Fluidization: Idealized and Bubbleless, with Applications

By M. Kwauk, Ellis Horwood, New York, 1992, 277 pp., $85.50.

While this book does give a reasonable review of the basic concepts of fluidization, it is primarily a summary of the research activities spanning the author's career. The first three chapters review the regimes of fluidization and different types of fluidization systems, contrast gas-solid and liquid-solid systems, in terms of their fluidization characteristics, and discuss various empirical relationships for the drag coefficient. Chapters 4 through 7 review the author's research in fluidized leaching and washing, solid segregation of polydisperse particle mixtures in fluidized beds, conical fluidized beds, and moving beds, respectively. Chapters 8 through 12 focus on his research in the area of bubbleless gas-solid contacting systems. These systems include dilute raining particles, fast fluidization, shallow fluidized beds, and particles fluidized under the influence of oscillating fluid flow. Chapter 13 details a multiscale energy minimization model developed by the author and Dr. J. Li. Chapter 14 discusses his work on powder characterization by fluidized-bed collapsing experiments and methods to improve fluidization characteristics by the addition of fines.

It should be noted that one-half of the pages in the text are figures or tables, and over two-thirds of these figures are taken directly from the publications of the author or his students. Unfortunately, some of the notations in the figures and tables are not explained in the text or in the nomenclature section. Therefore, the reader must refer to the original citations to understand clearly these figures and tables. Some of the references, however, are in obscure sources, written in Chinese or unpublished. About one-third of the references in the text represent post-1980 work, with one-third of these more recent references representing work of the author or his students.

The author uses a simplistic approach to predict the relationships existing among the operating variables of the various fluidization systems discussed and, in the author's own words he, "has not avoided presenting quantitative deliberations which have not been subject to rigorous experimental verification." To describe fluidization systems involving polydisperse particles, the author gives proposed corrections to the simplified relationships among the operating variables throughout the text. Notably absent in the text is any treatment of the general equations of change which are descriptive of fluid-particle motion at large.

For a more comprehensive treatment of fluidization, the author refers readers in the preface to two sections of the *Chinese Chemical Engineering Handbook*, which the author helped organize. It is somewhat surprising that the classic and widely adopted book in fluidization, *Fluidization Engineering*, by D. Kunii and O. Levenspiel, now in its second edition and recently reviewed by Professor L. S. Fan (*AIChE J.*, December 1992), is not mentioned or referenced anywhere in the text.

Overall, this text is a very good review of the author's significant contributions to the fluidization field. The text, however, cannot stand alone as a general book on fluidization.

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Porous Media: Geometry and Transport

By Pierre M. Adler, Butterworth-Heinemann, Stoneham, MA, 1992, 544 pp.

This book addresses the geometry of porous media in terms of phase functions and their integral transforms (Chapter 2), and then Stokes flow of liquid together with simple Fick's law diffusion of highly dilute solute in certain ideal, rigid pore structures. Those idealizations are spatially periodic structures (Chapter 4); so-named deterministic fractal networks and continuous fractals (Chapter 5); random networks and random continua (Chapter 6); and constructs called reconstructed porous media, (Chapter 7). There are over 500 pages of text. Altogether they might better have been titled "Mathematics of Discontinuously Heterogeneous Systems"

Serial sectioning and image analysis of porous media are mentioned, as are tomographic methods, Mapping of pore structure is not covered. Inertial effects in flow, deformation rate-sensitive viscosity, and Bingham yielding are touched on. Slip flow, fines movement, filtration, mechanical deformation, swelling, shrinking, adsorption and chemical reaction are among aspects of porous media geometry and transports *not* broached. Only single-fluid occupancy and flow are covered, so that fluid displacement transport processes such as imbibition and displacement are excluded. So too are phase change transport processes such as condensation and drying.

What are covered extensively are the mathematical formalisms of, and whole bodies of derived results about, spatially periodic dispersions and consolidated arrays, including networks of capillaries; convection with diffusion of a dilute component, including Taylor-Aris dispersion; fractal capillary networks, Apollonian (or Leibniz) packings, Menger sponges, and several related topics; and volume averaging. Site and bond percolation on networks, Kirchhoff's laws in graph-theoretic terms, finite size-scaling, renormalization and effective medium approximations are described. The chapter references are extensive and useful. They are particularly helpful in identifying unpublished as well as published work of Adler and his collaborators, and Brenner and his (Brenner was Adler's mentor more than a decade ago). Concrete applications of the formal derivations are frustratingly few in the text.

Periodic arrays of cylinders and spheres do appear; among networks, only the square lattice; among fractal structures, the Sierpinski gasket, fractal foam, and Menger sponge.

A sample from the text that relates Darcy permeability to Stokes flow in spatially periodic networks of passages by the loop form of Kirchhoff's laws (not always the most efficient representation, although this is not mentioned) is indicative:

"The basic graph is defined as the set of vertices $V\Gamma_b$ linked by the set of [non-equivalent] edges $E\Gamma_b$ . . . . The local graph Γ_ℓ is obtained by identifying the homologous vertices of the basic graph . . . When an arbitrary orientation is given to the local graph, it can be completely described by its incidence matrix $\mathbf{D}_\ell$ . . . . extend to the local graph whose component J_j represents the algebraic flow rate . . . . on edge j of the flow rate vector (m_ℓ components) $\mathbf{J}_\ell$ . . . . The components of the pressure difference vector $\mathbf{P}_\ell$ are equal to the pressure differences between the vertices . . . . The $m_\ell \times m_\ell$ diagonal conductance matrix $\mathbf{M}_\ell$ is defined . . . . The m_ℓ relationships . . . for the pressure generator can be expressed as $G_\ell = \mathcal{R}_\ell \cdot \overline{\nabla \bar{p}}$ where $\mathcal{R}_\ell$ is a $m_\ell \times 3$ matrix . . . defined on the edge space and on the three-dimensional Euclidean space . . . . Ohm's law between the vertices can be written as $\mathbf{P}_\ell = \mu \mathbf{M}_\ell \cdot \mathbf{J}_\ell + \mathbf{G}_\ell$ . . . . The conservation of the fluid at each vertex can be written in a simple form by using the incidence matrix $\mathbf{D}_\ell$: $\mathbf{D}_\ell \cdot \mathbf{J}_\ell = 0$ . . . . Let ξ_Q be a cycle vector of the local graph; then Kirchhoff's law [for loops] can be expressed as $\xi_Q \cdot \mathbf{P}_\ell = 0$. . . . Let $\mathbf{C}_\ell$ denote the matrix whose ith column is the ith basis cycle vector. The [last] can be summed up as $\mathbf{C}_\ell^t \cdot \mathbf{P}_\ell = 0$. Now let's solve . . . for $\mathbf{J}_\ell$ and $\mathbf{P}_\ell$ . . . . Choose a spanning tree in the local graph Γ_ℓ . . . . The edge space $E\Gamma_\ell$ can be split as $E_T + E_N$, where E_T is the subspace spanned by the tree edges and E_N is that spanned by the chords . . . ."

And so on. The result $\mathbf{J}_\ell = -\mu^{-1}\mathbf{C}_\ell \cdot (\mathbf{C}_\ell^t \cdot \mathbf{M}_\ell \cdot \mathbf{C}_\ell)^{-1} \cdot \mathbf{C}_\ell^t \cdot \mathbf{G}_\ell$ is arrived at a page later and Darcy permeability the page after that. An equivalent formula, for the average impedance and hence the equivalent conductance of unbounded regular, or symmetrical, networks, was worked out more simply by R. M. Foster and published in 1949. It is not cited.

The author states that "the major purpose of this book is to present transport phenomena through heterogeneous systems using a unified and modern framework, where the emphasis is on . . . a rigorous mathematical treatment," and he dreamed that it "would be at the same time an elementary introduction, a graduate textbook, and a reference book." In most parts, the approach is reportorial, not interpretive nor analytical, much less didactic. The reader is frequently referred to papers for details and, at other junctures, is told "(so-and-so) was able to show that," "it can be shown that," "it is easily shown that," "it is now a simple matter for the reader to . . . ," "it is left as an exercise," etc.

Before teaching again recently the biannual course on the science of porous media that H. T. Davis and I, with help from others, have developed at Minnesota, I read the backbone parts of Adler's book and skimmed the rest, taking notes as I went. That course draws first-year graduate students, a few seniors, a sprinkling of second-year graduate students, and various auditors. The match was such that no presentation from the book found a place in the course, although the book did loom as a useful reference for the two students who were PhD candidates in early stages of researches on the physics of liquid flow and of dispersion processes in actual porous media. Now I have been through the book again, and have come to the following view. The science of porous media has shaped up over the past two decades. This book is in major respects a transect through a portion of the theoretical underpinnings of the science. But it often misses plain versions of basics, uncomplicated developments of consequences, and instructive examples of applications. It is antithetic to the dictum that in science the ultimate in sophistication is simplicity. It dwells on mathematical formalisms, or rigorous mathematical treatments, that have interested or occupied the author in his quest for a unified, modern development of transport phenomena through heterogeneous systems. It is neither an elementary introduction nor a graduate textbook. As a research monograph and reference work, it will be valuable to a rather sparse audience.

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Carbon Adsorption for Pollution Control

By Nicholas P. Cheremisinoff and Paul N. Cheremisinoff, Prentice Hall, Englewood Cliffs, NJ, 1993, 216 pp., $57.00

This is a rudimentary book, apparently intended as a "how-to" manual on design and selection of activated carbon adsorption equipment for removing gaseous and aqueous pollutants. Although generally informative, the text is written at a needlessly elementary level, clearly below that appropriate to typical bachelor-level chemical engineers.

The presentation leaves much to be desired. A number of descriptive passages are reiterated several times in the book. Even figures are repeated (for example, Figures 1.8 and 4.1, 1.7 and 4.3, 3.18 and 6.10). There are a good number of typographical errors (e.g., in Tables 4.4 and 4.5). The sources of the figures and tables in the text are not cited; in fact, the entire text is devoid of references. The 30-page appendix is largely irrelevant, listing physical properties of hydrocarbons, such as critical constants and heats of combustion, which bear no relation to adsorption.

There are features of the book that are unique. The process flowsheets and schematics of equipment may find use by practitioners. The tables on "retentivity" (amount adsorbed) for different organic vapors by carbon would constitute another serviceable feature of the book if the corresponding partial pressures or concentrations were given. A practicing engineer would be better off obtaining more meaningful and useful information for the organics in question directly from the manufacturers of activated carbons. Nonetheless, the tables presented here could provide a qualitative estimate of the relative amounts adsorbed for different organic compounds.

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Applied Optimal Control and Estimation

By Frank L. Lewis, Prentice Hall and Texas Instruments, Englewood Cliffs, NJ, 1992, 624 pp.

This book, subtitled *Digital Design and Implementation*, has as its stated goal