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Book Review

Incompressible Computational Fluid Dynamics

M. D. Gunzburger and R. A. Nicolaides (eds.), Cambridge University Press, 1993, 481 pp., $59.95.

Gunzburger and Nicolaides provide a useful compilation of work on incompressible computational fluid dynamics. Though not explicitly stated in the title, a glance at the table of contents reveals the book to be focused on finite element methods with a seasoning of other approaches for balance.

The book is comprised of 14 chapters written by 28 authors. The coverage is highly variable and inconsistent among chapters–the shortest is 17 pages and the longest 75 – and the amount of detail quite disparate. In addition, there is no real cohesion outside the fundamental topic itself. Finally, it would be helpful to have a introductory chapter setting the stage for problems in incompressible flow–theoretical and computational–and strengths and weaknesses of existing approaches. Instead, the reader is expected to be familiar with computational methods, especially finite elements, and have knowledge of the Babuska-Brezzi condition (or LBB—Ladyzhenskaya-Babuska-Brezzi condition as it is more commonly known in structural mechanics) and its implications. Most of the theoretical work is restricted to the Stokes equations, where a variational statement exists and analysis can be made rigorous. Most problems of interest require the full Navier-Stokes equations, however, and the ability to compute convective flows is crucial. Though the Stokes equations embody the phenomenon of diffusion and contain pressure, extension of such analyses to nonlinear equations is nontrivial. Methods successful for the linear Stokes flows may not extrapolate well to more general flows, and having guidance here would be most helpful.

These comments made, the book is a useful reference. Several extensive articles review integration methods (including stability, accuracy and convergence analyses); methods to satisfy and/or circumvent the LBB condition; considerations for developing practical 3-D problem solving tools using the Navier-Stokes equations; and means for assessing errors for both accuracy estimates and criteria for adapting a grid to the solution. There is also a short chapter on the numerical implications and requirements for incorporating turbulence models in a Navier-Stokes code–more detail would be welcome here. (There is a chapter that purports to be an industrial perspective, but merely lists different industries that could benefit from CFD, and concludes that such real world problems are difficult.) In addition, there are chapters discussing other approaches for solving the governing equations: vortex methods, spectral methods, lattice gas (cellular automata) methods, and emerging tools from nonlinear dynamical systems theory, such as inertial projection methods (though this last work is geared toward direct numerical simulations of turbulence rather than routine calculations with the Reynolds-averaged equations).

In summary, it is natural that a collection by so many authors results in diversity and lacks cohesion and continuity. However, the editors have done a commendable job in assembling the contributions into a useful, readable reference on the finite elements method for incompressible computational fluid dynamics.

J. M. Barton
University of Tennessee