Contents

Preface to the 2nd edition — V

Preface ——	۷	1	ı
------------	---	---	---

1	Process Integration and Intensification: An Introduction —— 1
1.1	Process Intensification — 1
1.2	Process Systems Engineering and Process Integration —— 3
1.3	Contributions to PIs and PI to energy and water saving —— 4
1.4	What is Process Integration? —— 4
1.5	A short history of the development of Process Integration —— 5
1.6	The aim and scope of this textbook —— 8
2	Setting energy targets and Heat Integration —— 13
2.1	Introduction —— 13
2.1.1	Initial development of Heat Integration —— 14
2.1.2	Pinch Technology and targeting Heat Recovery: The thermodynamic roots —— 14
2.1.3	Supertargeting: Full-fledged HEN targeting —— 15
2.1.4	Modifying the Pinch Idea for HEN Retrofit —— 16
2.1.5	Benefits of Process Integration —— 16
2.2	Pinch Analysis for maximizing energy efficiency —— 17
2.2.1	Introduction to Heat Exchange and Heat Recovery —— 17
2.2.2	Basic principles —— 19
2.2.3	Basic Pinch Technology —— 28
2.3	Summary —— 65
3	Synthesis of Heat Exchanger Networks —— 71
3.1	Introduction —— 71
3.2	HEN synthesis —— 71
3.2.1	The Pinch Design Method —— 72
3.2.2	Methods using mathematical programming —— 93
3.3	Grassroots and retrofits; impact of economic criteria — 97
3.3.1	Network optimization —— 97
3.3.2	The Network Pinch —— 98
3.4	Summary —— 100
4	Total Site Integration —— 103
4.1	Introduction —— 103
4.2	What is a Total Site and what are the benefits? —— 104



6.1	Water management and minimization —— 191
6	Introduction to Water Pinch Analysis —— 191
5.4	Conclusion — 100
5.3.5	Summarized network diagram —— 186 Conclusion —— 186
5.3.4	Stage 4: Targeting for low CO ₂ emission with CEPA (Tool 3) —— 181
.	with PoPA (Tool 2) —— 179
5.3.3	Stage 3: Targeting for hybrid power system integrating RE resources
	TSHI (Tool 1) —— 177
5.3.2	Stage 2: Targeting for Total Site Heat Recovery with cogeneration using
5.3.1	Stage 1: Baseline study —— 175
5.3	Case Study —— 174
5.2	Framework for Low CO ₂ Emissions Industrial Site Planning —— 171
5.1	Introduction —— 171
5	An Integrated Pinch Analysis Framework for Low CO ₂ Industrial Site Planning —— 171
4.9	Summary — 166
4.0.3	Analysis — 159
4.8.5	Targeting for Low CO ₂ Emissions with CO ₂ Emission Pinch
4.8.3 4.8.4	Numerical tools for Total Site Heat Integration —— 141 Power Integration —— 147
4.8.2	Retrofit of industrial energy systems at the site level —— 140
482	differences — 139
4.8.1	Introduction of process-specific minimum allowed temperature
4.8	Advanced Total Site developments —— 139
4.7.2	Choice of optimal steam pressure levels —— 137
4.7.1	Targeting CHP using the SUGCC —— 135 Chaica of ontimal steam prossure levels —— 137
471	during process design —— 135 Targeting CHR using the SUGCC 125
4.7	Targeting of Combined Heat and Power generation (CHP, Cogeneration)
4.6.3	Utility system: An illustrative example —— 132
4.6.2	Utility network modelling: Simulation and optimization —— 130
4.6.1	A flexible steam turbine model for cogeneration evaluation — 124
4.6	Modeling of Utility Systems — 124
4.5	Site Utility Grand Composite Curve (SUGCC) —— 123
4.4	Total Site Profiles and Total Site Composite Curves —— 116
4.3.3	Working session —— 113
4.3.2	Step-by-step guide —— 107
4.3.1	The algorithm —— 107
4.3	HI extension for Total Sites: Data extraction for Total Sites —— 107
4.2.2	Total Site Analysis interfaces —— 106
4.2.1	Total Site definition —— 105

6.2	History and definition of Water Pinch Analysis —— 192
6.3	Applications of Water Pinch Analysis —— 193
6.4	Water Pinch Analysis steps —— 194
6.5	Analysis of water networks and data extraction —— 195
6.5.1	Analysis of water networks —— 195
6.5.2	Data extraction —— 197
6.5.3	Example —— 198
7	Setting the maximum water recovery targets —— 205
7.1	Introduction —— 205
7.2	Maximum water recovery target for single pure freshwater — 209
7.2.1	Water Cascade Analysis technique —— 209
7.2.2	Source/Sink Composite Curves (SSCC) —— 212
7.2.3	Significance of the Pinch region —— 213
7.3	Maximum water recovery target for a single impure freshwater source —— 214
7.3.1	Pinched problems —— 214
7.3.2	Threshold problems —— 221
7.4	Maximum water recovery targets for multiple freshwater sources —— 221
7.5	Working session —— 225
7.6	Solution —— 225
8	Water network design/retrofit —— 231
8.1	Introduction —— 231
8.2	Source/Sink Mapping Diagram (SSMD) —— 231
8.3	Source and Sink Allocation Curves (SSAC) —— 233
8.3.1	Example of network design using SSCC for utility purity superior to all other streams —— 236
8.3.2	Freshwater purity not superior to all other streams —— 240
8.3.3	Simplification of a water network or constructing other network possibilities —— 244
8.4	Working session —— 247
8.5	Solution —— 247
8.6	Optimal Water [©] software —— 249
9	Design of Cost-Effective Minimum Water Network (CEMWN) —— 253
9.1	Introduction —— 253
9.2	Water Management Hierarchy —— 253
9.3	Cost-Effective Minimum Water Network (CEMWN) —— 255
9.4	Industrial case study – a semiconductor plant —— 265
9.4.1	Using CEMWN targets as reference benchmarks —— 279

10	Conclusions and sources of further information —— 287
10.1	HEN targeting, synthesis, and retrofit —— 287
10.2	Total Site Integration —— 288
10.3	Total Site methodology addressing variable energy supply and demand —— 289
10.4	Utility system optimization accounting for cogeneration —— 290
10.5	Maximum water recovery targeting and design —— 291
10.5.1	Recommended books for further reading — 291
10.5.2	State of-the-art review —— 293
10.6	Analysing the designs of isolated energy systems —— 294
10.7	PI contribution to supply chain development —— 295
10.8	Hydrogen networks design and management —— 295
10.9	Oxygen Pinch Analysis —— 296
10.10	Pressure drop considerations and heat transfer enhancement in Process Integration —— 297
10.11	Power (Electricity) and Hybrid Pinch —— 299
10.12	Computational and modeling tools suitable for applying PI —— 300
10.12.1	Heat and power PI applications —— 300
10.12.2	Water Pinch software —— 301
10.13	Challenges and recent developments in Pinch-based PI —— 302
10.14	PRES Conferences on Process Integration, Modelling and Optimisation for Energy Saving and Pollution Reduction —— 303

Index --- 309