THE GLOBAL MANUFACTURING REVOLUTION
Product-Process-Business Integration and Reconfigurable Systems

YORAM KOREN
Professor and Director, NSF-Sponsored Engineering Research Center for Reconfigurable Manufacturing Systems
The University of Michigan, Ann Arbor

RODNEY HILL
Illustration and Technical Cartooning
Contents

Preface xi
Acknowledgments xvii

1 Globalization and Manufacturing Paradigms 1
  1.1 The Importance of Manufacturing to Society 2
  1.2 The Basics of Manufacturing in Large Quantities 5
  1.3 The 1990s: A Decade of Intensified Globalization 9
  1.4 The Global Manufacturing Revolution 12
  1.5 The Manufacturing Paradigm Model 22
  1.6 Four Major Manufacturing Paradigms 24
  1.7 Paradigm Transitions Over Time
      Problems 32
      References 39

2 Product Invention Strategy 41
  2.1 Technology-Driven Products 42
  2.2 Customer-Driven Products 51
  2.3 Competition-Driven Products 55
  2.4 Classification of Product Inventions 57
  2.5 Product Development for Globalization 59
  2.6 The Product Development Process 62
CONTENTS

2.7 Head in the Sky, Feet on the Ground—Be a Dreamer on a Solid Foundation 68
Problems 69
References 71

3 Customized, Personalized and Reconfigurable Products 72
3.1 Introduction to Customization 72
3.2 Design for Mass Customization 75
3.3 Personalized Products 77
3.4 Product Modularity 88
3.5 Reconfigurable Products 96
3.6 Design of Customized and Reconfigurable Products 98
Problems 101
References 102

4 Mass Production and Lean Manufacturing 103
4.1 The Principles of Mass Production 104
4.2 Supply and Demand 108
4.3 The Mathematical Model of Mass Production 110
4.4 Lean Production—Goals and Benefits 114
4.5 The Principles of Lean Production 117
Problems 124
References 125

5 Analysis of Mass Customization 126
5.1 Introduction to Mass Customization 126
5.2 Business Strategies of Mass Customization 129
5.3 Manufacturing System Characteristics 134
5.4 Economics of Product Variation 136
5.5 Mathematical Analysis of Mass Customization 142
5.6 Summary 145
Problems 146

6 Traditional Manufacturing Systems 148
6.1 Manufacturing Systems 148
6.2 Production of Complex Products 150
6.3 The State of Art at the End of the Twentieth Century 154
6.4 Assembly Systems 167
CONTENTS ix

6.5 Industry Experience with FMS—A Survey 170
Problems 173
References 174

7 Economics of System Design 175
7.1 Life-Cycle Economics 176
7.2 Capacity Planning Strategies 178
7.3 Economics of System Configurations 186
7.4 The Economics of Buffers 188
7.5 Batch Production 192
7.6 Optimal Cutting Speeds 199
Problems 201
References 203

8 Reconfigurable Machines 205
8.1 The Rationale for Reconfigurable Machines 206
8.2 Characteristics and Principles of Reconfigurable Machines 210
8.3 Reconfigurable Machine Tools 211
8.4 Reconfigurable Fixtures 218
8.5 Reconfigurable Inspection Machines 220
8.6 Open-Architecture Controllers 224
Problems 225
References 226

9 Reconfigurable Manufacturing Systems 227
9.1 The Challenges of Globalization 227
9.2 RMS—A New Class of Systems 232
9.3 Characteristics and Principles of Reconfiguration 235
9.4 Integrated RMS Configurations 240
9.5 System Rapid Ramp-Up 243
9.6 Hexagonal RMS Configurations 246
Problems 250
References 252

10 System Configuration Analysis 253
10.1 Classification of Configurations 253
10.2 Comparing RMS with Cell Configurations 257
10.3 Calculating the Number of RMS Configurations 260
10.4 Example of System Design 261
10.5 Impact of Configuration on Performance 266
    Problems 278
    References 280

11 Business Models for Global Manufacturing Enterprises 281
  11.1 Examples of Business Models 281
  11.2 Business Model of Manufacturing Companies 285
  11.3 Competitive Advantage 289
  11.4 Strategic Resources 293
  11.5 Supply Chains 297
  11.6 Responsive Business Models for Global Opportunities 304
  11.7 Product Life cycle Business Model 307
    Problems 309
    Case Study I—The Rise and Fail of FriendlyRobotics 310
    Case Study II—He Bet on Botox and Won 312
    References 313

12 IT-Based Enterprise Organizational Structure 315
  12.1 Twentieth-Century Organizational Structure 316
  12.2 Twenty-First Century IT-Based Organizational Structure 318
  12.3 Information Transfer in Manufacturing Systems 323
  12.4 IT-Based Maintenance of Large Systems 327
    Problems 330
    References 330

13 Enterprise Globalization Strategies 331
  13.1 Why Enterprises Become Global 332
  13.2 Countries of Potential New Markets 336
  13.3 Product Design for Globalization 338
  13.4 Location of Manufacturing Plants 340
  13.5 Global Business Strategies 343
  13.6 Global Strategic Alliances 349
    Problems 357
    References 358
14 The Twenty-first Century Global Manufacturing Enterprise 360
14.1 P—Productivity 361
14.2 R—Responsiveness and Reconfiguration 363
14.3 I—Integration of Product, Process, and Business 364
14.4 D—Design for the Global Manufacturing Paradigm 368
14.5 E—Empowerment of the Workforce 369
14.6 The Dilemma of Globalization 370
14.7 Where are Manufacturing Enterprises Headed? 375
References 380

Appendices

Appendix A: Computer Controlled Milling Machine in 1973 381
Appendix B: Three Types of Manufacturing Systems 383
Appendix C: Business Cycles 384
Appendix D: Term Project: Project Description and Requirements 386

Author Biography 391

Author Index 393

Subject Index 395