

BOOK REVIEWS

Viscous Hypersonic Flow: W. H. DORRANCE, McGraw-Hill, New York, 1962, 97s.

STANDARD textbooks on heat transfer and boundary layer theory all stop short of the high-Mach-number flows which aerospace developments have made topical. The appearance of the present book therefore fills a gap that has been felt by students and teachers alike. The fact that the author has himself made notable contributions to the research literature of the subject, and is in close touch with U.S. aerospace activities, adds importance to this publishing event.

In the present context, viscous hypersonic flow means the boundary-layer flow of a chemically reacting gas mixture. The author is mainly concerned to review and present the best theories which are available for calculating drag, heat transfer and mass transfer in these circumstances. Eight of the ten chapters are directly or indirectly concerned with these problems; the remaining two provide useful introductions to the methods by which the thermodynamic and transport properties of gases may be calculated from statistical mechanics and kinetic theory.

Compared with thermodynamics, say, or heat conduction, viscous hypersonic flow is a new subject. This means that the author of a textbook on it has to make his own decisions about which are the points to emphasize and which theories, though often cited in the literature, are too idiosyncratic to be of lasting value; he has no earlier book which can serve as a model, or as a warning example. If he gives the subject a firm shape of his own, critics who prefer a different shape, or no shape at all, can find innumerable reasons for complaint; and inevitably the author will be unable to anticipate, and so remove, all the difficulties which the student will find; nor can he provide a secure foundation for every one of the next generation of developments. The reviewer therefore wishes to record his gratitude to Dr. Dorrance for writing this book; though unlikely to become a classic, it is a valuable pioneering work and will be of assistance to many, not least to future authors.

One of the difficulties about the present subject is that aerodynamics, transfer processes, and chemistry are closely intertwined in it; the individual strands have to be disentangled and examined separately, and then reunited in a manner which permits clear perception of how calculations are to be carried out. The author shows awareness of this, particularly by providing an early chapter, on surface-material-boundary-layer interactions, which includes a few pages on thermochemistry. It might be argued that he has not gone far enough in this regard. Thus some important and general results about chemical kinetics and the role of the enthalpy driving force are included in a chapter on the laminar boundary layer; yet

they are applicable to the turbulent boundary layer as well, and might economically have been dealt with separately.

The treatment of the theory of the turbulent boundary layer is a particular version of the Couette-flow analysis, making use of the Prandtl form of the mixing-length theory and a density-velocity relation which takes account of the possibility of dissociation. Three criticisms might be made here: First, the doubt which attaches to any Couette-flow analysis of heat transfer in a boundary layer could have been more clearly emphasized; secondly, the reader ought to have been told that other authors have made rather different decisions about the starting point (e.g. von Kármán's mixing-length expression is favoured by many), and about how the arbitrary constants should depend upon Mach number, etc.; thirdly, Dr. Dorrance's procedure (p. 194) is such as to use numerical evaluation for the momentum-thickness quadrature, so losing the closed-form simplicity given by any one of the more popular approximate integrations, and in the next step to throw away the resultant gain in exactness by equating the local to the overall drag coefficient. Nevertheless, the author's closing remarks should be quoted. They are: "While the author is not completely satisfied with the assumptions . . . it is gratifying to note that the expressions which result agree with experiment. . . ." Such honesty is refreshing.

It is hard to judge whether novices in the subject will find this book helpful. The reviewer found it necessary to mark his copy so as to make the important equations stand out from the mere algebra in which they were often embedded; and sometimes the construction of sentences was such as to necessitate their being read through twice. Probably the reader will have to work rather harder than is usually considered proper if full benefit is to be obtained from the text. Nevertheless, such benefit can be gained; and many readers will undoubtedly feel that their effort has been well rewarded.

D. B. SPALDING

Molecular Energy Transfer in Gases: T. L. COTTRELL and J. C. MCCOURBEY, Butterworths, 1961.

THIS book is concerned with the transfer of energy between molecules during collisions in the gas phase. Except for the last chapter, attention is confined to the exchange of energy between the translational, rotational and vibrational degrees of freedom of molecules in their electronic ground states.

Information on the probability of energy transfer occurring during a collision can be obtained from measurement of the relaxation time of the gas when it is

perturbed from thermal equilibrium by supplying energy to one of the degrees of freedom. Chapter 2 gives the basic analysis which shows how measurements of the absorption and dispersion of sound waves by a gas can yield data on relaxation times. Chapter 3 describes the ultrasonic techniques by which most of the data so far has been obtained. Other experimental methods are briefly discussed in Chapter 4, including shock-wave techniques and those exciting rotational and vibrational degrees of freedom instead of that of translation.

Chapter 5 is an extremely useful compilation of relaxation data on a large number of gases, accompanied by a commentary on the experimental conditions, accuracy and reliability of the data. This chapter, and the following one on the theory, are the two main topics dealt with and take up nearly half the book.

Chapter 6 is about the theory; it is mainly concerned with simplified treatments of the complex process of energy transfer during the collision of an atom with a diatomic molecule. It requires the reader to have an elementary knowledge of quantum mechanics. The authors have aimed at keeping a good physical picture in their theoretical discussion, avoiding more rigorous theoretical treatments and refinements which can be obtained from the recent book by Herzfeld and Litovitz (*Absorption and Dispersion of Ultrasonic Waves*, Academic Press, New York and London 1959) on the subject, or from the literature.

The authors have justified the general title of the book by introducing the reader in their last chapter to the more complicated subject of energy transfer between the gas molecules involving electronically excited states which arise from irradiation or chemical reaction. The discussion of this aspect of the subject is, however, limited.

The book is an excellent introduction to the research which has been done on the subject of energy transfer between molecules in low-lying energy states, and is suitable for reading and reference by chemists, engineers and physicists alike. It is written in the style of a review of the subject, with frequent reference to the literature. It is well printed, except for some slight blemishes on pages 68-72 of the reviewer's copy.

P. L. DAVIES

Thermal Properties of Dispersed Materials: A. F. CHUDNOVSKY. M., Fizmatgiz, 1962. 456 pp., 1r. 68kop. (In Russian).

TREMENDOUS achievements in engineering urge the growing necessity to accumulate and systematize available data on thermal properties of materials and, in the first place, on thermal conductivity, temperature diffusivity and thermal capacity. Knowledge of these properties and their temperature relations is required for engineering calculations of various apparatuses and processing operations based on the solution of heat- and mass-transfer equations.

At present many authors usually give numerical data of thermal properties as Appendices to the works discussing

not only heat- and mass-transfer problems but those indirectly connected with them.

However, there are a few works devoted solely to thermal properties. The book under review is such a work.

While various manuals often present only numerical data, Chudnovsky pays great attention to heat conduction processes, describing methods of thermal properties determination and of their accuracy estimation.

This is the main advantageous difference of this book from usual handbooks and therefore it may be of great help for an engineer to justify his calculations.

The book consists of three parts.

The first part "The Mechanism of Physical Processes in Dispersed Materials" contains basic notions and relationships of the heat conduction theory, discussions of the processes manifesting effective character of thermal properties of dispersed materials (convection, radiation, moisture transport, etc.), a description of the contact heat conduction process, estimations of the dependence of thermal properties on voidage fraction, volume weight, moisture content and temperature.

The second part "Methods and Instruments for Determining Properties of Dispersed Materials" deals with the methods developed in this country and abroad for determination of heat capacity, stationary technique for thermal conductivity measuring, the methods based on regular thermal regime and also quasistationary and non-stationary methods for thermal properties determination of dispersed materials.

In the third part "Thermal Properties of Various Dispersed Materials" vast material is presented concerning the measurement technique and (which is of extreme importance) results of measuring thermal properties of various dispersed materials: bound materials of solid structure, as well as non-bound, fibrous, heat resistant ones.

Special chapters deal with thermal properties of semi-conductors, soils, grounds, rocks and low temperatures. Various factors affecting thermal properties of the dispersed materials of the types considered are estimated.

A list of references is given after each part.

The book contains many tables, diagrams, calculations and formulae which will be certainly of great value for engineers in various fields.

A. G. SHASHKOV

Flow Measurement in Closed Conduits. DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH. Her Majesty's Stationery Office, Edinburgh, 2 Vols. 767 pp., 84s.

THE basic principles of flow measurement are usually dealt with in the earlier years of an engineering education, for they are simple and easily understood. However, the details of their application in engineering work, and the assessment of the accuracy gained under operational conditions has given many lifetimes of experience to those in industry and research. Indeed it is fair to say that most advanced processes at research or production stage depend heavily on accurate flow measurements using