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Book review

Book review "*The dynamics of fluidized particles*" by Roy Jackson, Cambridge University Press, 2000

Fluidization represents one of the most complex multiphase flow phenomena. Its complexity arises from the intricate, interactive behavior of fluid and particles leading to the formation of various flow regimes of inherent micro-, meso- and macro-scale structures. Fluidization operations are central to the development of many physical, chemical, and petrochemical processing technologies and have far reaching economic impacts on commercial use of this technology. Fundamental understanding of the dynamics of fluidized particles and the ability to predict them is thus of great importance.

Fluidization has been a subject of extensive fundamental and applied research for over half a century. It is richly reported in the literature, which has included such classic monographs or textbooks as Davidson and Harrison (Cambridge University Press, 1963) and Kunii and Levenspiel (Wiley, 1969; Butterworths, 1991). These earlier publications each have their own unique features: for the former, it is its elegant account of gas and solid flow structures around gas bubbles associated with transport processes using strikingly simple analytical expressions and, for the latter, it is its thoughtful approach from the chemical reaction engineering viewpoint in describing the complex fluidized bed operation for reactor applications. The current book will join this collection of classics for its rigorous illustration of the multifaceted fluidized phenomena from well-derived equations of motion for fluids and particles.

Specifically, this monograph provides comprehensive theoretical accounts of some of the most intriguing phenomena of fluid–particle systems. It summarizes the outstanding career work of the author on this topic, the majority of which has already been widely cited in the literature. The style of the presentation is systematic, methodic, and well organized. The book is impressive with its unified concept and penetrating views on the mechanisms of complex fluidized phenomena. The book contains seven chapters. Chapter 1 describes the concept of mathematical modeling of fluidized suspensions. It indicates the robust nature of the various salient fluidization phenomena, such as bubble formation, particle clustering, and choking, which can readily be captured even by a simple form of the equations of motion. It also illustrates the importance of recognizing the interactive effects of flow properties due to column devices such as compressors and blowers. Chapter 2 provides the backbone of the ensuing chapters. It presents a detailed derivation of the well-known, widely cited, weighted, local volume averaged equations of motion. It reveals complete expressions for the fluid and particle stress tensors, which include extra fluid–particle interaction terms of some sort arriving from the Taylor expansion of the fluid–particle interaction force around the particle surface. It also presents various constitutive relationships in characterizing the stress tensors and introduces the granular temperature concept from gas kinetic theory. The chapter importantly distinguishes several forms of the decomposition of fluid–particle

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interactive forces and their relationship to the definition of particle buoyancy force in a suspended medium. This decomposition is highlighted as the source of discrepancies in the various forms of the expression for the averaged equations of motion used by different researchers.

Chapter 3 describes a mechanistic model that accounts for the pressure hysterisis behavior in the fluidization and defluidization processes. It emphasizes the important role of wall stress and normal stress that particles experience during bed consolidation and dilation. Chapter 4 explores the stability of the uniform fluidized state using small-amplitude perturbation theory. The analysis is made based on the local averaged equations of motion for gas and particles. It points out that while the theory is capable of predicting bed instability, it is not fully adequate in distinguishing between bed instability arising from gas bubble formation from that without gas bubble formation. Chapter 5 presents the fundamental characteristics of large inhomogenous structures such as bubbles in a dense fluidized bed and clusters in a dilute fluidized bed. These structures are shown to arise from the growth of small perturbations. The pioneering modeling work of Davidson on gas bubbles is also introduced in conjunction with other more refined calculations by the author as well as Murray in the prediction of the size of bubble clouds and the pressure distribution around the bubbles. Chapter 6 gives a mechanistic account of riser flow, which is of significant practical interest. The simulation is made based on governing equations given in Chapter 2 associated with various forms of closure relationships and boundary conditions. Extensive discussion, in light of experimental data, is made of the sensitivity analysis of the model prediction due to such model parameters as the coefficient of restitution. Effects due to pseudo-turbulence are also elaborated. Chapter 7 describes another topic of practical interest, i.e., standpipe and feed hopper flows. The chapter reveals complex multiplicity behavior between the particle velocity and the pressure drop in steady standpipe flow. Multiple flow regimes can also be present in standpipe flow with or without aeration. As the treatment of the mechanics of standpipe flow is scarce in the literature, the author's work described in this chapter is among a handful of important contributions available on this topic.

Overall, this is an unparalleled treatise on the mechanics of fluidization. It is rich with ideas regarding the direction in which further research is warranted. It also provides new thoughts with respect to potential strategies to pursue for the operation of the fluidized bed. This book will be treasured by researchers and instructors who wish to gain insight into the mechanistic interpretation of such intriguing questions as the genesis of bubbles. Others will find this book to be an invaluable reference. Due to the advanced nature of the material presented and the brevity of treatment of some topics, for example, nonlinear analysis of bed instability (Chapter 5), the book would be most suitable as a text for teaching advanced graduate students.

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