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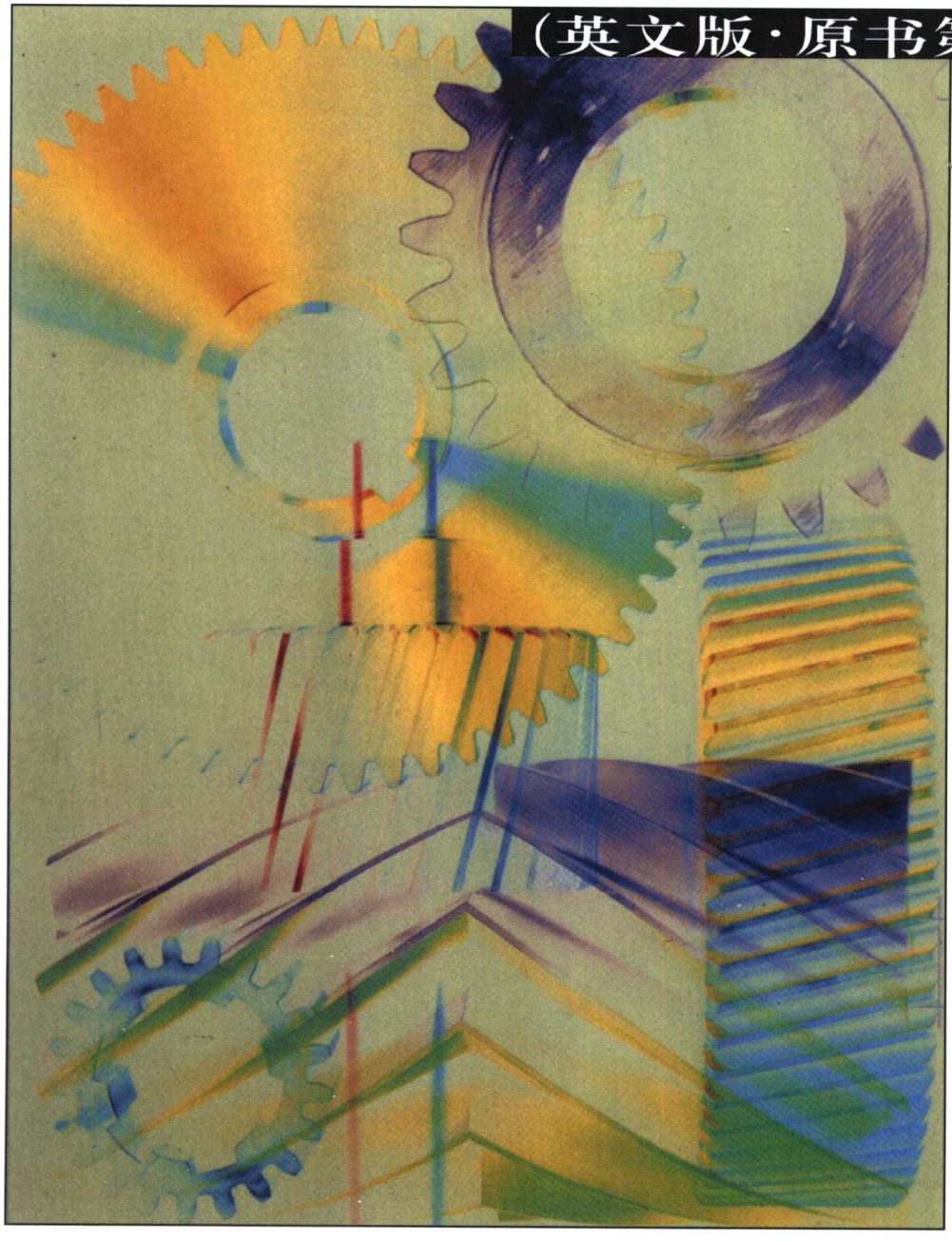
机械设计中的机械零件

Machine Elements in Mechanical Design

（英文版·原书第3版）



（美）罗伯特 L.莫特 （Robert L.Mott）著

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出版说明

随着我国加入WTO，国际间的竞争越来越激烈，而国际间的竞争实际上也就是人才的竞争、教育的竞争。为了加快培养具有国际竞争力的高水平技术人才，加快我国教育改革的步伐，国家教育部近来出台了一系列倡导高校开展双语教学、引进原版教材的政策。以此为契机，机械工业出版社拟于近期推出一系列国外影印版教材，其内容涉及高等学校公共基础课，以及机、电、信息领域的专业基础课和专业课。

引进国外优秀原版教材，在有条件的学校推动开展英语授课或双语教学，自然也引进了先进的教学思想和教学方法，这对提高我国自编教材的水平，加强学生的英语实际应用能力，使我国的高等教育尽快与国际接轨，必将起到积极的推动作用。

为了做好教材的引进工作，机械工业出版社特别成立了由著名专家组成的国外高校优秀教材审定委员会。这些专家对实施双语教学做了深入细致的调查研究，对引进原版教材提出许多建设性意见，并慎重地对每一本将要引进的原版教材一审再审，精选再精选，确认教材本身的质量水平，以及权威性和先进性，以期所引进的原版教材能适应我国学生的外语水平和学习特点。在引进工作中，审定委员会还结合我国高校教学课程体系的设置和要求，对原版教材的教学思想和方法的先进性、科学性严格把关，同时尽量考虑原版教材的系统性和经济性。

这套教材出版后，我们将根据各高校的双语教学计划，举办原版教材的教师培训，及时地将其推荐给各高校选用。希望高校师生在使用教材后及时反馈意见和建议，使我们更好地为教学改革服务。

机械工业出版社

2002年3月

序

本书是美国大学现行的机械设计教材，其内容与我国的机械设计基础教材近似，但有一些增减。本书的内容包括机械设计概论、机械设计中常用材料、材料力学基础、各种载荷下的计算、机械传动设计、其他零件（如弹簧、机架、螺旋、紧固件、联轴器和离合器）、公差与配合、电动机等。其主要特点是：

1. 书中对各零件设计基本理论的论述深入程度较为适当，比较详细地介绍了美国的标准（如螺纹、V带、滚动轴承、润滑剂、常用材料等）、计算方法、材料选择、常用机械零件图的画法等，有利于国家间的技术交流和了解。

2. 本书每章开头有“The Big Picture”、“You Are the Designer”，对该章的生产实际背景和设计中应考虑的主要问题作了一些启发性的提示，可以增加读者学习的主动性并便于应用。

3. 书中共有例题108题，习题832题，较国内一般教材为多。其内容密切联系实际，广泛实用，对使用本书的读者有较大的启发性。

4. 本书习题和例题兼有公制和英制，并给出了适用的换算表，使用很方便。

5. 在我国加入世界贸易组织后，需要了解国外机械设计的发展情况，本书具有一定的代表性和参考价值。

本书可以作为机械工程设计与制造专业的教师、大学生、研究生的教材或教学参考书；对从事机械工程设计、制造、安装、修理、实验工作，以及与国外有相关业务的工程技术人员或管理人员，是一本很好的参考书。本书专业词汇广泛，语言通顺，也可以作为学习工程英语的参考书。

吴宗泽
清华大学精密仪器系
2002年2月

Preface

The objective of this book is to provide the concepts, procedures, data, and decision analysis techniques necessary to design machine elements commonly found in mechanical devices and systems. Students completing a course of study using this book should be able to execute original designs for machine elements and integrate the elements into a system composed of several elements.

This process requires a consideration of the performance requirements of an individual element and of the interfaces between elements as they work together to form a system. For example, a gear must be designed to transmit power at a given speed. The design must specify the number of teeth, pitch, tooth form, face width, pitch diameter, material, and method of heat treatment. But the gear design also affects, and is affected by, the mating gear, the shaft carrying the gear, and the environment in which it is to operate. Furthermore, the shaft must be supported by bearings, which must be contained in a housing. Thus, the designer should keep the complete system in mind while designing each individual element. This book will help the student approach design problems in this way.

This text is designed for those interested in practical mechanical design. The emphasis is on the use of readily available materials and processes and appropriate design approaches to achieve a safe, efficient design. It is assumed that the person using the book will be the designer, that is, the person responsible for determining the configuration of a machine or a part of a machine. Where practical, all design equations, data, and procedures needed to make design decisions are specified.

It is expected that students using this book will have a good background in statics, strength of materials, college algebra, and trigonometry. Helpful, but not required, would be knowledge of kinematics, industrial mechanisms, dynamics, materials, and manufacturing processes.

Among the important features of this book are the following:

1. It is designed to be used at the undergraduate level in a first course in machine design.
2. The large list of topics allows the instructor some choice in the design of the course. The format is also appropriate for a two-course sequence and as a reference for mechanical design project courses.
3. Students should be able to extend their efforts into topics not covered in classroom instruction because explanations of principles are straightforward and include many example problems.
4. The practical presentation of the material leads to feasible design decisions and is useful to practicing designers.
5. The text advocates and demonstrates use of computer spreadsheets in cases requiring long, laborious solution procedures. Using spreadsheets allows the designer to make decisions at several points within the problem while the computer performs all computations; see the chapters on spur gears (Chapter 9), springs (Chapter 19), columns (Chapter 6), shafts (Chapter 12), and shrink fits (Chapter 13).
6. References to other books, standards, and technical papers assist the instructor in presenting alternate approaches or extending the depth of treatment.

7. In addition to the emphasis on original design of machine elements, much of the discussion covers commercially available machine elements and devices, since many design projects require an optimum combination of new, uniquely designed parts and purchased components.
8. For some topics the focus is on aiding the designer in selecting commercially available components, such as rolling contact bearings, flexible couplings, ball screws, electric motors, belt drives, chain drives, clutches, and brakes.
9. Computations and problem solutions use both the International System of Units (SI) and the U.S. Customary System (inch-pound-second) approximately equally. The basic reference for the usage of SI units is Standard E380, *Metric Practice Guide,* issued by the American Society for Testing and Materials (ASTM).
10. Extensive Appendices are included along with detailed tables in many chapters to help the reader to make real design decisions, using only this text.

Features of the Third Edition

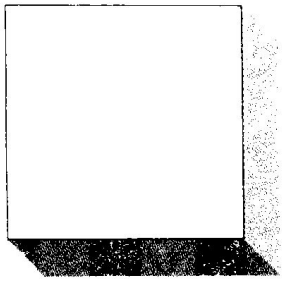
While retaining the practical approach of the first and second editions, this new edition includes several changes: new features have been added; data and techniques have been updated; the presentation has been refined; and the chapters have been reorganized into three parts as described below:

- Each chapter starts with **The Big Picture** (a new feature) to engage the students in a discussion of the many contexts in which the principles in that chapter are used in real, practical design. It draws on the students' own experiences and builds their knowledge of the mechanical design field. It is based on the learning theories that students learn better when they can relate new concepts to past experiences and when they consider the *whole* before tackling the details. It is recommended that instructors use **The Big Picture** to encourage dialogue among the students.
- Each chapter retains the use of the scenario called **You Are the Designer,** in which a specific design assignment is presented that is relevant to the material in that chapter. This feature, initiated in the second edition, focuses the students' thinking from **The Big Picture** to the details of the chapter.
- Each chapter also retains the section called **Objectives of This Chapter,** which describes the competencies that the students will acquire as they complete the chapter.
- The book has been divided into three parts to help students relate chapters to each other and help them envision a cohesive, integrated view of mechanical design.
- Part I, Chapters 1–6, helps students gain an understanding of design philosophies and build on earlier-learned principles of strength of materials, materials science, and manufacturing processes. An extensive coverage of combined stresses and design for different types of loading provides important extensions from the traditional coverage of strength of materials courses, necessary to virtually all following chapters.
- Part II, Chapters 7–15, encompasses the design of machine elements that are typically part of a mechanical power transmission: belt drives and chain drives; gears; keys, couplings, and seals; shafts; and rolling contact bearings. But, more importantly, the chapters are tied together to help students see the interrelationships among the individual elements.

- **Chapter 15, Completion of the Design of the Power Transmission,** takes the student through the complete design of a gear-type speed reducer, from conceptualization, decision analysis, and general layout, to design and analysis of the components, tolerances and fits, applied to critical elements, and detail drawings and specifications of the housing and the major components of the reducer. This is a completely new chapter for the third edition.
- Part III, Chapters 16–22, presents methods of analysis and design of several important machine elements that were not pertinent to the design of the power transmission as presented in Part II. These chapters can be covered in any order or can be used as reference material for general design projects. Covered here are plain surface bearings; power screws and ball screws; fasteners; springs; machine frames, bolted connections, and welded joints; electric motors; and clutches and brakes.
- Chapter 23 briefly outlines 30 design projects that instructors can select to give students practice in the application of their mechanical design skills.

My appreciation is extended to all who provided helpful suggestions for the changes to be made from the second edition. I thank the editorial and production staffs of Prentice Hall Publishing Company, those who provided illustrations, and the many users of the book with whom I have had discussions. Special appreciation goes to my colleagues at the University of Dayton, Professors Philip Doepker and David Myszka, who have used the first and second editions of this book and who have offered constructive suggestions for improvement. I also thank those who reviewed the manuscript: Rich Englund, Pennsylvania State University, Erie-Behrend Campus; and Harvey Hoy, Milwaukee School of Engineering. I especially thank my students—past and present—for their encouragement and their positive response to this book.

Contents



PART I

Principles of Design and Stress Analysis

OBJECTIVES AND CONTENT OF PART I

As you complete the first six chapters of this book, you will gain an understanding of design philosophies, and you will build on earlier-learned principles of strength of materials, materials science, and manufacturing processes. The competencies gained from these chapters are useful throughout the book and in general machine design or product design projects.

Chapter 1: The Nature of Mechanical Design helps you see the big picture of the process of mechanical design. Several examples are shown from different industry sectors: consumer products, manufacturing systems, construction equipment, agricultural equipment, transportation equipment, ships, and space systems. The responsibilities of designers are discussed, along with an illustration of the iterative nature of the design process. Units and conversions complete the chapter.

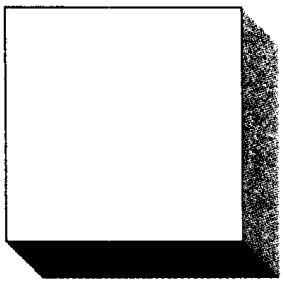
Chapter 2: Materials in Mechanical Design emphasizes the design properties of materials. Much of this chapter is probably review for you, but it is presented here to emphasize the importance of material selection to the design process and to explain the data for materials presented in the Appendices.

Chapter 3: Stress and Deformation Analysis is a review of the basic principles of stress and deflection analysis. It is essential that you understand the basic concepts summarized here before proceeding with later material. Reviewed are direct tensile, compressive, and shearing stresses; bending stresses; and torsional shear stresses.

Chapter 4: Combined Stresses and Mohr's Circle is important because many general design problems and the design of machine elements covered in later chapters of the book involve combined stresses. You may have covered these topics in a course in strength of materials.

Chapter 5: Design for Different Types of Loading is an in-depth discussion of design factors, fatigue, and many of the details of stress analysis as used in this book.

Chapter 6: Columns discusses the long, slender, axially loaded members that tend to fail by buckling rather than by exceeding the yield, ultimate, or shear stress of the material. Special design and analysis methods are reviewed here.



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The Nature of Mechanical Design