Book Reviews

Ninth International Conference on Numerical Methods in Fluid Dynamics,

H. Araki, S. Oubbaramayer, and J. P. Bougot (editors),
Springer-Verlag Inc., New York, 1985, 612 pp., $32.00.

The International Conference on Numerical Methods in Fluid Dynamics (ICNMFD) is held once every two years (each even year) in a different country. The upcoming 10th Conference is scheduled to be held in Beijing in the People's Republic of China. The Conferences provide a forum for interaction among computational fluid dynamicists from countries throughout the world.

The volume begins with an inaugural lecture, followed by five invited lectures, and approximately 98 contributed papers encompassing a very wide variety of topics in computational fluid dynamics (CFD). The inaugural lecture provides some remarks on two classes of approximation schemes. The first class draws from homogenization theory and uses asymptotic expansion techniques which may be thought of as related to the more classical fractional-step methods. The second class of methods is based on optimal control theory of distributed systems—a connection that has been long recognized but not fully exposed. The five invited papers provide quick surveys on the topics they address. Owing to the rapidly advancing and expanding nature of CFD, the invited papers address rather specialized topics, therefore, their titles are included here:

Topics in the Numerical Simulation of High-Temperature Flows; Compact Explicit Finite-Difference Approximations to the Navier-Stokes Equations; Time Splitting and the Finite-Element Method; Spectral Methods for Compressible Flow Problems; and Global Relaxation Procedures for a Reduced Form of the Navier-Stokes Equations.

The contributed papers address the development of new numerical methods, the improvement of existing methods as well as the application of these methods in the analysis of flows of topical interest. The methods discussed for the solution of laminar incompressible flows in general, consider three-dimensional flows and are based on the concepts of artificial compressibility, the vorticity vector-potential formulation or the vorticity-velocity formulation; vortex methods are also dealt with. In other words, the tendency appears to be one that avoids the Neumann boundary-value problem for the pressure. Turbulent-flow calculation methods range from large-eddy simulation (LES) techniques using sub-grid scale (SGS) modeling, to direct simulation using the unsteady Navier-Stokes equations. Because of the high resolution required at increasing Reynolds numbers, spectral or pseudospectral methods are generally employed to perform the computation. Spectral methods, *per se*, are also discussed in conjunction with nonturbulent flow problems to provide details of several methods of this class. For example, a spectral element method employs the ideas of conventional spectral techniques in a finite-element procedure. Over half-a-dozen papers are devoted to finite-element methods used in the solution of the full potential equation, the Euler equations as well as the time-dependent Navier-Stokes equations. One of the ideas that appears novel for finite-element methods, is to draw on the maturing grid-generation techniques to map the complex topology of the physical domain onto a rectangular transformed domain, and apply the finite-element techniques in the transformed domain to obtain the flow solution. The approach is stated to reduce the associated discretization errors. Similarly, pseudo-spectral techniques, multi-grid solution methodology as well as adaptive mesh refinement are also considered in the framework of finite-element techniques.

Solution of the Euler equations is discussed in six papers. These include the consideration of steady transonic flow over complete aircraft, the effect of unsteadiness and rotation in the oncoming freestream as well as a comparison of the Euler solution with the corresponding full-potential solution. The computation of fine-grid solutions of Euler equations, Navier-Stokes equations, as well as the potential equation, is considered in at least eight papers using supercomputers and/or multi-grid methodology. Frequently, these treat three-dimensional flows. Existing methods have been adapted for obtaining solutions for some rather complex problems of interest, e.g., the space shuttle, an auto-rotating airfoil, orifice flows and other vortex-dominated flows. Some inviscid-flow problems with complex discontinuities are analyzed using a singularity-separating differencing method. A limited number of papers treat the solution of complex flows with separation using viscous/inviscid interacting approaches.

The four or so papers dealing with grid generation emphasize the need for improved grids and simplifying the procedures for obtaining these grids. Toward this goal, flow-adaptive grid generation is discussed in two of these papers.

Finally, mention must be made of a paper which discusses some of the concepts underlying the techniques of artificial intelligence, in particular, those of expert systems. Artificial intelligence techniques are undoubtedly expected to play a significant role in the future of aerodynamic simulation.

The proceedings of this Ninth ICNMFD is a valuable reference (containing over 100 papers), because of the wide variety of topics covered. The contributed papers are currently arranged in the volume in alphabetical order according to the last name of the first author. This arrangement is convenient for locating the paper of a specific author, however, to facilitate locating papers on a particular topic, it would be convenient to have them arranged in groups according to subject matter. Therefore, would like to suggest that future volumes include, perhaps as an appendix, the technical program of the Conference, so as to also provide an arrangement of these papers grouped according to subject matter.

Furthermore, to include over 100 papers in a book and yet keep the book size practical, requires limiting each paper to a maximum of six small pages. Frequently, results appear to get excluded from the papers. Perhaps books of this type would be of greater value if only those papers which contain new contributions substantiated adequately by results, were selected for inclusion.

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Computational Methods for Fluid Flow, by Roger Peyret and Thomas D. Taylor, Springer-Verlag Inc., New York, 1983, 358 pp., $22.00.

This welcome addition to the CFD literature is clearly a reference book rather than a text book, with an audience of active researchers, although some sections are clearly and successfully didactic. The trans-atlantic coauthorship by two highly regarded researchers gives a nice perspective, including both U.S. and French contributions.

Some of the material is really outstanding. There are detailed discussions of pitfalls and subtleties of boundary conditions in both directional- and operator-splitting methods. There is also a very complete analysis and organization of two-step Lax-Wendroff schemes (pp. 48-57), based on original work coauthored by Peyret. The methods of Godunov and Glimm are covered in some detail, and good introductions are given to "specialized methods" like potential flow, panel methods, discrete vortex methods, and cloud-in-cell.

The treatment of the artificial compressibility method (Chorin, etc.) is very good, including a discussion of the advantages of a staggered mesh (but without a discussion of difficulties of artificial compressibility on nonstaggered and nonorthogonal meshes), and an excellent original analysis of the persistent (nonconsistent) error of linear reflection applicable to all staggered mesh methods. Chorin's other method, fractional steps (called a projection method), is also well explained, but the discussion touches too lightly on the compatibility condition for Neumann boundary conditions. Their comparison with MAC is good work, a big effort on a tough subject, and very helpful.

Chapter 9 gives a necessarily brief introdution to turbulence modeling, covering turbulence in 12 pages, including closure, large eddy simulations, and direct simulations. It would be easy to criticize the brevity, but I actually thought that the chapter was good. Likewise, the introduction to finite element methods was brief but successful. On the other hand, I found the description of spectral methods much too fast.

In their explanation for upwind corrected schemes, they do understand that the oscillations of centered difference steady-state solutions are simply the discrete solutions, and are not cured by the iterative procedure. On the other hand, they present upwinding with no rationale. Similarly, conservation is defined in terms of algebraic sums, but with no interpretation or motivation.

The stability analysis for the forward time, centered space method (inadequately defined as just "the explicit scheme") does not get caught in the common error of identifying the cell Reynolds number limit with von Neumann stability. It is unfortunate that the authors did not emphasize the past errors polluting the literature, probably out of courtesy to the guilty authors (including myself). On the other hand, they did repeat the erroneous simple-minded extension of the stability limit from one to two dimensions. (I suppose neither error really does much harm, and it is amusing to watch them propagate and reflect about the literature. I wonder, will we ever converge?)

The higher order Hermitian and OCI related methods are presented, though rather quickly. But no mention is made of conventional higher order methods or deferred corrections or Richardson extrapolation. Only briefest mention is made of skew upstream methods.

The book has a surprisingly detailed presentation of delta formulation of the Beam-Warming method, and the difference from the earlier Briley and McDonald method. (Also, the authors do not make it a big issue or offend anyone, but the correct historical precedence is there.) The discussion of ADI methods (p. 66) does not distinguish the Peaceman-Rachford from the Douglas-Gunn methods.

The book unfortunately uses nonstandard technical terminology in some important areas. For example, the reader will look in vain for the "Thomas algorithm" or any of its aliases. Instead, the authors use the uncommon term "method of factorization." "Successive over-relaxation" or SOR is not used, rather it is called the "successive-relaxation method," with no references. (It is also given as a two-step method, which is misleading.) Even worse, the term "multigrid" is not used, but instead is called "multiple-grid method."

The 2½ page appendix on multigrid methods misses the mark pretty badly, in my opinion. Besides the wrong terminology, the description is incomplete, fails to give the proper historical credit to Brandt, and does not in-