

## CONTENTS OF VOLUMES IN THIS SERIAL

### Volume 1

- J. W. Westwater, *Boiling of Liquids*  
A. B. Metzner, *Non-Newtonian Technology: Fluid Mechanics, Mixing, and Heat Transfer*  
R. Byron Bird, *Theory of Diffusion*  
J. B. Opfell and B. H. Sage, *Turbulence in Thermal and Material Transport*  
Robert E. Treybal, *Mechanically Aided Liquid Extraction*  
Robert W. Schrage, *The Automatic Computer in the Control and Planning of Manufacturing Operations*  
Ernest J. Henley and Nathaniel F. Barr, *Ionizing Radiation Applied to Chemical Processes and to Food and Drug Processing*

### Volume 2

- J. W. Westwater, *Boiling of Liquids*  
Ernest F. Johnson, *Automatic Process Control*  
Bernard Manowitz, *Treatment and Disposal of Wastes in Nuclear Chemical Technology*  
George A. Sofer and Harold C. Weingartner, *High Vacuum Technology*  
Theodore Vermeulen, *Separation by Adsorption Methods*  
Sherman S. Weidenbaum, *Mixing of Solids*

### Volume 3

- C. S. Grove, Jr., Robert V. Jelinek, and Herbert M. Schoen, *Crystallization from Solution*  
F. Alan Ferguson and Russell C. Phillips, *High Temperature Technology*  
Daniel Hyman, *Mixing and Agitation*  
John Beck, *Design of Packed Catalytic Reactors*  
Douglass J. Wilde, *Optimization Methods*

### Volume 4

- J. T. Davies, *Mass-Transfer and Interfacial Phenomena*  
R. C. Kintner, *Drop Phenomena Affecting Liquid Extraction*  
Octave Levenspiel and Kenneth B. Bischoff, *Patterns of Flow in Chemical Process Vessels*  
Donald S. Scott, *Properties of Concurrent Gas-Liquid Flow*  
D. N. Hanson and G. F. Somerville, *A General Program for Computing Multistage Vapor-Liquid Processes*

### Volume 5

- J. F. Wehner, *Flame Processes—Theoretical and Experimental*  
J. H. Sinfelt, *Bifunctional Catalysts*  
S. G. Bankoff, *Heat Conduction or Diffusion with Change of Phase*  
George D. Fulford, *The Flow of Liquids in Thin Films*  
K. Rietema, *Segregation in Liquid-Liquid Dispersions and its Effects on Chemical Reactions*

**Volume 6**

- S. G. Bankoff, *Diffusion-Controlled Bubble Growth*  
John C. Berg, Andreas Acrivos, and Michel Boudart, *Evaporation Convection*  
H. M. Tsuchiya, A. G. Fredrickson, and R. Aris, *Dynamics of Microbial Cell Populations*  
Samuel Sideman, *Direct Contact Heat Transfer between Immiscible Liquids*  
Howard Brenner, *Hydrodynamic Resistance of Particles at Small Reynolds Numbers*

**Volume 7**

- Robert S. Brown, Ralph Anderson, and Larry J. Shannon, *Ignition and Combustion of Solid Rocket Propellants*  
Knud Østergaard, *Gas-Liquid-Particle Operations in Chemical Reaction Engineering*  
J. M. Prausnitz, *Thermodynamics of Fluid-Phase Equilibria at High Pressures*  
Robert V. Macbeth, *The Burn-Out Phenomenon in Forced-Convection Boiling*  
William Resnick and Benjamin Gal-Or, *Gas-Liquid Dispersions*

**Volume 8**

- C. E. Lapple, *Electrostatic Phenomena with Particulates*  
J. R. Kittrell, *Mathematical Modeling of Chemical Reactions*  
W. P. Ledet and D. M. Himmelblau, *Decomposition Procedures for the Solving of Large Scale Systems*  
R. Kumar and N. R. Kuloor, *The Formation of Bubbles and Drops*

**Volume 9**

- Renato G. Bautista, *Hydrometallurgy*  
Kishan B. Mathur and Norman Epstein, *Dynamics of Spouted Beds*  
W. C. Reynolds, *Recent Advances in the Computation of Turbulent Flows*  
R. E. Peck and D. T. Wasan, *Drying of Solid Particles and Sheets*

**Volume 10**

- G. E. O'Connor and T. W. F. Russell, *Heat Transfer in Tubular Fluid-Fluid Systems*  
P. C. Kapur, *Balling and Granulation*  
Richard S. H. Mah and Mordechai Shacham, *Pipeline Network Design and Synthesis*  
J. Robert Selman and Charles W. Tobias, *Mass-Transfer Measurements by the Limiting-Current Technique*

**Volume 11**

- Jean-Claude Charpentier, *Mass-Transfer Rates in Gas-Liquid Absorbers and Reactors*  
Dee H. Barker and C. R. Mitra, *The Indian Chemical Industry—Its Development and Needs*  
Lawrence L. Tavlarides and Michael Stamatoudis, *The Analysis of Interphase Reactions and Mass Transfer in Liquid-Liquid Dispersions*  
Terukatsu Miyauchi, Shintaro Furusaki, Shigeharu Morooka, and Yoneichi Ikeda, *Transport Phenomena and Reaction in Fluidized Catalyst Beds*

**Volume 12**

- C. D. Prater, J. Wei, V. W. Weekman, Jr., and B. Gross, *A Reaction Engineering Case History: Coke Burning in Thermoform Catalytic Cracking Regenerators*  
Costel D. Denson, *Stripping Operations in Polymer Processing*  
Robert C. Reid, *Rapid Phase Transitions from Liquid to Vapor*  
John H. Seinfeld, *Atmospheric Diffusion Theory*

**Volume 13**

- Edward G. Jefferson, *Future Opportunities in Chemical Engineering*  
Eli Ruckenstein, *Analysis of Transport Phenomena Using Scaling and Physical Models*  
Rohit Khanna and John H. Seinfeld, *Mathematical Modeling of Packed Bed Reactors: Numerical Solutions and Control Model Development*  
Michael P. Ramage, Kenneth R. Graziano, Paul H. Schipper, Frederick J. Krambeck, and Byung C. Choi, *KINPTR (Mobil's Kinetic Reforming Model): A Review of Mobil's Industrial Process Modeling Philosophy*

**Volume 14**

- Richard D. Colberg and Manfred Morari, *Analysis and Synthesis of Resilient Heat Exchange Networks*  
Richard J. Quann, Robert A. Ware, Chi-Wen Hung, and James Wei, *Catalytic Hydrometallation of Petroleum*  
Kent David, *The Safety Matrix: People Applying Technology to Yield Safe Chemical Plants and Products*

**Volume 15**

- Pierre M. Adler, Ali Nadim, and Howard Brenner, *Rheological Models of Suspensions*  
Stanley M. Englund, *Opportunities in the Design of Inherently Safer Chemical Plants*  
H. J. Ploehn and W. B. Russel, *Interactions between Colloidal Particles and Soluble Polymers*

**Volume 16**

*Perspectives in Chemical Engineering: Research and Education*

Clark K. Colton, *Editor*

Historical Perspective and Overview

L. E. Scriven, *On the Emergence and Evolution of Chemical Engineering*

Ralph Landau, *Academic—industrial Interaction in the Early Development of Chemical Engineering*

James Wei, *Future Directions of Chemical Engineering*

Fluid Mechanics and Transport

L. G. Leal, *Challenges and Opportunities in Fluid Mechanics and Transport Phenomena*

William B. Russel, *Fluid Mechanics and Transport Research in Chemical Engineering*

J. R. A. Pearson, *Fluid Mechanics and Transport Phenomena*

Thermodynamics

Keith E. Gubbins, *Thermodynamics*

J. M. Prausnitz, *Chemical Engineering Thermodynamics: Continuity and Expanding Frontiers*

H. Ted Davis, *Future Opportunities in Thermodynamics*

Kinetics, Catalysis, and Reactor Engineering

Alexis T. Bell, *Reflections on the Current Status and Future Directions of Chemical Reaction Engineering*

James R. Katzer and S. S. Wong, *Frontiers in Chemical Reaction Engineering*

L. Louis Hegedus, *Catalyst Design*

Environmental Protection and Energy

John H. Seinfeld, *Environmental Chemical Engineering*

T. W. F. Russell, *Energy and Environmental Concerns*

Janos M. Beer, Jack B. Howard, John P. Longwell, and Adel F. Sarofim, *The Role of Chemical Engineering in Fuel Manufacture and Use of Fuels*

Polymers

Matthew Tirrell, *Polymer Science in Chemical Engineering*

Richard A. Register and Stuart L. Cooper, *Chemical Engineers in Polymer Science: The Need for an Interdisciplinary Approach*

Microelectronic and Optical Material

Larry F. Thompson, *Chemical Engineering Research Opportunities in Electronic and Optical Materials Research*

Klavs F. Jensen, *Chemical Engineering in the Processing of Electronic and Optical Materials: A Discussion*

Bioengineering

James E. Bailey, *Bioprocess Engineering*

Arthur E. Humphrey, *Some Unsolved Problems of Biotechnology*

Channing Robertson, *Chemical Engineering: Its Role in the Medical and Health Sciences*

Process Engineering

Arthur W. Westerberg, *Process Engineering*

Manfred Morari, *Process Control Theory: Reflections on the Past Decade and Goals for the Next*

James M. Douglas, *The Paradigm After Next*

George Stephanopoulos, *Symbolic Computing and Artificial Intelligence in Chemical Engineering: A New Challenge*

The Identity of Our Profession

Morton M. Denn, *The Identity of Our Profession*

## **Volume 17**

Y. T. Shah, *Design Parameters for Mechanically Agitated Reactors*

Mooson Kwauk, *Particulate Fluidization: An Overview*

## **Volume 18**

E. James Davis, *Microchemical Engineering: The Physics and Chemistry of the Microparticle*

Selim M. Senkan, *Detailed Chemical Kinetic Modeling: Chemical Reaction Engineering of the Future*

Lorenz T. Biegler, *Optimization Strategies for Complex Process Models*

**Volume 19**

- Robert Langer, *Polymer Systems for Controlled Release of Macromolecules, Immobilized Enzyme Medical Bioreactors, and Tissue Engineering*  
J. J. Linderman, P. A. Mahama, K. E. Forsten, and D. A. Lauffenburger, *Diffusion and Probability in Receptor Binding and Signaling*  
Rakesh K. Jain, *Transport Phenomena in Tumors*  
R. Krishna, *A Systems Approach to Multiphase Reactor Selection*  
David T. Allen, *Pollution Prevention: Engineering Design at Macro-, Meso-, and Microscales*  
John H. Seinfeld, Jean M. Andino, Frank M. Bowman, Hali J. L. Forstner, and Spyros Pandis, *Tropospheric Chemistry*

**Volume 20**

- Arthur M. Squires, *Origins of the Fast Fluid Bed*  
Yu Zhiqing, *Application Collocation*  
Youchu Li, *Hydrodynamics*  
Li Jinghai, *Modeling*  
Yu Zhiqing and Jin Yong, *Heat and Mass Transfer*  
Mooson Kwauk, *Powder Assessment*  
Li Hongzhong, *Hardware Development*  
Youchu Li and Xuyi Zhang, *Circulating Fluidized Bed Combustion*  
Chen Junwu, Cao Hanchang, and Liu Taiji, *Catalyst Regeneration in Fluid Catalytic Cracking*

**Volume 21**

- Christopher J. Nagel, Chonghun Han, and George Stephanopoulos, *Modeling Languages: Declarative and Imperative Descriptions of Chemical Reactions and Processing Systems*  
Chonghun Han, George Stephanopoulos, and James M. Douglas, *Automation in Design: The Conceptual Synthesis of Chemical Processing Schemes*  
Michael L. Mavrovouniotis, *Symbolic and Quantitative Reasoning: Design of Reaction Pathways through Recursive Satisfaction of Constraints*  
Christopher Nagel and George Stephanopoulos, *Inductive and Deductive Reasoning: The Case of Identifying Potential Hazards in Chemical Processes*  
Keven G. Joback and George Stephanopoulos, *Searching Spaces of Discrete Solutions: The Design of Molecules Processing Desired Physical Properties*

**Volume 22**

- Chonghun Han, Ramachandran Lakshmanan, Bhavik Bakshi, and George Stephanopoulos, *Nonmonotonic Reasoning: The Synthesis of Operating Procedures in Chemical Plants*  
Pedro M. Saraiva, *Inductive and Analogical Learning: Data-Driven Improvement of Process Operations*  
Alexandros Koulouris, Bhavik R. Bakshi and George Stephanopoulos, *Empirical Learning through Neural Networks: The Wave-Net Solution*  
Bhavik R. Bakshi and George Stephanopoulos, *Reasoning in Time: Modeling, Analysis, and Pattern Recognition of Temporal Process Trends*  
Matthew J. Realff, *Intelligence in Numerical Computing: Improving Batch Scheduling Algorithms through Explanation-Based Learning*

**Volume 23**

Jeffrey J. Siirola, *Industrial Applications of Chemical Process Synthesis*

Arthur W. Westerberg and Oliver Wahnschafft, *The Synthesis of Distillation-Based Separation Systems*

Ignacio E. Grossmann, *Mixed-Integer Optimization Techniques for Algorithmic Process Synthesis*

Subash Balakrishna and Lorenz T. Biegler, *Chemical Reactor Network Targeting and Integration: An Optimization Approach*

Steve Walsh and John Perkins, *Operability and Control in Process Synthesis and Design*

**Volume 24**

Raffaella Ocone and Gianni Astarita, *Kinetics and Thermodynamics in Multicomponent Mixtures*

Arvind Varma, Alexander S. Rogachev, Alexandra S. Mukasyan, and Stephen Hwang, *Combustion Synthesis of Advanced Materials: Principles and Applications*

J. A. M. Kuipers and W. P. M. van Swaaij, *Computational Fluid Dynamics Applied to Chemical Reaction Engineering*

Ronald E. Schmitt, Howard Klee, Debora M. Sparks, and Mahesh K. Podar, *Using Relative Risk Analysis to Set Priorities for Pollution Prevention at a Petroleum Refinery*

**Volume 25**

J. F. Davis, M. J. Piovoso, K. A. Hoo, and B. R. Bakshi, *Process Data Analysis and Interpretation*

J. M. Ottino, P. DeRoussel, S. Hansen, and D. V. Khakhar, *Mixing and Dispersion of Viscous Liquids and Powdered Solids*

Peter L. Silverston, Li Chengyue, Yuan Wei-Kang, *Application of Periodic Operation to Sulfur Dioxide Oxidation*

**Volume 26**

J. B. Joshi, N. S. Deshpande, M. Dinkar, and D. V. Phanikumar, *Hydrodynamic Stability of Multiphase Reactors*

Michael Nikolaou, *Model Predictive Controllers: A Critical Synthesis of Theory and Industrial Needs*

**Volume 27**

William R. Moser, Josef Find, Sean C. Emerson, and Ivo M. Krausz, *Engineered Synthesis of Nanostructure Materials and Catalysts*

Bruce C. Gates, *Supported Nanostructured Catalysts: Metal Complexes and Metal Clusters*

Ralph T. Yang, *Nanostructured Absorbents*

Thomas J. Webster, *Nanophase Ceramics: The Future Orthopedic and Dental Implant Material*

Yu-Ming Lin, Mildred S. Dresselhaus, and Jackie Y. Ying, *Fabrication, Structure, and Transport Properties of Nanowires*

**Volume 28**

Qiliang Yan and Juan J. DePablo, *Hyper-Parallel Tempering Monte Carlo and Its Applications*

Pablo G. Debenedetti, Frank H. Stillinger, Thomas M. Truskett, and Catherine P. Lewis, *Theory of Supercooled Liquids and Glasses: Energy Landscape and Statistical Geometry Perspectives*

Michael W. Deem, *A Statistical Mechanical Approach to Combinatorial Chemistry*

- Venkat Ganesan and Glenn H. Fredrickson, *Fluctuation Effects in Microemulsion Reaction Media*
- David B. Graves and Cameron F. Abrams, *Molecular Dynamics Simulations of Ion–Surface Interactions with Applications to Plasma Processing*
- Christian M. Lastoskie and Keith E. Gubbins, *Characterization of Porous Materials Using Molecular Theory and Simulation*
- Dimitrios Maroudas, *Modeling of Radical-Surface Interactions in the Plasma-Enhanced Chemical Vapor Deposition of Silicon Thin Films*
- Sanat Kumar, M. Antonio Floriano, and Athanassios Z. Panagiotopoulos, *Nanostructured Formation and Phase Separation in Surfactant Solutions*
- Stanley I. Sandler, Amadeu K. Sum, and Shiang-Tai Lin, *Some Chemical Engineering Applications of Quantum Chemical Calculations*
- Bernhardt L. Trout, *Car-Parrinello Methods in Chemical Engineering: Their Scope and potential*
- R. A. van Santen and X. Rozanska, *Theory of Zeolite Catalysis*
- Zhen-Gang Wang, *Morphology, Fluctuation, Metastability and Kinetics in Ordered Block Copolymers*

**Volume 29**

- Michael V. Sefton, *The New Biomaterials*
- Kristi S. Anseth and Kristyn S. Masters, *Cell–Material Interactions*
- Surya K. Mallapragada and Jennifer B. Recknor, *Polymeric Biomaterials for Nerve Regeneration*
- Anthony M. Lowman, Thomas D. Dziubla, Petr Bures, and Nicholas A. Peppas, *Structural and Dynamic Response of Neutral and Intelligent Networks in Biomedical Environments*
- F. Kurtis Kasper and Antonios G. Mikos, *Biomaterials and Gene Therapy*
- Balaji Narasimhan and Matt J. Kipper, *Surface-Erodible Biomaterials for Drug Delivery*

**Volume 30**

- Dionisios G. Vlachos, *A Review of Multiscale Analysis: Examples from Systems Biology, Materials Engineering, and Other Fluid Surface Interacting Systems*
- Lynn F. Gladden, M.D. Mantle and A.J. Sederman, *Quantifying Physics and Chemistry at Multiple Length-Scales using Magnetic Resonance Techniques*
- Juraj Kosek, František Štěpánek, and Miloš Marek, *Modelling of Transport and Transformation Processes in Porous and Multiphase Bodies*
- Saikat Chakraborty and Vemuri Balakotaiah, *Spatially Averaged Multiscale Models for Chemical Reactors*