FLUID MECHANICS,
HEAT TRANSFER, AND
MASS TRANSFER
Practice of Science is Engineering
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Professor K. S. N. Raju has presented the technical community with an interesting, valuable, and unique book on the practice of chemical engineering in the broad areas of fluid mechanics, heat transfer, and mass transfer. Based upon his five decades of experience as an educator, researcher, and consultant, Professor Raju has chosen to adopt the question–answer format.

Consider, for example, an engineer faced with the analysis and design of a fired heater. This book on chemical engineering practice immediately answers design questions such as how the tubes are arranged in the furnace and how many rows are usually provided and also the rationale for the optimum design choice. In addition, the book introduces the theoretical background of radiant heat transfer by explaining concepts such as emissivity and absorptivity and key design relationships like the Stefan–Boltzmann equation and Kirchoff’s law. Finally, this thorough book presents and resolves operational issues, for example, hot spots, high-temperature creep, corrosion, and tube life. Professor Raju’s book equips the practicing engineer with the tools to design a fired heater as well as to diagnose and resolve operational problems.

Radiant Heat Transfer is one of the eight chapters in the section on Heat Transfer, which cover the theory and application of heat transfer in the process industries. In addition to Heat Transfer, the book has two other sections, Fluid Mechanics and Mass Transfer. Each section introduces the theoretical background, describes the applications and equipment, and anticipates and resolves operational issues. The Mass Transfer section introduces underlying concepts (phase equilibria, mass transfer coefficients, correlations involving dimensionless numbers, polymorphic structures), describes applications (absorption, distillation, crystallization, adsorption), and equipment (tray and packed columns, crystallizers, dryers, and membrane modules), and anticipates and resolves operational issues (column flooding, liquid inclusion in crystals). It will be difficult to find an area in the chemical process industries not covered in this comprehensive book!

While this book is wide in scope, it is also quite detailed. As an example, an engineer who drills down into the chapter on crystallization will learn about the factors that restrict the productivity and purity of crystals (agglomeration, liquid impurities inside and outside the crystals, cavitation).

Professor Raju has structured his book in the question–answer format, which he feels stimulates interest in the subject matter and focuses attention on specific topics. I completely agree. As I read the book, I found that it precisely explained concepts and applications in areas where I have some expertise, and also sparked my interest and gave me new understanding in subjects outside my specialization.

The style, structure, preciseness, and clarity of Professor Raju’s book are a reflection of his five decades of experience as an educator, researcher, and consultant. As an educator, he has taught graduate and undergraduate students, created and delivered on-site courses for industry, and developed and nurtured new chemical engineering departments. He has published over 90 papers in international journals. His consultancy has covered the chemical, petroleum, petrochemical, and fertilizer industries and government organizations. Professor Raju’s students report that his teaching style was always practical, focusing on solving real-world problems rather than just teaching a concept; he invariably used examples from his extensive
experience to help students understand chemical engineering problems. That practical teaching style is clearly evident in this book.

*Fluid Mechanics, Heat Transfer, and Mass Transfer: Chemical Engineering Practice* is intended as a text book to undergraduate and graduate students and a reference book for practicing engineers in the chemical process industries. I plan to keep a copy handy as a reference to understand and resolve new technical issues I am confronted with.

PAUL M. MATHIAS

*Fluor Corporation*
*Irvine, California*
PREFACE

The book is intended for use by students at undergraduate and graduate levels, faculty in Chemical Engineering Departments across the world, working and consulting engineers in areas such as petroleum refineries, petrochemical, gas processing and fertilizer plants, design organizations, food and pharmaceutical processing, environmental engineering, and the like. The book is also useful to mechanical engineering students and faculty.

The book is written with emphasis on practice with brief theoretical concepts in the form of Questions and Answers, bridging the two areas of theory and practice with respect to the core areas of chemical engineering.

The author considers that the question–answer approach adopted stimulates interest in the subject matter and focuses attention to specific topics in a better and concise manner than running matter given in normal text and reference books.

The approach was used by the author in the classroom for several years, spanning a period of over four decades. Feedback from faculty, students, alumni, and practicing engineers in several institutions/organizations appreciated this approach when the author used this approach during continuing education and training courses, besides classroom instruction. This prompted the author to embark upon writing this book.

The book is an attempt to bridge the gap between theory and practice in a balanced manner, so that it will be easy for students and academics to get a grasp of practice and industry personnel to understand theoretical concepts necessary to appreciate the genesis involved in practice.

At the teaching level, the book is suitable for different courses involving fluid mechanics, heat transfer, mass transfer, and membrane technology as well as design courses at both undergraduate and graduate levels. The author considers it to be useful in design project work by students and others. It can be used as a textbook and/or a reference book.

In the market, there is no such book in these areas linking theory with broad practical aspects and to this effect it is original in nature with almost no competitors on the subject. It avoids referring to several text and reference books, to get information on specific topics/content.

The vast literature available in the form of articles in chemical engineering magazines, monographs, and manufacturers literature has been used in its preparation along with the active interaction of the author with practicing world over a period spanning nearly five decades.

To summarize, features include emphasis on practical aspects in the learning process for students and faculty and ease and convenience in the use of the theoretical and practical aspects of the subject in the practice of professional engineers.

Question–answer approach focuses on individual topics in a more effective way than the normally used running matter in textbooks. Adds to learning process, creating better interest among students, faculty, and others for whom time factor is important.

Involves the core areas of chemical engineering and fulfills the need for a single source, avoiding the requirement of using several books, articles, and other sources for the topics covered in the book.

The core areas of fluid mechanics, heat transfer, mass transfer, and membrane processes are covered in the book in a balanced way, avoiding making the book bulky and unwieldy in its use.

Most parts of the book are easily understandable by those who are not experts in the field. For example, it covers types on pumps, valves, process equipment, membranes, and areas of their use, their merits, and drawbacks and selection in a simple way.
No author of any book, other than those written as purely research publications or biographies, can claim the contents of their books as original contributions by them. To this extent, the author admits that the book is a collection and compilation of the material available in literature with the interpretations and comments by the author and acknowledges the individuals and groups of pioneers who contributed to the evolution of the subject matter over centuries. The author wishes to dedicate the book to all such pioneers who contributed to the evolution of chemical engineering as a profession.

K. S. N. RAJU
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Encouragement and support received from Sri K. V. Vishnu Raju, Chairman, Sri Vishnu Educational Society, Faculty, Associates, Alumni, and Students from Panjab University, B. V. R. Institute of Technology, B. S. University of Technology, Libya, and several other institutions provided the necessary motivation to write the book, which the author wishes to acknowledge.

Comments from several individuals, who include Dr. J. M. Alford, Chairman of AIChE New Books Committee, Peer Reviewers, Academic and Industry Professionals, and scores of others, have been valuable and the author duly acknowledges their inputs.

Involvement and review of the content of the book by Dr. Paul M. Mathias of Fluor Corporation, who happened to be one of the authors to *Perry’s Chemical Engineers’ Handbook*, has been particularly valuable. He has been very considerate in offering valuable suggestions and comments during the process of preparation of the book. He readily agreed to write Foreword for the book unhesitatingly. The author is very much indebted to him.

Ms. Haeja Han of AIChE, Bob Esposito, Michael Leventhal, and Rosalyn Farkas of John Wiley, Sanchari Sil and Joseph Varghese of Thomson Digital and others at AIChE and John Wiley have been very helpful in processing the contents of the book and making it more presentable. Special appreciation is due to all of them. The author duly acknowledges the help received from D. V. S. S. Prasad of Shanna Technologies (India) Private Limited, Srinivas Vadla and their Associates in Graphics Work.

Patience and tolerance by my wife Bangaramma, computer and other inputs by my son Prasad, daughter Anuradha, granddaughter Suhasa, and daughter-in-law Usha have made me to accomplish my work and they deserve my appreciation.

K. S. N. RAJU
ABOUT THE AUTHOR

The author is a Retired Professor of Chemical Engineering with involvement in Chemical Engineering Education and Research covering graduate and undergraduate students for 50 years. Published over 90 papers and articles in International magazines and journals. Supervised Graduate Research at Doctoral and Post Doctoral levels. Acted as Reviewer for publications in International Journals and Magazines in Engineering, including the prestigious assignment by Applied Mechanics Reviews of American Institute of Mechanical Engineers for 3 years.

Delivered invited lectures on Plate Heat Exchangers at NATO Advanced Institute along with highly distinguished speakers at International level. This material appeared in the book form by Hemisphere Publishing Corporation, Washington D.C.

Gave Onsite Courses in industry, covering refineries, gas processing, petrochemical, and fertilizer plants with practice-oriented approach. Delivered lectures on several areas of chemical engineering to trainees and practicing engineers in petroleum and petrochemical industry and at International forums.

Involved in active interaction with industry taking up projects and executing them with the induction of graduate students on-site in selected industries.

Has been responsible for developing Chemical Engineering Departments at Panjab University, Chandigarh, India, B. S. University of Technology, Libya, and B. V. R. Institute of Technology, Andhra Pradesh, India.

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