Int. J. Heat Mass Transfer. Vol. 14 pp. 333–336. Pergamon Press 1971. Printed in Great Britain

BOOK REVIEWS

A. V. Luikov, **Heat-Conduction Theory.** Vyssh. Shkola, Moscow. (1968). (In English by Academic Press, New York, 1969).

The heat-conduction theory is one of the basic sections in the heat-transfer theory; it is most widely spread in design calculations of apparatuses and machines of power machine-building, energy engineering, production of building materials, etc.

The heat-conduction theory is also of importance for modern technique, where unsteady-state heat-transfer processes acquire particular significance.

The monograph under review is devoted to the solution of unsteady-state problems of the heat-conduction theory. The novelty of the book is introduction of the boundary conditions of the fourth kind and a solution of the problems for these very conditions. The method of solving these problems by operational calculus is developed. The author has extended the range of these problems. A number of problems for the fourth kind boundary conditions with an arbitrary initial distribution are solved by the Fourier finite transformations. That allowed a new approach to convective heat-transfer problems. In particular, a strict statement of the problem on convective heat transfer is reduced to the solution of an equation system of heat transfer in a boundary layer of a fluid or a solid in a fluid flow. Nowadays such a problem statement is known as the solution of an ajoint problem, and the problems with boundary conditions of the fourth kind have become of great significance.

The book is valuable for the solution of applied engineering problems; it is extremely useful for engineers having no special mathematical knowledge, since it permits them to solve complicated problems without methods of the analytical function theory. This is possible because of a wide use of the Laplace transforms. In particular, by his own method the author derives expansion theorems for a general case of multiple roots, not making use of a contour integral and the Cauchy residue theorem.

As the result, using the relations of operational calculus, algebra and higher mathematics, one succeeds in solving the basic problems of the heat-conduction theory which are usually solved by a rather complicated method.

Operational methods allow the basic problems to be solved in two forms: as the Laplace transform and the Fourier transform. The first form is of use for small Fourier numbers, while the second one is convenient for large ones. The author demonstrates an efficiency of the solution for small Fourier numbers by numerical calculations.

The book is well compiled. The problems are arranged according to the types of boundary conditions so that from one chapter to another they become more and more complicated. First, detailed solution procedures are given. The solutions are illustrated by numerical calculations which are then compared with the data of tables and graphs. With this end, the author presents many graphs and nomograms which may successively be used for approximate engineering calculations.

The book contains some new important results, obtained by the author. The author's method for the solution of nonlinear heat conduction problems for the case of thermophysical properties, dependent on the coordinates, is of a particular note. This method allowed the general solution to be obtained of one-dimensional nonlinear problems.

The second important result in the field of the heat-conduction theory is a development of the method for asymptotic estimates on the basis of analytical properties of the Laplace transform. With this object in purpose the author has written a special chapter (15) dealing with the elements of the analytical function theory. Such analytical estimates are of particular importance for the cases when exact solutions are not easy to be obtained.

In the book a mathematical analysis is given in close relation with the physical essence of a phenomenon considered. As an example we may mention the relationship found between the operational calculus of Heaviside–Laplace and the theory of generalized variables (the similarity theory). Such a relationship allows physical interpretation of transformed solutions.

To conclude the review, it may be said that linking of a mathematical analysis with the physical significance of heat-transfer processes, applicability to the solution of practical problems, presentation of new results and ideas of the heat-conduction theory make this monograph to be useful for students and engineers.

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L. L. Vasiliev

V. I. Subbotin, D. N. Sorokin, D. M. Ovechkin and A. P. Kudryavtsev, **Boiling Heat Transfer in Metals Under Natural Convection,** Moscow, Nauka (1969).

The book under review represents experimental and theoretical results of works carried out by the authors on heat transfer in boiling alkali metals. In the book the works published in the USSR and abroad are analysed.

The book contains four chapters.

Chapter 1 deals with experimental methods for heat transfer at boiling liquids and experimental installation to be used in such kind of researches.

Modes of heating experimental sections are described in detail, an emphasis being laid on electronic heating used in the authors' experimental installations.

The chapter contains basic information necessary for experiments on heat transfer at boiling liquid metals.

Chapter II is devoted to boiling heat transfer of alkali metals and also to the analysis of experimental data on boiling heat transfer for mercury and amalgams.

There are presented summary tables on experimental results reported in literature on boiling heat transfer for the heat-transfer agents, mentioned above including the pressure and heat flux ranges, characteristics of the working sections and empirical formulae for heat transfer.

The chapter reports in detail the experimental results of the authors in boiling heat transfer for sodium, potassium and cesium over a flat horizontal disc, 38 mm dia., heated by electron bombardment. The heat fluxes ranged approximately from 10^5 kcal/m^{2}h to critical heat fluxes.

Three heat release regions are considered for vaporization under natural convection: heat release due to convection with the subsequent removal of heat by evaporation from free surface; developed boiling heat release; heat release at transition boiling which is most characteristic for boiling alkali metals over a wide range of pressures and heat fluxes. There are analysed the following factors which determine the existence of this or that heat release region: heat flux and pressure, material and finish of the heat transfer surface, the contact time with heat-transfer fluid and presence of inert gas.

Experimental results on developed boiling heat transfer for alkali metals are compared with the known generalized relationships for prediction of coefficients for boiling heat transfer of non-metallic liquids. Predictions by these formulae, in general, do not agree with experimental data on boiling alkali metals.

The authors recommend two generalized relationships satisfactorily describing experimental data on heat transfer in developed boiling of sodium, potassium and cesium in certain ranges of reduced pressures.

Chapter III is given over to experimental results of the authors on critical heat fluxes in boiling sodium, potassium and cesium over a horizontal disc, 38 mm dia. The experiments are run at reduced pressures of $4 . 10^{-5}$–$3 . 10^{-2}$, i.e. at those which may be of use in modern technique. The appropriate graphs represent scanty available experimental data on critical heat fluxes vs. pressure at boiling sodium, potassium and rubidium over horizontal tubes. A satisfactory agreement with the authors' results for the same heat release region may be found. The authors have investigated critical heat fluxes at steady and transient boiling. Critical heat fluxes for transient boiling involving high values of low-frequency fluctuations of a wall temperature have appeared to be lower than those for steady boiling. Generalized formulae for critical heat fluxes at boiling non-metallic liquids in the case of boiling alkali metals are shown to be not valid. For critical heat fluxes in boiling sodium, potassium, cesium and rubidium at pressures from hundredths of fractions of an atmosphere up to several atmospheres, the formula is suggested

$$q_{kp} = \left[1 + \frac{c}{p_{kp}}\left(\frac{p_H}{p_{kp}}\right)^{-m}\right] B . r(g\gamma'')^{\frac{1}{2}} [\sigma(\gamma' - \gamma'')]^{\frac{1}{4}}.$$

This is Kutateladze's formula including a new group suggested by the authors to allow for heat flux removal from the heated liquid surface.

There are presented experimental results for boiling mercury and magnesium amalgams and formulae are given which satisfactorily describe experimental results in the range of pressures investigated.

The last chapter treats some physical aspects of boiling metals. In general, an analysis of local characteristics of boiling liquid metals is done on the basis of works on these characteristics at non-metallic liquid boiling under comparable conditions and scanty available works on metallic boiling.

Some aspects of vapour-bubble growth and the separation frequency are considered for the case of boiling metals and non-metallic liquids. The predicted and experimental values obtained have allowed the authors to conclude that a majority of formulae for prediction of bubble growth rates in boiling non-metallic liquids are not valid for the case of boiling metals, particularly at low pressures.

In the summary for this chapter the main differences are formulated between local boiling characteristics of non-metallic and metallic liquids, which, in their turn, may lead to a difference between integral characteristics.

However, available information is insufficient for a complete description of boiling heat transfer not only of metals but of non-metallic liquids as well.

This book may be considered the first experience in generalization of investigation results on heat transfer of boiling metals under natural convection.

The book is well written and eminently readable. It will be of benefit to many involved in a research of boiling and application of metals and their vapors as heat-transfer agents.

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A. S. Ginevsky, **The Theory on Turbulent Streams and Wakes.** Moscow, Mashinostroenie (1964).

The monograph presents theoretical and experimental results on turbulent jets with constant and variable density. The book contains five chapters.

Chapter I is given over to derivation of turbulent boundary layer equations in differential and integral forms. The errors in semiempirical turbulence theories for similar and non-similar jet flows are estimated; the microstructure of turbulent incompressible jet flows is investigated.

Chapter II treats approximate integration methods on calculation of plane and axisymmetric submerged jets and also of jets and wakes in a cocurrent flow. Herein is presented an approximate theory of a transient jet region and is given the calculational method on non-vortex flow for turbulent jets issuing into finite and non-finite space.

Chapter III compres exact solutions for similar laminar jet flows and numerical solutions for the corresponding non-similar flows with approximate solutions, obtained in Chapter II. The results are confronted with the experimental data, and the experimental constant entering into the predicting formulae is determined.