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REVIEWS

Electrically Induced Vortical Flows. By V. Bojarevics, Ya. Freibergs, E. I. Shilova and E. V. Shcherbinin. Kluwer, 1989. 380 pp. Dfl 280 or $134 or £79.50.

This book examines in detail the behaviour of a conducting fluid through which an electric current is passed. The Lorentz force associated with diverging current lines drives a rotational flow, which is of great significance in practical applications, such as arc-furnaces and welding. The authors belong to the magnetohydrodynamics group at the Physics Institute of the Latvian Academy of Sciences in Riga, a group whose international reputation has long stood high. The book is a skillful translation by one of the authors (Bojarevičs) of the Russian text *Electro-vortical Flows* published by Zinatne in 1985, although some addition and revision has taken place for the English edition. Occasional imperfections in the English (such as a superfluous definite article) remind one of the book's origin, but the meaning is always clear.

The emphasis of the book is on analytical work, although comparison with experimental and numerical results is common. The authors restrict themselves almost invariably to axisymmetric geometries and time-independent problems. The magnetic field induced by fluid motions is neglected. Under these circumstances, the MHD equations decouple into separate electromagnetic and fluid problems, which can be solved sequentially. By making these approximations early on, the authors are able to concentrate on a particular class of MHD flows, in contrast to the more diffuse coverage of the whole subject common in other texts.

In the first part of the book, detailed consideration is given to exact solutions. The authors list some forty solutions for axisymmetric current flow in various coordinate systems. They then examine those current distributions for which there exist exact solutions of the Navier–Stokes equations, such as the Landau–Squire jets. Spherical and cylindrical geometries are considered, including those periodic along the symmetry axis. In the middle portion of the book, the authors consider more specific problems. An MHD model of a tornado is described, albeit one which neglects some aspects of the atmospheric phenomenon. By far the most important applications of these flows occur in the metallurgical industry. Heavy currents are used to melt metals both in electric arc-furnaces and in arc-welding processes. In the former case, the induced circulation of the metal influences furnace design, while in the latter it has great significance for the depth and resultant strength of the weld. With these applications in mind, the flow induced by currents diverging from a localized electrode is discussed in some depth. For the archetypal model problem with a point electrode, it is well known that a singularity in the velocity field develops for a sufficiently large current, even when viscous effects are included. Variants avoiding this singularity, involving submerged electrodes, swirl and imposed magnetic fields are considered.

In the final third of the book, the interaction of these flows with other physical processes is examined. The separation of inhomogeneities is considered in a calculation of the forces on included particles whose conductivity differs from that of surrounding liquid metal. Mass transfer from an included spherical particle is analysed with regard to alloy manufacture and electrolytic processes. Numerical calculations of heat and mass transfer across a cylindrical container are described.

Finally, specific applications of all these flows are discussed, together with descriptions of the associated experiments.

Given the Gargantuan nature of the task, the book is fairly successful in its aim of providing a thorough discussion of a particular class of MHD flows, although inevitably there are a few omissions from the extensive, and very instructive, references. Until recently there has been regrettably little contact between the Riga group and western researchers, and the publication of this book in English is a welcome development. The price is high for individuals, especially for those with a copy of the original Russian text. Nevertheless, this book provides an interesting description of the state-of-the-art in one area of magnetohydrodynamics, and researchers will find it a useful reference work.

A. J. MESTEL

Visualized Flow. Compiled by the Japan Society of Mechanical Engineers. Edited by Y. NAKAYAMA, W. A. WOODS and D. G. CLARK. Pergamon Press, 1988. 137 pp. £15.

The observation and investigation of fluid flow by visualization methods was started in modern scientific form by Leonardo; among the first group of his followers O. Reynolds and L. Prandtl should be noted. It has attracted ever-growing attention in the last two decades, especially after the appearance of Milton Van Dyke's splendid *Album of Fluid Motion* (Parabolic Press, 1982). However, long before this album appeared, people involved in education started to collect and use for teaching purposes the instructive fluid-flow photographs appearing in periodicals, especially those published by Japanese and French authors including S. Taneda and H. Werlé. So the present volume was anticipated with definite expectations.

The volume begins with a series of colour photographs of flows, varying from those around an aerofoil and streamlined car model to transonic and supersonic gas flows. They are impressive, also, from a purely aesthetic viewpoint. Later all these photographs are used in the basic text. The main part of the volume contains black-white photographs and is divided into the following sections: (1) Summary of flow visualization methods, (2) The fundamentals of fluid flow, (3) Laminar and turbulent flows, (4) Laws of similarity, (5) Compressible flow, (6) Jets, (7) Miscellaneous features of the flow past solid bodies: wakes, (8) Pipe and channel flows, (9) Circulation, (10) Wings, (11) Cascades and fluid dynamic machinery, (12) Unsteady flow, (13) Cavitation, (14) Behaviour of a non-Newtonian fluid. It appears from the list of presenters of photographs that they all belong to Japanese authors.

The present writer found useful the short explanations of fluid-flow phenomena, visualization methods and some theoretical background dispersed in the text along with photographs. The photographs showing fluid flows in complicated wings and cascades including cavitation phenomena make a valuable addition to what can be found in the Van Dyke *Album*, as well as the photographs of non-Newtonian flows. Very important is the evidence of the general engineering trend revealed in the selection and presentation of the material.

However, it is sad to see how national limitations have lowered the value of this collection. For instance, the very mediocre photographs of Taylor vortices (figures 28, 29) cannot be compared in quality with photographs by Koschmieder (figures 127, 128, 131 in the Van Dyke *Album*) or photographs by Fenstermacher, Swinney & Gollub (*J. Fluid Mech.* vol. 94, 1979, p. 1) which are not even mentioned in the present book. The important photograph 32 cannot be compared in quality with the

most instructive photograph in figure 103 in the Van Dyke *Album*. It is remarkable that this latter photograph was taken by Johannesen and Lowe on the original O. Reynolds installation carefully preserved at Manchester University. Again this photograph is not mentioned in this book. Looking at figures 25–34 (hydrogen bubble photographs of a turbulent boundary layer along a flat plate) I could not understand why these mediocre repetitions of the classical photographs of Kline and his colleagues (*J. Fluid Mech.* vol. 30, 1967, p. 4; vol. 30, 1971, p. 4) were presented instead of the original photographs, which are much better in quality and more instructive. Again, the work of Kline's group is not mentioned at all. The works of the French ONERA, and in particular of Werlé (see especially his splendid review with colour photographs in *Annual Reviews of Fluid Mechanics*, vol. 5, 1973) are also not mentioned, and it is the reader who loses because, for instance, Werlé's photograph of a Tollmien–Schlichting wave (Van Dyke *Album*, figure 104) is much better in quality and more instructive than photographs 23, 24 here. In the preface and foreword it is mentioned that the book was published previously in Japanese in 1984. To my regret I came to the conclusion that in an important sense the book is misleading for both Japanese and Western readers in what concerns the present state of knowledge in this field.

It is obvious that there exists only one science and it is international. In this field this has been stressed by Van Dyke, who presented a genuinely international collection of fluid motion pictures including, by the way, the best Japanese ones: quality was the only criterion. I am speaking about this obvious matter because in the late forties my own country passed through a phase of preparing such nationally based books and we can now appreciate fully the harm of such an approach.

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