Chapter 1

Introduction to Transport Phenomena in Materials Processing

Abstract

Transport phenomena is defined as the transfer of heat, mass, and momentum, and their importance to the study and practice of materials processing is shown through examples in the processing of metals, ceramics, polymers, and semiconductors. An approach to modeling transport phenomena is outlined, with a balance of the movement of heat, mass, and momentum in a control volume supplemented by the various constitutive equations to describe some phenomena. Constitutive equations for fluid flow include Newton's Law of Viscosity and various nonlinear correlations between deformation rate and shear stress for complex, "non-Newtonian" fluids. Fourier's Law for conduction, Newton's Law of Cooling, and a simplified rate equation for radiation (for conduction, convection, and radiation heat transfer, respectively) are introduced, and Fick's First Law of Mass Diffusion is also developed. The physical bases for these relations and the experimental bases used to model various phenomena in later chapters are discussed. Approaches to solving the mathematical models are discussed, with the pros and cons of each, with emphasis on understanding relevant physical phenomena and estimating behavior. Scaling analysis in particular is encouraged as a starting point for interrogating models, a basis for making engineering decisions, and a guide to more complicated modeling. This process is profitably used to elicit information from complicated models, even when the complicated equations are not actually solved.