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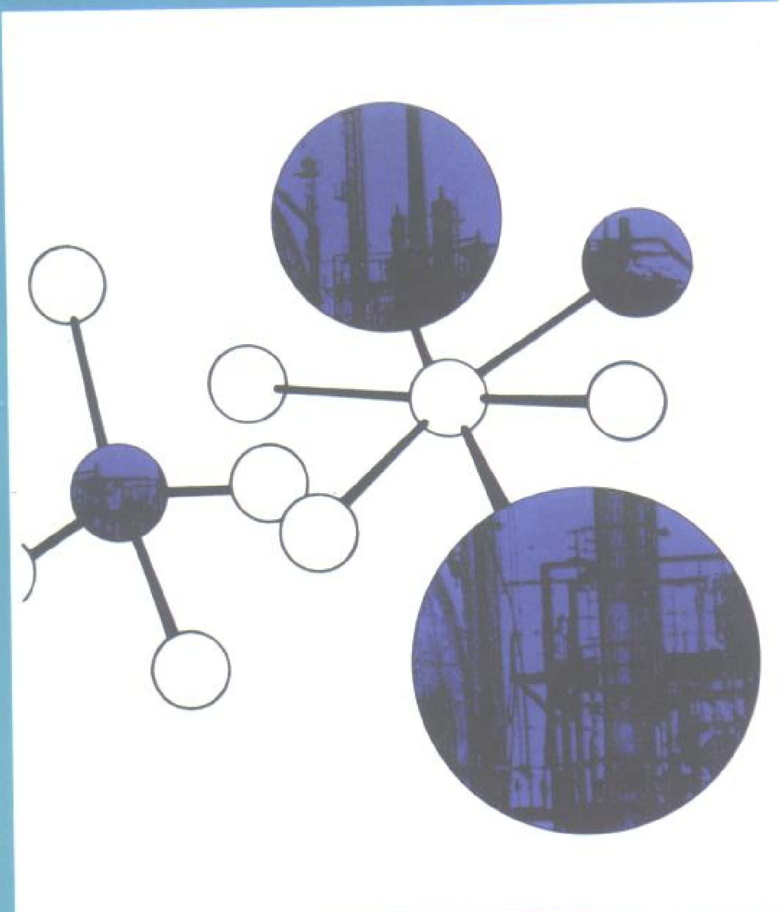

VOLUME 3

3

Chemical & Biochemical Reactors & Process Control

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Coulson & Richardson's

CHEMICAL ENGINEERING

VOLUME 3

THIRD EDITION

Chemical & Biochemical Reactors & Process Control

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CHEMICAL ENGINEERING

VOLUME 3

THIRD EDITION

Chemical & Biochemical Reactors & Process Control

Preface to Third Edition

The publication of the Third Edition of *Chemical Engineering* Volume 3 marks the completion of the re-orientation of the basic material contained in the first three volumes of the series. Volume 1 now covers the fundamentals of Momentum, Heat and Mass Transfer, Volume 2 deals with Particle Technology and Separation Processes, and Volume 3 is devoted to Reaction Engineering (both chemical and biochemical), together with Measurement and Process Control.

Volume 3 has now lost both Non-Newtonian Technology, which appears in abridged form in Volume 1, and the Chapter on Sorption Processes, which is now more logically located with the other Separation Processes in Volume 2. The Chapter on Computation has been removed. When Volume 3 was first published in 1972 computers were, by today's standards, little more than in their infancy and students entering chemical engineering courses were not well versed in computational techniques. This situation has now completely changed and there is no longer a strong case for the inclusion of this topic in an engineering text book. With some reluctance the material on numerical solution of equations has also been dropped as it is more appropriate to a mathematics text.

In the new edition, the material on Chemical Reactor Design has been re-arranged into four chapters. The first covers General Principles (as in the earlier editions) and the second deals with Flow Characteristics and Modelling in Reactors. Chapter 3 now includes material on Catalytic Reactions (from the former Chapter 2) together with non-catalytic gas–solids reactions, and Chapter 4 covers other multiphase reactor systems. Dr J. C. Lee has contributed the material in Chapters 1, 2 and 4 and that on non-catalytic reactions in Chapter 3, and Professor W. J. Thomas has covered catalytic reactions in that Chapter.

Chapter 5, on Biochemical Engineering, has been completely rewritten in two sections by Dr R. L. Lovitt and Dr M. G. Jones with guidance from the previous author, Professor B. Atkinson. The earlier part deals with the nature of reaction processes controlled by micro-organisms and enzymes and is prefaced by background material on the relevant microbiology and biochemistry. In the latter part, the process engineering principles of biochemical reactors are discussed, and emphasis is given to those features which differentiate them from the chemical reactors described previously.

The concluding two chapters by Dr A. P. Wardle deal, respectively, with Measurement, and Process Control. The former is a completely new chapter describing the various in-line techniques for measurement of the process variables which constitute the essential inputs to the control system of the plant. The last chapter gives an updated treatment of the principles and applications of process control and concludes with a discussion of computer control of process plant.

January 1994

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Preface to Second Edition

Apart from general updating and correction, the main alterations in the second edition of Volume 3 are additions to Chapter 1 on Reactor Design and the inclusion of a Table of Error Functions in the Appendix.

In Chapter 1 two new sections have been added. In the first of these is a discussion of non-ideal flow conditions in reactors and their effect on residence time distribution and reactor performance. In the second section an important class of chemical reactions—that in which a solid and a gas react non-catalytically—is treated. Together, these two additions to the chapter considerably increase the value of the book in this area.

All quantities are expressed in SI units, as in the second impression, and references to earlier volumes of the series take account of the modifications which have recently been made in the presentation of material in the third editions of these volumes.

Preface to the First Edition

Chemical engineering, as we know it today, developed as a major engineering discipline in the United Kingdom in the interwar years and has grown rapidly since that time. The unique contribution of the subject to the industrial scale development of processes in the chemical and allied industries was initially attributable to the improved understanding it gave to the transport processes—fluid flow, heat transfer and mass transfer—and to the development of design principles for the unit operations, nearly all of which are concerned with the physical separation of complex mixtures, both homogeneous and heterogeneous, into their components. In this context the chemical engineer was concerned much more closely with the separation and purification of the products from a chemical reactor than with the design of the reactor itself.

The situation is now completely changed. With a fair degree of success achieved in the physical separation processes, interest has moved very much towards the design of the reactor, and here too the processes of fluid flow, heat transfer and mass transfer can be just as important. Furthermore, many difficult separation problems can be obviated by correct choice of conditions in the reactor. Chemical manufacture has become more demanding with a high proportion of the economic rewards to be obtained in the production of sophisticated chemicals, pharmaceuticals, antibiotics and polymers, to name a few, which only a few years earlier were unknown even in the laboratory. Profit margins have narrowed too, giving a far greater economic incentive to obtain the highest possible yield from raw materials. Reactor design has therefore become a vital ingredient of the work of the chemical engineer.

Volumes 1 and 2, though no less relevant now, reflected the main areas of interest of the chemical engineer in the early 1950s. In Volume 3 the coverage of chemical engineering is brought up to date with an emphasis on the design of systems in which chemical and even biochemical reactions occur. It includes chapters on adsorption, on the general principles of the design of reactors, on the design and operation of reactors employing heterogeneous catalysts, and on the special features of systems exploiting biochemical and microbiological processes. Many of the materials which are processed in chemical and bio-chemical reactors are complex in physical structure and the flow properties of non-Newtonian materials are therefore considered worthy of special treatment. With the widespread use of computers, many of the design problems which are too complex to solve analytically or graphically are now capable of numerical solution, and their application to chemical engineering problems forms the subject of a chapter. Parallel with the growth in complexity of chemical plants has developed the need for much closer control of their operation, and a chapter on process control is therefore included.

Each chapter of Volume 3 is the work of a specialist in the particular field, and the authors are present or past members of the staff of the Chemical Engineering Department of the University College of Swansea. W. J. Thomas is now at the Bath University of Technology and J. M. Smith is at the Technische Hogeschool. Delft.

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