PREFACE

This book is concerned with simultaneous transfer of momentum, heat and particulate mass in turbulent gas flows containing a relatively small (by volume) fraction of solid particles. Multiple-transfer processes of this type appear in natural phenomena and in a wide range of industrial systems for drying, heat exchange and pneumatic conveying, as well as in more recent applications such as gas-cooled nuclear reactors with naturally-occurring or added entrained particles, MHD and EGD devices, etc.

Interest in this subject [1] has caused a number of publications to appear. The problem is dealt with only in passing in handbooks on heat transfer fundamentals and applications [2–6], attention therein being focused primarily on packed and fluidized beds or gas-water systems. Some of the available references analyze specific transfer processes. The book by Beddow [7], for instance, covers the formation, mixing, storage and separation of particles. Classic reference books by Fortier [8] and Soo [9], and recent publications [10–15] deal principally with particle transport in turbulent flows. Books by Gorbis [16–18] chiefly describe heat transfer by convection in disperse flows. Nigmatulin [19] is concerned with the mechanics of heterogeneous media. Boothroyd [20] provides introduction to features specific to suspension flows. Friedlander [21] focuses on mass transfer in aerosol flows.

Separate analysis of different transfer processes in such a flow is fundamentally incomplete when applied to a situation in which they occur simultaneously. To present a methodology for analysis of simultaneous transport processes on a unified basis this book is based on the following principles:

1. An approach developed by the authors is used to incorporate the actual heterogeneous structure of the flows under study. This allows gaining insight into specific features of the flows and establishing the effects associated with them.

2. The various physical and mathematical models, corresponding analytic solutions and available experimental data for each form of transport phenomena are analyzed.

3. The different problems are taken in order of increasing difficulty. Thus, for example, taking each of the transport modes (momentum, mass, and heat trans-

fer), transport within the components is first analyzed, then the interaction between components, and then interactions with the entire disperse flow. Similarly, momentum transport may be first analyzed, followed by transport of particle mass with allowance for transport of momentum, and then analysis of heat and mass transfer based on all the previous sections. Some examples of utilization of turbulent gas-suspension flows are given in the final chapter.

The overwhelming majority of applications of particle-laden gas streams are turbulent, and this book therefore deals exclusively with turbulent transport phenomena. It is assumed that the components are not subject to phase transitions and do not interact chemically.

Many software packages have become commercially available for implementation of computational fluid dynamic (CFD) methods for modeling gas-particle flows. Experience with CFD has shown that it is invaluable for evaluating overall flow patterns, especially in complex geometries. These capabilities make it important that computation be based on models which reflect the nature of the transport phenomena under study with sufficient completeness. Hopefully the results presented in this book will be instrumental in refinement of computer models, increasing accuracy and reliability of CFD predictions for gas-solid flows (especially for non-dilute and non-isothermal gas suspensions).

The contents of this book are based primarily on results obtained and compared with published data by the authors.

It is hoped that the information set forth here will be helpful to those engineers, physicists, environmentalists, and others involved in the study, design, interpretation or operation of systems utilizing turbulent gas-solid flows.

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California,
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Zinovy R. Gorbis
Felix E. Spokoyny

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