机械工程专业英语

（第 17 版）

施平　主编

English in Mechanical Engineering

哈爾濱工業大學出版社

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内 容 提 要

本书以培养学生专业英语能力为主要目标。内容包括：力学、机械零件与机构、机械设计、机械制造、管理、现代制造技术、科技写作。全书共有62篇课文，其中33篇课文有参考译文。

本书可以作为机械设计制造及其自动化，机械工程及自动化，机电工程等专业的专业英语教材，也可以供从事机械工程专业的科技人员参考使用。

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再版前言

专业英语是大学英语教学的一个重要组成部分，是促进学生们完成从英语学习过渡到实际应用的有效途径。教育部颁布的“大学英语教学大纲”明确规定专业英语为必修课程，要求通过四年不断线的大学英语学习，培养学生以英语为工具交流信息的能力。根据此精神编写了这本《机械工程专业英语》教材，以满足高等院校机械工程各专业学生们的专业英语教学需求。

本书所涉及的内容包括：力学、机械零件与机构、机械设计、机械制造、管理、现代制造技术、科技写作等方面。通过这本教材，学生们不仅可以熟悉和掌握本专业常用的及与本专业有关的英语单词、词组及其用法，而且可以深化本专业的知识，从而为今后的学习和工作打下良好的基础。

在此次再版前，编者们吸取了多所大学在使用本书过程中提出的许多宝贵意见，对全书进行了修订和补充。全书由 62 篇课文组成，其中 33 篇课文有参考译文。本书选材广泛，内容丰富，语言规范，难度适中，便于自学。

本书由施平主编，参加编写工作的有胡明、乔世坤、田锐、施晓东、魏思欣、李越、侯双明、王旭、张宏祥、杜勇、孙德金、王海军、郭启臣、胡淼、陶文成、梅竹、丁印成、郭晓江、林晓东、张志伟、梁东伟，由贾艳敏担任主审。由于水平有限，书中难免有不足和欠妥之处，恳请广大读者批评指正。

编　者

2016 年 2 月

Contents

1 Basic Concepts in Mechanics

The branch of scientific analysis which deals with motions, time, and forces is called mechanics and is made up of two parts, statics and dynamics. Statics deals with the analysis of stationary systems, i.e., those in which time is not a factor, and dynamics deals with systems which change with time.

Forces are transmitted into machine members through mating surfaces, e. g., from a gear to a shaft or from one gear through meshing teeth to another gear (see Fig. 1.1), from a V belt to a pulley, or from a cam to a follower (see Fig. 1.2). It is necessary to know the magnitudes of these forces for a variety of reasons. For example, if the force operating on a journal bearing becomes too high, it will squeeze out the oil film and cause metal-to-metal contact, overheating, and rapid failure of the bearing. If the forces between gear teeth are too large, the oil film may be squeezed out from between them. This could result in flaking and spalling of the metal, noise, rough motion, and eventual failure. In the study of mechanics we are principally interested in determining the magnitude, direction, and location of the forces.

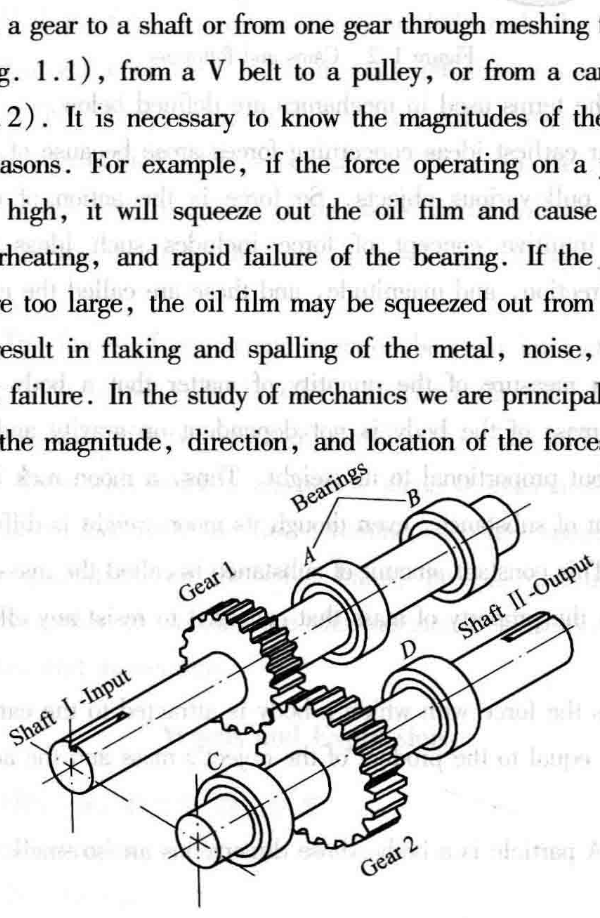

Figure 1.1 Two shafts carrying gears in mesh

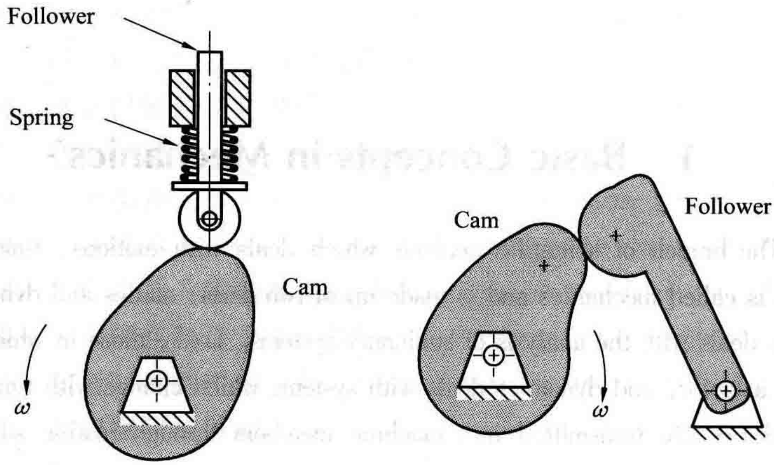

Figure 1.2 Cams and followers

Some of the terms used in mechanics are defined below.

Force Our earliest ideas concerning forces arose because of our desire to push, lift, or pull various objects. So force is the action of one body on another. Our intuitive concept of force includes such ideas as place of application, direction, and magnitude, and these are called the characteristics of a force.

Mass is a measure of the quantity of matter that a body or an object contains. The mass of the body is not dependent on gravity and therefore is different from but proportional to its weight. Thus, a moon rock has a certain constant amount of substance, even though its moon weight is different from its earth weight. This constant amount of substance is called the mass of the rock.

Inertia is the property of mass that causes it to resist any effort to change its motion.

Weight is the force with which a body is attracted to the earth or another celestial body, equal to the product of the object's mass and the acceleration of gravity.

Particle A particle is a body whose dimensions are so small that they may be neglected.

Rigid Body A rigid body does not change size and shape under the action of forces. Actually, all bodies are either elastic or plastic and will be deformed if acted upon by forces. When the deformation of such bodies is small, they are frequently assumed to be rigid, i.e., incapable of deformation, in order to simplify the analysis. A rigid body is an idealization of a real body.

Deformable Body The rigid body assumption cannot be used when internal stresses and strains due to the applied forces are to be analyzed. Thus we consider the body to be capable of deforming. Such analysis is frequently called elastic body analysis, using the additional assumption that the body remains elastic within the range of the applied forces.

Newton's Laws of Motion Newton's three laws are:

Law 1 If all the forces acting on a body are balanced, the body will either remain at rest or will continue to move in a straight line at a uniform velocity.

Law 2 If the forces acting on a body are not balanced, the body will experience an acceleration. The acceleration will be in the direction of the resultant force, and the magnitude of the acceleration will be proportional to the magnitude of the resultant force and inversely proportional to the mass of the body.

Law 3 The forces of action and reaction between interacting bodies are equal in magnitude, opposite in direction, and have the same line of action.

Mechanics deals with two kinds of quantities: scalars and vectors. Scalar quantities are those with which a magnitude alone is associated. Examples of scalar quantities in mechanics are time, volume, density, speed, energy, and mass. Vector quantities, on the other hand, possess direction as well as magnitude. Examples of vectors are displacement, velocity, acceleration, force, moment, and momentum.

Words and Expressions

statics [ˈstætiks] ***n.*** 静力学,静止状态
dynamics [daiˈnæmiks] ***n.*** 动力学
i.e.那就是,即(= that is)
mating [ˈmeitiŋ] ***n.***; ***a.*** 配合(的),配套(的),相连(的)

mating surface 配合表面,接触表面
e.g. 例如(=for example)
gear [gіə] ***n.*** 齿轮,齿轮传动装置
shaft [ʃɑ:ft] ***n.*** 轴
meshing [ˈmeʃiŋ] ***n.*** 啮合
bearing [ˈbɛəriŋ] ***n.*** 轴承,支承,承载
pulley [ˈpuli] ***n.*** 带轮
cam [kæm] ***n.*** 凸轮
follower [ˈfɔləuə] ***n.*** 从动件
spring [spiŋ] ***n.*** 弹簧
magnitude [ˈmægnitju:d] ***n.*** 大小,尺寸,量度,数值
journal bearing 滑动轴承,向心滑动轴承
squeeze [skwi:z] ***v.*** 挤压,压缩;***n.*** 压榨,挤压
squeeze out 挤压,压出
flaking [ˈfleikiŋ] ***n.*** 薄片,表面剥落,压碎;***a.*** 易剥落的
spall [spɔ:l] ***v.*** 削,割,打碎,剥落,脱皮;***n.*** 裂片,碎片
intuitive [inˈtjuitiv] ***a.*** 直觉的,本能的,天生的
inertia [iˈnə:ʃiə] ***n.*** 惯性,惯量,惰性
celestial [siˈlestjəl] ***a.*** 天体的
celestial body 天体
incapable [inˈkeipəbl] ***a.*** 无能力的,不能的,无用的,无资格的
deformation [ˌdi:fɔ:ˈmeiʃən] ***n.*** 变形
deformable [diˈfɔ:məbl] ***a.*** 可变形的
acceleration [ækˌseləˈreiʃən] ***n.*** 加速度,加速度值,促进,加快
resultant [riˈzʌltənt] ***a.*** 合的,组合的,总的; ***n.*** 合力,合量
scalar [ˈskeilə] ***n.***;***a.*** 数量(的),标量(的)
vector [ˈvektə] ***n.*** 矢量,向量
displacement [disˈpleismənt] ***n.*** 位移
velocity [viˈlɔsiti] ***n.*** 速度
moment [ˈməumənt] ***n.*** 力矩
momentum [məuˈmentəm] ***n.*** 动量

2 Simple Stress and Strain

In any engineering structure the individual components or members will be subjected to external forces arising from the service conditions or environment in which the component works. If the component or member is in equilibrium, the resultant of the external forces will be zero but, nevertheless, they together place a load on the member which tends to deform that member and which must be reacted by internal forces set up within the material.

There are a number of different ways in which load can be applied to a member. Loads may be classified with respect to time:

(a) A static load is a gradually applied load for which equilibrium is reached in a relatively short time.

(b) A sustained load is a load that is constant over a long period of time, such as the weight of a structure. This type of load is treated in the same manner as a static load; however, for some materials and conditions of temperature and stress, the resistance to failure may be different under short time loading and under sustained loading.

(c) An impact load is a rapidly applied load (an energy load). Vibration normally results from an impact load, and equilibrium is not established until the vibration is eliminated, usually by damping forces.

(d) A repeated load is a load that is applied and removed many thousands of times.

(e) A fatigue or alternating load is a load whose magnitude and sign are changed with time.

It has been noted above that external force applied to a body in equilibrium is reacted by internal forces set up within the material. If, therefore, a bar is subjected to a uniform tension or compression, i.e. a force, which is uniformly applied across the cross-section, then the internal forces set up are also distributed uniformly and the bar is said to be subjected to a uniform normal stress, the stress being defined as

$$stress(\sigma) = \frac{load}{area} = \frac{P}{A} \quad (2.1)$$

Stress σ may thus be compressive or tensile depending on the nature of the load and will be measured in units of Newtons per square meter (N/m^2) or multiples of this.

If a bar is subjected to an axial load, and hence a stress, the bar will change in length. If the bar has an original length L and changes in length by an amount δL, the strain produced is defined as follows:

$$strain(\varepsilon) = \frac{change\ in\ length}{original\ length} = \frac{\delta L}{L} \quad (2.2)$$

Strain is thus a measure of the deformation of the material and is non-dimensional, i.e. it has no units; it is simply a ratio of two quantities with the same unit.

Since, in practice, the extensions of materials under load are very small, it is often convenient to measure the strains in the form of strain $\times 10^{-6}$, i.e. microstrain, when the symbol used becomes $\mu\varepsilon$.

Tensile stresses and strains are considered positive in sense. Compressive stresses and strains are considered negative in sense. Thus a negative strain produces a decrease in length.

Figure 2.1 shows a typical stress-strain curve for a material such as ductile low-carbon steel. Ductility refers to the ability of a material to withstand a significant amount stretching before it breaks. Structural steels and some aluminum alloys are examples of ductile metals, and they are often used in machine components because when they become overloaded, they tend to noticeably stretch or bend before they break. On the other end, so-called brittle materials such as cast iron, engineering ceramics, and glass break suddenly and without much prior warning when they are overloaded.

A stress-strain curve for a ductile material is broken down into two regions: the low-strain elastic region (where no permanent deformation remains after a load has been applied and removed) and the high-strain plastic region (where the load is large enough that, upon removal, the material is permanently elongated). For strains below the proportional limit A in Fig. 2.1, stress is proportional to strain. Hooke's law applies, it has been shown that

$$E = \frac{stress}{strain} = \frac{\sigma}{\varepsilon} \tag{2.3}$$

The quantity E is called the elastic modulus, and it has units of force per unit area, such as N/m^2 or GPa. The elastic modulus is a material property, and it is measured simply as the slope of the stress-strain curve in its straight-line region.

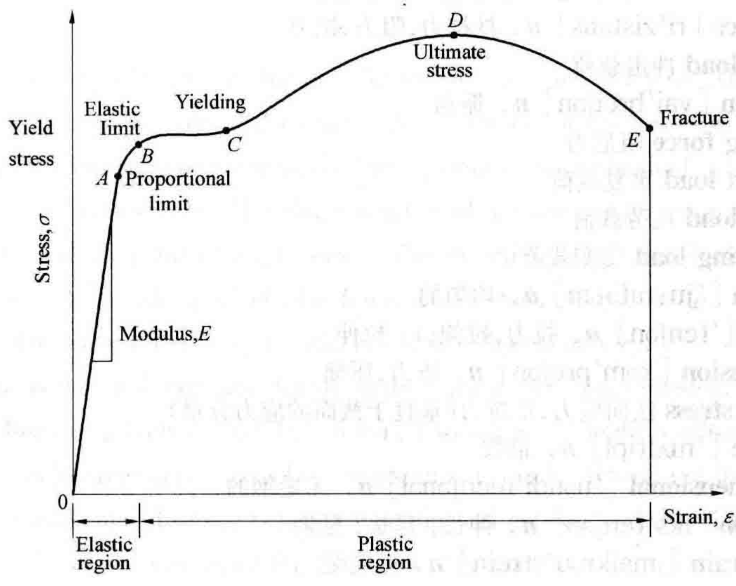

Figure 2.1 Stress-strain curve for a typical low-carbon steel in tension

Elastic modulus E is generally assumed to be the same in tension or compression and for most engineering materials has a high numerical value. Typically, $E = 200 \times 10^9\ N/m^2$ for steel, so that it will be observed from Eq. (2.3) that strains are normally very small.

In most common engineering applications strains rarely exceed 0.1%. The actual value of elastic modulus for any material is normally determined by carrying out a standard test on a specimen of the material.

Words and Expressions

stress [stres] ***n.*** 应力
strain [strein] ***n.*** 应变
service condition 使用状况,使用条件
component [kəm'pəunənt] ***n.*** 部件,构件
equilibrium [ˌi:kwi'libriəm] ***n.*** 平衡,均衡
internal force 内力
gradually ['grædjuəli] ***ad.*** 逐渐地
sustained load 长期(施加的)载荷,持续载荷
resistance [ri'zistəns] ***n.*** 抵抗力,阻力,抗力
impact load 冲击载荷
vibration [vai'breiʃən] ***n.*** 振动
damping force 阻尼力
repeated load 重复载荷
fatigue load 疲劳载荷
alternating load 交变载荷
uniform ['ju:nifɔ:m] ***a.*** 均匀的
tension ['tenʃən] ***n.*** 拉力,拉伸;***v.*** 拉伸
compression [kəm'preʃən] ***n.*** 压力,压缩
normal stress 法向应力,正应力(垂直于截面的应力分量)
multiple ['mʌltipl] ***n.*** 倍数
non-dimensional ['nɔndi'menʃənəl] ***a.*** 无量纲的
extension [iks'tenʃən] ***n.*** 伸长, 延长, 延期
microstrain [ˌmaikrəu'strein] ***n.*** 微应变
sense [sens] ***n.*** 方向
ductile ['dʌktail] ***a.*** 延性的
ductility [dʌk'tiliti] ***n.*** 延性
yield stress 屈服应力
yielding ['ji:ldiŋ] ***n.*** 屈服
proportional limit 比例极限
ultimate stress 极限应力
elesticity [ilæs'tisiti] ***n.*** 弹性
elastic modulus 弹性模量
permanent ['pə:mənənt] ***a.*** 永久的,持久的
specimen ['spesimən] ***n.*** 试件,标本,样品

3 Forces and Moments

When a number of bodies are connected together to form a group or system, the forces of action and reaction between any two of the connecting bodies are called constraint forces. These forces constrain the bodies to behave in a specific manner. Forces external to this system of bodies are called applied forces.

Electromagnetic and gravitational forces are examples of forces that may be applied without actual physical contact. A great many of the forces with which we shall be concerned occur through direct physical or mechanical contact.

Force $\boldsymbol{F}$ is a vector. The characteristics of a force are its magnitude, its direction, and its point of application. The direction of a force includes the concept of a line, along which the force is directed, and a sense. Thus, a force is directed positively or negatively along a line of action.

Two equal and opposite forces acting along two noncoincident parallel straight lines in a body cannot be combined to obtain a single resultant force. Any two such forces acting on a body constitute a couple. The arm of the couple is the perpendicular distance between their lines of action, and the plane of the couple is the plane containing the two lines of action.

The moment of a couple is another vector $\boldsymbol{M}$ directed normal to the plane of the couple; the sense of $\boldsymbol{M}$ is in accordance with the right-hand rule for rotation. The magnitude of the moment is the product of the arm of the couple and the magnitude of one of the forces.

A rigid body is in static equilibrium if:

(1) The vector sum of all forces acting upon it is zero.

(2) The sum of the moments of all the forces acting about any single axis is zero.

Mathematically these two statements are expressed as

$$\Sigma \boldsymbol{F} = 0 \quad \Sigma \boldsymbol{M} = 0$$