Lesson 2

Fundamentals of Machine Design

Section Ⅰ Text

Design is essentially a decision-making process. If we have a problem, we need to design a solution. In other words, to design is to formulate a plan to satisfy a particular need and to create something with a physical reality. A bad decision leads to a bad design and a bad product.

There are many factors to be considered while attacking a design problem. In many cases this is a common sense approach to solving a problem. [1] Some of these factors are as follows.

- What device or mechanism to be used — This is best judged by understanding the problem thoroughly. Sometimes a particular function can be achieved by a number of means or by using different mechanisms and the designer has to decide which one is the most effective under the circumstances.
- Material — This is a very important aspect of any design. A wrong choice of material may lead to failure, over or undersized product or expensive items. [2] The choice of materials is thus dependent on suitable properties of the material for each component, their suitability of fabrication or manufacture and the cost.
- Load — The external loads cause internal stresses in the elements and these stresses must be determined accurately since these will be used in determining the component size.
- Size, shape, space requirements and weight — Preliminary analysis would give an approximate size. But if a standard element is to be chosen, the next larger size must be taken. [3] Shapes of standard elements are known but for non-standard element, shapes and space requirements must depend on available space in a particular machine assembly. A scale layout drawing is often useful to arrive at an initial shape and size. [4] Weight is important depending on

application.

- Manufacture — Care must always be taken to ensure that the designed elements may be manufactured with ease, within the available facilities and at low cost.

- How will it operate — In the final stage of the design, a designer must ensure that the machine may be operated with ease. In many power operated machines, it is simply a matter of pressing a knob or switch to start the machine. [5] However in many other cases, a sequence of operations is to be specified. This sequence must not be complicated and the operations should not require excessive force.

- Reliability and safety — Reliability is an important factor in any design. A designed machine should work effectively and reliably. The probability that an element or a machine will not fail in use is called reliability. Reliability lies between $0 < R < 1$. To ensure this, every detail should be examined. Possible overloading, wear of elements, excessive heat generation and other such detrimental factors must be avoided. There is no single answer for this but an overall safe design approach and care at every stage of design would result in a reliable machine.

Safety has become a matter of paramount importance these days in design. Machines must be designed to serve mankind, not to harm it. Industrial regulations ensure that the manufacturer is liable for any damage or harm arising out of a defective product. [6]

- Maintenance, cost and aesthetics — Maintenance and safety are often interlinked. Good maintenance ensures good running condition of machinery. Often a regular maintenance schedule is maintained and a thorough check up of moving and loaded parts is carried out to avoid catastrophic failures. Low friction and wear is maintained by proper lubrication. This is a major aspect of design since wherever there are moving parts, friction and wear are inevitable. High friction leads to increased loss of energy. Wear of machine parts leads to loss of material and premature failure.

Cost and aesthetics are essential considerations for product design. Cost is essentially related to the choice of materials which in turn depends on the stresses developed in a given condition. [7] Although in many cases aesthetic considerations are not essential aspects of machine design, ergonomic aspects must be taken into considerations.

Section II New Words and Phrases

decision-making		*n.*	决策
formulate	[ˈfɔːmjuleit]	*v.*	制订
thoroughly	[ˈθʌrəli]	*adv.*	彻底地
circumstance	[ˈsəːkəmstəns]	*n.*	情况
undersized	[ʌndəˈsaizd]	*adj.*	欠尺寸的,尺寸不够的
component	[kəmˈpəunənt]	*n.*	组件,元件
external	[eksˈtəːnl]	*n.*	外部的
internal	[inˈtəːnəl]	*n.*	内部的
stress	[stres]	*n.*	应力
approximate	[əˈprɔksimit]	*adj.*	近似的
standard element			标准件
scale	[skeil]	*n.*	比例
scale layout drawing			按比例的设计图
common sense approach			常识性的方法
with ease			轻而易举
facility	[fəˈsiliti]	*n.*	设施
knob	[nɔb]	*n.*	把手,旋钮
sequence	[ˈsiːkwəns]	*n.*	顺序,序列
excessive	[ikˈsesiv]	*adj.*	过分的,过度的
reliability	[rilaiəˈbiliti]	*n.*	可靠性
probability	[prɔbəˈbiliti]	*n.*	可能性,概率
overloading	[əuvəˈləudiŋ]	*n.*	过载
excessive heat			过热
preliminary	[priˈliminəri]	*adj.*	初步的
assembly	[əˈsembli]	*n.*	装配
paramount	[ˈpærəmaunt]	*adj.*	至高无上的
detrimental	[detriˈmentl]	*adj.*	不利的,有害的
industrial regulations			工业法规

liable	[ˈlaiəbl]	*adj.*	对……负责
defective	[diˈfektiv]	*adj.*	有缺陷的
aesthetics	[iːsˈθetiks]	*n.*	美学,审美
maintenance	[ˈmeintinəns]	*n.*	维护,维修
catastrophic	[kætəˈstrɔfik]	*n.*	灾难性的
friction and wear			摩擦与磨损
lubrication	[luːbriˈkeiʃən]	*n.*	润滑
check up			检查
inevitable	[inˈevitəbl]	*adj.*	不可避免的
premature	[preməˈtjuə]	*adj.*	过早的
ergonomics	[əːgəuˈnɔmiks]	*n.*	人体工程学

Section III Notes to Complex Sentences

[1] In many cases this is a common sense approach to solving a problem.

许多场合下,通过常识就可解决问题。

approach to solving a problem:解决问题的途径。common sense 此处作定语,修饰 approach.

[2] A wrong choice of material may lead to failure, over or undersized product or expensive items.

选材错误会导致产品失败、尺寸过大或过小及成本过高。

这里 over or... 与前面的 failure 并列,作为 lead to 的宾语。

[3] But if a standard element is to be chosen, the next larger size must be taken.

如果选用标准件,就要取稍大一点的尺寸。

这里 the next larger size 指稍大一级的标准件尺寸。

[4] A scale layout drawing is often useful to arrive at an initial shape and size.

按比例画出一张布置图往往对形成初步的形状和尺寸很有帮助。

scale:比例。arrive at:形成,达到。

[5] ... it is simply a matter of pressing a knob or switch to start the machine.

……只不过是按一下旋钮开机那么简单的事情。

It is a matter of... 是…… 的事情。

[6] Industrial regulations ensure that the manufacturer is liable for any damage or harm arising out of a defective product.

工业法规确保制造商对有缺陷产品造成的任何损害和伤害负责。

arising out of... 由……产生的。

[7] Cost is essentially related to the choice of materials which in turn depends on the stresses developed in a given condition.

成本最终取决于材料的选择,而材料的选择又取决于给定条件下的应力状况。

which 引出定语从句,作主语,等同于前面的 choice of materials. in turn:依次,此处可译为“又”。

Section IV Exercise

Translate the following into Chinese.

Machine design may be classified by the following 3 types.

- Adaptive design: This is based on existing design, for example, standard products or systems adopted for a new application. Conveyor belts, control system of machines and mechanisms or haulage systems are some of the examples where existing design systems are adapted for a particular use.
- Developmental design: Here we start with an existing design but finally a modified design is obtained. A new model of a car is a typical example of a developmental design.
- New design: This type of design is an entirely new one but based on existing scientific principles. No scientific invention is involved but requires creative thinking to solve a problem. Examples of this type of design may include designing a small vehicle for transportation of men and material on board a ship or in a desert. Some research activity may be necessary.

Section V Supplementary Reading

Factors in Design

The first step in product developments is design. Design is motivated by the following factors.

- The need for a specific product.
- The level of available manufacturing technology.
- Mass production capability and production cost.

Need

Most products are designed and produced because a need has developed for them. With the tremendous capability of modern industrial manufacturing, needs for products are easily developed. Therefore product designers are engaged in a constant process of designing and redesigning products to fulfill a continuing need.

Capability of Available Manufacturing Technology

The capability of the existing manufacturing technology is an extremely important consideration in product design and development. As technology develops new and better processes and materials, the designer naturally makes use of these to design and redesign products accordingly.

Production Capability and Costs

Most products that are made for the general public are only successful if they can be mass produced and marketed at affordable prices. The best product design is only as good as its ability to be competitively produced. Therefore a designer must consider the following important questions when a product is being developed.

- Is the production capability presently available?
- If not, will sales of the product justify development of new production technology?
- Can the product be manufactured and marketed at a cost that will return investment and profits?

Safety and Reliability

Safety and reliability are critical factors in the design of many products. In recent years product safety considerations have attained greater importance. This has been of increased public awareness. The designer's responsibility is equal where personal and public safety are concerned.

Marketability

If the manufacturing capability exists or can be developed, the next stop involves marketing and distribution. It has often been started that invention is one thing, but distribution is everything. Costs incurred in marketing include such things as advertising, national or international sales organizations, packaging, distributors and agents, distribution costs, and warranty services. The selling price to the end customer must reflect any or all of these expenses while being low enough to support sales and meet competition.

Engineering Materials

Section I Text

Introduction

Common engineering materials are normally classified as metals and nonmetals. Metals may conveniently be divided into ferrous and non-ferrous metals.

Important ferrous metals for the present purpose are:

(i) Cast iron.

(ii) Wrought iron.

(iii) Steel.

Some of the important non-ferrous metals used in engineering design are:

(i) Light metal group such as aluminium and its alloys.

(ii) Copper based alloys such as brass (Cu-Zn), bronze (Cu-Sn).

(iii) White metal group such as nickel, silver, zinc, etc.

Ferrous Materials

Cast iron: It is an alloy of iron, carbon and silicon and it is hard and brittle.

Carbon content may be within 1.7% to 3% and carbon may be present as free carbon or iron carbide Fe_3C.

Wrought iron: This is a very pure iron where the iron content is of the order of 99.5%.[1] It is produced by re-melting pig iron and some small amount of silicon, sulphur, or phosphorus may be present.[2] It is tough, malleable and ductile and can easily be forged or welded. It cannot however take sudden shock. Chains, crane hooks, railway couplings and such other components may be made of this iron.

Steel: This is by far the most important engineering material and there is an enormous variety of steel to meet the wide variety of engineering requirements. Steel is basically an alloy of iron and carbon in which the carbon content can be less than 1.7% and carbon is present in the form of iron carbide to impart hardness and strength. Two main categories of steel are plain carbon steel and alloy steel.

(i) Plain carbon steel: The properties of plain carbon steel depend mainly on the carbon percentages and other alloying elements are not usually present in more than 0.5% to 1% such as 0.5% Si or 1% Mn, etc.[3]

(ii) Alloy steel: These are steels in which elements other than carbon are added in sufficient quantities to impart desired properties, such as wear resistance, corrosion resistance, electric or magnetic properties.[4] Chief alloying elements added are usually nickel for strength and toughness, chromium for hardness and strength, tungsten for hardness at elevated temperature, vanadium for tensile strength, manganese for high strength in hot rolled and heat treated condition, silicon for high elastic limit.

Non-ferrous Metals

Metals containing elements other than iron as their chief constituents are usually referred to as non-ferrous metals. There is a wide variety of non-metals in practice. However, only a few exemplary ones are discussed below.

- Aluminium: This is the white metal produced from Alumina. In its pure state it is weak and soft but addition of small amounts of Cu, Mn, Si and Magnesium makes it hard and strong. It is also corrosion resistant, low weight and non-toxic.
- Magnalium: This is an aluminium alloy with 2% to 10 % magnesium. It also contains 1.75% Cu. Due to its light weight and good strength it is used for aircraft and automobile components.
- Copper alloys: Copper is one of the most widely used non-ferrous metals in industry. It is soft, malleable and ductile and is a good conductor of heat and electricity. The following two important copper alloys are widely used in practice.

▲ Brass (Cu-Zn alloy): It is fundamentally a binary alloy with Zn up to 50%. Brass is highly corrosion resistant, easily machinable and therefore a good bearing material.

▲ Bronze (Cu-Sn alloy): This is mainly a copper-tin alloy where tin percentage may vary between 5% to 25%. It provides hardness but tin content also oxidizes resulting in brittleness.[5] It was originally made for casting guns but used now for boiler fittings, bushes, glands and other such uses.

Non-metals

Non-metallic materials are also used in engineering practice due to principally their low cost, flexibility and resistance to heat and electricity. Though there are many suitable non-metals, plastics is the most important from design point of view. They are synthetic materials which can be moulded into desired shapes under pressure with or without application of heat. They are now extensively used in various industrial applications for their corrosion resistance, dimensional stability and relatively low cost.

Section II New Words and Phrases

classify	[ˈklæsifai]	*v.*	分类
conveniently		*adv.*	方便地
ferrous	[ˈferəs]	*adj.*	含铁的,铁的
cast iron			铸铁
wrought	[rɔːt]	*n.*	锻造
wrought iron			可锻铸铁
alloy	[ˈælɔi]	*n.*	合金
nickel	[ˈnikəl]	*n.*	镍
zinc	[ziŋk]	*n.*	锌
silicon	[ˈsilikən]	*n.*	硅
brittle	[ˈbritl]	*adj.*	脆的
carbide	[ˈkɑːbaid]	*n.*	碳化物 iron carbide 碳化铁
pig iron			生铁
sulphur	[ˈsʌlfə]	*n.*	硫
phosphorus	[ˈfɔsfərəs]	*n.*	磷
malleable	[ˈmæliəbl]	*adj.*	可塑的
crane	[krein]	*n.*	起重机
hook	[huk]	*n.*	钩子
coupling	[ˈkʌpliŋ]	*n.*	配件
ductile	[ˈdʌktail]	*adj.*	可延展的;韧的

forge	[fɔːdʒ]	*v.*	锻造;伪造
by far			最(通常用于最高级前,起加强语气作用)
hardness and strength			硬度和强度
category	[ˈkætiɡəri]	*n.*	类别
plain carbon steel			(纯)碳钢
impart	[imˈpɑːt]	*v.*	添加;传给
corrosion resistance			抗腐蚀性
hot roll			热轧
elastic limit			弹性极限
toughness	[ˈtʌfnis]	*n.*	韧性
tensile	[ˈtensail]	*n.*	拉伸
exemplary	[iɡˈzempləri]	*adj.*	举例的
constituent	[kənˈstitjuənt]	*n.*	成分
tungsten	[ˈtʌŋstən]	*n.*	钨
chromium	[ˈkrəumjəm]	*n.*	铬
vanadium	[vəˈneidiəm]	*n.*	钒
manganese	[mæŋɡəˈniːz]	*n.*	锰
non-toxic		*adj.*	无毒的
binary alloy			二元合金
brass	[brɑːs]	*n.*	黄铜
bearing	[ˈbɛəriŋ]	*n.*	轴承
bronze	[brɔnz]	*n.*	青铜
boiler fittings			锅炉配件
oxidize	[ˈɔksidaiz]	*v.*	氧化
gland	[ɡlænd]	*n.*	密封盖,端盖
flexibility	[fleksəˈbiliti]	*n.*	灵活性
synthetic	[sinˈθetik]	*adj.*	合成的
mould, mold	[məuld]	*n.*	模具 *v.* 模塑
extensively		*adv.*	广泛地
dimensional stability			尺寸稳定性

Section III Notes to Complex Sentences

[1] This is a very pure iron where the iron content is of the order of 99.5%.
这是一种非常纯的铁,其中铁的含量约占 99.5%。
to be of the order:在……数量级。

[2] It is produced by re-melting pig iron and some small amount of silicon, sulphur, or phosphorus may be present.
它是由生铁重新熔化而成,其中含有少量硅和硫,或者还有少量磷。
or 引导的从句表示另一种选择,与主句平行。

[3] The properties of plain carbon steel depend mainly on the carbon percentages and other alloying elements are not usually present in more than 0.5% to 1% such as 0.5% Si or 1% Mn, etc.
纯碳钢的性能主要取决于含碳百分比,其他合金元素通常不到 0.5% ~1%,例如,0.5% 的硅或者 1% 的锰。
and other alloying elements... 由 and 连接的两个并列复合句。

[4] These are steels in which elements other than carbon are added in sufficient quantities to impart desired properties, such as wear resistance, corrosion resistance, electric or magnetic properties.
这种钢添加了除碳以外的足够数量的其他元素,用以提供期望的性能,比如抗磨损性、抗腐蚀性、电磁特性等。
such as... 修饰 properties。

[5] It provides hardness but tin content also oxidizes resulting in brittleness.
它提供硬度,但锡也会氧化从而导致脆性。

Section IV Exercise

Please find answers from the text to the following questions.

Q.1: Classify common engineering materials.

Q.2: What are the advantages of malleable cast iron over white or grey cast iron?

Q.3: A standard alloy steel used for making engineering components is 20Cr18Ni2. State the composition of the steel.

Q.4: How are plain carbon steel designated?

Q.5: Name two important copper alloys and give their typical compositions.

Q.6: List at least five important non-metals commonly used in machine design.

Q.7: State at least 5 important mechanical properties of materials to be considered in machine design.

Q.8: Define resilience and discuss its implication in the choice of materials in machine design.

Section V Supplementary Reading

Mechanical Properties of Engineering Materials

Choice of materials for a machine element depends very much on its properties, cost, availability and such other factors. It is therefore important to have some idea of the common engineering materials and their properties before learning the details of design procedure.

The important properties from design point of view are as follows.

- Strength: The strength of a material refers to the material's ability to withstand an applied stress without failure. Yield strength refers to the point on the engineering stress-strain curve (as opposed to true stress-strain curve) beyond which the material begins deformation that cannot be reversed upon removal of the loading. Ultimate strength refers to the point on the engineering stress-strain curve corresponding to the maximum stress. The applied stress may be tensile, compressive, or shear.
- Hardness: Property of the material that enables it to resist permanent deformation, penetration, indentation, etc. Sizes of indentations by various types of indenters are the measure of hardness, e.g., Brinnel hardness test, Rockwell hardness test, Vickers hardness (diamond pyramid) test. These tests give hardness numbers which are related to yield pressure (MPa).
- Elasticity: This is the property of a material to regain its original shape after deformation when the external forces are removed. All materials are plastic to some extent but the degree varies, for example, both mild steel and rubber are elastic materials but steel is more elastic than rubber.
- Plasticity: This is associated with the permanent deformation of material when the stress level exceeds the yield point. Under plastic conditions materials ideally deform without any

increase in stress.

- Ductility: This is the property of the material that enables it to be drawn out or elongated to an appreciable extent before rupture occurs. The percentage elongation or percentage reduction in area before rupture of a test specimen is the measure of ductility. Normally if percentage elongation exceeds 15% the material is ductile and if it is less than 5% the material is brittle. Lead, copper, aluminium, mild steel are typical ductile materials.
- Malleability: It is a special case of ductility where it can be rolled into thin sheets but it is not necessary to be so strong. Lead, soft steel, wrought iron, copper and aluminium are some materials in order of diminishing malleability.
- Brittleness: This is opposite to ductility. Brittle materials show little deformation before fracture and failure occur suddenly without any warning. Normally if the elongation is less than 5% the material is considered to be brittle. E. g. cast iron, glass, ceramics are typical brittle materials.
- Resilience: This is the property of the material that enables it to resist shock and impact by storing energy. The measure of resilience is the strain energy absorbed per unit volume.
- Toughness: This is the property which enables a material to be twisted, bent or stretched under impact load or high stress before rupture. It may be considered to be the ability of the material to absorb energy in the plastic zone. The measure of toughness is the amount of energy absorbed after being stressed up to the point of fracture.
- Creep: When a member is subjected to a constant load over a long period of time it undergoes a slow permanent deformation and this is termed as "creep." This is dependent on temperature. Usually at elevated temperatures creep is high.

Lesson 4

Basic Concepts in Mechanics

Section I Text

Introduction

In its original sense, mechanics refers to the study of the behavior of systems under the action of forces. Statics deals with cases where the forces either produce no motion or the motion is not of interest. Dynamics deals properly with motions under forces. Mechanics is subdivided according to the types of systems and phenomena involved. [1]

An important distinction is based on the size of the system. Those systems are large enough and can be adequately described by the Newtonian law of classical mechanics. In this category, for example, are celestial mechanics, the study of the motions of planets, stars, and other heavenly bodies, and fluid mechanics, which treats liquids and gases on a macroscopic scale. [2] Fluid mechanics is a part of a larger field called continuum mechanics, involving any essentially continuous distribution of matter, whether rigid, elastic, plastic, or fluid. On the other hand, the behavior of microscopic systems such as molecules, atoms, and nuclei can be interpreted only by the concepts and mathematical methods of quantum mechanics. From its inception, quantum mechanics had two apparently different mathematical forms: the wave mechanics of E. Schrodinger, which emphasizes the spatial probability distributions in the quantum states, and the matrix mechanics of W. Heisenberg, which emphasizes the transitions between states. These are now known to be equivalent.

Mechanics may also be classified as nonrelativistic and relativistic mechanics, the latter applying to systems with material velocities comparable to the velocity of light. This distinction pertains to both classical and quantum mechanics.

Finally, statistical mechanics uses the methods of statistics for both classical and quantum systems containing very large number of similar subsystems to obtain their large-scale properties.

Basic Concepts in Mechanics

That branch of scientific analysis which deals with motions, times, and forces is called mechanics and is made up of two parts: statics and dynamics. [3] 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 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. 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. 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.

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.

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

Mass. Newton defined mass as the quantity 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 of substance, or quantity of matter, is called the mass of the rock.

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

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—the meter for length, the kilogram for mass, the Newton 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 non-technical fields to mean either the force of gravity acting on a body or the mass of a body itself.

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

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.

Deformation Body. The rigid-body assumption can not 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. Newton's three laws are:

Law1: 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.[4]

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

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.

Section II New Words and Phrases

statics	[ˈstætiks]	*n.*	静力学
dynamics	[daiˈnæmiks]	*n.*	动力学
spatial	[ˈspeiʃəl]	*adj.*	空间的
microscopic	[maikrəˈskɔpik]	*adj.*	微观的

macroscopic	[ˌmækrəuˈskɔpik]	*adj.*	宏观的
inception	[inˈsepʃən]	*n.*	开始
emphasize	[ˈemfəsaiz]	*v.*	强调
transition	[trænˈziʃən]	*n.*	跃迁,过渡
relativistic	[relətiˈvistik]	*n.*	相对论 *adj.* 相对论的
pertain	[pəˈtein]	*v.*	涉及
surmise	[səˈmaiz]	*v.*	推测
nevertheless	[nevəðəˈles]	*adj.*	然而
inherent	[inˈhiərənt]	*adj.*	内在的,固有的
quotation	[kwəuˈteiʃən]	*n.*	引用(一段话)
pertinent	[ˈpəːtinənt]	*adj.*	相关的
statistics	[stəˈtistiks]	*n.*	统计学
sleeve	[sliːv]	*n.*	套筒,轴套,空心轴
inertia	[iˈnəːʃjə]	*n.*	惯性,惯量
mating	[ˈmeitiŋ]	*adj.*	配合的,配套的
magnitude	[ˈmægnitjuːd]	*n.*	量,大小
mesh	[meʃ]	*v.*	啮合
flake	[fleik]	*v.*	成片(剥落)
spall	[spɔːl]	*v.*	层裂
pulley	[ˈpuli]	*n.*	滑轮,滚筒
intuitive	[inˈtjuitiv]	*adj.*	直觉的
deformation	[ˌdiːfɔːˈmeiʃən]	*n.*	变形,形变
elastic	[iˈlæstik]	*adj.*	弹性的,有弹力的
classical mechanics			经典力学
heavenly body			天体
fluid mechanics			流体力学
quantum mechanics			量子力学
wave mechanics			波动力学
continuum mechanics			连续介质力学
relativistic mechanics			相对论力学
matrix mechanics			矩阵力学
statistical mechanics			统计力学
material velocity			实际速度

mating surface	啮合表面
sleeve bearing	套筒轴承

Section III Notes to Complex Sentences

[1] Mechanics is subdivided according to the types of systems and phenomena involved.
根据系统类型和涉及的现象，力学被再次细分。

[2] In this category, for example, are celestial mechanics, the study of the motions of planets, stars, and other heavenly bodies, and fluid mechanics, which treats liquids and gases on a macroscopic scale.
本句是一个倒装句，celestial mechanics and fluid mechanics 为主语，相当于 celestial mechanics... are in this category.

[3] That branch of scientific analysis which deals with motions, times, and forces is called mechanics and is made up of two parts: statics and dynamics.
研究运动、时间和力的科学分支称为力学，它由两部分组成：静力学与动力学。
That...：由 that 引导的主语从句，作主语；为避免重复，and 后面的主语(mechanics)省略。

[4] 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.
proportional to ... 所引导的介词短语作定语，修饰 acceleration.

Section IV Exercises

1. Read the following statements, fill in the blanks with true or false.

(1) Those systems large enough can be adequately described by the Newtonian law of quantum mechanics. ( )

(2) On the other hand, the behavior of microscopic systems such as molecules, atoms, and nuclei can be interpreted only by the concepts and mathematical methods of wave mechanics. ( )

(3) The wave mechanics emphasizes the spatial probability distributions in the quantum

states. ( )

(4) Mechanics may also be classified as nonrelativistic or relativistic mechanics, the former applying to systems with material velocities comparable to the velocity of light. ( )

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

2. Answer the following questions.

(1) What does statics deal with?

(2) What are the differences between classical and continuum mechanics?

(3) What is the meaning of relativistic mechanics?

(4) What is the meaning of matter?

(5) What are Newton's Laws?

Section V Supplementary Reading

Applied Mechanics Overview

Applied mechanics is a branch of the physical sciences and the practical application of mechanics. Applied mechanics examines the response of bodies (solids and fluids) or systems of bodies to external forces. Some examples of mechanical systems include the flow of a liquid under pressure, the fracture of a solid from an applied force, or the vibration of an ear in response to sound. A practitioner of the discipline is known as a mechanician.

Applied mechanics, as its name suggests, bridges the gap between physical theory and its application to technology. As such, applied mechanics is used in many fields of engineering, especially mechanical engineering. In this context, it is commonly referred to as engineering mechanics. Much of modern engineering mechanics is based on Isaac Newton's laws of motion while the modern practice of their application can be traced back to Stephen Timoshenko, who is said to be the father of modern engineering mechanics.

Within the theoretical sciences, applied mechanics is useful in formulating new ideas and theories, discovering and interpreting phenomena, and developing experimental and computational tools. In the application of the natural sciences, mechanics was said to be complemented by thermodynamics, which is the study of heat and more general energy, and electromechanics, which is the study of electricity and magnetism.

Applied Mechanics in Practice

As a scientific discipline, applied mechanics derives many of its principles and methods from the Physical sciences (in particular, Mechanics and Classical Mechanics), from Mathematics and, increasingly, from Computer Science. As such, Applied Mechanics shares similar methods, theories, and topics with Applied Physics, Applied Mathematics, and Computational Science.

As an enabling discipline, applied mechanics has received impetus from the study of natural phenomena such as orbits of planets, circulation of blood, locomotion of animals, crawling of cells, formation of mountains, and propagation of seismic waves. Such studies have resulted in disciplines such as celestial mechanics, biomechanics and geomechanics.

As a practical discipline, applied mechanics has also advanced by participating in major inventions throughout history, such as buildings, ships, automobiles, railways, petroleum refineries, engines, airplanes, nuclear reactors, composite materials, computers, and medical implants. In such connections, the discipline is also known as Engineering Mechanics, often practiced within Civil Engineering, Mechanical Engineering, Construction Engineering, Materials Science and Engineering, Aerospace Engineering, Chemical Engineering, Electrical Engineering, Nuclear Engineering, Structural Engineering and Bioengineering.

Lesson 5

Hydraulics

Section Ⅰ Text

The word "hydraulics" generally refers to power produced by moving liquids. Modern hydraulics is defined as the use of confined liquid to transmit power, multiply force, or produce motion. Though hydraulic power in the form of water wheels and other simple devices has been in use for centuries, the principles of hydraulics weren't formulated into scientific law until the 17th century. It was then that French philosopher Blaise Pascal discovered that liquids cannot be compressed.[1] He discovered a law which states: Pressure applied on a confined fluid is transmitted in all directions with equal force on equal areas.

Hydraulic systems contain the following key components.

- Fluid — can be almost any liquid. The most common hydraulic fluids contain specially compounded petroleum oils that lubricate and protect the system from corrosion.[2]
- Reservoir or tank — acts as a storehouse for the fluid and a heat dissipater.
- Hydraulic pump — converts the mechanical energy into hydraulic energy by forcing hydraulic fluid, under pressure, from the reservoir into the system.
- Fluid lines or pipes — transport the fluid to and from the pump through the hydraulic system. These lines can be rigid metal tubes, or flexible hose assemblies. Fluid lines can transport fluid under pressure or vacuum (suction).
- Hydraulic valves — control pressure, direction and flow rate of the hydraulic fluid.
- Actuator — converts hydraulic energy into mechanical energy to do work. Actuators usually take the form of hydraulic cylinders. Hydraulic cylinders are used on agricultural, construction, and industrial equipment.

In actual hydraulic systems, Pascal's law defines the basis of the results which are obtained from the system. Thus, a pump moves the liquid in the system. The intake of the pump is connected to the reservoir or tank. Atmospheric pressure, pressing on the liquid in the reservoir, forces the liquid into the pump. When the pump operates, it forces liquid from the tank into the discharge pipe at a suitable pressure. The flow of the pressurized liquid discharged by the pump is controlled by valves. Three control functions are used in most hydraulic systems: ① control of the liquid pressure, ② control of the liquid flow rate, and ③ control of the direction of flow of the liquid.

Hydraulic drives are used in preference to mechanical systems when ① power is to be transmitted between points too far apart for chains or belts; ② high torque at low speed is required; ③ a very compact unit is needed; ④ a smooth transmission, free of vibration, is required; ⑤ easy control of speed and direction is necessary; and ⑥ output speed is varied steplessly.

Fig. 5. 1 gives a diagrammatic presentation of the components of a hydraulic installation. Electrically driven oil pressure pumps establish an oil flow for energy transmission, which is fed to hydraulic motors or hydraulic cylinders, converting it into mechanical energy. The control of the oil flow is by means of valves. The pressurized oil flow produces linear or rotary mechanical motion. The kinetic energy of the oil flow is comparatively low, and therefore the term hydrostatic driver is sometimes used. There is little constructional difference between hydraulic motors and pumps. Any pump may be used as a motor. The quantity of oil flowing at any given time may be varied by means of regulating valves (as shown in Fig. 5. 1) or the use of variable-delivery pumps.

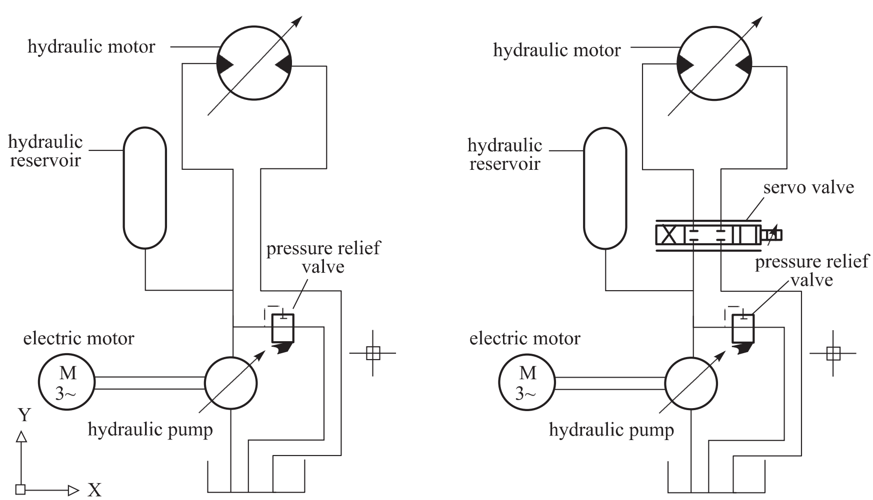

Fig. 5. 1 Speed-control methods for hydraulic motors

Hydraulic machine tool drive offers a great many advantages.[3] One of them is that it can give infinitely-variable speed control over wide ranges. In addition, they can change the direction of drive as easily as they can vary the speed. As in many other types of machine, many complex mechanical linkages can be simplified or even wholly eliminated by the use of hydraulics.

The flexibility and resilience of hydraulic power is another great virtue of this form of drive. Apart from the smoothness of operation thus obtained, a great improvement is usually found in the surface finish on the work and the tool can make heavier cuts without detriment and will last considerably longer without regrinding. [4]

Section II New Words and Phrases

hydraulics	[haiˈdrɔːliks]	*n.*	液压技术,水力学
confine	[kənˈfain]	*v.*	封闭
transmit	[trænzˈmit]	*v.*	传送
multiply	[ˈmʌltiplai]	*v.*	乘,增加,放大
reservoir	[ˈrezəvwɑː]	*n.*	(油)箱,水库
hose	[həuz]	*n.*	软管,水龙头
valve	[vælv]	*n.*	阀门
actuator	[ˈæktjueitə]	*n.*	执行器
intake	[ˈinteik]	*n.*	进(气、水)口
discharge	[disˈtʃɑːdʒ]	*v.*	卸载,卸货
torque	[tɔːk]	*n.*	力矩
vibration	[vaiˈbreiʃən]	*n.*	振动
steplessly		*adv.*	无级地
linear	[ˈliniə]	*adj.*	线性的
rotary	[ˈrəutəri]	*adj.*	旋转的
diagrammatic	[daiəgrəˈmætik]	*adj.*	图表的,概略的 diagram 图
oil pressure pump			油泵
hydraulic motor			液压电机
hydraulic cylinder			油缸
kinetic energy			动能

hydrostatic driver			静压传动
variable-delivery pump			变量泵
by no means			决不……
self-contained		*adj.*	独立的,配套的,整体的
regulating valve			调压阀
stimulate	[ˈstimjuleit]	*v.*	促进,激励
resilience	[riˈziliəns]	*n.*	跳回,恢复力,回弹
virtue	[ˈvəːtjuː]	*n.*	优点,效力,功能
finish		*n.*	光洁度
work			工件
cut			进刀量
detriment	[ˈdetrimənt]	*n.*	损害,不利
regrind		*v.*	重磨 grind 磨(刀)

Section III Notes to Complex Sentences

[1] It was then that French philosopher Blaise Pascal discovered that liquids cannot be compressed.

It was then that... :强调句型,it 是形式主语,then 是表语,that 引导的从句作逻辑主语,强调“then”。第二个 that 引导的从句作 discovered 的宾语。

全句可译为:正是在当时,法国哲学家巴斯卡发现液体是不能被压缩的。

[2] The most common hydraulic fluids contain specially compounded petroleum oils that lubricate and protect the system from corrosion.

最常见的液压流体含有特制石油化合油,起润滑和保护系统不受腐蚀的作用。

contain:含有; that 引导的定语从句,修饰 oils,翻译时可转换成状语。

[3] Hydraulic machine tool drive offers a great many advantages.

液压机床驱动具有许多优点。

drive 这里是名词; offer 是谓语;a great many:许多。

[4] ... a great improvement is usually found in the surface finish on the work and the tool can make heavier cuts without detriment and will last considerably longer without regrinding.

……通常可见工件的表面光洁度得到大大改善,刀具进刀量可以加大而不至损伤,并且持

续更长时间无须重磨。

surface finish:表面光洁度;tool:刀具;cuts:切削量;last:持续。

Section IV Exercise

Translate the following paragraph.

Compressors are used in petrochemical plants to raise the static pressure of air and process gases to levels required to overcome pipe friction, to affect a certain reaction at the point of final delivery, or to impart desired thermodynamic properties to the medium compressed. These compressors come in a variety of sizes, types, and models, each of which fulfills a given need and is likely to represent the optimum configuration for a given set of requirements. Selection of compressor types must, therefore, be preceded by a comparison between service requirements and compressor capabilities. This initial comparison will generally lead to a review of the economies of space, installing cost, operating cost, and maintenance requirements of competing types. Where the superiority of one compressor type or model over a competing offer is not obvious, a more detailed analysis may be justified.

Section V Supplementary Reading

Mechanism Systems

While some simple machines consist of only one kind of mechanisms, in most cases, using only one simple mechanism is not enough to perform the required mechanical actions in a machine. Two working links (or output links) are needed to shape a flat surface. They are the sliding block with the shaping tool (cutter) and the worktable holding the workpiece. Carrying the cutter, the sliding block moves back and forth to perform the cutting motion and the stroke of this motion is adjustable to fit the size of the workpiece. The worktable moves intermittently to provide the feeding action while the sliding block moves back. The amount of feed is also adjustable. Such a working process needs several simple mechanisms working together in a machine and form a mechanism system. Another example of a mechanism system is the well-known internal combustion engine, which consists of a crank and slider mechanism, cam mechanisms and a gear mechanism. The crank and slider mechanism converts the back and forth movement of the piston into rotation of the crankshaft. The gear mechanism and cam mechanisms control the movements of the valves exactly and ensure the synchronized operation of the whole engine. According to system theory, a machine can be seen as a system of mechanisms and a mechanism is a sub-system of a machine. Hence, the design of a machine is the design of a mechanism system.

The quality, performance and compatibility of a mechanical product depend mainly on its design. Any error, defect or carelessness in design may result in considerable extra cost in manufacture or even the failure of the product. The importance of design is obvious here.

Lesson 6

Engineering Graphics

Section I Text

Engineering graphics is a cornerstone of engineering. The essence of engineering — that is, design — requires graphics as the means of communication within the design process. Graphics serves as the common treaty between design and the manufacturing and construction processes. [1]

Study of the fundamentals of engineering graphics is one key to your success as an engineer. Being able to describe an idea with a sketch is a prerequisite of the engineering profession. The ability to put forth a three-dimensional geometry in a form that can be communicated to other engineers, scientists, technicians, and nontechnical personnel is a valuable asset. [2] Of equal importance is knowing how to read and understand the graphics prepared by others. [3]

The ability to communicate is the key to success for a practicing engineer. Graphic communication, along with written and oral communication, constitutes an important part of a program of study in engineering. The fundamentals of the graphics language are universal in the industrialized world, an advantage not afforded by the written and spoken language. Thus graphics may be said to be "a language for engineers."

The study of graphics involves three aspects: terminology, skills and theory. Definitions of general terms encountered in graphic applications are introduced below.

Engineering graphics is the area of engineering which involves the application of graphic principles in the development and conveyance of design concepts.

Engineering design is the systematic process by which a solution to a problem is created. Engineering graphics provides visual support, a basis for engineering analysis, and documentation for the design process.

Descriptive geometry is a set of principles which enable the geometry of an object to be identified and delineated by graphic means. It is the theory by which spatial (three-dimensional) problems involving angles, shapes, sizes, clearances, and intersections are solved with two-dimensional representation.

Computer graphics utilizes the digital computer to define, manipulate, and display devices, processes, and systems for the purpose of analysis, design, and communication of engineering solutions. [4]

Geometric modeling is the representation of a concept, process, or system operation usually in a mathematical form, and more specifically as an electronic database. Computer-based geometric modeling may conveniently be classified as wireframe, surface, or solid.

Engineering graphics is in a period of rapidly changing graphics technology. The traditional tools of graphics, such as the T-square, compass, and drafting machines, are being displaced by computer hardware and soft ware. We are in an exciting era in which we will experience the transition from scales, triangles, and dividers to a computer keyboard and from blueprints to databases.

The engineers of today see the engineering drawing as a by-product of the CAD process. The control of the design-manufacture cycle is now the electronic database of the design. Changes are incorporated instantly in all aspects of the design. New product models can be quickly developed and oftentimes proved with computer simulations, thus bypassing the prototype. If drawings are desired for manufacture or documentation, they may be quickly obtained from the database.

The engineering student of today will study graphics from the standpoint of supporting the design process. Geometric modeling techniques, analysis techniques which are mathematically based, and practice in visualization of three-dimensional geometries will be the focus of intensive computer utilization. [5] In order to prepare concepts for modeling and analysis, freehand techniques will be studied and practiced. The student will learn to produce and interpret multiviews and pictorials both via sketches and computer techniques. Many of the graphics standards for appropriate representation of object features (sections, dimensioning, multiviews) will be studied.

Working in three dimensions with the computer, graphics will be produced easily in two- or three-dimensional modes depending upon the application. [6] Creating two-dimensional graphics such as XY plots and schematics will be accomplished with CAD software. Two-dimensional geometric primitives such as circles and rectangles which serve as the generating geometry for cylinders and prisms are a part of two-dimensional software. Special applications, for example, dimensioning, generally utilize a two-dimensional view or series of two-dimensional views.

Three-dimensional geometric modeling involves wireframe, surface, and solid models. A wireframe model shows a series of nodes connected by lines to form an object. The solid model is a total definition of an object which includes knowledge of all boundary and internal points. From a solid model, a complete analysis of performance of the object can be performed on the computer with appropriate software.

Computer graphics has become a powerful design tool which promises to enhance significantly the engineer's ability to be creative and innovative in the solution of complex problems.

The information revolution is well under way. The rapid advancement of electronic technology has changed the way we work and live. The language of graphics will continue to be a cornerstone of communication for engineers and other technical persons. However, the changes we are seeing in the methods of transferring graphic, written, and spoken material are astounding. These changes are improving the productivity of industries and individuals as well as increasing the quality of products and the working environment. The requirements for the twenty-first century engineer will include a sound understanding of the fundamentals of graphics and the implementation of graphics to support the design process.

Section II New Words and Phrases

graphics	[ˈgræfiks]	*n.*	制图学,图形学,图解
cornerstone	[ˈkɔːnəstəʊn]	*n.*	基础,基石
essence	[ˈesns]	*n.*	本质,要素,精华
means of communication			交流工具(手段),通信工具(手段)
fundamental	[ˌfʌndəˈmentl]	*n.*	基本原理 *adj.* 基本的
prerequisite	[ˈpriːˈrekwizit]	*n.*	先决条件 *adj.* 首要必备的
put forth			提出,发表,拿出
nontechnical	[ˈnɔnˈteknikl]	*adj.*	非技术性的
practicing		*adj.*	开业的,从业的,在工作的
industrialized	[inˈdʌstriəlaizd]	*adj.*	工业化的
conveyance	[kənˈveiəns]	*n.*	运输,运输工具,运送,传送
descriptive geometry			画法几何
delineate	[diˈlinieit]	*v.*	描绘,描述
geometric modeling			几何建模,几何模型建立,形状模型化

T-square			丁字尺
compass	[ˈkʌmpəs]	*n.*	圆规
drafting		*n.*	制图,起草
scale		*n.*	比例尺,刻度尺
divider		*n.*	分规,两脚规
blueprint		*n.*	蓝图,设计图
database		*n.*	数据库
by-product		*n.*	副产品,副产物
prototype	[ˈprəutətaip]	*n.*	原型,样机,样品
geometric modeling			几何建模
visualization	[viʒʊəlaiˈzeiʃən]	*n.*	可视化,显形
freehand		*adj.*	徒手画的
pictorial	[pikˈtɔːriəl]	*adj.*	用图表示的,图解的
section		*n.*	截图
dimensioning		*n.*	标注尺寸
plot		*n.*	曲线,图形
schematic	[skiˈmætik]	*adj.*	示意的,简略的 *n.* 简图
node		*n.*	结点,交点,中心点
primitive	[ˈprimitiv]	*adj.*	原始的,基本的 *n.* 基元,图元
rectangle	[ˈrektæŋgl]	*n.*	长方形,矩形
prism	[ˈprizəm]	*n.*	棱柱
wireframe model			线框模型
surface model			曲面模型
solid model			实体模型
innovative	[ˌinəʊvetiv]	*adj.*	创新的,革新的
astound	[əsˈtaund]	*v.*	使……大吃一惊,令人震惊
sound		*adj.*	可靠的,合理的 *adv.* 彻底地,充分地

Section III Notes to Complex Sentences

[1] Graphics serves as the common treaty between design and the manufacturing and construction processes.

图样在设计与加工制作过程中间充当共同协议的作用。

[2] The ability to put forth a three-dimensional geometry in a form that can be communicated to other engineers, scientists, technicians, and nontechnical personnel is a valuable asset.

能与其他工程师、科学家、技术人员和非技术人员以一种表达空间立体的方式进行交流沟通,这种能力是一笔有价值的财富。

[3] Of equal importance is knowing how to read and understand the graphics prepared by others.

知道如何读懂其他人准备的图纸也同等重要。

这是一个倒装句,主语是 knowing how. . . , of equal importance 作表语,意为“具有同样重要性”。

[4] Computer graphics utilizes the digital computer to define, manipulate, and display devices, processes, and systems for the purpose of analysis, design, and communication of engineering solutions.

计算机绘图利用数字计算机来定义、操作和显示设备、过程及系统,其目的是分析、设计和交流工程问题的解决途径。

本句是一个简单句,谓语是 define,manipulate and display 3 个并列动词,它们共同的宾语为 devices,processes and systems.

[5] Geometric modeling techniques, analysis techniques which are mathematically based, and practice in visualization of three-dimensional geometries will be the focus of intensive computer utilization.

作为以数学为基础的几何建模技术、分析技术以及三维几何图形显现方法的练习将是计算机应用的中心。

[6] Working in three dimensions with the computer, graphics will be produced easily in two- or three-dimensional models depending upon the application.

基于计算机三维图形,依实际需要很容易生成二维或三维模型的图形。

Section IV Exercise

Translate the following into Chinese.

Engineering drawings are often referred to as "blueprints" or "bluelines." However, the terms are rapidly becoming an anachronism, since most copies of engineering drawings that were formerly made using a chemical-printing process that yielded graphics on blue-colored paper or, alternatively, of blue-lines on white paper, have been superseded by more modern reproduction processes that yield black or multicolour lines on white paper. The more generic term "print" is now in common usage in the U. S. to mean any paper copy of an engineering drawing.

Engineering drawings can now be produced using computer technology. Drawings are extracted from three dimensional computer models and can be printed as two dimensional drawings on various media formats (colour or monochrome). Engineered computer models can also be printed in three dimensional form using special 3D printers.

The process of producing engineering drawings, and the skill of producing them, is often referred to as technical drawing, although technical drawings are also required for disciplines that would not ordinarily be thought of as parts of engineering.

Section V Supplementary Reading

An Overview of Engineering Drawing

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The process of producing engineering drawings, and the skill of producing them, is often referred to as technical drawing, although technical drawings are also required for disciplines that would not ordinarily be thought of as parts of engineering.

Drawings convey the following critical information.

(1) Geometry — the shape of the object; represented as views; how the object will look when it is viewed from various standard directions, such as front, top, side, etc.

(2) Dimensions — the size of the object is captured in accepted units.

(3) Tolerances — the allowable variations for each dimension.

(4) Material — represents what the item is made of.

(5) Finish — specifies the surface quality of the item, functional or cosmetic. For example, a mass-marketed product usually requires a much higher surface quality than, say, a component that goes inside industrial machinery.

Lesson 7

Mechanical Parts

Section I Text

Gears

Gears are direct contact bodies, operating in pairs, that transmit motion and force from one rotating shaft to another, or from a shaft to a slide (rack), by means of successively engaging projections called teeth.[1]

Tooth profiles The contacting surfaces of gear teeth must be aligned in such a way that the drive is positive; i. e., the load transmitted must not depend on frictional contact. As shown in the treatment of direct contact bodies, this requires that the common normal to the surfaces not pass through the pivotal axis of either the driver or the follower.

As it is known as direct contact bodies, cycloidal and involute profiles provide both a positive drive and a uniform velocity ratio; i. e., conjugate action.

Basic relations The smaller of a gear pair is called the pinion and the larger is the gear. When the pinion is on the driving shaft the pair acts as a speed reducer; When the gear drives, the pair is a speed increaser. Gears are more frequently used to reduce speed than to increase it.

If a gear having N teeth rotates at n revolutions per minute, the product N * n has the dimension "teeth per minute." This product must be the same for both members of a mating pair if each tooth acquires a partner from the mating gear as it passes through the region of tooth engagement.

For conjugate gears of all types, the gear ratio and the speed ratio are both given by the ratio of the number of teeth on the gear to the number of teeth on the pinion. If a gear has 100 teeth and a mating pinion has 20, the ratio is 100/20 = 5. Thus the pinion rotates five times as fast as the gear, regardless of the speed of the gear. Their point of tangency is called the pitch point, and since it lies on the line of centers, it is the only point at which the tooth profiles have pure rolling contact. Gears on nonparallel, non-intersecting shafts also have pitch circles, but the rolling-pitch-circle concept is not valid.

Gear types are determined largely by the disposition of the shafts; in addition, certain types are better suited than others for large speed changes. This means that if a specific disposition of the shafts is required, the type of gear will more or less be fixed. On the other hand, if a required speed change demands a certain type, the shaft positions will also be fixed.

Spur gears and helical gears A gear having tooth elements that are straight and parallel to its axis is known as a spur gear. A spur pair can be used to connect parallel shafts only.

If an involute spur pinion were made of rubber and twisted uniformly so that the ends rotated about the axis relative to one another, the elements of the teeth, initially straight and parallel to the axis, would become helices. [2] The pinion then in effect would become a helical gear.

Worm and bevel gears In order to achieve line contact and improve the load carrying capacity of the crossed axis helical gears, the gear can be made to curve partially around the pinion, in somewhat the same way that a nut envelops a screw. The result would be a cylindrical worm and gear. Worms are also made in the shape of an hourglass, instead of cylindrical, so that they partially envelop the gear. This results in a further increase in load-carrying capacity.

Worm gears provide the simplest means of obtaining large ratios in a single pair. They are usually less efficient than parallel-shaft gears, however, because of an additional sliding movement along the teeth.

V-belt

The rayon and rubber V-belt are widely used for power transmission. Such belts are made in two series: the standard V-belt and the high capacity V-belt. The belts can be used with short center distances and are made endless so that difficulty with splicing devices is avoided.

First, cost is low, and power output may be increased by operating several belts side by side. All belts in the drive should stretch at the same rate in order to keep the load equally divided among them. When one of the belts breaks, the group must usually be replaced. The drive may be inclined at any angle with tight side either top or bottom. Since belts can operate on relatively small pulleys, large reductions of speed in a single drive are possible.

Second, the included angle for the belt groove is usually from 34° to 38°. The wedging action of the belt in the groove gives a large increase in the tractive force developed by the belt.

Third, pulley may be made of cast iron, sheet steel, or die-cast metal. Sufficient clearance must be provided at the bottom of the groove to prevent the belt from bottoming as it becomes narrower from wear. [3] Sometimes the larger pulley is not grooved when it is possible to develop the required tractive force by running on the inner surface of the belt. The cost of cutting the grooves is thereby eliminated. Pulleys are on the market that permit an adjustment in the width of the groove. The effective pitch diameter of the pulley is thus varied, and moderate changes in the speed ratio can be secured.

Section II New Words and Phrases

projection	[prəˈdʒekʃən]	*n.*	凸出,投影,投射
cycloidal	[saiˈklɔidəl]	*adj.*	摆线的 cycloid 摆线,轮转线
cycloidal profile			摆线轮廓
involute	[ˈinvəluːt]	*n.*	渐开线
involute profile			渐开线轮廓
conjugate	[ˈkɔndʒugit]	*adj.*	共轭的
pinion	[ˈpinjən]	*n.*	小齿轮
dimension		*n.*	量纲, 尺寸,维
mate		*v.*	啮合
engagement		*n.*	啮合
tangency	[ˈtændʒənsi]	*n.*	接触,相切
pitch	[pitʃ]	*n.*	齿节,节距
intersect	[intəˈsekt]	*v.*	交叉
disposition	[dispəˈziʃən]	*n.*	排列,配置,布置
helical	[ˈhelikəl]	*adj.*	螺旋状的 helical gear 螺旋齿轮,斜齿轮
spur	[spəː]	*n.*	刺 spur gear 正齿轮
worm		*n.*	涡轮,蜗杆
bevel	[ˈbevəl]	*n.*	斜边和斜面 bevel gear 伞形齿轮
hourglass	[ˈauəglɑːs]	*n.*	沙漏
V-belt			V 型带
splice	[splais]	*n.*	连接, 接合
pulley	[ˈpuli]	*n.*	(皮带)轮
groove	[gruːv]	*n.*	沟,槽

tractive	[ˈtræktiv]	*adj.*	牵引的,曳引的
clearance	[ˈkliərəns]	*n.*	间隙,清算

Section III Notes to Complex Sentences

[1] Gears are direct contact bodies, operating in pairs, that transmit motion and force from one rotating shaft to another, or from a shaft to a slide (rack), by means of successively engaging projections called teeth.

齿轮是直接接触、成对工作的实体,在称为齿的凸出物的连续啮合作用下,齿轮能将运动和力从一个旋转轴传递到另一个旋转轴,或从一个轴传递到一个滑块(齿条)。

operating in pairs: 分词短语,修饰前面的 Gears。

that 引导的从句,修饰前面的 Gears。

by means of 表示"借助""通过"的意思。

[2] If an involute spur pinion were made of rubber and twisted uniformly so that the ends rotated about the axis relative to one another, the elements of the teeth, initially straight and parallel to the axis, would become helices.

如果一个渐开线直齿小齿轮是用橡皮制成的,能均匀扭曲,从而一端会绕另一端为轴进行旋转,这样小齿轮上的齿开始将是直的并行于传动轴,最后会变成螺旋形。

注意本句是虚拟语句。

were made of:"由……组成"。

so that 引导结果状语从句。

parallel to:"平行于……"。

[3] Sufficient clearance must be provided at the bottom of the groove to prevent the belt from bottoming as it becomes narrower from wear.

在带轮槽的底部需要留有足够的间隙,以保证 V 型带不接触带轮槽的底部,因为那将因磨损变得越来越窄。

at the bottom of... "在……的底部"。

prevent... from bottoming"防止触底"。

Section IV　Exercise

Translate the following paragraphs.

A gear having tooth elements that are straight and parallel to its axis is known as a spur gear. A spur pair can be used to connect parallel shafts only. Parallel shafts, however, can also be connected by gears of another type, and a spur gear can be mated with a gear of a different type. Helical gears have certain advantages; for example, when connecting parallel shafts they have a higher load-carrying capacity than spur gears with the same tooth numbers and cut with the same cutter. Helical gears can also be used to connect nonparallel, non-intersecting shafts at any angle to one another. Ninety degrees is the most common angle at which such gears are used.

Worm gears provide the simplest means of obtaining large ratios in a single pair. They are usually less efficient than parallel shaft gears, however, because of an additional sliding movement along the teeth. Because of their similarity, the efficiency of a worm and gear depends on the same factors as the efficiency of a screw.

Section V　Supplementary Reading

Chain

The first chain-driven or "safety" bicycle appeared in 1874, and chains were used for driving the rear wheels on early automobiles. Today, as the result of modern design and production methods, chain drives that are much superior to their prototypes are available, and these have contributed greatly to the development of efficient agricultural machinery, well-drilling equipment, and mining and construction machinery. Since about 1930 chain drives have become increasingly popular, especially for power saws, motorcycle, and escalators, etc.

There are at least six types of power-transmission chains; three of these will be covered in this article, namely the roller chain, the inverted tooth, or silent chain, and the bead chain. The essential elements in a roller-chain drive are a chain with side plates, pins, bushings (sleeves), and rollers, and two or more sprocket wheels with teeth that look like gear teeth. Roller chains are assembled from pin links and roller links. A pin link consists of two side plates connected by two pins inserted into holes in the side plates. The pins fit tightly into the holes, forming what is known as a press fit. A roller link consists of two side plates connected by two press-fitted bushings, on which two hardened steel rollers are free to rotate. When assembled, the pins are a free fit in the bushings and rotate slightly, relative to the bushings when the chain goes on and leaves a sprocket.

Standard roller chains are available in single strands or in multiple strands. In the latter type, two or more chains are joined by common pins that keep the rollers in the separate strands in proper alignment. The speed ratio for a single drive should be limited to about 10:1; the preferred shaft center distance is from 30 to 35 times the distance between the rollers and chain speeds greater than about 2,500 feet (800 meters) per minute are not recommended. Where several parallel shafts are to be driven without slip from a single shaft, roller chains are particularly well suited.

An inverted tooth, or silent chain is essentially an assemblage of gear racks, each with two teeth, pivotally connected to form a closed chain with the teeth on the inside, and meshing with conjugate teeth on the sprocket wheels. The links are pin-connected flat steel plates usually having straight-sided teeth with an included angle of 60 degrees. As many links are necessary to transmit the power and are connected side by side. Compared with roller-chain drives, silent-chain drives are quieter, operate successfully at higher speeds, and can transmit more load for the same width. Some automobiles have silent-chain camshaft drives.

Bead chains provide an inexpensive and versatile means for connecting parallel or nonparallel shafts when the speed and power transmitted are low. The sprocket wheels contain hemispherical or conical recesses into which the beads fit. The chains look like key chains and are available in plain carbon and stainless steel and also in the form of solid plastic beads molded on a cord. Bead chains are used on computers, air conditioners, television tuners, and Venetian blinds. The sprockets may be steel, die-cast zinc or aluminum, or molded nylon.

Lesson 8

Lathes and Lathe Operations

Section Ⅰ Text

Lathes are generally considered to be the oldest machine tools. Although woodworking lathes were originally developed during the period 1000 B. C. —1 B. C., metalworking lathes with lead screws were not built until the late 1700s. The most common lathe was originally called an engine lathe because it was powered with overhead pulleys and belts from nearby engines. Today these lathes are equipped with individual electric motors.

Although simple and versatile, an engine lathe requires a skilled machinist because all controls are manipulated by hand. Consequently, it is inefficient for repetitive operations and for large production runs.

Lathe Components

Lathes are equipped with a variety of components and accessories. The basic components of a common lathe are described below.

Bed. The bed supports all major components of the lathe. Beds have a large mass and are rigidly built, usually from gray or nodular cast iron. The top portion of the bed has two ways, with various cross-sections, that are hardened and machined for wear resistance and dimensional accuracy during use.

Carriage. The carriage, or carriage assembly, slides along the ways and consists of an assembly to the cross-slide, tool post, and apron. The cutting tool is mounted on the tool post, usually with a compound rest that swivels for tool positioning and adjustment. The cross-slide moves radially in and out, controlling the radial position of the cutting tool in operations such as facing.[1] The apron is equipped with mechanisms for both manual and mechanized movement of the carriage and the cross-slide by means of the lead screw.

Headstock. The headstock is fixed to the bed and is equipped with motors, pulleys, and V-belts that supply power to the spindle at various rotational speeds. The speeds can be set through manually-controlled selectors. Most headstocks are equipped with a set of gears, and some have various drives to provide a continuously variable speed range to the spindle. Head-stocks have a hollow spindle to which workholding devices, such as chucks and collets, are attached, and long bars or tubing can be fed through for various turning operations.

Tailstock. The tailstock, which can slide along the ways and be clamped at any position, supports the other end of the workpiece. It is equipped with a center that may be fixed (dead center) or may be free to rotate with the workpiece (live center). Drills and reamers can be mounted on the tailstock quill (a hollow cylindrical part with a tapered hole) to drill axial holes in the workpiece.

Feed rod and lead screw. The feed rod is powered by a set of gears from the headstock. It rotates during the operation of the lathe and provides movement to the carriage and the cross-slide by means of gears, a friction clutch, and a keyway along the length of the rod.[2] Closing a split nut around the lead screw engages it with the carriage; it is also used for cutting threads accurately.

Lathe Specifications

A lathe is usually specified by (a) its swing, that is, the maximum diameter of the workpiece that can be machined, (b) the maximum distance between the headstock and tailstock centers, and (c) the length of the bed. For example, a lathe may have the following size: 360mm (14in.) swing by 760mm (30 in.) between centers by 1,830 mm (6ft) length of bed. Lathes are available in a variety of styles and types of construction and power.

Bench lathes are placed on a workbench; they have low power, are usually operated by hand feed, and are used to precision-machine small workpieces.[3] Toolroom lathes have high precision, enabling the machining of parts to close tolerances. Engine lathes are available in a wide range of sizes and are used for a variety of turning operations. In gap bed lathes, a section of the bed in front of the headstock can be removed to accommodate larger-diameter workpieces.

Special-purpose lathes are used for applications such as railroad wheels, gun barrels, and rolling-mill rolls, with workpiece sizes as large as 1.7m in diameter by 8m in length (66in. × 25ft.) and capacities of 450 kw (600hp). The cost of engine lathes ranges from about \$2,000 for bench types to over \$100,000 for larger units.

Lathe Operations

In a typical turning operation, the workpiece is clamped by any one of the workholding devices. Long and slender parts should be supported by a steady rest and follow rest placed on the bed; otherwise, the part will deflect under the cutting forces.[4] These rests are usually equipped with three adjustable fingers or rollers, which support the workpiece while allowing it to rotate freely. Steady rests are clamped directly on the ways of the lathe, whereas follow rests are clamped on the carriage and travel with it.

The cutting tool, attached to the tool post, which is driven by the lead screw, removes material by traveling along the bed. A right-hand tool travels toward the headstock, and a left-hand tool toward the tailstock. Facing operations are done by moving the tool radially with the cross-slide, and clamping the carriage for better dimensional accuracy.

Form tools are used to produce various shapes on round workpieces by turning. The tool moves radially inward to machine the part. Machining by form cutting is not suitable for deep and narrow grooves or sharp corners because they may cause vibration and result in poor surface finish.[5] As a rule, (a) the formed length should not be greater than about 2.5 times the minimum diameter of the part, (b) the cutting speed should be reduced from turning settings, and (c) cutting fluids should be used.

The boring operation on a lathe is similar to turning. Boring is performed inside hollow workpieces or in a hole made previously by drilling or other means. Out-of-shape holes can be straightened by boring. The workpiece is held in a chuck or in some other suitable workholding device. Drilling can be performed on a lathe by mounting the drill bit in a drill chuck into the tailstock quill (a tubular shaft). The workpiece is placed in a workholder on the headstock, and quill is advanced by rotating the hand wheel.[6] Holes drilled in this manner may not be concentric because of the tendency for the drill to drift radially. The concentricity of the hole is improved by subsequently boring the drilled hole. Drilled holes may be reamed on lathes in a manner similar to drilling, thus improving hole tolerances.

Section II New Words and Phrases

lathe	[leið]	*n.*	车床
pulley	[ˈpuli]	*n.*	滑车,滑轮
manipulate	[məˈnipjuleit]	*vt.*	(熟练地)操作,使用(机器等),操纵(人或市价、市场),利用,应付,假造

nodular	[ˈnɔdjulə]		cast iron 球墨铸铁
cross-section			横截面,断面,剖面图
carriage	[ˈkæridʒ]	*n.*	(机械)车架
mount	[maunt]	*n.*	固定架 *vt.* 装上,设置,安放,固定,爬上,上演
assembly	[əˈsembli]	*n.*	装配,组装,集合,集会,集结,汇编
tool post			刀架,刀座
apron	[ˈeiprən]	*n.*	挡板,护坦
compound rest			复式刀架;(车床)小刀架
swivel	[ˈswivl]	*v.*	旋转
lead screw			导螺杆,丝杆
deflect	[diˈflekt]	*v.*	(使)偏斜,(使)偏转
headstock	[ˈhedstɔk]	*n.*	主轴箱,头架
hollow	[ˈhɔləu]	*n.*	穴,腔,窟窿 *adj.* 空的,中空的,空腹的,凹的
tubing	[ˈtjuːbiŋ]	*n.*	装管,管道系统 *adj.* 管状的,管制的,制管的
spindle	[ˈspindl]	*n.*	锭子,纺锤,轴,杆,心轴 *adj.* 锭子的,锭子似的
chuck	[tʃʌk]	*n.*	卡盘
collet	[ˈkɔlit]	*n.*	筒夹,夹头 *vt.* 镶进底座,装筒夹或夹头
tailstock	[ˈteilstɔk]	*n.*	尾架,尾座,顶针座
tailstock quill			尾架顶尖套筒,尾架顶心套筒
clamp	[klæmp]	*n.*	夹子,夹具,夹钳 *vt.* 夹住,夹紧
workpiece		*n.*	工件,加工件
reamer	[ˈriːmə]	*n.*	钻孔器,刀,铰床
cylindrical	[siˈlindrikl]	*adj.*	[计]圆柱的
feed rod			分配杆,进给杆,进刀杆,光杆
friction clutch	[ˈfrikʃən klʌtʃ]		摩擦离合器
nut		*n.*	螺母,坚果
thread	[θred]	*n.*	螺纹,线,细丝,线索,思路

swing	[swiŋ]	*n.*	振幅，摆程，摇摆，摆动，秋千 *v.* 摇摆，摆动，回转，旋转
in.			英寸（inch 的简写）
ft.			英尺（feet 的简写）
hp.			（英制单位）马力（1hp＝745.7W）
diameter	[daiˈæmitə]	*n.*	直径
bench lathe			台式车床
workbench	[ˈwəːkbentʃ]	*n.*	工作台，成型台
precision-machine	[priˈsiʒən-...]	*v.*	精密加工
toolroom lathe			工具车，工具车床
close tolerance			紧公差，严格的容限
engine lathe			普通车床
gap bed lathe			马鞍式车床
slender	[ˈslendə]	*adj.*	苗条的，微薄的，细长的
follow rest			跟刀架
form tool			样板刀；成形刀
groove	[gruːv]	*n.*	凹槽 *vt.* 开槽于
cutting fluid			切削液；乳化切削油
workholder		*n.*	工件夹具，工件夹持装置
boring	[ˈbɔːriŋ]	*n.*	钻（孔）
out-of-shape			形状不规则

Section III Notes to Complex Sentences

[1] The cutting tool is mounted on the tool post, usually with a compound rest that swivels for tool positioning and adjustment. The cross-slide moves radially in and out, controlling the radial position of the cutting tool in operations such as facing.

刀具安装在刀架上，通常采用旋转复合刀架以便刀具定位和调整。横向滑板可以径向移进移出，以控制切削加工中（如车端面）刀具的径向位置。

[2] It rotates during the operation of the lathe and provides movement to the carriage and the cross-slide by means of gears, a friction clutch, and a keyway along the length of the rod.

进给杆在车床操作时可以旋转，然后靠齿轮、一个摩擦离合器和一个长杆键槽提供运动量给机架和横向滑板。

by means of 意为“用……；依靠……”。

e.g. Thoughts are expressed by means of words.

思想靠语言来表达。

[3] Bench lathes are placed on a workbench; they have low power, are usually operated by hand feed, and are used to precision-machine small workpieces.

台式车床放在工作台上，它们功率低，通常用手操作进刀，用来精密加工小工件。

[4] Long and slender parts should be supported by a steady rest and follow rest placed on the bed; otherwise, the part will deflect under the cutting forces.

细长零件必须由一个稳定的支撑架和安放在机床上的跟刀架支撑；否则，零件就会在切削力的作用下偏转。

follow rest：跟刀架。

[5] The tool moves radialy inward to machine the part. Machining by form cutting is not suitable for deep and narrow grooves or sharp corners because they may cause vibration and result in poor surface finish.

成形刀径向移动加工零件。成形刀不适合深且窄的凹槽加工或是锐角转角加工，因为它们加工时会振动，从而导致完成的表面质量较差。

[6] The workpiece is placed in a workholder on the headstock, and quill is advanced by rotating the hand wheel.

加工件用工件夹具固定在主轴箱上，尾架顶尖套筒靠手轮旋转向前运动。

Section IV Exercise

Translate the following sentences.

1. Although simple and versatile, an engine lathe requires a skilled machinist because all controls are manipulated by hand.

2. Head-stocks have a hollow spindle to which workholding devices, such as chucks and collets, are attached, and long bars or tubing can be fed through for various turning operations.

3. Drilling can be performed on a lathe by mounting the drill bit in a drill chuck into the tailstock quill (a tubular shaft).

Section V Supplementary Reading

Milling

Milling is a machining process for removing material by relative motion between a workpiece and a rotating cutter having multiple cutting edges. In some applications, the workpiece is held stationary while the rotating cutter is moved past it at a given feed rate (traversed). In other applications, both the workpiece and cutter are moved in relation to each other and in relation to the milling machine. More frequently, however, the workpiece is advanced at a relatively low rate of movement or feed to a milling cutter rotating at comparatively high speed, with the cutter axis remaining in a fixed position. A characteristic feature of the milling process is that each milling cutter tooth takes its share of the stock in the form of small individual chips. Milling operations are performed on many different machines.

Since both the workpiece and cutter can be moved relative to one another, independently or in combination, a wide variety of operations can be performed by milling. Applications include the production of flat or contoured surfaces, slots, grooves, recesses, threads, and other configurations.

Milling is one of the most universal, yet complicated machining methods. The process has more variations in the kinds of machines used, workpiece movements, and types of tooling than any other basic machining method. Important advantages of removing material by means of milling include high stock removal rates, the capability of producing relatively smooth surface finishes, and the wide variety of cutting tools that are available. Cutting edges of the tools can be shaped to form any complex surface.

The major milling methods are peripheral and face milling; in addition, a number of related methods exist that are variations of these two methods, depending upon the type of workpiece or cutter.