

Contents

- 1 *History, Structural Formulation of the Field Through Elementary Steps, and Future Perspectives, 1***
 - 1.1 Historical Notes, 1
 - 1.2 Current Polymer Processing Practice, 7
 - 1.3 Analysis of Polymer Processing in Terms of Elementary Steps and Shaping Methods, 14
 - 1.4 Future Perspectives: From Polymer Processing to Macromolecular Engineering, 18

- 2 *The Balance Equations and Newtonian Fluid Dynamics, 25***
 - 2.1 Introduction, 25
 - 2.2 The Balance Equations, 26
 - 2.3 Reynolds Transport Theorem, 26
 - 2.4 The Macroscopic Mass Balance and the Equation of Continuity, 28
 - 2.5 The Macroscopic Linear Momentum Balance and the Equation of Motion, 32
 - 2.6 The Stress Tensor, 37
 - 2.7 The Rate of Strain Tensor, 40
 - 2.8 Newtonian Fluids, 43
 - 2.9 The Macroscopic Energy Balance and the Bernoulli and Thermal Energy Equations, 54
 - 2.10 Mass Transport in Binary Mixtures and the Diffusion Equation, 60
 - 2.11 Mathematical Modeling, Common Boundary Conditions, Common Simplifying Assumptions, and the Lubrication Approximation, 60

- 3 *Polymer Rheology and Non-Newtonian Fluid Mechanics, 79***
 - 3.1 Rheological Behavior, Rheometry, and Rheological Material Functions of Polymer Melts, 80
 - 3.2 Experimental Determination of the Viscosity and Normal Stress Difference Coefficients, 94
 - 3.3 Polymer Melt Constitutive Equations Based on Continuum Mechanics, 100
 - 3.4 Polymer Melt Constitutive Equations Based on Molecular Theories, 122

- 4 *The Handling and Transporting of Polymer Particulate Solids, 144***
 - 4.1 Some Unique Properties of Particulate Solids, 145
 - 4.2 Agglomeration, 150
 - 4.3 Pressure Distribution in Bins and Hoppers, 150
 - 4.4 Flow and Flow Instabilities in Hoppers, 152
 - 4.5 Compaction, 154
 - 4.6 Flow in Closed Conduits, 157
 - 4.7 Mechanical Displacement Flow, 157
 - 4.8 Steady Mechanical Displacement Flow Aided by Drag, 159
 - 4.9 Steady Drag-induced Flow in Straight Channels, 162
 - 4.10 The Discrete Element Method, 165

- 5 *Melting, 178***
 - 5.1 Classification and Discussion of Melting Mechanisms, 179
 - 5.2 Geometry, Boundary Conditions, and Physical Properties in Melting, 184
 - 5.3 Conduction Melting without Melt Removal, 186
 - 5.4 Moving Heat Sources, 193
 - 5.5 Sintering, 199
 - 5.6 Conduction Melting with Forced Melt Removal, 201
 - 5.7 Drag-induced Melt Removal, 202
 - 5.8 Pressure-induced Melt Removal, 216
 - 5.9 Deformation Melting, 219

- 6 *Pressurization and Pumping, 235***
 - 6.1 Classification of Pressurization Methods, 236
 - 6.2 Synthesis of Pumping Machines from Basic Principles, 237
 - 6.3 The Single Screw Extruder Pump, 247
 - 6.4 Knife and Roll Coating, Calenders, and Roll Mills, 259
 - 6.5 The Normal Stress Pump, 272
 - 6.6 The Co-rotating Disk Pump, 278
 - 6.7 Positive Displacement Pumps, 285
 - 6.8 Twin Screw Extruder Pumps, 298

- 7 *Mixing, 322***
 - 7.1 Basic Concepts and Mixing Mechanisms, 322
 - 7.2 Mixing Equipment and Operations of Multicomponent and Multiphase Systems, 354
 - 7.3 Distribution Functions, 357
 - 7.4 Characterization of Mixtures, 378
 - 7.5 Computational Analysis, 391

- 8 *Devolatilization, 409***
 - 8.1 Introduction, 409
 - 8.2 Devolatilization Equipment, 411
 - 8.3 Devolatilization Mechanisms, 413

- 8.4 Thermodynamic Considerations of Devolatilization, 416
 - 8.5 Diffusivity of Low Molecular Weight Components in Molten Polymers, 420
 - 8.6 Boiling Phenomena: Nucleation, 422
 - 8.7 Boiling–Foaming Mechanisms of Polymeric Melts, 424
 - 8.8 Ultrasound-enhanced Devolatilization, 427
 - 8.9 Bubble Growth, 428
 - 8.10 Bubble Dynamics and Mass Transfer in Shear Flow, 430
 - 8.11 Scanning Electron Microscopy Studies of Polymer Melt Devolatilization, 433
- 9 *Single Rotor Machines, 447***
- 9.1 Modeling of Processing Machines Using Elementary Steps, 447
 - 9.2 The Single Screw Melt Extrusion Process, 448
 - 9.3 The Single Screw Plasticating Extrusion Process, 473
 - 9.4 The Co-rotating Disk Plasticating Processor, 506
- 10 *Twin Screw and Twin Rotor Processing Equipment, 523***
- 10.1 Types of Twin Screw and Twin Rotor–based Machines, 525
 - 10.2 Counterrotating Twin Screw and Twin Rotor Machines, 533
 - 10.3 Co-rotating, Fully Intermeshing Twin Screw Extruders, 572
- 11 *Reactive Polymer Processing and Compounding, 603***
- 11.1 Classes of Polymer Chain Modification Reactions, Carried out in Reactive Polymer Processing Equipment, 604
 - 11.2 Reactor Classification, 611
 - 11.3 Mixing Considerations in Multicomponent Miscible Reactive Polymer Processing Systems, 623
 - 11.4 Reactive Processing of Multicomponent Immiscible and Compatibilized Immiscible Polymer Systems, 632
 - 11.5 Polymer Compounding, 635
- 12 *Die Forming, 677***
- 12.1 Capillary Flow, 680
 - 12.2 Elastic Effects in Capillary Flows, 689
 - 12.3 Sheet Forming and Film Casting, 705
 - 12.4 Tube, Blown Film, and Parison Forming, 720
 - 12.5 Wire Coating, 727
 - 12.6 Profile Extrusion, 731
- 13 *Molding, 753***
- 13.1 Injection Molding, 753
 - 13.2 Reactive Injection Molding, 798
 - 13.3 Compression Molding, 811

14 *Stretch Shaping, 824*

- 14.1** Fiber Spinning, 824
- 14.2** Film Blowing, 836
- 14.3** Blow Molding, 841

15 *Calendering, 865*

- 15.1** The Calendering Process, 865
- 15.2** Mathematical Modeling of Calendering, 867
- 15.3** Analysis of Calendering Using FEM, 873

Appendix A *Rheological and Thermophysical Properties of Polymers, 887*

Appendix B *Conversion Tables to the International System of Units (SI), 914*

Appendix C *Notation, 918*

Author Index, 929

Subject Index, 944