BOOK REVIEWS

The Art of Chemical Process Design

By G. L. Wells and L. M. Rose, Elsevier Science Pub., Co., New York, NY, 704 pp. 1986, $88.00

The need for up-to-date text materials in the area of chemical process design has been recognized by practitioners, students, and instructors for many years. Very few texts have appeared and, unfortunately, these have not been widely accepted. In an attempt to fill this void, *The Art of Chemical Process Design* introduces the underlying principles and current practices with many examples. However, it leaves readers uncertain about its intended audience, a concern that neither the preface nor the advertising summary appear to resolve.

For practitioners in the field of process design, Wells and Rose have placed in one volume a broad introduction to the latest developments with many useful references; a treatment that should be effective as the basis for continuing education courses. For the senior level process design course, this book is less viable due to several factors that are enumerated below. Foremost is the difficulty of providing sufficient quantitative information to teach each subject adequately in the limited space available. This is the principal factor that has discouraged authors from writing textbooks in process design. Most faculty remain resigned to teach the senior courses with a collection of manuals, chapters from books, monographs, and journal articles, rather than prepare broad-based introductions that are not sufficiently detailed in many areas. Unfortunately, the Wells and Rose book, while a significant improvement over prior works, would not stand alone for adequate instruction in many areas. At a cost of $88.00, few instructors can be expected to require their students to purchase a copy. Rather, the book will most likely be assigned to the reference list, with selected materials emphasized in lectures.

Chapter 1, Process Design, provides a concise introduction to the elements of process design, the iterative nature of design strategies, the importance of data banks, and the need to document the design.

Chapter 2, The Whole Project, focuses on the project organization and personnel, planning to carry-out a process design, preparing a project brief, selecting a design basis, and the steps in project engineering, among other related issues.

Chapter 3, Process Economics, presents a very brief introduction to this topic, probably adequate for establishing approximate objectives for process synthesis and the optimization of process flowsheets, but provides minimum coverage on the time-value of money and no explicit coverage of annuities, perpetuities, and capitalized costs. The discussions of the net present value and internal rate of investment criteria are principally by example and they are limited in scope. Emphasis is not placed on cash flows, depreciation, and taxation, although some coverage is included in the text or Appendix D. In addition, Chapter 3 discusses uncertainities in the economic forecast, financial implications and the corporate plan, and production capacity decisions. It concludes with very brief sections on capital cost estimation and profitability analysis. Minimal coverage is provided for factored cost estimation and the estimation of manufacturing costs.

Chapter 4, Material and Heat Balances-Fundamentals, provides 52 pages of review material that is probably not needed by seniors in a process design course and should be well-known to practicing engineers, even those with little experience in process design.

Chapter 5, Developing the Flowsheet, focuses on the reaction and separation steps in the synthesis of process flowsheets. Included are: selection of reaction paths based upon free energy changes, considerations in selecting reactors and their operating conditions, an introduction to the synthesis of separation trains, and several examples of heuristics and evolutionary strategies in the synthesis of total processes.

Chapter 6, Heat Exchanger Networks and Exergy, emphasizes the important concepts of heat and power recovery and thermodynamic efficiency. The chapter begins by defining the heat integration problem. Then, a brief introduction is provided to a design method that minimizes external utilities; i.e., the temperature interval method that defines the pinch temperature. The graphical approach is not introduced at this point and the significance of the pinch temperature only gradually clarified in the material that follows. Methods for matching streams above and below the pinch temperature are briefly introduced, followed by minimal coverage of the breaking of heat loops and stream-splitting. Similarly, the design target in which the number of heat exchangers is minimized is introduced briefly, with just one example. Finally, the grand composite heating and cooling curves are discussed. These curves should have been presented sooner. The section on heat integration finishes with a brief introduction to operability analysis and retrofitting. To conclude the chapter, the topic of exergy is addressed in just nine pages. Concepts such as availability changes in reactors, lost work, and thermodynamic efficiency are not introduced and are briefly discussed.

Chapter 7, Distillation Trains, follows naturally the concepts of process synthesis in Chapters 5 and 6. A design strategy is presented for synthesizing distillation trains that are highly heat-integrated. This is followed by closer examination of energy-efficient designs for single distillation towers; e.g., involving multiple effects, heat pumping, vapor recompression, and reboiler flashing. No attempt is made to show the differences in lost work, thermodynamic efficiency, and cost for designs of typical separators. These comparisons can be very helpful in clarifying the advantages and disadvantages of these designs.

Having presented several concepts on the synthesis of process flow sheets, Wells and Rose turn to process analysis in Chapter 8, Material and Heat Balances-Practice, Chapter 9, The Design Tool-The Flowsheet Program, Chapter 10, Data Banks and Data Bases, and Chapter 11, Flowsheet Program Application. Chapter 8 introduces programs for the analysis of process flowsheets with emphasis on individual equipment models and recycle analysis. Brief mention is made of material balances for batch processes and dynamic simulation of continuous processes. Then, Chapter 9 focuses on the methods of equation-solving (so-called sequential modular, simultaneous, and simultaneous modular methods), the program architecture (executive, equipment model library, and physical properties data bank), stream convergence methods, control strategies, etc. Chapter 10 briefly introduces physical property data banks, polynomial fits of property

data, methods for estimating vapor-liquid equilibria, group-contribution methods, data sources, and computerized data banks. Finally, the CHEMCO data bank, whose manual is in Appendix E, is described with a sample program illustrated as Example 10.1. In Chapter 11, several topics are addressed concerning the practical usage of a flowsheet program. These are followed by the simulation of a toluene hydrodealkylation process, with a program presented in Table 11.1 for simulation using the UNICORN program, whose "mini-manual" is in Appendix E. The approach in Chapters 8–11, although helpful, does not appear to teach the important concepts as effectively as can be accomplished with numerous examples using one or more flowsheet programs.

Chapter 12, Process Optimization, offers a 38 page introduction to this important subject. The concepts of linear programming are reviewed, but not taught. For nonlinear systems, univariate search procedures are introduced. These are followed by 12 pages of qualitative descriptions of the direct search, steepest ascent, generalized reduced gradient, quadratic programming, simplex, and adaptive random search algorithms, with some comparative performance results. The chapter finishes with introductions to integer optimization and the optimization of batch processes, and Example 12.5, in which a network of heat exchangers is optimized.

Chapter 13, Safety and Loss Prevention, is especially timely and contains a fine qualitative introduction to this subject. After a brief introduction, the section on loss prevention identifies the kinds of hazards, followed by considerations in reducing the danger, either in the design stage or during the operation of a plant. Then, a section on implementing safety measures during design completes the qualitative treatment very effectively. The next section focuses on the more quantitative methods of risk analysis. First, hazard indices are introduced followed by formal hazard studies, such as the HAZOP, Failure Mode and Effect Analysis, and Fault Tree Analysis, and finally the use of expert systems. These measures and methods of risk analysis need more emphasis in design courses, but unfortunately the Wells and Rose discussion seems inadequate for teaching students how to apply and utilize these quantitative methods. Three brief sections follow with qualitative discussions on site and plant layout, implementing loss prevention programs, and the consideratons in storing and unloading chlorine. The last section considers the application of all of these methods to a process for the hydrodealkylation of toluene. This process study is well-conceived, but nine pages are barely sufficient to confirm the importance of hazard analysis and the utilization of the methods presented in the chapter.

Chapter 14, Storage Scheduling and Plant Availability, provides a brief introduction to the optimal use of storage for raw materials, products, and intermediates in continuous and batch processes. This is followed by similarly brief sections on the scheduling of batch operations, plant availability, and the use of stochastic simulation.

Finally, Chapter 15, Flow Diagrams and Control, in just 34 pages introduces some important design considerations with sections devoted to the synthesis of the control system, microprocessor based controllers, and the piping and instrumentation diagram.

In summary, The Art of Chemical Process Design, provides coverage of the topics most educators seek to include in a modern process design course. However, the treatment is too introductory, with many examples, but too little information for students to master the design methodologies that enable them to undertake quantitative design studies as seniors in chemical engineering curricula. The book contains many exercises following the chapters and these should be very helpful to design instructors.

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Polymer Surfaces and Interfaces

By W. J. Feast and H. S. Munro, Eds., John Wiley and Sons, New York, NY, 257 pp., 1987

This book is a collection of 12 articles summarizing presentations made at a symposium of the same title that was held in Durham, UK in April 1985 under the auspices of the Pure and Applied Macromolecular Chemistry Group of the Royal Society of Chemistry and the Society of the Chemical Industry of the UK.

The volume has several strengths. First there is a diversity of topics, covering polymer blends to proteins to plasmas, with especially good introductions to an array of modern instrumental techniques that those in the field working on surfaces will find useful even if they are not particularly concerned with each specific application discussed by the author. The chapters are authoritative and the material is up-to-date.

Several chapters are particularly good in surveying the topic well and providing a good basis for research in their area. These include Winnik's on luminescence techniques, Kinloch's on metal-adhesive interfaces, Petty's on Langmuir-Blodgett techniques and Lundstrom, et al., on protein adsorption. Several of the articles focus more narrowly than they should on the author's own contributions to the field, thus limiting their usefulness as survey articles. This certainly is not unusual in a symposium volume where it is difficult to enforce complete uniformity of style and coverage.

There is no doubt that anyone interested in polymer surfaces and interfaces will want to peruse this volume.

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Annual Review of Numerical Fluid Mechanics and Heat Transfer, Volume 1

By T. C. Chawla, Ed., Hemisphere Publishing, 454 pp., 1987 $149.95

The editor's preface states that this new series will survey fluid mechanics and heat transfer for nonspecialists such as graduate students. The chapter titles are:

Chapter 1. Thermal Radiation in Particulate Media with Dependent and Independent Scattering (Tien and Drolen)

Chapter 2. Pressure-Velocity Coupling in Incompressible Fluid Flow (Comini and del Giudice)

Chapter 3. New Explicit Methods for the Numerical Solution of Diffusion Problems (Evans)

Chapter 4. Numerical Methods for One-Dimensional Reaction-Diffusion Equations Arising in Combustion Theory (Ramos)

Chapter 5. Buckling Flows: A New Frontier in Fluid Mechanics (Bejan)

Chapter 6. Numerical Methods for Multidimensional Radiative Transfer Analysis in Participating Media (Chan)

Chapter 7. Fundamental Aspects of Analytical and Numerical Methods on