1

3

15

35

79

CONTENTS

Chapter 1. Introduction

Chapter 2. Heat Transfer Fundamentals

- Concept of Unit Operations / 3 2-1
- 2-2 Heat and the First Law of Thermodynamics / 3
- 2-3 Temperature and Internal Energy / 5
- 2-4 Continuous and Steady-State Systems / 5
- 2-5 Formulation of the First Law for Continuous Systems / 6
 2-6 Thermodynamic Variables / 8
- 2-7 Heat Transfer Mechanisms / 9 Glossary / 13

Chapter 3. Heat Conduction in Solids

- 3-1 General Equation of Conduction in Solids / 15
- 3-2 Heat Conduction Through a Wall / 16
- 3-3 Steady-State Conduction Heat Transfer in Multidimensional Systems / 26
- 3-4 Thermal Insulation / 28 Glossary / 34 References / 34

Chapter 4. Convection

- 4-1 Forced Convection Over a Flat Plate / 35
- 4-2 Forced Convection Inside Tubes / 44
- 4-3 Forced Convection Around Submerged Objects / 60
- 4-4 Natural Convection / 66 Glossary / 76 References / 77

Chapter 5. Fundamentals of Heat Transfer Between Fluids

- 5-1 The Enthalpy Balance / 79
- 5-2 Heat Transfer Area and Heat Transfer Coefficient / 81
- 5-3 Expression of the Overall Heat Transfer Coefficient as a Function of the Film Coefficients / 82
- 5-4 Mean Temperature Difference Between Two Fluids / 86
- 5-5 Calculation of the Overall Heat Transfer Coefficient and Pressure Drop for Double-Tube Heat Exchangers / 94
- 5-6 Heat Exchanger Process Specifications / 98
- 5-7 Design Procedure for a Double-Tube Heat Exchanger / 102 Glossary / 111 References / 113

Chapter 6. Shell-and-Tube Heat Exchangers

- 6-1 Design and Construction Standards / 115
- 6-2 Principal Components of a Shell-and-Tube Heat Exchanger / 116
- 6-3 Baffles / 117
- 6-4 Tubes and Tube Distribution / 122
- 6-5 Tubes to Tubesheets Joint / 124
- 6-6 Multipass Heat Exchangers / 127
- 6-7 Heat Exchangers with Multiple Shell Passes / 129
- 6-8 Front Heads (Inlet Heads) / 132
- 6-9 Fixed-Tubesheet and Removable-Bundle Heat Exchangers / 133
- 6-10 Tube Vibration / 141
- 6-11 Specification Sheet / 145
- 6-12 Design and Construction of Heat Exchangers / 145 References / 146

Chapter 7. Thermal Design of Shell-and-Tube Heat Exchangers

7-1	Basic	Principles	1	147
-----	-------	------------	---	-----

- 7-2 LMTD Correction Factors for Other Flow Configurations / 151
- 7-3 Basic Design Parameters of a Heat Exchanger / 157
- 7-4 Convection Film Coefficient and Pressure Drop in the Tube Side / 160
- 7-5 Heat Transfer Coefficient and Pressure Drop at the Shell Side / 164
- 7-6 Design and Rating of Heat Exchangers / 193
 7-7 Heat Exchanger Effectiveness / 205 Glossary / 213
 - Glossary of the Heat Exchanger Geometry / 214 References / 215

Chapter 8. Finned Tubes

- 8-1 Double-Tube Heat Exchangers with Longitudinal Fins / 217
- 8-2 Air Coolers / 231 Glossary / 251 References / 253

Chapter 9. Plate Heat Exchangers

- 9-1 Operating Principles and General Description / 255
- 9-2 Series-Parallel Combination / 258
- 9-3 Components of a Gasketed Plate Heat Exchanger / 260
- 9-4 Use and Limitations of Gasketed Plate Heat Exchangers / 264
- 9-5 Welded and Semiwelded Plate Heat Exchangers / 265
- 9-6 Plate Heat Exchangers versus Shell-and-Tube Heat Exchangers / 265
- 9-7 Typical Heat Transfer Coefficients / 266
- 9-8 Heat Transfer and Pressure-Drop Correlations for Plate Heat Exchangers / 267
- 9-9 LMTD Correction Factor / 269
- 9-10 Fouling Resistances / 269
- 9-11 Number of Transfer Units and Specific Pressure Drop / 272 Glossary / 273 References / 274

Chapter 10. Condensation of Vapors

10-1 Mechanisms of Condensation / 275

255

275

147

217

¹⁰⁻² Condensation of Single-Component Vapors / 277

- 10-3 Single-Component Vapors Condensers / 292
- 10-4 Desuperheater Condensers / 303
- 10-5 Condensation of Vapor Mixtures / 309
 10-6 The Use of Steam as Process Heating Medium / 318 Glossary / 327 References / 329

Chapter 11. Boiling

- 11-1 Mechanisms of Heat Transfer to Boiling Liquids / 331
- 11-2 Pool Boiling / 345
- 11-3 Flow Boiling in Tubes / 352
- 11-4 Reboilers / 367 Glossary / 392 References / 394

Chapter 12. Thermal Radiation

12-1 Heat Transfer by Radiation Through Transparent Media / 395
12-2 Radiant Heat Transmission in Absorbing Media / 426 Glossary / 438 References / 438

Chapter 13. Process Fired Heaters

- 13-1 Simplified Schematic / 439
- 13-2 Combustion / 439
- 13-3 Applications of Fired Heaters / 446
- 13-4 Heater Types / 448
- 13-5 Heater Components / 452
- 13-6 Elements for the Design and Verification of the Capacity of a Fired Heater / 458 Glossary / 482 References / 483

Appendix A. Distillation

Control Scheme / 487 Total and Partial Condenser / 488 Simulation of Distillation Columns / 488 Phase Equilibrium in a Multicomponent System / 489 Mass and Energy Balances / 490 Condensation and Boiling Curves / 492

Appendix B	LMTD Correction Factors for E-Shell Heat Exchangers	495
------------	---	------------

Appendix D. Tube Count Tables

331

395

439

485

501

Appendix E. Tube Layout	509
Appendix F. Fouling Factors	523
Appendix G. Typical Heat Transfer Coefficients	527
Appendix H. Dimensions of Tubes According to BWG Standard	529
Appendix I. Physical Properties of Pure Substances	531
Appendix J. Heat Exchanger Data Sheet	547
Appendix K. Unit Conversions	551

.

•

Index 555