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Book Review

Computational Methods in Hypersonic Aerodynamics

T. K. S. Murthy (ed.), Kluwer Academic, Dordrecht, The Netherlands, 490 pp., $149.00.

This book contains 12 chapters written by well-known researchers in the field of computational hypersonic aerodynamics. These chapters cover many of the main topics associated with the simulation of high temperature reacting flows. Some recent computational results are presented along with useful descriptions of the physics of these flows.

In the first chapter, R. Grundmann discusses basic terminology used to describe reacting flows and some results from a simple reacting boundary layer analysis are presented. In the second chapter, D. Hänel discusses the conservation equations in more detail, and gives an overview of computational methods that are in current use. The reference list is up to date and leads the reader to other sources for greater detail. In Chapter 3, J. S. Shang discusses the conservation equations with emphasis on the details of the internal energy modeling. Upwind schemes, such as Steger-Warming and TVD, are discussed, and the implicit line-relaxation algorithm of MacCormack is outlined. Again, the reference list is excellent and current. P. A. Gnoffo develops in detail a point-implicit computational method for nonequilibrium flows and he presents some impressive results obtained with this method. Chapter 5, by P. Cinnella and B. Grossman, also has a clear description of the governing equations with a nice discussion of different time scales associated with the nonequilibrium processes that occur in these flows.

There is an excellent discussion of current upwind differencing methods for equilibrium and nonequilibrium hypersonic flows. B. Koren and P. W. Hemker discuss a multigrid method for perfect gas hypersonic flows. D. Arnal has an excellent tutorial on laminar-to-turbulent transition for hypersonic flows. He discusses instability modes for hypersonic boundary layers and the use of e^n methods for compressible flows. The effects of various flow parameters on transition are outlined. The reference list is exhaustive. In Chapter 8, J. P. Brazier, B. Aupoix, and J. Cousteix discuss second-order effects in perfect gas boundary layers and make some useful extensions to the Van Dyke matching scheme. Then the latter two authors discuss the effect of chemical reactions on heat transfer and extend the classical Fay and Riddell results. Chapter 10, by O. Baysal, discusses a local-linearization method for finding optimal hypersonic vehicle afterbody geometries. J. A. Désidéri describes a computational method for hypersonic flows using unstructured grids. In the final chapter, J. Häuser, J. Muylaert, H. Wong, and W. Berry present an overview of work related to European space activities. The conservation equations are discussed and some interesting results are presented.

The 12 chapters present a very good picture of the status of computational hypersonic aerodynamics. Several different computational approaches are presented and many illustrative results are given. There are chapters that provide excellent reference material for researchers who are developing computational tools. However there are some problems with the book. The chapters are essentially independent of each other, and were obviously written without any communication among the authors. Thus, the book reads more like a compilation of research papers, rather than as a coherent book. For example, in almost every chapter, the conservation equations are developed, often with different terminology. Perhaps this is unavoidable with this type of book, but it makes the book more difficult for the reader to follow.

There are several topics that have not been addressed. There is no chapter that describes in detail some of the physical issues that are relevant in hypersonic flows. It is important to have a firm grasp of both computational and physical modeling to do work in this field. For example, the important topic of vibration-dissociation coupling is only mentioned obliquely a few times. Also, there is little discussion of how to simulate ionizing flows. There is no discussion of high speed combustion or other issues related to hypersonic cruise vehicles.

There are an above-average number of typographical errors and translation difficulties in several of the chapters, but they should not present a problem to the reader. Finally, a major concern with the book is its cost. It is essentially a collection of recent research papers, and thus it would be possible to obtain copies of these papers for a much lower cost than the $149 list price.

In summary, this book is a useful grouping of current research papers from well-known researchers in the field of computational hypersonic aerodynamics. The book would be useful to individuals who are starting to work in this field, but for someone who is already well versed it may be superfluous.

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