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Book Reviews

Airfoil Design and Data

Richard Eppler, Springer-Verlag, New York, 562 pp., $69.00.

This book, along with an extensive catalog of airfoil design solutions, is essentially a user's manual for an incompressible potential flow code. Discussion of complex potential theory is limited to the use of the code itself. Eppler assumes that the user is already quite fluent with the theory. The book offers some very useful information and insight on boundary layer behavior and its influence on airfoil design, particularly in the low Reynolds number flight regime, although examples of correlation with experimental results are limited and include only Eppler airfoils.

Modern airfoil design and analysis has moved beyond the restrictions of incompressible potential flow. Transonic flows with viscous interaction are the current norm. This capability has become essential, even in the low Reynolds number flight regime. Although the cruise Mach number may be 0.4 or lower, requirements for high design lift coefficients often imply transonic regions. Also, the omnipresent laminar separation bubble at low Reynolds numbers must be carefully analyzed. The Eppler code predicts the bubble and issues a "bubble warning" with no adjustment in the airfoil performance, whereas the MIT ISIS code (which uses an Euler solver with viscous interaction) predicts the bubble and calculates the airfoil pressure distribution and drag with the bubble present. It would have been informative to show comparisons of the predictions between the Eppler code and a code such as ISIS using wind tunnel data to give a representative array of airfoils and flow conditions. This would provide the potential user with a firmer basis for selecting and applying an airfoil design and analysis method.

The book presents a summary of the experiences and thoughts of a pioneering and successful airfoil designer. It is an important addition to the low-speed airplane designer's library.

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Bifurcations in Flow Patterns—Some Applications of the Qualitative Theory of Differential Equations in Fluid Dynamics

P. G. Bakker, Kluwer Academic, 1991, 209 pp., $72.00.

A topological approach to fluid flows has much to recommend it. As Leonardo da Vinci realized, a good qualitative sketch of the connectivity of streamlines will provide a physically useful picture of the overall flow and will focus attention on significant properties of the flow field that might otherwise escape discussion. The topology of flow addresses such questions as the following: Is there a closed streamline that traps fluid in a certain region of the flow? What is the nature of some point of separation on a rigid body? What happens in general to a given flow pattern as one changes a certain flow parameter? And so on. It is natural that such questions have been asked for some time, and that the answers invoke a distinct type of analysis.

This analysis is local in the sense that it makes use of expansions, typically power series, that have a finite radius of convergence about some point in the flow. Using such expansions, the consequences of the dynamical equations and the boundary conditions are imposed. This leads to a number of relations between the coefficients appearing in the expansions. Nevertheless, many coefficients remain undetermined, and the basic goal of the theory is to classify possible flow patterns in terms of these coefficients as they vary over their respective allowed ranges. If one simply expands about an arbitrary point in the flow, the degeneracy of the problem is so great that almost nothing of consequence can be said. However, if one expands about a special point, such as a stagnation point or a point of separation—a *singular* point in the terminology of dynamical systems—then the additional physical properties of the expansion point lead to important relations between the coefficients, and to predictions about the flow behavior in the vicinity.

This kind of analysis was applied to viscous flow over a rigid surface in the mid-1950s by Oswatitsch and Legendre with distinct aerodynamic applications in mind. Most readers will be aware of the elegant synopsis of the theory by Lighthill in the well-known volume on laminar boundary layers edited by Rosenhead.

The topological theory under discussion fits into the general framework of what is known as the qualitative theory of differential equations, in particular so-called center manifold theory, and the notions of bifurcation and unfolding. This mathematical apparatus was developed in the 1950s and 1960s, and thus requires a modern exposition to bring it in contact with the less systematic methods of the early "flow topologists." Bakker's text attempts to fill this need. Based on work that he and his