

Contents

1	Introduction	1
1.1	Logistic Key Performance Indicators for Manufacturers.....	1
1.2	Dilemma of Operations Planning.....	4
1.3	Model Based Problem Solving Process	6
1.4	Objectives of Production Logistics	9
1.5	Logistic Operating Curves – an Explanatory Model for Production Logistics.....	11
1.6	Goals and Structure of the Book	13
2	Basic Principles of Modeling Logistic Operating Curves	17
2.1	Funnel Model as a Universal Model for Describing Production Processes.....	17
2.1.1	Work Content and Operation Times.....	17
2.1.2	Throughput Time.....	21
2.1.3	Lateness	23
2.2	Logistic Objectives in a Throughput Diagram.....	24
2.2.1	Output Rate and Utilization.....	25
2.2.2	Work in Process (WIP).....	27
2.2.3	Weighted Throughput Time and Range	28
2.3	Little’s Law	31
2.4	Logistic Operating Curves for Production Processes.....	35
3	Traditional Models of Production Logistics	39
3.1	Queuing Models.....	40
3.1.1	M/G/1 Model	42
3.1.2	Using Queuing Theory to Determine Logistic Operating Curves.....	45
3.1.3	A Critical Review of the Queuing Theory Approach.....	46

3.2	Simulation	48
3.2.1	PROSIM III Simulation System	49
3.2.2	Simulation as an Aid in Determining Logistic Operating Curves.....	50
3.2.3	A Critical Review of Simulation	52
4	Deriving the Logistic Operating Curves Theory	59
4.1	Ideal Logistic Operating Curves	60
4.1.1	Ideal Minimum WIP Level.....	60
4.1.2	Maximum Possible Output Rate.....	63
4.1.3	Constructing Ideal Logistic Operating Curves for the Output Rate and Time Parameters	64
4.2	Deriving an Approximation Equation for Calculating an Output Rate Operating Curve.....	66
4.2.1	C_{norm} Function as the Basic Function for a Calculated Output Rate Operating Curve.....	68
4.2.2	Transforming the C_{norm} Function	70
4.2.3	Parametrizing the Logistic Operating Curves Equation	72
4.3	Calculating Output Rate Operating Curves.....	77
4.4	Calculating Operating Curves for the Time Parameters	80
4.5	Normalized Logistic Operating Curves.....	85
4.6	Logistic Operating Curves Theory and Little's Law – a Model Synthesis	88
4.7	Verifying the Logistic Operating Curves Theory	91
4.7.1	Simulation Based Model Validation.....	91
4.7.2	Validating the Model Based on Field Analyses.....	96
4.7.2.1	Underload Operating Zone	97
4.7.2.2	Transitional Operating Zone	99
4.7.2.3	Overload Operating Zone	100
4.8	Extending the Logistic Operating Curves Theory.....	101
4.8.1	Hierarchically Aggregating Logistic Operating Curves.....	101
4.8.2	Manufacturing System Operating Curves	104
4.8.3	Workstations with Common WIP Buffers.....	110
4.8.4	Considering Overlapping Production	111
4.9	Prerequisites for Applying Calculated Logistic Operating Curves	113
4.10	Schedule Reliability Operating Curves	115
4.10.1	Mean Relative Lateness Operating Curve	115
4.10.2	Deriving an Operating Curve for Describing the Schedule Reliability.....	118
4.11	Summarizing the Derivation of the Logistic Operating Curves Theory.....	123

- 5 Basic Laws of Production Logistics** 127
 - 5.1 First Basic Law of Production Logistics 127
 - 5.2 Second Basic Law of Production Logistics..... 128
 - 5.3 Third Basic Law of Production Logistics 129
 - 5.4 Fourth Basic Law of Production Logistics..... 130
 - 5.5 Fifth Basic Law of Production Logistics..... 131
 - 5.6 Sixth Basic Law of Production Logistics 132
 - 5.7 Seventh Basic Law of Production Logistics 133
 - 5.8 Eighth Basic Law of Production Logistics..... 134
 - 5.9 Ninth Basic Law of Production Logistics 135

- 6 Applications of the Logistic Operating Curves Theory** 137
 - 6.1 Developing and Analyzing Calculated Logistic Operating Curves 137
 - 6.1.1 Calculating the Logistic Operating Curves..... 138
 - 6.1.2 Applying Logistic Operating Curves for Analyzing a Simulated Manufacturing Process 140
 - 6.2 Evaluating Alternative Methods for Developing Potential for Logistic Improvement 143
 - 6.2.1 Varying the Work Content Structure..... 145
 - 6.2.2 Varying the Capacity Structure 147
 - 6.3 Calculating Logistic Operating Curves with Missing or Incorrect Operating Data 148
 - 6.3.1 Incorrect Work Content and Transport Time Data..... 148
 - 6.3.1.1 Case 1: WC_m incorrect; WC_v correct; TTR_m correct..... 149
 - 6.3.1.2 Case 2: WC_m correct; WC_v incorrect; TTR_m correct..... 150
 - 6.3.1.3 Case 3: WC_m correct; WC_v correct; TTR_m incorrect..... 151
 - 6.3.2 Missing or Incorrect Data for the Maximal Possible Output Rate..... 152
 - 6.3.3 An Incorrect Stretch Factor α_1 155
 - 6.4 Impact of an Unsteady Process State on Developing and Interpreting Logistic Operating Curves..... 157
 - 6.4.1 Time Related Changes to the Work Content Structure..... 157
 - 6.4.2 Time Related Changes in the WIP Level..... 159
 - 6.5 Possibilities for Employing Logistic Operating Curves in Designing and Controlling Production Processes 163
 - 6.5.1 Logistic Positioning 165
 - 6.5.2 Implementing Logistic Operating Curves in Production Control 169

- 6.5.3 Logistic Oriented Design and Parameterization of Planning and Control Strategies 171
 - 6.5.3.1 Throughput Oriented Lot Sizing 172
 - 6.5.3.2 Flow Rate Oriented Scheduling 173
 - 6.5.3.3 Integrating the Logistic Operating Curves Theory in Load Oriented Order Release 175
- 6.5.4 Logistic Oriented Production Design 177
 - 6.5.4.1 Employing the Logistic Operating Curves in Factory Planning 177
 - 6.5.4.2 Logistic Oriented Evaluation of Supply Chains 178
- 7 Practical Applications of Bottleneck Oriented Logistic Analyses 181**
 - 7.1 Conducting a Bottleneck Oriented Logistic Analysis 181
 - 7.1.1 Determining Key Figures 182
 - 7.1.1.1 Key Work Content Figures 182
 - 7.1.1.2 Key Throughput Figures 183
 - 7.1.1.3 Key Output Rate Figures 183
 - 7.1.1.4 Key Work in Process Figures 183
 - 7.1.1.5 Key Lateness Figures 183
 - 7.1.2 Determining Logistically Relevant Workstations 184
 - 7.1.2.1 Goal: Reducing the Order’s Mean Throughput Time 185
 - 7.1.2.2 Goal: Increasing Scheduling Adherence 185
 - 7.1.2.3 Goal: Reducing Loss of Utilization 186
 - 7.1.2.4 Goal: Reducing the WIP 186
 - 7.1.3 Determining Measures 187
 - 7.2 Bottleneck Oriented Logistic Analysis in a Circuit Board Manufacturer 190
 - 7.2.1 Analysis’ Objectives 190
 - 7.2.2 Data Compilation 191
 - 7.2.3 Order Throughput Analysis 191
 - 7.2.4 Workstation Analysis 196
 - 7.2.4.1 Analysis of Key Performance Figures 196
 - 7.2.4.2 Identifying Throughput Time Determining Workstations 198
 - 7.2.4.3 Detailed Analysis of Chosen Work Stations 199
 - 7.2.4.4 The Resist Coating Workstation 199
 - 7.2.4.5 The Hot Air Leveling Workstation 203
 - 7.2.4.6 Drilling Workstation 206
 - 7.2.5 Quantifying the Potential for Logistic Improvement 207
 - 7.2.6 Experiences in Applying Bottleneck Oriented Logistic Analyses 210

- 7.3 Applying the Bottleneck Oriented Logistic Analysis in a Circuit Board Insertion Department..... 211
 - 7.3.1 Determining Throughput Time Relevant Workstations 212
 - 7.3.2 Estimating Existing Potential for Logistic Improvement..... 213
 - 7.3.3 Deriving and Implementing Workstation Specific Measures..... 214
 - 7.3.3.1 Manual Insertion Workstation 214
 - 7.3.3.2 SMD Workstation 216
 - 7.3.3.3 HF Testing Workstation..... 218
 - 7.3.4 Summary of Application Experiences 220
- 7.4 Strategies for Implementing the Bottleneck Oriented Logistic Analysis..... 221

- 8 Applying the Logistic Operating Curves Theory to Storage Processes 223**
 - 8.1 Throughput Diagram as a Model for the Logistic Procurement Process Chain..... 224
 - 8.2 Storage Operating Curves 226
 - 8.3 Determining Storage Operating Curves Using Simulations..... 229
 - 8.4 Determining Storage Operating Curves Using an Approximation Equation..... 230
 - 8.4.1 Ideal Storage Operating Curve 231
 - 8.4.2 Integrating Plan Deviations 233
 - 8.4.3 Parametrizing the Approximation Equation 239
 - 8.4.4 Verifying Storage Operating Curves Using Simulations..... 241
 - 8.5 Possible Applications 244
 - 8.6 Fields and Limits of Application..... 245
 - 8.7 Examples of Applying Storage Operating Curves in order to Evaluate Suppliers..... 248

- 9 Applying the Logistic Operating Curves Theory to Supply Chains 253**
 - 9.1 Supply Chain Objectives..... 253
 - 9.1.1 Weighted Service Level..... 254
 - 9.1.2 An Approximation Equation for a Service Level Operating Curve 255
 - 9.2 Correlations between the Supply Chain’s Logistic Parameters 257
 - 9.3 Example of a Supply Chain Logistic Analysis..... 259
 - 9.3.1 Logistic Oriented Storage Analysis of the Manufacturer’s Finished Goods Store..... 260
 - 9.3.1.1 Calculating Potential Based on Logistic Operating Curves 260
 - 9.3.1.2 Deriving Measures 264

- 9.3.2 Conducting a Bottleneck Oriented Logistic Analysis
of the Manufacturer’s Production 265
- 9.3.3 Logistic Oriented Storage Analysis
of the Manufacturer’s Input Stores 268
- 9.3.4 Bottleneck Oriented Logistic Analysis
of the Supplier’s Production 268
- 9.3.5 Supply Chain’s Total Potential 269
- 9.4 Summary of Applying Operating Curves
to the Supply Chain 271

- 10 Conclusions 273**

- Appendix: Software Documentation 277**

- Bibliographic References 301**

- Index 309**