Contents

1 Particle characterization by size, shape and surface for individual particles— N. G. STANLEY-WOOD 1

- 1.1 Scope 1
- 1.2 Characterization of individual particles 2
- 1.3 Averages 11
- 1.4 Shape 18

1.5 Application of shape factors for surface area evaluation35References39

2 Particle characterization by size, shape and surface for contacted particles— N.G. STANLEY-WOOD 43

- 2.1 Porosity, voidage and particle porosity 43
- 2.2 Nitrogen adsorption 52
- 2.3 Mercury penetration 95
- 2.4 Application of nitrogen isotherms Types II and IV and mercury intrusion to compacted solids 99 Pafarances 116

References 116

3 Mixing of powders—N. HARNBY 120

- 3.1 Powder mixing 120
- 3.2 The mixing process 121
- 3.3 Quantitative assessment of mixture quality 126 References 127

4 Mechanisms of size enlargement—P. J. LLOYD 128

- 4.1 Introduction 128
- 4.2 Basic mechanisms 128
 4.3 The granulation process 131
 Bibliography 135
 References 135
- 5 Flow and handling of solids; the design of solid handling plants—J. C. WILLIAMS 136
 - 5.1 Introduction 136
 - 5.2 Types of storage hopper 136
 - 5.3 Measurement of the failure properties of a particulate solid 138

199

142 5.4 Design of mass flow hoppers 5.5 Design of a plant for mass flow 145 References 147 6 Pharmaceutical granulation and compaction—B. HUNTER 148 Introduction 148 6.1 Theoretical considerations 149 6.2 6.3 Powder preconditioning 153 6.4 Compression scale-up 155 6.5 Formulation and process optimization 158 References 159 7 Mechanisms of compaction—J. J. BENBOW 161 Introduction and scope 161 7.1 165 Application of pressure and frictional effects 7.2 7.3 Particle rearrangement 167 7.4 Deformation without rearrangement 168 7.5 Strength-producing mechanisms 171 7.6 Load removal and stress relaxation 172 7.7 Material properties 173 7.8 Powder compaction equations 174 7.9 Tabletting defects 174 7.10 Conclusions 176 References 177 179 8 Fluidized bed granulation—A. W. NIENOW Basic fluidized bed concepts 179 8.1 Definitions and applications 180 8.2 181 8.3 Variations on the basic process: practical difficulties 8.4 Ouenching 181 8.5 Mass and moisture balance 182 8.6 Heat balance 182 183 8.7 Particle growth mechanisms: dynamic equilibrium 8.8 Growth models and rates 186 186 8.9 Batch versus continuous operation 8.10 Pilot plant testing 187 8.11 The use of inert 'nuclei' 187 References 188 9 Compact characterization-N. G. STANLEY-WOOD 189 9.1 Strength of materials: fundamentals 189 9.2 Soil mechanics stress-strain curves for granular materials 9.3 Volume reduction in unidimensional consolidation 205 9.4 Compaction of powders 213 References 225 10 Instrumentation of tablet machines-H. S. THACKER 227 10.1 Introduction 227 Instrumentation of single acting machines 227 10.2 230 10.3 Instrumentation of rotary tablet machines

x Contents

10.4Force measuring systems23110.5Uses of instrumentation235References240

11 Compaction of ceramics—H. M. MACLEOD 241

- 11.1 Introduction and scope 241
 - 11.2 Pressure transmission through powders 241
- 11.3 Pressure-volume relationships 253
- 11.4 Friction and lubrication 261
- 11.5 Process variables 265

References 274

12 Isostatic pressing and compacting techniques-D. E. LLOYD,

- I. K. BLOOR and R. D. BRETT 277
- 12.1 Introduction 277
- 12.2 Component shapes 279
- 12.3 Tooling 279
- 12.4 Isostatic pressing of a sphere 280
- 12.5 Tooling for rods and discs 281
- 12.6 Tooling for complex shapes 282
- 12.7 General aspects of tool design 283

References 287