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REVIEWS

Mathematical Modeling of Melting and Freezing Processes. By V. Alexiades and A. D. Solomon. Taylor & Francis, 1993. 323 pp. £35.

This book is designed as a text for engineering students at an advanced undergraduate, or graduate level. An undergraduate course in heat and mass transfer, following texts such as those by Bird, Stewart & Lightfoot or Incropera & de Witt, would serve as a useful, though not essential prerequisite. Not essential because the book is quite self-contained and derives everything that it needs from fundamental principles. In this respect, it serves as much as a text about mathematical modelling for the thermal engineer as it does as a specific text about melting and solidification.

The book starts with a general overview of solidification and melting, followed by derivations of the basic equations and boundary conditions needed to tackle such problems. I found this section a little choppy, with the authors making lengthy asides, such as a discussion of the well-posedness of general partial differential equations (including the wave equation, which is hardly relevant to problems of phase change). Nevertheless, if one skips over these, it is quite readable and introduces the essential physical ideas and mathematical tools well.

The meat of the book is contained in three chapters (2, 3 and 4) dealing with exact analytical solutions, approximate analytical methods and numerical methods. Chapter 2, on problems with explicit solutions, works through the details of a number of one-dimensional problems that admit similarity solutions. It includes many variants of the classical Stefan problem, and its extensions include the solidification of alloys and the effects of shrinkage. Constitutional supercooling, morphological instability and mushy layers are all discussed, though the modelling of these stops short of the significant advances that have been made in the last ten years or so. The inherent nonlinearity of phase-change problems renders them difficult to solve analytically. Consequently, most of the soluble problems are covered in the text, leaving the exercises at the end of the chapter dealing more with the setting up of appropriate equations than with their solution.

Chapter 3 describes some very important approximate analytical methods. Where the similarity solutions of the second chapter allow significant insight into physical processes, the methods in this chapter are more useful tools for the practical engineer. For more complicated problems, including those in two and three dimensions, numerical methods of solution are invaluable. These are introduced in chapter 4, which begins with the introduction of finite-difference schemes for the diffusion equation. The chapter moves quickly to the enthalpy method, in which phase boundaries are 'captured' rather than being 'tracked'. This important technique is well introduced and explained. Towards the end of this chapter, in two long sections, the authors discuss the mathematical framework of the enthalpy method and its convergence properties in terms that I imagine would leave most engineers cold. It is a strange departure into the realm of theorems and lemmas, which will probably be ignored by most readers.

I found chapter 5 to be somewhat of an anticlimax. Having visited the exciting world of complex, evolving phase boundaries, we return to a discussion of latent-heat-storage systems, where overall heat balances suffice and dynamical considerations are abandoned. This chapter could easily form part of a more standard, elementary text on heat transfer.

A notable omission, as the authors confess in the preface, is any consideration of convection. Such, they argue, would require a doubling of the size of the book, giving convection a disproportionate place relative to its importance in the subject. 'Relative to its treatment in the literature' would be truer statement, for convection of the melt can play an important and fascinating role in the evolution of solidifying systems but has 'largely been ignored or accounted for approximately (by enhancing the diffusivities)'. Herein lies a challenge for the fluid-mechanics community. This book would provide a useful introduction for anyone wishing to pick up the gauntlet.

GRAE WORSTER

High Angle of Attack Aerodynamics. By J. ROM. Springer, 1992. 415 pp. DM 178.

It is the computation of flow fields around configurations typical of aircraft and weapons at large angles of incidence that chiefly concerns Professor Rom. The configurations are of the slender, highly swept-back type on which regimes of steady separated flow dominated by vortices can occur. This is an area which has seen a great deal of activity, intensifying over the past thirty years, in which conceptual and computational difficulties still abound. Since the author aimed to provide a complete and up-to-date account it is not surprising that his success is only partial. However, the inclusion of a substantial amount of material from conferences held in 1990 and 1991 in a book published in 1992 must be regarded as a real achievement by author and publisher. Over 500 authors are indexed, and a similar number of papers referred to.

The book opens with a description of flows at high angle of attack, containing 58 figures. This introduces the reader to a wide range of steady and unsteady flows around both idealized and realistic configurations, at Mach numbers up to 6 and incidences up to 60°. Most of the figures are taken from other sources, and unfortunately some of them lack the clarity that would be needed to support the accompanying account. However, the material succeeds in conveying a real impression of the complexity of many of the phenomena involved.

The next substantial chapter deals with panel methods for calculating subsonic and supersonic flows in the small-disturbance approximation. A number of methods of US origin are described and compared. These have no direct application to the theme of the book, but they underlie two of the methods subsequently presented for calculating flows at high incidence.

The first of these, to which the author and his colleagues have contributed significantly, is the nonlinear vortex-lattice method (NLVLM). The vortex lines of the conventional vortex-lattice method lie in the surface of the configuration and in a wake aligned with the undisturbed stream. In the NLVLM they are allowed to enter the flow along specified separation lines and are then constrained by an iterative calculation to follow the local flow direction. This method is described in some detail for incompressible flow, and a representative selection of results is presented and compared with measurements. This section is of lasting value, and it should be consulted by anyone thinking of using the method or of developing anything similar. In the second method, based on a panel representation, part of the shed rotation is represented by a vortex sheet or doublet layer. This method, developed at Boeing, is presented in the framework of subsonic small-disturbance theory, again with sample comparisons with measurements.

The final two chapters are likely to be of greatest current interest, dealing as they do with field solutions of the Euler and Navier–Stokes equations. In fact the majority of the Navier–Stokes solutions employ either the thin-layer or the parabolized approximations, in the Reynolds-averaged form, with a simple local turbulence model. Nonetheless, they appear strikingly successful, suggesting that the prediction of the separation of a turbulent boundary layer is very much easier in a highly three-dimensional flow than in a quasi-two-dimensional one.

The numerical solutions of the Euler equations presented in the penultimate chapter show separation occurring at salient edges, with the vortices captured realistically. Consequential secondary separations from smooth surfaces are not reproduced of course, so overall agreement with experiment is inferior to that obtained with the simplified Navier–Stokes equations.

The author is to be commended for bringing together a wealth of material unified in relation to its application. The diligent student will need to consult the references when the going gets tough, but it was not the author's intention to produce a text-book.

J. H. B. SMITH

SHORTER NOTICES

Interactive Dynamics of Convection and Solidification. Edited by S. H. DAVIS, H. E. HUPPERT, U. MÜLLER and M. G. WORSTER. Kluwer, 1992. 277 pp.

The transformation of fluid into a solid phase occurs on scales that range from the sub-millimetre scale of crystals manufactured for the microchip industry to the thousands of kilometres associated with the solidification of the inner core of the Earth. Investigations of the solidification of a static fluid, which involve the solution of often complex free-boundary value problems, were initiated over a century ago. Recently, interest has turned to consideration of the effects of vigorous motion in the fluid on the solidification process. Such flows can play vital roles in a variety of industrial and natural situations. The motions can be driven by thermal effects, but in general much stronger motions result from compositional effects. These occur because in general the composition of the solid that is formed differs from that in the original liquid; fluid of a different density is hence released at the sites of solidification.

This book contains almost all the papers presented at the first international conference devoted to the fundamental fluid mechanical phenomena associated with solidification. There are seven full-length reviews accompanying 36 three-page contributions. The conference, and the papers, are arranged in order of scale. After an interesting historical introduction, the papers concerned with microscale effects consider the linear and nonlinear instabilities of the solidification surface and the development of long thin structures, known as dendrites. On the mesoscale the most important concept is that of a mushy layer, wherein often highly convoluted solid dendrites grow within the liquid. It would be too complicated to follow the evolution of each individual dendrite, and so a continuum approach is employed which derives and then solves equations valid over regions which suitably incorporate both the solid and liquid phases in the mushy region. The book concludes with papers on macroscale processes which include industrial processing, segregation in castings and geological situations. Any fluid dynamicist who wants to learn about or contribute to this fascinating and rapidly growing field, which is yielding many theoretical and experimental investigations, would find much thought-provoking material in this collection of papers.

Turbulent Motion and the Structure of Chaos. By YU. L. KLIMONTOVICH (translated from Russian). Kluwer, 1991. 397 pp. £89.

The last decade has seen the arrival of several large books on the general field of dynamical systems, bifurcations, chaos, self-organization, synergetics, etc. Here is yet another, and in a Shorter Notice all one can do is to indicate the style and scope of the book to help readers to choose whether to look at it further.

The style is intuitive and informal rather than mathematical and rigorous. Much of the work is quoted and reviewed, without supplying any derivation. The scope is enormous: besides the topics just mentioned one finds open systems, non-equilibrium statistical mechanics and irreversibility, fluctuation-dissipation theorems, Brownian motion, plasma kinetics, biological diversity, self-organization in cosmology, turbulent motion of fluids, pattern recognition, and more besides!

The level attained is, not surprisingly, not very advanced, given the space available. The professional in one of these subfields is likely to find the parts of the book that deal with other specialities to be easy reading, and a useful way to become generally informed about them, while the part on his own subject stops just as it is becoming interesting. That, I think, is how the readers of the *Journal of Fluid Mechanics* will react to chapter 6 on turbulent motion. However, such a book certainly has a place. It would for instance be very helpful to the beginning graduate student wanting to scan the whole panorama of this field before choosing a topic for research. I would single out chapter 3 on fluctuation-dissipation theorems as providing a particularly good and up-to-date account.

The book is on the whole attractively written and produced. The translation is clear but occasionally unidiomatic.

Wave Asymptotics. Edited by P. A. MARTIN and G. R. WICKHAM. Cambridge University Press, 1992. 244 pp. £22.95.

Festschrifts come in many different forms, but this one, which marks the retirement of Fritz Ursell from his Professorship of Applied Mathematics at the University of Manchester in 1990, is unusual. It is a pleasant mix of expository articles, lectures given at a two-day meeting, and scientific autobiography, all revolving around Ursell's life-long studies of linear theory of water waves and asymptotic methods. The articles are all by former colleagues or research students of Ursell and are evidence of his influence. The last chapter contains a list of his publications grouped by subject, and an interesting set of notes on these papers explaining their origin and purpose and associated unresolved issues. Ursell's biographers will thank him for these notes.

Write in Style. By RICHARD PALMER. Spon, 1993. 364 pp. £12.95.

The sub-title of this substantial book is *A Guide to Good English*, which describes it well. The author's aim is to enable a reader to write with confidence and clarity. He does this by imparting the usual information about grammar, punctuation and sentence structure, and by discussing the merits and demerits of well-chosen pieces of writing in a large number of different contexts, such as letters, essays, novels, poetry, reviews, reports and minutes. The author's own writing is brisk, attractive and undogmatic, and a distinguishing feature of the whole book is his obvious enjoyment of his task. He denies totally the view that a concern for discipline and accuracy is incompatible with pleasure in writing. Fun and skill can go hand in hand according to the author, and they obviously do in this book.

The book is not directed especially at scientists or at any other professional group, which is perhaps as it should be, since the principles of good writing transcend the boundaries of interest groups. The poor standard of writing in many published scientific papers impedes understanding and gives little pleasure to the reader. Is this a consequence of a lack of instruction in the use of language? This book would undoubtedly help any trainee scientist to improve his skill in transferring information in English – and to enjoy doing so.

Annual Review of Fluid Mechanics, vol. 25. Edited by J. L. LUMLEY and M. VAN DYKE. Annual Reviews Inc., 1993. 641 pp. $49.

The list of articles and authors in the current volume of this periodical is as follows:

The History of Poiseuille's Law, by Salvatore P. Sutera and Richard Skalak.

The Structure and Stability of Laminar Flames, by John Buckmaster.

Resonant Interactions Among Surface Water Waves, by J. L. Hammack and D. M. Henderson.

Flow-Induced Vibrations in Arrays of Cylinders, by Peter M. Moretti.

Aerodynamics of Horizontal-Axis Wind Turbines, by A. C. Hansen and C. P. Butterfield.

Up-To-Date Gasdynamical Models of Hypersonic Aerodynamics and Heat Transfer with Real Gas Properties, by G. A. Tirsky.

Computational Methods for Aerodynamic Design of Aircraft Components, by T. E. Labrujère and J. W. Slooff.

Surface Waves and Coastal Dynamics, by Chiang C. Mei and Phillip L.-F. Liu.

Vortices in Rotating Fluids, by E. J. Hopfinger and G. J. F. van Heijst.

Boundary Mixing and Arrested Ekman Layers: Rotating Stratified Flow near a Sloping Boundary, by Chris Garrett, Parker MacCready and Peter Rhines.

Quantum Vortices and Turbulence in Helium II, by Russell J. Donnelly.

Wave Breaking in Deep Water, by M. L. Banner and D. H. Peregrine.

Order Parameter Equations for Patterns, by Alan C. Newell, Thierry Passot and Joceline Lega.

Perspectives on Hypersonic Viscous Flow Research, by H. K. Cheng.

Aerodynamics of Road Vehicles, by Wolf-Heinrich Hucho and Gino Sovran.

The Proper Orthogonal, Decomposition in the Analysis of Turbulent Flows, by Gal Berkooz, Philip Holmes and John L. Lumley.

The Impact of Drops on Liquid Surfaces and the Underwater Noise of Rain, by Andrea Prosperetti and Hasan N. Oğuz.