

Conceptual Design of Distillation Systems

By M. F. Doherty and M. F. Malone,
McGraw-Hill, New York, 2001, 568 pp., \$85.31.

A few comments to clarify the title of this book are in order. *Conceptual design* of a process covers that stage in the evolution of a *final design* where enough information is at hand to enable reliable estimates of capital and operating costs. Such estimates are often used to obtain capital appropriations from company management. It is different from *final design*, where specifications are exact enough to enable equipment purchasing and construction to begin. Another point to be made: *distillation systems* includes more than just the columns, that is, heat exchangers, pumps, controls, and the like. In a sense, the authors might have used "columns" in the title instead of "systems." Emphasis here is only on the column, singly or in tandem with other columns.

The authors propose the book as an undergraduate text, perhaps for the first course of a separations sequence. They offer a possible one-semester course outline, and the book chapters abound with good home problems. A CD-ROM is provided that contains a demonstration version of Hyprotech's simulator DISTIL. This reviewer feels that the book can also be valuable to process designers in industry, where conceptual and final designs are taken very seriously.

There are ten well-written chapters supported by over 300 figures, example calculations, a detailed appendix, and the CD-ROM mentioned above. The introductory chapter provides a framework for distillation applications. Example processes are described, and the place of distillation in the context of fluid mixture separations is emphasized. A detailed description of an industrial reactive distillation system is included.

Chapter 2 covers phase equilibria for simple and complex mixtures. Guidelines are presented for choosing a VLE model, but detailed descriptions of the models and their thermodynamic bases are avoided. For unusual or poorly known systems, the user will have to go

to the supporting references to develop VLE model parameters. More likely, the user will obtain the parameters from a simulation program. The latter part of the chapter covers equilibrium flash calculations and the concepts are developed in how they might be combined to form a multistage distillation column. It is clear that the authors assume that the user has available a process simulator, whether commercial or in-house, a quite reasonable assumption these days.

Binary distillation is covered in the third chapter, with the McCabe-Thiele graphical method given some emphasis. Concepts of minimum stages and minimum reflux are developed and incorporated into short-cut design procedures. Multicomponent distillation is covered in the fourth chapter, with azeotropic mixtures saved until later. Extensive use is made of residue maps for ternary mixtures and, to some extent, quaternary mixtures. The use of the Fenske-Underwood-Gilliland method for multicomponent mixtures is given adequate attention. Again, the user is left on his or her own regarding the use of simulators for multicomponent mixtures.

Homogeneous azeotropic distillation, a favorite research field of the authors, is the subject of Chapter 5. This chapter and a later one (8) on heterogeneous azeotropic distillation occupy a large portion of the book, a result more of the intellectual intrigue of the methodology than of the proportion of actual problems encountered in practice. Surprisingly, the coverage of commonly-practiced extractive distillation is slight, and is limited to the use of an entrainer to separate close-boiling azeotropic mixtures. The separation of close-boiling nonazeotropes should have been mentioned, as well as the approximate methods for handling such mixtures on a solvent-free basis. The extensive coverage of azeotropic distillation appears justified because of the paucity of coverage of the methodology in other references.

Column design and economics is the subject of Chapter 6, and the treatment is entirely adequate for conceptual design. The authors recognize wisely that one does not need to get involved with such details as contacting device selection and analysis. Methods are included for estimating costs of columns, packings, heat exchangers, and so on.

Such costs are related to the Marshall-Swift Index for inflation corrections. Costs of utilities are discussed, but are largely left to the user's particular situation.

Chapter 7 is involved with process synthesis, in particular with column sequencing. Heuristics are provided for approximating the ultimate optimal sequence. Used in conjunction with the DISTIL or other simulators, this chapter can be quite powerful. Many existing industrial distillation sequences are not optimal, and can be so identified—even though they are destined to remain that way because of revision costs.

The last two chapters cover near-virgin territory, at least in college textbooks. Chapter 9 deals with batch distillation and Chapter 10 with reactive distillation. Again, distillation residue curves are used extensively to identify possible and impossible concentration regions and map the likely concentration profiles. The procedures are carefully presented and are supported by worked-out examples. These chapters, plus the two on azeotropic distillation, present much new material and are themselves worth the cost of the entire book.

This book will serve well as an undergraduate text if the course can be accommodated by today's changing chemical engineering curriculum. It could also serve a graduate course elective, where the emphasis would be placed on azeotropic, batch, and reactive distillations. As mentioned earlier, it can also serve the needs of practitioners, especially those with, or serving, companies producing high-valued specialty chemicals. Coverage of extractive distillation, particularly related to solvent selection, could be added. The book does not cover all elements of the "system" as normally defined, but rather is confined to the most challenging and economically important part of the system, the column. The writing is clear and has a bit of style not always found in scientific textbooks. The book is recommended to those with the interests indicated above.

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