Aitber Bizhanov · Valentina Chizhikova

Agglomeration in Metallurgy

Springer
Contents

1 Sinter Production .......................................................... 1
  1.1 General Information About the Sintering Process ............... 1
  1.2 Raw Materials of the Sintering Process .......................... 7
  1.3 Preparation of Charge Components for Sintering (Crushing,
      Dosing, Mixing, Pelletizing) ...................................... 13
    1.3.1 Dosing of the Components of the Sinter Charge ........... 14
    1.3.2 Pelletizing of the Sinter Charge ........................... 16
  1.4 Mass Exchange Processes in the Sintering Layer ................. 42
    1.4.1 Chemical Reactions with Participation of Solid Phases ... 43
    1.4.2 Processes in the Formation of the Liquid Phase During
          Melting ....................................................... 56
    1.4.3 Processes During Solidification (Crystallization)
          of the Melt ............................................... 57
  1.5 Heat Transfer in the Sintering Layer ............................ 58
    1.5.1 General Information on the Sintering Heat Exchange ..... 58
    1.5.2 Zonal Heat Balances of Sintered Layer .................... 61
    1.5.3 Mathematical Model of Heat Exchange
          During Sintering ........................................... 65
    1.5.4 Three-Dimensional Mathematical Model of the Sintering
          Process .................................................... 67
    1.5.5 Calculation of the Specific Yield of the Sintering Gas ... 71
    1.5.6 Vertical Sintering Speed .................................. 72
  1.6 The Gas Dynamics of the Sintering Process ....................... 73
    1.6.1 The Basic Equation of Dynamics of the Porous Layer ..... 73
    1.6.2 Gas-Dynamic Resistance Coefficients ....................... 74
    1.6.3 Porosity of the Sintering Layer .......................... 76
    1.6.4 Gas Dynamics of Sintering Technology ....................... 77
    1.6.5 Sinter Machine Performance ............................... 80
    1.6.6 Ways to Improve the Performance of Sintering
          Machines ..................................................... 81
1.7 Quality of the Sinter in Terms of Influence on the Performance of Blast Furnace Smelting ................................................................. 88
  1.7.1 Sinter Quality Indicators ................................................................. 88
  1.7.2 Influence of Sinter Quality on Gas-Dynamic Parameters of Blast Furnace Smelting ................................................................. 90
  1.7.3 Requirements for Sinter Quality ........................................................ 93
  1.7.4 Basic Solutions to Improve Quality of Sinter ..................................... 99
  1.7.5 Technology of Sintering Under Pressure .......................................... 116
1.8 Energy Efficiency of the Sintering Technology ...................................... 118
1.9 Environmental Aspects of Sinter Production (Best Available Technologies) ................................................................. 123
  1.9.1 Thermodynamic Modeling of Emissions in the Sintering Process ............ 124
  1.9.2 Characteristics of Emissions from Sinter Production .......................... 126
  1.9.3 Influence of Technological Factors on the Emission of Pollutants During Sintering ................................................................. 128
  1.9.4 Environmental Requirements as the Main Priority of Production Modernization ................................................................. 133
  1.9.5 Waste Gas Recirculation Concept .................................................. 148
  1.9.6 Recommendations on the Best Available Technologies (BAT) in Sintering ................................................................. 159
  1.9.7 Sinter Plant Without Chimney ....................................................... 161
References .................................................................................. 165

2 Pellet Production ........................................................................ 171
  2.1 General Information About Pellet Production ........................................ 171
    2.1.1 Technological Scheme of the Production of Pellets ............................ 171
    2.1.2 Formation of Raw Pellets ............................................................... 174
    2.1.3 Strengthening of Raw Pellets ......................................................... 176
  2.2 Charge Components for the Production of Pellets .................................... 179
  2.3 Formation of Raw Pellets ................................................................. 184
    2.3.1 Interaction Between Wetted Particles During the Formation of a Raw Pellet ................................................................. 184
    2.3.2 The Nature of the Action of Binding Additives in the Strengthening of Raw Pellets ................................................................. 187
    2.3.3 The Effectiveness of Various Strengthening Additives in Pelletizing ................................................................. 189
  2.4 Cold-Bonded Pellet Production .......................................................... 200
    2.4.1 General Information About Cold Agglomeration ................................ 200
    2.4.2 Strengthening Mechanism of Portland Cement Binders ....................... 201
    2.4.3 Cold Strengthening Under Normal Conditions .................................... 203
    2.4.4 Cold Agglomeration at Moderate Temperatures ................................... 205
2.4.5 Cold Agglomeration with Accelerated Strengthening ... 206
2.4.6 Advantages of Cold Agglomeration Method ... 208

2.5 Strengthening Pellets with Thermal Methods ... 208
2.5.1 Phenomenology of Mass Transfer Processes During Heat Treatment of Pellets ... 210
2.5.2 Simulation of Mass Transfer Processes During Heat Treatment of Pellets ... 212
2.5.3 Pellet Roasting as a Complicated Case of Sintering ... 226
2.5.4 The Pellet Macrostructure and Strength ... 247

2.6 Metallurgical Properties of Iron Ore Pellets ... 251
2.6.1 Pellet Quality Test Methods ... 251
2.6.2 Quality Requirements for Pellets ... 254
2.6.3 Basic Solutions for Improving the Quality of Pellets ... 258

2.7 Resource Saving in the Production of Pellets ... 268
2.7.1 Resource Consumption in the Production of Pellets ... 268
2.7.2 Energy Efficiency of Conveyor Machines as Units for Pellets Roasting ... 269
2.7.3 Best Available Technologies (BAT) in the Production of Pellets Aimed at Improving Energy Efficiency ... 272

2.8 Environmental Aspects of Pellet Production ... 274
2.8.1 General Characteristics of Emissions to the Environment in the Production of Pellets ... 274
2.8.2 Sources of Emissions from Technological Operations in the Production of Pellets ... 276
2.8.3 The Best Available Technology in the Production of Pellets ... 280

References ... 282

3 Briquetting ... 287
3.1 General Information on Briquetting of Natural and Anthropogenic Raw Materials ... 287

3.2 History of the Industrial Briquetting in Ferrous Metallurgy ... 291
3.2.1 Beginning of the Twentieth Century—The 20s of the Twentieth Century ... 297
3.2.2 30–50s of the Twentieth Century ... 304
3.2.3 60–70s of the Twentieth Century ... 307
3.2.4 The 80s—The End of the Twentieth Century ... 314
3.2.5 Twenty-First Century ... 321

3.3 Basic Materials for Briquetting ... 328
3.3.1 Mining and Beneficiation of Ores ... 328
3.3.2 Sinter and Pellet Production ... 330
3.3.3 Coke Production ... 330
3.3.4 Blast Furnace Production ... 331
3.3.5 Steelmaking ................................................. 331
3.3.6 Rolling Production ........................................... 332
3.3.7 Ferroalloy Production ....................................... 333
3.3.8 Direct Iron Production ...................................... 334

3.4 Basic Industrial Technologies of Briquetting in Ferrous Metallurgy ............................................. 334
3.4.1 Briquetting Using Roller Presses ................................ 334
3.4.2 Vibropressing for Briquetting ............................... 342
3.4.3 Stiff Vacuum Extrusion Briquetting Technology .......... 351

3.5 Requirements to Metallurgical Properties of Briquettes ............................................................... 370
3.5.1 Briquetting of Natural and Anthropogenic Materials in Blast Furnace (BF) Production ......................... 370
3.5.2 Briquetting of Natural and Anthropogenic Raw Materials for Ferroalloy Production ......................... 397
3.5.3 Briquetting in Direct Reduced Iron (DRI) Production .... 428

References ................................................................. 441

4 Best Available Technologies for Agglomeration of the Raw Materials for Blast Furnaces ............................... 449
4.1 Production of Sinter as a BAT ................................... 449
4.2 Production of Pellets as a BAT .................................. 451
4.3 Stiff Extrusion Briquetting as a BAT ............................ 452
4.4 Comparative Analysis of Technologies for Agglomeration of the Raw Materials for Blast Furnace ................. 453

References ................................................................. 454