BOOK REVIEWS

Circulating Fluidized Bed Boilers: Design and Operations

By P. Basu and S. Fraser, 1423 pp.

This book is very useful for introducing engineers to the design and operation of circulating fluidized-bed (CFB) boilers and is probably the best book available for this purpose. It provides a reasonably comprehensive review of the state-of-the-art engineering design and application of circulating fluidized-bed boilers. One of the best features of this book is that it not only provides useful insight into the design and operation of the circulating fluidized-bed boiler, but it also provides readers with knowledge about air pollution, waste disposal, and materials selection. Although it contains a great deal of description and analysis of the phenomena associated with circulating fluidized-bed boilers, it lacks advanced mathematical formulation of the process. In view of recent advances in computation and numerical analysis, the mathematical description of the overall system including mass, momentum and energy equations and computational techniques is considered the state-of-the-art in circulating fluidized-bed process design.

Chapter 1 presents an excellent introduction to circulating fluidized-bed boilers with a strong emphasis on features, application and advantages of circulating fluidized-bed systems in different areas.

Chapter 2 includes reviews of fluidization and hydrodynamics which are treated empirically with a significant emphasis on cluster formations and their roles. Although radial distribution and solid mixing are discussed, this chapter primarily describes one-dimensional (plug flow) behavior.

Chapter 3 includes a clear description of the heat-transfer mechanism in circulating fluidized-bed boilers and empirical correlations for heat-transfer parameters.

Chapter 4 explains clearly combustion of coal particles, devolatilization, char combustion and behavior of particles in circulating-bed combustion, particularly in the illustrated examples. It also includes phenomena that affect combustion such as particles collision and attrition. However, this chapter lacks a detailed discussion of agglomeration and slag formation which are important phenomena during the combustion process.

Chapter 5 discusses emission and gaseous pollutants such as SO_x, NO_x, CO and HC, with their standards, which are emitted during combustion. Although this chapter includes very useful information, much more has been developed in the literature, particularly in sulfur removal, which is not included.

Chapter 6 provides essential tools and major steps involved in the design of circulating fluidized-bed boilers using available correlations with a good illustrative example at the end.

Chapters 7 and 8 present available basics of engineering design and correlations essential to design different components of circulating fluidized-bed systems including cyclone, internal separators, nonmechanical valves (solid feed system) and gas distributors. The discussions are very clear and demonstrate state-of-the-art fundamentals of engineering design available in the literature. Furthermore, the chapters examine the relevance of different associated components to the operation of the CFB boilers.

Chapter 9 describes the nature of excess solid waste produced by CFB boilers with SO_x emission control and suggests possible utilization and disposal of the solid waste. This chapter is one of the best features of this book. In addition to the design of the system, it educates the readers about an important environmental consideration.

Chapter 10 briefly discusses materials selection criteria and possible associated problems such as erosion and corrosion. It introduces readers to an important issue of different materials and their roles and makes an engineer aware of potential problems.

In summary, the book provides engineers and undergraduate students with insight into the design and operation of CFB boilers with brief discussion of important environmental issues and materials selection. Although more advanced design tools and a more mathematical approach are more suitable for graduate students and researchers in this area, this book offers all readers a basic understanding of concepts, application and many aspects of CFB boilers.

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Diffusion in Zeolites (and Other Microporous Solids)

By Jörg Kärger and Douglas M. Ruthven, Wiley, New York, 1992, 605 pp.

Since the invention of the low (near-ambient) temperature route to their synthesis in the 1950s, zeolites have found major and widespread industrial applications, first in adsorptive separation/purification and shortly thereafter in catalysis. In the main applications being practiced today, such as air (O_2/N_2) separation, hydrogen purification, and fluid catalytic cracking, diffusional limitations to intracrystalline mass transfer generally have a negative effect and hence are referred to as a "resistance." A better understanding of the pore diffusion processes could lead to better designs of sorbents and catalysts. In a few situations, diffusional resistance is exploited to achieve the desired separations (for example, kinetic separations of air and CO_2/CH_4) or to control the desired cat-

alytic product selectivity (for example, the use of ZSM-5 for xylene isomerization and the methanol-to-gasoline process). However, the present ability to capitalize on diffusion effects clearly falls short of its potential; many more industrial applications could be realized if the diffusion process were better understood. For these reasons, diffusion in zeolites has been the focus of a considerable body of research. Various aspects of this work have been covered previously by chapters and reviews appearing in various books and journals. The time is ripe for an entire book such as this one to be dedicated to the subject.

Because of the interdisciplinary nature of the subject, one of the goals of the book, as stated in the Preface, was to bridge the gap between theoreticians and experimentalists, and between scientists and engineers. This goal has apparently been achieved as a result of the collaboration between two authors having very different backgrounds.

The book comprises an introductory chapter and 16 subsequent chapters grouped into four parts as follows:

Part I:
Theory of Diffusion in Microporous Solids
Part II:
Measurement of Diffusion in Microporous Solids
Part III:
Diffusion in Selected Systems
Part IV:
Diffusion Controlled Processes

The first four chapters (Introduction and Part I) cover both molecular and continuum theories. The bulk of Chapters 5-7 (in Part II) is devoted to an authoritative discussion of the measurement of diffusivity by NMR techniques. The NMR techniques are "microscopic" that measure the diffusivity within the crystal of the zeolite. Chapters 8-10 (also in Part II) discuss more traditional "macroscopic" methods for measuring diffusivity, including uptake, steady-state and transient measurements, and chromatographic techniques. The next five chapters, which form Part III, are probably the most useful part of the book to the practitioner, because they address the diffusion in different zeolites and molecular sieve carbon. These include three chapters each covering diffusion in one of the three types of zeolites: A, X (and Y) and ZSM-5. Chapter 15, under the heading "Selected Topics," is an interesting chapter; it speculates on the possible reasons for the observed discrepancies between the diffusivities measured by the NMR techniques and those measured by the macroscopic techniques. This problem was apparently the matchmaker that initially stimulated the two authors to collaborate on the book. The last two chapters (Chapters 16 and 17, forming Part IV) summarize catalytic and separation processes in which diffusion plays a role.

The book is comprehensive, and in fact, tends to be overly exhaustive in some places. There are, however, two subjects that could have used more coverage: binary/multicomponent diffusion and molecular dynamics simulation. It is known that the multicomponent effects are very significant for diffusion in zeolites as manifested in the large magnitude of the cross-term diffusion coefficients. Discussions on this topic are scattered throughout the book, totaling about only ten pages. Because of the importance of the subject, a separate chapter dedicated to it would have been more desirable. Molecular dynamics simulation receives a five-page coverage. It would have been a good idea to invite a guest author who works in this area to address this topic. It is worth noting that these two subjects are moving rapidly and that much work has been done since the authors completed the book in January, 1991. The experimental techniques are discussed in great detail—taking up over 200 pages. However, there is only one page on the differential adsorption bed (DAB) technique. The DAB technique is a most powerful and versatile method for measuring mixture diffusion; it can also provide equilibrium as well as information on pure components. Moreover, the initial contribution by Habgood on this technique (published in 1958) is not mentioned.

Despite these minor criticisms, as a whole, it is indeed an excellent reference book. The authors should be commended for undertaking such a monumental effort in producing this text. No doubt, it will serve as an essential reference for anyone interested in diffusion in zeolites.

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Dynamic Modeling of Transport Process Systems

By C. A. Silebi and N. E. Schiesser, Academic Press, 1992, 518 pp.

This book is apparently the outgrowth of notes for a second-semester, third-year course in chemical engineering at Lehigh University. It is proposed as a text for such courses as well as for use by analysts and researchers outside as well as inside chemical engineering.

Transient problems of increasing complexity are generally described first in purely mathematical terms and then illustrated with one or more physical examples. The mathematical descriptions of physical problems are derived in great detail, with particular attention to attaining correct signs and consistent units from term to term. Surprisingly, all of the problems are solved in dimensional terms; dimensional analysis and dimensionless forms are not utilized.

Methods of integration are discussed in varying detail before referring to standardized computer programs prepared by the authors or others. Their own programs are fully documented in the Appendices as are programs to call subroutines such as the well-known LSODE and DASSL for stiff ordinary differential equations (ODEs). The software discussed and utilized in the book is said to be available on diskette from the authors for use with a FORTRAN 77 computer. Programs for the 200 applications listed in the Appendix are also said to be available from the authors in the same format. The charges, if any, for these necessary complements of the book are not specified.

The first of three chapters describe Euler's method and Runge-Kutta algorithms for ODEs. A good case is made for using error control to select the step size in time. The transient level in a tank with inflow and outflow, and the transient composition in a continuous, perfectly mixed, isothermal reactor with a first-order reaction are used for illustration.

Stability analysis is introduced in the fourth chapter, primarily in the framework of stiffness. Backward differentiation formulas are first discussed. The LSODE and DASSL integrators are then introduced and applied. Details of these two codes are not provided. Patience in waiting for a discussion of the qualifications and limitations of various procedures is usually rewarded, but not with