石油化工专业英语系列丛书

过程装备与控制工程专业英语

石油化工专业英语教材编委会 编

中国石化出版社
HTTP://WWW.SINOPEC-PRESS.COM
教·育·出·版·中·心

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前　言

在经济全球化和高等教育国际化的21世纪，中国高等教育正在与国际接轨，从教育理念、培养目标、育人环境到教材更新和教学方法等方面更加注重学生基本素质、知识结构及实际操作能力的培养，旨在使学生具备较强竞争力和发展潜质，能够在未来的专业领域和职业生涯中迅速适应环境，胜任所从事的工作，成为有所作为的人。专业外语水平是衡量大学生基本素质和综合能力的重要指标之一，在一定程度上决定着学生未来的学术潜力和工作能力。在实际教学过程中，我们发现目前适合工科大学专业外语教学需求的教材比较匮乏。我们应邀编写本系列专业外语教程，就是为了满足工科大学学生和相应读者群的迫切需求。

本套专业外语系列教程包括《过程装备与控制工程专业英语》《仪表自动化专业英语》《环境科学与工程专业英语》《石油加工专业英语》《材料科学与工程专业英语》五部教材。每部教材由30个单元组成，每单元包括课文、词汇表、阅读材料及其注释。课文与阅读材料均选自原版外语教科书、学术报告、专业著作及学术期刊等，语言标准，文体规范，学术性强，难易适度，具有较高的可读性和实用性。

大学本科生在经历基础阶段外语学习之后，通过阅读本教材，能够初步接触本专业领域的基础外语词汇、专业术语和表达方式，领略专业外语的文体和风格，提高专业外语阅读理解能力，为将来直接阅读专业外语文献、进行专业外语写作和学术交流打下良好基础，从而使自己的专业外语水平取得实质性跃进。我们希望本系列教程会对有志于相关专业领域学术研究与发展的学生和读者提供有益的帮助和参考。

为了使这套系列专业外语教程取得理想的教学效果，编者建议选用本教程的学生课前务必认真预习，课堂上教师可组织学生采用介绍、讲述、问答、讨论、归纳等方式，创造积极活跃的课堂气氛，使学生能够得到充分的实践机会，以期达到熟练掌握之目的，尽量避免把专业外语课上成枯燥乏味的翻译课。

《过程装备与控制工程专业英语》是为过程装备与控制工程专业三、四年级本科生编写的专业英语教材。本书的内容包括：力学、材料、过程工程、过程设备、过程机械和过程控制等领域的专业基础知识和科技文献，旨在丰富学生专业英语知识的广度和深度，开拓学生视野。本书选材严谨，内容新颖，适用面宽，针对性强，可以作为化工类及相关专业的专业英语教材，也可以作为机械类工程技术人员的备用参考书。

本系列教程由辽宁石油化工大学外国语学院英语教师和相关专业英语教师共同编撰。由于时间仓促、水平有限，编写过程中难免出现纰漏，欢迎广大读者在使用过程中不吝赐教，在此深表谢意。由于课文选材比较广泛，故未能一一注明出处，在此向原作者一并表示感谢。

本书编写人员

华克清　张　丽　李　铭　宋　佳　韩　晶

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Unit 1

Text

General Equilibrium Conditions of a System

Basic Concepts in Mechanics

That branch of scientific analysis which deals with motions, time, and forces is called mechanics and is made up of two parts, statics and dynamics.[1] 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, from a connecting rod through a bearing to a lever, from a V belt to a pulley, or from a cam to a follower. It is necessary to know the magnitudes of these forces for a variety of reasons. The distribution of the forces at the boundaries or mating surfaces must be reasonable, and their intensities must be within the working limits of the materials composing the surfaces.[2] For example, if the force operating on a sleeve 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.[3] In the study of dynamics we are principally interested in determining the magnitude, direction, and location of the forces.

Some of the terms used in this phase of our studies are defined below.

1. 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 acting 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.

2. Matter Matter is any material or substance; if it is completely enclosed, it is called a body.

3. Mass Newton defined mass as the quantity of matter of a body as measured by its volume and density. This is not a very satisfactory definition because density is the mass of a unit volume. We can excuse Newton by surmising that he perhaps did not mean it to be a definition. Nevertheless, he recognized the fact that all bodies possess some inherent property that is different from 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, or quantity of matter, is called the mass of the rock.

4. Inertia Inertia is the property of mass that causes it to resist any effort to change its motion.[4]

5. Weight Weight is the force of gravity acting upon a mass. The following quotation is pertinent:

The great advantage of SI units is that there is one, and only one unit for each physical quantity-the metre for length, the kilogram for mass, theNewton for force, the second for time, etc. To be consistent with this unique feature it follows that a given unit or word should not be used as an accepted technical name for two physical quantities. However, for generations the term"weight"has been used in both technical and nontechnical fields to mean either the force of gravity acting on a body or the mass of a body itself. ⑤

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

7. Rigid Body 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.

8. 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. ⑥

9. Newton's Laws Newton's three laws are:

Law 1 If all the forces acting on a particle are balanced, the particle 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 particle are not balanced, the particle will experience an acceleration proportional to the resultant force and in the direction of the resultant force.

Law 3 When two particles react, a pair of interacting forces come into existence: these forces have the same magnitudes and opposite senses, and they act along the straight line common to the two particles.

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. ⑦ These forces constrain the bodies to behave in a specific manner. Forces external to this system of bodies are called applied forces.

Electric, magnetic, and gravitational forces are examples of forces that may be applied without actual physical contact. ⑧ A great many, if not most, 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:

$$\sum F = 0 \sum M = 0$$

The term "rigid body" as used here may be an entire machine, several connected parts of a machine, a single part, or a portion of a part. A free-body diagram is a sketch or drawing of the body, isolated from the machine, on which the forces and moments are shown in action. ⑨ It is usually desirable to include on the diagram the known magnitudes and directions as well as other pertinent information.

The diagram so obtained is called "free" because the part or portion of the body has been freed from the remaining machine elements and their effects have been replaced by forces and moments. If the free-body diagram is of an entire machine part, the forces shown on it are the external forces (applied forces) and moments exerted by adjoining or connected parts. If the diagram is a portion of a part, the forces and moments acting on the cut portion are the internal forces and moments exerted by the part that has been cut away.

The construction and presentation of clear and neatly drawn free-body diagrams represent the heart of engineering communication. This is true because they represent a part of the thinking process, whether they are actually placed on paper or not, and because the construction of these diagrams is the only way the results of thinking can be communicated to others. You should acquire the habit of drawing free-body diagrams no matter how simple the problem may appear to be. Construction of the diagrams speeds up the problem-solving process and greatly decreases the chances of making mistakes. ⑩

The advantages of using free-body diagrams can be summarized as follows:

(1) They make it easy for one to translate words and thoughts and ideas into physical models.

(2) They assist in seeing and understanding all facets of a problem.

(3) They help in planning the attack on the problem.

(4) They make mathematical relations easier to see or find.

(5) Their use makes it easy to keep track of one's progress and helps in making simplifying assumptions.

(6) The methods used in the solution may be stored for future reference.

(7) They assist your memory and make it easier to explain and present your work to others.

In analyzing the forces in machines we shall almost always need to separate the machine into its individual components construct free-body diagrams showing the forces that act upon each component. Many of these parts will be connected to each other by kinematic pairs.

New Words and Expressins

1. **equilibrium**/ˌi:kwiˈlibriəm/*n.* 平衡，平静，均衡，保持平衡的能力
2. **statics**/ˈstætiks/*n.* [物] 静力学
3. **dynamics**/daiˈnæmiks/*n.* 动力学
4. **stationary**/ˈsteiʃ(ə)nəri/*adj.* 固定的
5. **gear**/ giə/*n.* 齿轮，传动装置；*v.* 调整，(使)适合，换档
6. **shaft**/ʃɑ:ft/*n.* 轴，杆状物
7. **connecting rod**〈机〉连杆
8. **bearing**/ˈbɛəriŋ/*n.* 轴承，关系，方面
9. **lever**/ˈli:və, ˈlevə/*n.* 杆，杠杆，控制杆；*v.* 抬起
10. **pulley**/ˈpuli/*n.* 滑车，滑轮
11. **cam**/kæm/*n.* 凸轮
12. **squeeze out** 榨出，挤出
13. **film**/ film/*n.* 薄膜，膜层，胶卷；*vt.* 在……上覆以薄膜
14. **overheating**/ ˈəuvəhi:tiŋ/*n.* 过热，热度过高
15. **flaking**/ˈfleikiŋ/*n.* 刨成片，压成片
16. **spalling**/ˈspɔ:liŋ/*n.* (水泥的)散裂
17. **phase**/feiz/*n.* 阶段，状态，相，相位；*v.* 定相
18. **surmise**/ˈsə:maiz/*v.* 猜测；*n.* 猜度
19. **inertia**/iˈnə:ʃjə/*n.* 惯性，惯量
20. **pertinent**/ˈpə:tinənt/*adj.* 有关的，相干的，中肯的
21. **strain**/ strein/*n.* 紧张，张力，应变；*vt.* 扭伤，损伤
22. **uniform velocity** 匀速度
23. **applied force** 外加力，作用力
24. **gravitational force** 引力，重力，地心吸力
25. **physical contact** 直接接触，体接触
26. **vector**/ˈvektə/*n.* [数]向量，矢量；*vt.* 无线电导引
27. **perpendicular distance** 垂(直)距(离)
28. **static equilibrium** 静力平衡
29. **rotation**/rəuˈteiʃən/*n.* 旋转

Notes

1. That branch of scientific analysis which deals with motions, time, and forces is called mechanics and is made up of two parts, statics and dynamics.
对于运动、时间和作用力作出科学分析的分支称为力学，它由静力学和动力学两部分组成。
2. The distribution of the forces at the boundaries or mating surfaces must be reasonable, and their intensities must be within the working limits of the materials composing the surfaces.
这些力在边界或在配合表面的分布必须合理，它们的大小必须在构成配合表面的材料的工作极限以内。
3. This could result in flaking and spalling of the metal, noise, rough motion, and eventual failure.
这会造成金属的碎裂和剥落，噪音增大，运动不精确，直至报废。result in 导致，造成。
4. Inertia is the property of mass that causes it to resist any effort to change its motion.
惯性使质量具有抵抗任何外力改变其本身运动状态的性质。

5. However, for generations the term "weight" has been used in both technical and nontechnical fields to mean either the force of gravity acting on a body or the mass of a body itself.
但是许多年以来,"重量"这个词在技术领域和非技术领域中都被用来既表示作用在一个物体上的重力,又表示物体本身的质量。either… or … 意为既……又……。

6. Such analysis is frequently called elastic-body analysis, using the additional assumption that the body remains elastic within the range of the applied forces.
这样的分析通常被称为弹性体分析,这时所用的假设为,在作用力的范围内,物体是弹性的。elastic-body 弹性体。

7. 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.
当一些物体连接在一起形成一个组合或者系统时,任何两个相连接的物体之间的作用力和反作用力被称为约束力。

8. Electric, magnetic, and gravitational forces are examples of forces that may be applied without actual physical contact.
电力、磁力和重力是可以不需要真正的直接接触而施加的力的实例。

9. A free-body diagram is a sketch or drawing of the body, isolated from the machine, on which the forces and moments are shown in action.
自由物体受力图是一个从机器中隔离出来的物体的草图或视图,在图中标出所有作用在物体上的力和力矩。

10. Construction of the diagrams speeds up the problem-solving process and greatly decreases the chances of making mistakes.
绘制自由物体受力图可以提高解决问题的速度和大大减少产生错误的机会。

Supplementary Reading

Mechanics

Mechanics is that branch of physical science which deals with the state of rest or motion of bodies under the action of forces. No one subject plays a greater role in engineering analysis than does mechanics. The early history of this subject is synonymous with the very beginnings of engineering. Modern research and development in the fields of vibrations, stability and strength of structures and machines, robotics, rocket and spacecraft machines and apparatus, and molecular, atomic, and subatomic behavior are highly dependent upon the basic principles of mechanics. A thorough understanding of this subject is an essential prerequisite for work in these and many other fields.

Mechanics is the oldest of the physical sciences. The earliest recorded writings in this field are those of Archimedes (287B. C. ～212B. C.) which concern the principle of the lever and the principle of buoyancy. Substantial progress awaited the formulation of the laws of vector combination of forces by Stevinus (1548～1620), who also formulated most of the principles of statics. The first investigation of a dynamic problem is credited to Galileo(1564～1642)in connection with his experiments with falling stones. The accurate formulation of the laws of motion, as well as the law of gravitation, was made by Newton(1642～1727), who also conceived the idea of the infinitesimal in mathematical analysis. Substantial contributions to the development of mechanics were also made by da Vinci, Varignon, Euler, D'Alembert, Lagrange, Laplace, and others.

The principles of mechanics as a science embody the rigor of mathematics upon which they are highly dependent. Thus mathematics plays an important role in achieving the purpose of engineering mechanics, which is the application of these principles to the solution of practical problems. The basic principles of mechanics are relatively few in number, but they have exceedingly wide application, and the methods employed in mechanics carry over into many fields of engineering endeavor.

The subject of mechanics is logically divided into two parts: statics, which concerns the equilibrium of bodies under the action of forces, and dynamics, which concerns the motion of bodies.

Certain concepts and definitions are basic to the study of mechanics, and they should be understood at the outset.

Space is the geometric region occupied by bodies whose positions are described by linear and angular measurements relative to a coordinate system. For three-dimensional problems our space will require three independent coordinates. For two-dimensional problems only two coordinates will be required.

Time is the measure of the succession of events and is a basic quantity in dynamics. Time is not directly involved in the analysis of statics problems.

Mass is a measure of the inertia of a body, which is its resistance to a change of velocity. Of more importance to us in statics, mass is also the property of everybody by which it experiences mutual attraction to other bodies.

Force is the action of one body on another. A force tends to move a body in the direction of its action. The action of a force is characterized by its magnitude, by the direction of its action, and by its point of application. Force is a vector quantity.

Particle A body of negligible dimensions is called a particle. In the mathematical sense a particle is a body whose dimensions approach zero so that it may be analyzed as a point mass. Also, when the dimensions of a body are irrelevant to the description of its position or the action of forces applied to it, the body may be treated as a particle.

Rigid Body A body is considered rigid when the relative movements between its parts are negligible for the purpose at hand. For instance, the calculation of the tension in the cable which supports the boom of a mobile crane under load is essentially unaffected by the small internal strains(deformations)in the structural members of the boom. For the purpose, then, of determining the external forces which act on the boom, we may treat it as a rigid body. Statics deals primarily with the calculation of external forces which act on rigid bodies which are in equilibrium. To determine the internal stresses and strains, the deformation characteristics of the boom material would have to be analyzed. This type of analysis belongs in the study of the mechanics of deformable bodies, which comes after the study of statics.

Mechanics deals with two kinds of quantities—scalars and vectors. Scalsr 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.

Notes

1. No one subject plays a greater role in engineering analysis than does mechanics.
   在工程分析中没有比力学更能发挥重要作用的角色了。
2. Modern research and development in the fields of vibrations, stability and strength of structures and machines, robotics, rocket and spacecraft machines and apparatus, and molecular, atomic, and subatomic behavior are highly dependent upon the basic principles of mechanics.
   当今在振动学、结构和机器的稳定学和强度学、机器人学、火箭学、宇宙飞船设计、自动控制、工程性能、流体流动、电器仪表以及分子、原子和亚原子的性能等领域都是以力学为基础研究和发展起来的。
3. physical sciences 自然科学
4. law of gravitation 万有引力定律
5. Certain concepts and definitions are basic to the study of mechanics, and they should be understood at the outset.
   某些概念和定义是研究力学的基础,所以应该首先理解它们。at the outset 开头,开始,最初。
6. For three-dimensional problems our space will require three independent coordinates.
   对于三维问题需要建立三个独立的坐标。
7. Mechanics deals with two kinds of quantities—scalars and vectors.
   力学处理两种类型的量——标量和矢量。

Unit 2

Stress

Introduction

The main objective of the study of mechanics of materials is to provide the engineer with the means of analyzing and designing various machines and load-bearing structures. ①

Consider the structure shown in Fig. 2. 1, consisting of a boom AB and a rod BC. We propose to determine whether a 30kN load may safely be supported at B by this structure.

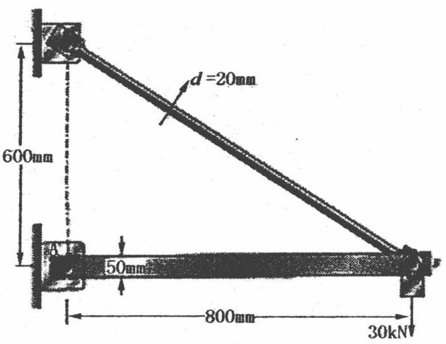

Fig. 2. 1

From our knowledge of statics, we recognize that *AB* and *BC* are two-force members acted upon at each end by equal and opposite axial forces: F_{AB} and F'_{AB} of magnitude F_{AB}, and F_{BC} and F'_{BC} of magnitude F_{BC} (Fig. 2. 2). Drawing the free-body diagram of pin *B* and the corresponding force triangle(Fig. 2. 3), we write from similar triangles

$$\frac{F_{AB}}{4\text{m}} = \frac{F_{BC}}{5\text{m}} = \frac{30\text{kN}}{3\text{m}}$$

and obtain

$$F_{AB} = 40\text{kN} \qquad F_{BC} = 50\text{kN}$$

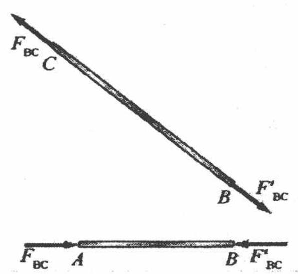

Fig. 2. 2

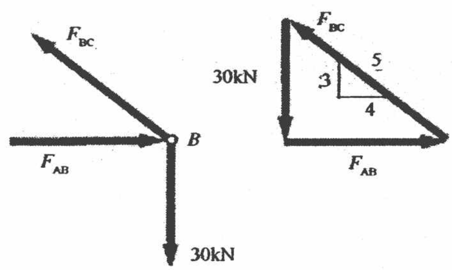

Fig. 2. 3

Passing a section through rod *BC* at some arbitrary point *D*, we obtain two portions *BD* and *CD*. Since 50kN forces must be applied at *D* to both portions of rod to keep them in equilibrium, we conclude that an internal force of 50kN is produced in rod *BC* when a 30kN load is applied at *B*, and further note that rod *BC* is in tension. A similar reasoning shows that the force in boom *AB* is 40kN and that the boom is in compression.

While the results obtained represent a first and necessary step in the analysis of the structure, they do not tell us whether the given load may be safely supported.[2] Whether rod BC, for example, will break or not under this loading depends not only upon the value found for the internal force F_{BC}, but also upon the cross-sectional area of the rod and the material of which the rod is made. Indeed, the internal force F_{BC} actually represents the resultant of elementary forces distributed over the entire area A of the cross section (Fig. 2.4) and the intensity of these distributed forces is equal to the force per unit area, F_{BC}/A, in the section. Whether or not the rod will break under the given loading clearly depends upon the ability of the material to withstand the corresponding value F_{BC}/A of the intensity of the distributed internal forces. It thus depends upon the force F_{BC}, the cross sectional area A, and the material of the rod.

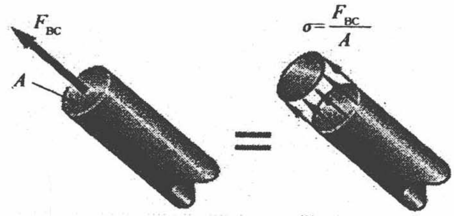

Fig. 2.4

The force per unit area, or intensity of the forces distributed over a given section, is called the stress on that section and is denoted by the Greek letter σ (sigma). The stress in a member of cross-sectional area A subjected to an axial load P is therefore obtained by dividing the magnitude P of the load by the area A:

$$\sigma = \frac{P}{A} \qquad (2.1)$$

A positive sign will be used to indicate a tensile stress (member in tension) and a negative sign to indicate a compressive stress (member in compression).

Since SI metric units are used in this discussion, with P expressed in newtons (N) and A in square meters (m^2), the stress σ will be expressed in N/m^2. This unit is called a pascal (Pa). However, one finds that the pascal is an exceedingly small quantity and that, in practice, multiples of this unit must be used, namely, the kilopascal (kPa), the megapascal (MPa), and the gigapascal (GPa). We have

$$1\ \text{kPa} = 10^3\ \text{Pa} = 10^3\ \text{N/m}^2$$
$$1\ \text{MPa} = 10^6\ \text{Pa} = 10^6\ \text{N/m}^2$$
$$1\ \text{GPa} = 10^9\ \text{Pa} = 10^9\ \text{N/m}^2$$

Considering again rod BC, we shall assume that it is made of steel and has a diameter of 20mm. We have

$$P = F_{BC} = +50\text{kN} = +50\times10^3\ \text{N}$$

$$A = \pi r^2 = \pi\left(\frac{20\text{mm}}{2}\right)^2 = \pi(10\times10^{-3}\text{m})^2 = 314\times10^{-6}\text{m}^2$$

$$\sigma = \frac{P}{A} = \frac{+50\times10^3\text{N}}{314\times10^{-6}\text{m}^2} = +159\times10^6\text{Pa} = +159\text{MPa}$$

To determine whether the rod BC may be used to support the given 30kN load, we must compare the value obtained for σ under this loading with the maximum value of the stress