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BOOK REVIEWS

Continuum Methods of Physical Modeling. By K. Hutter & K. Jöhnk. Springer, 2004. 635 pp. ISBN 3 540 20619 1. £61.50.

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The fields of continuum mechanics and turbulence have had a long and sometimes uneasy relationship starting with ideas put forth by R. S. Rivlin almost 50 years ago. This book, which is divided into three parts, begins with the development of balance laws or conservation equations and ends with a sequence of chapters devoted to turbulence. Nestled between these is a part that deals with the theoretical foundation of dimensional analysis and similitude. The book is intended for students in the engineering disciplines whose interests lie in fluid dynamics. Depending on the mathematical maturity of the student, the level of difficulty is roughly at the advanced undergraduate or entry graduate level.

Part I focuses on continuum mechanics and its adaptation to the kinematics of fluid flows. In Chapters 1 to 4, balance equations for conserved variables are developed and, in addition, for the entropy when a discussion of thermomechanical processes is introduced. The discussion of such balance equations is nicely augmented by a thorough and illustrative discussion of jump conditions within a body and the impact on the balance equations. In keeping with the continuum mechanics background of the authors, the extension to moving reference frames is couched in more general transformation rules familiar to the continuum mechanicist. The concepts of invariance and indifference are also introduced.

While the first four chapters focus on the balance laws that apply to all material behaviour, Chapter 5 deals with material properties. The discussion is not limited to fluids but also encompasses the usual (from a continuum mechanics standpoint) discussion of isotropic and anisotropic solids. Fortunately, the text reads much more clearly than usual continuum mechanics books on the subject so that it is a useful and informative guide for the engineering student to these important material concepts. The first part of the book is completed with two chapters focusing on material phase transitions and the mechanics and thermodynamics of mixtures. Both chapters are of sufficient depth to give the student an informed perspective of such phenomena and, most importantly, within the context of a continuum dynamics framework.

Dimensional analysis is the subject of Part II of the book. In addition to Chapter 8 which treats the formal theoretical foundations of such analyses, the following Chapter 9 deals with the concept of (physical) models or mappings of a physical process at reduced scale. Such ideas are inherently connected to the notion of dimensional analysis through the identification of parametric variables needed in deducing the proper rules of ‘downscaling’ associated with physical models. Since dimensional analysis and scaling can be an important tool in analysing turbulence, the formalism established in these chapters could be useful.

The remaining four chapters deal with turbulence and comprise the third and final part of the book. The material they contain is intended to provide only an introduction into the topic. Chapter 10 of Part III covers a broad range of topics ranging from the concepts and definitions of turbulent length and time scales and the corresponding energy cascade to the definition of the Reynolds stresses and the associated mean and fluctuating balance equations. Chapter 11 deals with the derivation and analysis of the k–ε model equations for both incompressible and compressible flows. Although all of the material is contained in many other sources, the chapter does serve to provide the student with a unified view of the model construct within the context of a continuum mechanics framework. No examples or illustration of the model performance are given so some readers may find the material somewhat abstract.

Although not in the main stream of most engineering turbulent model formulations and discussions, the application of thermodynamic principles to the construct of turbulent closure relations is of interest and is discussed in Chapter 12. Unfortunately, the chapter begins with the unsettling referral to RANS as Reynolds Averaged Numerical Simulation, although the term is properly defined earlier in the book. Unfortunately, this ambiguity occurs in the Index where RANS is listed on page 440 (where it is properly defined as Reynolds averaged Navier–Stokes) and on page 523 under the listing Reynolds Averaged Numerical Simulation. Nevertheless, the discussion that follows provides the student with an introduction and guide to the ideas used in developing turbulent closures by imposing thermodynamic constraints on the functional descriptors of the turbulent flow field. The reader should be cautioned by the authors enthusiasm for such an approach. While the authors claim that "… the view, already well accepted in turbulence theory that the turbulent flow of a Navier–Stokes fluid may be viewed as a laminar flow of a certain non-Newtonian fluid," it may be more accurate to say that it is a recognized view rather than an accepted view. Research articles do appear in the literature and this chapter is a useful basic guide to the ideas behind such formulations. Unfortunately, the authors leave the impression that this is the only means by which algebraic Reynolds stress models and/or turbulent heat flux models can be derived. In fact, such Reynolds stress models are more often viewed as nonlinear eddy viscosity models since they are not extracted directly from the transport equations of the Reynolds stresses. Models extracted from the Reynolds stress transport and properly scaled turbulent heat flux equations subject to what are termed weak equilibrium conditions can yield the same functional form as the models described within the text, but retain the values of the closure coefficients used in the differential transport equations themselves.

The book ends with an application chapter, Chapter 13, which in my view is somewhat out of place and of limited value to the broader audience. It may be a useful chapter to the classes that one of the authors (K. H.) teaches and from which this book is an outgrowth; however, the problem of diurnal and seasonal temperature variation in lakes as posed in the chapter is relatively simplistic and of little general value. The problem is simplified to the extent that the reader would not get an appreciation of the complex flow problems being calculated by these methods currently and the associated difficulties with proper posing of boundary and initial conditions.

Overall, the book can be a useful reference source for students studying fluid dynamics. From an editorial standpoint, the grammatical structure is somewhat awkward at different points in the book reflecting the fact that the authors' native language is not English. In addition, the Index is poorly laid out. As well as the ambiguous reference to RANS cited above, "theory of turbulence" is listed on page 4 while "turbulence theory" is listed on pages 1, 4, 446. A citation also appears for "sun rise" which has questionable value to any potential reader of the book. These are only a minor nuisance to someone who knows the material in the book; however, for someone searching out information, it raises questions about the accuracy of the material within. The text is somewhat narrowly tailored to the course requirements of one of the authors (K. H.) and may not be adaptable in its entirety to others developing similar courses in fluid dynamics. However, a unique feature of the book is the inclusion of solutions to exercises at the end of each chapter. As a reference source for students, this may be quite useful to those looking for clarification on specific topics or for alternative points of discussion. Certainly a book with a both interesting and unique topical mixture.

T. B. Gatski

Theory and Applications of Viscous Fluid Flows. By R. Kh. Zeytounian. Springer, 2004. 488 pp. ISBN 3 540 44013 5. £69.00.

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This ambitious and on the whole successful book comprises ten main chapters entitled (1) Navier–Stokes-Fourier (NSF) (equations governing the flow of viscous, heat-conducting fluids) exact model, (2) Some features and various forms of NSF equations, (3) Some simple examples of Navier, NS and NSF viscous fluid flows, (4) The limit of very large Reynolds numbers, (5) The limit of very low Reynolds numbers, (6) Incompressible limit: low Mach number asymptotics, (7) Some viscous fluid motions and problems, (8) Some aspects of a mathematically rigorous theory, (9) Linear and nonlinear stability of fluid motion, (10) A finite-dimensional dynamical system approach to turbulence, together with a useful subject index and an extensive bibliography listing 1156 references. It is a sequel to the author's *Theory and Applications of Non-viscous Fluid Flows* published in 2002.

Some of the important formal parts of the book are mathematically heavy going, but all readers will find something of value in the well-chosen examples of specific flows included in the book, such as Stokes–Oseen flow, Hagen–Poiseuille flow, Taylor–Couette flow, Bénard–Maragoni flow, Rayleigh–Bénard convection, Hele-Shaw flow, Tollmien–Schlichting waves, rotating-disk flow, detached shear-layer flows and a variety of boundary-layer flows elucidated by powerful multiple-deck concepts. The book can be recommended to advanced students and research workers interested in theoretical fluid dynamics.

Raymond Hide