

## Contents

**Preface** *xi*

### **Part I Production Control in General** 1

#### **1 Production Control – A Logistic Control Function** 3

- 1.1 Logistics 3
- 1.2 Logistics Planning and Control 6
- 1.3 Logistic Concepts in Production 7
- 1.4 Terminology for Production Control 10
  - 1.4.1 Concepts Used in Production Control 10
  - 1.4.2 Complexity, Uncertainty, and Flexibility 12
- References 13

#### **2 Horizontal and Vertical Decomposition** 15

- 2.1 Horizontal Decomposition 16
- 2.2 Vertical Decomposition 22
- 2.3 Types of Release Triggers 25
  - 2.3.1 Just-in-Time Versus Just-in-Case 25
  - 2.3.2 Push Versus Pull in Logistics 28
- 2.4 An Example of Decomposition 30
- References 32

#### **3 Planning and Control in Production Units** 33

- 3.1 Production Control in General 33
- 3.2 Basic Forms of Production 35
  - 3.2.1 Process-Wise Production 35
  - 3.2.2 Mass Assembly/Flow Production 36
  - 3.2.3 (Repetitive) Small Series Production (Also Called Job-Shop) 36
  - 3.2.4 (Repetitive) Project-Wise Production 37
  - 3.2.5 Throughput Time Production Units 37
- References 39

**4 Framework for Logistic Planning and Control in Production Systems 41**

- 4.1 General Framework 41
- 4.2 Position of this Book 45
- References 46

**Part II Planning and Control of Decoupling Points 47****5 Decoupling Point Control 49**

- 5.1 Decoupling Point Control – An Introduction 49
- 5.2 Performance Measures for Decoupling Point Control 53
- 5.3 Demand and Forecasting 58
  - 5.3.1 Demand Pattern 59
  - 5.3.2 Forecasting Methods 60
    - 5.3.2.1 Time Series-Related Forecasting for Stationary Demand 63
    - 5.3.2.2 Time Series-Related Forecasting for Demand with a Trend 67
- 5.4 Order Size 71
  - 5.4.1 Optimal Batch Size in Case of Fixed Order Size 72
  - 5.4.2 Relaxation of Assumptions 75
    - 5.4.2.1 Known or Predicted Demand Variation 75
    - 5.4.2.2 Quantity Discount 78
    - 5.4.2.3 Minimum Order Quantity 79
    - 5.4.2.4 No Variable Order-Related Costs 79
    - 5.4.2.5 Interdependencies of Order Sizes – Not BOM Related 80
    - 5.4.2.6 Interdependencies of Order Sizes – BOM Related 81
  - 5.4.3 Single Period Problem 83
- Appendix 5.A The Wagner-Whitin Algorithm 84
- Appendix 5.B Example Impact Advanced and Optimal Approach for Determining Batch Sizes 87
- Appendix 5.C Newsvendor Problem 87
- References 90

**6 Reorder Point Decoupling Point Control Systems 93**

- 6.1 General Discussion of Reorder Point Systems 93
- 6.2 When to Order? 96
  - 6.2.1 Continuous Review 97
  - 6.2.2 Periodic Review 99
  - 6.2.3 The Reorder Level – Continuous Review 100
  - 6.2.4 The Reorder Level – Periodic Review 107
- 6.3 How Much to Order? 109
  - 6.3.1 Fixed Amount 109
  - 6.3.2 Maximum Level 109

6.3.2.1	( $s, S$ )	109
6.3.2.2	( $R, s, S$ )	110
Appendix 6.A	Table of the One-Sided Standard Normal Distribution	110
Appendix 6.B	Table Standard Normal Loss Function	112
Appendix 6.C	Reorder Level Determination in Case of a General Distribution	113
6.C.1	Discrete Demand	113
6.C.2	Continuous Demand	115
6.C.3	Determining the Reorder Level	116
	References	116
<b>7</b>	<b>MRP Decoupling Point Control Systems</b>	<b>117</b>
7.1	General Discussion of MRP Systems	117
7.1.1	Material Requirements Planning (MRP-I)	117
7.1.2	Manufacturing Resources Planning (MRP-II)	119
7.1.2.1	Engine	119
7.1.2.2	Front End	120
7.1.2.3	Back End	121
7.2	When to Order	122
7.3	How Much to Order?	125
7.4	Discussion on MRP-Related Issues	128
7.4.1	Dealing with Uncertainty	128
7.4.2	Bill-of-Materials Versus Bill-of-Distribution	130
Appendix 7.A	MRP Formulas	132
7.A.1	Rescheduling Assumption	132
	References	133
<b>8</b>	<b>Systems Using Echelon Stock (ESC, LRP)</b>	<b>135</b>
8.1	General Discussion of Systems Using Global Norms	135
8.1.1	Discussion on ROP and MRP	136
8.1.2	Echelon Stock Control Systems	137
8.1.3	Line Requirements Planning	138
8.2	When and How Much to Order?	139
8.2.1	When and How Much to Order in Echelon Stock Systems?	139
8.2.2	When and How Much to Order in Line Requirements Planning Systems?	139
8.3	Discussion on Echelon Stock Systems	142
	References	143
<b>9</b>	<b>Choosing an Appropriate DPC System</b>	<b>145</b>
9.1	General Considerations	145
9.2	Advantages/Disadvantages of the Different DPC Systems	146
9.2.1	Bullwhip Effect	147
9.3	Which Decoupling Point Control System to Use?	150
	References	157

**Part III Production Unit Control 159**

- 10 General Discussion of Production Control Decisions 163**
  - 10.1 Priority Control 164
  - 10.2 Capacity Allocation 165
  - 10.3 Work Order Release/Work Order Detail Planning (Scheduling) 166
  - References 168
  
- 11 Production Control for Deterministic, Static Production Situations (Scheduling) 169**
  - 11.1 Sequencing Orders Without Delivery Date (Throughput Time Oriented) 170
    - 11.1.1 Work Orders with One Operation and Work Centers with One Machine 171
      - 11.1.1.1 Relation Between Work-in-Process and Throughput Time 171
      - 11.1.1.2 Minimization of the Average Throughput Time 171
      - 11.1.1.3 Minimization of Weighted Average Throughput Time 171
    - 11.1.2 Work Orders with One Operation and Work Centers with Parallel, Identical Machines 172
      - 11.1.2.1 Minimizing the Makespan 172
      - 11.1.2.2 Minimizing the Average Throughput Time 172
    - 11.1.3 Work Orders with Multiple Operations and Work Centers with One Machine 173
      - 11.1.3.1 Minimizing the Makespan for a Flow Shop with Two Operations 174
      - 11.1.3.2 Minimizing the Makespan for a Flow Shop with More Than Two Operations 176
  - 11.2 Sequencing Orders with a Delivery Date (Reliability Oriented) 178
    - 11.2.1 Minimizing the Average Lateness 179
    - 11.2.2 Minimizing the Maximum Tardiness 179
    - 11.2.3 Minimizing the Number of Tardy Orders ( $N_T$ ) 179
    - 11.2.4 Minimizing the Average Tardiness 181
  - 11.3 Relaxing Assumptions 183
    - 11.3.1 Orders with Sequence-Dependent Set-Up Times 183
    - 11.3.2 Sequencing Orders with Different Routings 184
    - References 185
  
- 12 Flow Process Production 187**
  - 12.1 General Description 187
  - 12.2 Main Control Attention Points of Flow Process Production 189
    - 12.2.1 General 189
      - 12.2.2 Cycle Time Determination 190
        - 12.2.2.1 A Stable Level of Demand 191
        - 12.2.2.2 Variable Demand 194
        - 12.2.2.3 Different Cycles on One Production Line 196

- 12.3 Production Control Decisions for Flow Process Production in MTS Situations 196
  - 12.3.1 Sequencing 196
  - 12.3.2 Capacity Allocation 197
  - 12.3.3 Work Order Release 197
- 12.4 Production Control Decisions for Flow Process Production in MTO Situations 197
  - 12.4.1 Sequencing and Work Order Release 198
  - 12.4.2 Capacity Allocation 200
- 12.5 Application 200
  - References 204
  
- 13 Mass Assembly Production 205**
  - 13.1 General Description 205
  - 13.2 Main Control Attention Points of Mass Assembly Production 207
    - 13.2.1 Pure Flow Production 208
      - 13.2.2 Variants of Pure Flow Production 209
        - 13.2.2.1 Different Processing Times 209
        - 13.2.2.2 Variable Processing Times 211
        - 13.2.2.3 Different Products (Needing Different Materials and/or Resources) 211
          - 13.2.2.4 Disturbances at the Work Centers 212
          - 13.2.2.5 No Availability of Efficient Technology 212
          - 13.2.2.6 A Variety of Routings (Some Operations Are Skipped) 213
      - 13.2.3 Quantitative Models for Analyzing the Effect of Buffers 214
        - 13.2.3.1 Two Stations Without Failures 215
        - 13.2.3.2 More Than Two Stations Without Failures 216
        - 13.2.3.3 Two Stations with (Time-Dependent) Failures 216
        - 13.2.3.4 More Than Two Stations with (Time-Dependent) Failures 218
    - 13.2.4 Cross Training 219
  - 13.3 Production Control Decisions for Mass Assembly Production 220
    - 13.3.1 Sequencing 220
    - 13.3.2 Capacity Allocation 220
    - 13.3.3 Work Order Release 221
  - 13.4 Application 222
    - References 224
  
- 14 Small Series Production 227**
  - 14.1 General Description 227
  - 14.2 Main Control Attention Points of Small Series Production 229
    - 14.2.1 Fundamental Results from Queueing Theory 230
      - 14.2.2 Throughput Time-Related Aspects 236
        - 14.2.2.1 Production Layout 236
        - 14.2.2.2 Measures Based Upon Insights from Queueing Theory 236
        - 14.2.2.3 Customer Differentiation 238
      - 14.2.3 Lead Time Reliability Related Aspects 239

14.2.3.1	Due Date Determination Rules	240
14.2.3.2	The Effect of the Value of the Slack on the Delivery Reliability	246
14.2.3.3	Internal Versus External Due Date	248
14.3	Production Control Decisions for Small Series Production	248
14.3.1	Throughput Time	249
14.3.1.1	Sequencing	249
14.3.1.2	Capacity Allocation	252
14.3.1.3	Work Order Release/Work Order Detail Planning	256
14.3.2	Lead Time Reliability	259
14.3.2.1	Sequencing	259
14.3.2.2	Capacity Allocation	262
14.3.2.3	Work Order Release	263
14.4	Application	263
Appendix 14.A	Short-Term Capacity Adjustment	265
Appendix 14.B	Flexible Batching	267
Appendix 14.C	The Effect of Workload Control in Case There Is a Relationship Between Productivity and Workload	268
	References	271
<b>15</b>	<b>(Repetitive) Project-Based Production</b>	<b>273</b>
15.1	General Description	273
15.2	Main Control Attention Points of Project-Based Production	275
15.2.1	Construction of a Network	276
15.2.1.1	Terminology	276
15.2.1.2	Duration of the Activities	279
15.2.1.3	Critical Path and Project Duration in Case Activity Times Are Deterministic	279
15.2.1.4	Slack	281
15.2.1.5	Uncertainty in Project Duration Due to Stochastic Activity Times	282
15.2.1.6	Realistic Estimates of the Activity Times	284
15.2.1.7	Activity on Node Networks	284
15.3	Production Control Decisions for Project-Based Production	286
15.3.1	Sequencing	286
15.3.2	Capacity Allocation (and Scheduling)	286
15.3.2.1	Resource Loading	286
15.3.2.2	Resource Leveling	286
15.3.2.3	(Constrained Resource) Scheduling	287
15.3.3	Work Order Release/Project Scheduling	289
15.3.3.1	Work Order Scheduling	289
15.3.3.2	Work Order Release	290
15.4	Application	291
	References	295
	<b>Index</b>	<b>297</b>