
Contents

Introduction	xi
Chapter 1. Available Technologies	1
1.1. Introduction	1
1.2. The simplest form of heat exchanger: single-tube or coaxial.	1
1.3. Shell-and-tube heat exchangers	2
1.4. Coil-in-tank heat exchangers	3
1.5. Compact heat exchangers	5
1.5.1. Finned-tube cross-flow heat exchangers	5
1.5.2. Car radiators	6
1.5.3. Plate-fin heat exchangers	7
1.5.4. Plate heat exchangers	8
1.5.5. Spiral heat exchangers	10
1.5.6. Printed-circuit heat exchangers.	12
1.6. Rotary regenerative heat exchangers	15
1.7. Phase-change heat exchangers.	16
1.7.1. Condensers.	16
1.7.2. Reboilers and evaporators.	18
1.7.3. Heat-pipe heat exchangers	21
1.8. Heat exchangers for power electronics.	23
1.8.1. Electronic radiators and heat sinks.	23
1.8.2. Forced-convection heat sinks.	24
1.8.3. Cold-plate heat exchangers	25
1.8.4. Microchannel coolers	25
1.8.5. Refrigerated heat exchangers	27

1.8.6. Spray heat exchangers: spray coolers	28
1.8.7. Micro heat pipes for electronic systems	29
1.8.8. Evaporation-chamber heat exchangers	30
Chapter 2. Tubular Heat Exchanger Design	33
2.1. Introduction	33
2.2. Coaxial tubular heat exchangers	34
2.3. Tubular coil-in-tank heat exchangers.	34
2.4. Multitube heat exchanger technology	36
2.4.1. Tube plates.	36
2.4.2. Fixed-head heat exchangers.	36
2.4.3. Floating-head heat exchangers	38
2.4.4. Multipass heat exchangers	38
2.4.5. Transverse baffles	40
2.4.6. Arrangement of tubes inside tubular heat exchangers	41
2.5. Flow in a tubular heat exchanger	46
2.6. Position of transverse baffles and flow parameters	48
2.6.1. Position of baffles in the shell	48
2.6.2. Baffle geometry.	49
2.6.3. Illustration: A_F , δ_F and θ from ϵ	50
2.6.4. Shell-baffle and baffle-tube clearances	51
2.6.5. Longitudinal free area	52
2.6.6. Transverse free area	52
2.6.7. Flowrates.	53
2.7. Calculation of the Reynolds number for flow in the shell.	54
2.7.1. Use of hydraulic diameter for shells without baffles	54
2.7.2. The Bell-Delaware method for shells with baffles	55
Chapter 3. Compact Heat Exchanger Design	59
3.1. Introduction.	59
3.2. General parameters of compact heat exchangers	60
3.2.1. Compactness.	60
3.2.2. Hydraulic diameter	60
3.2.3. Porosity.	61
3.2.4. Relationship between compactness and hydraulic diameter	61
3.3. Finned-tube compact heat exchanger technology and design	62
3.3.1. Individually-finned tube heat exchangers.	62
3.3.2. Collectively-finned tube heat exchangers.	63

3.4. Plate-fin heat exchanger technology and design	67
3.4.1. Flow configuration	67
3.4.2. Fin type and arrangement	67
3.4.3. Fin-plate attachments and exchange modules	68
3.4.4. Geometric parameters	69
3.4.5. Calculation of the hydraulic diameter for plate-fin heat exchangers	72
3.4.6. Calculation of the Reynolds number	72
3.5. Plate heat exchanger technology and design	73
3.5.1. Gasketed-plate heat exchangers	75
3.5.2. Brazed-plate heat exchangers	76
3.5.3. Sizing parameters	77
3.6. Spiral heat exchanger technology	81
3.6.1. Gap	82
3.6.2. Hydraulic diameter	82
3.6.3. Reynolds number	83
3.6.4. Relationship between number of revolutions and length	83
3.7. Printed-circuit heat exchanger technology and design	84
3.7.1. Diameter-pitch-thickness relationship	86
3.7.2. Constraints on the number of channels per layer	87
3.7.3. Constraints on numbers of layers	87
3.7.4. Hydraulic diameter	88
3.7.5. The Reynolds number	88
3.7.6. Mechanical strength	88
3.8. New developments in compact heat exchangers	89
Chapter 4. Heat Exchanger Selection, and Sizing Parameters	91
4.1. Introduction	91
4.2. Choosing the type of heat exchanger to be used	92
4.2.1. Nature of fluids and temperature ranges	92
4.2.2. Design pressure	93
4.2.3. Thermal schedule of a heat exchanger	93
4.2.4. The selection itself	94
4.3. Selection of fluid circuits: which fluid for what side?	96
4.4. Choosing the flow configuration	97
4.5. Illustration: choosing a heat exchanger and determining its thermal schedule	97
4.6. Sizing, a complex problem	99
4.6.1. Parameters to be determined by the designer	99
4.6.2. Origin of the complexity	106

Chapter 5. Sizing Methods	109
5.1. Introduction	109
5.2. Analysis of temperature profiles in an exchanger	110
5.3. Overall heat transfer coefficient	112
5.3.1. Overall coefficient for a clean exchanger	113
5.3.2. Overall coefficient for a fouled exchanger	115
5.3.3. Overall coefficient for finned heat exchangers	117
5.4. Illustration: overall heat transfer coefficient for a fouled exchanger	119
5.5. Calculation of the heat flux transferred	122
5.5.1. Heat balances	122
5.5.2. Relationship between flux and transfer area	123
5.6. Method based on the calculation of efficiency: NTU method	124
5.6.1. Definition of efficiency	124
5.6.2. Efficiency of a co-flow heat exchanger	125
5.6.3. Number of transfer units (NTU)	127
5.6.4. Illustration: outlet temperatures of a heat exchanger	127
5.6.5. Efficiency of other heat exchanger types	129
5.6.6. Practical calculations of efficiency	134
5.6.7. Illustration: heat recovery from industrial waste heat	134
5.7. Method based on logarithmic mean temperature difference	138
5.7.1. Case of a one-pass heat exchanger	138
5.7.2. Illustration: comparison of flow configurations	139
5.7.3. Case of multipass and cross-flow heat exchangers	142
5.7.4. Determination of the correction factors	144
Chapter 6. Sizing Algorithms for Heat Exchangers	153
6.1. Introduction	153
6.2. Principle of heat exchanger sizing	154
6.3. Calculation algorithm for multitube heat exchangers	155
6.4. Illustration: implementation of the shell-and-tube algorithm	162
6.5. Calculation algorithm for cross-flow heat exchangers	175
6.5.1. General algorithm	177
6.5.2. Case of embedded heat exchangers	181
6.6. Illustration: sizing of car radiators	185
6.7. Calculation algorithm for plate heat exchangers	197
6.8. Illustration: implementation of the plate heat exchanger algorithm	202

6.9. Calculation algorithm for spiral heat exchangers.	211
6.10. Illustration: implementation of the spiral heat exchanger algorithm.	213
6.11. Calculation algorithm for printed-circuit heat exchangers.	221
6.12. Illustration: implementation of the PCHE calculation algorithm.	225
 Appendices	233
 Appendix 1. Database	235
 Appendix 2. Calculation of Convection Heat Transfer Coefficients in Exchangers	269
 Appendix 3. Calculation of Pressure Drops in Exchangers	299
 Appendix 4. Fouling of Heat Exchangers	315
 Appendix 5. Nomenclature	321
 References	327
 Index	339