Study On Gas Liquid Two Phase Flow Patterns And Pressure

This is an up-to-date review of recent advances in the study of two-phase flows, with focus on gas-liquid flows, liquid-liquid flows, and particle transport in turbulent flows. The book is divided into several chapters, which after introducing basic concepts lead the reader through a more complex treatment of the subjects. The reader will find an extensive review of both the older and the more recent literature, with abundance of formulas, correlations, graphs and tables. A comprehensive (though non exhaustive) list of bibliographic references is provided at the end of each chapter. The volume is especially indicated for researchers who would like to carry out experimental, theoretical or computational work on two-phase flows, as well as for professionals who wish to learn more about this topic.

Heat transfer in non-boiling gas-liquid two phase flow finds its practical application in chemical and petroleum industries. So far, majority of the research dedicated to study heat transfer in non-boiling two phase flow is limited to horizontal and vertical pipe orientations with very little attention given to the study of this phenomenon in inclined systems. To contribute and further enhance the general understanding of heat transfer in non-boiling two phase flow, the main focus of this work is to experimentally measure local and average convective heat transfer coefficients for different flow patterns in horizontal and near horizontal upward inclined two phase flow. In total, 368 experiments are carried out in a 12.5 mm I.D. schedule 10S stainless steel pipe at 0, +5, +10 and +20 degrees pipe orientations using air-water as fluid combination. For each pipe orientation, the superficial gas and liquid Reynolds number is varied from 200 to 19,000 and 2000 to 18,000, respectively and the measured values of the averaged heat transfer coefficient were found to be in a range of 1300 W/m2K to 8000 W/m2K. The two phase heat transfer coefficients are compared among the above mentioned orientations. It is found that the two phase heat transfer coefficient increases from 0° to +5° and +10° and then decreases at +20°. Also, correlations in the literature were tested and the best performing correlations have been discussed in the experimental study. Correlation using the concept of Reynolds analogy was developed by modification of the existing correlation in the literature leading towards the better understanding of the relationship of heat transfer phenomenon with the pressure drop.

The objectives of this book are twofold: to provide insight and understanding of two-phase flow phenomena and to develop analytical tools for either designing two-phase flow systems or conducting research in this area. The traditional approach for two-phase flow prediction has been the empirical approach, which was based on the development of an empirical correlation from experimental data. This book presents the recent approach, in which mathematical mechanistic models are developed, based on the physical phenomena, for the prediction of two-phase flow behavior. The models can be verified and refined with limited experimental data. However, as these models incorporate the physical phenomena and the important flow variables, they can be extended to different operational conditions and can enable scaleup with significant confidence.

Within the oil industry there is a need to measure and predict the form of the multiphase liquid and gas flows that are present within oil production and processing pipelines. Knowledge of the flow regimes present allows the engineer to optimise the configuration of the pipeline and downstream processes to achieve the most, economic and reliable design. The applications of these technologies are collectively known as flow assurance. Within oil production systems, one component which has received little attention is the characterisation of the multiphase flow around bends under various process conditions. To predict the flow regimes in greater details requires the development of instrumentation that can measure and characterise the flow within the pipes. To circumvent this challenge, two experimental investigations were carried out in two rigs available in the Chemical and Environmental Engineering Laboratories at the University of Nottingham. These are: (1) a 67 mm internal diameter pipe joined to a 90o bend, in which air/silicone oil flows were investigated using advanced instrumentation: Electrical Capacitance Tomography (ECT), Wire Mesh Sensor Tomography (WMS), and high-speed video. The first two provide time and cross-sectionally resolved data on void fraction. The ECT probes were mounted 10 diameters upstream of the bend whilst the WMS was positioned either immediately upstream or immediately downstream of the bend. The downstream pipe was maintained horizontal whilst the upstream pipe was mounted either vertically or horizontally. The bend (R/D = 2.3) was made of transparent acrylic resin. The superficial velocities of the air ranged from 0.05 to 4.73 ms-1 and for the silicone oil from 0.05 to 0.38 ms-1. (2) a 127 mm internal diameter riser joined to a vertical 180o bend, in which measurements of film fraction and liquid film thickness distribution for an air-water system were obtained using the electrical conductance technique. The former was measured using the ring conductance probes placed 17 and 21 diameters, respectively upstream and downstream of the bend, 45o, 90o and 135o within the bend. The latter were obtained using pin and parallel wire probes. The pin probes were used for thin films measurement whilst the parallel wire probes for thick films. The bend, made of transparent acrylic resin, has a curvature ratio (R/D = 3). The superficial velocities of the air ranged from 3.5 to 16.1 ms-1 and for the water from 0.02 to 0.2 ms-1. The experimental results for the 90o bend study reveal that bubble/spherical cap bubble, slug, unstable slug and churn flows were observed before the bend for the vertical pipe and plug, slug, stratified wavy and annular flows when the pipe was horizontal. Bubble, stratified wavy, slug, semi-annular and annular flows are seen after the bend for the vertical 90o bend, the flow patterns remained the same as before the horizontal 90o bend. These results were confirmed by the high-speed videos taken around the bend. For the vertical 180o return bend, the average film fraction was identified to be higher in straight pipes than in bends. For low liquid and higher gas flow rates, due to the action of gravity drainage, film breakdown occurs at the 45o bend. A previously proposed criterion, to determine stratification after the 90o bend, based on a modified Froude number have been shown to be valid for a liquid different from that tested in the original paper. Similarly, for the 180o return bend, the condition for which the liquid goes either to the inside or outside of the bend are identified based on published material. Variations between average liquid film thickness and bend angles are reported for the vertical 180o bend. Contrary to the conclusions reached by Hills (1973) and Anderson and Hills (1974), the liquid film thickness becomes annular flow in the 180o bend at low liquid flow rates and stratified flow at higher liquid superficial velocities. In addition, a CFD code has been used to successfully model the hydrodynamics of the slug flow pattern in a riser and vertical 90o bend, using the Volume of Fluid model based on the Eulerian approach, implemented in the commercial CFD package Star-CCM+. The modelling results are validated with the experiments and also provide more detailed information on the flow such as the velocity field.

Wave Propagation in Gas-Liquid Media (translated from the Russian 2nd Edition, published in 1990) presents the fundamentals of wave dynamics of two-phase gas-liquid systems. The study of multiphase systems is of growing importance in mechanics and thermophysics, particularly for applications in industrial, energy, power, chemical, and aerospace engineering. This book presents investigations of non-linear wave dynamics, as well as practical applications of wave motion. A system of non-stationary gas-dynamics to replace studies of conventional gas-dynamics is constructed by the book's contributors. Topics discussed include acoustics and shock waves in homogenous gas- and vapor-liquid mixtures, dynamics of gas and vapor bubbles, wave processes in gas-liquid systems, wave propagation in a liquid with vapor bubbles, wave processes on the interface of two media, wave flow of liquid films, and basic calculation formulas for wave dynamics of gas- and vapor-liquid media. The book will be a useful reference for thermophysicists, mechanical engineers, and aerospace engineers.

The ability to predict gas-liquid flow patterns is crucial to the design and operation of two-phase flow systems in the microgravity environment. Flow pattern maps have been developed in this study which show the occurrence of flow patterns as a function of gas and liquid superficial velocities as well as tube diameter, liquid viscosity and surface tension. The results have demonstrated that the location of the bubble-slug transition is affected by the tube diameter for air-water systems and by surface tension, suggesting that turbulence-induced bubble fluctuations and coalescence mechanisms play a role in this transition. The location of the slug-annular transition on the flow pattern maps is largely unaffected by tube diameter, liquid viscosity or surface tension in the ranges tested. Void fraction-based transition criteria were developed which separate the flow patterns on the flow pattern maps with reasonable accuracy. Weber number transition criteria also show promise but further work is needed to improve these models. For annular gas-liquid flows of air-water and air- 50 percent glycerine under reduced gravity conditions, the pressure gradient agrees fairly well with a version of the Lockhart-Martinelli correlation but the measured film thickness deviates from published correlations at lower Reynolds numbers. Nusselt numbers, based on a film thickness obtained from standard normal-gravity correlations, follow the relation, Nu = A Re(sup n) Pr(exp l/3), but more experimental data in a reduced gravity environment are needed to increase the confidence in the estimated constants, A and n. In the slug flow regime, experimental pressure gradient does not correlate well with either the Lockhart-Martinelli or a homogeneous formulation, but does correlate nicely with a formulation based on a two-phase Reynolds number. Comparison with ground-based correlations implies that the heat transfer coefficients are lower at reduced gravity than at normal gravity under the same ...

Two-phase gas-liquid flows in microscale fractal-like branching channel flow networks were experimentally studied to assess the validity of existing void fraction correlations and flow regimes based on superficial gas and liquid velocities. Void fractions were assessed using two different methods. First, void fraction data were acquired using a High-Speed-High-Resolution (HSHR) camera and computed by area-based two-dimensional image analysis. Void fraction data were also computed using a slip ratio, defined as gas velocity over liquid velocity. Liquid velocity represents the bulk-averaged liquid velocity as determined by microscale particle image velocimetry (micro-PIV). Gas velocity was determined by averaging gas-liquid interface velocities made at the channel centerline. The fractal-like branching channel flow network has five bifurcation levels of different channel widths varying from 400 [mu]m to 100 [mu]m with a fixed channel depth of 250 [mu]m. Each downstream width decreases by 30% whereas the downstream lengths increase by 40%. The total flow length through a single path is approximately 18 mm. Filtered air and deionized water were used as the gas and liquid working fluids, respectively. Mass flow rates of air and water into each k=0 branch were varied from 0.3 g/min to 2.5

g/min and from 5.2x10?5 g/min to 1.3x10?2 g/min, respectively. These flow rates yielded superficial air and water velocities through the same branch level between 0.007 m/s and 1.8 m/s and between 0.05 m/s and 0.42 m/s, respectively. For each branching level, due to an increase in flow area, the superficial liquid and gas flow rates change. A two-phase flow regime map was generated for each level of the fractal-like branching flow network and compared to maps developed using the Taitel and Dukler (1976) model and to maps presented in Chung and Kawaji (2004). Flow regime transitions are well predicted with the Taitel and Dukler (1976) model for each branching level. Void fraction assessed using the slip ratio shows very good agreement with the homogeneous void fraction model for all branching levels. On the other hand, void fraction determined by area-based two-dimensional image analysis shows better agreement with the void fraction correlation of Zivi (1964).

Accurately predicting the behaviour of multiphase flows is a problem of immense industrial and scientific interest. Modern computers can now study the dynamics in great detail and these simulations yield unprecedented insight. This book provides a comprehensive introduction to direct numerical simulations of multiphase flows for researchers and graduate students. After a brief overview of the context and history the authors review the governing equations. A particular emphasis is placed on the 'one-fluid' formulation where a single set of equations is used to describe the entire flow field and interface terms are included as singularity distributions. Several applications are discussed, showing how direct numerical simulations have helped researchers advance both our understanding and our ability to make predictions. The final chapter gives an overview of recent studies of flows with relatively complex physics, such as mass transfer and chemical reactions, solidification and boiling, and includes extensive references to current work.

Numerical simulation of multiphase reactors with continuous liquid phase provides current research and findings in multiphase problems, which will assist researchers and engineers to advance this field. This is an ideal reference book for readers who are interested in design and scale-up of multiphase reactors and crystallizers, and using mathematical model and numerical simulation as tools. Yang and Mao’s book focuses on modeling and numerical applications directly in the chemical, petrochemical, and hydrometallurgical industries, rather than theories of multiphase flow. The content will help you to solve reacting flow problems and/or system design/optimization problems. The fundamentals and principles of flow and mass transfer in multiphase reactors with continuous liquid phase are covered, which will aid the reader’s understanding of multiphase reaction engineering. Provides practical applications for using multiphase stirred tanks, reactors, and microreactors, with detailed explanation of investigation methods. Presents the most recent research efforts in this highly active field on multiphase reactors and crystallizers. Covers mathematical models, numerical methods and experimental techniques for multiphase flow and mass transfer in reactors and crystallizers.

Scale-Up Study of Gas-Liquid Two-Phase Flow in DowncomerStudy of Gas-liquid Two-phase Flow Pattern Transitions in Horizontal Pipe, Annulus and Nuclear Fuel Type Rod Bundle Flow Systems [microform]National Library of CanadaTwo-Phase Gas-Liquid Flow in Pipes with Different OrientationsSpringer

This is the second volume of Multiphase Science and TechnoJogy, a new international series of books intended to provide authoritative overviews of im portant areas in multiphase systems. The alm is to have systematic and tutorial presentations of the state of knowledge in various areas. The objective of the chapters is to allow the nonspecialist reader to gain an up-to-date idea of the present state of development in a given subject. The response to Volume 1 of the se ries has been very positive, and we believe that the present volume will be equally weil received. Volume 1 was concerned entirely with gas-liquid systems, and the first four chapters of the present volume also relate to such systems. However, the inten tion of the se ries is to cover a wide range of multiphase systems, and we are, therefore, pleased to include in the present volume chapters that refer to liquid liquid and gas-solid multiphase flows, respectively. The first chapter in the present volume is by Professor A. E. Dukler of the University of Houston, Texas, and Professor Y. Taitel of Tel-Aviv University, Israel.

Low-gravity gas-liquid flow research can be conducted aboard the NASA Lewis Research Center DC-9 or the Johnson Space Center KC-135. Air and water solutions serve as the test liquids in cylindrical test sections with constant or variable inner diameters of approximately 2.54 cm and lengths of up to 3.0 m. Superficial velocities range from 0.1 to 1.1 m/sec for liquids and from 0.1 to 25 m/sec for air. Flow rate, differential pressure, void fraction, film thickness, wall shear stress, and acceleration data are measured and recorded at data rates of up to 1000 Hz throughout the 20-sec duration of the experiment. Flow is visualized with a high-speed video system. In addition, the apparatus has a heat-transfer capability whereby sensible heat is transferred between the test-section wall and a subcooled liquid phase so that the heat-transfer characteristics of gas-liquid two-phase flows can be determined. McQuillen, John B. and Neumann, Eric S. and Shoemaker, J. Michael Glenn Research Center RTOP 963-20-00

A unified theory of multiphase flows, providing tools for practical applications.

Fine dispersion of gas into liquid is one of the most important criteria for momentum, mass and energy transfer between the phases. It not only provides an intense mixing but also creates increased interfacial area and high mass transfer coefficient. A comprehensive study have been done on the gas holdup, pressure drop and energy dissipation during the gas-liquid two-phase flow in an ejector induced downflow bubble column. Experimental results were analyzed by previously established models. Correlations were also developed to predict the gas entrainment, gas holdup, two-phase friction factor and frictional loss coefficients in terms of physical, dynamic variables and the system parameters. Studies have also been made to measure the interfacial area and mass transfer coefficient of the present system using chemical method. It has been found that interfacial area and mass transfer coefficients are strong functions of superficial gas velocity.

"Modern energy concerns have resulted in the necessity to create and understand alternative energy sources and develop systems to effectively utilize them. One such source is hydrogen, which can be utilized in a Proton Exchange Membrane Fuel Cell (PEMFC). This fuel cell has moved to the forefront for adaptability to the automotive industry. With this increased prominence the understanding of two-phase flow phenomena within the anode and cathode channels is needed. Much research has been performed in the area of two-phase flow within macro, mini, and micro-channels of both circular and rectangular cross-sections. However r previous research has been performed with a constant water and air introduction at the beginning of the channel. In a PEMFC water is introduced periodically along the length of the channel, resulting in more water at the end of the channel than at the beginning. A situation arises where the two-phase flow phenomena of the channel changes with distance, and the pressure drop model needs to be modified for the instantaneous flow phenomena. Previous studies have attempted to provide transition equations between the observed flow regimes, and several approaches have been taken. The two-phase flow in the gas channels of proton exchange membrane fuel cell (PEMFC) is studies with an ex-situ setup using a gas diffusion layer (GDL) as the sidewall of the channel. Air is introduced at the channel inlet with continuous uniform water introduction through the GDL. This is different from that use din two-phase studies reported in literature, where the air/water system is introduced at the inlet of the channel simultaneously. The GDL is compressed between the gas channels and the water changers to simulate PEMFC conditions. Superficial velocity for air and water ranged from 33 to 3962 (make m/s) and .02 to .2 (make m/s) respectively. The ex-situ cell was run in both vertical and horizontal orientations, with two GDLs (Baseline and SGL25BC) and three channel treatments (hydrophobic, hydrophilic, and untreated Lexan). The flow regime is observed at different locations along the channel and is expressed as a function of the superficial air and water velocities. Flow regime criteria are developed and validated against the range of ex-situ data observations. A new pressure drop calculation scheme is developed in order to account for the variation of water formations along the channel. Pressure drop models are developed for specific flow regimes and validated against experimental data. The final model is able to predict the pressure drop of experimental data within 8%"--Abstract.

An attempt is made to predict gas-liquid two-phase flow regime in a pipe in a microgravity environment through scaling analysis based on dominant physical mechanisms. Simple inlet geometry is adopted in the analysis to see the effect of inlet configuration on flow regime transitions. Comparison of the prediction with the existing experimental data shows good agreement, though more work is required to better define some physical parameters. The analysis clarifies much of the physics involved in this problem and can be applied to other configurations. Lee, Jinho and Platt, Jonathan A. Glenn Research Center RTOP 694-03-0A...

A three?dimensional CFD study of the two?phase flow field in a Gas?Liquid Cylindrical Cyclone (GLCC) using the finite volume?based finite element method is presented. The numerical analysis was made for air?water mixtures at near atmospheric conditions, while both liquid and gas flow rates were changed. The two?phase flow behavior is modeled using an Eulerian?Eulerian approach, considering both phases as an interpenetrating continuum. This method computed the inter?phase phenomena by including a source term in the momentum equation to consider the drag between the liquid and gas phases. The gas?liquid flow is modeled using an inhomogeneous mixture model, in order to capture the interfacial effects associated to the general complex interfacial boundaries. Results are compared to experiments and to results from a bi?modal inhomogeneous particle model. The CFD technique here proposed, demonstrates to satisfactorily reproduce important features not easily depicted in experiments and not computed when using the particle model. Results show phase distributions and velocity profiles inside the GLCC, as well as the computed gas carry?under for different operating conditions.

This book provides design engineers using gas-liquid two-phase flow in different industrial applications the necessary fundamental understanding of the two-phase flow variables. Two-phase flow literature reports a plethora of correlations for determination of flow patterns, void fraction, two- phase pressure drop and non-boiling heat transfer correlations. However, the validity of a majority of these correlations is restricted over a narrow range of two -phase flow conditions. Consequently, it is quite a challenging task for the end user to select an appropriate correlation/model for the type of two-phase flow under consideration. Selection of a correct correlation also requires some fundamental understanding of the two-phase flow physics and the underlying principles/assumptions/limitations associated with these correlations. Thus, it is of significant interest for a design engineer to have knowledge of the flow patterns and their transitions and their influence on two-phase flow variables. To address some of these issues and facilitate selection of appropriate two-phase flow models, this volume presents a succinct review of the flow patterns, void fraction, pressure drop and non-boiling heat transfer phenomenon and recommend some of the well scrutinized modeling techniques.

Presenting tools for understanding the behaviour of gas-liquid flows based on the ways large scale behaviour relates to small scale interactions, this text is ideal for engineers seeking to enhance the safety and efficiency of natural gas pipelines, water-cooled nuclear reactors, absorbers, distillation columns and gas lift pumps. The review of advanced concepts in fluid mechanics enables both graduate students and practising engineers to tackle the scientific literature and engage in advanced research. It focuses on gas-liquid flow in pipes as a simple system with meaningful experimental data. This unified theory develops design equations for predicting drop size, frictional pressure losses and slug frequency, which can be used to determine flow regimes, the effects of pipe diameter, liquid viscosity and gas density. It describes the effect of wavy boundaries and temporal oscillations on turbulent flows, and explains transition between phases, which is key to understanding the behaviour of gas-liquid flows.

The subject of the book is uid dynamics and heat transfer in micro-channels. This problem is important for understanding the complex phenomena associated with single- and two-phase ows in heated micro-channels. The challenge posed by high heat uxes in electronic chips makes thermal management a key factor in the development of these systems. Cooling of mic- electronic components by new cooling technologies, as well as improvement of the existing ones, is becoming a necessity as the power dissipation levels of integrated circuits increases and their sizes decrease. Miniature heat sinks with liquid ows in silicon wafers could signi cantly improve the performance and reliability of se- conductor devices. The improvements are made by increasing the effective thermal conductivity, by reducing the temperature gradient across the wafer, by reducing the maximum wafer temperature, and also by reducing the number and intensity of localized hot spots. A possible way to enhance heat transfer in systems with high power density is to change the phase in the micro-channels embedded in the device. This has motivated a number of theoretical and experimental investigations covering various aspects of heat transfer in micro-channel heat sinks with phase change. The ow and heat transfer in heated micro-channels are accompanied by a n- ber of thermohydrodynamic processes, such as liquid heating and vaporization, bo- ing, formation of two-phase mixtures with a very complicated inner structure, etc., which affect signi cantly the hydrodynamic and thermal characteristics of the co- ing systems.

A IUTAM symposium on "Measuring Techniques in Gas-Liquid Two Phase Flows" was held on July 5-8, 1983 in Nancy, France.

This topic in cluded instrumentation for steam-water and liquid-vapor flows but strictly excluded measuring techniques for gas or liquid flows with solid particles. The top priority in the paper selection was given to presentations of new methods which had been substantiated by theoretical modeling, calibration tests and comparison tests with other techniques. Examples of experimental resul ts obtained with the proposed instrumentation had to be displayed. However the interpretation of these results in terms of two-phase flow or heat transfer modeling did not fall wi thin the scope of the meeting. Thirty four papers were presented during the Symposium and 79 participants coming from Canada, European countries, Japan and the United States attended the sessions. They represented not only Universities but also state agencies and private companies. After the meeting each paper was peer-reviewed by at least three referees. The Editors of this Procee dings Volume are pleased to extend their deep gratitude to the following reviewers: J.L. Achard, R.J. Adrian, B. Azzopardi, J.A. Boure, G. Costigan, M. Courtaud, A.E. Dukler, F. Durst, J.R. Fincke, G. Gouesbet, P. Griffith, T.J. Hanratty, A. Hawighorst, T.R. Heidrick, G. Hetsroni, Y.Y. Hsu, M.

This book has been written for graduate students, scientists and engineers who need in-depth theoretical foundations to solve two-phase problems in various technological systems. Based on extensive research experiences focused on the fundamental physics of two-phase flow, the authors present the detailed theoretical foundation of multi-phase flow thermo-fluid dynamics as they apply to a variety of scenarios, including nuclear reactor transient and accident analysis, energy systems, power generation systems and even space propulsion.

Two phase gas-liquid flow and its associated interfaces exist in a wide variety of situations of importance to the Navy and this has prompted the study of the basic flow mechanics which underlie this complex process. The existence of wind-wave interactions over large bodies of water have long been recognized as a special case of two phase flow where the presence of the deformable interface plays a complex role in the generation of waves due to the action of the wind. Less well recognized, but of great importance, are situations of two phase flow which are found in component of power systems such as condensers, boilers refrigeration loops and cryogen lines. Here the characteristics of two phase flow are critical to the reliable design and safe operation of such systems.

Providing a comprehensive introduction to the fundamentals and applications of flow and heat transfer in conventional and miniature systems, this fully enhanced and updated edition covers all the topics essential for graduate courses on two-phase flow, boiling, and condensation. Beginning with a concise review of single-phase flow fundamentals and interfacial phenomena, detailed and clear discussion is provided on a range of topics, including two-phase hydrodynamics and flow regimes, mathematical modeling of gas-liquid two-phase flows, pool and flow boiling, flow and boiling in mini and microchannels, external and internal-flow condensation with and without noncondensables, condensation in small flow passages, and two-phase choked flow. Numerous solved examples and end-of-chapter problems that include many common design problems likely to be encountered by students, make this an essential text for graduate students. With up-to-date detail on the most recent research trends and practical applications, it is also an ideal reference for professionals and researchers in mechanical, nuclear, and chemical engineering.