The Engineering of Chemical Reactions

By Lanny D. Schmidt, Oxford University Press, New York, 1998 536 pp., $75.00.

Professor Schmidt has made an important contribution to the chemical engineering profession with the publication of his textbook on chemical reaction engineering. The book breaks new ground in two important ways. First, it fully integrates analyses of industrial reactions and reactors into the presentation of fundamental principles of reaction engineering. Secondly, it includes a substantial treatment of chemistry and chemical kinetics, which is lacking in most undergraduate reaction engineering texts.

By incorporating descriptions of industrial reactions and reactors into a text on chemical reaction engineering, Dr. Schmidt has successfully combined the qualitative material that traditionally had been presented in courses on "Industrial Chemistry" with the rigorous mathematical analyses traditionally presented in courses on reaction and reactor engineering. The traditional reaction engineering analyses benefit from the practical examples, and the rationale behind industrial processes becomes more apparent to students when the designs are subjected to reaction engineering analyses.

Chemistry and chemical kinetics are incorporated into the text through many examples, and the traditional focus on single step, elementary reactions $(A \Rightarrow B)$ is replaced by more realistic exampls. The variety of topics covered is impressive, ranging from petroleum refining and chemical manufacturing to biotechnology and environmental chemistry.

Although the text is innovative, instructors will find the organization familiar. After an introductory chapter (Chapter 1), the text begins with a treatment of reaction rates and batch reactors (Chapter 2). This is followed by the traditional treatment of continuous, stirred-tank reactors and plug-flow, tubular reactors in Chapter 3. Chapter 4 covers complex reaction networks, and

Chapter 5 covers nonisothermal reactors. Each of these chapters includes descriptions of relevant industrial processes.

In Chapter 6, Dr. Schmidt presents multiple steady-state and transient behavior. In most reaction engineering texts, this material is relegated to a chapter on specialized topics. Schmidt, however, makes a convincing case for the importance of heat management in reactor design, justifying the prominence given to this highly mathematical material. Chapter 7 concludes the presentation of reaction engineering fundamentals with a discussion of catalytic reactors and mass transfer.

Chapters 8–12 deal with specific applications, including bioreactors, environmental modeling, reactions of solids, combustion reactions, reactor safety, polymerization reactions, and multiphase reactors. These chapters are designed so that the instructor may choose to present any or all of the material.

The text is written in a very readable style. The problems at the end of the chapters are numerous, and involve both analytic and numerical solution procedures. The problems requiring extensive computation are written in a manner such that they can be solved using any of a variety of software packages, and an Appendix provides introductory material for a number of common equation solvers. My only quibble with the text is the referencing procedure. The references are collectively presented at the end of the first chapter, and are not cited individually. This may make it difficult for instructors to present more detailed analyses of the industrial technologies presented throughout the book. Overall, however, Dr. Schmidt has created a wonderful text. He has weaved the fundamentals of chemical reaction engineering together with the history and practice of chemical manufacturing. The result is a new direction and a new standard for chemical engineering texts.

David T. Allen
Chemical Engineering Dept.
The Unviersity of Texas at Austin
Austin, TX 78712

Rheology of Polymeric Systems, Principles and Applications

By P. J. Carreau, D. C. R. De Kee, and R. P. Chhabra, Hanser/Gardner Publications, Cincinnati, OH, 1997, 520 pp., $197.50.

This book is an extended compilation covering many topics that are somehow (that is, more or less directly) related to polymer rheology. In other words, the book does not focus on any specific aspect of rheology, and, rather, attempts at covering them all. Thus, although the book lacks in depth, it contains, altogether, many pieces of information not readily available in other books with similar titles. It should also be clear that the book is written by chemical engineers and is directed to chemical engineers, in the most traditional fashion. That is to say, the modern approach to polymer rheology taken mostly (but not exclusively) by theoretical physicists is not followed in this book.

After a generic introduction in Chapter 1, the second chapter starts with the definition of material functions and goes on with an extended list of constitutive relationships for the viscosity in steady shear, many of which were contributed by, and named after, one or more of the authors. Chapter 2 ends with a discussion on the effect of temperature, pressure, and molecular weight on shear viscosity. Here, what had been a regular and smooth chapter ends in a somewhat surprising way. Indeed, to explain the famous 3.4 power law of η vs. M in the entangled state, the authors choose to refer to an old argument by Bueche (1952), which, unfortunately, happens to be wrong. The authors seem to ignore completely (at least here) well-known modern concepts like reptation and tube length fluctuations.

Chapter 3 on rheometry is standard as far as shear flows are concerned. We find the capillary, concentric cylinders, cone-and-plate, and concentric disk geometries. There is also a brief section on yield stress determination, while elongational flows are not considered in this chapter. A short discussion on elongational measurements can be found in the previous chapter in con-

junction with the definition of the material functions of elongational flows. Chapter 4 is on transport phenomena in simple flows. It contains the solution for velocity and pressure profiles in simple geometries for power-law fluids, as well as heat and mass transfer to laminar flows of the same fluids. Here, the reader finds ample material to learn that most solutions of transport problems to constant-viscosity fluids in laminar flow can readily be extended to the case of non-Newtonian fluids as long as the viscosity dependence on shear rate is described by a power law.

Chapters 5 and 6 are devoted to linear and nonlinear viscoelasticity, respectively. Linear viscoelasticity is dealt with by using the traditional springs and dashpots. The chapter ends with the time-temperature superposition concept, and the WLF equation that goes with it. Chapter 6 is a long chapter. It starts with the concept of large deformations that the authors choose to describe by using Lodge's embedded coordinates. Thus, we find all the heavy symbolism of the covariant and contravariant metric, and so on. For further calculations, the authors refer to Appendix A which contains all the mathematical ingredients popular among rheologists of the 1960s and 1970s, such as the Christoffel symbols of the first and second kind. The chapter goes on by introducing specific deformations like the uniaxial and planar elongations, the expansion or compression, and simple shear. Here, inexplicably, the uniaxial elongation is taken to be synonymous with pure deformation. Then, the general requirements to be fulfilled by a constitutive equation (like the material objectivity) are stated and, finally, a long list of constitutive equations is presented, of both the differential and the integral form. Along the way, the authors also discuss a couple of flows of technological interest, like the journal bearing and the spinning line. We essentially agree with the concluding remarks made by the authors at the end of the chapter. They point out that the numerous equations previously described "... constitute only a small selection of constitutive equations which have been proposed in the literature ...". This state of confusion (my choice of words) will perhaps improve by virtue of "... molecular theories and direct computer simulation using nonequilibrium molecular dynamics ...".

Chapter 7 is on constitutive equations from molecular theories. It is divided in four sections that tough upon bead and spring models, network theories, reptation theories, and conformation tensor models, respectively. The material presented is basically correct, but the chapter suffers from lack of unity and perspective. The reader may easily remain confused on what is really important and bound to last. Also, admittedly, many important developments are left out.

Multiphase systems are considered in Chapter 8. The first section is on suspension and emulsions, and it starts with the Einstein expression for the viscosity of a dilute suspension of solid spheres. Although Figure 8.2-1 showing the flow about a sphere in simple shear ignores the sphere rotation, the calculations are run down correctly. Next, come the old emulsion model proposed by Oldroyd and the recent one advanced by Palierne. The section ends with a discussion of the rheology of concentrated suspensions. The next two sections deal with the flow of a power-law fluid past a solid sphere and past a gas bubble, respectively. The last two deal with power-law fluids through fixed and fluidized beds, respectively. Here, classical themes of chemical engineering are generalized, to the extent that seems possible, to non-Newtonian fluids. In a similar vein, the last chapter of the book, Chapter 9, deals with mixing. The authors find it useful to classify the agitators in three categories on the basis of the type of impeller and geometry of the system. A quick mention of extruders concludes the chapter and the book.

As mentioned at the beginning, the authors make a serious and honest effort toward covering as much material as possible in this book. The references are numerous, although, perhaps, too many of them fairly old. There are also many problems and illustrations. The book does not represent a breakthrough in the subject, but it may prove a useful reference to chemical engineers who deal, even occasionally, with polymer rheology.

G. Marrucci
Chemical Engineering Dept.
Univeristy of Naples
80125 Naples, Italy