Chemical Engineering Design Principles, Practice, and Economics of Plant and Process Design

By G. Towler and R. Sinnott, Butterworth-Heinemann, Boston, MA, 2007, 1245 pp. $89.95.

Overall this chemical process design textbook is well conceived in terms of content. It also contains several unique features such as a list of key learning objectives at the beginning of each chapter, significant references throughout, nomenclature at the end of each chapter, and supplementary materials available on adoption (power point lecture slides and a solution manual), all of which I find useful for teacher and student.

The first three chapters of the book, the introduction, fundamentals to material balances, and fundamentals of energy balances and utilization, provide perspective and fundamental introductory material for the student. These chapters easily form the basis for an introductory design class for freshman or sophomore students who have not yet taken or are concurrently taking the traditional first course in chemical engineering in mass and energy balancing. Chapter 1 presents the notion that design is usually very vaguely defined exercise, but then takes the student through the basic principles of design from the generation of conceptual designs to computations, equipment design, financial considerations and dealing with trade-offs using optimization. The introduction also contains more detailed material on optimization than most design texts, covers single and multivariable optimization, constraints in design, linear and nonlinear programming, mixed integer nonlinear programming and superstructure considerations, and ends the chapter with an example illustrating the optimization of total annualized costs for a distillation involving five components.

The subject of chapter 2 is mass balances and is well conceived. While the inclusion of the equivalence of mass and energy and the Einstein relationship $E = mc^2$ seems a bit out of place, the authors do an excellent job of presenting standard topics such as defining system boundaries, the importance of units, the role of a basis in mass balance calculations, and the need to solve simultaneous algebraic equations. I particularly like the parts of the chapter that cover bypass and purge streams, because they often go unmentioned in many texts. Unfortunately, there is very little space devoted to unsteady-state mass balance calculations, and this is something I see as a general weakness of most texts, not just this one. Understanding unsteady-state mass balancing is important to understanding process dynamics and control, and with the recent emphasis on synergistic design and control, I would have expected more on this and related subjects. Process control, in this text, is embedded in Chapter 5: Piping and Instrumentation.

Chapter 3 on energy balances draws a valuable connection between fundamental concepts like internal energy, heat, work, enthalpy and heat capacities covered in traditional classical thermodynamics courses and energy balancing in the design process. However, the first 25 pages of this chapter are essentially a review of certain aspects of sophomore thermodynamics and, as in the chapter on material balances, there is very little material on unsteady-state energy balances. The remainder of chapter 3 is devoted to energy recovery and heat exchanger network design using pinch technology. Considerable space is given to heat exchanger network synthesis and design for networks involving multiple hot and cold streams. I find the subject material in this part of chapter 3, which is often absent in most design texts, informative and useful for beginning and senior students. Far too often students in design are not introduced to synthesis concepts, but rather their design experience is relegated to the use of steady-state simulators with fixed configurations to perform "design". It is nice to see an approach to teaching design that includes synthesis as an integral part of the total design effort.

Chapter 4 is concerned with process flow sheeting. Various types of process representations and key information included in a typical flow diagram are described. Commonly used process simulation programs available to academic and industrial practitioners and their main attributes are also listed. The authors then describe the basic steps commonly employed in constructing a flow sheet, including:

1. Specification of components and choice of appropriate physical properties models.
2. Specification of typical process units.
3. The use of spreadsheets.
4. User-specified units.

Many aspects of building a flow sheet are nicely illustrated with UniSim Design process simulator. The sequential modular and equation-oriented approaches to flow sheet computation are well described, as are the advantages and disadvantages of each with regard to processes with recycle. The concept of "tearing" recycle streams in the sequential modular approach is nicely presented with the help of a simple reaction-separation-recycle process and several traditional methods of converging tear streams are presented. While material on flowsheet optimization, dynamic simulation and concepts like real-time optimization are only mentioned in passing, on the whole, this chapter is a good introduction to steady-state process flow sheeting.

Chapter 5 is entitled piping and instrumentation, and introduces the student to pumps and compressors, net positive suction head, and mechanical aspects of pumps and pump seals — something often lacking in other textbooks. A similar approach is presented for piping with regard to ASME standards for piping, piping selection, materials of construction, and so on. I find the placement of control in this chapter a bit unusual, but not detrimental to the flow of the book. Typical control schemes for level, flow, temperature, and pressure control are illustrated for single input-single output, and multiple input-multiple output processes. However, the material on process control is not connected to dynamical simulation (perhaps because there is little in the textbook on dynamic simulation) so the student is left a bit in the dark.

The subject of chapter 6 is project cost estimation and, together with chapters 1, 2 and 3, is intended to provide a good introduction to chemical process design for beginning students (freshman or sophomore level) who have not taken or are currently taking the traditional introductory chemical engineering mass and energy balance course. Personally I believe that unless students receive some hands on experience using a process simulator, much of the authors' intent with regard to chapters 1, 2, 3, and 6 as an introduction to design will be lost. Students learn by doing and, in design, this invariably means performing numerical simulations so I would have included chapter 5 in this short list of chapters that form a good introduction. Nevertheless, I feel chapter 6 is an important chapter because it gives the student basic process economics early on in their design training, because economics is what drives the industry, and because students need to know this upfront. This chapter treats many of the standard aspects of economics, including capital investment costs, operating costs, purchased equipment costs, and so on, with many examples given in isolation. What might have worked better would have been a process redesign exercise with a timely focus on reducing energy consumption. That is, given an existing process with significant energy consumption, consider the redesign of that process to improve overall energy efficiency, and then pose for the student the many related questions that have bearing on overall process economics.

Chapter 7 is concerned with materials of construction and provides a basic overview of the importance of and commonly encountered issues in selecting materials for various services.

Chapter 8 deals with design data and design information, and shows the student how to find physic-chemical data, how it can be predicted when no data is available, and how to choose an appropriate phase equilibrium model. While the authors do describe the use of handbooks and other reference books, correlations, tables, charts, and some group contribution approaches for obtaining basic physical properties data (density, thermal conductivity, heat capacity, etc.), in my opinion their approach does not teach the student to be resourceful. While well intended, pointing the way for students is not always the best approach to learning. In many of my courses, I often deliberately leave information out, tell students what I have done, and why I have left information out, and then strongly encourage them to become resourceful.

Process safety and loss prevention is the subject of chapter 9. This is a very useful chapter that clearly reflects the industrial background of the authors. In my opinion, industry takes safety far more seriously than academia does. This chapter gives the student a solid appreciation for the seriousness with which safety should be

AiChE Journal, Vol. 54, 3034–3035 (2008)

DOI 10.1002/aic.11633
Published online October 6, 2008 in Wiley InterScience (www.interscience.wiley.com).

viewed and discusses in some depth topics that are always intended to be part of material safety data sheets (MSDS), but are often not such as toxicity and other exposure limits, flammability, flash points, etc. Other processing issues such as excessive pressures and temperatures, identification of electrical sources of ignition, and explosion are also discussed. The safety checklist provided at the end of this chapter is invaluable in my opinion. A good addition to this chapter might have been an in-depth study of a recent industrial accident (e.g., the explosion in the Texas City, TX plant in which there was loss of life). Case studies are often helpful because they are real and leave a meaningful impression, and could have been presented in a factual manner as learning experience.

As noted by the authors in the preface, chapters 10 through 13 are concerned with equipment selection, which is often overlooked in many design textbooks. While some of the material in these chapters can be found in other texts, like the topics on distillation design in chapter 11, it is unfortunate that the authors do not consider this material part of the core material in design courses in terms of subject matter. Students often learn very little if anything, for example, about tray hydraulics and entrainment in mass transfer and stage-wise operations courses. I feel some of the material in chapters 10 through 13 should be selectively included in senior design courses (not just in a second design course as the authors suggest), perhaps on the basis of relevance to a particular design project. Many chemical engineering curricula still require two design courses, and, therefore, this often overlooked material could easily be included.

The final chapter of the book deals with plant layout. Many of the aspects of site selection, plant layout, and utilities are not necessarily something a design engineer is directly concerned with. These decisions are often made at a much higher managerial level. Nonetheless, some familiarity with basic considerations associated with building plants is useful. Perhaps the most useful part of chapter 14 for the design engineer is the material on environmental impact.

Overall, the book is well conceived and well written. The 14 main chapters interweave subject material rather well. There are also nine appendices that range in content from MSDS, to conversion factors to sample design projects. Not all of these appendices are strictly necessary and some omissions might have actually fostered more student resourcefulness. Problems at the end of each chapter in a design text are unnecessary. In my opinion, design should always be taught in the context of a course-long project, not as a series of problems at the end of each chapter. Finally, do I recommend this textbook for design? Yes! I think it makes a good teaching text, as well as a valuable reference book for students within the context of a team-based design project in capstone design courses.

Angelo Lucia
University of Rhode Island
Crawford Hall, 16 Greenhouse Road
Kingston, RI 92881

Microbial Fuel Cells

By Bruce E. Logan, Wiley InterScience, Hoboken, NJ, 2008, 216 pp. $90.50.

The book reviews the current status of Microbial Fuel Cells covering mainly the research and experience gained by the author and is introductory in nature. The book covers broad themes relevant to the area, however not detailing many aspects to a depth. The book discusses current and future energy demands and the resulting greenhouse emissions, and the need for MFCs.

The book starts with describing microbiology of exoelectrogens, that is microorganisms capable of directly transferring electrons to a chemical or a material that is not an immediate electron acceptor. The chapter reviews recent work in the area of nanowire generation by such a microorganism and various methods that can be used to formulate MFCs using different mechanisms used by different types of microorganisms. The next chapter describes basics of voltage generation in a fuel cell. Simple thermodynamic calculations to demonstrate the capability of MFC to generate electricity and hydrogen are covered. Voltage generation by fermentative systems, the enzymatic and anodic capacities are elegantly described. The book also introduces to power generation, energy efficiency calculations and its applications to MFCs.

A chapter is dedicated in the book that describes the challenges in the choice of material for the anode and cathode to be used in a MFC. The main objective is in the choice of material that maximizes power generation and columbic efficiency. A good comparative analysis of various materials used as anode and cathode are described. The book also introduces membrane based hydrogen fuel cells. The basics are covered including definitions of chemical flux and calculations of mass-transfer coefficients in such reactors. The chapter is exhaustive in detailing all the aspects in choosing materials in MFCs.

After covering microbiology, basics of voltage and power generation, materials, the book describes the reactor architecture of MFCs. The equipment description of various reactor types such as continuous flow tubular reactor, packed-bed reactors, flat-plate reactors, fed-batch reactors are described. This leads to the next chapter on basics of kinetics and mass transfer. The book makes an attempt to describe Monod's model of growth kinetics and relate that to the mass-transfer limitations in biofilm. There is a specific chapter detailing MFCs for hydrogen production detailing the definitions necessary to evaluate efficiency and performance. The last three chapters cover recent development of use of MFCs for wastewater treatment, other MFC technologies and future directions.

The book gives an overview of the current status in MFC technology. The book is self-sufficient and provides relevant introductory material for a general reader not familiar with areas such as microbiology, materials, kinetics, mass transfer, etc. This makes the book readable for a broad set of researchers with varied backgrounds interested in microbial fuel cells. Another useful aspect of the book is that each chapter contains simple quantitative illustration of a concept which helps in easy comprehension of the broad topics covered in the book. However, the overview of various topics makes the reading simple, but the book cannot offer in depth knowledge in any specific area. The book can be useful as an easy reference material in the important area of MFCs.

K. V. Venkatesh
Dept of Chemical Engineering
Indian Institute of Technology Bombay
Powai, Mumbai 400 076, India
E-mail: venks@iitb.ac.in

AiChE Journal, Vol. 54, 3035 (2008)

DOI 10.1002/aic.11634
Published online October 9, 2008 in Wiley InterScience (www.interscience.wiley.com).