

Chemical Process Design

By Robin Smith, McGraw-Hill, New York, 1995, 459 pp., \$65.00.

Process synthesis, a key step in chemical process design, is concerned with identifying the basic flowsheet structure to be used from a typically large number of alternatives. Process economics and a number of other quality measures, such as controllability, safety, compliance with environmental and other regulations, largely depend on the results of this conceptual design phase. There are many different approaches to process synthesis which include: the expert system approach, the conceptual design or physical insights approach, and the optimization or algorithmic approach. Each of these approaches features its own advantages and provides promising directions for process synthesis. This book describes the conceptual design or physical insights to process synthesis. Two earlier books in this area are *Process Synthesis* by Rudd, Powers and Sirola (1973) and *Conceptual Design of Chemical Processes* by Douglas (1988). This book is a welcome addition to the above two widely-used books.

The book first describes the hierarchical decision-making process, which the author calls the "onion model." In this model, a reactor design is needed before separation and recycle systems can be designed, and so on. The hierarchical decision-making process is described differently by different authors. For example, Jim Douglas' hierarchical decisions pertain to: 1) batch vs. continuous operation modes, 2) input-output structures, 3) recycle structure of the flowsheet, 4) general structure of separation systems, and 5) heat exchanger network. It would have been more instructional to contrast the onion model from this approach and generally discuss the similarities and differences among alternative approaches in this chapter.

Chapter 2 is devoted to the choice of reactors. Detailed heuristics for choice of types of reactors and operating parameters in terms of different reaction types is described. It also briefly describes different practical reactors. Very good heuristic rules are presented.

However, the chapter misses detailed discussions on reactor path synthesis and reactor network synthesis. These topics are treated very extensively in the chemical engineering literature. The next layer in the onion model is the separation system selection described in Chapter 3. The chapter presents units like sedimentation, flotation, centrifugal separation, filtration, distillation, and absorption for homogenous mixtures. This chapter also describes operation of evaporators and dryers. Chapter 4 on synthesis of reaction separation systems describes the recycle structure of the process and some heuristics for batch process synthesis. Unlike Douglas' hierarchical design procedure which decides batch vs. continuous operation up-front, the onion model does not talk about batch processes. Therefore, the description of batch process in this chapter seems to be slightly out of line.

In chemical engineering, the most widely-studied process synthesis problems pertain to reaction path synthesis, reaction network synthesis, distillation synthesis, and heat exchanger network synthesis. This book covers the latter two topics. Distillation synthesis is the focus of Chapter 5, which mostly deals with simple distillation sequencing and heat-integrated distillation synthesis. However, the chapter only considers ideal nonazeotropic systems. Azeotropic distillation is an important and widely used separation technique, and there has been a concerted effort during the last decade toward developing methodologies for azeotropic distillation synthesis. The chapter does not cover the subject of azeotropic distillation sequencing and hence is lacking in this respect.

Heat exchanger network synthesis using pinch technology is a very popular concept. Chapters 6 and 7 explain the basics of the pinch technology concept. Chapter 8 discusses briefly local and global economic tradeoffs and optimization keeping the heat exchanger networks and energy targeting in perspective. Each layer of the onion model is revisited for energy integration through application of the pinch technology in Chapters 12 to 16. Chapter 12

outlines the principles involved in process modifications for heat integration. Chapter 13 deals with heat integration of the reactors and Chapter 14 with heat integration of distillation columns. Evaporators and dryers are considered in Chapter 15. Chapter 16 concentrates on overall heat exchanger network synthesis in a process. These chapters outline the recent literature on pinch technology.

In the past, the design of environmentally compatible manufacturing plants generally meant the use of end-of-pipe treatment or separation devices through which effluent gases or liquids pass on their way to the environment. However, during the past few years, a movement has grown that stresses waste reduction or pollution prevention at the conceptual design stage itself. Recognizing this fact, the author has devoted three chapters on waste minimization and waste treatment. Safety and health considerations for the overall plant using again the onion model philosophy are discussed in Chapter 9. Waste minimization for the overall plant and life cycle analysis is the topic of Chapter 10. Different effluent treatment options and unit operations required for the effluent treatment are presented in Chapter 11.

Chapter 17 summarizes the hierarchical decision-making process used in the process design as described in Chapters 2 to 16.

Overall, *Chemical Process Design* is a well-written, comprehensive book on the subject of conceptual design. The book's main contribution comes from the treatment of recent advances in pinch technology, and the discussions on waste minimization and effluent treatment. Most chapters can be understood by a novice and an expert alike. Although it could be used as a textbook for an advanced undergraduate or graduate course in process synthesis, it is more in the line of a reference book, since there are no exercises of the type to be assigned as homework problems for students.

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