
CONTENTS

Preface

CHAPTER 1 Heat Exchanger Types and Construction

Fluid-Flow Arrangement, 1
Types of Application, 2
References, 22

CHAPTER 2 Heat Exchanger Fabrication

Tubular Versus Flat-Plate Construction, 23
Tube-to-Header Joints, 24
Header-Sheet Mounting, 28
Finned Surfaces, 29
Tube Bending and Joining, 32
References, 38

CHAPTER 3 Heat Transmission and Fluid Flow

Thermal Conduction, 39
Thermal Radiation, 42
Fluid Flow, 44

ix Heat Transfer Between Fluids and Solid Surfaces, 52
Heat Transfer to Boiling Liquids, 65
Condensing Vapors, 65
1 References, 68

CHAPTER 4 Performance Estimation

23 Temperature Distribution and Its Implications, 70
Calculational Procedures, 74
Effectiveness of Units With Nonuniform Surface Temperatures, 80
Comparison of Heat Transfer Fluids, 81
References, 85

CHAPTER 5 Boiling Heat Transfer and Flow Stability

39 Pool Boiling, 87
Heat Flux and Surface Temperature, 87
Forced-Convection Boiling, 89
Effects of Flow Regime on the Heat Transfer Mechanism, 91

vi CONTENTS

Liquid Superheating and the Effects of Nucleation Sites, 92
Heat Transfer Coefficients for Nucleate Boiling With Forced Convection, 96
Burn-Out Limitations, 96
Pressure Drop Under Two-Phase Flow Conditions, 99
Heat Transfer Coefficients for Nucleate Boiling in Cryogenic Systems, 105
Characteristics of Mist Flow, 106
Heat Transfer Enhancement for Once-Through Boilers, 110
Flow Stability in Heat Transfer Matrices Under Boiling Conditions, 111
Dynamic Instability in Boiling Systems, 124
References, 125

CHAPTER 6 Heat Pipes

127

Heat Pipe Structures, 127
Typical Applications, 128
Basic Relations, 128
Performance Characteristics of a Typical Heat Pipe, 129
Estimating Heat Pipe Performance From Table 6.1, 135
Materials Compatibility, 137
Relation Between the Operating Temperature and the Heat Load, 138
Special Effects, 138
References, 139

CHAPTER 7 Fluidized Beds

140

Fluidization, 141
Heat Transfer, 143
Pressure Drop, 145
Special Problems, 146
Mechanical Design, 147
References, 149

CHAPTER 8 Flow Distribution Problems

151

Typical Velocity Distributions and Flow Patterns, 151

Effects of Channel Divergence, 154
Typical Cases, 165
References, 174

CHAPTER 9 Stress Analysis

175

Pressure Stresses in Tubes, Header Sheets, and Pressure Vessels, 175
Differential Thermal Expansion, 181
Vibration and Noise, 185
Allowable Stresses, 193
References, 197

CHAPTER 10 Service Life, Reliability, and Maintenance

200

Catastrophic Failures, 200
Nature of Failures and Their Effects, 202
Incidence of Failures in Typical Systems, 205
Failure Rates, 208
Maintenance, 213
References, 214

CHAPTER 11 General Design Considerations and Approaches

216

Delineation of Requirements, 216
Design Approaches to the Selection of a Heat Transfer Matrix Geometry, 221
Evaluation of Proposals, 223
Cost Estimation, 223
References, 226

CHAPTER 12 Liquid-to-Liquid Heat Exchangers

228

Heat Transfer Performance, 228
Analytical Approach, 230
Calculational Technique Including Allowances for Deviations From Ideality, 236
Plate-and-Frame Heat Exchangers, 244
References, 244

| | | | |
|--|------------|---|------------|
| CHAPTER 13 | | CHAPTER 17 | |
| Gas-to-Gas Heat Exchangers | 246 | Heat Exchangers for Liquid Metals and Molten Salts | 337 |
| Tubular Regenerators for Gas-Turbine Central Stations, 247 | | Applications, 338 | |
| Regenerators for Mobile Gas-Turbine Plants, 251 | | Heat Exchangers for Test Facilities, 340 | |
| Periodic-Flow Static Heat Transfer Matrices, 259 | | A Compact Molten Salt-to-NaK Heat Exchanger, 341 | |
| Recuperators Utilizing Heat Pipes, 263 | | NaK-to-Air Radiator, 350 | |
| References, 265 | | Design of a Heat Exchanger for a Molten-Salt Reactor Power Plant, 354 | |
| CHAPTER 14 | | Steam Generators, 357 | |
| Liquid-to-Gas Heat Exchangers | 266 | References, 363 | |
| Comparison of Fin Geometries, 266 | | CHAPTER 18 | |
| Design of Finned Matrices, 275 | | Heat Exchangers Operating on Radiant Energy | 365 |
| Design of Automotive Radiators, 276 | | Radiators for Space Power Plants, 365 | |
| Design of a Building Air Heater, 281 | | Solar Energy Collector Applications, 377 | |
| References, 283 | | Cryogenically Cooled Walls for Space Chambers, 380 | |
| CHAPTER 15 | | References, 381 | |
| Steam Generators | 285 | CHAPTER 19 | |
| Design Features of a Typical Modern Boiler for a Large Coal- or Oil-Fired Steam Power Plant, 285 | | Cooling Towers | 383 |
| Major Problem Areas in Boiler Design, 287 | | Types of Cooling Towers, 383 | |
| Fluidized-Bed Combustors, 290 | | Basic Relations, 386 | |
| Steam Generators for Nuclear Power Plants, 300 | | Reasons for Large Uncertainties, 398 | |
| Steam Generators for Pressurized Water Reactors, 302 | | Environmental Problems, 399 | |
| Steam Generators for Gas-Cooled Reactors, 307 | | Wind Loads, 399 | |
| References, 313 | | Dry Cooling Towers, 399 | |
| CHAPTER 16 | | References, 400 | |
| Condensers | 316 | CHAPTER 20 | |
| Heat Transfer From Condensing Vapors, 316 | | Heat Exchanger Tests | 402 |
| Condensers for Steam Power Plants, 319 | | Performance Tests on Models, 402 | |
| Condenser-Evaporators for Desalination Plants, 326 | | Instrumentation, 406 | |
| Design of Condensers for Refrigerating and Air-Conditioning Systems, 330 | | Heat Transfer Performance Tests, 410 | |
| Feedwater Heaters, 333 | | Analysis of Test Results, 410 | |
| References, 336 | | Flow Tests, 411 | |
| | | Structural Tests, 412 | |
| | | Endurance Tests, 413 | |
| | | Leak Tests, 413 | |
| | | References, 414 | |

HANDBOOK

| | | | |
|--|------------|--|------------|
| SECTION 1 Nomenclature, Constants, and Conversion Factors | 418 | SECTION 6 Geometric Data for Tube Bundles and Header Sheets | 490 |
| SECTION 2 Physical Properties Affecting Heat Transfer | 423 | SECTION 7 Dimensional and Related Data for Pipes, Tubes, and Fins | 502 |
| SECTION 3 Fluid Flow and Pressure Drop | 440 | SECTION 8 Stress Analysis | 517 |
| SECTION 4 LMTD and Thermal Effectiveness | 452 | SECTION 9 Cost Estimation | 529 |
| SECTION 5 Heat Transfer Coefficients | 462 | Index | 537 |