Foreword

This collection of 13 chapters on gas-solids flow describes the new theories, numerical methods and some new applications (e.g. polymerization reactors and volcanic eruptions) that have emerged in the last two decades. This book is similar to “Fluidization”, edited by J.F. Davidson and D. Harrison, Academic Press, 1971. Both books review various subjects in depth and can be read by both beginners and experts. Hence this book, like the Davidson and Harrison volume, should be useful to researchers, graduate students and professors. I used the Fluidization book in class in a graduate course at IIT in the mid- seventies and still use some chapters to-date in my consulting work.

The Fluidization book was followed by a second edition, edited by J.F. Davidson, R. Clift and D, Harrison in 1985. Similarly, this book needs to be followed up by a second volume treating subjects, such as detailed treatment of heat transfer, nanoparticles, cohesive particles, erosion and new applications, such as blood flow.

A comparison between the Davidson and Harrison’s books and the present volume shows the tremendous progress made in the last two decades due to the development of the kinetic theory of multiphase flow and fast computers. In my opinion, many multiphase reactors as documented in this book, such as coal gasifiers and fluidized bed silicon production reactors can now be designed and optimized using multiphase computational dynamics codes. This is a cost- and time-effective approach than the construction of billion dollar synthetic fuel demonstration plants in the 1980s.

The Morgantown group has been a leader in funding innovative research in multiphase flows for the last three decades. The 1982 Coal Gasification modeling workshop proceedings, edited by M. Ghate and J.W. Martin describe the first gas-solids computational fluid dynamics code. I have reviewed this study in my 1994 book. Madhava Syamlal and Tom O’Brien have been supporters of this transformational research for the last two decades and it is now bearing fruit.

The first chapter, in the “Theory Section,” by Syamlal and Pannala describes the mass, momentum, energy and chemical species balances and their approximations found in the DOE NETL MFIX computer code. This code and similar commercial codes are now being used in design and scale-up of gas-solids reactors all over the world.

The second chapter by Dufty and Baskaran reviews the kinetic theory as a basis for hydrodynamics. It combines the classical physics approach with some recent numerical simulations.

The third chapter by Hrenya reviews some of the recent polydisperse kinetic theories. In a mixture of gases, the temperatures of the components are equal. But in a mixture of particles the granular temperatures differ greatly due to inelastic collisions. This leads to unequal particle viscosities and segregation phenomena which as yet remain unexplained.

The fourth chapter by Ge, Yang, Wang and Jinghai Li reviews the interfacial drag relations. The unique energy minimization multiscale model of Li and Kwauk gives some trends similar to those being developed by Sundaresan using different methods. Corrections to standard drag relations are as old as fluidization, but still require further research to quantitatively predict some flow regimes, such as the dense and the dilute regions in turbulent fluidization, where Li and Kwauk's corrections were the key to prediction. The fifth chapter reviews the heat and mass transfer relations. It has been known for half a century that the Nusselt and Sherwood numbers for fluidization of fine particles are orders of magnitude below the conduction or diffusion limit of two. It is only recently that we are finding out that this is probably due to the formation of clusters.

In chapter one, part two, "Numerical Methods", van Wachem reviews the coupled solvers for gas-solids flow. His example is for a single phase cavity driven flow.

In chapter two, Passalacqua, Vedula and Fox describe the quadrature based moment methods for polydisperse gas-solids flows. In this method local isotropy is not assumed. In addition to granular temperature, all velocity moments are computed. In principle, convergence should be obtained. Hence, this is a more advanced kinetic theory based method. The third chapter on numerical methods by Garg, Tenneti, Yusof and Subramaniam describes the immersed boundary method. This approach has reproduced known results for the average drag in Stokes flow past ordered arrays of particles. The fourth chapter by Snider and O'Rourke describe their multiphase numerical method for predicting dense particulate flow. In this method the fluid is treated as a continuum and the solids are modeled by Lagrangian computational particles.

The first chapter under "Practice" by Cocco, Karri and Knowlton gives a thorough review of applications, hydrodynamics, axial and radial solids profiles, clusters, segregation and CFD modeling of circulating fluidized beds. The authors favor the Barracuda code described by Snider and O'Rourke for polydisperse particles. The second chapter under "Practice" by Pugsley, Karimipour and Wang describes CFD modeling of bubbling fluidized beds of Geldart A powders. The authors used the MFIX code to model a stripper. The third chapter by Rokkam, Fox and Muhle describes computational modeling of gas-solids fluidized bed polymerization reactors. The authors are using ANSYS FLUENT 6.3 software to predict slugs. The last chapter by Dartevelle describes explosive modeling of volcanoes. Videos of the simulations and actual pyroclastic flows have been shown on public television all over the world. In this context, multiparticle size simulation is described by A.Neri, et al in Journal of Geophysical Research (2003) using a code based on Syamlal's early computer code and multisize particle model.

A comparison between the 1971 and 1985 Fluidization volumes and this collection of chapters shows the transition we have made in the last three decades from an almost empirical science to one based on computation. Hopefully the industry will use this new science to improve the efficiency of energy conversion and other processes.

In summary, this book will be a valuable resource to the gas-solids community of graduate students, academicians and researchers and serves as a good complement to existing books in this field.

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