

Chapter 5

Transient Heat Conduction: Analytical Methods

1 Introduction

Many heat conduction problems encountered in engineering applications involve time as an independent variable. The goal of analysis is to determine the variation of the temperature as a function of time and position $T(\mathbf{x}, t)$ within the heat conducting body. In general, we deal with conducting bodies in a three dimensional Euclidean space in a suitable set of coordinates ($\mathbf{x} \in \mathbb{R}^3$) and the goal is to predict the evolution of the temperature field for future times ($t > 0$).

Here we investigate specifically solutions to selected special cases of the following form of the heat equation

$$\rho C_p \frac{\partial T}{\partial t} = \nabla \cdot (k \nabla T) + g(\mathbf{r})$$

Solutions to the above equation must be obtained that also satisfy suitable initial and boundary conditions.

2 Fundamental Solutions

Transient problems resulting from the effect of instantaneous point, line and planar sources of heat lead to useful fundamental solutions of the heat equation. By considering media of infinite or semi-infinite extent one can conveniently ignore the effect of boundary conditions on the resulting solutions.

Let a fixed amount of energy H_0 (J) be instantaneously released (thermal explosion) at time $t = 0$ at the origin of a three dimensional system of coordinates inside a solid body of infinite extent initially at $T(\mathbf{x}, 0) = T(r, 0) = 0$ everywhere, where $\mathbf{x} = r = \sqrt{x^2 + y^2 + z^2}$. No other thermal energy input exists subsequent to the initial instantaneous release. Assuming constant thermal properties k , ρ and C_p , the heat equation is

$$\frac{\partial T}{\partial t} = \alpha \frac{1}{r^2} \frac{\partial}{\partial r} (r^2 \frac{\partial T}{\partial r})$$

Chapter Transient Heat Conduction Analytical Methods

Je-Hyoung Park



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Modelling Methods for Energy in Buildings Chris Underwood, Francis Yik, 2008-04-15 Climate change mitigation and sustainable practices are now at the top of political and technical agendas Environmental system modelling provides a way of appraising options and this book will make a significant contribution to the uptake of such systems It provides knowledge of the principles involved in modelling systems builds confidence amongst designers and offers a broad perspective of the potential of these new technologies The aim of the book is to provide an understanding of the concepts and principles behind predictive modelling methods review progress in the development of the modelling software available and explore modelling in building design through international case studies based on real design problems Heat Conduction M. Necati Özışık, 1993-03-22 This Second Edition for the standard graduate level course in conduction heat transfer has been updated and oriented more to engineering applications partnered with real world examples New features include numerous grid generation for finding solutions by the finite element method and recently developed inverse heat conduction Every chapter and reference has been updated and new exercise problems replace the old *Analytical Methods in Conduction Heat Transfer* Glen E. Myers, 1998 This book is designed for a one semester graduate course in conduction heat transfer The three major chapters are 3 separation of variables 8 finite differences and 9 finite elements Other topics include Bessel functions Laplace transforms complex combination normalization superposition and Duhamel's theorem Thermal Stresses—Advanced Theory and Applications Richard B. Hetnarski, M. Reza Eslami, 2019-04-11 This is an advanced modern textbook on thermal stresses It serves a wide range of readers in particular graduate and postgraduate students scientists researchers in various industrial and government institutes and engineers working in mechanical civil and aerospace engineering This volume covers diverse areas of applied mathematics continuum mechanics stress analysis and mechanical design This work treats a number of topics not presented in other books on thermal stresses for example theory of coupled and generalized thermoelasticity finite and boundary element method in generalized thermoelasticity thermal stresses in functionally graded structures and thermal expansions of piping systems The book starts from basic concepts and principles and these are developed to more advanced levels as the text progresses Nevertheless some basic knowledge on the part of the reader is expected in classical mechanics stress analysis and mathematics including vector and cartesian tensor analysis This 2nd enhanced edition includes a new chapter on Thermally Induced Vibrations The method of stiffness is added to Chapter 7 The variational principle for the Green Lindsay and Green Naghdi models have been added to Chapter 2 and equations of motion and compatibility equations in spherical coordinates to Chapter 3 Additional problems at the end of chapters were added **Colton** Larry Sheffield, 2004 Take a train to Southern California and you'll pass through Colton Once the home of Gabrielino and Serrano Indians Colton is now known as the Hub City the only place in the United States where the Union Pacific and the Burlington Northern Santa Fe railroads cross Westward bound rail passengers travel

through the horseshoe shaped valley along the same trails that served Spanish explorers journeying from Mexico to Monterey in the 1770s The valley s early settlers made use of the rich soil and ready transportation cultivating fruit trees and shipping their harvest north and east Legendary figures have also roamed Colton s streets including the famous Tombstone gunslingers Wyatt Earp and his brother Virgil who was Colton s first marshal and their father Nicholas who served as a justice of the peace and city recorder Over the 150 years of the community s history many have passed through Colton and all have left their mark on this classically Californian town

Inverse Heat Conduction James V. Beck, Ben Blackwell, Charles R. St. Clair (Jr.), 1985-10-02 Here is the only commercially published work to deal with the engineering problem of determining surface heat flux and temperature history based on interior temperature measurements Provides the analytical techniques needed to arrive at otherwise difficult solutions summarizing the findings of the last ten years Topics include the steady state solution Duhamel s Theorem ill posed problems single future time step and more

Applied Mechanics Reviews ,1967 *High-Speed Precision CNC Machine Tools* Chi Ma, Jialan Liu, 2025-09-01 High Speed Precision CNC Machine Tools The Theory and Methods of Thermal Behavior Simulation and Control summarizes the thermal structure interaction simulation and optimization of high speed precision machine tools It begins by examining the current research status of high speed precision machine tools followed by the thermal structure interaction characteristic modeling and simulation of high speed precision machine tools Later chapters are related to the application of the topology optimization method and axial rotating heat pipe in high speed precision machine tools Provides an important boundary condition for modelling the thermal structure interaction characteristics of high speed precision CNC machine tools Covers the systematic modeling method for thermal structure interaction characteristics of high speed precision CNC machine tools Includes detailed coverage of the application of axial rotating heat pipe in high speed precision machine tool thermal error control

Analytical Heat Transfer Je-Chin Han, 2016-04-19 Filling the gap between basic undergraduate courses and advanced graduate courses this text explains how to analyze and solve conduction convection and radiation heat transfer problems analytically It describes many well known analytical methods and their solutions such as Bessel functions separation of variables similarity method integral method and matrix inversion method Developed from the author s 30 years of teaching the text also presents step by step mathematical formula derivations analytical solution procedures and numerous demonstration examples of heat transfer applications

East Chip-level Static and Transient Thermal Analysis Method for Thermal Management of VLSI ICs in Packages Je-Hyoung Park, 2009 **mcgraw- hill series in mechanical engineering** ,1972 *International Series of Monographs in Aeronautics and Astronautics* ,1961 **Engineering Heat Transfer**

Bhalchandra V. Karlekar, Robert M. Desmond, 1977 Heat Conduction and Mass Diffusion Benjamin Gebhart, 1993

Containing not only classical material and analysis but using this as a basis for many kinds of application processes which are important in critical technologies this text provides a comprehensive treatment of heat and mass transfer at graduate level

Numerical Methods in Heat Transfer Roland Wynne Lewis, Kenneth Morgan, O. C. Zienkiewicz, B. A. Schrefler, 1981

Numerical Thermal Analysis Satish P. Ketkar, 1999 This reference for engineers who use computerized thermal analysis tools covers the basics of finite difference finite element and control volume methods The author also presents a hybrid method that combines features of finite element modeling with the computational efficiency of finite difference network solution techniques Annotation copyrighted by Book News Inc Portland OR

Elementary Heat Transfer Analysis Stephen Whitaker, 1976 Elementary Heat Transfer Analysis provides information pertinent to the fundamental aspects of the nature of transient heat conduction This book presents a thorough understanding of the thermal energy equation and its application to boundary layer flows and confined and unconfined turbulent flows *Computer-aided Heat Transfer Analysis* James Alan Adams, David F. Rogers, 1973

Nuclear Heat Transport Mohamed Mohamed El-Wakil, 1978 This book covers the processes of energy heat generation in nuclear processes the transport of that energy by the reactor coolant to the power cycle and the limitations imposed by the transport mechanism on the design of nuclear reactor cores Homework problems are presented at the end of each chapter

Numerical Methods in Heat Transfer Roland W. Lewis, Kenneth Morgan, 1985-09-12 This book consists of expanded and edited versions of selected papers presented at the Conference on Numerical Methods in Thermal Problems held in Seattle in 1983 The papers included cover the current status of numerical methods for thermal problems As well as discussion of the numerical methods now available and in use there is consideration of the many applications of these problems

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