BOOKS

Computational Analysis of Polymer Processing

Edited by JRA Pearson and S.M. Richardson, Elsevier Science Publishing Co., 1983, 343 pp., $66.75.

This book presents an outstanding collection of review papers, authored in almost every case by experts I would have recommended as the most active and knowledgeable in the specific topic area. It will appeal to engineers and scientists actively attempting to apply computational methods to analysis of polymer melt processing.

In the shortest chapter, JRA Pearson presents a concise introduction to "Polymer Melt Mechanics," as an aid to the subsequent detailed and specific reviews. This is followed by a general review of finite difference and finite element methods of Crochet and Walters, and aimed specifically at "Viscoelastic Fluid Flow," as opposed to the simpler problem of non-Newtonian but purely viscous flows.

Subsequent chapters deal with a variety of challenging and important problems that occur in melt processing. Tanner discusses computations of "Extrudate Swell," a free boundary problem. Fenner then describes methods of computing confined flows that occur in "Extrusion," including the melting problem. Purely viscous models are used—a reasonable assumption in this class of flow. Richardson then presents a discussion of nonisothermal "Injection Molding," with schemes for simulation of various stages of that process. Again, the discussion is restricted to purely viscous fluids. Denn presents a careful and detailed discussion of "Fiber Spinning," including both steady behavior as well as stability to infinitesimal and finite disturbances. C.J.S. Petrie follows with a discussion of models of "Film Blowing," "Blow Molding," and "Thermoforming," which includes nonisothermal and non-Newtonian effects.

In the longest chapter in this collection, Kistler and Scriven describe the remarkable progress, primarily by Scriven's own research group, toward the development of finite element methods for treatment of "Coating Flows." This is a class of flow that is especially complex because of the presence of free surfaces that are *a priori* unknown. In the final chapter, J. Wortberg describes a range of applications of microcomputers to "Process Control" of systems of hardware engaged in extrusion, injection molding, etc. The emphasis is on monitoring of various signals from a process and the use of such measurements to maintain or optimize the performance of a process.

In summary, this excellent collection will encourage those who are serious about solving the kinds of problems that arise in viscous flows subject to complex boundary conditions. It is not a "how to" book; many of the writers seem to have committed substantial portions of their careers to this topic during the past ten years. The reader is fortunate to have access to this history of their successes and their optimistic plans for continuation.

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The Chemistry and Technology of Coal

By James G. Speight, Marcel Dekker, 1983, 528 pp., $69.75.

This volume is a useful addition to a rapidly growing body of literature dealing with coal science and technology, since it provides a general introduction and overview of the field. Various chapters deal with the basic nature, composition, structure, and properties (physical and chemical) of coal; methods of testing and analysis; classification systems; chemical reactions and solvent extraction; and the technology of coal mining, conversion, and utilization. Because of the broad coverage, most topics are not covered in great depth. On the other hand, a bibliography at the end of each chapter provides a useful entry into the coal literature. Numerous illustrations serve to clarify meaning and add interest.

An important feature of the volume is a description of different coal utilization and conversion systems and processes. Flowsheets, equipment diagrams, and important operating conditions are presented for a large number of carbonization, liquefaction, and gasification processes. However, engineering and economic details are limited, and little indication of development status is provided. In many cases, there is no indication as to whether a process has reached the commercial stage or pilot-plant stage, or has even advanced beyond the laboratory stage.

The volume is a useful reference for most scientists and engineers who require a broad overview of coal science and technology. It could also serve as a text for an introductory course on this subject for college students with some background in chemistry and physics.

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Modeling and Identification of Dynamic Systems

By N.K. Sinha and B. Kuszta, Van Nostrand Reinhold, 1983, 334 pp., $32.50.

System identification ordinarily involves the determination of structure and parameter values of linear models. Such models can describe linear or nonlinear systems within a narrow operating range and are useful primarily for control purposes. System identification has evolved as an important component of control theory. Although

identification of the structure of nonlinear systems has received considerable interest, the available theory is inevitably less general and has not been put to practice. The estimation of parameters in nonlinear models of known structure is, of course, well-established and widely practiced by chemical engineers. This book contains material on both linear and nonlinear systems, although it focuses on the well-developed theory of linear systems.

Following the introduction, Chapter 2 reviews well-known "classical" methods. These include the *ad hoc* identification of low-order models from the frequency response curve or the step response curve, the deconvolution to determine the impulse response and the correlation method. The exposition is clearly written and aided by simple examples. Systematic treatment of identification commences with Chapter 3, dealing with the standard "off-line" methods for single-input, single-output systems. These include the weighted least squares, maximum likelihood, generalized least squares, and instrumental variables. These methods vary depending on the amount of computational effort required and the statistical properties of the parameter estimates. The exposition is straightforward, but contains occasional ambiguities in the discussion of the statistical properties of the estimates.

Chapter 4 deals with on-line methods, suitable for real-time computer implementation. Included are the sequential least squares, the generalized least squares, the instrumental variables, and the maximum likelihood. The exposition is for the most part straightforward, although some sections are hard to follow without referring to the original papers. The final section compares the methods by a numerical example of a simple low-order model. Methods for identification of multivariable, i.e., multiinput, multioutput systems are surveyed in Chapter 5. This intricate subject is treated rather briefly, referring to the journal literature for details.

The identification methods discussed in Chapters 2 through 5 require measurements of input as well as output. In problems of social, economic, and environmental systems, the inputs are too numerous or poorly understood to be measured or quantified. Such systems can be described by stochastic models, in which the effect of the inputs is characterized by a random forcing term. The discussion is rather brief and formal, providing little insight about the suitability of alternative models to particular classes of problems. Extensive reference is made to the well-known book of Box and Jenkins. In a short Chapter 7, the peculiarities of identification in systems with feedback are examined. Chapter 8 deals with the subject of model reduction, especially important in control applications. The exposition is straightforward, although it requires some familiarity with specialized topics of linear systems theory, such as minimal realizations. Clear numerical illustrations are given to illustrate the theory. Combined state and parameter estimation is treated in the brief Chapter 9.

Chapters 2 through 9 are addressed to systems that can be described by linear, time-invariant, ordinary differential or difference equations. The theory for these systems is well-developed, based firmly on linear algebra and probability theory. The remaining chapters deal with special topics, for which the theory is much less developed. Chapter 10, headed "Distributed Parameter Systems," is actually a brief survey of modern nonliear theory. The reader gets a fleeting glimpse into fascinating recent developments in nonlinear analysis and a useful access to the specialized literature. The treatment is by no means self-contained, and the connection with identification theory is necessarily tenuous. Chapter 11 deals with identification of systems described by nonlinear differential equations. In addition to standard parameter estimation by maximum likelihood, least squares, and other similar methods, the system's *structure* is identified by examining its dynamic behavior near bifurcation points. The subject is interesting, but has not progressed far enough to provide a tool for applications.

In Chapter 12, input signal choice for optimal identification is discussed. Several techniques of such input synthesis are presented, based mainly on the frequency domain. Chapter 13 deals with the determination of system order and structure, which relates to Chapters 2 through 9. Several available techniques are described for single-input, single-output and multivariable systems. The subject is important, especially for control applications. Chapter 14 discusses diagnostic tests and mode validation, a subject often ignored, despite its practical importance.

In conclusion, chemical and other engineers and graduate students working in control theory will find the book useful as a reference. The authors provide a complete survey of available identification methods, including reference to key journal literature. For most methods, advantages and disadvantages are discussed, and clear numerical illustrations are provided. An essential prerequisite for understanding the book is familiarity with linear systems theory, preferably in the format followed by electrical engineering textbooks. The broad coverage of material has resulted in a sketchy presentation of the more advanced subjects, particularly concerning multivariable systems. The book does not provide examples of applications to real-life problems which would be particularly valuable to graduate students.

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