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Experimental study on vertical downward air-water two-phase flow in a large diameter pipe

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ABSTRACT

Downward two-phase flows in large diameter pipes are important in various industrial applications, especially for the safety analysis in nuclear reactors. To address the issue that few data of downward flow in large diameter pipes is available for model evaluation, experiments of air–water downward flow in a pipe with inner diameter of 203.2 mm have been performed. Area-averaged void fraction and pressure measurement, as well as flow visualization, have been conducted at several axial locations. The flow conditions for superficial gas velocity range from 0.05 m/s to 3.00 m/s and for superficial liquid velocity range from 0.1 m/s to 1.5 m/s, which cover cap-bubbly flow, churn-turbulent flow and annular/falling film flow. The flow structure at several axial locations and the transition from churn-turbulent flow to annular/falling film flow have been discussed. Current available drift-flux models developed for downward flow in regular pipes as well as for upward flow in large pipes are evaluated using newly collected data. For churn-turbulent flow, the data indicates a larger drift velocity than the model prediction. Corresponding drift-flux constitutive equations are suggested which can reduce the prediction error from 34.37% to 11.75%.

1. Introduction

Two-phase flow in large diameter pipes is often encountered in various industrial applications. In chemical and petroleum industries, the large bubble column chemical reactor and pump systems are commonly used. In the nuclear industry, two-phase flow often occurs in large channels. Thus, the fundamental knowledge of two-phase flow in large diameter pipes is especially important for the nuclear safety. A large diameter pipe is defined as a pipe whose diameter is larger than the maximum cap bubble size, which is proposed by Kataoka and Ishii [1] as

$$D_h^* = \frac{D_h}{\sqrt{\frac{\sigma}{g\Delta\rho}}} \geq 40 \quad (1)$$

where the D_h is the hydraulic diameter of channel, σ is the surface tension, g is gravitational acceleration, $\Delta\rho$ is the density difference between the liquid and gas phases. Once the flow channel diameter is larger than this critical size, the slug bubble bridging the entire channel can no longer exist due to the Taylor instability, which results in the disintegration of large cap bubbles and induces three-dimensional recirculatory behaviors [2]. Therefore, the bubble behavior, void fraction and velocity profiles in large pipes can be very different from those in small pipes, in which slug bubbles can be sustained. These changes cause different physical mechanisms of gas and liquid transport, implying the models developed for small-diameter pipes may be no longer applicable for large diameter channels [1]. The capability to accurately predict the two-phase flow in large channel system is extremely important for nuclear safety.

The drift-flux model [3,4] and the two-fluid model [5] are two most commonly used models to formulate a general transient two-phase flow problem. Compared with the rigorous two-fluid model, the drift-flux model is an approximate formulation but can provide acceptable prediction accuracy with much less computational efforts. In addition, the one-dimensional two-fluid model requires a drift-flux relation as a constitutive equation to calculate the area-averaged relative velocity for the interfacial drag, and the advanced computer codes typically used in the nuclear system analysis, such as RELAP and TRACE, are based on one-dimensional form of the two-fluid model. Therefore, a complete set of drift-flux models covering various flow systems and geometries is necessary for the accurate prediction of these codes.

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Concurrent Bubbly Flow In Large Diameter Vertical Pipe Experimental And Analytical Study

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Multiphase Flow 1995 A. Serizawa,T. Fukano,J. Bataille,2012-12-02 There is increasing world wide interest in obtaining an understanding of various multiphase flow phenomena and problems in terms of a common language of multiphase flow This volume contains state of the art papers which have been contributed from all over the world by experts working on all aspects of multiphase flows The volume also highlights international technology sharing in the fields of energy environment and public health in order to create a brighter and sustainable future for man and for all life in the next century It is intended that this volume will serve as a major source of literature for the advancement of multiphase flow and allied fields *SPE Production & Facilities* ,1998 *Theoretical Chemical Engineering Abstracts* ,1986 *Petroleum Abstracts* ,1992

Applied Mechanics Reviews ,1973 *Fundamentals of Gas Lift Engineering* Ali Hernandez,2016-02-18 Fundamentals of Gas Lift Engineering Well Design and Troubleshooting discusses the important topic of oil and gas reservoirs as they continue to naturally deplete decline and mature and how more oil and gas companies are trying to divert their investments in artificial lift methods to help prolong their assets While not much physically has changed since the invention of the King Valve in the 1940s new developments in analytical procedures computational tools and software and many related technologies have completely changed the way production engineers and well operators face the daily design and troubleshooting tasks and challenges of gas lift which can now be carried out faster and in a more accurate and productive way assuming the person is properly trained This book fulfills this training need with updates on the latest gas lift designs troubleshooting techniques and real world field case studies that can be applied to all levels of situations including offshore Making operational and troubleshooting techniques central to the discussion the book empowers the engineer new and experienced to analyze the challenge involved and make educated adjustments and conclusions in the most economical and practical way Packed with information on computer utilization inflow and outflow performance analysis and worked calculation examples made for training the book brings fresh air and innovation to a long standing essential component in a well s lifecycle Covers essential gas lift design troubleshooting and the latest developments in R D Provides real world field experience and techniques to solve both onshore and offshore challenges Offers past and present analytical and operational techniques available in an easy to read manner Features information on computer utilization inflow and outflow performance analysis and worked calculation training examples **Japanese Technical Abstracts** ,1988 **Petroleum Abstracts. Literature and Patents** ,1988 *Nuclear Science Information of Japan. Oral Presentation* ,1995 **Japanese Technical Periodical Index** ,1987

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In a digital era where connections and knowledge reign supreme, the enchanting power of language has be more apparent than ever. Its power to stir emotions, provoke thought, and instigate transformation is actually remarkable. This extraordinary book, aptly titled "**Concurrent Bubbly Flow In Large Diameter Vertical Pipe Experimental And Analytical Study**," written by a very acclaimed author, immerses readers in a captivating exploration of the significance of language and its profound effect on our existence. Throughout this critique, we will delve to the book is central themes, evaluate its unique writing style, and assess its overall influence on its readership.

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