Computational Models For Polydisperse Particulate And Multiphase Systems

Presents the fundamentals of chemical engineering fluid mechanics with an emphasis on valid and practical approximations in modeling.

A unique text covering basic and advanced concepts of optimization theory and methods for process systems engineers. With examples illustrating key concepts and algorithms, and exercises involving theoretical derivations, numerical problems and modeling systems, it is ideal for single-semester, graduate courses in process systems engineering.

The era of the fourth industrial revolution has fundamentally transformed the manufacturing landscape. Products are getting increasingly complex and customers expect a higher level of customization and quality. Manufacturing in the Era of 4th Industrial Revolution explores three technologies that are the building blocks of the next-generation advanced manufacturing.The first technology covered in Volume 1 is Additive Manufacturing (AM). AM has emerged as a very popular manufacturing process. The most common form of AM is referred to as 'three-dimensional (3D) printing'. Overall, the revolution of additive manufacturing has led to many opportunities in fabricating complex, customized, and novel products. As the number of printable materials increases and AM processes evolve, manufacturing capabilities for future engineering systems will expand rapidly, resulting in a completely new paradigm for solving a myriad of global problems.The second technology is industrial robots, which is covered in Volume 2 on Robotics. Traditionally, industrial robots have been used on mass production lines, where the same manufacturing operation is repeated many times. Recent advances in human-safe industrial robots present an opportunity for creating hybrid work cells, where humans and robots can collaborate in close physical proximities. This Cobots, or collaborative robots, has opened up to opportunity for humans and robots to work more closely together. Recent advances in artificial intelligence are striving to make industrial robots more agile, with the ability to adapt to changing environments and tasks. Additionally, recent advances in force and tactile sensing enable robots to be used in complex manufacturing tasks. These new capabilities are expanding the role of robotics in manufacturing operations and leading to significant growth in the industrial robotics area.The third technology covered in Volume 3 is augmented and virtual reality. Augmented and virtual reality (AR/VR) technologies are being leveraged by the manufacturing community to improve operations in a wide variety of ways. Traditional applications have included operator training and design visualization, with more recent applications including interactive design and manufacturing planning, human and robot interactions, ergonomic analysis, information and knowledge capture, and manufacturing simulation. The advent of low-cost solutions in these areas is accepted to accelerate the rate of adoption of these technologies in the manufacturing and related sectors.Consisting of chapters by leading experts in the world, Manufacturing in the Era of 4th Industrial Revolution provides a reference set for supporting graduate programs in the advanced manufacturing area.

This book contains selected papers of the 11th OpenFOAM® Workshop that was held in Guimarães, Portugal, June 26 - 30, 2016. The 11th OpenFOAM® Workshop had more than 140 technical/scientific presentations and 30 courses, and was attended by circa 300 individuals, representing 180 institutions and 30 countries, from all continents. The OpenFOAM® Workshop provided a forum for researchers, industrial users, software developers, consultants and academics working with OpenFOAM® technology. The central part of the Workshop was the two-day conference, where presentations and posters on industrial applications and academic research were shown. OpenFOAM® (Open Source Field Operation and Manipulation) is a free, open source computational toolbox that has a larger user base across most areas of engineering and science, from both commercial and academic organizations. As a technology, OpenFOAM® provides an extensive range of features to solve anything from complex fluid flows involving chemical reactions, turbulence and heat transfer, to solid dynamics and electromagnetics, among several others. Additionally, the OpenFOAM technology offers complete freedom to customize and extend its functionalities.

From Collective Beings to Quasi-Systems

Chemical Engineering Design and Analysis

Chromatographic Processes

Green Catalysis and Reaction Engineering

OpenFOAM®

Thermodynamics and Statistical Mechanics

Practical Multiscaling covers fundamental modelling techniques aimed at bridging diverse temporal and spatial scales ranging from the atomic level to a full-scale product level. It focuses on practical multiscale methods that account for fine-scale (material) details but do not require their precise resolution. The text material evolved from over 20 years of teaching experience at Rensselaer and Columbia University, as well as from practical experience gained in the application of multiscale software. This book comprehensively covers theory and implementation, providing a detailed exposition of the state-of-the-art multiscale theories and their insertion into conventional (single-scale) finite element code architecture. The robustness and design aspects of multiscale methods are also emphasised, which is accomplished via four building blocks: upscaling of information, systematic reduction of information, characterization of information utilizing experimental data, and material optimization. To ensure the reader gains hands-on experience, a companion website hosting a lite version of the multiscale design software (MDS-Lite) is available. Key features: Combines fundamental theory and practical methods of multiscale modelling Covers the state-of-the-art multiscale theories and examines their practical usability in design Covers applications of multiscale methods Accompanied by a continuously updated website hosting the multiscale design software Illustrated with colour images Practical Multiscaling is an ideal textbook for graduate students studying multiscale science and engineering. It is also a must-have reference for government laboratories, researchers and practitioners in civil, aerospace, pharmaceutical, electronics, and automotive industries, and commercial software vendors.

A fresh look to process control. State-space and traditional approaches presented in parallel with relevant computer software.

Bridging Scales in Modelling and Simulating Reacting Flows, Part I , Volume 52 presents key

methods to bridge scales in the simulation of reacting single phase flows. New sections in the updated release include topics such as quadrature-based moment methods for multiphase chemically reacting flows, the collaboration of experiments and simulations for the development of predictive models, a simulation of turbulent coalescence and breakage of bubbles and droplets in the presence of surfactants, a section on salts and contaminants, and information on the numerical simulation of reactive flows. Contains reviews by leading authorities in their respective areas Presents up-to-date reviews of the latest techniques in the modeling of catalytic processes Includes a broad mix of US and European authors, as well as academic, industrial and research institute perspectives Provides discussions on the connections between computational and experimental methods

Granular materials are a special topic of recent research and are a milestone of science and technology. These materials are very simple: they are large conglomerations of discrete macroscopic particles. Granular materials have a broad area of development, which is growing rapidly day by day. Their impact on commercial applications and academia and education is huge. The basic points of this book are the important applications and properties of granular materials. For example, special mention is made of rheological points, shapes, and civil engineering aspects.

An Integrated Approach

Chemical Looping Partial Oxidation

Design and Processing of Particulate Products

Dynamics of Multiphase Flows

Bridging Scales in Modelling and Simulation of Non-Reacting and Reacting Flows

Manufacturing In The Era Of 4th Industrial Revolution: A World Scientific Reference (In 3 Volumes)

This research project is concerned with the Eulerian-Eulerian mathematical modelling of fluidized suspensions. We first derive new averaged equations of motion for particulate systems made up of a finite number of monodisperse particle classes; this clarifies the mathematical origin and physical meaning of the terms featuring in the equations and allows to attain a well-posed multiphase model. We then tackle the closure problem of the fluid-particle interaction force in monodisperse fluidized suspensions, laying emphasis on the buoyancy, drag and elastic forces. We analyze critically several constitutive relations used to express these forces, we identify their shortcomings and we advance new, and more accurate, closure equations. To validate them we study, analytically and computationally, the expansion and collapse of homogeneous fluidized beds and their transition to the bubbling regime, comparing the result with experimental data. We then address the mathematical modelling of polydisperse fluidized suspensions, which are characterized by a continuous distribution of the particle properties, such as size or velocity. Here we adopt a more powerful modelling approach based on the generalized population balance equation (GPBE). Whereas the classical transport equations of continuum mechanics are three-dimensional, the GPBE is usually higher-dimensional and incompatible with customary computational schemes. To solve it, we use the method of moments (MOM), which resorts to a limited number of GPBE moments to derive three-dimensional transport equations that can be handled by normal CFD codes. The limited set of equations, which replaces the single multidimensional GPBE, keeps the problem tractable when applied to complicated multiphase flows; the main obstacle to the method is that the moment transport equations are mathematically unclosed. To overcome the problem, we present two very efficient methods, the direct quadrature method of moments (DQMOM) and the quadrature method of moments (QMOM). Both approximate the volume density function (VDF) featuring in the GPBE by using a quadrature formula. The methods are very flexible: the number of nodes in the quadrature corresponds to the number of disperse phases simulated. The more the nodes, the better the quadrature approximation; more nodes, however, entail also more complexity and more computational effort. For monovariate systems, i.e., systems with only one internal coordinate in the generalized sense, the methods are entirely equivalent from a theoretical standpoint; computationally, however, they differ substantially. To conclude the work, we use DQMOM to simulate the dynamics of two polydisperse powders initially arranged as two superposed, perfectly-segregated packed systems. As fluidization occurs, the simulation tracks the evolution in time and physical space of the quadrature nodes and weights and predicts the mixing attained by the system. To validate the method, we compare computational predictions with experimental results.

This book develops the theoretical foundations of disperse two-phase flows, which are characterized by the existence of bubbles, droplets or solid particles finely dispersed in a carrier fluid, which can be a liquid or a gas. Chapters clarify many difficult subjects, including modeling of the interfacial area concentration. Basic knowledge of

the subjects treated in this book is essential to practitioners of Computational Fluid Dynamics for two-phase flows in a variety of industrial and environmental settings. The author provides a complete derivation of the basic equations, followed by more advanced subjects like turbulence equations for the two phases (continuous and disperse) and multi-size particulate flow modeling. As well as theoretical material, readers will discover chapters concerned with closure relations and numerical issues. Many physical models are presented, covering key subjects including heat and mass transfers between phases, interfacial forces and fluid particles coalescence and breakup, amongst others. This book is highly suitable for students in the subject area, but may also be a useful reference text for more advanced scientists and engineers.

Computational Models for Polydisperse Particulate and Multiphase SystemsCambridge University Press

With this unique and comprehensive text, readers will gain the quantitative tools needed to engineer the particulate processes and products that are ubiquitous in modern life. Covering a series of particle and particulate delivery form design processes, with emphasis on design and operation to control particle attributes, and supported by many worked examples, it is essential reading for students and practitioners. Topics covered include a range of particle design processes such as crystallization and precipitation, granulation, grinding, aerosol processes and spray drying, as well as forms of delivery such as granules, tablets, dry powders, and aerosols. Readers will learn from real-world examples how the primary particle properties and the structure and properties of the delivery form can lead to high performance products, ranging from pharmaceuticals, consumer goods and foods, to specialty chemicals, paints, agricultural chemicals and minerals.

Eulerian Modelling and Computational Fluid Dynamics Simulation of Mono and Polydisperse Fluidized Suspension

Numerical Methods with Chemical Engineering Applications

Optimization for Chemical and Biochemical Engineering

An Integrated Approach with Industrial Case Studies

Chemical Production Scheduling

Computational Transport Phenomena of Fluid-Particle Systems

Understand common scheduling as well as other advanced operational problems with this valuable reference from a recognized leader in the field. Beginning with basic principles and an overview of linear and mixed-integer programming, this unified treatment introduces the fundamental ideas underpinning most modeling approaches, and will allow you to easily develop your own models. With more than 150 figures, the basic concepts and ideas behind the development of different approaches are clearly illustrated. Addresses a wide range of problems arising in diverse industrial sectors, from oil and gas to fine chemicals, and from commodity chemicals to food manufacturing. A perfect resource for engineering and computer science students, researchers working in the area, and industrial practitioners. This innovative reference provides a coherent and critical view on the potential benefits of a transition from batch to continuous processes in the biopharmaceutical industry, with the main focus on chromatography. It also covers the key topics of protein stability and protein conjugation, addressing the chemical reaction and purification aspects together with their integration. This book offers a fine balance between theoretical modelling and illustrative case studies, between fundamental concepts and applied examples from the academic and industrial literature. Scientists interested in the design of biopharmaceutical processes will find useful practical methodologies, in particular for single-column and multi-column chromatographic processes.

The Special Issue presents almost 40 papers on recent research in modeling of pyrometallurgical systems, including physical models, first-principles models, detailed CFD and DEM models as well as statistical models or models based on machine learning. The models cover the whole production chain from raw materials processing through the reduction and conversion unit processes to ladle treatment, casting, and rolling. The papers illustrate how models can be used for shedding light on complex and inaccessible processes characterized by high temperatures and hostile environment, in order to improve process performance, product quality, or yield and to reduce the requirements of virgin raw materials and to suppress harmful emissions.

Doctoral Thesis / Dissertation from the year 2013 in the subject Engineering - Mechanical Engineering, grade: 1, University of Linz (Department on Particulate Flow Modelling), language: English, abstract: The numerical hybrid model EUgran+, which is an Eulerian-Eulerian granular phase model extended with models from the Eulerian-Lagrangian model for dense rapid particulate flows, is modified to account for poly-dispersed particle diameter distributions. These modifications include the implementation of I) a new poly-dispersed drag law and of II) new particle boundary conditions distinguishing between sliding and non-sliding particle-wall collisions and III) a new implementation of the population balance equation in the agglomeration model using the Eulerian-Lagrangian approach, referred to as Bus-stop model. Further, the applicability of the EUgran+ model is extended to cover dilute to dense poly-disperse particulate flows. Furthermore, this provides an improvement in the numerical simulation of dust separation and the formation of particle strands in industrial scale cyclones. In this PHD thesis, the EUgran+Poly model is validated at 3 specific cases with different mass loadings: I) poly-dispersed particle conveying in a square pipe with a 90 degree bend

at low mass loading (L = 0:00206); II) a particle conveying case in a rectangular pipe with a double-loop at high mass loading (L = 1:5); III) in a vertical pipe the implementation of the agglomeration model is validated. To show the applicability of the presented models a simulation of an industrial cyclone in experimental scale is presented. The validation and application shows that considering a poly-disperse Eulerian-Eulerian granular phase improves the accordance of the simulation results with measurements significantly. Finally, the hybrid model is a good compromise for a computational efficient simulation of particulate transport and separation with different mass loading regimes.

Advanced Optimization for Process Systems Engineering
Modeling, Simulation, and Design
Perfusion Cell Culture Processes for Biopharmaceuticals
Theory, Methods and Practice
Encyclopedia of Information Science and Technology, Fifth Edition
Thermodynamics with Chemical Engineering Applications

Master the principles of thermodynamics, and understand their practical real-world applications, with this deep and intuitive undergraduate textbook.

This book outlines a possible future theoretical perspective for systemics, its conceptual morphology and landscape while the Good-Old-Fashioned-Systemics (GOFS) era is still under way. The change from GOFS to future systemics can be represented, as shown in the book by the conceptual change from Collective Beings to Quasi-systems. With the current advancements, problems and approaches occurring in contemporary science, systemics are moving beyond the traditional frameworks used in the past. From Collective Beings to Coherent Quasi Systems outlines a conceptual morphology and landscape for a new theoretical perspective for systemics introducing the concept of Quasi-systems. Advances in domains such as theoretical physics, philosophy of science, cell biology, neuroscience, experimental economics, net science and many others offer new concepts and technical tools to support the creation of a fully transdisciplinary General Theory of Chang This circumstance requires a deep reformulation of systemics, without forgetting the achievements of established conventions. The book is divided into two parts. Part I, examines classic systemic issues from new theoretical perspectives and approaches. A new general unified framework is introduced to help deal with topics such as dynamic structural coherence and Quasi-systems. This new theoretical framework compared and contrasted with the traditional approaches. Part II focuses on the process of translation into social culture of the theoretical principles, models and approaches introduced in Part I. This translation is urgent in post-industrial societies where emergent processes and problems are still dealt with by using the classical or non-systemic knowledge of the industrial phase.

A unique text providing comprehensive coverage of fundamental particle science, processing and technology. Including quantitative tools, r world case studies and end-of-chapter problems, it is ideal for students in engineering and applied sciences, as well as for practitioners in a range of industries manufacturing particulate products.

The rise of intelligence and computation within technology has created an eruption of potential applications in numerous professional industries. Techniques such as data analysis, cloud computing, machine learning, and others have altered the traditional processes of vario disciplines including healthcare, economics, transportation, and politics. Information technology in today's world is beginning to uncover opportunities for experts in these fields that they are not yet aware of. The exposure of specific instances in which these devices are being implemented will assist other specialists in how to successfully utilize these transformative tools with the appropriate amount of discretion, safety, and awareness. Considering the level of diverse uses and practices throughout the globe, the fifth edition of the Encyclopedia of Information Science and Technology series continues the enduring legacy set forth by its predecessors as a premier reference that contribu the most cutting-edge concepts and methodologies to the research community. The Encyclopedia of Information Science and Technology, Edition is a three-volume set that includes 136 original and previously unpublished research chapters that present multidisciplinary research and expert insights into new methods and processes for understanding modern technological tools and their applications as well as emergi theories and ethical controversies surrounding the field of information science. Highlighting a wide range of topics such as natural language processing, decision support systems, and electronic government, this book offers strategies for implementing smart devices and analytics various professional disciplines. The techniques discussed in this publication are ideal for IT professionals, developers, computer scientists practitioners, managers, policymakers, engineers, data analysts, and programmers seeking to understand the latest developments within th field and who are looking to apply new tools and policies in their practice. Additionally, academicians, researchers, and students in fields tha include but are not limited to software engineering, cybersecurity, information technology, media and communications, urban planning, computer science, healthcare, economics, environmental science, data management, and political science will benefit from the extensive knowledge compiled within this publication.

Computational Gas-Solids Flows and Reacting Systems: Theory, Methods and Practice
Integrated Chemical Processes in Liquid Multiphase Systems
Understanding Process Dynamics and Control
Selected Papers of the 11th Workshop
Molecular Engineering Thermodynamics

Multiphase Particulate Systems in Turbulent Flows: Fluid-Liquid and Solid-Liquid Dispersions provides methods necessary to analyze complex particulate systems and related phenomena including physical, chemical and mathematical description of fundamental processes influencing crystal size and shape, suspension rheology, interfacial area of drops and bubbles in extractors and bubble columns. Examples of mathematical model formulation for different processes taking place in such systems is shown. Discussing connections between turbulent mixing mechanisms and precipitation, it discusses influence of fine-scale structure of turbulence, including its intermittent character, on breakage of drops, bubbles, cells, plant cell aggregates. An important aspect of the mathematical modeling presented in the book is multi-fractal, taking into account the influence of internal intermittency on different phenomena. Key Features Provides detailed descriptions of dispersion processes in turbulent flow, interactions between dispersed entities, and continuous phase in a single volume Includes simulation models and validation experiments for liquid-liquid, gas-liquid, and solid-liquid dispersions in turbulent flows Helps reader

learn formulation of mathematical models of breakage or aggregation processes using multifractal theory Explains how to solve different forms of population balance equations Presents a combination of theoretical and engineering approaches to particulate systems along with discussion of related diversity, with exercises and case studies

Explore and review novel techniques for intensifying transport and reaction in liquid-liquid and related systems with this essential toolkit. Topics include discussion of the principles of process intensification, the nexus between process intensification and sustainable engineering, and the fundamentals of liquid-liquid contacting, from an expert with over forty-five years' experience in the field. Providing promising directions for investment and for new research in process intensification, in addition to a unique review of the fundamentals of the topic, this book is the perfect guide for senior undergraduate students, graduate students, developers, and research staff in chemical engineering and biochemical engineering.

"This book provides various approaches to computational gas-solids flow and will aid the researchers, graduate students and practicing engineers in this rapidly expanding area"--Provided by publisher.

Describes dynamic state of metabolic systems, while paving the way for fully predictive modeling frameworks.

Introduction to Chemical Engineering Fluid Mechanics

Mixed-Integer Programming Models and Methods

Process Modeling in Pyrometallurgical Engineering

Practical Multiscaling

Micromechanical modeling of short-fiber reinforced composites

Fluid-Liquid and Solid-Liquid Dispersions

The first comprehensive guide to chemical looping partial oxidation processes, covering key principles, techniques, and applications.

Since their first introduction in natural sciences through the work of Einstein on Brownian motion in 1905 and further works, in particular by Langevin, Smoluchowski and others, stochastic processes have been used in several areas of science and technology. For example, they have been applied in chemical studies, or in fluid turbulence and for combustion and reactive flows. The articles in this book provide a general and unified framework in which stochastic processes are presented as modeling tools for various issues in engineering, physics and chemistry, with particular focus on fluid mechanics and notably dispersed two-phase flows. The aim is to develop what can referred to as stochastic modeling for a whole range of applications.

Discover tools to perform Life Cycle Analysis (LCA) and develop sustainable chemical technologies in this valuable guide for chemists, engineers and practitioners. Tackling one of the key challenges of modern industrial chemical engineering, this book introduces tools to assess the environmental footprint and economics of key chemical processes that make the ingredients of everyday products such as plastics, synthetic fibers, detergents and fuels. Describing diverse industrial processes in detail, it provides process flow diagrams including raw material sourcing, catalytic reactors, separation units, process equipment and recycle streams. The book clearly explains elements of LCA and how various software tools, available in the public domain and commercially, can be used to perform LCA. Supported by real-world practical examples and case studies provided by industrial and academic chemists and chemical engineers, this is an essential tool for readers involved in implementing LCA, and developing next-generation sustainable chemical technologies.

Building up gradually from first principles, this unique introduction to modern thermodynamics integrates classical, statistical and molecular approaches and is especially designed to support students studying chemical and biochemical engineering. In addition to covering traditional problems in engineering thermodynamics in the context of biology and materials chemistry, students are also introduced to the thermodynamics of DNA, proteins, polymers and surfaces. It includes over 80 detailed worked examples, covering a broad range of scenarios such as fuel cell efficiency, DNA/protein binding, semiconductor manufacturing and polymer foaming, emphasizing the practical real-world applications of thermodynamic principles; more than 300 carefully tailored homework problems, designed to stretch and extend students' understanding of key topics, accompanied by an online solution manual for instructors; and all the necessary mathematical background, plus resources summarizing commonly used symbols, useful equations of state, microscopic balances for open systems, and links to useful online tools and datasets.

Theory, Algorithms, Modeling and Applications

Stochastic Methods in Fluid Mechanics

Hybrid Particle Laden Flow Modelling

From Chemical Reaction to Process Design and Operation

Intensification of Liquid – Liquid Processes

Multiphase Particulate Systems in Turbulent Flows

"Optimization for Chemical and Biochemical Engineering - Theory, Algorithms, Modeling and Applications"--

Addressing all aspects of the design, modeling and simulation of chromatographic processes, this result-oriented primer provides a practical guide to all the necessary approaches, methodologies and tools. Beginning with key definitions and concepts, it builds up from the most simple to the most complex situations, including multicomponent systems, non-uniform velocity profiles, bed instability, particle size distributions, and the influence of complex environments on chromatographic process design. In addition to covering classical approaches, it introduces efficient tools for investigating chromatographic processes, such as the 'Russian-Lego' approach for linear systems, phenomenological models, and specific shortcuts for deriving the key properties of industrial processes. With an emphasis on real-world problems and applications, step-by step modeling design guidelines, and detailed exercises for self-assessment, this is a must-have guide for practitioners and researchers working in chemical, biochemical, food and pharmaceutical engineering.

This book concerns the most up-to-date advances in computational transport phenomena (CTP), an emerging tool for the design of gas-solid processes such as fluidized bed systems. The authors examine recent work in kinetic theory and CTP and illustrate gas-solid processes' many applications in the energy, chemical, pharmaceutical, and food industries. They also discuss the kinetic theory approach in developing constitutive equations for gas-solid flow systems and how it has advanced over the last decade as well as the possibility of obtaining innovative designs for multiphase reactors, such as those needed to capture CO2 from flue gases. Suitable as a concise reference and a textbook supplement for graduate courses, Computational Transport Phenomena of Gas-Solid Systems is ideal for practitioners in industries involved with the design and operation of processes based on fluid/particle mixtures, such as the energy, chemicals, pharmaceuticals, and food processing.

An essential text on practical application, theory and simulation, written by an international coalition of experts in the field and edited by the authors of Colloidal Suspension Rheology. This up-to-date work builds upon the prior work as a valuable guide to formulation and processing, as well as fundamental rheology of colloidal suspensions. Thematically, theory and simulation are connected to industrial application by consideration of colloidal interactions, particle properties, and suspension microstructure. Important classes of model suspensions including gels, glasses and soft particles are covered so as to develop a deeper understanding of industrial systems ranging from carbon black slurries, paints and coatings, asphalt, cement, and mine tailings, to natural suspensions such as biocolloids, protein solutions, and blood. Systematically presenting the established facts in this multidisciplinary field, this book is the perfect aid for academic researchers, graduate students, and industrial practitioners alike.

Theory and Applications of Colloidal Suspension Rheology

Chromatography, Bioconjugation, and Protein Stability

Process Development, Design, and Scale-up

CFD Simulations of Particle Laden Flows: Particle Transport and Separation

Continuous Biopharmaceutical Processes

Granularity in Materials Science

This book is a monography about perfusion cell cultures for the production of biopharmaceuticals, such as therapeutic proteins (i.e. biomolecules like monoclonal antibodies), and describes the fundamentals, design and operation of these processes. Context is given in the first chapters to understand the state-of-the-art of the technology. We then give an overview of the challenges and objectives in operating mammalian cell perfusion cultures and provide guidelines for the design and setup of lab-scale bioreactor systems, and the required control structure to achieve stable operation. Scale-down devices and PAT tools are described in the context of continuous manufacturing and guidelines for process optimization are given using a variety of case studies to illustrate different approaches. Scale-up is also adressed with a strong focus on bioreactor aeration and mixing, shear stress and cell retention device. Finally, a general introduction for the application of mechanistic and statistic models in bioreactor process development and optimization is given in the last chapter.

The essential principles of green chemistry are the use of renewable raw materials, highly efficient catalysts and green solvents linked with energy efficiency and process optimization in real-time. Experts from different fields show, how to examine all levels from the molecular elementary steps up to the design and operation of an entire plant for developing novel and efficient production processes.

Learn classical thermodynamics alongside statistical mechanics and how macroscopic and microscopic ideas interweave with this fresh approach to the subjects.

All-inclusive introduction to polydisperse multiphase flows linking theory to practice through numerous real-world examples and MATLAB scripts for key algorithms.

Cybernetic Modeling for Bioreaction Engineering

Mathematical Modeling of Disperse Two-Phase Flows

Computational Models for Polydisperse Particulate and Multiphase Systems

Gasification, Reforming, and Chemical Syntheses

This study presents the basic models for discrete and continuous particle laden flow simulation. An overview of the two main approaches, the Lagrangian discrete particle model and the Eulerian granular phase model is given. Moreover these two approaches are combined to a hybrid model to use the benefits of the discrete and continuous description. This safes computational time and increase the efficiency of particle laden flow simulations. Furthermore the models are extended to poly-disperse particles including a simple agglomeration model based on a population balance equation. Finally the usability of the models is shown at a pneumatic particle transport system including particle strand building and the separation of particles using an industrial cyclone.

The go-to guide to learn the principles and practices of design and analysis in chemical engineering.

This undergraduate textbook integrates the teaching of numerical methods and programming with problems from core chemical engineering subjects.

Address physical principles and unified theories governing multiphase flows, with methods, applications, and problems.