ing many technologically important phenomena, as the author points out in its introduction. Such phenomena include reaction zones in catalytic converters, water flow in unsaturated soils, chemical flooding of oil fields, combustion fronts, machining operations, phase change, and many, many more. Interestingly, relatively little headway has been made in the mathematical analysis of such problems, and modern numerical methods have allowed for great progress along the engineering front.

This book provides a good starting point for those interested in solving problems with moving fronts and moving boundaries. In Part I, "One-Dimensional Examples Solved With All Methods," the application and performance of several numerical methods are presented for several example problems, specifically Burger's equation and the convection-diffusion equation. In this reviewer's experience, no other book provides such an exhaustive series of tests of the many numerical methods that may be applied to such problems. On the one hand, this approach is refreshing, and useful results are presented; developers of new algorithms are notoriously lax at testing their performance against other techniques for a suite of test problems under common conditions. On the other, the repetitive nature of these tests makes for rather heavy reading. In conjunction with this portion of the book, some will find the accompanying test programs useful, which allow the reader to repeat the tests on their own personal computer.

Part II, "Applications and Two-Dimensional Examples," is not nearly as focused as Part I. Chapters cover a variety of areas, such as convection and diffusion with adsorption and reaction, phase change problems, the Navier-Stokes equations, polymer flow, and porous media flow. This reviewer had mixed feelings about these chapters. Since each of these topics has inspired entire texts, each chapter represents a rather incomplete account. Consequently, purists will quibble with the choice and focus of many of these chapters. Finlayson, however, does emphasize examples of moving boundaries in these areas and provides rather comprehensive references for those seeking more detailed information. For the student, these chapters may provide a good starting point for the study of these fields.

This book is aimed at novices to the area of moving boundary problems and succeeds as an introductory text. For those who may be interested in a useful companion text, the now-classic *Free and Moving Boundary Problems* by John Crank (Clarendon Press, Oxford, 1984) focuses more on the mathematical formulation of such problems with some examples of solution via numerical methods. All in all, *Numerical Methods for Problems with Moving Fronts* is a worthy addition to the libraries of those who commonly solve such problems or for those who wish to learn how to solve such problems.

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Membrane Handbook

Edited by W. S. Winston Ho, and Kamalesh K. Sirkar, Van Nostrand Reinhold, New York, 1992, 954 pp. $131.95.

The *Membrane Handbook* has been designed as a single source of reference material for the entire field of membrane science and technology, providing both a review of the current literature as well as a detailed description of the currently commercialized membrane processes. According to the editors, it is intended to provide a unified discussion of the underlying principles, membranes, modules, process designs, applications and cost estimates for different membrane processes, thus providing an essential bridge between the theory and practice involved in the development of membrane systems. This is obviously an enormous undertaking; although the authors have not quite met these ambitious goals, they have succeeded in preparing a handbook that should prove to be of considerable value to anyone interested in the use of membranes or membrane processes.

The book extensively discusses the principles and applications of eight existing commercial membrane systems: gas permeation, pervaporation, dialysis, electrodialysis, reverse osmosis, ultrafiltration, microfiltration, and emulsion liquid membranes. It also provides an overview of several new processes under development including membrane-based solvent extraction, membrane reactors, facilitated transport membranes and controlled release systems. In each case, the material has been prepared by leading experts in the respective fields, with many chapters coauthored by individuals from academia and industry for a more complete perspective on the subject matter. The editors have tried to maintain a consistent format throughout the text, with the material on each of these different processes organized into five distinct sections: (1) definitions, (2) theory, (3) design, (4) applications, and (5) cost estimates.

The material included is up-to-date, with a significant number of citations to the literature of the last several years. In all cases, the technical aspects of the presentation are first-rate, and the writing is of very high quality throughout the book. The text itself has been very well prepared and edited, the figures and tables are generally clear and informative, and both the notation sections and index have been meticulously prepared. The tables of available membranes, modules and manufacturers are some of the most extensive compilations of this material published, and they should prove to be an extremely valuable resource to both academic and industrial practitioners. I was particularly impressed with the economic data provided on a number of these membrane processes. This type of cost information is extraordinarily difficult to come by, and the authors have really done a tremendous service in putting this material together in such a usable form.

One of the disadvantages of the editors' decision to organize the material in the *Membrane Handbook* by membrane process is that it obscures many of the underlying themes that connect the general study of membrane science and technology. It also leads to a considerable amount of duplication in discussing topics that cut across different processes. For example, material on membrane casting is provided in at least a half-dozen different chapters, although the focus of the discussion does vary depending on the specific application. More striking is the material on module configurations. The hollow-fiber module is separately discussed in the chapters on dialysis, reverse osmosis, ultrafiltration, microfiltration, gas permeation, and liquid extraction, with a considerable amount of duplication among these presentations and with essentially no cross references to the material in other chapters. In some cases, the presentations of this material were nearly identical: the discussion of the ceramic membrane module in the chapters on ultrafiltration and microfiltration actually used the exact same figure.

One area in which the book falls considerably short of the editors' objectives is in the integration of the underlying theory with the actual process design. In several sections, the discussion of device design provides only minimal reference to the material presented in the

preceding sections on the theoretical aspects of that process. This was particularly true in the chapters on cross-flow microfiltration; the presentation of the design considerations had essentially no discussion of how to actually use any of the available theoretical models that have been developed for the filtrate flux in these systems.

As is almost inevitable in a book of this nature, there were a number of topics which were probably given insufficient coverage (despite the overall length of the text). For example, the chapters on membrane ultrafiltration provide almost no discussion of the issue of membrane selectivity or of the factors that ultimately determine the selectivity (such as the detailed pore size distribution and the presence of a small number of defects in the membrane skin). Likewise, there was only a very brief discussion of the hydrodynamic models that have been developed for the evaluation of membrane properties in terms of the solute and pore characteristics. I would also have liked to see a more detailed discussion of membrane fouling, including a more extensive discussion of the mechanisms and effects of protein fouling on the performance of both ultrafiltration and microfiltration systems, although this is probably in part just a reflection of my own particular interests in this area.

Overall, this book should prove to be an extremely valuable reference for researchers and practitioners interested in the underlying theory, application and design of a wide range of membrane processes. I have had a copy of the *Membrane Handbook* on my shelf for over a year, and I have used it extensively in both my teaching and research. Maybe even more importantly, the book has been borrowed by many of my colleagues, some of whom have only a passing interest in membranes, and they all found it to be a very valuable resource for their work.

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Rheology: Principles, Measurements, and Applications

By C. Macosko, VCH Publishers, 1994, 550 pp., $95.00.

Professor Macosko has established a solid reputation in the field of rheology and polymer processing. He is highly qualified to write a book covering these fields. The result is an excellent book and one highly recommended to all who have an interest in rheology and polymer processing.

The book is organized into three sections of 11 chapters in all. Part I covers constitutive relations, beginning with the elastic solid and the viscous liquid, and moving on from that base to chapters on linear and then nonlinear viscoelasticity. The treatment is a good combination of fundamental theory coupled with experimental observations. A large number of worked examples illustrates the major points of each subsection of these chapters.

Part II, nearly half the book, covers the broad range of principles and devices for rheological measurement. The material presented is comprehensive. In addition to the description of commercial instruments and the development of the equations with which one connects observations to material constants or functions, there is extensive presentation of flows that may be used to characterize complex fluids without necessarily yielding fundamental material constants.

The final section of the book is labeled "Applications," but is really two chapters on the relationship of the "structure" of a fluid to its rheological responses. Chapter 10 of that section is coauthored with Jan Mewis of Katholieke Universiteit Leuven in Belgium, a leading expert in the field of suspension rheology, which is the topic of that chapter. Again, basic principles are coupled with extensive experimental evidence for the relationships between suspension rheology and particle shape, concentration, size and interparticle forces.

Chapter 11 covers the rheology of polymeric liquids and is authored by Matthew Tirrell of the University of Minnesota, a leader in the applications of molecular theory to polymeric fluid dynamics. The treatment is concise, with appropriate referencing of the more extensive works of Bird, Doi and Edwards, des Cloizeaux and Jannink, de Gennes, and Graessley. The goal of connecting macromolecular structure to rheological response is achieved.

In addition to the contributions of Mewis and Tirrell, Chapter 4 (Nonlinear Viscoelasticity) is authored by Ronald Larson of ATT Bell Labs, and Chapter 9 (Rheo-Optics: Flow Birefringence) is authored by Timothy Lodge of the University of Minnesota. Thus, the book, as a whole, features chapters written by leading experts in their respective fields.

There are a few features of the book that I find fault with. Exercises of the type one would assign as homework problems are provided only for the first four chapters, and the number is small. Hence if one wished to assign this book as a text it would be necessary to supplement the book with a large number of appropriate exercises. Some of the typography is too small for comfort, such as Tables 2.2.1 and 4.4.1.

But these are minor points. Macosko's book will appeal to those with an interest in practical rheology, its applications, and the fundamental bases for designing and using the rheologist's tools.

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