ChE book reviews

INTRODUCTION TO MATERIAL AND ENERGY BALANCES

by G. V. Reklaitis
John Wiley & Sons, New York, NY (1983)

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Several textbooks are available for an introductory course on chemical engineering calculations. Such texts share similar goals, including bridging from pre-engineering courses to the chemical engineering curriculum, illustrating the broad applicability of chemical engineering concepts, even outside chemical plants, and developing skills used later in the curriculum. If achieved, these goals can show students who still may be unsure about continuing in chemical engineering how chemical engineering is related to, but different from, other areas.

Despite the similarity of goals, one of two different approaches usually emerges in introductory texts: 1) a survey of chemical engineering calculations, including not only steady state material and energy balances, but also a sampling of other topics, such as unsteady state mixing in stirred tanks and plug-flow reactors; and 2) a development of strategies for material and energy balance calculations–an approach that usually adopts a notational system that is easily adapted to more complex, multi-unit processes than are usually seen in approach number one.

The first approach typically draws more heavily on dynamics concepts, while the second gives students a deeper perspective on process synthesis and design. Either approach can illustrate the diversity of problems amenable to chemical engineering analyses, and in fact, most introductory courses are a mixture of the two perspectives mentioned. As examples of these approaches, *Introduction to Chemical Engineering Analysis* (T. W. F. Russell and M. M. Denn, Wiley, 1972) may be cited as an example of the first, *Process Synthesis* (D. F. Rudd, G. J. Powers, and J. Siirola, Prentice-Hall, 1973) as an example of the second, and *Elementary Principles of Chemical Processes* (R. M. Felder and R. W. Rousseau, Wiley, 1986) as an example of a mixed approach.

The present textbook is divided about equally between material and energy balances, with each type of balance treated in nearly parallel fashion. After presenting the appropriate balance equations, each half of the text contains chapters on balances for nonreacting and reacting systems. Each half also contains a chapter on the use of balances in process flowsheets, with sections on strategies for manual and machine computations. The discussion of material balances also contains a beneficial chapter on the relation between elemental and species balances, and the final chapter shows how material and energy balances can be solved simultaneously by means of a discussion of computational strategies. Overall, topics are very logically presented, and the parallel presentation of topics assists assimilation of the more difficult energy balances.

Although instructors will appreciate the degrees-of-freedom analyses, it is unusual for students (who generally try to solve a problem without first ascertaining whether it has a solution) to fully appreciate their value. However, the chapters on strategies for manual and machine calculations, which discuss linearizing nonlinear problems and simultaneous methods for solving systems of linear and nonlinear equations, show students that they can tackle relatively large problems with techniques from numerical methods courses. The discussion also apprises students of the limitations of the methods presented.

In each section consistent notation is developed, with N_j (or F_j) denoting the molar (mass) flowrate of species j throughout, for example, and with summation signs frequently used to obtain more compact equations. The very useful open system analysis, consistent with that in *Chemical and Engineering Thermodynamics* (S. I. Sandler, Wiley, 1988), is developed for energy balances.

Numerous examples serve as excellent aids to discussions of concepts. The homework problems amply illustrate ideas advanced in each chapter. For use in problems and examples, the appendix contains a relatively large compilation of physical properties, including heat capacities, heats of formation, Antoine constants, and steam tables. Most obvious by their omission are unsteady state problems. Furthermore, the problems tend not to give students a representative cross-section of the range of problems that they can solve; rather, the emphasis is on problems encountered in chemical plants.

The content of this textbook places it between the books mentioned previously by Rudd *et al.* and by Felder and Rousseau. This text would fit very well into a curriculum in which numerical techniques are presented prior to or even concurrently with the material presented. The use of the open system energy balance, the most useful form of this balance for process calculations, makes this text consistent with what students are likely to need later. Although the author, an eminent process design engineer, has put forward a text that leans toward process design, this is a very readable, substantial contribution that, with minor adaptations to the needs of particular curricula, would be welcomed enthusiastically by students in introductory courses. ❒