

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

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

Chapter 5 Transient Heat Conduction Analytical Methods

Didier Musso



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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

Surface Element Method in Transient Heat Conduction Problems Bahman Litkouhi, 1982 Fundamentals of the Finite Element Method for Heat and Fluid Flow Roland W. Lewis, Perumal

Nithiarasu, Kankanhalli N. Seetharamu, 2004-05-28 Discussing the fundamentals of how to use the finite element method to solve heat transfer and fluid mechanics problems this work explains how to solve various heat transfer problems with different types of boundary conditions Heating, Ventilating, Air Conditioning Guide, 1959 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 **Nuclear Science Abstracts**, 1975

International Series of Monographs in Aeronautics and Astronautics, 1961 *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 *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 *Basic Heat Transfer* M. Necati Özışık, M. Necati Özışık, 1977 **Polymer**

Processing Donald G. Baird, Dimitris I. Collias, 1998-04-22 *Polymer Processing Principles and Design* presents the background required to design processes for thermoplastics Often engineers are hired by the polymer industry to develop and design processes for thermoplastics to design polymer processing machinery to develop processes for new polymers and to optimize existing processes However at best they receive only a little training in polymer science and no training in the

design of polymer processes This book emphasizes the fundamental concepts that allow the student and the practicing engineer to carry out practical design decisions While most books leave the student with equations only Polymer Processing Principles and Design provides the numerical methods required to solve the equations using the personal computer and easy to use IMSL numerical subroutines and ensures a solid foundation in the principles underlying the design of polymer processing techniques

Mathematical Reviews, 2003 **Heat Transfer 1990** Gad Hetsroni, 1990 *AIAA Journal* American Institute of Aeronautics and Astronautics, 2003 [American Society of Heating and Ventilating Engineers Guide](#), 1960 **Fundamentals of Heat and Mass Transfer** Frank P. Incropera, David P. DeWitt, 2002 This book provides a complete introduction to the physical origins of heat and mass transfer Contains hundred of problems and examples dealing with real engineering processes and systems New open ended problems add to the increased emphasis on design Plus Incropera DeWitts systematic approach to the first law develops readers confidence in using this essential tool for thermal analysis

Chemical Engineering Education, 1987 **Boundary Elements**, 1990 **mcgraw- hill series in mechanical engineering**, 1972 *The Composite Materials Handbook-MIL 17* American Society for Testing and Materials, 2002 A government publication that contains extensive information on the design fabrication and use of composite materials It provides guidelines and material properties for polymer organic metal and ceramic matrix composite materials The first three volumes focus on but are not limited to polymeric composites intended for aircraft and aerospace vehicles Metal matrix composites MMC and ceramic matrix composites CMC are covered in volumes 4 and 5

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