

contents

Foreword	<i>xiii</i>
Preface	<i>xv</i>

chapter 1

GEAR-DESIGN TRENDS	<i>1.1</i>
Manufacturing Trends	<i>1.4</i>
1.1 Small, Low-Cost Gears for Toys, Gadgets, and Mechanisms	<i>1.5</i>
1.2 Appliance Gears	<i>1.7</i>
1.3 Machine Tools	<i>1.9</i>
1.4 Control Gears	<i>1.9</i>
1.5 Vehicle Gears	<i>1.12</i>
1.6 Transportation Gears	<i>1.14</i>
1.7 Marine Gears	<i>1.16</i>
1.8 Aerospace Gears	<i>1.19</i>
1.9 Industrial Gearing	<i>1.21</i>
1.10 Gears in the Oil and Gas Industry	<i>1.23</i>
1.11 Mill Gears	<i>1.24</i>

	Selection of the Right Kind of Gear	1.26
1.12	External Spur Gears	1.27
1.13	External Helical Gears	1.30
1.14	Internal Gears	1.31
1.15	Straight Bevel Gears	1.33
1.16	Zerol Bevel Gears	1.36
1.17	Spiral Bevel Gears	1.37
1.18	Hypoid Gears	1.38
1.19	Face Gears	1.40
1.20	Crossed-Helical Gears (Nonenveloping Worm Gears)	1.41
1.21	Single-Enveloping Worm Gears	1.43
1.22	Double-Enveloping Worm Gears	1.47
1.23	Spiroid Gears	1.49

chapter 2**PRELIMINARY DESIGN CONSIDERATIONS** 2.1

	Stress Formulas	2.1
2.1	Calculated Stresses	2.4
2.2	Gear-Design Limits	2.5
2.3	Gear-Strength Calculations	2.7
2.4	Gear Surface-Durability Calculations	2.14
2.5	Gear Scoring	2.24
2.6	Thermal Limits	2.32
	Preliminary Estimate of Gear Size	2.34
2.7	Gear Specifications	2.35
2.8	Size of Spur and Helical Gears by Q -Factor Method	2.36
2.9	Indexes of Tooth Loading	2.41
2.10	Estimating Spur- and Helical-Gear Size by K -Factor	2.44
2.11	Estimating Bevel-Gear Size	2.47
2.12	Estimating Worm-Gear Size	2.51
2.13	Estimating Spiroid-Gear Size	2.53
	Data Needed for Gear Drawings	2.55
2.14	Gear Dimensional Data	2.55
2.15	Gear-Tooth Tolerances	2.65
2.16	Gear Material and Heat Treat Data	2.67
2.17	Enclosed Gear Unit Requirements	2.68

chapter 3**DESIGN FORMULAS** 3.1

	Calculation of Gear-Tooth Data	3.1
3.1	Number of Pinion Teeth	3.3
3.2	Hunting Teeth	3.8
3.3	Spur-Gear-Tooth Proportions	3.9
3.4	Root Fillet Radii of Curvature	3.12

3.5	Long-Addendum Pinions	3.14
3.6	Tooth Thickness	3.19
3.7	Chordal Dimensions	3.21
3.8	Degrees Roll and Limit Diameter	3.23
3.9	Form Diameter and Contact Ratio	3.29
3.10	Spur-Gear Dimension Sheet	3.31
3.11	Internal-Gear Dimension Sheet	3.33
3.12	Helical-Gear Tooth Proportions	3.39
3.13	Helical-Gear Dimension Sheet	3.43
3.14	Bevel-Gear Tooth Proportions	3.45
3.15	Straight-Bevel-Gear Dimension Sheet	3.51
3.16	Spiral-Bevel-Gear Dimension Sheet	3.54
3.17	Zerol-Bevel-Gear Dimension Sheet	3.56
3.18	Hypoid-Gear Calculations	3.58
3.19	Face-Gear Calculations	3.59
3.20	Crossed-Helical-Gear Proportions	3.62
3.21	Single-Enveloping-Worm-Gear Proportions	3.65
3.22	Single-Enveloping Worm Gears	3.66
3.23	Double-Enveloping Worm Gears	3.69
	Gear-Rating Practice	3.73
3.24	General Considerations in Rating Calculations	3.74
3.25	General Formulas for Tooth Bending Strength and Tooth Surface Durability	3.78
3.26	Geometry Factors for Strength	3.88
3.27	Overall Derating Factor for Strength	3.93
3.28	Geometry Factors for Durability	3.108
3.29	Overall Derating Factor for Surface Durability	3.112
3.30	Load Rating of Worm Gearing	3.115
3.31	Design Formulas for Scoring	3.128
3.32	Trade Standards for Rating Gears	3.141
3.33	Vehicle Gear-Rating Practice	3.143
3.34	Marine Gear-Rating Practice	3.146
3.35	Oil and Gas Industry Gear Rating	3.148
3.36	Aerospace Gear-Rating Practices	3.150

chapter 4

GEAR MATERIALS	4.1	
Steels for Gears	4.4	
4.1	Mechanical Properties	4.5
4.2	Heat-Treating Techniques	4.6
4.3	Heat-Treating Data	4.11
4.4	Hardness Tests	4.13
	Localized Hardening of Gear Teeth	4.16
4.5	Carburizing	4.17
4.6	Nitriding	4.24
4.7	Induction Hardening of Steel	4.30
4.8	Flame Hardening of Steel	4.38

x CONTENTS

4.9	Combined Heat Treatments	4.39
4.10	Metallurgical Quality of Steel Gears	4.40
	Cast Irons for Gears	4.47
4.11	Gray Cast Iron	4.48
4.12	Ductile Iron	4.51
4.13	Sintered Iron	4.52
	Nonferrous Gear Metals	4.53
4.14	Kinds of Bronze	4.54
4.15	Standard Gear Bronzes	4.57
	Nonmetallic Gears	4.57
4.16	Thermosetting Laminates	4.58
4.17	Nylon Gears	4.61

chapter 5

GEAR-MANUFACTURING METHODS 5.1

	Gear-Tooth Cutting	5.3
5.1	Gear Hobbing	5.4
5.2	Shaping—Pinion Cutter	5.10
5.3	Shaping—Rack Cutter	5.16
5.4	Cutting Bevel Gears	5.23
5.5	Gear Milling	5.26
5.6	Broaching Gears	5.31
5.7	Punching Gears	5.34
5.8	G-TRAC Generating	5.36
	Gear Grinding	5.38
5.9	Form Grinding	5.39
5.10	Generating Grinding—Disc Wheel	5.46
5.11	Generating Grinding—Bevel Gears	5.51
5.12	Generating Grinding—Threaded Wheel	5.53
5.13	Thread Grinding	5.57
	Gear Shaving, Rolling, and Honing	5.59
5.14	Rotary Shaving	5.60
5.15	Rack Shaving	5.65
5.16	Gear Rolling	5.66
5.17	Gear Honing	5.70
	Gear Measurement	5.72
5.18	Gear Accuracy Limits	5.73
5.19	Machines to Measure Gears	5.80
	Gear Casting and Forming	5.86
5.20	Cast and Molded Gears	5.86

- 5.21 Sintered Gears 5.88
 5.22 Cold-Drawn Gears and Rolled Worm Threads 5.89

chapter 6**DESIGN OF TOOLS TO MAKE GEAR TEETH 6.1**

- 6.1 Shaper Cutters 6.2
 6.2 Gear Hobs 6.10
 6.3 Spur-Gear Milling Cutters 6.27
 6.4 Worm Milling Cutters and Grinding Wheels 6.29
 6.5 Gear-Shaving Cutters 6.36
 6.6 Punching Tools 6.39
 6.7 Sintering Tools 6.40

chapter 7**THE KINDS AND CAUSES OF GEAR FAILURES 7.1**

- Analysis of Gear-System Problems 7.2
- 7.1 Determining the Problem 7.2
 7.2 Possible Causes of Gear-System Failures 7.3
 7.3 Incompatibility in Gear Systems 7.7
 7.4 Investigation of Gear Systems 7.9
- Analysis of Tooth Failures and Gear Bearing Failures 7.11
- 7.5 Nomenclature of Gear Failure 7.11
 7.6 Tooth Breakage 7.17
 7.7 Pitting of Gear Teeth 7.19
 7.8 Scoring Failures 7.22
 7.9 Wear Failures 7.24
 7.10 Gearbox Bearings 7.28
 7.11 Rolling-Element Bearings 7.29
 7.12 Sliding-Element Bearings 7.32
- Some Causes of Gear Failure other than Excess Transmitted Load 7.35
- 7.13 Overload Gear Failures 7.35
 7.14 Gear Casing Problems 7.37
 7.15 Lubrication Failures 7.39
 7.16 Thermal Problems in Fast-Running Gears 7.47

chapter 8**SPECIAL DESIGN PROBLEMS 8.1**

- 8.1 Center Distance Problems 8.1
 8.2 Profile Modification Problems 8.12
 8.3 Load Rating Problem 8.22

chapter 9**APPENDIX MATERIAL 9.1**

- 9.1** Introduction to Gears (Supplement to Chap. 1) 9.1
- 9.2** Dynamic Load Theory (Supplement to Chap. 2) 9.9
- 9.3** Highest and Lowest Points of Single-Tooth Contact (Supplement to Chaps. 2 and 3) 9.15
- 9.4** Layout of Large Circles by Calculation (Supplement to Chaps. 2 and 3) 9.17
- 9.5** Special Calculations for Spur Gears (Supplement to Chap. 3) 9.19
- 9.6** Special Calculations for Internal Gears (Supplement to Chap. 3) 9.27
- 9.7** Special Calculations for Helical Gears (Supplement to Chap. 3) 9.31
- 9.8** Summary Sheets for Bevel Gears (Supplement to Chap. 3) 9.36
- 9.9** Complete AGMA and ISO Formulas for Bending Strength and Surface Durability (Supplement to Chap. 3) 9.37
- 9.10** Profile Modification Calculation Procedure (Supplement to Chap. 3) 9.48
- 9.11** The Basics of Gear-Tooth Measurement for Accuracy and Size (Supplement to Chap. 5) 9.50
- 9.12** Shaper-Cutter Tooth Thickness (Supplement to Chap. 6) 9.54
- 9.13** General Method for Determining Tooth Thicknesses When Helical Gears Are Operated on Spread Centers (Supplement to Chap. 8) 9.59
- 9.14** Calculation of Geometry Factor for Scoring (Supplement to Chap. 3) 9.63

References

Index