Book Review

Introduction to Thermal Sciences: Thermodynamics, Fluid Dynamics, Heat Transfer: Frank W. Schmidt, Robert E. Henderson, Carl H. Wolgemuth
476 pages, Second Edition, Wiley & Sons, New York etc., 1993.

The aim of the book is to introduce engineering undergraduates to the thermal sciences. The physics describing the fundamental phenomena is emphasized and sufficient mathematical description is given to enable the reader to solve relatively simple problems in the thermal sciences.
The book starts with the identification of the thermal sciences and its basic principles. The next chapters deal with the concepts and properties that are encountered in thermodynamics. This includes a discussion of heat, work, equilibrium and reversible processes and the fundamental laws of the thermodynamics. Emphasis is given to system analysis, especially to the analysis of a control volume that has mass flow across its boundary. A general relationship, the Reynolds transport theorem, is developed. The relationships describing the conservation of mass, linear momentum and energy for a control volume are developed in a one-dimensional form. Then the concepts of a fluid and a thermal boundary layer are introduced. The fluid boundary layer is examined and relationships are developed for estimating the friction drag and pressure drag experienced by a surface or object. The thermal boundary layer is investigated for both forced and natural convection heat transfer alone and the two in combination. Both laminar and turbulent flows are considered. A similar treatment of internal flows are presented and the flow and heat transfer are examined in piping systems and heat exchangers. Finally the problems of conduction and thermal radiation heat transfer are discussed.
Many of the faculties of chemistry do not teach these topics with a similar deepness. I think this book can be very valuable for those chemists in the field of thermal analysis who are lacking a true engeneering background or have already forgotten their former studies. It helps to understand the fundamental physical phenomena in the thermal analysis experiments and encourages the reader to make further efforts for a reliable mathematical modelling.

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Heat Conduction
Second Edition by M. Necati Özisik
John Wiley & Sons, Inc., New York, Chichester, Brisbane, Toronto, Singapore
1993, 692 pages

The author, M. Necati Özisik since 1963 has been Professor of Engineering at the Department of Mechanical and Aerospace Engineering, North Carolina State University, Raleigh.
He has written Heat Conduction in a systematic and understandable fashion, but the reader is expected to be armed with appropriate mathematical knowledge. Nevertheless, Professor Özisik successfully achieved the objective he declared, i.e. lengthy mathematical proofs have been omitted, instead examples have been used to illustrate the applications of various solution methodologies.
Indeed, the reader can find a lot of examples have been solved at the end of each chapter and 'problemes' have been collected to be solved.
The book consists of 15 chapters and 7 appendices.
Chapter 1 reviews the fundamentals and summarizes the background material needed to solve heat conduction problems. The author presents the basic laws relating the heat flow to the temperature gradient in the medium, the differential equation of heat conduction governing the temperature distribution in both stationary and moving solids, considering isotropic and anisotropic media as well. He also considers the boundary conditions appropriate for the analysis of heat conduction problems, and the rules of coordinate transformation needed to write the heat conduction equation in different orthogonal coordinate systems.
Chapters 2, 3, 4 are devoted to the solution of time-dependent homogeneous heat conduction problems. In these chapters the general aspects of separability of the heat conduction equation is discussed and the separation of the variables in rectangular, cylindrical and spherical coordinate systems is examined, respectively. Numerous solved examples are shown such as: solution of one-dimensional transient heat conduction equation given in terms of temperature $T(x, t)$ or in terms of heat flux $q(x, t)$ in finite, semi-infinite and infinite regions, separation of variables to the solution of multidimensional homogeneous heat conduction problems, solution of multidimensional steady-state heat conduction problems with and without heat generation. The solutions, the norms and the eigenvalues of the separated differential equations are collected in tables for different combinations of boundary conditions. Transient-temperature charts (which are useful for rapid estimation of temperature history in solids) for a slab, a long solid cylinder and a sphere subjected to convection can be found in this section.
In Chapter 5 application of the Duhamel's method is presented for the solution of heat conduction problems with time dependent boundary conditions and with energy generation.
Chapter 6 is devoted to the use of Green's function in the solution of homogeneous transient heat conduction processes with heat generation. Applications are shown to one-, two- and tree-dimensional problems of finite, semiinfinite and infinite media and illustrated with examples in different coordinate systems.
In Chapter 7 the method of Laplace transformation is described. This transformation is widely used in the solution of transient heat conduction problems, because the time dependent partial derivative can be removed from the differential equation by its application. The Laplace transformation method is defined and its properties are described in general. The illustration of its application in the solution of one-dimensional transient heat conduction problems is presented with numerous examples. In this chapter, the reader can find

the Laplace transform of various functions listed in a table which can be useful in the analysis of heat conduction processes.

In the Chapter 8 the application of the orthogonal expansion technic, the Green's function approach and the Laplace transformation method to solving heat conduction problems of composite media is demonstrated. The mathematical formulation of one-dimensional transient heat conduction in paralell layers of infinite and semiinfinite stabs, concentric cylinders and spheres is presented and illustrated with examples.

Chapter 9 presents approximate analytical methods that can be useful tools in solving the partial differential equations governing the heat conduction processes. The solutions discussed here are the integral method, the Galerkin method and the method of partial integration. The accuracy of approximate procedures are illustrated by comparing the results with the exact solutions of simple problems. Examples considered are: integral method application to linear and nonlinear transient heat conduction in semiinfinite medium; integral method application to a finite region; the Galerkin method application to steady-state and transient heat conduction problems with several boundary conditions; the partial integration method application to steady-state heat conduction with heat generation.

In Chapter 10 moving heat source problems are taken into account. Temperature and energy distribution in solids during welding, grinding, cutting, surface hardening of metallic alloys with flame or laser, and similar cases of engineering applications can be considered as a model of heat conduction involving of temperature fields source. Mathematical modeling of the determination of temperature fields in solids resulting from a moving point, line, and surface heat sources under quasi stationary state conditions is presented.

Chapter 11 contains a characterization of transient heat transfer processes in melting and solidification which often referred to as 'phase-change' or 'moving-boundary' problems. The solution of such problems is difficult because the interface between the solid and liquid phases is moving as the latent heat is absorbed or released at the interface. Mathematical formulation, exact-, approximate-, semi-analytic-, and numerical-solutions are presented.

Chapter 12 is devoted to the description of finite-difference methods which are useful for solving partial-differential equations cannot be handled by exact analysis because of their nonlinearities complicated boundary conditions, and complex geometries. Here a classification of partial-differential equations encountered in the mathematical formulation of heat transfer processes is presented and the application of finite-difference methods to the solution of heat conduction problems is considered.

Chapter 13 provides a systematic description of the application of integral-transform technique in solving three-dimensional, time-dependent heat conduction problems in rectangular, cylindrical, and spherical coordinate systems.

Chapter 14 is an introduction to the theory and application of inverse heat conduction problems we are usually concerned with the determination of temperature-distribution in solids when the boundary and initial conditions, the heat generation rate, and physical properties of the medium are specified. In contrast, there are occasions when the boundary conditions, the heat flux at the surface, or the physical properties of the material have to be determined from the measured temperature history in the solid. Such situations for example, the determination of heat flux at the surface of a wall subjected to fire, or at the inside surface of a combustion chamber where the direct measurement is extremely difficult but inverse analytical methods can be successful.

Chapter 15 is an overview of the heat conduction in anisotropic media. Differential equations and the boundary conditions for anisotropic solids are presented, the solution of steady-state and time dependent problems are illustrated.

Heat Conduction is an excellent reference book that I could recommend to practicing engineers, scientists and researchers. It is also a systematic and detailed textbook, illustrated with numerous examples, for students of engineering both at undergraduate and postgraduate level as well.

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