
Contents

<i>Figures</i>	<i>xi</i>
<i>Tables</i>	<i>xvii</i>
<i>A guided tour</i>	<i>1</i>
<i>PART A Analysis techniques</i>	<i>3</i>
CHAPTER 1 <i>Key issues of assembly operations</i>	<i>5</i>
1.1. What is assembly?	<i>6</i>
<i>Scope of this book</i>	<i>6</i>
<i>Assembly = assembly and test.</i>	<i>6</i>
1.2. Factors in assembly performance	<i>8</i>
<i>Part supply</i>	<i>8</i>
<i>Assembly work design</i>	<i>9</i>
<i>Examples</i>	<i>10</i>
1.3. Waste in assembly work	<i>11</i>
<i>Recognizing waste in assembly work</i>	<i>11</i>
<i>Eliminating assembly waste</i>	<i>13</i>

CHAPTER 2	<i>Product quantity analysis</i>	15
2.1.	Purpose	16
2.2.	The concept of P-Q analysis	17
	<i>Difference with Group Technology</i>	18
2.3.	Bill of materials analysis for mixed-flow lines	20
2.4.	Order profiling for custom assembly	25
CHAPTER 3	<i>Trend and seasonality analysis</i>	27
3.1.	Purpose	28
3.2.	Responding to demand variability over time	29
3.3.	Data aggregation	30
3.4.	Making the sales data talk	32
3.5.	Demand variability upstream in the supply chain	37
3.6.	Conclusions	39
CHAPTER 4	<i>Takt time and capacity</i>	41
4.1.	What is the takt time?	42
	<i>Definition of the term</i>	42
	<i>Design takt time and operation takt time</i>	44
4.2.	Common mistakes about takt time	45
4.3.	Why takt time matters	46
4.4.	Global and local performance	48
4.5.	Takt time, labor requirements, and line design	50
	<i>The minimum required number of assemblers</i>	50
	<i>Assembler job design issues with short takt times</i>	52
	<i>Assembler job design issues with long takt times</i>	55
PART B	<i>Assembly concepts</i>	59
CHAPTER 5	<i>Visualizing the assembly process</i>	61
5.1.	Needs and evaluation criteria for visualization tools	62
5.2.	The problem with facility blueprints	63
5.3.	Lists and assembly master tables	67
5.4.	Abstract flow diagrams and their limitations	70
5.5.	Layout diagrams with flows	75
	<i>Two-dimensional diagrams</i>	75
	<i>Three-dimensional drawings</i>	78

<i>Integration of text and drawings</i>	79
5.6. Photographs	79
<i>Impact of digital photography</i>	79
<i>Shop floor photography guidelines</i>	80
5.7. Video recordings	81
5.8. Cardboard mock-ups	81
5.9. Discrete-event simulations	82
CHAPTER 6 <i>The concept of the assembly line</i>	85
6.1. What is an assembly line?	86
6.2. Bench assembly versus the assembly line	87
<i>Why assembly lines are still controversial</i>	88
<i>Comparing bench assembly with line assembly</i>	89
<i>Exceptions: where the bench still wins</i>	92
6.3. Assembly lines, assembly cells, and line segments	93
6.4. Assembly and subassembly	97
<i>All assembly work done in one single line</i>	97
<i>Final assembly line with subassembly feeder lines</i>	98
<i>Modular assembly</i>	99
.....	100
<i>Pros and cons of subassembly/feeder lines</i>	101
CHAPTER 7 <i>Collecting assembly time data</i>	103
7.1. Why this needs attention	103
7.2. Data collection methods	104
7.3. Current status of time and motion studies in manufacturing	105
<i>Predetermined time standards in the automobile industry</i>	105
<i>MTM and MOST</i>	107
7.4. Time studies with video recordings	111
CHAPTER 8 <i>Line balancing</i>	113
8.1. Assembly line balancing	114
8.2. Rebalancing a dedicated line	115
8.3. Multiproduct lines with batch versus leveled sequencing	119
8.4. Balancing assembly time among products on a mixed-flow line	121
8.5. Deliberate imbalances	122

PART C Detailed design	125
CHAPTER 9 Assembly station sizing	127
9.1. Issues with assembly station sizing	128
9.2. Assembly stations for small products	128
9.3. Assembly stations for large products	132
9.4. Ergonomics and safety	136
<i>Standing versus sitting</i>	136
<i>Work height and assembler height</i>	139
9.5. Stations with required dwell times	140
CHAPTER 10 Detailed design of assembly stations	143
10.1. Issues with assembly station details	144
10.2. Assembly fixtures	144
<i>Fixtures for manual assembly</i>	144
<i>Fixtures for mechanized or automated assembly</i>	149
<i>In-line mechanical automation</i>	151
10.3. Handheld tools	152
<i>Tools attached to the station and not to the assembler</i>	152
<i>Tool positioning and orientation</i>	154
10.4. Assembly instructions	157
<i>Instruction sheets</i>	157
<i>Contents of instruction sheets for manual assembly</i>	158
<i>Content of instruction sheets for mechanized assembly</i>	161
<i>Instruction sheets for mixed-flow assembly</i>	162
<i>Authoring instruction sheets</i>	163
<i>Use of information technology</i>	163
10.5. Visible management	164
<i>Self-explanatory devices, markings, and color codes</i>	164
<i>Tower lights, stop ropes, and other types of andons</i>	166
<i>Counters and production monitors</i>	168
CHAPTER 11 Part presentation	171
11.1. Scope and purpose	172
<i>Part presentation requirements</i>	172
<i>Controversies about part presentation</i>	175
11.2. Key principles of part presentation	176
<i>Removal of packaging materials before delivery</i>	176
<i>Location within arm's reach of the assembler</i>	178

<i>Orientation</i>	179
<i>Adjustments to specific part characteristics</i>	181
<i>Matching quantities</i>	182
<i>Containers with dunnage for counting</i>	184
<i>Kitting versus line-side supply</i>	185
11.3. Single-piece presentation and water spiders	186
<i>Single-piece presentation</i>	187
<i>Water spiders and supermarkets</i>	189
CHAPTER 12 <i>Conveyance between stations</i>	193
12.1. Issues with conveyance systems	194
12.2. Goals for the conveyance system	196
12.3. A few types of conveyance systems	197
<i>Unpowered conveyance</i>	197
<i>Powered conveyance</i>	199
CHAPTER 13 <i>Assembly cells</i>	201
13.1. About assembly cells	202
13.2. The motivation for cell conversion	203
13.3. Part supply to assembly cells	206
13.4. Range of applicability of the U-shape	208
13.5. Pseudo U-shaped cells	210
CHAPTER 14 <i>Overall shape of assembly lines</i>	211
14.1. Beyond cells	211
14.2. Car and related assembly lines	212
14.3. Airplane assembly lines	218
PART D <i>Assembly quality</i>	221
CHAPTER 15 <i>Preventing picking errors</i>	223
15.1. About this chapter	224
15.2. Mistake-proofing assembly operations	225
15.3. Approaches to automatic identification	226
15.4. Using kit pallets and product fixtures to prevent mistakes	228
15.5. Mistake-proofing lineside picking	231
15.6. Mistake-proofing the kitting process	235
15.7. From stores to the line	237

15.8. Storage and retrieval	238
15.9. Naming items to avoid confusion	240
15.10. From the supplier to the dock	242
CHAPTER 16 <i>Inspection, test, and rework operations</i>	243
16.1. The issues of inspection, test, and rework	244
16.2. The literature	246
<i>The quality control literature</i>	246
<i>The lean manufacturing literature</i>	246
<i>The general literature on assembly</i>	247
16.3. Is self-inspection possible?	247
16.4. Inspection and test sequencing	249
<i>Sequencing by decreasing figure of merit and its limitations</i>	250
<i>Sequencing by induction</i>	252
16.5. Testing multiple units at once	254
16.6. Designing automatic binning operations	256
16.7. Rework operations	257
<i>Self-inflicted rework</i>	258
<i>Rework operations</i>	259
<i>Bibliography</i>	263
0.1. Books in English	264
0.2. Books in Japanese	265
0.3. Books in German	265
0.4. Books in French	266
<i>Index</i>	267