

upstream band shown in Figure 4. Students can also gain insights into numerical calculations, such as the effects of numerical instability, since they are able to observe the calculation proceed in time. Many types of spreadsheet programs also incorporate graphics capabilities, which further enhances their educational value. In particular, when using version 2.x of 1-2-3, we recommend also using the program *SeeMORE*<sup>TM</sup> (Personics Corporation), which can be employed to produce multiple live graphs as the simulation proceeds.

## NOMENCLATURE

- $a_s$  = interfacial area per unit volume in bed ( $\text{cm}^{-1}$ )  
 $a_i$  = Langmuir isotherm parameter ( $\text{cm}^3\text{g}^{-1}$ )  
 $b_i$  = Langmuir isotherm parameter ( $\text{cm}^3\text{mole}^{-1}$ )  
 $C_i$  = concentration of component  $i$  ( $\text{mole cm}^{-3}$ )  
 $C_{i,\text{feed}}$  = feed concentration ( $\text{mole cm}^{-3}$ )  
 $D_{\text{axial}}$  = axial dispersion coefficient ( $\text{cm}^2\text{s}^{-1}$ )  
 $D_i$  = diffusivity of component  $i$  in particle ( $\text{cm}^2\text{s}^{-1}$ )  
 $d_p$  = particle diameter (cm)  
 $L$  = length of bed (cm)  
 $k_i$  = coefficient in linear driving force approximation, ( $\text{cm s}^{-1}$ )  
 $q_i$  = amount adsorbed per mass of sorbent averaged over particle ( $\text{mole (g of sorbent)}^{-1}$ )  
 $q_i^*$  = value of  $q_i$  in equilibrium with interparticle fluid ( $\text{mole (g of sorbent)}^{-1}$ )  
 $q_{i,\text{feed}}^*$  = value of  $q_i$  in equilibrium with  $C_{i,\text{feed}}$  ( $\text{mole (g of sorbent)}^{-1}$ )  
 $R_i$  = rate of solute uptake per bed volume ( $\text{mole cm}^{-3}\text{s}^{-1}$ )  
 $t$  = time (s)  
 $T$  = dimensionless time  
 $v_{\text{fluid}}$  = interstitial fluid velocity ( $\text{cm s}^{-1}$ )  
 $z$  = distance in column (cm)

## Greek Symbols

- $\alpha$  = bed void volume  
 $\rho_b$  = bulk density of bed ( $\text{g cm}^{-3}$ )  
 $\rho_p$  = particle density ( $\text{g cm}^{-3}$ )

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## ChE book review

### THERMODYNAMICS: AN ADVANCED TEXTBOOK FOR CHEMICAL ENGINEERS

Gianni Astarita

Plenum Press, 233 Spring St., New York 10013

444 pages, \$69.50 (1989)

#### Reviewed by

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Thermodynamics, as the subtitle implies, is primarily a textbook intended for an advanced thermodynamics course for chemical engineers. Such a course is typically part of the graduate core curriculum, and the graduate and advanced undergraduate students taking it would have completed beginner's courses in thermodynamics, physical chemistry, and transport phenomena. The book has two parts, the first emphasizing macroscopic theory and the second engineering applications. The subject coverage is unusually broad, including chapters on the thermodynamics of relaxation, surface thermodynamics, and dissipative phenomena in the first part, and electrochemistry, polymers (written by G. Marrucci) and the thermodynamics of electromagnetism (by R.E. Rosenweig) in the second part. The point of view of the authors is almost entirely macroscopic.

There are a number of strong points to this book. It is perhaps the most comprehensive in coverage of the current graduate thermodynamics textbooks for chemical engineers. With research activities shifting away from "traditional" chemical engineering areas into new intellectual territories, the need for a fresh look at what is included in a thermodynamics course is clear. By discussing topics such

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## REVIEW: THERMODYNAMICS

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as liquid crystals, rubbers, biological systems, and non-equilibrium thermodynamics, Professor Astarita makes it easier for the student to appreciate the relevance of thermodynamics to diverse systems that he or she will encounter later as a researcher.

The author consistently adheres to a high standard of logical and mathematical rigor. A number of intellectually challenging examples and problems are included at the end of each chapter. Extensive literature for further study is also provided. Even small details, such as the usually interesting (but not always obviously relevant) quotations at many points in the text and the attractive typographical layout of the book, help retain the attention of the reader.

It is clear that the intention of this book is to give a broad, somewhat philosophical treatment of classical thermodynamics. Because of this, the book is sometimes limited in the depth of coverage of some of its many topics. I found the omission of certain key concepts, such as Legendre transforms or stability in general thermodynamic systems, to be the most significant potential weakness of the book. Also, no attempt is made to provide the student with the computational skills required to handle complex real-life problems. A minor complaint that I have is that a different notation is used in each chapter; this might lead to some confusion.

Overall, this book is a welcome addition to the thermodynamics literature and is worthy of consideration as a textbook for all or part of an advanced thermodynamics course. The last chapters of the book might provide a useful starting point to researchers interested in applications of classical thermodynamic theory to polymers, electrochemical, and electromagnetic systems. □