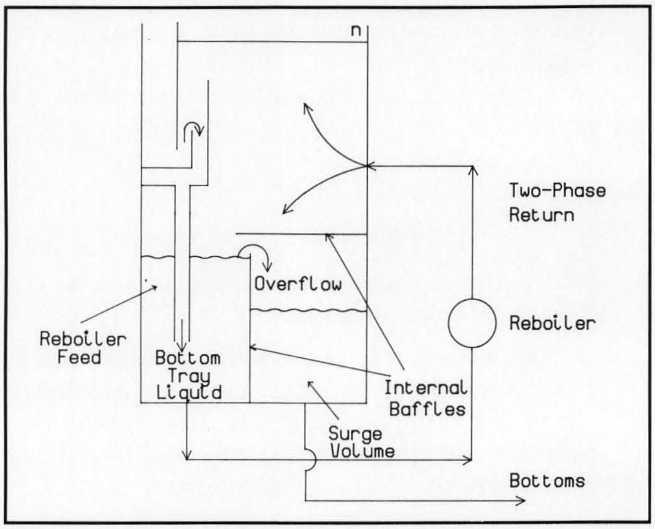

Figure 7

to implement the philosophy. In summary, the philosophy is to preferentially route the bottom tray liquid to the reboiler and sufficient reboiler return liquid to the bottoms. Excess reboiler return liquid (not needed as bottoms) joins the bottom tray liquid as reboiler feed. One way of implementing this on larger diameter columns is illustrated in Figure 7; note that the down-pipe from the trap-out mixes the bottom tray liquid into the excess reboiler return liquid well below the overflow level—this ensures the overflow is predominantly reboiler return liquid. With this type of design, the vapor return and bottoms are in equilibrium so the system acts as one theoretical stage.

INDUSTRIAL PRACTICE

The loss of part of a theoretical stage is widely recognized in industry, but response varies considerably. At one extreme some companies do not take credit for the separation due to the reboiler (treating it as a safety factor) unless it is a kettle when full credit is taken for one theoretical stage. At the other extreme, others simply count the reboiler (irrespective of type) as one theoretical stage—but then a conservative tray efficiency applied to the column hides any shortcoming. Based on the approach in this article, it seems that a recirculating reboiler generally has a separation efficiency of at least 60%. Hence, even though one might not wish to actually perform the construction as described, it would be quite safe to credit the reboiler with a separation equivalent to an efficiency of 50%.

REFERENCES

1. Henley, E.J., and J.D. Seader, *Equilibrium-Stage Operations in Chemical Engineering,* John Wiley & Sons, New York, p. 323 (1981)
2. King, C.J., *Separation Processes,* McGraw-Hill Book Co., New York, p. 216 (1971)
3. Treybal, R.E., *Mass-Transfer Operations,* 3rd ed., McGraw-Hill Book Co., New York, p. 373 (1980)
4. Van Winkle, M., *Distillation,* McGraw-Hill Book Co., New York, p. 195 (1967)
5. Coulson, J.M., and J.F. Richardson, *Chemical Engineering, Vol. 2,* 3rd ed., Pergamon Press, Oxford, England, p. 422 (1978)
6. McCabe, W.L., and J.C. Smith, *Unit Operations of Chemical Engineering,* 3rd ed., McGraw-Hill Book Co., New York, p. 549 (1976)
7. Smith, B.D., *Design of Equilibrium Stage Processes,* McGraw-Hill Book Co., New York, p. 127 (1963)
8. Jacobs, J.K., *Hydrocar. Proc. and Petrol. Refiner,* **40**(7), p. 189 (1961)
9. Palen, J.W., "Introduction to Shell-and-Tube Reboilers," page 3.6.1-1 in Hewitt, G.F. (ed), *Hemisphere Handbook of Heat Exchanger Design,* Hemisphere Publishing Corporation (1990) ❐

ChE book review

CHEMICAL ENGINEERING: Vol. 1. Fluid Flow, Heat Transfer and Mass Transfer

by J.M. Coulson and J.F. Richardson, with J.R. Backhurst and J.H. Harker

Pergamon Press, Headington Hill Hall, Oxford, OX3 0BW, United Kingdom; $48 (paperback) (1990)

Reviewed by
Chang-Won Park
University of Florida

This book is an undergraduate text on the unit operations of chemical engineering and is published in the United Kingdom. Since the first edition was published in 1954 it has been revised three times, updating the material as significant developments in chemical engineering have been made. The material is divided into thirteen chapters: the first eight chapters are on fluid flow, and the following two chapters are devoted to heat and mass transfer, respectively; Chapter 11 gives a brief overview of the boundary layer theory, and in Chapter 12 the molecular diffusion in momentum, heat, and mass transfer is described; finally, humidification and water cooling are treated in Chapter 13.

The level of treatment seems adequate for undergraduate students who have an elementary knowledge of material and energy balances but who may not have taken a course in transport phenomena. This book uses slightly different nomenclature than textbooks published in the U.S., but not to an extent that will cause a serious problem. Compared to *Unit Operations of Chemical Engineering* (4th edition), by McCabe, Smith, and Harriott (which may be the most widely used textbook in the U.S. on the subject), this book contains more example problems, more figures, and more pictures (especially for the section on fluid flow), which may be an important feature for a textbook. It also contains more detailed design aspects of pumps, flow meters, heat exchangers, etc.

Units and dimensions are briefly covered in Chapter 1, followed by elementary thermodynamic principles in Chapter 2. Chapter 3 describes the flow in pipes and channels, including an adequate level of description for non-Newtonian behaviors. The flow of compressible fluids is described in Chapter 4. Starting with the flow of gas through a nozzle or orifice, the unique features of compressible fluid flow are well enough described so that students can comprehend the subject matter without too much difficulty. Multiphase flow, which is important in many areas of chemical engineering but which is a difficult subject to handle at the undergraduate level, is treated in Chapter 5. The empirical developments of liquid-gas and fluid-solid systems are described, including up-to-date literature references. Chapters 6, 7, and 8 describe flow measurements, liquid mixing, and pumping of fluids, respectively.

Chapter 9 is devoted to heat transfer. This long chapter covers the fundamentals of conduction, convection, and radiation as well as heat transfer involving a phase change and heat exchangers. The material and the level of treatment are similar to those of many other undergraduate textbooks. Finally, mass transfer is treated in Chapter 10. However, only the fundamentals of mass transfer are described in this volume—the various mass transfer processes such as distillation, liquid-liquid extraction, and gas absorption are covered in Volume 2 of the Chemical Engineering Series, *Particle Technology and Separation Processes.* The flow past immersed bodies, including fluidized beds and packed beds, is also covered in Volume 2.

In summary, this volume can serve as an excellent textbook or a principal reference for an unit operations course on fluid flow and heat transfer. Chapters 1 through 9 constitute an adequate amount of material to be covered in one semester, and the many example and homework problems contained in this volume are a useful feature. The treatment of mass transfer, however, is rather brief and a separate volume must be used if a course is to be devoted to mass transfer operations. ❐

ChE book review

CHEMICAL ENGINEERING: Vol. 2. Particle Technology and Separation Processes, 4th ed.

by J.M. Coulson, J.F. Richardson, J.R. Backhurst, and J.H. Harker

Pergamon Press, Headington Hill Hall, Oxford, OX3 0BW, United Kingdom; 968 pgs, $51 (paperback) (1991)

Reviewed by
Benjamin J. McCoy
University of California, Davis

This book, nearly 1000 pages in length and weighing over four pounds, is a bargain at $51.00. Part of a six-volume introduction to chemical engineering, this particular volume covers separation and particle processes. The rule-of-thumb that any book in its 4th edition is worth knowing applies in this case. The authors have prepared a carefully written and judiciously planned book which is rewarding to read and study. Material from the 3rd edition has been revised, reordered, and rewritten, and new chapters have been added on adsorption, ion exchange, and chromatographic and membrane separations.

With the need for chemical engineering to expand beyond its traditional central role in the petrochemical industries, this book provides a satisfactory background for the particle and separation technologies important to biotechnology, biomedical applications, materials science, and environmental engineering. It will serve nicely as either a handbook on the shelf of the practicing chemical engineer or the teacher of chemical engineering, or as a textbook used in a course on separations and applied mass transfer. The prerequisite courses are introductory physics, chemistry, and calculus. The book has an adequate supply of homework problems and an abundance of cited references for the researcher.

The authors have maintained a commendable balance of practical engineering and mathematical fundamentals. Necessary for application to industrial applications, the book is well stocked with photographs, diagrams, and explanations of equipment. The book supplements the now-usual mass, momentum, and energy transport phenomena approach and includes thermodynamics of adsorption, physics of particles, and dynamics of chromatography. Treating the essential physical processes, the authors present concise derivations of mathematical relationships that succinctly capture the significant, basic quantitative concepts.

Continued on page 199.