Contents

Contributors	xi
Preface	XV
Teldee	
a series de des la landaria	1
1. Smart manufacturing in the food industry	,
Jim Wetzel and Chris Damsgard	
1. Introduction	1
2. Overview of the food processing industry in the Unit	ed States: Challenges and
pressures	. 2
3. Manufacturing process	5
4. Prior methods and concepts, their benefits and disac	
5. Smart manufacturing concepts and methods, and th	eir benefits 11
6. Case studies	12
7. Future opportunities	16
8. Conclusion	18
References	19
lan a said a	21
2. Advancing smart manufacturing in the pharm	
Sudarshan Ganesh, Qinglin Su, Zoltan Nagy, and Gint	aras Reklaitis
1. Introduction	21
2. Modernization of pharmaceutical manufacturing	23
3. Continuous tablet manufacturing	30
4. Developments in CM operations management	35
5. Conclusion	52
Acknowledgments	52
References	53
	9
3. Smart manufacturing in the semiconductor in	dustry: An evolving nexus
of business drivers, technologies, and standar	ds 59
Alan Weber	
1. Introduction	6
2. Historical background	6
Definition of smart manufacturing	7
4. Smart manufacturing standards	7
5. Smart manufacturing implementation checklist	8
6. Smart manufacturing application technologies	9

7	. Where are we headed?	101
	. Conclusion	105
	eferences	105
		107
	mart reservoir management in the oil and gas industry	107
[David Castiñeira, Hamed Darabi, Xiang Zhai, and Wassim Benhallam	
1	. Introduction	107
-	. Methods and concepts	110
3	3. Case studies	127
4	I. Conclusion	139
-	References	140
5	Smart manufacturing in fine/specialty chemical industries	143
	Cliff P. Kowall	
,		143
	1. Introduction	145
	2. What is process intensification?	146
	3. Basic principles of process intensification4. Process intensification as a design platform	148
	5. Application to design	149
	6. Use of a heat map to identify high potential areas for Pl	154
	7. Intensification using continuous modular versus batch processing	161
	8. Modeling and simulation as "in silico" process design	166
	9. Establishing specific company targets/metrics for process intensification	172
	10. Process intensification value to manufacturing and the enterprise	173
	11. Conclusion	175
	References	175
6	Smart manufacturing of paints and coatings	179
0.	Masoud Soroush and Michael C. Grady	
		179
	1. Introduction	186
	 Smart manufacturing concepts and methods Process systems engineering view of the manufacturing problems 	191
	to the state of th	196
	4. Mathematical modeling and inference methods5. Prior methods and concepts: Their advantages and disadvantages	205
	6. Future opportunities	205
	7. Conclusion	211
	Acknowledgments	212
	References	212
7	Smart manufacturing in additive manufacturing	219
	Timothy Phillips, Jared Allison, Carolyn Seepersad, and Joseph Beaman	
	1. Introduction	219
	2. Additive manufacturing in practice	220

		Contents
	 Additive manufacturing technologies Industrial additive manufacturing Defect avoidance through part design Process control in industrial selective laser sintering Conclusion References 	221 229 230 243 252 253
8.	Smart manufacturing enabled by continuous monitoring and control of polymer characteristics Michael F. Drenski, Alex W. Reed, Aide Wu, and Wayne F. Reed	257
	 Introduction Manufacturing process Current methods for polymerization monitoring and control Automatic Continuous Online Monitoring of Polymerization reactions (ACOMP) and smart polymer manufacturing ACOMP principles and operation Case studies Future opportunities Conclusion Acknowledgments References 	257 259 260 261 262 276 295 303 304 304
9.	Application of smart manufacturing methods to steam methane reformers Ankur Kumar, Apratim Bhattacharya, Michael Baldea, and Thomas F. Edgar	309
	 Introduction Hydrogen manufacturing process Prior methods for steam methane reformer operational optimization Smart manufacturing method for steam methane reformer Conclusion References 	309 311 314 315 331 332
10	Smart manufacturing in industrial gas production: A digital transformation Jeffrey E. Arbogast, Cyril Defaye, Irene Lotero, Ajit Gopalakrishnan, Thierry Roba, and Athanasios Kontopoulos	333
	 Introduction Manufacturing process and industrial context Literature review Anomaly detection, an illustration of smart manufacturing in practice SIO.Predict case studies SIO.Optim-related case studies Case studies: General insights from SIO at Air Liquide 	334 335 337 341 351 362 373 378
	8. Future opportunities	3/0

vii

	9. Conclusion	379
	Acknowledgments	381
	References	382
11.	Advanced decision-support technologies for the design and management	
	of industrial gas supply chains	387
	Sivaraman Ramaswamy, Tarun Madan, Karthik Thyagarajan, Jose M. Pinto, and Jose M. Laínez-Aguirre	
	1. Introduction	387
	2. Industrial gas supply chain overview	390
	3. Contributions	396
	4. Challenges and perspectives	412
	5. Conclusion	417
	References	418
12.	Smart manufacturing: A sustainable energy perspective	423
	Prodromos Daoutidis, Andrew Allman, and Matthew J. Palys	
	1. Introduction: Sustainable energy manufacturing	423
	2. Microgrids for distributed generation	427
	3. Combined renewable energy and chemical production	440
	4. Conclusion	450
	References	451
13.	Smart manufacturing and smart grids	455
	Tariq Samad and Rolf Bienert	
	1. Introduction	455
	2. Smart manufacturing and electrical energy	457
	3. Templates for smart grid integration with smart manufacturing	461
	4. OpenADR 2.0: A unifying protocol for customer engagement with the smart grid	466
	5. Challenges	471
	6. Conclusion	473
	Acknowledgments	473
	References	473
14.	Smart manufacturing: Machine learning-based economic MPC and	
	preventive maintenance	477
	Zhe Wu and Panagiotis D. Christofides	
	1. Introduction	477
	2. Preliminaries	479
	3 Recurrent neural network	480

		Contents	ix
4. Lyapunov-based El	MPC using ensemble RNN models	485	
5. Machine learning E	MPC scheme for handling actuator maintenance	492	
6. Conclusion		496	
References		497	
Index		499	