E. M. Gol'dfarb

THERMAL TECHNIQUES OF METALLURGICAL PROCESSES*

Reviewed by M. K. Kleiner

An urgent need for more thorough theoretical analysis of thermal processes in metallurgy has grown owing to intensification of metallurgical processes in which heat treatment plays a leading part.

The monograph by Gol'dfarb differs from the known books in this field by the extent of material examined in it. This book is basically a general review of the author's work over the period 1952-1962.

In accordance with the classification of the author in the monograph precise and approximate solutions of problems of heat absorption in suspended, moving, and stationary layers are given (Chapter II), problems of heat absorption in regenerators (Chapter III), and problems of heat absorption by the stonework of metallurgical furnaces during initial heating, and during periodically repeated heating and cooling (Chapter IV) are examined.

In the monograph great attention is paid to problems of heat absorption with moving boundaries (Chapter V). Here self-simulated and quasi-steady-state solutions of heat absorption problems associated with melting and solidification of bodies are examined as well as self-modeling problems of mass transfer (diffusion) with phase conversions. In our opinion the method of solving problems of heat absorption with moving boundaries developed by Gol'dfarb is quite interesting; this method makes use of thermal potentials, and a special feature is the elimination of the potentials of the binary layer which undergo rupture during transfer through the boundary of the region, and representing them in the form of determinate integrals.

The latter is achieved by corresponding selection of the Green function.

In addition to the accurate solutions the author has obtained approximate solutions of problems with moving boundaries by a method of an instantaneous regular state. By using approximate methods an analysis of different cases of solidification of castings of simple and complex configuration is carried out.

A separate chapter (Chapter VI) is devoted to problems of heat absorption in the case of chemical conversions in the gaseous phase or in the liquid fusion, whose intensity depends linearly on the temperature. Here cases of heat absorption in thin and massive bodies, the thermal balances of flame furnaces in the presence of internal or external sources of heat, and also some problems of similarity for open-hearth furnaces are examined.

In the monograph problems of heat absorption in radiant and convective heat exchange are also examined. On examining asymmetrical heating of a rectangular prism, the author comes to the conclusion that the temperature field for this case can be obtained by the multiplication of the temperature fields of two asymmetrically heated plates of limited thickness.

The basic accurate and approximate analytical and numerical methods of solving the problems of heat conductivity are set out briefly and simply in the first chapter for better understanding of the material of the book.

It must be noted that in this book all the problems are examined as applied to the generalized equation of thermal conductivity, which incorporates all the three main shapes of a body (plate, cylinder, sphere).

*Metallurgiya, 1967, 439 pages.

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This distinguishes Gol'dfarb's monograph from other books in which the problems for each shape of a body are examined individually.

A large number of the theoretical solutions obtained are used for analysis of the operation of actual aggregates, for example, blast furnace air heaters, open-hearth furnaces, heating ducts, etc.

The results of the analysis enabled the author to recommend methods of intensifying the processes.

The material is presented on a high scientific level. The striving for generalization of the problems examined is felt everywhere.

In our opinion Gol'dfarb's book is quite useful for specialists engaged in metallurgical thermal technology and allied scientific fields.

J. E. Anderson

MAGNETOHYDRODYNAMIC SHOCK WAVES

Reviewed by P. M. Kolesnikov and B. A. Kolovandin

The Russian translation of this book [1] by the well-known US scientist Anderson will be of definite use to those investigating MHD shock waves in liquids and plasmas. An extensive literature has grown up on MHD shock waves, starting with one of the early studies by Hoffman and Teller [2]. Interest in this topic arises because the MHD shock waves which necessarily accompany supersonic MHD flow radically affect the flow pattern and properties. The waves are of intrinsic interest because they qualitatively affect the pattern of MHD flow. The existence, stability, structure, and other aspects of shock waves frequently require special research methods. A comparison of ordinary gas-dynamic and MHD shock waves shows that the presence of electromagnetic fields leads to new types of shock waves, such as slow and fast shock waves, etc., which greatly enrich the classical theory of shock waves.

Although Soviet scientists have made important contributions to the understanding of MHD collisional and collisionless shock waves, the Soviet literature, although containing pertinent reviews [3, 4] and chapters in various books [5-8], has lacked a monograph with a systematic account of progress in the study of MHD shock waves. This deficiency is made up to some extent by the translation of Anderson's book, which gives a unified treatment of the theory of collisional shock waves.

The book consists of seven chapters. In the introduction, Anderson emphasizes the questions discussed in the monograph and summarizes the basic results.

In Chapter 2, Anderson analyzes MHD shock waves in an ideal liquid, offering graphical methods for interpreting this "classical" field.

Chapter 3 is devoted to small perturbations in MHD and to the stability of MHD waves with respect to small perturbations and to the boundary conditions on shock waves. The fundamental importance of the concept of group velocity is demonstrated in the interpretation of Friedrichs diagrams, which describe the shape of a perturbation due to a point source. The phase velocity and types of MHD waves are studied, and a study is made of the interaction of small perturbations with shock waves, evolving shock waves, and nonevolving shock waves.

In Chapter 4 the generalized equations of MHD are formulated on the basis of equations with generalized heat-flow and stress-tensor laws, and a generalized Ohm's law is analyzed. The equations of one-dimensional hydrodynamics are analyzed, and a study is made of the effects which various factors have on MHD shock waves.

Chapter 5 is devoted to a study of the structure of shock waves. This study is based on a qualitative theory of differential equations; singularities and the behavior of integral curves as a whole are studied; and the structure and stability conditions are studied for fast, slow, and intermediate shock waves. The same problems are pursued in Chapter 6 for simpler cases and models. A novel approach in this book is that in which the effects of current inertia on shock waves are studied. It is shown that two types of oscillations arise in a shock wave, electrostatic and those due to current inertia, and the thickness of a shock wave is evaluated. It is shown that rapid and slow shock waves have a steady-state structure and are stable, while intermediate (super-Alfven and sub-Alfven waves) are unstable, although the flow may have a steady-state structure in certain parameter ranges.

As an appendix to this book there is an article by Heiser on an experimental test of Anderson's shock wave theory for the case of MHD shock waves in an electromagnetic shock tube. A definite correspondence is found between theory and experiment.

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Advantages of the book are its definite and limited goals, comparative completeness, and clarity. The account is up-to-date.

Since the publication of this book in 1963, new results have been found in shockwave theory, particularly by Soviet scientists. For example, there have been a study of MHD shock waves in which various types of reaction (endothermic and exothermic) are occurring [9], a study of relaxation in shock waves [10], a study of collisionless shock waves [11], prediction and study of new types of electromagnetic shock waves [12, 13], a study of thermal shock waves [14], etc.

In analyzing several studies, Anderson criticizes certain positions which he finds doubtful, but his criticism does not always seem warranted.

On the whole, Anderson's monograph is a quite complete exposition of research results in the field of collisional MHD shock waves which had been reported by the early 1960s. This Russian translation of the book will be of considerable interest for scientists involved with MHD.

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