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BOOK REVIEWS

Physicochemical Hydrodynamics, an Introduction, by R. F. Probstein. Butterworth, London (1989). 352 pp. ISBN 409-90089-3. $65.

V. Levich made pioneering contributions to physicochemical hydrodynamics, and wrote a famous monograph with this title. Professor Probstein has given us a very well written textbook on this subject and the choice of the material he has presented is excellent. Probstein has made available in clear form, to both students and research workers, a large body of important and basic material which is organized logically, uses notation that is not overwhelming, is indexed well, contains many physical explanations and analogies that make the material more meaningful, and reflects the author's long association with, and good understanding of, the subject matter with which he deals. The author emphasizes relatively simple examples of the various phenomena described in order to convey a clear sense of the similarity among the seemingly diverse processes considered. Occasionally one might wish for additional examples; and occasionally his descriptions may be slightly disturbing to those who insist on literal interpretations of titles, as in section 4.5, for example, in which flow past a flat plate with constant surface concentration is entitled flow past a reacting flat plate. However, the overall result is very good.

I think it is also advantageous that Professor Probstein, who resides in MIT's Department of Mechanical Engineering, has treated a subject with such strong physical, chemical and biochemical overtones that it is of great interest to engineers and scientists in many fields, especially chemical engineering.

The book starts in Chap. 1 with a useful introduction to the field and moves in Chap. 2 to the transport properties of fluids in which the point of departure is an introduction to electrical conductivity and charge transport. This sets the scene for Chaps 6 and 7 in which solutions of electrolytes and charged particles are treated.

Chapter 3 describes adequately the equations of change, including those for charged species, without going into too much detail.

Chapter 4 begins with some useful comments (which will serve as review for chemical engineers) on chemical reactions and their effect on the equations of change and boundary conditions. Also included in Chap. 4 is a discussion of membrane separations, which is illustrated by solving a reverse osmosis problem with crossflow. The subjects of gel chromatography and capillary models of porous media are preceded by a discussion of Taylor diffusion in tubes.

Macromolecules and particles in low Reynolds number flow are taken up in Chap. 5 and this naturally leads to a discussion of Brownian motion and the viscosity of dilute suspensions. Sedimentation and ultrafiltration are the applications discussed in this chapter. Probstein shows that the gel and the osmotic pressure models, which are used to explain the limiting flux behavior observed in ultrafiltration, can be considered to be equivalent if one defines the diffusion coefficient in a particular way.

Chapter 6 is entitled "Solutions of Electrolytes" and deals with electrolytic cells, electrodialysis, ion exchange, double layers and electrokinetic phenomena, and electroosmosis in the context of transport phenomena. In Chap. 7 the discussion of electrical phenomena is extended to macromolecules and particles, and some of the processes which are used to separate them. Electrophoresis is introduced by a discussion of Henry's work and its limitations. Electrophoretic separations are discussed in sufficient detail to give the reader an appreciation of this interesting process.

Colloidal stability, particle capture and the force fields which contribute to these phenomena are described in Chap. 8. This chapter is completed by describing an application of Happel's free surface model to flow in porous media, which is then used to make the connection between individual collectors and an assemblage of them. It might have been interesting to have noted that Happel's idea of a free surface or mobile cell has been applied to numerous transport problems in which assemblages of units are a key factor, including hollow fiber reverse osmosis modules, the history of which has been referenced in some detail by Soltanieh [*Chem. Engng Commun.* **18,** 311–330 (1982); *Desalination* **49,** 57–88 (1984)]. If space had permitted, Professor Probstein could have made the connection between his sections 4.4, 4.7 and 8.5 in this context.

The final chapter of this book is entitled "Surface Tension". The author develops the subject very well, starting with the classical work of Young, LaPlace, Gibbs and Rayleigh, followed by the work of Levich and culminating with descriptions of articles published in the 1980s on surface-tension-driven flows. Perhaps this chapter could have been strengthened somewhat by the inclusion of a discussion of the now classical paper of Pearson [*J. Fluid Mech.* **4**, 489–500 (1958)], in which he explains elegantly that surface tension plays a major role in Rayleigh–Benard convection, the mechanisms for which are of fundamental importance in many of the applications which are of great interest today.

In summary, I think that Professor Probstein has written an excellent textbook which is available for a reasonable price. It satisfies very well the author's intention of addressing the needs of chemical, environmental and mechanical engineering graduate students as well as those in material science and biotechnology.

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Gas–Liquid–Solid Fluidization Engineering, by L.-S. Fan. Butterworth, London (1989). 736 pp. ISBN 409-96179-X. $85.

Three-phase fluidization is among the most complicated and challenging areas of multiphase flow, involving a bewildering array of flow regime and reactor behavior. On the other hand, an increasingly large number of applications involve the use of three-phase reactors. These applications include trickle-bed reactors, catalytic processing in refinery operations, processing of low-grade resources such as oil shale and the increasingly important areas of bioprocessing and waste treatment. Accordingly, there have appeared several review articles on the subject, notably those of Østergaard [in *Fluidization* (Edited by Davidson, J. & Harrison, D.). Academic Press, New York (1971)] and Darton [in *Fluidization*, 2nd edn (Edited by Davidson, J. *et al.*). Academic Press, New York (1985)]. However, because of space limitations, previous review articles have been compact and have necessarily dealt with subsets of the phenomena and applications. This book is a welcome first attempt at a comprehensive treatment of the subject.

The book is divided into three parts: "Introduction"; "Fundamentals"; and "Applications". The first is somewhat shorter than the others, and serves to introduce not only the subject, but also the author's classification of flow regimes and process configurations used throughout the remainder of the book. Included in these regimes are trickle beds and slurry reactors, making the treatment somewhat broader than usually associated with three-phase fluidization, and accordingly making the book somewhat ambitious in its scope. The second major section, "Fundamentals", deals with information regarding hydrodynamics, transport phenomena, hold-up, mixing, flow regime maps etc. associated with the subject. Some of this material, e.g. correlations on hold-up, deals with macroscopic phenomena in an empirical way, while other sections deal with hydrodynamic phenomena, e.g. vortex shedding from wakes of bubbles, in a fair amount of detail. This reviewer found the treatment uneven in this regard, and often wondered about the author's definition of "fundamentals". The presentation throughout the book is almost entirely descriptive, with few if any derivations of the many equations presented. The final section, "Applications" is an interesting compendium of technological applications that exploit the contacting properties of three-phase systems, and relates these applications back to earlier material whenever possible. The text is augmented by a large number of figures, tables, photographs and process schematics. The production of the text is nicely done, in a print that is easy to read. Some of the tables, however, are apparently reproduced from typewritten originals, and as a result are extremely difficult to read. The nomenclature suffers (as does the field) from the requirement of a large number of subscripted quantities, which frequently sends the reader flipping back to the tables of nomenclature in order to follow the text. The literature citations are voluminous, but the discussions of citations in the text are often cursory, involving insufficient detail to describe what might be found in the reference. Accordingly, the book suffers from the drawback of not having *titles* included in the citation. While this would have undoubtedly increased the total length of the book, the publishers missed an opportunity to provide a bibliography of true utility and high impact.