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## ChE book reviews

### PROCESS FLUID MECHANICS

by Morton M. Denn  
 Prentice-Hall Publishing Co.,  
 Englewood Cliffs, NJ

Reviewed by  
 John Eggebrecht  
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At Iowa State University "Momentum Transport" is required as the first of a three-semester sequence which continues with "Heat" and "Mass." The second-year student has, with adequate high school preparation, completed the introductory calculus and physics courses. Frequently students are concurrently enrolled in introductory ordinary differential equations.

As the instructor, I see the focus of the course, and of the engineering science curricula in general, as a development of analytical skills. The significant part of a section of text in support of this is not the derivation or the equation confined by a box at the end, but the physical principles, assumptions and approximations which are expressed by these. Many students, having restricted their intellectual objectives to those which they perceive as appropriate for a BS engineer, regard only the "formulae." Some students, enraptured by the mechanics of the calculus, only regard the derivation. To persuade both groups to my point of view I need a text which emphasizes the physics of fluid flow both in the development of topics and in their relations.

On the other hand, engineering practice is as much art, *viz.*, design, as it is science. A responsibility of the course is to introduce the jargon and operational empiricism of process equipment. It is not possible to find a single text on fluid mechanics which encompasses this range of material and conforms to my focus.

However, Denn's text is superior to all others which I have considered in the treatment of the physical principles of fluid flow. It is much easier to compensate for the omission of material, which can be extracted from handbooks, than for a presentation which shares the students' bias for either formula or calculus. I am especially appreciative of the organization of the text. Topics appear in an order which reflects the evolution of understanding of fluid flow, and for that reason, I believe, the order which is most easily understood by the student.

The text opens with observation and experimentation on flow primitives; the cylindrical filled conduit and the submerged sphere. This can provide a framework for an appreciation of the analysis of simple systems by the identification of key physical dependencies and the analysis of complex systems by construction from primitives. Also, this introduction establishes the proper relationship between observation and analysis and may help to correct the mistaken perception that discovery is deductive. The prediction of the pressure drop in a straight pipe leads, through Reynolds, to the friction factor correlation and the viscous force on a falling sphere leads, through Stokes, to the drag coefficient correlation. The similarity of these two important results is striking and properly emphasized. Key discoveries are followed by extension to more complex systems and the presentation acknowledges this process by presenting reasonable, yet simple arguments, which lead to correlations for non-cylindrical conduits, partially filled conduits, rough pipes, non-spherical submerged objects and packed beds. These progressions allow me to highlight central themes; the importance of symmetry and frame invariance, the emergence of design correlations from the identification of the significant physics and the replacement of complex systems by simpler systems through judicious approximation. All of this is accomplished without ever taking a derivative.

While the first section of the text is the greatest strength, the following section must be supplemented as an introduction to the application of the conservation of energy to the analysis of macroscopic flows. The derivation of the mechanical energy balance equation is easily understood and very thorough in the statement of assumptions by which the conservation equation is simplified to a "formula." The conservation of linear momentum is combined with the energy conservation equation to analyze a sequence of increasing complexity; expansion, elbow, contraction, free jet and manifold. A logical parallel of the first section

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would have been to present a detailed presentation of a few important design correlations. A more complete treatment of the application of the mechanical energy balance to non-isothermal and compressible systems is needed.

In the third section the development of differential balances of mass and linear momentum is given, with the same clarity and in the same notation as the macroscopic balances of the preceding section. The presentation of the Cauchy and Navier-Stokes equations is made in tensor notation. I have not found this to be an impediment to students' understanding. To the contrary, the dimensional relationship between vectors and tensors provides a clear distinction between force and stress. Students in my classes are very willing to learn new mathematics when they believe it is motivated by a need to frame an otherwise difficult concept and not by a pretense of rigor. The following chapter applies these conservation equations to the usual one dimensional flows.

The next section of the text is a skillful arrangement of topics in which creeping and inviscid flow limits are taken on the Navier-Stokes equation in reduced form. These limits are first introduced in a separate chapter on Hamel flow which is an excellent choice of problems, since numerical solutions can be obtained easily and compared to the limiting analytic solutions. This gives me a chance to reiterate the importance of the reduction of complex problems to underlying primitives and to make the connection between this reduction and the limiting process.

The final section is composed of a series of "special topics," which includes chapters on turbulence and

viscoelasticity. Much of the background for a discussion of turbulence is provided in the preceding chapters on inviscid and boundary layer flow and the emphasis here is on the time averaging of the Navier-Stokes equation and the development of the universal velocity distribution. I believe that a brief introduction to stochastic processes is more useful to the student at this point than the following chapter on numerical solutions of PDEs. This allows for some continuity in the introduction of viscoelastic behavior as "fluid with memory." Missing from the chapters on viscoelastic and turbulent flows are the "gee-whiz" phenomenon which leave the student at the end of the semester with a taste for the variety of scientific experience and provide the qualitative extension to complex systems which had, otherwise, been the consistent theme of the text. □

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## ENGINEERING FLOW AND HEAT EXCHANGE

by Octave Levenspiel

Plenum Press, New York, NY 10013 (1984)

366 pages, \$34.50

Reviewed by

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This book presents the basic macroscopic equations for the solution of fluid flow and heat transfer problems in concise form. However, the major thrust of the book is in the application of these fundamental equations to the solution of problems not usually encountered in typical courses in fluid flow and heat transfer (particularly those dealing with particulate systems).

On paging through the book, one is first struck by the freehand illustrations (did a human being write this book rather than a computer?) and fluid flow problems with such intriguing titles as "Counting Canaries Italian Style." I have often thought of Octave Levenspiel as the Dr. Seuss of chemical engineering—an author who uses the premise that even the learning of engineering principles can be fun. Just as Dr. Seuss introduced us to the alphabet beyond the letter "z" in "On Beyond Zebra," so Octave Levenspiel might well have titled this work "On Beyond Transport Phenomena."

The book is divided almost equally between the two areas, and the fluids portion successively treats: Basic Equations for Flowing Streams, Flow of Incom-

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