

时代教育·国外高校优秀教

Mc
Graw
Hill
Education

Shigley's

机械工程设计

(注释版·原书第10版)

Mechanical Engineering Design

[美] 理查德 G. 巴蒂纳斯 (Richard G. Budynas) 著
J. 基斯 尼斯比特 (J. Keith Nisbett) 著
朱殿华 注释



机械工业出版社
CHINA MACHINE PRESS



THD2
YB-4

时代教育 国外高校优秀教材精选

Shigley's Mechanical Engineering Design

机械工程设计 (注释版 原书第10版)

[美] 理查德 G. 巴蒂纳斯 (Richard G. Budynas)

J. 基斯 尼斯比特 (J. Keith Nisbett)

著

常州大学图书馆
藏书章

朱殿华 注释



RFID

机械工业出版社

Richard. G. Budynas, J. Keith Nisbett
Shigley's mechanical Engineering Design
ISBN 9780073398204

Copyright © 2014 by McGraw-Hill Education.

All Rights reserved. No part of this publication may be reproduced or transmitted in any form or by any means, electronic or mechanical, including without limitation photocopying, recording, taping, or any database, information or retrieval system, without the prior written permission of the publisher.

This authorized English reprint is jointly published by McGraw-Hill Education and China Machine Press. This edition is authorized for sale in the People's Republic of China only, excluding Hong Kong, Macao SAR and Taiwan.

Copyright © 2016 by McGraw-Hill Education and China Machine Press.

版权所有。未经出版人事先书面许可，对本出版物的任何部分不得以任何方式或途径复制或传播，包括但不限于复印、录制、录音，或者通过任何数据库、信息或可检索的系统。

本授权影印版由麦格劳-希尔（亚洲）教育出版公司和机械工业出版社合作出版。此版本经授权仅限在中华人民共和国境内（不包括香港特别行政区、澳门特别行政区和台湾地区）销售。

版权©2016 由麦格劳-希尔（亚洲）教育出版公司与机械工业出版社所有。

本书封面贴有 McGraw-Hill Education 公司防伪标签，无标签者不得销售。

北京市版权局著作权合同登记 图字：01-2014-7073 号。

采用该书作教材的教师可向 McGraw-Hill Education 麦格劳-希尔教育出版公司北京代表处联系索取教学课件资料，
传真：010-59575582，电子邮件：instructorchina @ mcgraw-hill. com。

图书在版编目（CIP）数据

机械工程设计 = Shigley's Mechanical Engineering Design: 注释版: 原书第 10 版: 英文/(美)巴蒂纳斯 (Budynas, R. G.), (美)尼斯比特 (Nisbett, J. K.) 著; 朱殿华注释. —北京: 机械工业出版社, 2016. 2
(时代教育·国外高校优秀教材精选)

ISBN 978-7-111-52630-8

I. ①机… II. ①巴…②尼…③朱… III. ①机械设计—计算机辅助设计—高等学校—教材—英文 IV. ①TH122

中国版本图书馆 CIP 数据核字 (2015) 第 311357 号

机械工业出版社 (北京市百万庄大街 22 号 邮政编码 100037)

策划编辑: 余 焱 责任编辑: 丁昕祯

责任校对: 陈 越 封面设计: 张 静

责任印制: 李 洋

三河市宏达印刷有限公司印刷

2016 年 6 月第 1 版第 1 次印刷

204mm × 255mm · 68.5 印张 · 1702 千字

标准书号: ISBN 978-7-111-52630-8

定价: 198.00 元

凡购本书, 如有缺页、倒页、脱页, 由本社发行部调换

电话服务

网络服务

服务咨询热线: 010-88379833 机工官网: www.cmpbook.com

读者购书热线: 010-88379649 机工官博: weibo.com/cmp1952

教育服务网: www.cmpedu.com

封面无防伪标均为盗版

金书网: www.golden-book.com

Dedication

To my wife, Joanne, my family, and my late brother, Bill, who advised me to enter the field of mechanical engineering. In many respects, Bill had considerable insight, skill, and inventiveness.

Richard G. Budynas

To my wife, Kim, for her unwavering support.

J. Keith Nisbett

Dedication to Joseph Edward Shigley

Joseph Edward Shigley (1909–1994) is undoubtedly one of the most well-known and respected contributors in machine design education. He authored or coauthored eight books, including *Theory of Machines and Mechanisms* (with John J. Uicker, Jr.), and *Applied Mechanics of Materials*. He was coeditor-in-chief of the well-known *Standard Handbook of Machine Design*. He began *Machine Design* as sole author in 1956, and it evolved into *Mechanical Engineering Design*, setting the model for such textbooks. He contributed to the first five editions of this text, along with coauthors Larry Mitchell and Charles Mischke. Uncounted numbers of students across the world got their first taste of machine design with Shigley's textbook, which has literally become a classic. Nearly every mechanical engineer for the past half century has referenced terminology, equations, or procedures as being from "Shigley." McGraw-Hill is honored to have worked with Professor Shigley for more than 40 years, and as a tribute to his lasting contribution to this textbook, its title officially reflects what many have already come to call it—*Shigley's Mechanical Engineering Design*.

Having received a bachelor's degree in Electrical and Mechanical Engineering from Purdue University and a master of science in Engineering Mechanics from the University of Michigan, Professor Shigley pursued an academic career at Clemson College from 1936 through 1954. This led to his position as professor and head of Mechanical Design and Drawing at Clemson College. He joined the faculty of the Department of Mechanical Engineering of the University of Michigan in 1956, where he remained for 22 years until his retirement in 1978.

Professor Shigley was granted the rank of Fellow of the American Society of Mechanical Engineers in 1968. He received the ASME Mechanisms Committee Award in 1974, the Worcester Reed Warner Medal for outstanding contribution to the permanent literature of engineering in 1977, and the ASME Machine Design Award in 1985.

Joseph Edward Shigley indeed made a difference. His legacy shall continue.

About the Authors

Richard G. Budynas is Professor Emeritus of the Kate Gleason College of Engineering at Rochester Institute of Technology. He has more than 50 years experience in teaching and practicing mechanical engineering design. He is the author of a McGraw-Hill textbook, *Advanced Strength and Applied Stress Analysis*, Second Edition; and coauthor of a McGraw-Hill reference book, *Roark's Formulas for Stress and Strain*, Eighth Edition. He was awarded the BME of Union College, MSME of the University of Rochester, and the PhD of the University of Massachusetts. He is a licensed Professional Engineer in the state of New York.

J. Keith Nisbett is an Associate Professor and Associate Chair of Mechanical Engineering at the Missouri University of Science and Technology. He has more than 30 years of experience with using and teaching from this classic textbook. As demonstrated by a steady stream of teaching awards, including the Governor's Award for Teaching Excellence, he is devoted to finding ways of communicating concepts to the students. He was awarded the BS, MS, and PhD of the University of Texas at Arlington.

前言

本书的写作目的

本书针对那些刚刚开始学习机械工程设计的学⽣，核⼼内容就是将工程实际中的零件设计规范与相应概念的基本发展状况相融合，引领学⽣逐渐熟悉零件的设计标准、规范及选用依据。因此，对于实现将学⽣逐步培养成设计工程师的目标，本书具有不可替代的作用。本书的写作宗旨如下：

- 涵盖关于机械设计的全部基础知识，包括设计过程，工程力学和工程材料，动载荷和静载荷作用下零部件失效形式的预防，及常用机械零部件的主要特征。
- 针对研究内容提供广泛应用的工程实例及相应解决方案。
- 鼓励、培养学生将设计和分析结合在一起，将基本概念和工程实践中的零件设计规范结合在一起。

新版特色

本书第 10 版对如下内容进行了修订和改进：

- 新增加第 20 章“几何尺寸和公差”。该章是机械设计中的一个重要主题。绝大多数制造企业在机器的设计、生产和质量控制过程中将尺寸和公差（GD&T）做为精确描述零件和装配体的一种标准化手段，但令人遗憾的是，许多机械工程师尚未充分地借助尺寸和公差的相关定义和概念来解读图样。

当几何尺寸和公差在制造业日益盛行之时，许多工程院校正在逐步淘汰复杂的制图课程，倾向于计算机辅助设计教学，后者随后转变为三维（3D）实体建模。在这种建模过程中，零件采用理想化尺寸构建。然而，在采用三维尺寸创建完美零件的这一能力培养过程中，往往缺少从生产和质检的角度来唯一和精确地描述零件的思想，这实在是令人感到惋惜！

要充分理解和掌握几何尺寸和公差方面的知识，就必须经过完整系统的课程学习或培训。一些工程师也许会从严格的培训计划中获益，然而所有的机械工程师都必须熟悉尺寸和公差方面的基本定义和概念。本书第 20 章的内容旨在为所有的机械设计师提供此方面必备的基础知识。

在一门课程中，教材附加章节的讲授会受到学时限制，为此，本书以适合学⽣自学的方式来编排附加章节。每章后面均附有习题，这些习题旨在检查学⽣对一些最基本概念的理解程度。教师可以将附加章节作为一项课后作业提供给学生，同时给予少量讲解或课后讨论，当然，每章中也提供了大量内容用于扩展讨论和演示。

- 在第 1 章“机械工程设计导论”中，在设计实践方面做了扩充。对设计要素进行了进一步阐述，同时，也对设计要素中的可靠度和失效概率间存在的统计学关系进行了描述。这与上一版中将设计过程中的统计学要素作为最后一章内容加以描述有所不同。“尺寸和公差”这一节的内容也进行了扩充，着重阐明对产品的尺寸和公差的确定是机械设计过程中至关重要的一部分内容。

- 新版中去除了上一版中“统计学计算”一章的内容。此章内容中与新版保持一致的相关统计学知识已包括在新版中有关统计学的相关章节中。同样，新版中删去了包含在上一版第 6 章“变载荷作用下的疲劳失效”中有关随机方法这一节内容，这样做的原因是基于读者反馈和作者的深入考虑：该

节包含了过多的内容和数据，这对解决那些简单的设计问题反而无益。

在第 11 章“滚动轴承”中，将韦布尔概率分布引入到轴承寿命计算过程中。

为了更好地与工程实际衔接，新版对每章后的习题进行了重新检查，以确保这些习题都已得到清晰描述。差不多一半的习题设计用于解决工程实际问题，新版的习题中也配置了许多开放性的题目以供读者去探索和设计。

与工程衔接

新版将继续彰显麦格劳-希尔与工程衔接的教育特色——提供作业布置和评价平台，借助此平台教师可轻松实现在线作业、测验和测试。学生们则可根据自己的进度安排进行在线学习以获得重要的技能锻炼机会。遗憾的是，使用本引进教材的国内读者，暂时无法进行在线学习。

麦格劳-希尔的 LearnSmart

麦格劳-希尔的 LearnSmart 是一个可以帮助学生快速高效学习的自适应学习系统。学生可借助此系统获得更多的知识以走向更大的成功。通过解答一系列自适应性问题，LearnSmart 能准确获知每个学生的学习水平，并为每个学生定制个性化学习计划，教师亦可通过该系统获知学生的学习动态。因此，可将该系统视为一个按等级分配作业的内在评价系统。读者可咨询当地的麦格劳-希尔销售代表获得重要信息，也可通过访问网址：www.mhlearnsmart.com 观看该系统演示。同样的，国内读者暂时也享受不到本项服务。

麦格劳-希尔的 SmartBook

借助智能自适应引擎 LearnSmart，麦格劳-希尔的 SmartBook 将为该系统的使用者提供绝无仅有的可持续性阅读体验。SmartBook 把学生已掌握的知识和尚未掌握的知识区分开来，不断地夯实学生最可能遗忘的基本概念，并为每个学生定制个性化的阅读内容。使用 SmartBook，可将阅读过程由被动的体验转变为一个充满活力的、令人振奋的过程。在这一过程中，学生将掌握更多的重要知识，为走入课堂做好充分的准备。SmartBook 包括功能强大的报告，这些报告囊括了学生学习所需的特定题目和学习目标。借助这些报告，教师可以洞察学生对书本知识的掌握情况，感受班级动态，提高课堂利用率，与学生单独互动并对学生成绩进行评估。

SmartBook 是如何工作的？每一个 SmartBook 包括四个组件：预览、阅读、练习和巩固练习。首先，通过预览每章内容和关键学习目标，学生们学习相关内容。接下来，根据 SmartBook 持续提供的自适应诊断结果，学生们被引导到他们最需要练习的主题进行阅读和练习，直到 SmartBook 引导他们进入巩固练习阶段，该阶段针对学生最可能忘记的重要内容进行加强练习，以保证重要的概念已被学生掌握和牢记。

麦格劳-希尔的 CreateTM

使用该功能可以帮助读者轻松实现章节重排、多资源内容衔接和快速上传读者自行编写的教学大纲、讲义等内容。可以借助 Create 查找成千上万本麦格劳-希尔的相关教材，编排适合自己风格的教材。该功能甚至可以通过挑选封面和在封面上添加署名、学校和课程信息的方式实现个性化教材展现。

教师可在网 (www.mcgrawhillcreate.com) 上体验麦格劳-希尔 Create™ 下的个性化教学定制过程。

在网站中 (www.mhhe.com/shigley) 还可看到如下媒体产品信息:

学生辅助学习内容

- 机械设计师工程基础 (FE) 考试题目。为学生提供交互性的习题及答案, 这些题目以自测题的形式提供给学生, 为参加 FE 考试做好充分准备。

教师辅助教学内容

- 解题手册。该手册向教师提供每章课后非设计类题目的习题答案。
- PowerPoint 幻灯片。这些幻灯片涵盖课程大纲内容, 包括本书中列出的所有的图、表和方程。教师可在这些幻灯片的基础上开展课堂讲解。
- C. O. S. M. O. S. 这是一个完整的在线组织式解题手册系统。教师可使用该系统进行常规作业的布置、小测验以及使用每章课后习题进行考试。

当然, 本项服务仅在美国本土提供, 其他教材引进国家暂时无法体验。

致谢

本书第 10 版出版之际, 作者谨向 50 年来一直致力于本书第 10 版及前 9 版出版工作的所有人员致以诚挚的谢意! 本书第 10 版编写过程中, 加州州立大学的 Peter J. Schuster 完成了本书的扩展部分, 高科技制造有限公司的 Glenn Traner 完成了本书第 20 章的绘图工作, 西英格兰大学的 Jędrzej Galecki 完成了原版书封面 CAD 模型的设计工作。参与本书审阅的全体人员包括亚利桑那州的 Kenneth Huebner、艾奥瓦州的 Gloria Starns、麦吉尔大学的 Tim Lee、密尔沃基工学院的 Robert Rizza、密西西比州立大学 Richard Patton、罗切斯特理工学院的 Stephen Boedo、伊利诺伊大学的 Om Agrawal、得克萨斯州农工大学的 Arun Srinivasa、阿尔伯塔大学的 Jason Carey、匹兹堡大学的 Patrick Smolinski 和弗吉尼亚理工大学的 Dennis Hong, 以及为本书在中国顺利出版而进行注释工作的天津大学朱殿华。在此, 作者对上述人员在参与本书出版过程中所做出的卓有成效的工作致以特别感谢!

符号说明

\mathcal{L}	Life in hours
l	Length
M	Fundamental dimension mass, moment
\mathbf{M}	Moment vector
m	Mass, slope, strain-strengthening exponent
N	Normal force, number, rotational speed, number of cycles
n	Load factor, rotational speed, factor of safety
n_d	Design factor
P	Force, pressure, diametral pitch
PDF	Probability density function
p	Pitch, pressure, probability
Q	First moment of area, imaginary force, volume
q	Distributed load, notch sensitivity
R	Radius, reaction force, reliability, Rockwell hardness, stress ratio, reduction in area
\mathbf{R}	Vector reaction force
r	Radius
\mathbf{r}	Distance vector
S	Sommerfeld number, strength
s	Distance, sample standard deviation, stress
T	Temperature, tolerance, torque, fundamental dimension time
\mathbf{T}	Torque vector
t	Distance, time, tolerance
U	Strain energy
u	Strain energy per unit volume
V	Linear velocity, shear force
v	Linear velocity
W	Cold-work factor, load, weight
w	Distance, gap, load intensity
X	Coordinate, truncated number
x	Coordinate, true value of a number, Weibull parameter
Y	Coordinate
y	Coordinate, deflection
Z	Coordinate, section modulus, viscosity
z	Coordinate, dimensionless transform variable for normal distributions
α	Coefficient, coefficient of linear thermal expansion, end-condition for springs, thread angle
β	Bearing angle, coefficient
Δ	Change, deflection
δ	Deviation, elongation
ϵ	Eccentricity ratio, engineering (normal) strain
ε	True or logarithmic normal strain
Γ	Gamma function, pitch angle

γ	Pitch angle, shear strain, specific weight
λ	Slenderness ratio for springs
μ	Absolute viscosity, population mean
ν	Poisson ratio
ω	Angular velocity, circular frequency
ϕ	Angle, wave length
ψ	Slope integral
ρ	Radius of curvature, mass density
σ	Normal stress
σ'	Von Mises stress
$\hat{\sigma}$	Standard deviation
τ	Shear stress
θ	Angle, Weibull characteristic parameter
ϕ	Cost per unit weight
$\$$	Cost

Preface vi

Part 1 Basics 2

1 Introduction to Mechanical Engineering Design 3

- 1-1 Design 4
- 1-2 Mechanical Engineering Design 5
- 1-3 Phases and Interactions of the Design Process 5
- 1-4 Design Tools and Resources 8
- 1-5 The Design Engineer's Professional Responsibilities 10
- 1-6 Standards and Codes 12
- 1-7 Economics 13
- 1-8 Safety and Product Liability 15
- 1-9 Stress and Strength 16
- 1-10 Uncertainty 16
- 1-11 Design Factor and Factor of Safety 18
- 1-12 Reliability and Probability of Failure 20
- 1-13 Relating Design Factor to Reliability 24
- 1-14 Dimensions and Tolerances 27
- 1-15 Units 31
- 1-16 Calculations and Significant Figures 32
- 1-17 Design Topic Interdependencies 33
- 1-18 Power Transmission Case Study Specifications 34
- Problems 36

2 Materials 41

- 2-1 Material Strength and Stiffness 42
- 2-2 The Statistical Significance of Material Properties 46
- 2-3 Strength and Cold Work 49
- 2-4 Hardness 52

- 2-5 Impact Properties 53
- 2-6 Temperature Effects 54
- 2-7 Numbering Systems 56
- 2-8 Sand Casting 57
- 2-9 Shell Molding 57
- 2-10 Investment Casting 58
- 2-11 Powder-Metallurgy Process 58
- 2-12 Hot-Working Processes 58
- 2-13 Cold-Working Processes 59
- 2-14 The Heat Treatment of Steel 60
- 2-15 Alloy Steels 63
- 2-16 Corrosion-Resistant Steels 64
- 2-17 Casting Materials 65
- 2-18 Nonferrous Metals 67
- 2-19 Plastics 70
- 2-20 Composite Materials 71
- 2-21 Materials Selection 72
- Problems 79

3 Load and Stress Analysis 85

- 3-1 Equilibrium and Free-Body Diagrams 86
- 3-2 Shear Force and Bending Moments in Beams 89
- 3-3 Singularity Functions 91
- 3-4 Stress 93
- 3-5 Cartesian Stress Components 93
- 3-6 Mohr's Circle for Plane Stress 94
- 3-7 General Three-Dimensional Stress 100
- 3-8 Elastic Strain 101
- 3-9 Uniformly Distributed Stresses 102
- 3-10 Normal Stresses for Beams in Bending 103
- 3-11 Shear Stresses for Beams in Bending 108
- 3-12 Torsion 115
- 3-13 Stress Concentration 124

3-14	Stresses in Pressurized Cylinders	127
3-15	Stresses in Rotating Rings	129
3-16	Press and Shrink Fits	130
3-17	Temperature Effects	131
3-18	Curved Beams in Bending	132
3-19	Contact Stresses	136
3-20	Summary	140
	Problems	141

4 Deflection and Stiffness 161

4-1	Spring Rates	162
4-2	Tension, Compression, and Torsion	163
4-3	Deflection Due to Bending	164
4-4	Beam Deflection Methods	166
4-5	Beam Deflections by Superposition	167
4-6	Beam Deflections by Singularity Functions	170
4-7	Strain Energy	176
4-8	Castigliano's Theorem	178
4-9	Deflection of Curved Members	183
4-10	Statically Indeterminate Problems	189
4-11	Compression Members—General	195
4-12	Long Columns with Central Loading	195
4-13	Intermediate-Length Columns with Central Loading	198
4-14	Columns with Eccentric Loading	198
4-15	Struts or Short Compression Members	200
4-16	Elastic Stability	204
4-17	Shock and Impact	205
	Problems	206

Part 2 Failure Prevention 226

5 Failures Resulting from Static Loading 227

5-1	Static Strength	230
5-2	Stress Concentration	231
5-3	Failure Theories	233
5-4	Maximum-Shear-Stress Theory for Ductile Materials	233

5-5	Distortion-Energy Theory for Ductile Materials	235
5-6	Coulomb-Mohr Theory for Ductile Materials	241
5-7	Failure of Ductile Materials Summary	244
5-8	Maximum-Normal-Stress Theory for Brittle Materials	249
5-9	Modifications of the Mohr Theory for Brittle Materials	249
5-10	Failure of Brittle Materials Summary	252
5-11	Selection of Failure Criteria	252
5-12	Introduction to Fracture Mechanics	253
5-13	Important Design Equations	262
	Problems	264

6 Fatigue Failure Resulting from Variable Loading 273

6-1	Introduction to Fatigue in Metals	274
6-2	Approach to Fatigue Failure in Analysis and Design	280
6-3	Fatigue-Life Methods	281
6-4	The Stress-Life Method	281
6-5	The Strain-Life Method	284
6-6	The Linear-Elastic Fracture Mechanics Method	286
6-7	The Endurance Limit	290
6-8	Fatigue Strength	291
6-9	Endurance Limit Modifying Factors	294
6-10	Stress Concentration and Notch Sensitivity	303
6-11	Characterizing Fluctuating Stresses	308
6-12	Fatigue Failure Criteria for Fluctuating Stress	311
6-13	Torsional Fatigue Strength under Fluctuating Stresses	325
6-14	Combinations of Loading Modes	325
6-15	Varying, Fluctuating Stresses; Cumulative Fatigue Damage	329
6-16	Surface Fatigue Strength	335
6-17	Road Maps and Important Design Equations for the Stress-Life Method	338
	Problems	341

Part 3 Design of Mechanical Elements 350

7 Shafts and Shaft Components 351

- 7-1 Introduction 352
- 7-2 Shaft Materials 352
- 7-3 Shaft Layout 353
- 7-4 Shaft Design for Stress 358
- 7-5 Deflection Considerations 371
- 7-6 Critical Speeds for Shafts 375
- 7-7 Miscellaneous Shaft Components 380
- 7-8 Limits and Fits 387
- Problems 392

8 Screws, Fasteners, and the Design of Nonpermanent Joints 401

- 8-1 Thread Standards and Definitions 402
- 8-2 The Mechanics of Power Screws 406
- 8-3 Threaded Fasteners 414
- 8-4 Joints—Fastener Stiffness 416
- 8-5 Joints—Member Stiffness 419
- 8-6 Bolt Strength 424
- 8-7 Tension Joints—The External Load 427
- 8-8 Relating Bolt Torque to Bolt Tension 429
- 8-9 Statically Loaded Tension Joint with Preload 432
- 8-10 Gasketed Joints 436
- 8-11 Fatigue Loading of Tension Joints 436
- 8-12 Bolted and Riveted Joints Loaded in Shear 443
- Problems 451

9 Welding, Bonding, and the Design of Permanent Joints 467

- 9-1 Welding Symbols 468
- 9-2 Butt and Fillet Welds 470
- 9-3 Stresses in Welded Joints in Torsion 474
- 9-4 Stresses in Welded Joints in Bending 479

- 9-5 The Strength of Welded Joints 481
- 9-6 Static Loading 484
- 9-7 Fatigue Loading 488
- 9-8 Resistance Welding 490
- 9-9 Adhesive Bonding 490
- Problems 499

10 Mechanical Springs 509

- 10-1 Stresses in Helical Springs 510
- 10-2 The Curvature Effect 511
- 10-3 Deflection of Helical Springs 512
- 10-4 Compression Springs 512
- 10-5 Stability 514
- 10-6 Spring Materials 515
- 10-7 Helical Compression Spring Design for Static Service 520
- 10-8 Critical Frequency of Helical Springs 526
- 10-9 Fatigue Loading of Helical Compression Springs 528
- 10-10 Helical Compression Spring Design for Fatigue Loading 531
- 10-11 Extension Springs 534
- 10-12 Helical Coil Torsion Springs 542
- 10-13 Belleville Springs 549
- 10-14 Miscellaneous Springs 550
- 10-15 Summary 552
- Problems 552

11 Rolling-Contact Bearings 561

- 11-1 Bearing Types 562
- 11-2 Bearing Life 565
- 11-3 Bearing Load Life at Rated Reliability 566
- 11-4 Reliability versus Life—The Weibull Distribution 568
- 11-5 Relating Load, Life, and Reliability 569
- 11-6 Combined Radial and Thrust Loading 571
- 11-7 Variable Loading 577
- 11-8 Selection of Ball and Cylindrical Roller Bearings 580
- 11-9 Selection of Tapered Roller Bearings 582
- 11-10 Design Assessment for Selected Rolling-Contact Bearings 592

- 11-11 Lubrication 596
- 11-12 Mounting and Enclosure 597
- Problems 601

12 Lubrication and Journal Bearings 609

- 12-1 Types of Lubrication 610
- 12-2 Viscosity 611
- 12-3 Petroff's Equation 613
- 12-4 Stable Lubrication 615
- 12-5 Thick-Film Lubrication 616
- 12-6 Hydrodynamic Theory 617
- 12-7 Design Considerations 621
- 12-8 The Relations of the Variables 623
- 12-9 Steady-State Conditions in Self-Contained Bearings 637
- 12-10 Clearance 640
- 12-11 Pressure-Fed Bearings 642
- 12-12 Loads and Materials 648
- 12-13 Bearing Types 650
- 12-14 Thrust Bearings 651
- 12-15 Boundary-Lubricated Bearings 652
- Problems 660

13 Gears—General 665

- 13-1 Types of Gears 666
- 13-2 Nomenclature 667
- 13-3 Conjugate Action 669
- 13-4 Involute Properties 670
- 13-5 Fundamentals 670
- 13-6 Contact Ratio 676
- 13-7 Interference 677
- 13-8 The Forming of Gear Teeth 679
- 13-9 Straight Bevel Gears 682
- 13-10 Parallel Helical Gears 683
- 13-11 Worm Gears 687
- 13-12 Tooth Systems 688
- 13-13 Gear Trains 690
- 13-14 Force Analysis—Spur Gearing 697
- 13-15 Force Analysis—Bevel Gearing 701
- 13-16 Force Analysis—Helical Gearing 704

- 13-17 Force Analysis—Worm Gearing 706
- Problems 712

14 Spur and Helical Gears 725

- 14-1 The Lewis Bending Equation 726
- 14-2 Surface Durability 735
- 14-3 AGMA Stress Equations 737
- 14-4 AGMA Strength Equations 739
- 14-5 Geometry Factors I and J (Z_I and Z_J) 743
- 14-6 The Elastic Coefficient C_p (Z_E) 748
- 14-7 Dynamic Factor K_v 748
- 14-8 Overload Factor K_o 750
- 14-9 Surface Condition Factor C_f (Z_R) 750
- 14-10 Size Factor K_s 751
- 14-11 Load-Distribution Factor K_m (K_H) 751
- 14-12 Hardness-Ratio Factor C_H (Z_W) 753
- 14-13 Stress-Cycle Factors Y_N and Z_N 754
- 14-14 Reliability Factor K_R (Y_Z) 755
- 14-15 Temperature Factor K_T (Y_θ) 756
- 14-16 Rim-Thickness Factor K_B 756
- 14-17 Safety Factors S_F and S_H 757
- 14-18 Analysis 757
- 14-19 Design of a Gear Mesh 767
- Problems 772

15 Bevel and Worm Gears 777

- 15-1 Bevel Gearing—General 778
- 15-2 Bevel-Gear Stresses and Strengths 780
- 15-3 AGMA Equation Factors 783
- 15-4 Straight-Bevel Gear Analysis 795
- 15-5 Design of a Straight-Bevel Gear Mesh 798
- 15-6 Worm Gearing—AGMA Equation 801
- 15-7 Worm-Gear Analysis 805
- 15-8 Designing a Worm-Gear Mesh 808
- 15-9 Buckingham Wear Load 812
- Problems 813

16 Clutches, Brakes, Couplings, and Flywheels 817

- 16-1 Static Analysis of Clutches and Brakes 819
- 16-2 Internal Expanding Rim Clutches and Brakes 824

16-3	External Contracting Rim Clutches and Brakes 832	Part 4	Special Topics 944
16-4	Band-Type Clutches and Brakes 836	19	Finite-Element Analysis 945
16-5	Frictional-Contact Axial Clutches 837	19-1	The Finite-Element Method 947
16-6	Disk Brakes 841	19-2	Element Geometries 949
16-7	Cone Clutches and Brakes 845	19-3	The Finite-Element Solution Process 951
16-8	Energy Considerations 848	19-4	Mesh Generation 954
16-9	Temperature Rise 849	19-5	Load Application 956
16-10	Friction Materials 853	19-6	Boundary Conditions 957
16-11	Miscellaneous Clutches and Couplings 856	19-7	Modeling Techniques 958
16-12	Flywheels 858	19-8	Thermal Stresses 961
	Problems 863	19-9	Critical Buckling Load 961
17	Flexible Mechanical Elements 871	19-10	Vibration Analysis 963
17-1	Belts 872	19-11	Summary 964
17-2	Flat- and Round-Belt Drives 875		Problems 966
17-3	V Belts 890	20	Geometric Dimensioning and Tolerancing 969
17-4	Timing Belts 898	20-1	Dimensioning and Tolerancing Systems 970
17-5	Roller Chain 899	20-2	Definition of Geometric Dimensioning and Tolerancing 971
17-6	Wire Rope 908	20-3	Datums 976
17-7	Flexible Shafts 916	20-4	Controlling Geometric Tolerances 981
	Problems 917	20-5	Geometric Characteristic Definitions 985
18	Power Transmission Case Study 925	20-6	Material Condition Modifiers 994
18-1	Design Sequence for Power Transmission 927	20-7	Practical Implementation 996
18-2	Power and Torque Requirements 928	20-8	GD&T in CAD Models 1001
18-3	Gear Specification 928	20-9	Glossary of GD&T Terms 1002
18-4	Shaft Layout 935		Problems 1005
18-5	Force Analysis 937		Appendixes
18-6	Shaft Material Selection 937	A	Useful Tables 1011
18-7	Shaft Design for Stress 938	B	Answers to Selected Problems 1067
18-8	Shaft Design for Deflection 938		
18-9	Bearing Selection 939		
18-10	Key and Retaining Ring Selection 940		
18-11	Final Analysis 943		
	Problems 943		

目 录

前言

符号说明

第1部分 基础知识 2

第1章 机械工程设计导论 3

- 1-1 设计 4
- 1-2 机械工程设计 5
- 1-3 设计过程中的名词术语 5
- 1-4 设计工具及资源 8
- 1-5 设计工程师的职业责任 10
- 1-6 标准和规范 12
- 1-7 经济性 13
- 1-8 安全性和产品责任 15
- 1-9 应力及强度 16
- 1-10 不确定性 16
- 1-11 设计因子和安全系数 18
- 1-12 可靠性和失效概率 20
- 1-13 可靠性设计中的设计因子 24
- 1-14 尺寸和公差 27
- 1-15 单位 31
- 1-16 计算和有效数字 32
- 1-17 设计方案的关联性 33
- 1-18 动力传动设计案例 34
- 习题 36

第2章 材料 41

- 2-1 材料的强度及刚度 42
- 2-2 材料性能的统计学意义 46
- 2-3 强度和冷加工 49
- 2-4 硬度 52
- 2-5 冲击性能 53
- 2-6 温度的影响 54
- 2-7 代号体系 56
- 2-8 砂型铸造 57
- 2-9 壳型铸造 57
- 2-10 熔模铸造 58

2-11 粉末冶金工艺 58

2-12 热加工工艺 58

2-13 冷加工工艺 59

2-14 钢的热处理 60

2-15 合金钢 63

2-16 耐蚀钢 64

2-17 铸造材料 65

2-18 有色金属 67

2-19 塑料 70

2-20 复合材料 71

2-21 材料选择 72

习题 79

第3章 载荷和应力分析 85

3-1 平衡及受力图 86

3-2 梁的剪力及弯矩 89

3-3 奇异函数 91

3-4 应力 93

3-5 笛卡儿应力分量 93

3-6 平面应力条件下的莫尔圆 94

3-7 三向应力状态 100

3-8 弹性应变 101

3-9 均布应力 102

3-10 弯曲梁的正应力 103

3-11 弯曲梁的剪应力 108

3-12 扭转 115

3-13 应力集中 124

3-14 受压圆柱面应力分析 127

3-15 旋转环中的应力 129

3-16 压装与热装 130

3-17 温度效应 131

3-18 曲梁的弯曲 132

3-19 接触应力 136

3-20 总结 140