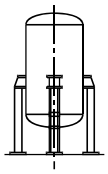
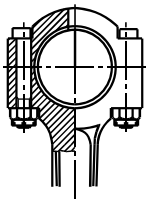
CONTENTS



Chapter 1
Design of Cylinders and Pressure Vessels 1 - 126

1.1 Thin and Thick Cylinders 2
1.2 Design of Thin Cylindrical Vessels 2
1.3 Design of Thin Walled Spherical Vessels 4
1.4 Joint Efficiency 5
1.5 Solved Examples 5
1.6 Design of Thick Cylinders 9
1.7 Lamé's Theory 14
1.8 Design Based on Maximum Shear Stress Theory 15
1.9 Design Based on Maximum Distortion Energy Theory 16
1.10 Design Based on Maximum Strain Theory of Failure 17
(Clavarino's and Birnie's Equations) 17
1.11 Solved Examples 19
1.12 Design of Hydraulic and Pneumatic Cylinders 29
1.13 Design of Gasket Joint in Cylinders 31
1.14 Solved Examples 35
1.15 Cylinders Subjected to External Pressure 43
1.16 Prestressing of Thick Cylinders 45
1.17 Analysis of Compound Cylinders 47
1.18 Solved Examples 50
1.19 Design Criterion and Failure Modes in Pressure Vessels ... 69
1.20 Unfired Cylindrical Pressure Vessels 70

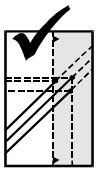
1.21 Categories of Welded Joints 71
1.22 Material Selection for Pressure Vessels 72
1.23 Design of Shell due to Internal Pressure 73
1.24 Cylindrical Vessel Subjected to Combined Loading 73
1.25 Formed Heads 76
1.26 Corrosion Allowance 83
1.27 Solved Examples 83
1.28 Openings in Pressure Vessel 98
1.29 Solved Examples 101
1.30 Support for Pressure Vessels 120
Exercises ? 122
Problems 123



Chapter 2
Design of IC Engine Components 127 - 322

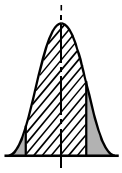
2.0 IC engines 128
2.1 Selection of Material for IC Engine Components 129
2.2 IC Engine Cylinder and Liners 129
2.3 Design of Cylinder 131
2.4 Design of Cylinder Head and Studs 136
2.5 Solved Examples 138
2.6 Piston 149
2.7 Design Requirements for a Piston 150
2.8 Piston Materials 150
2.9 Piston Head Thickness 151
2.10 Piston Ribs and Piston Cup 154
2.11 Piston Rings 155
2.12 Piston Pins 159
2.13 Solved Examples 162
2.14 Design of Connecting Rods 178
2.15 Stresses in a Connecting rod 179
2.16 Solved Examples 183

2.17 Connecting Rod Ends 187
2.18 Solved Examples 191
2.19 Crank Shaft 202
2.20 Crank shaft Materials 204
2.21 Design Criteria of Crank Shaft 204
2.22 Centre Crank Analysis at Top Dead Centre Position 205
2.23 Centre Crank Analysis at Angle of Maximum Torque 211
2.24 Solved Example 220
2.25 Side Crank Analysis at Top Dead Centre Position 237
2.26 Side Crank Analysis at Angle of Maximum Torque 241
2.27 Solved Example 246
2.28 Valve Gear System 259
2.29 Design of Valves 260
2.30 Design of Rocker Arm 264
2.31 Design of Tappet 272
2.32 Design of Valve Spring 273
2.33 Design of Push Rods 277
2.34 Cam and Followers 278
2.35 Solved Examples 284
Exercises ? 315
Problems 318



Chapter 3
Optimum Design 323 - 376

3.1 Optimum and Adequate Design 324
3.2 Johnson's Method of Optimum Design 325
3.3 Case of Normal Specifications 326
3.4 Solved Examples 326
3.5 Case of Redundant Specifications 354
3.6 Solved Examples 354
3.7 Case of Incompatible Specifications 374
3.8 Solved Example 374
Exercises ? 376



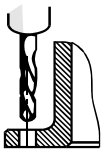
Chapter 4
Statistical Considerations in Design 377 - 436

4.1 Statistics and Design 378
4.2 Variance, Standard Deviation & Standardised Variable 380
4.3 Solved Example 381
4.4 Normal Distribution or Gaussian Distribution 382
4.5 Confidence Intervals 384
4.6 Solved Examples 384
4.7 Population Combinations 390
4.8 Design and Natural Tolerances 393
4.9 Solved Examples 395
4.10 Mechanical Reliability 410
4.11 Solved Examples 413
4.12 Statistical Considerations for Factor of Safety 415
4.13 Solved Examples 417
Exercises ? 433
Problems 434

Chapter 5
Aesthetics and Ergonomics in Design 437 - 456

5.1 Aesthetics in Product Design 438
5.2 Basic Type of Product Forms 438
5.3 Designing for Appearance 439
5.4 Ergonomics in Design 441
5.5 Man-Machine Closed Loop System 442
5.6 Design Considerations in Displays 445
5.7 Design Considerations in Controls 449

5.8 Layout of Panels 453
5.9 Characteristics of A Human 455
5.10 General Workplace Environment 455
Exercises ? 456



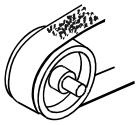
Chapter 6
Design for Manufacture, Assembly and Safety 457 - 485

6.1 Introduction 458
6.2 Principles of Design for Manufacture and Assembly 458
6.3 Design Principles in Castings 460
6.4 Design Principles in Forgings 469
6.5 Design Principles in Machining 473
6.6 Design Principles in Powder Metallurgy 477
6.7 Design Principles in Welding 479
6.8 Design for Safety 483
Exercises ? 484

Chapter 7
Design of Machine Tool Gear Box 486 - 589

7.1 Introduction 487
7.2 Basic Considerations in Design of Drives 488
7.3 Determination of Variable Speed Range 489
7.4 Advantages of Geometric Progression 495
7.5 Preliminary Steps in the Design of Multi-speed Gear Box 498
7.6 Concept of a Structure Diagram 507
7.7 Selection of the Best Structure Diagram 514
7.8 Solved Examples 517

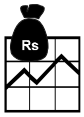
7.9 Graphical Representation of Ray and Speed Diagram 524
7.10 Solved Examples 530
7.11 Rules and Guidelines for Gear box Layout 541
7.12 Solved Examples 546
7.13 Analysis of Composite Twelve speed gear box 581
Exercises ? 586
Problems 587



Chapter 8
Design of Material Handling System 590 - 694

8.1 Introduction to Material Handling 591
8.2 System Concept for Material Handling 591
8.3 Basic Objectives of Material Handling System 591
8.4 Types of Load 592
8.5 Classification of Material Handling Equipment 595
8.6 Hoisting Equipment 595
8.7 Conveying Equipment 599
8.8 Surface and Over Head Equipment 602
8.9 Basic Principles in Selection of Material Handling Equipment 602
8.10 Belt Conveyors 604
8.11 Advantages of a Belt Conveyor over other Conveyors 607
8.12 Types of Belt Conveyor Layouts 607
8.13 Methods of Loading and Discharging of Conveyors 608
8.14 Requirements of the Belt used in a Conveyor System 613
8.15 Constructional Details of a Conveyor Belt 614
8.16 Conveyor Pulleys 619
8.17 Belt Take-up Devices 626
8.18 Belt Cleaning Devices 629
8.19 Drive Unit for Belt Conveyors 631
8.20 Important Terms for Conveyor Design 633
8.21 Solved Examples 640
8.22 Estimated Power Requirements of Belt Conveyors 649
8.23 Force Analysis in Belt Conveyors 650

8.24 Number of plies in a belt 661
8.25 Conveyer Belt Sags 662
8.26 Solved Examples 663
8.27 Introduction to the Design of Cranes 687
Exercises ? 690
Problems 691



Chapter 9
System Failures and other Aspects of Design **695 - 710**

9.1 Defects and System Failure 696
9.2 Hardware and Software Failures 696
9.3 Human Failure 697
9.4 Organisational Failure 698
9.5 Failure Analysis and Reporting 698
9.6 Mechanical Reliability 700
9.7 Factor of Safety 701
9.8 Design of Experiments (DOE) 702
9.9 Other Aspects of Design - Cost Estimation 702
9.10 Concurrent Engineering 705
9.11 Reverse Engineering 706
9.12 Design for Patents 707

Appendix **i - xiv**

A1. ISO Metric Screw Threads - Fine and Course Series ii
A2. Materials and Their Properties iii
Table A2-1 : Physical Constants of Typical Materials iii
Table A2-2 : Properties of Cast Iron iv
Table A2-3 : Properties and Applications of Typical Steels .. iv

Table A2-4 : Properties of Stainless and Heat Resistant Steels v
Table A2-5 : Properties of General Use Cast Steels vii
Table A2-6 : Properties of High Tensile Cast Steels vii
Table A2-7 : Properties and Typical Uses of Aluminium Wrought Alloys vii
Table A2-8 : Properties and Typical Uses of Aluminium Cast Alloys viii
Table A2-9 : Typical Copper Alloys and their Applications. .. ix
Table A2-10 : Physical Properties of Brass x
A3. Plates xi

Alphabetical Index ***xv - xxi***