Contents

Preface xiii
Acknowledgements xix

1 Introduction to Steam Turbines 1
   1.1 Why Do We Use Steam Turbines? 1
   1.2 How Steam Turbines Work 2
      1.2.1 Steam Generation 5
      1.2.2 Waste Heat Utilization 5
      1.2.3 The Rankine Cycle 7
   1.3 Properties of Steam 8
      1.3.1 Turbine Design Configurations 11
   1.4 Steam and Water Requirements 13
      1.4.1 Steam Conditions for Steam Turbines 13
      1.4.2 Water Conditions for Steam Turbines 13
      1.4.3 Advantages of Steam Turbine Drives 14
      1.4.4 Speed Control 16
      1.4.5 Turbine Overspeed Protection 17
   Questions 18
   Answers 19

2 General Purpose Back Pressure Steam Turbine 21
   2.1 Single-Stage Back Pressure Steam Turbine 22
      2.1.1 Steam Flow Path 23
   2.2 Mechanical Components in General Purpose Back Pressure Steam Turbines 31
      2.2.1 Radial and Thrust Bearings 31
      2.2.2 Bearing Lubrication 33
      2.2.3 Force Lubrication Systems 37
      2.2.4 Lubrication 38
      2.2.5 Bearing Housing Seals 40
8 Centrifugal Pump and Centrifugal Compressor
Shutdowns with a Steam Turbine Driver 137
  8.1 Centrifugal Pump Steam Turbine Shutdown 139
  8.2 Centrifugal Compressor Steam Turbine Shutdown 141
Questions 144
Answers 145

9 Installation, Commissioning and First Solo Run 147
  9.1 Introduction 147
  9.2 Equipment Installation 148
    9.2.1 Foundations 148
    9.2.2 Grouting 150
    9.2.3 Piping 157
  9.3 Commissioning 160
    9.3.1 Steam Blowing 162
    9.3.2 Strainers 165
    9.3.3 Lubrication 167
    9.3.4 Oil Sump Lubrication 167
    9.3.5 Flushing Pressure Lubricated System 169
    9.3.6 Hydraulic Governors 172
  9.4 Turbine First Solo Run on Site 174
    9.4.1 First Solo Run Pre-checks 175
    9.4.2 Steam Turbine First Solo Run Procedure 179
Questions 186
Answers 187

10 Reinstating Steam Turbine after Maintenance 189
  10.1 Turbine Reinstatement after Maintenance 189
  10.2 Reinstatement after Maintenance Check List 190
  10.3 Steam Turbine Reinstatement after Maintenance Procedure 194
Questions 201
Answers 202

11 Steam Turbine Reliability 205
  11.1 Repairs versus Overhauls 205
  11.2 Expected Lifetimes of Steam Turbines and Their Components 206
  11.3 Common Failure Modes 207
  11.4 Improvement Reliability by Design 211
Questions 214
Answers 215
Appendix A: An Introduction to Steam Turbine Selection 261
Appendix B: Glossary of Steam Turbine Terms 289
Appendix C: Predictive and Preventative Maintenance Activities 299
Appendix D: Properties of Saturated Steam 301
Index 305