transport processes in adiabatic and diabatic multi-phase and/or multi-component flows. Better and faster MRI sequences could improve spatial and temporal resolutions significantly.

1. Introduction

The knowledge of the instantaneous or time-averaged spatially-resolved phase and void fraction distribution is crucial information in characterization of the multi-phase and/or multi-component flow systems.

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doi:10.1016/j.nucengdes.2005.02.024