西安交通大学学术专著丛书

管路内气液两相流特性及其工程应用

林宗虎 著

西安交通大学出版社

XI'AN JIAOTONG UNIVERSITY SERIES

Characteristics of Gas-Liquid Two-Phase Flow in Pipelines and Their Engineering Applications

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作者简介

林宗虎，浙江省吴兴市人，1933年生，1957年交通大学锅炉专业研究生毕业。1980～1982年曾任美国迈阿密大学访问教授。现为西安交通大学能源系锅炉教研室教授，热能工程专业博士导师，中国电机工程学会锅炉专业委员会副主任，陕西省计量测试学会副理事长，陕西省工程热物理学会副理事长，美国《国际工程流体力学》学术期刊国际顾问，美国荣誉性科研学会“Sigma Xi”学

会正会员。1988年被授予“国家级有突出贡献中青年专家”称号，1989年被授予“陕西省优秀科技工作者”称号。其专长为热能工程，多相流体力学及其测量与沸腾传热。主要著作已出版的有《气液固多相流测量》、《强化传热及其工程应用》、《气液两相流和沸腾传热》、《锅内过程》、《锅炉手册》、《计量测试技术手册力学分册(压力、真空、流量)》、《大型电站锅炉锅内传热和水力特性》和《管路内气液两相流特性及其工程应用》；与国外学者 N. P. Cheremisinoff 和 S. Kakac 教授合著的著作有 Encyclopedia of Fluid Mechanics Vol. 3和 Boilers, Evaporators and Condensers。在国内外已发表的有关热能工程、多相流体力学、沸腾传热、强化传热和多相流测量方面的论文有50余篇。其科研成果曾多次获得国家级及部委级奖：1985年得到国家教委科技进步二等奖，1986年得到国家教委科技进步二等奖，1987年得到国家教委科技进步一等奖，1988年得到国家自然科学三等奖。此外，还曾得到陕西省高校科研一等奖两次，并有三项成果分别被批准为三项中国专利。

ABOUT THE AUTHOR

Lin Zong-hu is professor of the Energy and Power Engineering Department, Xi'an Jiaotong University. He also serves as the vice chairman of the Engineering Thermalphysics Society of Shaanxi Province, the vice chairman of the Metrology and Measurement Society of Shaanxi Province, the vice director of the Chinese Electric Engineering Society Boiler Division and the Advisor of the International Journal of Engineering Fluid Mechanics (published in U. S. A.) etc. 。

Professor Lin graduated from the Graduate School of Jiaotong University in 1957 and has worked in Xi'an Jiaotong University since then.

He has published widely in fields of two-phase flow, heat transfer and boiler design, among them the following seven books written by him alone or acted as the first author have been published: Gas-Liquid Two-Phase Flow and Boiling Heat Transfer (1987); Heat Transfer Augmentation and Its Engineering Application (1987); Measurement of Multiphase Flow-Gas, Liquid and Solid Particles (1988); Handbook of Boilers (1988); The Internal Process of Boilers (1990); Handbook of Metrology and Measurement Techniques--Flowrate, Vacuum and Pressure (1991); Characteristics of Gas-Liquid Two-Phase Flow in Pipelines and Their Engineering Applications (1991).

He has also made important contributions in many other books, such as: Characteristics of Hydrodynamic and Heat Trasfer in Large Utility Boilers (1978), Encyclopedia of Fluid Mechanics Vol. 3 (1986 published in U. S. A.), Boilers Evaporators and Condensers (1991 published in U. S. A.) etc..

Besides, he has published more than 50 papers in the above mentioned fields.

Prof. Lin's scientific research work is fruitful. Up to now he has obtained the third award of the National Natural Science once; the first award of Scientific Research given by the National Educational Committee once; and the second award of Scientific Research given by the National Educational Committee twice etc..

Some of his research results have been approved to be three Chinese Patents.

On account of Professor Lin's achievements, he has obtained the title of "The National Class Specialist with Distinguished Contributions" given by the goverment since 1988 and the title of "The Excellent Scientific Researcher of Shaanxi Province" since 1989.

“西安交通大学学术专著丛书”出版说明

“西安交通大学学术专著丛书”是西安交通大学学术专著出版基金委员会支持的学术著作系列书。

“西安交通大学学术专著丛书”的作者主要是我校教师和海内外校友。它对学术专著的要求是：内容的主题必须是著作者本人或与合作者一起的研究成果，具有鲜明的特色和独特的见解或方法，推进或补充了前人在某学科领域的创造，达到国内外先进水平。投来的书稿由基金委员会聘请校内外学者、教授、专家若干人认真评审，复经基金委员会（由校长聘请若干名教授组成）严肃讨论并最后采取无记名投票方式裁定。

学术著作的水平，是一个国家、一个民族科学文化水平的标志之一。它不仅代表了一定的学术文化水平和理论深度，而且其中蕴

含着丰富的潜在生产力。"西安交通大学学术专著丛书"是反映我校较高学术水平和科研水平的一个窗口，也是我国学术海洋的一朵浪花。涓涓的细流汇入浩瀚大海，让我们为伟大祖国的学术繁荣，四个现代化的突飞猛进共同努力吧！

A PUBLICATION DESCRIPTION OF TECHNICAL WRITING SERIES OF XI'AN JIAOTONG UNIVERSITY

"Xi'an Jiaotong University Series" is a set of technical writings supported by a publication fund from Xi'an Jiaotong University.

"Xi'an Jiaotong University Series" is intended to publish technical writings of teaching staff and alumni both at home and abroad. It is required that the writings to be published should be individuals' or co-partners' scientific investigations and research results with obvious peculiarities, originative viewpoints and methods, which may enhance and supplement predecessors' creativeness in some field, and which have reached national or world advanced levels. Any manuscript sent to the University Press will first be conscientiously evaluated by scholars, professors and experts inside and outside the university, who are invited by the Fund Commission. Then, it will be re-examined strictly by the Fund Commission itself which is made up of a few distinguished professors appointed by the president. And finally, whether the manuscript may be published or not will be decided by ballot.

The merit of technical writings signifies one of the scientific and cultural levels of a country and of a nation. It is not only the sign of a

certain level of technical culture but also theory in depth, and it embod ies abundant potentialities of the productive forces as well . " Xi' an Jiaotong University Series" may serve as a window from which to get a glimpse of the excellences of higher academic and scientific researches taking place at our university. It also reflects that "Xi' an Jiaotong University Series" seems to be like a tiny drop of water in waves that flows into vast oceans of millions of books published all over China . We are now striving for academic prosperity in our great country and making efforts to stride with rapid steps in the four moderrizations.

内容简介

气液两相流是流体力学的一个分支。近40年来，由于工业发展的需要而得到了迅速的发展。这门学科对于动力、化工、核能、制冷、石油和冶金等工业的设备设计、研制和运转均具有重要用途。

本书作者林宗虎教授长期从事气液两相流及沸腾传热方面的研究工作，成绩卓然。曾被授予“国家级有突出贡献专家”等称号。他的研究成果，其中有不少项目得到国家级及部委级奖励，有些已被国家标准采用，或被批准为中国专利。

本书是一本学术专著。主要论述了作者近30年来，在气液两相流体力学及沸腾传热方面，做出的系统而丰硕的研究成果。其中包括气液两相流的管内摩擦阻力研究；截面含气率研究；气液两相流局部阻力研究；气液两相流体流过孔板和文丘利管时的流阻计算方法研究；多通道管件中两相工质分配均匀性及阻力研究；U 型管、直管及各种强化传热管中气液两相流体脉动流动试

验研究;气液两相流体的脉动传热及过冷沸腾传热研究;应用气液两相局部阻力特性来测量两相流量和干度的方法研究;以及气液两相流理论在工程中的其它应用等。本书可供高等院校有关专业师生、广大的工程技术人员和研究人员参考应用。

A BRIEF INTRODUCTION OF THE BOOK

Gas-liquid two-phase flow is a branch of the fluid mechanics . In the past 40 years, due to the requirements of the developements of industries, this branch developes rapidly. Two-phase flow theory is very important and can be applied to the design, research and operation of apparatuses of many engineering systems, such as power plants, chemical industry, nuclear energy industry, refrigeratory industry, petroleum industry and metallurgical industry.

The author of this book, Professor Lin Zong-hu is a well-known scientist in the fields of power engineering, two-phase flow and two-phase flow measurements . He has engaged in the research and teaching work of gasliquid two-phase flow and boiling heat transfer for a long time and has obtained a lot of fruitful achievements in scientific research . He has been conferred the titles of "National class specialist with distinguished contributions" and "The outstanding researcher of Shaanxi Province", Many of his achievements have obtained the national class scientific award, the scientific award of National Educational Committee etc. and some of them have been accepted by the national standard or approved as Chinese Patents.

This book is an academic monograph which expresses the abundent and systematic research achievements in gas-liquid two-phase flow and boiling heat transfer field obtained by the author within recent 30 years .

In this book the following contents are included: the investigation of gas-liquid two-phase frictional pressure drop in a tube, the investigation of gas void fraction, the investigation of gas-liquid two-phase minor losses, the investigation of pressure drops due to gas-liquid two-phase fluid passing through orifices or venturis, the investigation of two-phase working medium distribution characters and minor losses

of multi-channel pipe elements, the investigation of gas-liquid two-phase oscillating flow in U type tubes, straight tubes and various tubes with heat transfer enhancement techniques, the study of boiling heat transfer in oscillating flows and subcooled boiling heat transfer in stable flows, the study of two-phase flow rate and two-phase contents measurements by using characteristics of two-phase minor losses and other engineering applications of gas-liquid two-phase flow theories, These contents not only promote the developement of the gas-liqid two-phase flow theories, but also can be applied to many engineering practices.

This book is an excellant academic monograph and applies to teachers and students of universities or researchers and engineers of relevant specialities.

前　言

自1962年我的第一篇有关气液两相流的论文发表以来，近30年过去了。本书论述的内容主要是，在此期间我和协同人员所取得的有关管路内气液两相流方面的研究成果。这些成果大多达到国际水平，有些达到国际先进水平。

这些成果内容广泛且富有系统性。其中包括气液两相流管内摩擦阻力研究；截面含气率研究；气液两相流局部阻力研究；气液两相流体流过孔板和文丘利管时的流量计算方法研究；多通道管件中两相工质分配均匀性及阻力研究；U 型管、直管及各种强化传热管中气液两相流体脉动流动的试验研究；气液两相流体的脉动传热及过冷沸腾传热研究等。并根据气液两相流体局部阻力特性，研究出气液两相流体的流量及质量含气率的测量方法多种。这些

成果，不仅发展了气液两相流体力学理论，而且具有重要工程实用意义。

在完成本书论著时，我应该感谢我的导师中国科学院学部委员陈学俊教授，我的同事陈立勋教授，我的研究生郑亦朋、王栋、张旭、车得福、毕勤成、耿生斌、赵剑云和符小林等。此外，我还应对美国迈阿密(Miami)大学的魏齐鲁格罗(Veziroglu, T. N.)教授，李世泽(Lee, Samuel S.)教授，卡卡奇(Kakac, S.)教授和曼特斯(Mentes, A)博士等深表谢意。因为这些研究成果不少是和上述各位一起协同获得的，是和他们的支持、帮助和合作分不开的。

在得出这些研究成果时，作者得到了中国国家自然科学基金会、美国国家科学基金会、胜利油田和上海锅炉厂等单位的支持和资助，作者在此表示衷心感谢。

我还应感谢西安交通大学学术专著出版基金委员会各位成员，对他们在本书的出版过程中所给予的支持与帮助，表示由衷的感谢。

西安交通大学能源系教授
林宗虎
1991年1月于西安

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