Part 1

Foundation of Mechanics

Unit 1
Introduction to Mechanical Design

Text

Mechanical design is the application of science and technology to devise new or improved products for the purpose of satisfying human needs. [1] It is a vast field of engineering technology which not only concerns itself with the original conception of the product in terms of its size, shape and construction details, but also considers the various factors involved in the manufacture, marketing and use of the product.

People who perform the various functions of mechanical design are typically called designers, or design engineers. Mechanical design is basically a creative activity. However, in addition to being innovative, a design engineer must have a solid background in the areas of mechanical drawing, kinematics, dynamics, materials engineering, strength of materials and manufacturing processes.

As stated previously, the purpose of mechanical design is to produce a product which will serve a need for human. Inventions, discoveries and scientific knowledge by themselves do not necessarily benefit people; only if they are incorporated into a designed product will a benefit be derived. It should be recognized, therefore, that a human need must be identified before a particular product is designed.

Mechanical design should be considered to be an opportunity to use innovative talents to envision a design of a product, to analyze the system and then make sound judgments on how the product is to be manufactured. It is important to understand the fundamentals of engineering rather than memorize mere facts and equations. There are no facts or equations which alone can be used to provide all the correct decisions required to produce a good design. On the other hand, any calculations must be done with the utmost care and precision. For example, if a decimal point is misplaced, an otherwise acceptable design may not function.

Good designers require trying new ideas and being willing to take a certain amount of risk, knowing that if the new idea does not work the existing method can be reinstated. Thus a designer must have patience, since there is no assurance of success for the time and effort expended. Creating a completely new design generally requires that many old and well-established methods be thrust aside. This is not easy since many people cling to familiar ideas, techniques and attitudes. A design engineer should constantly search for ways to improve an existing product and must decide what old, proven concepts should be used and what new, untried ideas should be incorporated.

New designs generally have "bugs" or unforeseen problems which must be worked out before the superior characteristics of the new designs can be enjoyed. Thus there is a chance for a superior product, but only at higher risk. It should be emphasized that, if a design does not warrant radical new methods, such methods should not be applied merely for the sake of change.

During the beginning stages of design, creativity should be allowed to flourish without a great number of constraints. Even though many impractical ideas may arise, it is usually easy to eliminate them in the early stages of design before firm details are required by manufacturing. In this way, innovative ideas are not inhibited. Quite often, more than one design is developed, up to the point where they can be compared against each other, it is entirely possible that the design which is ultimately accepted will use ideas existing in one of the rejected designs that did not show as much overall promise.

Psychologists frequently talk about trying to fit people to the machines they operate. It is essentially the responsibility of the design engineer to strive to fit machines to people. This is not an easy task, since there is really no average person for which certain operating dimensions and procedures are optimum.

Another important point which should be recognized is that a design engineer must be able to communicate ideas to other people if they are to be incorporated. Communicating the design to others is the final, vital step in the design process. Undoubtedly many great designs, inventions, and creative works have been lost to mankind simply because the originators were unable or unwilling to explain their accomplishments to others. Presentation is a selling job. The engineer, when presenting a new solution to administrative, management, or supervisory persons, is attempting to sell or to prove to them that this solution is a better one. Unless this can be done successfully, the time and effort spent in obtaining the solution have been largely wasted.

Basically, there are only three means of communication available to us. These are the written, the oral, and the graphical forms. Therefore the successful engineer will be technically competent and versatile in all three forms of communication. A technically competent person who lacks ability in any one of these forms is severely handicapped. If ability in all three forms is lacking, no one will ever know how competent that person is!

The competent engineer should not be afraid of the possibility of failure in a presentation. In fact, occasional failure should be expected because failure or criticism seems to accompany every really creative idea. There is a great deal to be learned from a failure, and the greatest gains are obtained by those willing to risk defeat. [2] In the final analysis, the real failure would lie in deciding not to make the presentation at all.

To communicate effectively, the following questions must be answered:

(1) Does the design really serve a human need?

(2) Will it be competitive with existing products of rival companies?

(3) Is it economical to produce?

(4) Can it be readily maintained?

(5) Will it sell and make a profit?

Only time will provide the true answers to the preceding questions, but the product should be designed, manufactured and marketed only with initial affirmative answers. The design engineer must also communicate the finalized design with manufacturing through the use of detail and assembly drawings.

Quite often, a problem will occur during the manufacturing cycle. It may be that a change is required in the dimension or tolerance of a part so that it can be more readily produced. [3] This falls in the category of engineering changes which must be approved by the design engineer so that the product function will not be adversely affected. In other cases, a deficiency in the design may appear during assembly or testing just prior to shipping. These realities simply bear out the fact that design is a living process. There is always a better way to do it and the designer should constantly strive towards finding that better way.

New Words & Expressions

mechanical design 机械设计
application /ˌæpliˈkeiʃən/ *n*. 应用，适用
devise /diˈvaiz/ *v*. 设计；发明
original /əˈridʒənl/ *adj*. 最初的；独创的
function /ˈfʌŋkʃən/ *n*. 功能
innovative /ˈinəuveitiv/ *adj*. 创新的
mechanical drawing 机械制图
kinematics /ˌkinəˈmætiks/ *n*. 运动学
dynamics /daiˈnæmiks/ *n*. 动力学
materials engineering 工程材料
strength of materials 材料力学
incorporate /inˈkɔːpəreit/ *v*. 合并
fundamental /ˌfʌndəˈmentl/ *n*. 基本原则（或原理）
precision /priˈsiʒən/ *n*. 精确；精度
decimal /ˈdesiməl/ *adj*. 小数的
thrust /θrʌst/ *v*. 用力推
technique /tekˈniːk/ *n*. 技巧，技法
for the sake of 为了
flourish /ˈfləːriʃ/ *v*. 繁荣；茂盛；活跃
ultimately /ˈʌltimitli/ *adv*. 最后，终于
psychologist /saiˈkɔlədʒist/ *n*. 心理学家
optimum /ˈɔptiməm/ *adj*. 最理想的
accomplishment /əˈkɔmpliʃmənt/ *n*. 成就；完成
graphical /ˈgræfikəl/ *adj*. 图解的
versatile /ˈvəːsətail/ *adj*. 多功能的；多才多艺的
handicap /ˈhændikæp/ *v*. 妨碍，使不利
affirmative /əˈfəːmətiv/ *adj*. 肯定的
assembly /əˈsembli/ *n*. 装配
manufacturing cycle 制造周期

Complex Sentence Analysis

[1]It is a vast field of engineering technology which not only concerns itself with the original conception of the product in terms of its size,shape and construction details,but also considers the various factors involved in the manufacture,marketing and use of the product. 它涉及工程技术的各个领域,不仅研究产品的尺寸、形状和详细结构的基本构思,还研究包括产品在制造、销售和使用等方面的问题。

①...which not only concerns itself with the original conception of the product in terms of its size,shape and construction details,but also considers the various factors involved in the manufacture,marketing and use of the product:这是一个由 which 引导的限制性定语从句,其先行词为 field,其中 not only...but also 引导的是两个并列成分。

②in terms of:根据,按照。

[2]In the final analysis,the real failure would lie in deciding not to make the presentation at all. 总之,决定不把方案提交出来才是真正的失败。

①in the final analysis:总之,归根结底。

②lie in:在于……。

[3]This falls in the category of engineering changes which must be approved by the design engineer so that the product function will not be adversely affected. 但是,工程上的更改必须经过设计工程师批准,以保证不会损伤产品的功能。

①fall in the category of:属于哪一类。

②which must be approved by the design engineer so that the product function will not be adversely affected:这是一个由 which 引导的限制性定语从句,其先行词为 engineering changes。

Exercises

Ⅰ. Translate the following into Chinese or English.

1. mechanical design ____________________
2. 机械制图 ____________________
3. kinematics ____________________
4. 工程材料 ____________________
5. strength of materials ____________________
6. 冒一定的风险 ____________________
7. unforeseen problems ____________________
8. 为了…… ____________________
9. operating dimensions ____________________
10. 制造周期 ____________________

Ⅱ. Mark the following statements with True(T) or False(F) according to the text.

( )1. Mechanical design is the application of science and technology to devise new or improved products for the purpose of satisfying human needs.

( )2. In addition to being innovative, a design engineer must have a solid background in the areas of mechanical drawing, kinematics, dynamics, engineering material, strength of or improved products for the purpose of earning a profit.

( )3. It is equally important to understand the fundamentals of engineering as well as memorize relevant facts and equations.

( )4. During the beginning stages of design, creativity should be allowed to flourish with a lot of constraints.

( )5. Undoubtedly many great designs, inventions, and creative works have been lost to mankind simply because the originators were unable or unwilling to explain their accomplishments to others.

Ⅲ. Fill in the blanks with the suitable words or phrases given below.

category	occur	adversely
strive	prior to shipping	dimension

Quite often, a problem will ___1___ during the manufacturing cycle. It may be that a change is required in the ___2___ or tolerance of a part so that it can be more readily produced. This falls in the ___3___ of engineering changes which must be approved by the design engineer so that the product function will not be ___4___ affected. In other cases, a deficiency in the design may appear during assembly or testing just ___5___. These realities simply bear out the fact that design is a living process. There is always a better way to do it and the designer should constantly ___6___ towards finding that better way.

Ⅳ. Translate the Chinese parts given in the brackets into English.

1. Mechanical design is the application of science and technology to devise new or improved products ____________ (为了满足人类的需求).

2. People who ____________ (从事各种机械设计工作) are typically called designers, or design engineers.

3. It is important to ____________ (掌握工程基础知识) rather than memorize mere facts and equations.

4. New designs generally ____________ (有许多缺陷和未能预料的问题) which must be worked out before the superior characteristics of the new designs can be enjoyed.

5. The design engineer must also communicate the finalized design to manufacturing ____________ (通过零件图和装配图).

Unit 2
Some Rules for Mechanical Design

Text

The purpose of design is to meet a kind of need, which can be real or imagined. Existing apparatus may need improvements in durability, efficiency, weight, speed, or cost. New apparatus may be needed to perform a function previously done by men, such as computation, assembly, or servicing. [1] With the objective wholly or partly defined, the next step in design is the conception of mechanisms and their arrangements that will perform the needed functions. For this purpose, freehand sketching is commonly adopted. Since freehand sketching can record one's thoughts and is helpful in communicating your ideas to others. It can also visualize one's ideas, thus stimulating his creativity.

When the general shape and a few dimensions of the several components become apparent, the relevant analysis can be commenced. The analysis will have as its objective satisfactory or superior performance, plus safety and durability with minimum weight, and a competitive cost. Optimum proportions and dimensions will be sought for each critically loaded section, together with a balance between the strength of the several components. Materials and their treatment will be chosen. [2] These important objectives can be attained only by analysis based upon the principles of mechanics, such as those of statics for reaction forces and for the optimum utilization of friction; of dynamics for inertia, acceleration, and energy; of elasticity and strength of materials for stress and deflection; and of fluid mechanics for lubrication and hydrodynamic drives.

Finally, a design based upon function and reliability will be completed, and a prototype may be built. If its tests are desirable, and if the device is to be produced in quantity designers should undergo certain modifications that enable it to be manufactured in quantity at a lower cost. During subsequent years of manufacture and service, the design is likely to undergo changes as new ideas are conceived or as further analysis based upon tests and experience indicate alterations. Sales appeal, customer satisfaction, and manufacture cost are all related to design, and ability in design is intimately involved in the success of an engineering innovation.

The following tips may be helpful in stimulating creative ideas of the designers.

(1) Apply ingenuity to utilize desired physical properties and to limit undesired ones.

[3] The performance requirements of a machine are met by utilizing laws of nature or properties of matter(e.g., flexibility, strength, gravity, inertia, buoyancy, centrifugal force, principles of the lever and inclined plane, friction, viscosity, fluid pressure, and thermal expansion), also the many electrical, optical, thermal, and chemical phenomena. However, what may be useful in one application may be detrimental in the next. For example, flexibility is desirable in valve springs but not in the valve camshaft; friction is desirable at the clutch face but not in the clutch bearing. Ingenuity in design should be applied to utilize and control the physical properties that are desirable and to minimize those that are not desirable.

(2) Provide for favorable stress distribute and stiffness with minimum weight. On components subjected to fluctuating stress, particular attention is given to a reduction in stress concentration, and to an increase of strength at fillets, threads, holes, and fits. Stress reduction is made by modification in shape, and strengthening may be done by prestressing treatments such as surface rolling and shallow hardening. Hollow shafts and tubing, and box sections give a favorable stress distribution, together with stiffness and minimum weight. Sufficient stiffness to maintain alignment and uniform pressure between contacting surfaces should be provided for crank, cam, gear shafts, and enclosures and frames containing bearing supports. The stiffness of shafts and other components must be suitable to avoid resonant vibrations.

(3) Use basic equations to calculate and optimize dimensions. The fundamental equations of mechanics and the other sciences are the accepted bases for calculations. These fundamental equations sometimes may be rearranged in special orders to facilitate the determination or optimization of dimensions, such as the beam and surface stress equations for determining gear-tooth size. Factors may be added to a fundamental equation for conditions not analytically determinable, e.g., on thin steel tubes, an allowance for corrosion added to the thickness based on pressure. [4] When it is necessary to apply a fundamental equation to shapes, materials, or conditions which only approximate the assumptions for its derivation, it is done in a manner which gives results "on the safe side". In situations where data are incomplete, equations of the sciences may be used as proportioning guides to extend a satisfactory design to new capacities.

(4) Choose materials with the consideration of the combination of different properties. Materials should be chosen for a combination of pertinent properties, not only for strengths, hardness, and weight, but sometimes for resistance to impact, corrosion, and low or high temperatures. Cost and fabrication properties are factors, such as weldability, machinabitity, sensitivity to variation in heat-treating temperatures, and required coating.

(5) Select carefully between stock and integral components. A previously developed component is frequently selected by a designer and his company from the stocks of parts manufacturers, if the component meets the performance and reliability requirements and

is adaptable without additional development costs to the particular machine being designed. However, the selection of these components should be carefully made with a full understanding of their properties, since the reputation and liability of the company suffers if there is a failure in any one of the machine's parts. In other cases, the strength, reliability, and cost requirements are better met if the designer of the machine also designs the component, with the particular advantage of compactness.

(6) Provide for accurate location and non-interference of parts in assembly. A good design provides for the correct locating of parts and for easy assembly and repair. Shoulders and pilot surfaces give accurate location without measurement during assembly. Shapes can be designed so that parts cannot be assembled backwards or in the wrong place. Interferences, as between screws in tapped holes, and between linkages must be foreseen and prevented. Inaccurate alignment and positioning between such assemblies must be avoided, or provision must be made to minimize any resulting detrimental displacements and stresses.

New Words & Expressions

apparatus /æpəˈreitəs/ *n*. 装置，设备，器具
durability /djuərəˈbiliti/ *n*. 耐久性，耐用性
optimum utilization 最适度利用
inertia /inˈəːʃiə/ *n*. 惯性
lubrication /ˌluːbriˈkeiʃən/ *n*. 润滑；润滑作用
hydrodynamic /ˈhaidrəudaiˈnæmik/ *adj*. 流体动力学的；水力的
sales appeal 销售吸引力
intimately /ˈintimitli/ *adv*. 密切地
buoyancy /ˈbɔiənsi/ *n*. 浮力
centrifugal force 离心力
principle of lever and inclined plane 杠杆原理和斜面原理
thermal expansion 热膨胀
detrimental /ˌdetriˈmentl/ *adj*. 有害的
fluctuating stress 交变应力
stress concentration 应力集中
fillet /ˈfilit/ *n*. 圆角
crank /kræŋk/ *n*. 曲柄，曲轴
cam /kæm/ *n*. 凸轮
gear shaft 齿轮轴
resonant vibration 共振
determinable /diˈtəːminəbl/ *adj*. 可决定的，可确定的
pertinent /ˈpəːtinənt/ *adj*. 有关的，相关的
weldability /weldəˈbiləti/ *n*. 焊接性
liability /ˌlaiəˈbiliti/ *n*. 责任，义务
compactness /kəmˈpæktnis/ *n*. 紧密，紧密度，体积小，小型
interference /intəˈfiərəns/ *n*. 冲突，干涉
tapped hole 螺纹孔

Complex Sentence Analysis

[1]With the objective wholly or partly defined, the next step in design is the conception of mechanisms and their arrangements that will perform the needed functions. 当目标完全或部分被确定后，下一个设计步骤就是对能够完成所需要功能的机构及其布局进行总体设计。

①with the objective wholly or partly defined：是独立主格成分，充当条件状语。

②that will perform the needed functions：是限制性定语从句，修饰先行词 mechanisms and their arrangements，可以译为“能够完成所需要功能的机构及其布局”。

[2]These important objectives can be attained only by analysis based upon the principles of mechanics, such as those of statics for reaction forces and for the optimum utilization of friction; of dynamics for inertia, acceleration, and energy; of elasticity and strength of materials for stress and deflection; and of fluid mechanics for lubrication and hydrodynamic drives. 只有根据力学原理进行分析才能达到这些重要目的。这些分析包括根据静力学原理分析反作用力和充分利用摩擦力，根据动力学原理分析惯性、加速度和能量，根据弹性力学和材料力学分析应力和变形，根据流体力学分析润滑和流体传动等。

①句中 based upon the principles of mechanics 是过去分词短语做后置定语，修饰 analysis，可以译为“根据力学原理进行的分析”。

②在 such as those of statics for reaction forces and for the optimum utilization of friction; of dynamics for inertia, acceleration, and energy; of elasticity and strength of materials for stress and deflection; and of fluid mechanics for lubrication and hydrodynamic drives 句中，those 后面跟了四个并列的介词短语成分。

[3]The performance requirements of a machine are met by utilizing laws of nature or properties of matter (e. g., flexibility, strength, gravity, inertia, buoyancy, centrifugal force, principles of the lever and inclined plane, friction, viscosity, fluid pressure and thermal expansion), also the many electrical, optical, thermal, and chemical phenomena. 可以利用自然法则或物质的性能(例如，柔性、强度、重力、惯性、浮力、离心力、杠杆原理和斜面原理、摩擦、黏性、流体压力和热膨胀性)和许多电学、光学和化学现象来满足一台机器的设计要求。

by utilizing laws of nature or properties of matter：是由介词 by 引导的动名词短语，表示手段和方法。

[4] When it is necessary to apply a fundamental equation to shapes, materials, or conditions which only approximate the assumptions for its derivation, it is done in a manner which gives results “on the safe side”. 当必须用一个基本公式来确定形状、材料和使用条件，而这些被确定的量仅仅与在公式推导中的假设比较接近时，要采取措施使结果“偏于安全”。

①句中 which only approximate the assumptions for its derivation 是由 which 引导的限制性定语从句，修饰先行词 shapes, materials, or conditions。

②which gives results "on the safe side" 也是 which 引导的限制性定语从句，修饰先行词 manner。短语 on the safe side 是"安全可靠"的意思。

Exercises

Ⅰ. Translate the following into Chinese or English.

1. optimum utilization ____________________
2. 销售吸引力 ____________________
3. centrifugal force ____________________
4. 杠杆原理和斜面原理 ____________________
5. thermal expansion ____________________
6. 交变应力 ____________________
7. stress concentration ____________________
8. 共振 ____________________
9. parts manufacturers ____________________
10. 螺纹孔 ____________________

Ⅱ. Mark the following statements with True(T) or False(F) according to the text.

(　　)1. Designing starts with a real need instead of an imagined one.

(　　)2. Freehand sketching, though a stimulant for creative ideas, is of no value since computer is so widely used in designing nowadays.

(　　)3. These important objectives can be attained only by analysis based upon the principles of mechanics, such as those of statics for reaction forces and for the optimum utilization of friction; of dynamics for inertia, acceleration, and energy, etc.

(　　)4. Ingenuity in design should be applied to utilize and control the physical properties that are desired and to maximize those that are not desired.

(　　)5. Special attention should be given to components subjected to fluctuating stress in order to reduce resonant vibration.

Ⅲ. Fill in the blanks with the suitable words or phrases given below.

fundamental	in a manner	facilitate
determinable	on the safe side	surface stress

The ___1___ equations of mechanics and the other sciences are the accepted bases for calculations. They are sometimes rearranged in special forms to ___2___ the determination or optimization of dimensions, such as the beam and ___3___ equations for determining gear-tooth size. Factors may be added to a fundamental equation for conditions not analytically ____4____, e.g., on thin steel tubes, an allowance for corrosion added to the thickness based on pressure. When it is necessary to apply a fundamental equation to shapes, materials, or conditions which only approximate the assumptions for its derivation, it is done ____5____ which gives results "____6____". In situations where data are incomplete, equations of the sciences may be used as proportioning guides to extend a satisfactory design to new capacities.

Ⅳ. Translate the Chinese parts given in the brackets into English.

1. The analysis will have as its objective satisfactory or ______________ (优良的工作性能), plus safety and durability with minimum weight, and a competitive cost.

2. These important objectives can be attained only by analysis ______________ (根据力学原理).

3. If its tests are satisfactory, and if the device is to be produced in quantity at a lower design will ______________ (做一些修改) that enable it to be manufactured in quantity at a lower cost.

4. The performance requirements of a machine are met ______________ (利用自然法则和物质的性能).

5. Materials should be chosen for a combination of pertinent properties, not only for strengths, hardness, and weight, but sometimes for ______________ (冲击韧性、耐蚀性和耐高温或低温的能力).

Unit 3

Mechanisms

Text

A mechanism is the components combination of more than two or two connected with the others to realize the regular motion made up by way of the activity. They are the component of machinery. Activity connections between two components that have the relative motion are called motion pairs. All motion pairs contacting with planes are called lower pairs and all motion pairs contacting with points or lines are called high pairs. [1] The motion specific property of mechanism chiefly depends on the relative size between the component, and the character of motion pairs, as well as the mutual disposition method, etc. The component is used to support the component of motion in the mechanism called the machine frame and used as the reference coordinate to study the motion system. The component that possesses the independence motion is called motivity component. The component except machine frame and motivity component being compelled to move in the mechanism is called driven component. The independent parameter (coordinate number) essential for description or definite mechanism motion is called the free degree of mechanism. For gaining the definite relative motion between the components of mechanism, it is necessary to make the number of motivity components of mechanism equal the number of free degrees.

Mechanisms may be categorized in several different ways to emphasize their similarities and differences. One such grouping divides mechanisms into planar and spatial categories. The two groups have many things in common; [2] the criterion which distinguishes the groups, however, is to be found in the characteristics of the motions of the links.

A planar mechanism is one in which all particles describe plane curves in space and all these curves lie in parallel planes; i.e. the loci of all points are plane curves parallel to a single common plane. [3] This characteristic makes it possible to represent the locus of any chosen point of a planar mechanism in its true size and shape on a single drawing or figure. The motion transformation of any such mechanism is called coplanar. The plane four-bar linkage, the plate cam and driven parts, and the slider-crank mechanism are familiar examples of planar mechanism. The vast majority of mechanism in use today is planar. The following Fig. 3-1 is cam mechanism.

A cam is a machine component that drives a follower through a specified motion. By the proper design of a cam, any desired motion to a machine component can be obtained. As such, cams are widely used in almost all machinery. They include internal combustion engines, a variety of machine tools and compressors. In general, a cam can be designed in two ways.

(1)The profile of a cam is so designed to give a desired motion to the follower.

(2)To choose a suitable profile to ensure a satisfactory performance for the follower.

A rotary cam is a part on a machine, which changes cylindrical motion to straight-line motion. The purpose of a cam is to transmit various kinds of motion to other parts of a machine.

Practically every cam must be designed and manufactured to fit special requirements. Though each cam appears to be quite different from the other, all of them work in similar ways. In each case, as the cam is rotated or turned, another part is connected with the cam, called a follower, is moved either right or left, up and down, or in and out. The follower is usually connected to other parts on the machine to accomplish the desired action. If the follower loses contact with the cam, it will fail to work.

Cams are classified according to their basic shapes. Fig.3-1 illustrates four different types of cams.

(1)Disc cam.

(2)Translation cam.

(3)Cylindrical cam.

(4)Face cam.

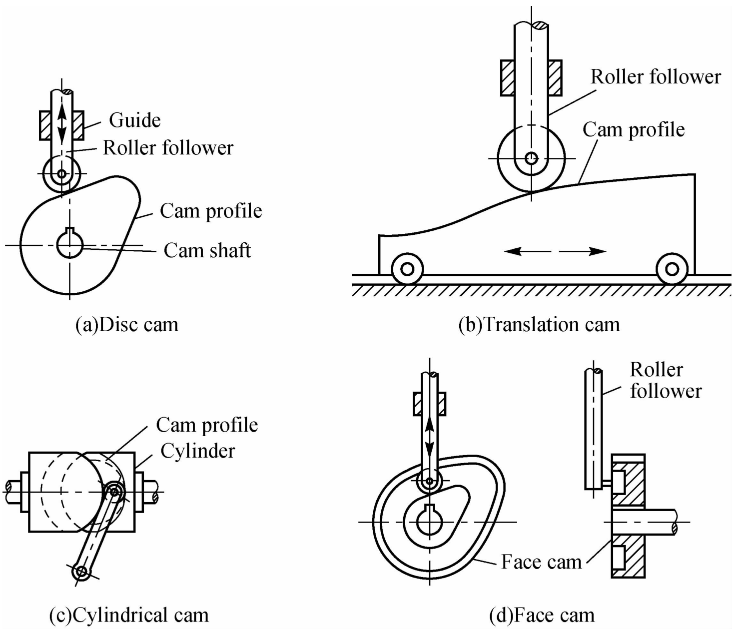

Fig.3-1　Types of cams

Planar mechanisms utilizing only lower pairs are called planar linkages; they may include only revolute and sliding pairs. Although a planar pair might theoretically be included, this would impose no constraint and thus be equivalent to an opening in the kinematics chain. Planar motion also requires that axes of all prismatic pairs and all revolute axes be vertical to the plane motion.

New Words & Expressions

motion pairs 运动副
disposition /ˌdispəˈziʃən/ *n*. 配置
machine frame 机架
coordinate /kəuˈɔːdneit/ *n*. 坐标
motivity member 原动件
driven member 从动件
parameter /pəˈræmitə/ *n*. 参变量
free degree 自由度
categorize /ˈkætigəˌraiz/ *v*. 分类
planar /ˈpleinə/ *adj*. 平面的，平坦的
spatial /ˈspeiʃəl/ *adj*. 空间的
category /ˈkætigəri/ *n*. 种类
loci /ˈləusai/ *n*. (locus 的复数形式)点的轨迹
sliding pairs 移动副

Complex Sentence Analysis

[1]The motion specific property of mechanism chiefly depends on the relative size between the component, and the character of motion pairs, as well as the mutual disposition method, etc. 机构的运动特性主要取决于构件间的相对尺寸、运动副的性质以及相互配置方式等。

①specific property：特性。

②as well as：不但……而且；和……一样；和；也，表示递进或并列关系。

[2]...the criterion which distinguishes the groups, however, is to be found in the characteristics of the motions of the links. 然而，区分的标准在于连杆运动的特性。

①which：引导限制性定语从句，修饰 criterion。

②to be found：为不定式的被动语态。

③links：连杆装置。

[3]This characteristic makes it possible to represent the locus of any chosen point of a planar mechanism in its true size and shape on a single drawing or figure. 有了这一特点，就能够在单个图形或图像上，以实际的尺寸和形状来绘出平面机构的任意选择点的轨迹。

①make it possible：使……可能。

②represent：描绘，展现。

③planar mechanism：平面机构。

④in size and shape：在大小和形状方面。

Exercises

Ⅰ. Translate the following into Chinese or English.

1. motion pairs ____________________
2. 参考坐标系 ____________________
3. planar mechanism ________________
4. 内燃机 ________________________
5. translation cam __________________
6. 圆柱凸轮 ______________________
7. plane four bar linkage ____________
8. 机构自由度 ____________________
9. machine frame __________________
10. 凸轮机构 _____________________

Ⅱ. Mark the following statements with True(T) or False(F) according to the text.

(　　)1. A mechanism is the components combination of more than two or two connections with the components to realize the regulation motion made up by way of the activity.

(　　)2. Mechanisms may be categorized in several different ways to emphasize their similarities.

(　　)3. A planar mechanism is one in which all particles describe plane curves in space and all these curves lie in parallel places; i.e. the loci of all points are plane curves parallel to a single common plane.

(　　)4. A rotary cam is a part on a machine, which changes cylindrical motion to straight-line motion.

(　　)5. Planar mechanisms utilizing only higher pairs are called planar linkages; they may include only revolute and sliding pairs.

Ⅲ. Fill in the blanks with the suitable words or phrases given below.

depends on	is used to	as well as
it is necessary to	being compelled to	

The motion specific property of mechanism chiefly ____1____ the relative size between the component, and the character of motion pairs, ____2____ the mutual disposition method, etc. The component ___3___ support the component of motion in the mechanism to be called the machine frame and used as the reference coordinate to study the motion system. The component that possesses the independence motion is called motivity component. The component except machine frame and motivity component ___4___ move in the mechanism is called driven component. The independent parameter (coordinate number) essential for description or definite mechanism motion is called the free degree of mechanism. For gaining the definite relative motion between the components of mechanism, ___5___ make the number of motivity components of mechanism equal the number of free degrees.

Ⅳ. Translate the Chinese parts given in the brackets into English.

1. All motion pairs contacting with planes ____________________（称为低副）and ____________________（凡为点或线接触的运动副）are called high pairs.

2. This characteristic makes it possible to represent the locus of any chosen point of a planar mechanism ____________________（在单个图形或图像上，以实际的尺寸和形状）.

3. ____________________（通过恰当的凸轮结构设计）, any desired motion to a machine component can be obtained.

4. Practically every cam must be ____________________（必须适合特定需要来设计和制造）.

5. Cams are classified ____________________（按照它们的基本形状）.

Unit 4
Optimal Design

Text

The integration of optimization techniques with finite element analysis(FEA) and computer aided design(CAD) is having pronounced effects on the product design process. [1] This integration has the power to reduce design costs by shifting the burden from the engineer to the computer. Furthermore, the mathematical rigor of a properly implemented optimization tool can add confidence to the design process. Generally, an optimization method controls a series of applications, including CAD software as well as FEA automatic solid mesh and analysis processors. This combination allows for shape optimizations on CAD parts or assemblies under a wide range of physical scenarios including mechanical and thermal effects.

Modern optimization methods perform shape optimizations on components generated within a choice of CAD packages. Ideally, there is seamless data exchange via direct memory transfer between the CAD and FEA applications without the need for file translation. Furthermore, if associativity between the CAD and FEA software exists, any changes made in the CAD geometry are immediately reflected in the FEA model. In the approach taken by ALGOR, the design optimization process begins before the FEA model is generated. The user simply selects which dimension in the CAD model needs to be optimized and the design criterion, which may include maximum stresses, temperatures or frequencies. The analysis process appropriate for the design criteria is then performed. The results of the analysis are compared with the design criterion, and, if necessary without any human intervention, the CAD geometry is updated. [2] Care is taken such that the FEA model is also updated using the principle of associativity, which implies that constraints and loads are preserved from the prior analysis. The new FEA model, including a new high-quality solid mesh, is now analyzed, and the results are again compared with the design criterion. This process is repeated until the design criterion is satisfied. Fig. 4-1 shows the procedure of shape optimization.

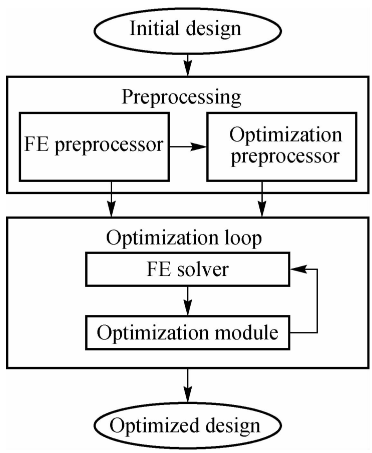

Fig. 4-1 Procedure of shape optimization

1. Introduction

The typical design process involves iterations during which the geometry of the part(s) is(are) altered. In general, each iteration also involves some form of analysis in order to obtain viable engineering results. Optimal designs may require a large number of such iterations, each of which is costly, especially if one considers the value of an engineer's time. The principle behind design optimization applications is to relieve the engineer of the laborious task by automatically conducting these iterations. At first glance, it may appear that design optimization is a means to replace the engineer and his or her expertise from the design loop. This is certainly not the case because any design optimization application cannot infer what should be optimized, and what are the design variables, the quantities or parameters that can be changed in order to achieve an optimum design. Thus, design optimization applications are simply another tool available to the engineer. The usefulness of this tool is gauged by its ability to efficiently identify the optimum.

Design optimization applications tend to be numerically intensive because they must still perform the geometrical and analysis iterations. [3] Fortunately, most design optimization problems can be cast as a mathematical optimization problem for which there exist many efficient solution methods. The drawback to having many methods is that there usually exists an optimum mathematical optimization method for a given problem. This complexity should be remedied by the design optimization application by giving the engineer not only a choice of methods, but also a suggestion as to which approach is most appropriate for his or her design problem.

In this unit, we focus on the design optimization of mechanical parts or assemblies. In this case, a typical optimized quantity is the maximum stress experienced. Typical design variables include geometric quantities, such as the thickness of a particular part. The design of the part or assembly is initiated within a CAD software application. If the component warrants an engineering analysis, the engineer will generally opt to apply finite element analysis(FEA) in order to model or simulate its mechanical behavior. The FEA results, such as the maximum stress, can be used to ascertain the validity of the design. During the design process, the engineer may alter parameters or characteristics of the CAD and/or FEA models, including some of the physical dimensions, the material or how the part or assembly is loaded or constrained. Associativity between the CAD and FEA software should allow the engineer to alter the model in either application, and have the other automatically reflect these changes. For example, if the thickness of a part is changed or a hole is added in the CAD software, the FEA model's mesh should automatically reflect those changes. Under most circumstances, engineers will employ linear static FEA to obtain the stresses. This analysis approach has the benefit of yielding a solution for FEA models with many elements in relatively little time. Obviously, linear static FEA has drawbacks as well. For example, significant engineering expertise may be required when estimating the magnitude and direction of loads that are a consequence of motion.

2. Background and Theory

In this section, we focus on the theory underlying some of the mathematical methods employed by design optimization procedures. But, first we describe how the optimization problem arises. Consider a three-step process:

(1) Generation of geometry of part or assembly in CAD.

(2) Creation of FEA model of part or assembly.

(3) Evaluation of results of FEA models.

For now, we limit ourselves to the case of linear static FEA. Therefore, the results are comprised of deflections and stresses at one instance. The manual design process involves all three steps, with the results being used to evaluate whether the design is appropriate. If the design is found inadequate, changes are made to steps (1) or (2) or both. It is clear from this description that the output of the FEA results is what should be optimized, and that any input to the CAD or FEA models can be viewed as a design variable. A design optimization algorithm conducts many FEA runs, each one with a different set of values for the design parameters. Before the manual design approach can be transformed into a design optimization algorithm, there must be associativity between the CAD and FEA applications. The rational behind this requirement is best explained using an example. Consider the initial design stage when the engineer applies constraints on a particular surface of the FEA model; it can be safely assumed that this surface coincides with a surface in the CAD model. Now, if the design optimization algorithm decides to alter the geometry of the CAD surface, then the FEA model must automatically reflect these changes, and apply the constraints on the new representation of this surface. Thus, associativity is required in order to achieve this automatic communication between the CAD and FEA models. Having defined the design optimization problem for mechanical systems, we now describe the mathematics used to solve these problems.

Most optimization problems are made up of three basic components.

(1) An objective function which we want to minimize (or maximize). For instance, in designing an automobile panel, we might want to minimize the stress in a particular region.

(2) A set of design variables that affect the value of the objective function. In the automobile panel design problem, the variables used define the geometry and material of the panel.

(3) A set of constraints that allow the design variables to have certain values but exclude others. In the automobile panel design problem, we would probably want to limit its weight.

It is possible to develop an optimization problem without constraints. Some may argue that almost all problems have some form of constraints. For instance, the thickness of the automobile panel cannot be negative. Although in practice, answers that make good sense in terms of the underlying physics, such as a positive thickness, can often be obtained without enforcing constraints on the design variables.

3. Benefits and Drawbacks

The elimination or reduction of repetitive manual tasks has been the impetus behind many software applications. Automatic design optimization is one of the latest applications used to reduce man-hours at the expense of possibly increasing the computational effort. It is even possible that an automatic design optimization scheme may actually require less computational effort than a manual approach. This is because the mathematical rigor on which these schemes are based may be more efficient than a human-based solution. Of course, these schemes do not replace human intuition, which can occasionally significantly shorten the design cycle. [4] One definite advantage of automated methods over manual approaches is that software applications, if implemented correctly, should consider all viable possibilities. That is, no variable combination of the design parameters is left unconsidered. Thus, designs obtained using design optimization software should be accurate to within the resolution of the overall method.

New Words & Expressions

optimization /ˌɔptimaiˈzeiʃən/ *n*. 最佳化，最优化
finite element analysis(FEA) 有限元分析
computer aided design(CAD) 计算机辅助设计
burden /ˈbəːdn/ *n*. (义务、责任等)的重担
rigor /ˈrigə/ *n*. 严格，严密，精确
mesh /meʃ/ *n*. 网孔，网格，网状物
scenario /siˈnɑːriəu/ *n*. (意大利语)情况
seamless /ˈsiːmlis/ *adj*. 无缝的
criterion /kraiˈtiəriən/ *n*. 标准，准则，规范
geometry /dʒiˈɔmitri/ *n*. 几何学，几何图形(形状)；轮廓
iteration /ˌitəˈreiʃən/ *n*. 迭代，反复
variable /ˈvɛəriəbl/ *n*. 变量，可变物 *adj*. 可变的，变量的
gauge /geidʒ/ *v*. 判断，测试，测定，测量
intensive /inˈtensiv/ *adj*. 强化的，加强的
cast /kɑːst/ *v*. 派(角色)；计算
warrant /ˈwɔːrənt/ *v*. 保证，担保
linear /ˈliniə/ *adj*. 线性的，线的，直线的
yield /jiːld/ *v*. 产出，产生；提供，给予
expertise /ˌekspəːˈtiːz/ *n*. 专门知识，专门技术
underlying /ˌʌndəˈlaiiŋ/ *adj*. 基础的；根本的；在下面的
assembly /əˈsembli/ *n*. 组(合)件，配件
function /ˈfʌŋkʃən/ *n*. 函数
impetus /ˈimpitəs/ *n*. 推动力，促进
scheme /skiːm/ *n*. 计划，方案

Complex Sentence Analysis

[1]This integration has the power to reduce design costs by shifting the burden from the engineer to the computer. 这种组合把工作任务从工程师转移给计算机，从而可以降低设计成本。

①power：能力，has the power to 译为“能够”。

②...shifting the burden from the engineer to the computer：……把任务从工程师转移给计算机。

[2]Care is taken such that the FEA model is also updated using the principle of associativity，which implies that constraints and loads are preserved from the prior analysis. 必须注意使用关联的原则使 FEA 模型得到更新，这就意味着要从前面的分析中保存约束和载荷。

①这个复句的主句很短，such that 引导状语从句。

②which：引导非限制性定语从句，which 代替前面整个句子。

[3]Fortunately，most design optimization problems can be cast as a mathematical optimization problem for which there exist many efficient solution methods. 值得庆幸的是，大多数优化设计问题可以看成是数学优化问题，而数学优化问题就有许多高效的求解方法。

①be cast as：在此处译为“看成是”。

②for which...：介词＋ which 引导的定语从句修饰其前面的 problem。

[4]One definite advantage of automated methods over manual approaches is that software applications，if implemented correctly，should consider all variable possibilities. 一个明显的优点是如果软件的应用正确的话，可以把一切可行的可能性考虑进来。

①advantage... over...：与……相比的优越性。

②that：引导表语从句，其中 if implemented correctly 是一个插入语。

Exercises

Ⅰ. Translate the following into Chinese or English.

1. finite element analysis ____________________
2. 计算机辅助设计 ____________________
3. seamless data exchange via ____________________
4. 优化设计过程 ____________________
5. design criterion ____________________
6. 最大应力 ____________________
7. human intervention ____________________

8. 典型设计变量 ______________________

9. mechanical behavior ______________________

10. 目标函数 ______________________

Ⅱ. Mark the following statements with True(T) or False(F) according to the text.

(　　)1. The integration of optimization techniques with finite element analysis (FEA) and computer aided design(CAD) is having pronounced effects on the product design process.

(　　)2. Modern optimization methods perform shape optimizations on components generated within a choice of CAD packages.

(　　)3. Ideally, there is seamless data exchange via indirect memory transfer between the CAD and FEA applications without the need for file translation.

(　　)4. The typical design process involves iterations during which the geometry of the part(s) is(are) altered.

(　　)5. Most optimization problems are made up of five basic components.

Ⅲ. Fill in the blanks with the suitable words or phrases given below.

in order to	In general	At first glance
an optimum design	a large number of	

The typical design process involves iterations during which the geometry of the part(s) is (are) altered. ___1___, each iteration also involves some form of analysis ___2___ obtain viable engineering results. Optimal designs may require ___3___ such iterations, each of which is costly, especially if one considers the value of an engineer's time. The principle behind design optimization applications is to relieve the engineer of the laborious task by automatically conducting these iterations. ___4___, it may appear that design optimization is a means to replace the engineer and his or her expertise from the design loop. This is certainly not the case because any design optimization application cannot infer what should be optimized, and what are the design variables, the quantities or parameters that can be changed in order to achieve ___5___. Thus, design optimization applications are simply another tool available to the engineer. The usefulness of this tool is gauged by its ability to efficiently identify the optimum.

Ⅳ. Translate the Chinese parts given in the brackets into English.

1. This integration has the power to ______________ (降低设计成本) by shifting the burden from the engineer to the computer.

2. Furthermore, the mathematical rigor of a properly implemented optimization tool can ______________________ (提高设计过程的可靠性).

3. If associativity between the CAD and FEA software exists, any changes made in the CAD geometry are ______________________ (立即在 FEA 模型中体现出来).

4. Fortunately, most design optimization problems can be cast as a mathematical optimization problem for which there exist ________________________________（许多高效解决办法）.

5. It is possible to develop an optimization problem without constraints. Some may argue that ____（几乎所有问题都应具有某种形式的约束）.

Unit 5

Engineering Drawing

Text

1. Coordinate System

The basic of all input AutoCAD is the Cartesian coordinate system, and the various methods of input(absolute or relative) rely on this system. In addition, AutoCAD has two internal coordinate systems to help you keep track of where you are in a drawing: the world coordinate system(WCS) and the user coordinate system(UCS).

The fixed Cartesian coordinate system locates all points on an AutoCAD drawing by defining a series of positive and negative axes to locate positions in space. Fig. 5-1(a) illustrates the axis for two-dimension(2D) drawing. There is a permanent origin point(0,0) which is referenced, an x axis running horizontally in a positive and negative direction from the origin, and a y axis traveling perpendicularly in a vertical direction. [1] When a point is located, it is based on the origin point unless you are working in the three dimensions, in which case, you will have a third axis, called the z axis(Fig. 5-1(b)).

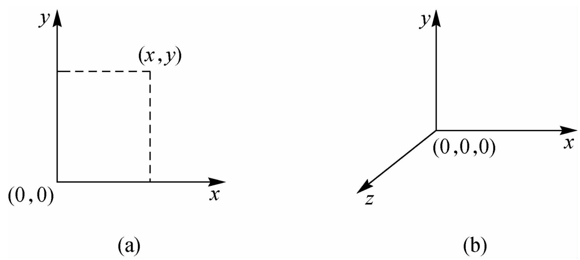

Fig. 5-1　The coordinate system

2. Types of Views

There are many view types which may be shown, as illustrated in Fig. 5-2.

(1) General view. Any view which is oriented by the user and is not dependent upon any other view for its orientation.

(2) Section view. Display a cross-section for a particular view.

(3) Auxiliary view. Any view created by projecting 90° to an inclined surface, datum plane, or along an axis.

(4) Projection view. An orthographic projection of an object as seen from the front, top, right side, etc.

(5)Detailed view. Any view which is derived by taking a portion of an existing view and scaling it for dimensioning and clarification purposes.

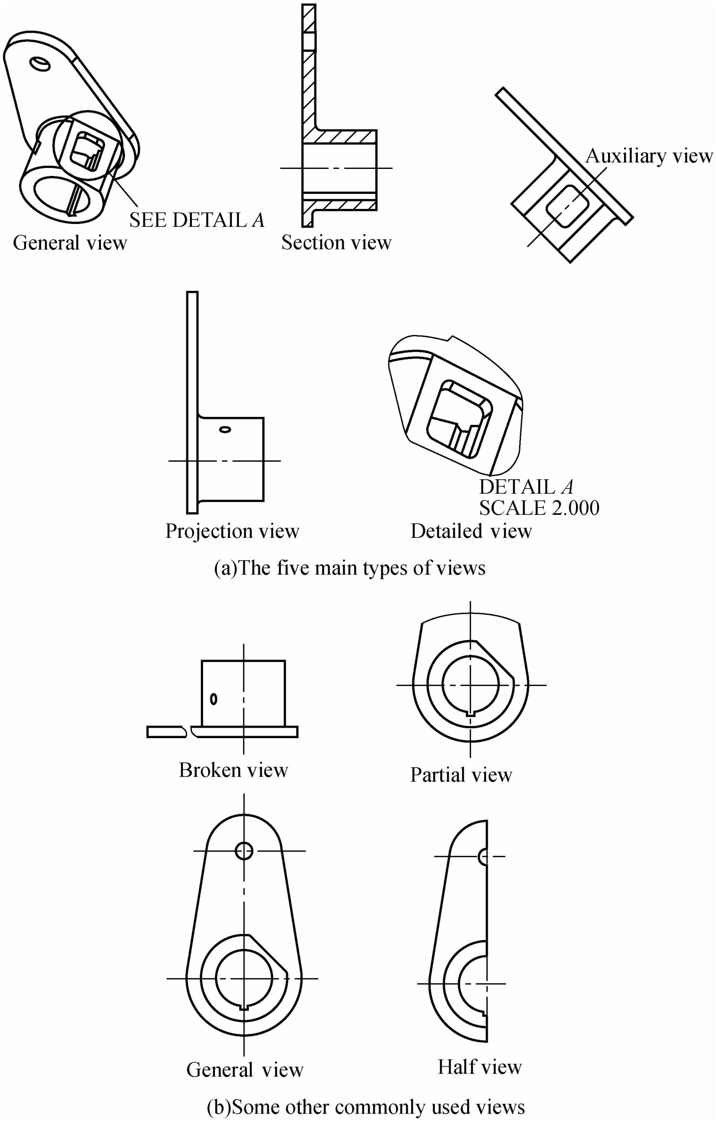

Fig.5-2 Types of views

(6)Broken view. Used on large objects to remove a section between two points and move the remaining sections close together.

(7)Partial view. When a symmetrical object is drafted, two views are sufficient to represent it(typically, one view is omitted). A partial view can be used to substitute one of the two views. [2]Sectional and auxiliary views are also commonly used to present part detail. Sectional views are extremely useful in displaying the detailed design of a complicated internal configuration. If the section is symmetrical around a centerline, only the upper half needs to be shown. The lower half is typically shown only in outline. Casting designers often employ sectional views to explode detail. When a major surface is inclined to three projection planes, only a distorted picture can be seen. An auxiliary plane that is parallel to the major surface can be used to display an undistorted view.

Study assembly constrains of describing mate, orient and insert assembly constrains, see Fig. 5-3.

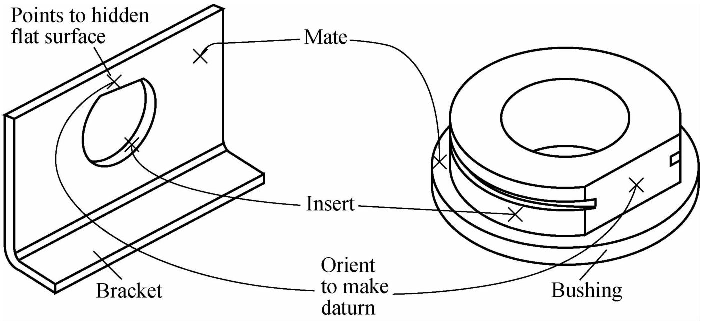

Fig. 5-3 Constrain for assembly the bracket and bushing parts

(8) Full view. Show the entire model.

(9) Half view. Show only the portion of the model on one side of a datum plane.

(10) Exploded view. The exploded view is a type of pictorial drawing designed to show several parts in their proper location prior to assembly, see Fig. 5-4. Although the exploded view is not used as the working drawing for the machinist, it has an important place in mechanical technology. Exploded views appear extensively in manuals and handbooks that are used for repair and assembly of machines and other mechanisms.

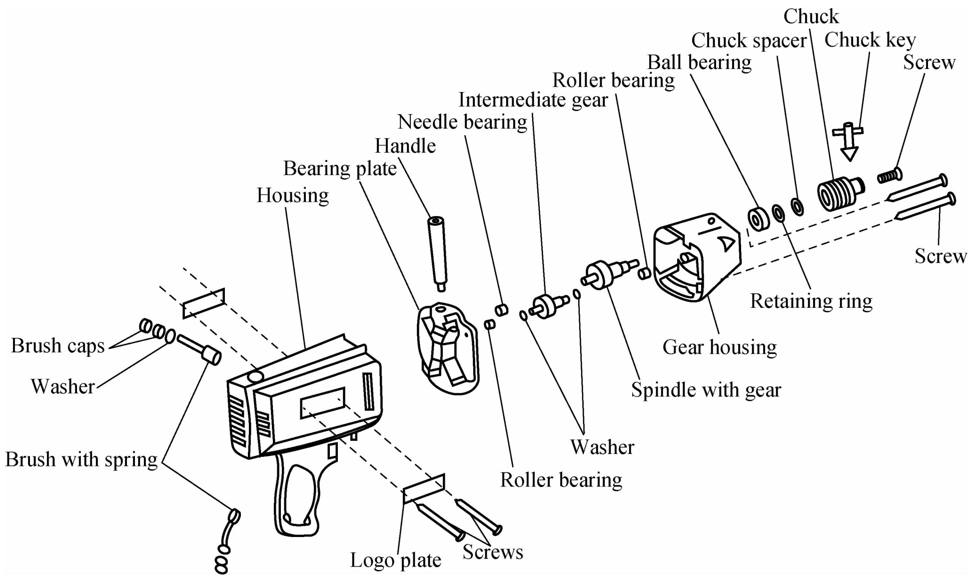

Fig. 5-4 Exploded view

3. Multiview Drawing

Engineering drawing is an abstract universal language used to represent a designer's idea to others. It is the most accepted medium of communication in all phases of industrial and engineering work.

In today's modern manufacturing industry, several types of drawing are acceptable. However, the standard is the multiview drawing, see Fig. 5-5. A multiview drawing usually contains two or three views (front, top, and side). Each view is an orthographic projection of a plane. In the United States and Canada, the third-angle projection is the system used, see Fig. 5-6. In the figure, the four quadrants of the *x*-*z* plane (called the Ⅰ, Ⅱ, Ⅲ, and Ⅳ angles) are illustrated. [3] For the third-angle projection, we always place the object in the third quadrant and project the object in three planes. This is done by projecting the object onto the frontal, horizontal, and profile planes. The projection on the frontal plane (*x*-*z*) is fixed and the image is called the front view. With the projected image, the horizontal plane (*x*-*y*) is rotated 90° clockwise on the *x* axis, the result is a top view of the object. The profile plane (*y*-*z*) is rotated 90° clockwise about the *z* axis to obtain a right-hand side view. Hidden lines are shown by using dashed lines on the drawing.

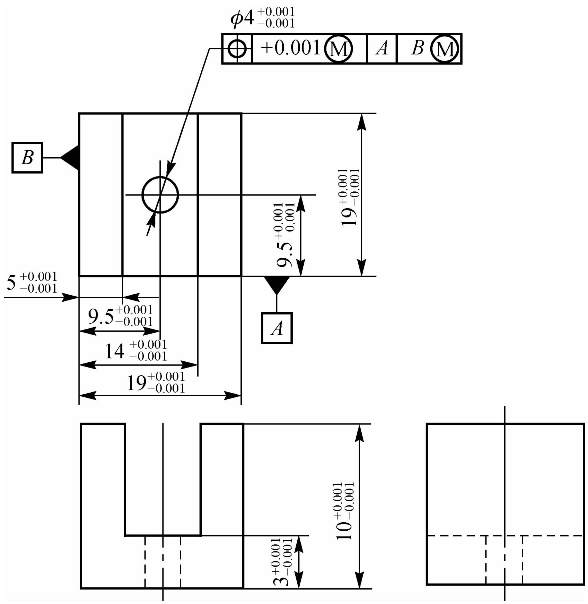

Fig. 5-5 Multiview drawing of a bracket

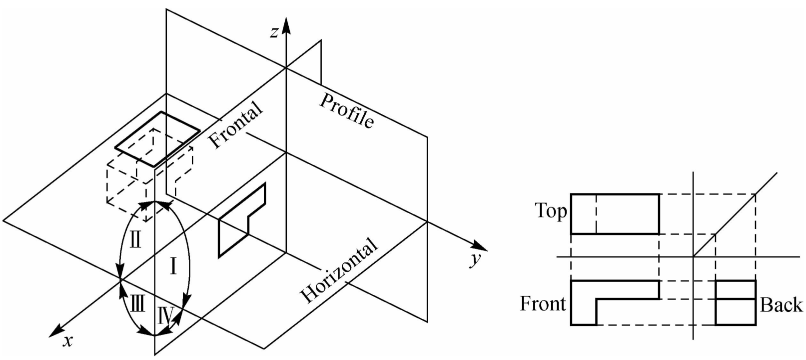

Fig. 5-6 Third-angle projection

New Words & Expressions

coordinate system 坐标系
Cartesian coordinate system 笛卡尔坐标系
keep track of 跟踪定位于
world coordinate system(WCS) 世界坐标系
user coordinate system(UCS) 用户坐标系
axis /ˈæksis/ *n*. 轴
perpendicularly /ˌpəːpənˈdikjuləli/ *adv*. 垂直地
projection /prəˈdʒekʃən/ *n*. 投影
orthographic projection 正交投影
auxiliary /ɔːgˈziljəri/ *adj*. 辅助的
datum plane 基准面
orientation /ˌɔːrienˈteiʃən/ *n*. 定位
revolve /riˈvɔlv/ *v*. 旋转
planar /ˈpleinə/ *adj*. 平面的，二维的
exploded view 分解视图
pictorial /pikˈtɔːriəl/ *adj*. 图示的
partial view 局部视图
symmetrical /siˈmetrikəl/ *adj*. 对称的
configuration /kənˌfigjuˈreiʃən/ *n*. 构造；配置
mate /meit/ *v*. 配合；连接
align /əˈlain/ *v*. 对齐
assembly constrain 装配约束
third-angle projection 第三角投影
quadrant /ˈkwɔdrənt/ *n*. 象限，四分仪
profile plane 侧面
dashed line 虚线

Complex Sentence Analysis

[1]When a point is located, it is based on the origin point unless you are working in the three dimensions, in which case, you will have a third axis, called the *z* axis. 根据原点(0,0)对其他任意一个点定位，但是在三维空间中绘图时，应该具有第三根轴，该轴称为 *z* 轴。

①unless：引导让步状语从句。

②in...case：在……情况下，which 指代 you are working in the three dimensions。

[2]Sectional and auxiliary views are also commonly used to present part detail. 剖视图和辅助视图经常用于表达零件的局部细节。

be used to do：被用来做……，注意区分该短语与 be used to doing 的区别，be used to doing 表示习惯做某事。

[3]For the third-angle projection, we always place the object in the third quadrant and project the object in three planes. 对于第三角投影来讲，总是将物体放在第三象限，同时将物体投影到三个面上。

Exercises

Ⅰ. Translate the following into Chinese or English.

1. engineering drawing ________________
2. 坐标系 ________________
3. world coordinate system ________________
4. 用户坐标系 ________________
5. orthographic projection ________________
6. 基准面 ________________
7. exploded view ________________
8. 局部视图 ________________
9. third-angle projection ________________
10. 侧面 ________________

Ⅱ. Mark the following statements with True(T) or False(F) according to the text.

( )1. AutoCAD has two internal coordinate systems to help you keep track of where you are in a drawing: the word coordinate system(WCS) and the user coordinate system(UCS).

( )2. When half view is adopted, it shows the entire model on one side of a datum plane.

( )3. The exploded view has a very important place in mechanical technology and it is frequently used as the working drawing for the machinist.

( )4. Exploded views appear extensively in manuals and handbooks that are used for repair and assembly of machines and other mechanisms.

( )5. In today's modern manufacturing industry, several types of drawing are acceptable. However, the standard is the third-angle projection.

Ⅲ. Fill in the blanks with the suitable words or phrases given below.

is parallel to	auxiliary	drafted
internal configuration	extremely	sufficient

When a symmetrical object is ___1___, two views are ___2___ to represent it (typically, one view is omitted). A partial view can be used to substitute one of the two views. Sectional and ___3___ views are also commonly used to present part detail. Sectional views are ___4___ useful in displaying the detailed design of a complicated ___5___. If the section is symmetrical around a centerline, only the upper half needs to be shown. The lower half is typically shown only in outline. Casting designers often employ sectional views to explode detail. When a major surface is inclined to three projection planes, only a distorted picture can be seen. An auxiliary plane that ___6___ the major surface can be used to display an undistorted view.

Ⅳ. Translate the Chinese parts given in the brackets into English.

1. The basic of all input AutoCAD is ________________（笛卡尔坐标系）, and the various methods of input(absolute or relative) rely on this system.

2. The fixed Cartesian coordinate system locates all points on an AutoCAD drawing ________________（通过定义一系列空间固定位置的正负轴）.

3. A point in space can be located based on the origin point unless ________________（在三维空间中绘图）.

4. Detailed view means taking a portion of an existing view and scaling it ________________（为了标注尺寸和看清图形）.

5. Engineering drawing is the most accepted medium of communication in ________________（工业和工程中的各个方面）.

Unit 6

Dimensional Tolerances and Surface Roughness

Text

Because of the highly competitive nature of most manufacturing businesses, the topic of finding ways to reduce cost is ever present. A good starting point for cost reduction is in the design of product. The design engineer should always keep in mind the possible alternatives available to him in design. It is often impossible to determine the best alternatives without a careful analysis of the probable production cost. Designing for function, interchangeability, quality, and economy requires a careful study of tolerances, surface finishes, processes, materials, and equipment.

To assure sound and economical design from a producibility standpoint, careful consideration of the following general design rules, both separately and together, is of paramount importance. The order of importance may vary according to design requirements or factors, but the overall importance always remains the same.

(1) Seek simplicity. Design for maximum simplicity in functional and physical characteristics.

(2) Determine the best production method. Seek the help of a production engineer to design for the most economical production methods.

(3) Analyze materials. Select materials that will lend themselves to low-cost production as well as to meeting design requirements.

(4) Eliminate fixturing and handling problems. Design for ease of locating, setting up, and holding parts.

(5) Adopt maximum acceptable tolerances and finishes. [1] Specify surface roughness and accuracy no greater than that which is commensurate with the type of part or mechanism being designed, and the production method or methods contemplated.

Tolerances on finishes and dimensions play an important role in the final achievement or absence of practical production design. A comprehensive study of the principles of interchangeability is essential for a thorough understanding and full appreciation of low-cost production techniques. Interchangeability is the key to successful production regardless of quantity. Details of all parts should be surveyed carefully to assure not only inexpensive processing but also rapid and easy assembly and maintenance. [2] It must be remembered that each production method has a well-established level of precision which can be maintained in continuous production without exceeding normal basic cost.

Economic manufacturing does not "just happen". It starts with design and considers practical limits of machine tools, processes, tolerances, and finishes. [3] Neither dimensional tolerances nor surface roughnesses should be specified to limits of accuracy closer than those which the actual function or design necessitate. This is done to assure the advantages of lowest possible cost and fastest possible production.

Without needing to know how to operate a particular machine to attain the desired surface roughness degree, there are certain aspects of all these methods which should be understood by the design engineer. Knowledge of such facts as roughness degree obtained by any operation, and the economics of attaining a smoother surface with each operation, will aid him in deciding just which surface roughness to specify.

Because of its simplicity, the arithmetical average *Ra* has been adopted internationally and is widely used. The applications of surface roughness *Ra* are described in the following paragraphs.

(1) 0.2 μm. The finish is used for the interior surface of hydraulic struts, for hydraulic cylinders, pistons and piston rods, for O-ring packings, for journals operating in plain bearing, for cam faces, and for roils of antifriction bearings when loads are normal.

(2) 0.4 μm. The finish is used for rapidly rotating shaft bearings, for heavily loaded bearings, for roils in bearings of ordinary commercial grades, for hydraulic applications, for static sealing rings, for the bottom of sealing-ring grooves, for journals operating in plain beings, and for extreme tension component.

(3) 0.8 μm. The finish is normally found on parts subject to stress concentrations and vibrations, for broached holes, gear teeth, and other precision machined parts.

(4) 1.6 μm. This finish is suitable for ordinary bearings, for ordinary machine parts where fairly close dimensional tolerances must be held, and for highly stressed parts that are not subject to severe stress reversals.

(5) 3.2 μm. The finish should not be used on sliding surfaces, but can be used for rough bearing surface where loads are light and infrequent, or for moderately stressed machine parts.

(6) 6.3 μm. The appearance of this finish is not objectionable, and can be used on non-critical component surface, and for mounting surfaces for brackets, etc.

New Words & Expressions

dimensional tolerance 尺寸公差
surface roughness 表面粗糙度
cost reduction 成本降低
interchangeability /ˈintəˌtʃeindʒəˈbiliti/
n. 交替性，互换性
surface finish 表面处理

paramount /ˈpærəmaunt/ *adj*. 极为重要的
commensurate /kəˈmenʃərit/ *adj*. 同量的，相称的
contemplate /ˈkɔntemˌpleit/ *v*. 预期
comprehensive /ˌkɔmpriˈhensiv/ *adj*. 广泛的，综合的
appreciation /əˌpriːʃiˈeiʃən/ *n*. 正确评价，鉴识
maintenance /ˈmeintinəns/ *n*. 维持，保养
hydraulic /haiˈdrɔːlik/ *adj*. 水压的，液压的
cylinder /ˈsilində/ *n*. 汽缸，圆柱状物
piston /ˈpistən/ *n*. 活塞
antifriction /ˌæntiˈfrikʃən/ *n*. 减摩装置，润滑剂
antifriction bearing 滚动轴承
shaft bearing 轴承
stress reversal 应力反向
bearing surface 承压面，支撑面
mounting /ˈmauntiŋ/ *n*. 底座，托架

Complex Sentence Analysis

[1]Specify surface roughness and accuracy no greater than that which is commensurate with the type of part or mechanism being designed, and the production method or methods contemplated. 在确定零件的表面粗糙度和尺寸精度时，不应该对零件或者机构的设计以及将要采用的生产方法提出过高的要求。

①that：指代 surface roughness and accuracy。

②be commensurate with：是"相称，同量"的意思。

③contemplated：分词做后置定语，修饰前面的 production method or methods。

[2]It must be remembered that each production method has a well-established level of precision which can be maintained in continuous production without exceeding normal basic cost. 这就必须记住每种加工方法都有一个适当的精度等级，以保证在正常的基本成本范围内连续加工。

①it：是形式主语，that 后面引导的从句是真正的主语。

②which：引导限制性定语从句，修饰先行词 level。

[3]Neither dimensional tolerances nor surface roughnesses should be specified to limits of accuracy closer than those which the actual function or design necessitate. 尺寸公差和表面粗糙度都不应该被限制在实际功能或设计需要的某个界限。

Exercises

Ⅰ. Translate the following into Chinese or English.

1. dimensional tolerance ______________

2. 表面粗糙度 ________________

3. cost reduction ________________

4. 追求简洁 ________________

5. the principles of interchangeability ________________

6. 经济生产 ________________

7. antifriction bearing ________________

8. 应力集中 ________________

9. stress reversal ________________

10. 承压面,支撑面 ________________

Ⅱ. Mark the following statements with True(T) or False(F) according to the text.

(　　)1. It is often impossible to determine the best alternatives without a careful analysis of the probable production cost.

(　　)2. When engineers design parts or mechanisms, they should seek simplicity in functional and physical characteristics.

(　　)3. 0.8 μm surface roughness is normally used on parts subject to stress concentrations and vibrations, for broached holes, gear teeth, and other precision machined parts.

(　　)4. 1.6 μm surface roughness should not be used on sliding surfaces, but can be used for rough bearing surface where loads are light and infrequent, or for moderately stressed machine parts.

(　　)5. 6.3 μm surface roughness is objectionable, and can be used on non-critical component surface, and for mounting surfaces for brackets, etc.

Ⅲ. Fill in the blanks with the suitable words or phrases given below.

regardless of	appreciation	maintenance
continuous	well-established	comprehensive

A ___1___ study of the principles of interchangeability is essential for a thorough understanding and full ___2___ of low-cost production techniques. Interchangeability is the key to successful production ___3___ quantity. Details of all parts should be surveyed carefully to assure not only inexpensive processing but also rapid and easy assembly and ___4___. It must be remembered that each production method has a ___5___ level of precision which can be maintained in ___6___ production without exceeding normal basic cost.

Ⅳ. Translate the Chinese parts given in the brackets into English.

1. Because of ________________ (大多数制造企业具有高度竞争的共性), the topic of finding ways to reduce cost is ever present.

2. The design engineer should always keep in mind ________________ (可能的选择) to him in making his design.

3. ________________________ (表面处理和尺寸公差) play an important role in the final achievement or absence of practical production design.

4. While designing, the engineer is expected to eliminate ________________ (固定与操作问题).

5. 3.2 μm surface roughness should not be used on sliding surfaces, but can be used for rough bearing surface where loads are light and infrequent, or ____________________ (张紧适度的机械零件).