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# Book Reviews

## *Optimum Aerodynamic Design & Parallel Navier–Stokes Computations*

Edited by J. Periaux, G. Bugeda, P. K. Chaviaropoulos, K. Giannakoglou, S. Lanteri, and B. Mantel, Verlag Vieweg, Wiesbaden, Germany, 1998, 468 pp., DM 298

To cover seamlessly the two emerging topics in the title of this book would be a challenge for any editor. Nonetheless, this book does precisely that, albeit in two decoupled parts. Its title encapsulates not only the ultimate goal for computational fluid dynamics (CFD) but also, considering the current computer technology, how this goal can be achieved efficiently. This book is yet another testimonial to the utility of CFD beyond merely simulating and analyzing a flowfield; CFD can and should be used for the purpose of design in order to cut down the cycle time for a new or an improved product. This, however, may be prohibitive in terms of the human and computational resources needed if, as often is the case, a large matrix of candidate designs or design variables is involved.

Motivated by the need to provide a test bed for approaches beyond the cut and try, an optimum aerodynamic design workshop was organized under the auspices of the European Computational Aerodynamics Research Project (ECARP Task 3). The complexity and the quality of the workshop contributions are evidence that significant resources have been expended by the sponsoring agencies, and their remarkable successes are reported in Part A of this book. Contributions to yet another workshop (ECARP Task 4.2), which studies a set of benchmark problems for Navier–Stokes methods on parallel computer architectures, are presented in Part B. It is refreshing that the efforts reported have not been perceived as purely of academic interest but were funded by involved European governments and corporations. Similar efforts that have emerged from the United States have been coordinated mostly by professional organizations without external funding. The editors rightfully contend that their main objective is to disseminate information about cost-effective methodologies for practical design problems and parallel processing for CFD. Indeed, these are both current needs, and the book serves its purpose very well and in a timely manner. What is missing, however, is parallel processing of the function analyses within a full-design optimization methodology rather than isolated function analyses on parallel computers.

Each part is organized to present first the definition of the test problems by the editors and then the solutions contributed by the authors from the participating European research organizations. The editors follow with syntheses and comparisons for all of the contributed solutions. Finally, the editors close each part of the book by presenting their perspectives and conclusions. The databases provided in those sections defining the test problems should be very useful to any computational aerodynamicist. They are well organized and include all pertinent detail. In addition to the problems and their solutions, the ancillary information provided, such as the coordinates of the airfoil sections, format for data storage, and visualization software, can be very handy. However, the book leaves the reader with the impression that it was rushed into print. The editing and print quality, particularly for the figures submitted by the contributing authors, could bear improvement. Inevitably, however, both the time to get the book out to its readership and the cost would increase. Maybe the final result was "optimal," considering all conceivable constraints!

The methods of Part I include inverse methods, discrete and continuous sensitivity analysis methods, gradient-based numerical optimization methods, adjoint methods, multipoint designs, and genetic algorithms with stochastic searches. These are conveniently tabulated by the editors in the following categories: flow analyzer, optimization technique, parameterization technique, test problems attempted by each contributing author, and comparative metrics, such as the number of objective function evaluations. The two-dimensional airfoil design problems were the most popular ones. Although this is to be expected, because the flows were two dimensional and over a simple geometry, it was rather impressive to read that three contributors also successfully attempted the complex problem of shaping the wing–pylon–nacelle assembly. The problems that attracted only one attempt each were the viscous shaping of an axisymmetric body and the case of "laminar" riblets in a channel flow.

For the parallel-processing workshop, the organizers (and the editors of this volume) have emphasized the three issues that perennially seem to go nowhere. These are load balancing when assigning work to each of the processors, scalability as the number of processors is increased, and portability of the codes, with the ultimate goal of platform independence. Of the five problems defined for this purpose, the two laminar flow cases are specified as compulsory. The designated benchmark data are either from experimental studies or sometimes from other CFD calculations. These, however, are not provided in the book.

The eight contributing groups demonstrate different approaches. These are produced on eight different platforms, all of which are distributed-memory architectures. In this age of rapidly growing rates of floating-point operations, it is no surprise that most of these research platforms are no longer around. In some cases, even their manufacturers are just fond memories. Mostly, these

solutions used some kind of a problem decomposition approach and multiple-instruction-multiple-data coding. The message-passing paradigm seems to be emphasized. Only two of the contributors use implicit CFD schemes, which probably is not a surprise owing to the difficult recursion problems associated with these schemes. As this book may be intended primarily for compressible aerodynamics problems, seven of the eight contributors use some kind of upwind-biased discretization method. It is interesting, however, that half of the contributions use unstructured methods. These are more complicated to parallelize because no two interprocessor data dependency patterns are alike. Finally, most of the contributions try the relatively less demanding problems.

In the synthesis chapter, the results are compared and contrasted by the editors. It is indicated that the data from these cases are stored for future use. However, there is no mention of their availability, perhaps in the form of a depository web site for downloading, to the reader. This undoubtedly would be a wonderful service to the "parallel CFD" community. The book also takes on the challenge of drawing some conclusions by comparing results. Excellent points are brought up, and a few clear conclusions are reached. Some of these confirm classical CFD dilemmas, such as "less diffusive schemes are more accurate but less convergent." However, there seem to be too many variables in this sampling to do a "scatter-gather." The editors conclude with the now famous paradigm of "better, faster, cheaper" still being the unattained target.

Overall, the book meets its objective by presenting these solutions as further developments toward real-life problems. The editors conclude, however, that aerodynamic design of complex three-dimensional configurations by higher-fidelity complex models is still beyond reach today. The editors identify some of the critical areas for future directions to achieve this goal using practical amounts of resources.

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## *Stress Analysis of Fiber-Reinforced Composite Materials*

M. W. Hyer, WCB/McGraw–Hill, Boston, 1998, 627 pp., $90.75

The continued increase in the use of composite materials in all types of structures required the introduction of courses dealing with various aspects of composite materials. There are a number of books on materials science, mechanics, analysis, design, and manufacturing aspects of composite materials. Although there are excellent textbooks emphasizing the mechanics and analysis aspects, very few present an elementary introduction based on basic concepts and discuss implications of various simplifying assumptions used to study the mechanical behavior of fiber-reinforced materials. The present book does this job admirably.

The book can be used as a textbook for senior undergraduate and first-year, graduate-level courses in engineering. It does not assume prior knowledge of composite materials. Engineers who have not taken a course on the subject during their college days may also find the book very valuable for self-study.

It begins with an overview of the various materials that may be manufactured in the fiber form. The associated load-transfer mechanisms are described. Pictures of various specimens are also provided. Details of various materials used to construct fibers and the resulting microstructure are also given. The various practical aspects of manufacture of composites are explained well. Chapter 2 contains a discussion of the basic constitutive equations for fiber-reinforced materials, including the effects of free thermal strains. An important aspect of composites is the prediction of the effective behavior, and Chapter 3 provides an insight into how the effective response of composites is characterized. The various micromechanical models are described, and comparisons with simple strength-of-materials models are made. Chapter 4 deals with the important topic of plane stress, where the derivation of constitutive equations for plane stress with additional considerations of thermal and moisture strains is presented. A derivation of the plane stress constitutive equations in the global coordinate system is presented in Chapter 5. The proper transformation relations are listed. Numerical examples are provided to aid the understanding of the theory and implications of the assumptions used in the derivation of plane stress constitutive equations. The transformation of material properties is also discussed.

Chapter 6 contains a detailed description and derivation of the field equations for laminate bending in light of the classical laminate plate theory. Detailed numerical examples are provided, and stress distribution patterns are given. The effect of curvature is also discussed. The theory and numerical examples are worked in tandem to help the reader to gain a clear understanding of the theory. Chapter 7 contains a derivation of the laminate

stiffnesses required in the classical plate theory. Stiffnesses are derived for various types of laminates, and the influence of various elastic coupling stiffnesses is discussed. Chapter 8 provides additional examples of analysis using the classical plate theory.

Chapter 9 contains a discussion of various failure theories and the failure modes in composites, along with examples. The reader will be able to better appreciate how each theory is applied to a specific failure pattern. Chapter 10 addresses the Tsai–Wu failure criterion, and in particular, the methodology to determine the various constants is outlined. The Tsai–Wu failure criterion is discussed in light of various types of loading. Chapter 11 focuses on environmentally induced stresses in laminates and is helpful in a laminate design. The effects of thermal loading and moisture are discussed. Chapter 13 provides an introduction to the fiber-reinforced laminated plates, with all of the equilibrium equations derived in terms of the displacements. Numerical results for the plate deflection under various types of loading and boundary conditions are provided. The last chapter, Chapter 14, is devoted to several methods of manufacture and has good pictures. Details about materials, tooling, and various steps involved in composite manufacture are provided.

The book does not discuss several topics that are useful in a graduate-level course. These include shear deformation plate theories, buckling and vibration of plates, and analytical and approximate solutions of rectangular plates for various boundary conditions. The list of references for additional reading on these topics is also incomplete.

The book is well written, clearly explains basic mechanics of fiber-reinforced composite materials, and includes examples and exercises. It also touches on related aspects of materials and manufacturing techniques. It is recommended as a textbook for an introductory course on mechanics of composite materials.

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