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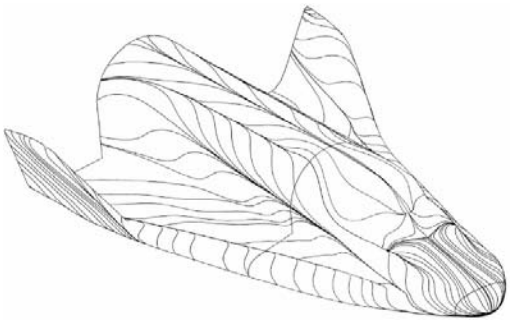
Basics of Aerothermodynamics



Springer

Jointly published with
the American Institute of Aeronautics and Astronautics (AIAA)

The book gives an introduction to the basics of aerothermodynamics. The first two chapters contain a broad vehicle classification (winged re-entry vehicles and airbreathing cruise and acceleration vehicles are the reference classes of the book) and a discussion of the flight environment. At the center of attention is the flight in the earth atmosphere at speeds below approximately 8.0 km/s at altitudes below approximately 100.0 km.

Outer surfaces of hypersonic flight vehicles primarily are radiation cooled. This is taken into account by an introduction to the problem of the thermal state of the surface, and especially to the phenomena connected with surface radiation cooling. These are themes, which reappear in almost all of the remaining chapters. The implications of radiation cooling are different for the different vehicle classes. Concerned are in any case the properties of both attached viscous and separating flows as well as thermo-chemical effects at and near the wall.

After a review of the issues of transport of momentum, energy and mass, real-gas effects as well as inviscid and viscous flow phenomena are treated. In view of the importance especially for airbreathing hypersonic flight vehicles, and for the discrete numerical methods of aerothermodynamics, much room is given to the discussion of issues of laminar-turbulent transition and turbulence. It follows a discussion of strong-interaction phenomena. Finally the simulation means of aerothermodynamics are critically considered. Computational methods and their modelling problems as well as the problems of ground facility and flight simulation, including the hot experimental technique, and the implications of Oswatitsch's Mach number independence principle are treated. The book closes with some supplementary chapters.

The use of the strongly evolving methods of numerical aerothermodynamics permits much deeper insights into the phenomena than was possible before. This then warrants a good overall knowledge but also an eye for details. Hence, in this book results of numerical simulations are discussed in much detail, and two major case studies are presented, many figures illustrate the text. All this is done in view also of the multidisciplinary implications of aerothermodynamics.

The book is for graduate students, doctoral students, design and development engineers, but also for technical managers. Emphasis was laid on the discussion of flow physics and thermo-chemical phenomena, and on the provision of simple methods for the approximate quantification of the phenomena of interest and for plausibility checks of data obtained with

numerical methods or with ground-simulation facilities. To this belongs also the introduction of the Rankine-Hugoniot-Prandtl-Meyer- (RHPM-) flyer as a highly simplified flight vehicle configuration for illustration and demonstration purposes. Throughout the book the units of the SI system are used, with conversions given at the end of the book. At the end of most of the chapters, problems are provided, which should permit to deepen the understanding of the material and to get a "feeling for the numbers".

The reader should be familiar with the basics of fluid mechanics, aerodynamics, and thermodynamics.

From the contents:

Introduction.- The Flight Environment.- The Thermal State of the Surface.- Transport of Momentum, Energy and Mass.- Real-Gas Aerothermodynamic Phenomena.- Inviscid Aerothermodynamic Phenomena.- Attached High-Speed Viscous Flow.- Laminar-Turbulent Transition and Turbulence in High-Speed Flow.- Strong Interaction Phenomena.- Simulation Means.- The RHPM-Flyer.- Governing Equations for Flow in General Coordinates.- Constants, Functions, Dimensions and Conversions.- Symbols.- Name Index.- Subject Index.- Permissions.

Date of Publication:

August 2004

2004. 413 p., Book.
Hardcover. EUR 89.95 , ₤ 69.00
ISBN 3-540-22132-8