Contents

Preface		х	
The International Institute for Applied System Analysis			xiii
1	Flex Juki	xible Technologies in Manufacturing ka Ranta	1
	1.1	The Changing Environment	3
	1.2	Production Automation: The Systems View	9
	1.3	Backward and Forward Linkages	13
		References	15
2	His	tory of Mechanization	17
	Robert U. Ayres		
	2.1	Gun Manufacturing (1760–1860)	17
	2.2	Other Influences: Machine Tools and	
		Precision Measurement	20
	2.3	The Period 1860–1910	21
	2.4	The Taylor–Ford Period (1910–1960)	28
	2.5	Post–World War II Era	30
	2.6	Summary and Conclusions	34
		Notes	36
		References	39
3	History of Programmable Automation Robert U. Ayres		41
	3.1	Programmability	41
	3.2	Numerical Controls Before Computerization	42
	3.3	Computers and Microelectronics	44
	3 .4	Computer Numerical Control of Machine Tools	52
	3.5	Robots	56

	3.6	Flexible Manufacturing Systems (FMS)	58
		References	59
4	Technology Push:		
	Electronics, Computers, and Communication		61
	Jukka Ranta		
	4.1	Basic Electronics	61
	4.2	Basic Silicon Technologies	67
	4.3	Semi-Custom and Custom-Specific Technologies	68
	4.4	Special Technologies:	
		GaAs, Superconductivity, and Opto-electronics	70
	4.5	Computers, Software, and Communication	72
		4.5.1 Basic processors	72
		4.5.2 Special architectures and signal processing	74
		4.5.3 Software engineering and communication	77
		4.5.4 Some concluding remarks	79
		Notes	79
		References	79
5	Cor	nputer Aided Design	83
	Tho	mas Åstebro	
	5.1	CAD Advantages	84
	5.2	CAD Techniques	85
	5.3	CAD Developers	87
	5.4	CAD Technology	88
	5.5	Conclusions	92
		Notes	94
		References	94
6	Integration of Premanufacturing and Manufacturing		
	6 1	Manufacturing Organization	97
	6.2	Systems View of Planning for Manufacturing	103
	6.3	Materials Resource Planning (MRP)	104
	6.4	Just-in-Time (IIT) and CIM	107
	0.1	6.4.1 JIT and cellular organization	109
		6.4.2 Effects of JIT on suppliers	111
		6.4.3 Restructuring of production control:	
		The reconciliation of JIT and MRP	112

Con	ten	ts
-----	-----	----

	6.5	Computer Assisted Production Planning (CAPP)	115
	6.6	Production Data Acquisition	119
	6.7	Organizational Integration of Production	120
	6.8	Intraplant Communication and Architectures	124
		Notes	129
		References	129
7	Flex	xible Metalworking Technologies	131
	Rob	ert U. Ayres, Jukka Ranta, and Hans-Juergen Warnecke	
	7.1	Cutting and Forming Operations	131
	7.2	Metal-Cutting and Metal-Forming Technologies	133
	7.3	Different Aspects of Flexibility	135
	7.4	Multifunction Machine Tools	139
	7.5	NC Machines and Controls	140
	7.6	Applications of Flexible Manufacturing Cells (FMCs)	142
	7.7	Applications of Flexible Manufacturing Systems (FMSs)	146
		Notes	150
		References	150
8	Ma	nipulation and Robotics	151
	Pau	ul K. Wright	
	8.1	Impact of Robotics on CIM	152
	8.2	Literature Review and Comparisons with Other Research	154
	8.3	Examples of Hardware and Software Configurations	159
		8.3.1 A machine tool hand	161
		8.3.2 Simple gripper with force-sensing wrist	161
		8.3.3 Single fingers to demonstrate control algorithms	165
		8.3.4 Utah/MIT dextrous hand carried by a PUMA 560	167
	8.4	The Design-Space Framework for CIM	169
		8.4.1 Mechanical design attributes	169
		8.4.2 Control attributes	169
		8.4.3 Coordination knowledge attributes	170
		8.4.4 Task decomposition clusters	172
	8.5	Discussion	174
	8.6	Conclusion	176
		Acknowledgment	176
		References	176

9	Fley	xible Assembly	179
	Jeffi	rey Funk and Hans-Juergen Warnecke	
	9.1	The Physical Process	179
	9.2	Classification of Parts and Operations	183
	9.3	Existing Methods of Assembly	185
	9.4	Flexible Assembly	188
	9.5	Assembly Robots	192
	9.6	New Applications of Assembly Robots	194
		9.6.1 Programmable assembly cell	
		with image-processing system	194
		9.6.2 Assembly of PCBs	194
		9.6.3 Cable harness assembly	196
		9.6.4 Automobile assembly systems	196
	9.7	Conclusion: Assembly Development Trends	197
		References	200
10	Inte	egration in Manufacturing:	
	From	m FMS and FMC to CIM	203
	Geo	rge L. Kovács and Géza Haidegger	
	10.1	Flexible Manufacturing Cells	204
	10.2	2 The Control Systems of FMC/FMS	206
		10.2.1 Cell-oriented systems	206
		10.2.2 System integration	207
		10.2.3 Data characteristics	207
		10.2.4 Operator interface	208
		10.2.5 Software modularity	208
	10.3	Flexibility and System Reconfiguration	209
	10.4	The FMC/FMS Design Process	210
	10.5	Cell Configuration and Reconfiguration	212
		10.5.1 Initial configuration	212
		10.5.2 Reconfiguration	213
	10.6	Software Configuration and Reconfiguration	213
	10.7	'Experimental Results	214
		10.7.1 An expert system tool	214
		10.7.2 Hybrid expert system for cell configura	tion
		and simulation	215
	10.8	3 Conclusion	216
		References	217

Contents

11 Human Factors in CIM	219
Robert U. Ayres and Karl-H. Ebel	
11.1 Man-Machine Interface	220
11.2 Human-Centered versus Technocentric Approaches	228
11.3 The Design of CIM Systems:	
Technocentric or Anthropocentric	233
References	241
12 The Technical Perspective and Outlook	245
Jukka Ranta and Karl-H. Ebel	
12.1 The State of the Art	245
12.2 Technology Gaps and Gaps in CIM	246
12.3 Software Integration	253
12.4 Further System Improvements	262
12.5 Summary and Outlook	266
References	268
List of Contributors	271
Index	272

i ix

Index