Book Review

Numerical Methods in Aeronautical Fluid Dynamics, edited by P. L. Roe Academic Press, New York, 1982, 548 pp., list price $55.50.

This book is a collection of papers given at a conference on numerical methods in aeronautical fluid dynamics held at the University of Reading, U.K., in March 1981. As such it represents a good cross section of current research and methodology as practiced by the aeronautical community, with particular reference to the European community.

The principal emphasis of the collected papers is on methods for analyzing inviscid flows about aeronautical configurations at transonic speeds, and is thereby concerned primarily with methods for solving the nonlinear potential flow equations and the Euler equations of gas dynamics. Methods for analyzing viscous flows through the use of the Reynolds averaged Navier-Stokes equations are not considered, although two related articles are included, one addressing viscous effects through the use of integral boundary-layer techniques and the other through analysis of the incompressible Navier-Stokes equations. In addition to articles on basic methodology there are several articles on related subjects, including grid generation techniques and relationships between computer architecture and numerical algorithm efficiency.

The book contains 15 articles, beginning with an excellent introductory article by J. E. Green, who surveys the principal methods and classes of problems of interest to the aeronautical community. A more detailed introductory survey is given by M. G. Hall, who addresses advances and shortcomings in the calculation of inviscid flows with shock waves and briefly describes some of the basic methodology.

The methods discussed for analyzing inviscid flows with shock waves can be classified into three basic groups, which are identified as follows: 1) finite difference, finite volume, and finite element methods for solving the nonlinear potential flow equations; 2) boundary integral methods for solving the same equations; and 3) finite difference, finite volume, and finite element methods for solving the Euler equations of gas dynamics.

There are two articles which fall into the category of finite difference/volume/element methods for potential flows. The first of these is an excellent article by T. J. Baker on approximate factorization ADI finite difference methods which have become a basic cornerstone of the subject, replacing the older and less efficient SLOR methods. The second article, by C. Hirsch and H. Deconinck, surveys similar advances using the finite method.

In the category of boundary integral methods for potential flows there are also two articles. The first, which constitutes a general survey, is by D. J. Butter, B. Hunt, and G. R. Hargreaves. The second article is by J. W. Slooff. It attempts to identify necessary developments in the next generation of integral methods. Although developed originally for solving linear potential flows without shock waves, the boundary integral methods have recently been extended to include nonlinear potential flows which contain shock waves and appear to be competitive with finite difference methods from the standpoint of numerical efficiency.

The third category of methods, or finite difference/volume/element methods for solving the Euler equations, constitutes one of the more challenging and rapidly developing fields of research in computational fluid dynamics. In the book, this category is represented by four basic articles, each representing a different methodological approach. An article by P. L. Roe surveys many of these new developments, in particular the use of upwind differencing techniques for achieving improvements in computational accuracy and efficiency, and includes some of his own more important contributions in this area. An article by J. D. Denton describes improvements in his original method for solving turbomachinery flows, using both upwind differencing and multigrid concepts. Two additional methods, one by A. Lerat and J. Sides and the other by A. Jameson, although not utilizing upwind or multigrid techniques, are also addressed to the development of methods for achieving improved computational accuracy and efficiency. All of the above methods are explicit methods and are based on the finite volume approach. As such, they are relatively time consuming techniques and do not yet appear to be practical for routine design calculations. This situation may be improved, however, through the use of implicit ADI techniques which, unfortunately, are not included in the text.

The five remaining articles represent a diverse sampling of topics of basic interest to aeronautical fluid dynamicists. An article by J.H.B. Smith reviews potential vortex methods for modeling highly swept flow separations. An important and extensive survey article on methods for estimating viscous effects is given by R. C. Lock and M.C.P. Firmin. These methods, which are extensions of the classical integral boundary-layer techniques, are very useful and efficient schemes for estimating attached and weakly separated boundary-layer flows. An article describing finite element methods for solving the incompressible Navier-Stokes equations is given by R. Glowinski. M. P. Carr and C. R. Forsey survey developments in numerical grid generation techniques, and, finally, an important article by R. W. Hockney discusses the relationships between computer architecture and numerical algorithm efficiency.

In summary, it may be said that the book constitutes an important collection of papers in computational aerodynamics that describes the 1981 state-of-the-art methodology as practiced by the European aeronautical community. As such, the book should be of considerable interest to researchers and practitioners in the field of aeronautical fluid dynamics.

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