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Book review

Advanced Heat and Mass Transfer, A. Faghri, Y. Zhang, J. Howell. Global Digital Press (2010). 956 pp., Hardcover, List Price: $89.95, ISBN: 978-0-9842760-0-4

This is an advanced-level textbook that covers all of the pertinent fundamental topics related to heat and mass transfer, which include heat conduction, convective heat transfer, mass transfer, radiation, and multiphase phenomena, in a single volume. It develops an understanding of the thermal and physical behavior of thermal-fluids systems for practical systems and modern applications in heat and mass transfer, energy systems, biological and biomedical systems, security, information technology, and nanotechnology.

This is an excellent textbook that covers the subject of heat and mass transfer with a focus on the significant advances in the field during the last decade, while emphasizing the basic, fundamental principles. The authors have achieved their goal to provide a single textbook to cover heat and mass transfer at the advanced level and avoid requiring the use of several textbooks by instructors. This was done by eliminating outdated materials and techniques and includes modern approaches. This is a significant time and cost saving to both students and instructors. It will also free up the credit hours to allow students to take more courses that cover cutting-edge developments in emerging science and engineering.

The book can be used as a textbook for undergraduate senior and graduate students in a wide variety of engineering disciplines that include, but are not limited to, mechanical, aerospace, chemical, biological and biomedical, food, nuclear, and materials engineering. Professional engineers will also find that this is an invaluable reference book for design and analysis of thermal systems that include everything from traditional thermal engineering and conventional energy systems to emerging and modern technologies.

The authors are the leading scientists and educators active in the field of heat and mass transfer, and all of them are elected Fellows of ASME who have authored other textbooks and monographs. Dr. Faghri is currently a Professor in the Department of Mechanical Engineering and formerly Dean of School of Engineering at the University of Connecticut. He has received many prestigious honors and awards including the 1998 AIAA Thermophysics Award, the 1998 ASME Heat Transfer Memorial Award and the 2005 ASME James Harry Potter Gold Medal. Dr. Zhang is a Professor of Mechanical and Aerospace Engineering at the University of Missouri. He is a recipient of the 2002 Office of Naval Research (ONR) Young Investigator Award, the 2010 the College of Engineering Senior Faculty Research Award and the 2010 Chancellor's Award for Outstanding Research and Creative Activity from the University of Missouri. Dr. Howell is the Ernest Cockrell, Jr. Memorial Chair Emeritus in the Department of Mechanical Engineering at the University of Texas at Austin. He received the ASME/AIChE Max Jakob Award (1997), the ASME Heat Transfer Memorial Award (1991), and the AIAA Thermophysics Award (1990). He is a member of the US National Academy of Engineering.

Chapter 1 covers the concept of phases of matter, molecular level presentation, review of the basics of momentum, heat and mass transfer, and some typical modern practical applications. The brief discussion of molecular presentation provides an opportunity for students to appreciate the physics behind the macroscopic and microscopic approaches used in the rest of the book. The generalized governing equations for heat and mass transfer, including generalized macroscopic (integral), differential governing equations in local-instance formulations for single phases, averaged differential formulations for multi-phases, and fundamentals of turbulence are all presented in Chapter 2. Average differential formulation is an important topic which is not presented in other conventional heat and mass transfer textbooks. Chapter 3 covers analytical approaches for steady- and unsteady-state heat conduction, basics of numerical simulation for heat conduction problems, melting and solidification and microscale heat conduction.

External forced convective heat and mass transfer is presented in Chapter 4, which includes boundary layer theory, various analytical solution methodologies, integral methods and computational methods as well as analogies and differences in various transport phenomena systems, and external turbulent flow and heat transfer. Chapter 5 discusses internal convective heat transfer that includes analytical methods and solutions for hydrodynamically and thermally fully developed laminar flow, hydrodynamically fully developed and thermally developing laminar flow, hydrodynamically fully developed flow with coupled thermal and concentration entry effects, and combined hydrodynamically and thermally developing flow. Also covered in Chapter 5 are full numerical solutions of internal forced convection, forced convection in microchannels, and internal turbulent flow and heat transfer. Given the coupled heat and mass transfer phenomena in most real applications, it is refreshing to see that the authors have integrated mass transfer throughout Chapters 4 and 5 rather than delegating it to a separate chapter as done in many textbooks.

Natural convection is presented in Chapter 6, beginning with discussion of governing equations and scale analysis, followed by in-depth discussion on external natural convection that includes various solution techniques for natural convection on a vertical surface, over inclined and horizontal surfaces, and over cylinders and spheres, and free boundary flow. Also covered in Chapter 6 are natural convection in enclosures, natural convection in melting and solidification, and instability analysis of natural convection.

Chapter 7 covers dropwise and filmwise condensation at both macro- and microscale levels, as well as evaporation from a heated wall and spray cooling. Each of the four pool boiling regimes (free convection, nucleate, transition, and film boiling), critical heat flux, minimum heat flux, direct numerical simulation, and the Leidenfrost phenomena are discussed in detail in Chapter 8.

Chapter 9 is on the fundamentals of thermal radiation, which includes electromagnetic waves and thermal radiation, blackbody as the ideal radiator, properties of real surfaces, application and

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exploitation of radiative properties, and high-energy radiation-surface interactions. In addition, this chapter also covers light pipes and fiber optics, infrared sensing, cameras and photography, as well as other contemporary applications and research. Chapter 10 covers radiative transfer through transparent media, the net radiation method for diffuse surfaces, multimode heat transfer with radiation, inverse problems, the effect of participating media and applications of radiative transfer.

The references at the end of each chapter include the classical as well as the most recent fundamental developments in the field. The book provides detailed transport properties of solid, gases and liquids at atmosphere, transport properties for phase change, mass transfer properties, configuration factors and surface properties for radiation, and a review of mathematical relations in the Appendices.

The entire book can be viewed free of charge at https://www.thermalfluidscentral.org/e-books/book-intro.php?b=37. The PowerPoint presentation associated with the book is available at https://www.thermalfluidscentral.org/e-resources/handle/item/62. The solutions manual is also available to instructors who adopt the book as the main textbook for a course.

I strongly recommend this book to engineering academics, practitioners, and scientists working in the field of heat and mass transfer as the most complete and updated resource.

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