

Book Review

Transport Phenomena in Multiphase Systems, Amir Faghri, Yuwen Zhang. Elsevier (2006). 1064 pp., 403 Figures, 292 Problems and 62 Examples, Hardcover, \$89.95, ISBN: 0-12-370610-6

This is one of the few textbooks to truly address transport phenomena in the context of all phase changes among solid, liquid and vapor including interfacial phenomena, and it provides a much needed fundamental treatment of these topics. The book develops an understanding of the thermal and physical behavior of multiphase systems with phase change, including microscale and porosity, for practical applications in variety of engineering disciplines.

Transport Phenomena in Multiphase Systems is effective as a textbook for undergraduate senior and graduate students in a wide variety of engineering disciplines. In recent years, graduate students and practicing engineers working in the thermal sciences have focused much attention on multiphase, multicomponent, non-conventional geometries with coupled heat and mass transfer and phase change, with the objective of full numerical simulation using a continuum or non-continuum approach. The authors of this textbook present an interesting approach for teaching modern transport phenomena through addressing the fundamental challenges and opportunities involved. This book can also be used as a text to teach modern convective and conductive heat and mass transfer – a topic which had previously been restricted to classical text books, unchanged for five decades. Both continuum and non-continuum approaches including molecular dynamic simulations and Boltzmann statistical averaging as well as Lattice Boltzmann methods are also presented, which is important for the application of transport phenomena in nanotechnology and biotechnology. This book is also an important reference for professional engineers covering a range of topics from heat exchanger design to chemical processing system design, and more.

The authors are the leading active scientists in the field of phase change heat and mass transfer in general and have worked in research areas related to heat pipes, fuel cells, and thermal manufacturing. Dr. Amir Faghri is the United Technologies Endowed Chair Professor in Thermal-Fluids Engineering at the University of Connecticut. He has received many honors and awards, including the 1998 AIAA Thermophysics Award, the 1998 ASME Heat Transfer Memorial Award and the 2006 ASME James Harry Potter Gold Medal. Dr. Yuwen Zhang is an Associate Professor

of Mechanical and Aerospace Engineering at the University of Missouri – Columbia. He is the 2002 recipient of an Office of Naval Research (ONR) Young Investigator Award.

Chapter 1 covers the concepts of phases of matter, the role of phases in multiphase systems, a review of transport phenomena, the classification of multiphase systems, and finally some typical practical applications. The thermodynamics of multiphase systems, thermodynamic surfaces and phase diagrams, the equilibrium criteria for single and multicomponent multiphase systems, and thermodynamics at the interface, are discussed in Chapter 2.

The generalized governing equations for transport phenomena in multiphase systems are covered in Chapters 3 and 4. Chapter 3 presents the generalized macroscopic (integral) and microscopic (differential) governing equations for multiphase systems in local-instance formulations. The averaged formulations obtained by averaging the local-instance governing equations are presented in Chapter 4. Also covered in Chapter 4 are single- and multiphase transport phenomena in porous media, and Boltzmann statistical averaging.

Chapter 5 discusses solid/liquid/vapor interfacial phenomena including the concepts of surface tension, wetting phenomena, contact angle, transport effects at the interfaces, heat and mass transfer through the thin film region during evaporation and condensation, dynamics of interfaces, and numerical simulations of phase interfaces and free surfaces. The detailed interfacial balances for mass, species, momentum, and energy for multicomponent and multiphase interfaces are also presented in this chapter.

Melting and solidification are treated in Chapter 6, which includes the classification of solid–liquid phase changes, generalized boundary conditions at the interface, as well as exact, integral approximate, and numerical solutions of melting and solidification. Other topics presented in Chapter 6 are solidification in binary solution systems, contact melting, melting and solidification in porous media, applications of solid–liquid phase change, and microscale solid–liquid phase change. Chapter 7 introduces sublimation and vapor deposition by providing an overview of solid–vapor phase change, sublimation without and with chemical reaction, as well as physical and chemical vapor deposition.

Chapter 8 covers dropwise and filmwise condensation at both macro- and microscale levels, as well as condensation

in microgravity and condensation in porous media. Chapter 9 deals with criteria and classification of evaporation, evaporation from an adiabatic wall, evaporation from a heated wall, evaporation in porous media, evaporation in micro/miniature channels, as well as direct-contact evaporation.

Chapter 10 discusses each of the four pool boiling regimes (free convection, nucleate, transition, and film boiling), critical heat flux, minimum heat flux, and direct numerical simulation. The Leidenfrost phenomena and boiling in porous media were also discussed. Chapter 11 covers two-phase flow patterns in vertical and horizontal tubes, two-phase flow models, and the two-phase flow regimes and heat transfer characteristics for forced convective condensation and boiling at both macro- and micro-scale levels.

Numerous publications on the subject cited in the text are referenced at the end of each chapter including recent developments that have taken place in the field. The constants and conversion factors, thermophysical properties, along with empirical correlations of thermal properties as functions of temperature, and a review of vector and tensor operations are presented in appendices. There are ample examples (62) and end-of-chapter problems (292). The

Solution Manual and PowerPoint presentation are available to the instructors.

This book could become a valuable textbook for engineering practitioners, academic researchers working in multiphase systems, and graduate students; constituting a complete and consistent resource for modern transport phenomena while amplifying and covering material taught traditionally in courses such as convection, conduction, and/or transport phenomena. The material included in the text requires more than one semester for its completion, but instructors can choose the material to be covered based on the needs and interests of their students. It also provides a highly pertinent textbook for a transport phenomena course.

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