Int. J. Heat Mass Transfer. Vol. 16, pp. 1659–1661. Pergamon Press 1973. Printed in Great Britain

BOOK REVIEWS

J. E. ANDERSON, **Transfer Phenomena in Thermal Plasma.** Energiya, Moscow (1972).

THERMAL plasma obtained with electric-arc heaters finds still wider application in industry. Electric-arc heaters are effective devices for realization of some chemical processes in plasma, treatment of refractory materials, etc.

This required vast experimentation and theoretical investigation of the properties of thermal plasma, interaction of electric-arc column with a gas flow, electrode phenomena, energy transfer from a plasma flow to channel walls and so on.

The theory to the problem on interaction of electric-arc column with a gas flow and external magnetic field is given in the book by Prof. J. E. Anderson, Minnesota University, U.S.A.

At present intense developments of calculation methods for investigation of electric arc in a gas flow which are more economic than experimental ones are carried out. Therefore the publication of Prof. J. E. Anderson's book in Russian edited by Acad. A. V. Luikov is up to the time.

In the first chapters of the book the concepts of magnetogas dynamics are introduced, and balance equations are discussed in application to thermal plasma with account taken of all the main effects. The generalized Ohm law is particularly derived which allows for the effect of a magnetic field (Hall's current), difference between ion and electron velocities (ion slip) and electronic pressure gradient. The estimation of the terms of equations from laboratory experiments with thermal plasma show that the displacement current may be neglected, plasma is neutral and magnetic Reynolds number is small. In the equation of momentum conservation the term of magnetic pressure may be significant. These and a number of other estimations allow the system of equations describing the behaviour of electric arc in a gas flow in the presence of a magnetic field to be simplified.

Next chapters deal with three particular problems.

In Chapter 6 consideration is given to solution of the problem on axisymmetric d.c. arc column in a longitudinal developed laminar gas flow with account for a proper magnetic field. Estimation shows that the radial pressure drop due to magnetic field may be neglected; at moderate Mach numbers the viscosity term in the energy equation is small compared to the Joule heating. It is assumed that the gas properties σ, U_r are independent of the pressure (its changes being slight); the intensity of radiation per unit volume is determined in a single way by the temperature and the arc radius (the column is optically thin).

Before treating the solution, the author gives an approximate estimation of the characteristic values. In particular, useful expression $r_e \approx I^{\frac{1}{2}}/70$ is obtained for the radius of arc column. An expression is derived for estimation of limit temperatures at the axis. Solution of the energy equation neglecting convection is sought by a numerical method. A linear relation between the function of the thermal conductivity $\varphi = \int_{TP}^{T} \lambda \alpha T$ and the variable $x = r^2/r_w^2$ is assumed as a first approximation.

An inverse problem is considered and it is shown how to calculate the thermal and electric conductivity and intensity of radiation per unit volume using the solution of the energy equation, and electric characteristics and radial temperature distribution found experimentally.

Chapter 7 deals with electric arc in the presence of axial and radial gas flows. The case under consideration corresponds to a possible design of an electric heater in which the walls of a channel with a discharge are cooled by transpiration. A condition is introduced for an ideal porous wall that all the heat supplied to the wall by radiation or convection should return to the channel with a radial gas flow.

The length of the channel section is estimated where the stagnation enthalpy of heated gas achieves an approximately constant value. Equations for a developed flow are considered and then reduced to ordinary differential equations using the similarity conditions. The numerical procedure of solving the equations and the range of validity are shown.

In Chapter 8 free arc column is considered, expressions for estimation of the radius of arc column, equilibrium conditions and curvature radius in the presence of a transverse gas flow are obtained.

The book gives a detailed consideration to some particular problems of arc column in a gas flow.

The book may serve as a text-book for university students.

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L. S. TONG, **Boiling Crisis and Critical Heat Flux.** AEC Critical Review Series. 82 pp. $3.

THIS book is a monograph on critical heat flux by one of the pioneer water-cooled, nuclear reactor designers. It is one of a series of AEC sponsored monographs on various topics concerning nuclear reactor design.

The material in the book can be divided into two categories: a discussion of the mechanisms of critical heat flux and a presentation of the empirical equations. We shall open this review with a discussion of Tong's treatment of the mechanisms of critical heat flux then turn to a discussion of the empirical equations used for design.

The great mass of CHF data and theory have been broken down into a small number of distinct mechanisms and these discussed from the point of view of the limiting process leading to CHF. The choice of mechanisms which Dr. Tong has made in order to describe the field is excellent. Neither too much detail nor unnecessary empiricism is included in the discussion. This section of the book would serve as an excellent discussion of CHF for a course in which two or three hours of class time might be devoted to this topic. The review of the literature here is excellent also.

The second category which Dr. Tong concerns himself with is the design equations. These are all complex, computer determined, functions of quality, mass velocity, pressure and system geometry. They are completely empirical and must be approached with caution. The possibility of misprints is very great as the equations are unfamiliar, dimensionally inconsistent and impossible to check. Example problems are not worked out so that one can, in general, check the arithmetic. In addition, empirical factors are used in the equations which are not clearly defined in the text. For instance the eddy diffusivity in equation 2.4 is unclear. It is not clear either what the boiling length is in equation 2.25. Is it the distance from the first boiling point or point of bulk boiling? If it is first boiling how does one determine the superheat at this point? Questions of this kind can only be answered by going back to the original references.

Another problem arises in the use of the rod bundle equations. The calculation of the local mass velocity and quality in the equation depends on the use of company classified codes for pressure drop, void, mixing and flow redistribution. These equations as they stand, are useless for calculating without methods of calculating mass velocity and quality for substitution in them. This information is not provided nor is it ever mentioned.

In spite of these criticisms, this is a valuable monograph. The general discussion of CHF and the listing of the recommended design equations removes much of the mystery from the thermal design of nuclear reactors. This book is useful for describing thermal and hydraulic design methods for reactors and showing the precision characteristic of these methods.

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JOHN G. COLLIER, **Convective Boiling and Condensation.** McGraw-Hill, 1972, 421 pp. £9.00

THIS book presents an excellent summary of the general purpose tools which are used to solve problems in the gas–liquid two-phase flow area. The book opens with a discussion of two-phase flow and presents the standard, overall calculation methods. Flow regimes and flow regime maps are discussed. Recommendations are made for when to use each correlation scheme. The sections in this book on subcooled void and pressure drop are unique. Recommendations are also made for calculating pressure drop in fittings.

The section on boiling reviews the heat transfer correlations and critical heat flux data from an overall point of view. Specific recommendations for design are not made for various pieces of equipment, though the characteristics of the different correlations are mentioned. In this respect the monograph of Tong supplements this work as he does make specific recommendations. Mention is also made of heat transfer beyond burnout and various means of raising the critical heat flux.

The book is unique in that a section on condensation heat transfer is also included. Both dropwise and film condensation are considered. Because of the space limits characteristic of general heat transfer texts, this section goes beyond what is usually included in a chapter on condensation and covers the effect of shear stress, condensation in tube bundles and the effect of non-condensible gases.

In summary this book is unique both from the point of view of combined two-phase flow and heat transfer coverage and the good taste displayed in the choice of material to present. Problems are given at the end of the chapters so that the book can be used for a text in a course. The book is self-contained and has the material needed for a graduate course in two-phase flow and heat transfer such as might be given to mechanical, chemical or nuclear engineers.

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CHRISTIE J. GEANKOPLIS, **Mass Transport Phenomena.** Holt, Reinhart and Winston, £8.00, 495 pp.

THIS book is primarily concerned with the principles of mass transport phenomena. The author emphasises the analytical approach of formulation and solution of mass transfer problems rather than applications *per se*.

The book begins with a review of the fundamentals of transport phenomena which will be helpful to those who have received no formal education in transport phenomena. The first three chapters elaborate the aspects of mass transfer in gases and liquids, with or without reaction. Useful methods of prediction of diffusion coefficients of gases and liquids are included, although nothing has been mentioned about the predictive methods for diffusion coefficients in highly viscous solutions. No mention has been made of the abnormal diffusive transport rates in macromolecular solutions. The section on multicomponent diffusion is a welcome addition but it is surprising to find that the established matrix generalisation techniques [H. L. TOOR, *A.I.Ch.E.Jl* **10**, 448, 460 (1964)] are not mentioned. There is a section on steady state multicomponent diffusion of gases but the corresponding section for liquids is absent although prediction methods for diffusion coefficients in liquids find a place.

The next chapter on mass transport in solids is very valuable particularly since previous texts on the same subject have almost exclusively dealt with gases and liquids. The chapter on unsteady state diffusion provides information which is well documented in monographs of Crank or Carslaw and Jaeger. The chapter on mass transfer coefficients in laminar and turbulent flows has a worthwhile section on the definitions and inter-relation of different mass transfer coefficients. The ideas of convective diffusion transport are simply introduced and clearly illustrated.

The problems of interphase mass transfer are next considered and the calculation procedures for the design of