Automation, Production Systems, and Computer-Integrated Manufacturing

Third Edition

Mikell P. Groover
Contents

Chapter 1  INTRODUCTION  
1.1 Production Systems  19  
1.2 Automation in Production Systems  25  
1.3 Manual Labor in Production Systems  29  
1.4 Automation Principles and Strategies  31  
1.5 Organization of this Book  36  

PART I:  OVERVIEW OF MANUFACTURING  39  

Chapter 2  MANUFACTURING OPERATIONS  39  
2.1 Manufacturing Industries and Products  43  
2.2 Manufacturing Operations  46  
2.3 Production Facilities  50  
2.4 Product/Production Relationships  55  
2.5 Lean Production  60  

Chapter 3  MANUFACTURING MODELS AND METRICS  64  
3.1 Mathematical Models of Production Performance  65  
3.2 Manufacturing Costs  73  
APPENDIX  Averaging Procedures for Production Models  82  

PART II:  AUTOMATION AND CONTROL TECHNOLOGIES  85  

Chapter 4  INTRODUCTION TO AUTOMATION  85  
4.1 Basic Elements of an Automated System  87  
4.2 Advanced Automation Functions  95  
4.3 Levels of Automation  100  

Chapter 5  INDUSTRIAL CONTROL SYSTEMS  104  
5.1 Process Industries Versus Discrete Manufacturing Industries  105  
5.2 Continuous Versus Discrete Control  107  
5.3 Computer Process Control  113  

5
Chapter 6  HARDWARE COMPONENTS FOR AUTOMATION AND PROCESS CONTROL  130
  6.1 Sensors  131
  6.2 Actuators  135
  6.3 Analog-to-Digital Converters  144
  6.4 Digital-to-Analog Converters  147
  6.5 Input/Output Devices for Discrete Data  150

Chapter 7  NUMERICAL CONTROL  155
  7.1 Fundamentals of NC Technology  158
  7.2 Computer Numerical Control  164
  7.3 Distributed Numerical Control  169
  7.4 Applications of NC  172
  7.5 Engineering Analysis of NC Positioning Systems  179
  7.6 NC Part Programming  187
  Appendix A 7: Coding for Manual Part Programming  205
  Appendix B 7: Part Programming with Apt  213

Chapter 8  INDUSTRIAL ROBOTICS  229
  8.1 Robot Anatomy and Related Attributes  231
  8.2 Robot Control Systems  237
  8.3 End Effectors  239
  8.4 Sensors in Robotics  240
  8.5 Industrial Robot Applications  241
  8.6 Robot Programming  249
  8.7 Robot Accuracy and Repeatability  257

Chapter 9  DISCRETE CONTROL USING PROGRAMMABLE LOGIC CONTROLLERS AND PERSONAL COMPUTERS  266
  9.1 Discrete Process Control  266
  9.2 Ladder Logic Diagrams  274
  9.3 Programmable Logic Controllers  278
  9.4 Personal Computers Using Soft Logic  285

PART III:  MATERIAL HANDLING AND IDENTIFICATION TECHNOLOGIES  289

Chapter 10  MATERIAL TRANSPORT SYSTEMS  289
  10.1 Introduction to Material Handling  290
  10.2 Material Transport Equipment  295
  10.3 Analysis of Material Transport Systems  312

Chapter 11  STORAGE SYSTEMS  329
  11.1 Storage System Performance and Location Strategies  330
  11.2 Conventional Storage Methods and Equipment  334
Contents
11.3 Automated Storage Systems 337
11.4 Engineering Analysis of Storage Systems 345

Chapter 12 AUTOMATIC IDENTIFICATION AND DATA CAPTURE 358
12.1 Overview of Automatic Identification Methods 359
12.2 Bar Code Technology 362
12.3 Radio Frequency Identification 370
12.4 Other AIDC Technologies 372

PART IV: MANUFACTURING SYSTEMS 375

Chapter 13 INTRODUCTION TO MANUFACTURING SYSTEMS 375
13.1 Components of a Manufacturing System 377
13.2 A Classification Scheme for Manufacturing Systems 382
13.3 Overview of the Classification Scheme 389

Chapter 14 SINGLE-STATION MANUFACTURING CELLS 394
14.1 Single-Station Manned Cells 395
14.2 Single-Station Automated Cells 396
14.3 Applications of Single-Station Cells 401
14.4 Analysis of Single-Station Systems 406

Chapter 15 MANUAL ASSEMBLY LINES 417
15.1 Fundamentals of Manual Assembly Lines 419
15.2 Analysis of Single Model Assembly Lines 426
15.3 Line Balancing Algorithms 433
15.4 Mixed Model Assembly Lines 438
15.5 Workstation Considerations 450
15.6 Other Considerations in Assembly Line Design 451
15.7 Alternative Assembly Systems 454

Chapter 16 AUTOMATED PRODUCTION LINES 464
16.1 Fundamentals of Automated Production Lines 465
16.2 Applications of Automated Production Lines 474
16.3 Analysis of Transfer Lines 478

Chapter 17 AUTOMATED ASSEMBLY SYSTEMS 497
17.1 Fundamentals of Automated Assembly Systems 498
17.2 Quantitative Analysis of Assembly Systems 504

Chapter 18 CELLULAR MANUFACTURING 523
18.1 Part Families 525
18.2 Parts Classification and Coding 528
18.3 Production Flow Analysis 532
18.4 Cellular Manufacturing  534  
18.5 Applications of Group Technology  539  
18.6 Quantitative Analysis in Cellular Manufacturing  541

Chapter 19  FLEXIBLE MANUFACTURING SYSTEMS  554  
19.1 What is a Flexible Manufacturing System?  556  
19.2 FMS Components  561  
19.3 FMS Applications and Benefits  571  
19.4 FMS Planning and Implementation Issues  574  
19.5 Quantitative Analysis of Flexible Manufacturing Systems  576

PART V:  QUALITY CONTROL IN MANUFACTURING SYSTEMS  601

Chapter 20  QUALITY PROGRAMS FOR MANUFACTURING  601  
20.1 Quality in Design and Manufacturing  602  
20.2 Traditional and Modern Quality Control  603  
20.3 Process Variability and Process Capability  606  
20.4 Statistical Process Control  610  
20.5 Six Sigma  621  
20.6 The Six Sigma DMAIC Procedure  624  
20.7 Taguchi Methods in Quality Engineering  631  
20.8 ISO 9000  636

Chapter 21  INSPECTION PRINCIPLES AND PRACTICES  645  
21.1 Inspection Fundamentals  646  
21.2 Sampling vs. 100% Inspection  651  
21.3 Automated Inspection  655  
21.4 When and Where to Inspect  657  
21.5 Quantitative Analysis of Inspection  661

Chapter 22  INSPECTION TECHNOLOGIES  674  
22.1 Inspection Metrology  675  
22.2 Contact vs. Noncontact Inspection Techniques  679  
22.3 Conventional Measuring and Gaging Techniques  680  
22.4 Coordinate Measuring Machines  681  
22.5 Surface Measurement  695  
22.6 Machine Vision  698  
22.7 Other Optical Inspection Methods  704  
22.8 Noncontact Nonoptical Inspection Techniques  707

PART VI:  MANUFACTURING SUPPORT SYSTEMS  713

Chapter 23  PRODUCT DESIGN AND CAD/CAM IN THE PRODUCTION SYSTEM  713  
23.1 Product Design and CAD  715  
23.2 CAD System Hardware  721
23.3 CAM, CAD/CAM, and CIM 724
23.4 Quality Function Deployment 728

Chapter 24  PROCESS PLANNING AND CONCURRENT ENGINEERING 735
24.1 Process Planning 736
24.2 Computer-Aided Process Planning 742
24.3 Concurrent Engineering and Design for Manufacturing 744
24.4 Advanced Manufacturing Planning 748

Chapter 25  PRODUCTION PLANNING AND CONTROL SYSTEMS 753
25.1 Aggregate Production Planning and the Master Production Schedule 756
25.2 Material Requirements Planning 757
25.3 Capacity Planning 763
25.4 Shop Floor Control 765
25.5 Inventory Control 771
25.6 Extensions of MRP 778

Chapter 26  JUST-IN-TIME AND LEAN PRODUCTION 785
26.1 Lean Production and Waste in Manufacturing 786
26.2 Just-in-Time Production Systems 790
26.3 Autonomation 797
26.4 Worker Involvement 801

Index 812
Automation will allow the player to become an armchair CEO - to build their own car company from the ground up. Create and run anything from a boutique supercar manufacturer to a mass-market multinational mogul. With powerful tools like the Engine Designer, the player can create cars and their engines in mind-boggling detail.