

CHAPTER 2 Unit 2

Overall Heat Transfer Coefficient and Insulation

Syllabus :

Thermal contact resistance, Critical radius of insulation, Electrical analogy, overall heat transfer coefficient, Heat Sources systems, Variable thermal conductivity.

Syllabus Topic : Variable Thermal Conductivity

2.1 Heat Conduction in Thick Wall with Variable Thermal Conductivity

The dependence of thermal conductivity on temperature can be expressed as :

$$k = k_0 (1 + \alpha \cdot T)$$

Where k_0 is the thermal conductivity at reference temperature, α is constant for a given material and T is the temperature.

Fouriers law of heat conduction through a thick is expressed as :

$$Q = -kA \cdot \frac{dT}{dx} = -k_0 (1 + \alpha \cdot T) A \frac{dT}{dx}$$

$$\therefore \frac{Q}{A} \cdot dx = k_0 (1 + \alpha \cdot T) \cdot dT \quad \dots(i)$$

Integrating the above equation with boundary conditions at $x = 0$, $T = T_1$ and at $x = x$, $T = T_2$.

$$\frac{Q}{A} \int_0^x dx = - \int_{T_1}^{T_2} k_0 (1 + \alpha T) \cdot dT$$

$$\frac{Q}{A} [x]_0^x = -k_0 \left[T + \frac{\alpha}{2} T^2 \right]_{T_1}^{T_2}$$

$$\frac{Q}{A} (x - 0) = -k_0 \left[(T_2 - T_1) + \frac{\alpha}{2} (T_2^2 - T_1^2) \right]$$

$$= k_0 \left[(T_1 - T_2) + \frac{\alpha}{2} (T_2 - T_1) (T_1 + T_2) \right]$$

$$\frac{Q}{A} \cdot x = +k_0 (T_1 - T_2) \left[1 + \frac{\alpha}{2} (T_1 + T_2) \right] \dots(2.1.1)$$

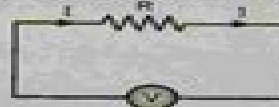
$$Q = \frac{k_m \cdot A (T_1 - T_2)}{x} \quad \dots(2.1.2)$$

Where $k_m = k_0 \left[1 + \frac{\alpha}{2} (T_1 + T_2) \right]$ represents the mean value of thermal conductivity calculated at mean temperature of $T = \left(\frac{T_1 + T_2}{2} \right)$

Electrical Analogy

2.2 Analogy between Heat Conduction and Electricity

Rate of heat flow has an analogy with current flow in an electrical system having the electrical resistance R with potential difference V as shown in Fig. 2.2.1.



(a) Heat conduction



(b) Electrical system

Fig. 2.2.1 : Analogy between electrical conduction and heat conduction system

From ohm's law for electrical system we can write,

$$\therefore \text{Current flow, } I = \frac{V}{R} \quad \dots(2.2.1)$$

For heat conduction system,

$$Q = \frac{k \cdot A (T_1 - T_2)}{x} = \frac{(T_1 - T_2)}{\left(\frac{x}{kA} \right)} = \frac{\Delta T}{R} \quad \dots(2.2.2)$$

By comparing Equations (2.2.1) and (2.2.2) we draw the following analogy between electricity and heat flow.

- Temperature difference $(T_1 - T_2)$ across the wall represents the driving force equivalent to potential difference, V .
- Heat flow rate Q corresponds to current flow I .

Heat Transfer Eng

Louis Theodore



Heat Transfer Eng:

Principles of Heat Transfer Frank Kreith, Mark Bohn, 2001 Frank Kreith and Mark Bohn's PRINCIPLES OF HEAT TRANSFER is known and respected as a classic in the field. The sixth edition has new homework problems and the authors have added new Mathcad problems that show readers how to use computational software to solve heat transfer problems. This new edition features its own web site that features real heat transfer problems from the industry as well as actual case studies. Engineering Heat Transfer, Second Edition William S. Janna, 1999-12-28 Most of the texts on heat transfer available in recent years have focused on the mathematics of the subject typically at an advanced level. Engineering students and engineers who have not moved immediately into graduate school need a reference that provides a strong practical foundation in heat transfer one that emphasizes real world problems and helps develop their problem solving skills. Engineering Heat Transfer fills that need. Extensively revised and thoroughly updated the Second Edition of this popular text continues to de-emphasize high level mathematics in favor of effective accurate modeling. A generous number of real world examples amplify the theory and show how to use derived equations to model physical problems. Exercises that parallel the examples build readers confidence and prepare them to effectively confront the more complex situations they encounter as professionals. Concise and user friendly Engineering Heat Transfer covers conduction convection and radiation heat transfer in a manner that does not overwhelm the reader and is uniquely suited to the actual practice of engineering. Heat Transfer Engineering C. Balaji, Balaji Srinivasan, Sateesh Gedupudi, 2020-11-21 Heat Transfer Engineering Fundamentals and Techniques reviews the core mechanisms of heat transfer and provides modern methods to solve practical problems encountered by working practitioners with a particular focus on developing engagement and motivation. The book reviews fundamental concepts in conduction forced convection free convection boiling condensation heat exchangers and mass transfer succinctly and without unnecessary exposition. Throughout copious examples drawn from current industrial practice are examined with an emphasis on problem solving for interest and insight rather than the procedural approaches often adopted in courses. The book contains numerous important solved and unsolved problems utilizing modern tools and computational sources wherever relevant. A subsection on common issues and recent advances is presented in each chapter encouraging the reader to explore a greater diversity of problems. Reveals physical solutions alongside their application in practical problems with an aim of generating interest from reality rather than dry exposition. Reviews pertinent contemporary computational tools including emerging topics such as machine learning. Describes the complexity of modern heat transfer in an engaging and conversational style greatly adding to the uniqueness and accessibility of the book. *Engineering Heat Transfer* M. M. Rathore, R. Kapuno, 2010-06-30 **Engineering Heat Transfer** J.R. Simonson, 1988-07-28 This undergraduate text incorporates extensive updating and modification whilst continuing to present heat transfer in the form in which it is usually taught in Engineering degree courses. After introducing the three basic heat transfer processes the book

covers each in turn in greater depth **Engineering Heat Transfer, Third Edition** William S. Janna, 2009-01-14 The third edition of this fundamental introduction to heat transfer keeps complex mathematics kept to a minimum providing a wide range of practical examples problems and applications to reinforce concepts FUNDAMENTALS OF HEAT AND MASS TRANSFER B. K. VENKANNA, 2010-01-01 This comprehensive text on the basics of heat and mass transfer provides a well balanced treatment of theory and mathematical and empirical methods used for solving a variety of engineering problems The book helps students develop an intuitive and practical understanding of the processes by emphasizing the underlying physical phenomena involved Focusing on the requirement to clearly explain the essential fundamentals and impart the art of problem solving the text is written to meet the needs of undergraduate students in mechanical engineering production engineering industrial engineering auto mobile engineering aeronautical engineering chemical engineering and biotechnology **Heat Transfer Engineering** , 2009 Engineering Heat Transfer M. M. Rathore, R. Kapuno, 2010-06-30 Intended as a textbook for undergraduate courses in heat transfer for students of mechanical chemical aeronautical and metallurgical engineering or as a reference for professionals in industry this book emphasizes the clear understanding of theoretical concepts followed by practical applications Treating each subject analytically and then numerically it provides step by step solutions of numerical problems through the use of systematic procedures by a prescribed format With more than a million users in industry MATLAB is the most popular computing programming language among engineers This Second Edition has been updated to include discussions on how to develop programs that solve heat transfer problems using MATLAB which allows the student to rapidly develop programs that involve complex numerical and engineering heat transfer computations *Engineering Heat Transfer* Donatello Annaratone, 2010-03-14 This book is a generalist textbook it is designed for anybody interested in heat transmission including scholars designers and students Two criteria constitute the foundation of Annaratone's books including the present one The first one consists of indispensable scientific rigor without theoretical exasperation The inclusion in the book of some theoretical studies even if admirable for their scientific rigor would have strengthened the scientific foundation of this publication yet without providing the reader with further applicable know how The second criterion is to deliver practical solution to operational problems This criterion is fulfilled through equations based on scientific rigor as well as a series of approximated equations leading to convenient and practically acceptable solutions and through diagrams and tables When a practical case is close to a well defined theoretical solution corrective factors are shown to offer simple and correct solutions to the problem **Engineering Heat Transfer** John R. Simonson, 1975 Previous edition published as *An introduction to engineering heat transfer* **Introduction to Engineering Heat Transfer** G. F. Nellis, S. A. Klein, 2020-07-30 This new text integrates fundamental theory with modern computational tools such as EES MATLAB and FEHT to equip students with the essential tools for designing and optimizing real world systems and the skills needed to become effective practicing engineers Real engineering problems are illustrated

and solved in a clear step by step manner Starting from first principles derivations are tailored to be accessible to undergraduates by separating the formulation and analysis from the solution and exploration steps to encourage a deep and practical understanding Numerous exercises are provided for homework and self study and include standard hand calculations as well as more advanced project focused problems for the practice and application of computational tools Appendices include reference tables for thermophysical properties and answers to selected homework problems from the book Complete with an online package of guidance documents on EES MATLAB and FEHT software sample code lecture slides video tutorials and a test bank and full solutions manual for instructors this is an ideal text for undergraduate heat transfer courses and a useful guide for practicing engineers **Heat Transfer Engineering** Hilbert Schenck (Jr.),1960

INTRODUCTION TO HEAT TRANSFER S. K. SOM,2008-10-24 This book presents a comprehensive treatment of the essential fundamentals of the topics that should be taught as the first level course in Heat Transfer to the students of engineering disciplines The book is designed to stimulate student learning through clear concise language The theoretical content is well balanced with the problem solving methodology necessary for developing an orderly approach to solving a variety of engineering problems The book provides adequate mathematical rigour to help students achieve a sound understanding of the physical processes involved Key Features A well balanced coverage between analytical treatments physical concepts and practical demonstrations Analytical descriptions of theories pertaining to different modes of heat transfer by the application of conservation equations to control volume and also by the application of conservation equations in differential form like continuity equation Navier Stokes equations and energy equation A short description of convective heat transfer based on physical understanding and practical applications without going into mathematical analyses Chapter 5 A comprehensive description of the principles of convective heat transfer based on mathematical foundation of fluid mechanics with generalized analytical treatments Chapters 6 7 and 8 A separate chapter describing the basic mechanisms and principles of mass transfer showing the development of mathematical formulations and finding the solution of simple mass transfer problems A summary at the end of each chapter to highlight key terminologies and concepts and important formulae developed in that chapter A number of worked out examples throughout the text review questions and exercise problems with answers at the end of each chapter This book is appropriate for a one semester course in Heat Transfer for undergraduate engineering students pursuing careers in mechanical metallurgical aerospace and chemical disciplines

Engineering Heat Transfer Bhalchandra V. Karlekar,Robert M. Desmond,1977 Heat Transfer Engineering Hilbert van Nydeck Schenck,1960 **Heat Transfer in Aerospace Applications** Bengt Sundén,Juan Fu,2016-10-19 Heat Transfer in Aerospace Applications is the first book to provide an overall description of various heat transfer issues of relevance for aerospace applications The book contains chapters relating to convection cooling heat pipes ablation heat transfer at high velocity low pressure and microgravity aircraft heat exchangers fuel cells and cryogenic cooling systems Chapters specific to

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