J. Fluid Mech. (1983), *vol.* 136, *pp.* 467–471
Printed in Great Britain

REVIEWS

Finite Elements in Fluids, Vol. IV. Edited by R. H. GALLAGHER, D. H. NORRIE, J. T. ODEN and O. C. ZIENKEWICZ. Wiley, 1982. 647 pp. $30.00.

Finite Element Flow Analysis. Edited by T. KAWAI. North Holland, 1983. 1096 pp. $95.00.

Over the past twenty years or so, an enormous amount of effort has been invested in the development of computational models of fluid-flow phenomena (an activity which is now widely referred to as computational fluid dynamics (CFD)). Traditionally, most of this effort has been geared to a finite-difference description of the field variables, with the result that the software now in use for industrial-design and performance-assessment purposes is largely based on the method of finite differences or one of its variants (e.g. finite volume). However, following its triumph in the field of solid mechanics, it became recognised that the finite-element method (FEM) offered, in principle, several distinct advantages as a basis for CFD (e.g. arbitrary local mesh refinement for capturing internal detail, a natural treatment of boundary conditions on arbitrarily shaped boundaries, high-order approximations etc.). By the early 1970s, exploratory flow calculations based on the method began to appear in the literature. This literature soon expanded rapidly, so that by early 1974 it was deemed appropriate by several pioneers to organise an international meeting (the first of a series) on 'Finite Element Methods in Flow Problems' in order to define the state of the art in all aspects of CFD. Finite-element-based methods in CFD have therefore been under development for approximately ten years, and it is perhaps timely to pose the questions 'What has been achieved in those ten years and what is the current rate of progress?'. The answers to both these questions are uniquely provided in admirable detail by the volumes forming the subject of this review.

Finite Elements in Fluids, Vol. IV comprises expanded versions of the feature lectures and selected contributed papers from the Third International Symposium on Finite Elements in Flow Problems, which was held at Banff, Canada in June 1980 (it is a pity that two years elapsed before its publication). The aim of the book is to highlight the key accomplishments that emerged from the conference. It contains 28 contributions (arranged in chapters) covering a wide range of CFD topics. These include theoretical and computational aspects of incompressible viscous flow, calculations of flows in large bodies of shallow water and through porous media, natural convection, an atmospheric boundary-layer model, applications in aerodynamics, a review of boundary-element methods, acoustic transmission, plasmas and viscoelastic flows.

Eleven of the chapters deal with applications or computational aspects of the FEM for viscous incompressible flow, underlining the editors' comment that this is indeed a 'key area'. Amongst these, chapters 3 and 4 address the topical question of convection modelling, and, in particular, introduce and test FEM generalizations of upwind differencing (or weighting) techniques. Whether or not this is a valid endeavour persists as a subject of controversy since it is often claimed that the purpose of such techniques, no matter how ingenious, is simply to obtain smooth results on meshes which are inadequate to follow the physical solution. Nonetheless, on such meshes the streamline–upwind procedure of Hughes and Brooks (chapter 3) is shown to perform better than standard Galerkin for several extreme test problems.

I found the chapter by Oden on reduced integration penalty methods for incorporating the continuity constraint particularly valuable, incisively clarifying both the theoretical foundations of this approach as well as its relationship to mixed methods (chapter 15). Even the inevitable functional analysis which pervades theoretical FEM studies seems somehow simpler to assimilate. However, it seems a pity that the reader is so often referred elsewhere for further illumination when the topic is being expounded so well and, in a book such as this, there is room to expand.

The contribution by Glowinski and his coworkers (chapter 18) is a tour-de-force of computational ingenuity and large scale application. The Navier–Stokes problem is reduced to the solution of a sequence of Poisson equations which are handled entirely in core using preconditioned conjugate gradient methods. Finally, impressive (over 6000 nodes) simulations of the complex flow around an air intake at large angles of attack are presented.

Various other applications to complex problems are presented in the book. In particular, one gains the impression that the FEM is contributing significantly to the solution of industrial problems in the field of estuarial hydrodynamics (where the boundary-fitting properties of the method are displayed to maximum advantage), aquifer/seepage flows and (to a lesser extent) compressible aerodynamics. However, it is noticeable that turbulent flow analysis, an area of considerable interest to JFM readers, hardly figures at all, the one exception being a fairly simple model of the atmospheric boundary-layer.

Finite Element Flow Analysis is a handsomely bound and presented tome containing the 132 papers presented at the Fourth International Symposium on Finite Elements in Flow Problems, held at Chuo University, Tokyo, in July 1982. When it is considered that only 73 papers were presented at the third conference in the series, there has either been an explosion of activity in the intervening two years or the venue has attracted a wider selection of participants (there is a sizeable contribution from China). What is certain is that the book represents a comprehensive statement of the current state of the art on a world scale. The papers are generally quite short (8.3 pages on average, with the shortest being just one page) and contain just the essential elements of the work reported. Consequently the reading will prove somewhat difficult for those unfamiliar with the subject matter, although generous reference to the background literature is usually provided. As in the previous volume, the range of topics covered is very wide, encompassing (apart from general lectures) mathematical analysis (7 papers), viscous flow (18), thermal convection (11), polymer flow (5), compressible flow (7), waves (5), free-surface flows (4), shallow-water flow (13), seepage flow (10), sediment transport (5), further applications (17), boundary-element methods (7) and computational techniques (19).

The value of such a large and comprehensive reference text depends much upon the careful grouping of the subject matter and the distribution of papers within those groups. For the most part, this task has been performed adequately but there are one or two exceptions. In particular, I found the section on computational techniques something of a hotch-potch, with many of the papers belonging more appropriately elsewhere. The difficulty of classifying papers must have been compounded by the fact that some of them, though of undoubted value, cannot be considered as either finite elements (e.g. the paper on thermodynamic inequalities in non-equilibrium processes, p. 237) or as addressing flow problems (e.g. the paper on the thermal modelling of the femur, p. 877).

Once again, viscous incompressible flow features as an area of great interest. Most of the mathematical-analysis and thermal-convection sections, all of the viscous-flow section, and various papers distributed across other sections are concerned with the subject (yet again highlighting the difficulties of classification). Browsing through these papers, it is clear that penalty methods and convection modelling continue to attract much attention. Of particular interest are two papers examining a novel approach for convection based on the method of characteristics (pp. 67 and 295). Noticeable developments are the attempts to produce practical Navier–Stokes models for three-dimensional flows (pp. 37 and 153) and the extension of the boundary-element method to the regime of nonlinear viscous flows (p. 931). However it is disappointing that still only three papers appear to deal with turbulent flow simulation. One continues to be impressed by practical applications in the fields of coastal and estuarial hydrodynamics, seepage/porous media and compressible flows.

To summarize, these volumes constitute a unique collection of papers recording the progress of the FEM in the field of computational fluid dynamics during the last two or three years and should prove valuable additions to the reference sections of university and research institute libraries. The subject is obviously in a healthy burgeoning state and I look forward to reading *Finite Elements in Fluids, Vol. V* (I hope before the fifth conference in the series).

A. G. HUTTON

SHORTER NOTICES

Science and Technology of Polymer Colloids. Edited by G. W. POEHLEIN, R. H. OTTEWILL and J. W. GOODWIN. Nijhoff, 1983. 635 pp. in two volumes. Dfl. 195.00.

Small spherical particles of polymer material of high molecular weight may be 'grown' chemically in a monomer solution by a process known as emulsion polymerization. The process can be controlled to give particles of specified size and constitution, and is widely used in the commercial production of a number of water-based dispersions such as emulsion paint. The average size of the polymer particles is usually of the order of one micron, so the particles remain dispersed in liquid for long periods; hence the name 'polymer colloids'.

This pair of volumes contains the texts of 30 of the lectures given at a NATO Advanced Study Institute held at Bristol in 1982. Most of the papers in the first volume are concerned with the techniques of preparation and manufacture of polymer colloids. In the second volume there are papers on applications and on dynamical properties of polymer colloids, and many of these will be of interest to fluid dynamicists. Microhydrodynamics plays a significant role in considerations of coagulation of particles, Brownian diffusion, electrokinetic phenomena, light scattering from colloids, and rheological properties. Theorists in particular are likely to find useful the surveys of data on these topics provided in several of the papers.

Mechanical Foundations of Engineering Science. By H. G. EDMUNDS. Ellis Horwood, 1981. 429 pp. £17.50.

This introductory text for engineering students includes vector algebra, kinematics, particle dynamics, analysis of stress and strain in continuous media, the deformation of Hookean solids (the chapter heading says 'and Newtonian fluids' but the section on fluids is minimal), the mathematical theory of elasticity, and structures of beams. An unusual mix, with more formal mathematical terminology than is customary for engineers.

Mathematics and Models in Engineering Science. Edited by A. McNabb, R. A. Wooding and M. Rosser. DSIR New Zealand, 1982. 183 pp. NZ $14.50.

The colleagues of C. M. Segedin have marked his retirement from the Headship of the Department of Theoretical and Applied Mechanics at the University of Auckland in 1980 by organizing a symposium and then by publishing 18 of the papers presented at the meeting. The papers are all concerned with mechanics, and about half with fluid mechanics. Problems of flow in porous media are prominent, this being a New Zealand speciality. It is an agreeable festschrift.

Mechanics of Fluids. By B. S. Massey. 5th edition. Van Nostrand Reinhold, 1983. 625 pp. Paperback £7.25.

This well-known text for students of mechanical and civil engineering was first published in 1968. Several minor changes have been made in the fifth edition; boundary layers are introduced at an earlier stage, there is a new section on gravity waves at a free surface, and the discussion on axial-flow pumps has been enlarged. The type has been reset throughout.

Fundamentals of Compressible Flow. By S. M. Yahya. Wiley Eastern, 1982. 356 pp. £9.00.

This textbook for engineering students has been written, printed and published in India. The author does not have a good command of English, and his grasp of the physics is also open to criticism. Elementary mathematical manipulations are given at length, and the conceptual level is low. One feels guiltily that one should applaud a local effort to produce a cheap introduction to gasdynamics for Indian students. But there remains the nagging question: since gasdynamics is international, does it help Indian students to have an inferior book by an Indian author?

Drying '82. Edited by A. S. Majumdar. Hemisphere, 1982. 254 pp. $70.00.

The removal of water from solid material of some kind plays an important role in industrial processing, especially of food products. Fluid mechanics, heat transfer, fluidized beds, percolation through porous media, particle adhesion, and the physical chemistry of surfaces are all involved, and so too are many technicalities of engineering practice. Developments in the subject are reported in a wide range of technical journals, and the editors have thought it useful to provide 'a single source of information on the recent developments and research activities' in this book. The book consists of 37 articles, said to be a mixture of invited and contributed. Each author provided camera-ready copy, and the mixture of typefaces and drawing styles is not pleasing.

Engineering Applications of Computational Hydraulics. Vol. II. By J. P. Benqué, A. Hauguel and P.-L. Viollet. Pitman, 1982. 160 pp. £22.50.

This monograph describes a number of numerical models developed by the staff of the Electricité de France, Laboratoire National d'Hydraulique to treat problems in environmental fluid mechanics. In all, seven models are considered, covering problems in tidal systems, in lakes and rivers and in the atmosphere. All are connected with the generation of electricity, for example the effects on the environment of the outflow from a coastal nuclear power station in the presence of strong tidal flows. The assumptions and relevant equations are given for each model, together with an outline of the algorithm used to obtain numerical solutions of the equation. This is followed by details of step sizes used and the convergence properties of the solution and finally by the presentation and discussion of the results of a typical calculation including comparison with measured data. Since all the chapters are relatively short this is not a book for the novice, but it should provide readers of JFM with an insight into the power (and limitations) of current numerical methods for the solution of environmental problems. It also gives a valuable account of the sorts of problems which have to be tackled in any industrial organization and should suggest many topics for university research.

Annual Review of Fluid Mechanics. Volume 15. Edited by M. VAN DYKE, J. V. WEHAUSEN and J. L. LUMLEY. Annual Reviews Inc., 1983. 534 pp. $28.00.

The 18 articles that make up this year's volume are as follows:

'Contributions of Ernst Mach to fluid mechanics', H. Reichenbach.
'Fluid mechanics of green plants', R. H. Rand.
'Snow avalanche motion and related phenomena', E. J. Hopfinger.
'On the theory of the horizontal-axis wind turbine', O. De Vries.
'The impact of compressible liquids', M. B. Lesser & J. E. Field.
'Autorotation', H. J. Lugt.
'Breaking waves on beaches', D. H. Peregrine.
'Instabilities, pattern formation and turbulence in flames', G. I. Sivashinsky.
'Homogeneous turbulence', J. N. Gence.
'Low-Reynolds-number airfoils', P. B. S. Lissaman.
'Numerical methods in non-Newtonian fluid mechanics', M. J. Crochet & K. Walters.
'Mathematical modelling of two-phase flow', D. A. Drew.
'Complex freezing-melting interfaces in fluid flow', M. Epstein & F. B. Cheung.
'Magneto-atmospheric waves', J. H. Thomas.
'Integrable, chaotic and turbulent vortex motion in two-dimensional flows', H. Aref.
'The form and dynamics of Langmuir circulations', S. Leibovich.
'The turbulent wall jet – measurements and modelling', B. E. Launder & W. Rodi.
'Flow in curved pipes', S. A. Berger, L. Talbot and L.-S. Yao.