BOOK REVIEWS

N. I. NIKITENKO

GRID METHODS IN HEAT AND MASS TRANSFER*

Reviewed by O. M. Alifanov

The current stage of development in the science of heat and mass transfer involves rapid advances in computing and a wide use of numerical methods; one of the most effective and widely used methods in this class is the finite-difference method, also called the grid method.

Nikitenko's book deals with the theoretical study of heat and mass transfer processes, particularly the definition and application of relatively simple grid algorithms for solving many thermophysical problems.

The volume consists of a foreword, seven chapters, and a bibliography.

The first chapter deals briefly with basic concepts on difference methods and considers grid algorithms for solving nonlinear inversion problems involving boundary values and coefficients for thermal conduction. These algorithms involve representing the function as a series in powers of time or temperature, where the coefficients are determined by successive approximation. Results are presented from a practical analysis of these algorithms, particularly the effects of errors in the input data on the errors of the solutions, which is important for inverse problems and treatments involving the processing and interpretation of experimental data.

The second chapter deals with heat transfer in systems with mobile phase boundaries; a general formulation is presented for the three-dimensional case. Consistency conditions are derived for the temperature within the regions as well as the heat-transfer parameters at the mobile boundaries. A grid method has been developed with explicit identification of the phase boundaries to determine the heat conduction. An advantage of this approach is that it can handle problems with internal and external mobile boundaries. The method has been used in solving some practical problems associated with casting solidification.

In the third chapter, an explicit difference method with explicit identification of the phase boundaries for thermal conduction is extended to the case where the conduction is accompanied by mass transport. Interest is attached to the research on crystallization of a binary alloy for various values of the impurity diffusion coefficient.

The fourth chapter gives a general formulation of heat and mass transfer in a body deformed by external forces and uneven temperature distributions; an explicit difference method is given for solving static and dynamic problems in thermoelasticity and thermoplasticity in the presence of mass transport. The method is used to examine the state of strain in continuous casting.

The fifth chapter deals with the flow of a viscous compressible liquid, and a system of equations is derived that falls between the Navier–Stokes and Boussinesq equations. An explicit two-layer difference scheme is used in considering the flow of a viscous liquid, whose advantage is the absence of restrictions on the grid dimensions. Grid methods are based on this scheme for handling the flow of gases and liquids, and a study is made of some flows of practical interest.

The sixth chapter uses an explicit two-layer difference scheme to consider laminar and turbulent flows and heat transfer in boundary layers and channels.

The seventh chapter deals with some aspects of the molecular-kinetic theory of transport. The author's heat-conduction model is used to derive an integrodifferential equation, which in the limit gives rise to classical and hyperbolic equations for heat conduction. This model also implies a linear radiation law, viz., that the energy of the quanta of a given frequency

*Naukova Dumka, Kiev (1978).

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emitted by an atom in unit time is proportional to the energy of the quanta of the same frequency absorbed by the atom. The author uses this law to derive standard energy distributions and the blackbody radiation law, and an equation of state is derived for condensed bodies that implies Hooke's law, the Gruneisen relation, and linear expansion on heating.

The book is an important contribution to numerical methods in transport theory and will facilitate the more general use of these in research on heat and mass transfer processes in power engineering, metallurgy, the chemical industry, building, etc.

Nikitenko's book is not free from certain shortcomings. For example, there is no comparison of these explicit difference schemes for heat and mass transfer with standard inexplicit schemes as regards computational performance. There is inadequate discussion of the choice of parameters for difference nets. Further, numerical methods of solving inverse problems in heat conduction and heat and mass transfer in the presence of phase transitions have been implemented only in a one-dimensional formulation. These comments should be borne in mind if the book is reissued.

B. I. Brounshtein and G. A. Fishbein

HYDRODYNAMICS AND HEAT AND MASS TRANSFER IN DISPERSED SYSTEMS*

Reviewed by B. M. Smol'skii, V. M. Borishanskii, and Z. P. Shul'man

Recently there has been a considerable increase in interest in the heat and mass transfer in two-phase flows of liquid–liquid, liquid–gas, solid–liquid, and solid–gas types. Results from such studies find many uses in the design of heat exchangers and various equipments used in chemical engineering.

A distinctive feature of this book is a combination of a rigorous approach to the choice of models for heat and mass transfer in laminar flow around the particles with the development of engineering methods of calculating heat and mass transfer processes in apparatus of column type. The book reflects the latest advances in this area, with appropriate emphasis on the authors' own researches.

There are seven chapters. The first three chapters deal with elementary aspects of the hydrodynamic and diffusion interactions between particles and a flow; here some new results are presented on flow and mass and heat transfer in the transitional range of Reynolds and Péclet numbers (from rather above 10 to some hundreds). This range of parameters is particularly characteristic of processes in chemical engineering. The subsequent chapters deal with heat and mass transfer in column systems under real conditions with longitudinal mixing.

The first chapter deals with hydrodynamic studies and presents in detail various aspects of the flow around particles at low and medium Reynolds numbers, particularly the flow in the wake behind the body, andgraphs are given for calculating resistance coefficients for Newtonian and non-Newtonian fluids, and simple models are given for hindered flows.

Unfortunately, we consider that this chapter devotes inadequate space to the very important rheological features of this problem.

The second chapter deals with mass and heat transfer to solid particles, droplets, and bubbles in a flow of viscous liquid. Details are given of the internal and external problems, and also of the case of comparable phase resistances. The theoretical results are presented as formulas, tables, and graphs for the heat and mass transfer coefficients for wide ranges in Re, Pr, and Pe. Studies are made of the evaporation and condensation of droplets in hot gases in the presence of a Stefan flow.

*Khimiya, Leningrad (1977).

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The third chapter deals with mass transfer complicated by chemical reactions. The analysis concerns mass transfer for irreversible reactions taking place in a body of dispersed phase or continuous medium. This is the first rigorous formulation to examine the equations for convective transport in the presence of chemical reactions. The limits to the utility of the model solutions often used in practice are discussed.

The fourth chapter deals with methods of determining longitudinal-mixing coefficients by the use of a one-parameter diffusion model. Formulas and graphs are given for longitudinal-mixing coefficients in terms of the response curve in stationary and nonstationary methods of trace input to columns of restricted height, and also for the limiting case of a column of infinite height. The basis of the method of moments is also presented.

The fifth and sixth chapters deal with the heat and mass transfer in industrial columns for systems with various numbers of components. Methods are given for calculating the extent of extraction (heating) and the height for a counter-current column for processes involving heat transfer, solvent extraction, absorption, and solution. Working formulas and graphs are given for ideal displacement and also for longitudinal mixing of the dispersed and continuous phases.

The seventh chapter deals with mass transfer in column reactors; methods are given for calculating the extent of conversion and the height for a counter-current reactor for a liquid—liquid or liquid—gas dispersed system showing irreversible chemical reactions of second order in the bulk of the dispersed and continuous phases in the presence of longitudinal mixing.

It would be extremely useful to extend this chapter in further editions of the book, and in particular to supplement it with examples of calculations of particular column reactors for dispersed systems.

On the whole, the book presents a novel and original consideration of the material, and it surveys and generalizes many researches, which are represented from the viewpoint of the current theory.

The book is of undoubted interest to a wide range of specialists in chemical engineering, nuclear power, heat engineering, and adjacent areas.