SUNWODA 欣旺达

机械英语

深圳市第一职业技术学校
THE FIRST VOCATIONAL TECHNICAL SCHOOL OF SHENZHEN

2021届现代学徒制班

机械英语

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目录

Unit1 Introduction of Mechanical Engineering

［**Target**］

（1）了解机械工程的背景、历史和未来

（2）了解机械工程师的作用的

1.1 Definition of Engineering

Engineering is the practical and creative application of science and mathematics to solve problems, and it is found in the world all around us. Engineering technologies improve the ways that we safely travel, work, communicate and even stay healthy. One who practices engineering is called an engineer. Engineers are the innovators, planners, and problem-solvers of our society. They are always seeking quicker, better, and less expensive ways to benefit mankind. In that sense, the work of an engineer differs from that of a scientist, who would normally emphasize the fundamental discovery of physical laws rather than their application to product development. Engineering serves as the bridge between scientific discovery, commercial application, and business marketing.

Fig.1.1

Mechanical engineering. The design of physical or mechanical systems, such as power and energy systems, aerospace/aircraft products, weapon systems, transportation products' engines , compressors power trains, kinematic chains, vacuum technology, and vibration isolation equipment.

Fig.1.2

Mechanical engineering is the branch of engineering that deals with machines and the production of power, applying the principles of physics and materials science for analysis, design, manufacturing, and maintenance of mechanical systems. It is particularly concerned with forces and motion.

(From English Communication for Mechanical Engineers by L. Kang)

1.2 History of Mechanical Engineering

The invention of the steam engine in the latter part of the 18th century, providing a key source of power for the Industrial Resolution, gave an enormous impetus to the development of machinery of all types. As a result a new major classification of engineering, separate from civil engineering and dealing with tools and machines, developed, receiving formal recognition in 1847 in the founding of the Institution of Mechanical Engineers in Birmingham, England.

Mechanical engineering has evolved from the practice by the mechanic of an art based largely on trial and error to the application by the professional engineer of the scientific method in research, design, and production.

The demand for increased efficiency, in the widest sense, is continually raising the quality of work expected from a mechanical engineer and requiring of him a higher degree of education and training. Not only must machines run more economically but capital costs also must be minimized.

The high material standard of living in the developed countries owes much to the machinery made possible by mechanical engineering. The mechanical engineer continually invents machines to produce goods and develops machine tools of increasing accuracy and complexity to build the machines.

The principal lines of development of machinery have been an increase in the speed of operation to obtain high rates of production, improvement in accuracy to obtain quality and economy in the product, and minimization of operating costs. These three requirements have led to the evolution of complex control systems.

The most successful production machinery is that in which the mechanical design of the machine is closely integrated with the control system, whether the latter is mechanical or electrical in nature. A modern transfer line (conveyor) for the manufacture of automobile engines is a good example of the mechanization of a complex series of manufacturing processes. Developments are in hand to automate production machinery further, using computers to store and process the vast amount of data required for manufacturing a variety of components with a small number of versatile machine tools. One aim is a completely automated machine shop for batch production, operating on a threeshift basis but attended by a staff for only one shift per day.

The mechanical engineer is also responsible for the much smaller internal combustion engines， both reciprocating (gasoline and diesel) and rotary (gas-turbine and Wankel) engines, with their widespread transport applications. In the transportation field generally, in air and space as well as on land and sea, the mechanical engineer has created the equipment and the power plant, collaborating increasingly with the electrical engineer, especially in the development of suitable control system.

The skills applied to war by the mechanical engineer are similar to those required in civilian applications, though the purpose is to enhance destructive power rather than to raise creative efficiency. The demands of war have channeled huge resources into technical fields, however, and led to developments that have profound benefits in peace. Jet aircraft and nuclear reactors are notable examples.

Bioengineering is a relatively new and distinct field of mechanical engineering that includes the provision of machines to replace or augment the functions of the human body and of equipment for use in medical treatment. Artificial limbs have been developed incorporating such lifelike functions as powered motion and touch feedback. Development is rapid in the direction of artificial spare-part surgery. Sophisticated heart-lung machines and similar equipment permit operations of increasing complexity and permit the vital functions in seriously injured or diseased patients to be maintained.

Many of the products of mechanical engineering, together with technological developments in other fields, have side effects on the environment and give rise to noise, pollution of water and air, and the dereliction of land and scenery. The rate of production, both of goods and power, is rising so rapidly that regeneration by natural forces can no longer keep pace. A rapidly growing field for mechanical engineers and others is environmental control, comprising the development of machines and processes that will produce fewer pollutants and of new equipment and techniques that can reduce or remove the pollution already generated.

1.3 Functions of Mechanical Engineering

Four functions of the mechanical engineering, common to all the fields mentioned, will be cited. The first is the understanding of and dealing with the bases of mechanical science. These include dynamics, concerning the relation between forces and motion, such as in vibration; automatic control; thermodynamics, dealing with the relations among the various forms of heat, energy, and power; fluid flow; heat transfer; lubrication; and properties of materials.

Second is the sequence of research, design, and development. This function attemptsto bring about the changes necessary to meet present and future needs. Such work requires not only a clear understanding of mechanical science and an ability to analyze a complex system into its basic factors, but also the originality to synthesize and invent.

Third is production of products and power, which embraces planning, operation, and maintenance. The goal is to produce the maximum value with the minimum investment cost while maintaining or enhancing longer term viability and reputation of the enterprise or the institution.

Fourth is the coordinating function of the mechanical engineering, including management, consulting, and, in some cases, marketting.

In all of these functions there is a long continuing trend toward the use of scientific of traditional or intuitive methods, an aspect of the ever-growing professionalism of mechanical engineering. Operations research, value engineering, and PABLA (problem analysis by logical approach) are typical titles of such new rationalized approaches. Creativity, however, cannot be rationalized. The ability to take the important and unexpected step that opens up new solutions remains in mechanical engineering, as elsewhere, largely a personal and spontaneous characteristic.

1.4 The Future of Mechanical Engineering

The number of mechanical engineers continues to grow as rapidly as ever, while the duration and quality of their training increases. There is a growing awareness, however, among engineers and in the community at large that the exponential increase in population and living standards is raising formidable problems in pollution of the environment and the exhaustion of natural resources; this clearly heightens the need for all of the technical professions to consider the long-term social effects of discoveries and developments. There will be an increasing demand for mechanical engineering skills to provide for man's needs while reducing to a minimum the consumption of scarce raw materials and maintaining a satisfactory environment.

(From Encyclopedia Britannica by J. F. Br. and P. MCG. R.)

Glossary

Practical ['præktikəl] adj. 实际的；实用性的

Science ['saiəns] n. 科学；技术；学科；理科

Innovator ['inəuveitə] n. 改革者，创新者

Emphasize ['emfəsaiz] vt. 强调，着重

Maintenance ['meintənəns] n. 维护，维修；保持；生活费用

Institution [,insti'tju:ʃən] n. 制度；建立；（社会或宗教等）公共机构；

Accuracy ['ækjurəsi] [数] 精确度，准确性

Versatile ['və:sətail] adj. 多才多艺的；通用的，万能的；多面手的

Lubrication [lu:bri'keiʃən] n. 润滑；润滑作用

Synthesize ['sinθisaiz] vt. 合成；综合

Typical ['tipikəl] adj. 典型的；特有的；象征性的

Environment [in'vaiərənmənt] n. 环境，外界

Exhaustion [ig'zɔ:stʃən] n. 枯竭；耗尽；精疲力竭

［思考与练习题］

1. 机械工程的历史?

2. 机械工程的未来?

［本章小结］

本章主要介绍了机械工程的历史，背景，现状和未来。

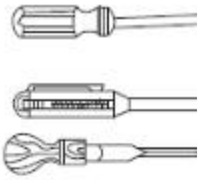
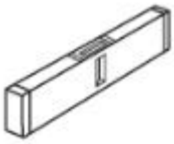
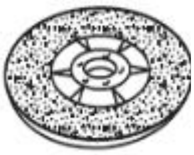
Unit2 Commonly Used Tools and Parts

［**Target**］

（1）了解常用工具的通俗叫法

（2）了解常用机械配件的通俗叫法

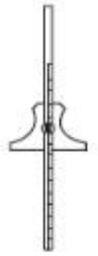
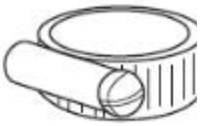
2.1 Commonly Used Tools

 screwdriver 改锥、螺丝刀	 spanner 扳手	 spirit level 水平仪(尺)	 rawhide hammer 皮锤
 ring spanner 梅花板手、闭口扳手 眼睛扳手	 pliers 钳子、夹钳	 Phillips screwdriver 十字形改锥	 pipe wrench 管扳手、管子钳
 abrasive disc 磨盘、砂轮	 adjustable spanner 可调扳手	 Allen key 内六角扳手	 buffing wheel 抛光轮
 G-clamp 弓形钩、夹钳	 die 板牙、拉丝模、冲模	 diestock 板牙、扳手	 anivil 铁砧

续

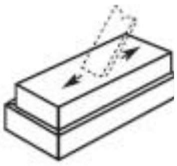
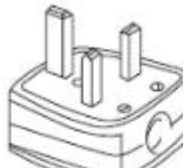
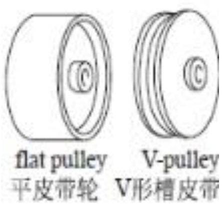
 electric drill (手)电钻	 instrument screwdriver 手捻、仪表起子	 hydraulic jack 液压千斤顶	screw jack 螺旋千斤顶  jack 千斤顶
 magnifying glass 放大镜	 mallet 木槌	 micrometer screw gauge 千分尺	 microscope 显微镜
 oil can 油壶	 pressure gauge 压力表	 vernier calliper gauge 游标卡尺	 try square 直角尺、矩尺、方角
 workbench 工作台	 pipe vice 管子台虎钳	 grinding machine 砂轮机、磨床	 grinding wheel 磨轮、砂轮

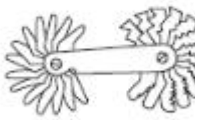
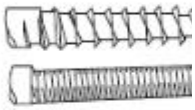
续

 drilling machine 钻床	 drill 钻头	 depth gauge 深(高)度尺	 gauge 量仪、量具
 socket spanner 套筒扳手	 box spanner 套筒扳手	 brace 弓摇钻	 breast drill 胸压手摇钻
 chuck 卡盘	 end mill 端面铣削	 half-round file 半圆锉	 hook spanner 钩形扳手
 hose clip 软管夹子	 hose 软管、胶管	 grub screw 平头螺钉	 Jubilee clip 箍圈

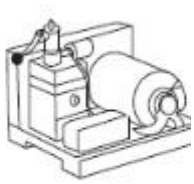
 keyway 键槽	 nail puller 起钉器	 nail 钉子	 nut 螺母

续

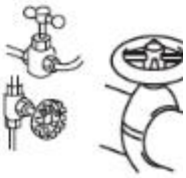
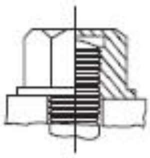
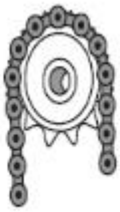
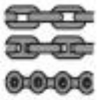
 oilstone 油石	 Phillips screw 十字槽螺钉	 Phillips screwdriver 十字形改锥	 plug 插头
 callipers 卡钳	 hammer 锤子	 pulley 皮带轮	 relay 继电器
		 rasp 粗锉	 screw 螺钉

 screw pitch gauge 螺纹(距)规、螺纹样板规	 screw thread 螺纹	 set screw 紧固螺钉	 snips 白铁剪
 torque wrench (spanner)扭力扳手	 tap wrench 丝锥扳手	ball bearings 滚球轴承  thrust bearing 止推轴承	 tool box 工具箱

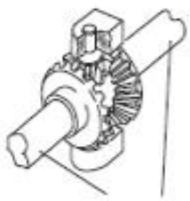
续

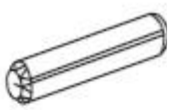
 U-bolt U形螺栓	 vacuum pump 真空泵	 vice 钳工台虎钳	 washer 垫片（圈）

2.2 Commonly Used Parts

 stopcock 旋塞阀	 ball bearing 滚珠轴承	 bifurcated rivet 开口铆钉	 belt 皮带
 bevel gear 伞齿轮	 bush 衬套	 camshaft 凸轮轴	 cap nut 外套螺母
 chain wheel 链轮	 chain 链条	 cheese-head screw 圆柱头螺钉	 cotter pin 销钉

续

 coupling 联轴器	 Oldham coupling 十字联轴器	 crank shaft 曲轴	 differential gear 差动齿轮



dowel
固定销,榫钉

eccentric wheel
偏心轮(盘)

hairspring
游丝

idler gear
惰轮

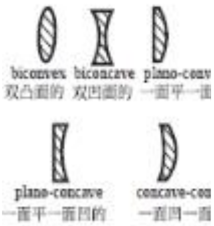
idler pulley
张紧带轮、惰轮

ingot
金属锭

impeller
叶轮

Jubilee clip
箍圈

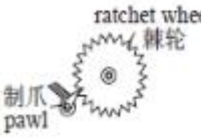
keyway
键槽



lens
透镜

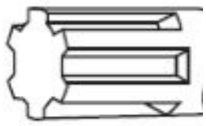
pitch
螺距、节距

propeller
螺旋桨



ratchet
棘轮机构

spindle
心轴、主轴



splined shaft
花键轴

split pin
开口销

stud
双头螺柱

thrust bearing
止推轴承

worm gear
蜗轮(蜗杆)副

spur gear
直齿轮、正齿轮

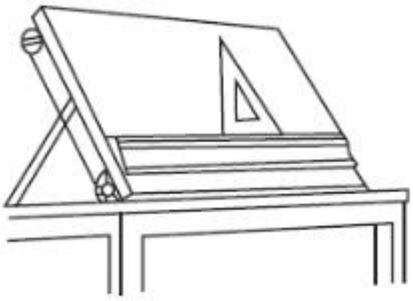
grinding wheel
磨轮、砂轮

gyroscope
陀螺仪

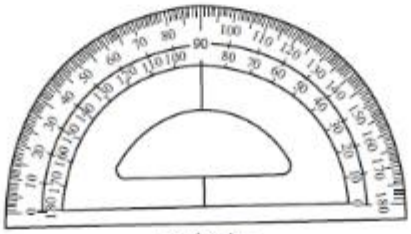
gudgeon pin
活塞销

gasket
垫片

2.3 Drawing Instruments

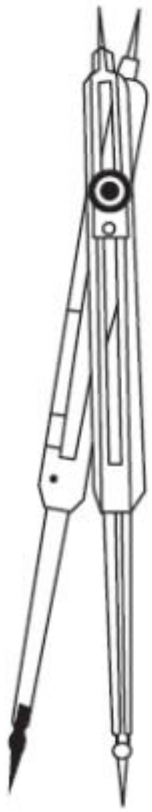


drawing board
绘图板

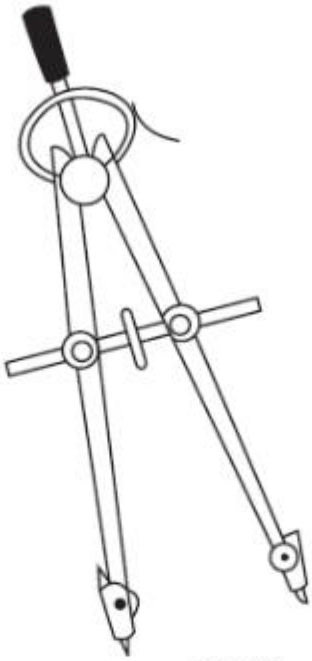


protractor
量角器，半圆规

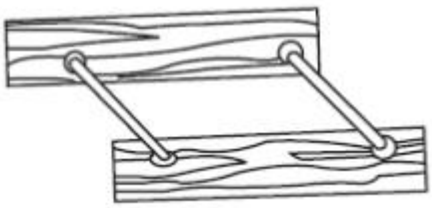
dividers
分规



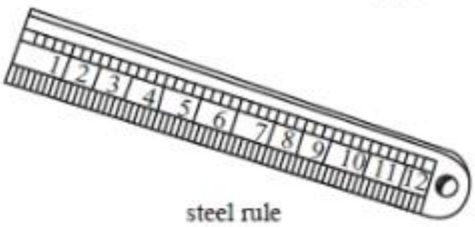
proportional dividers
比例规



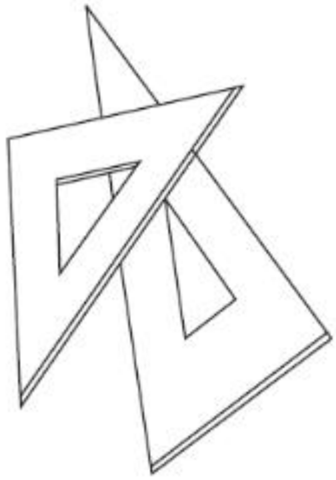
compass
圆规



parallels
平行仪

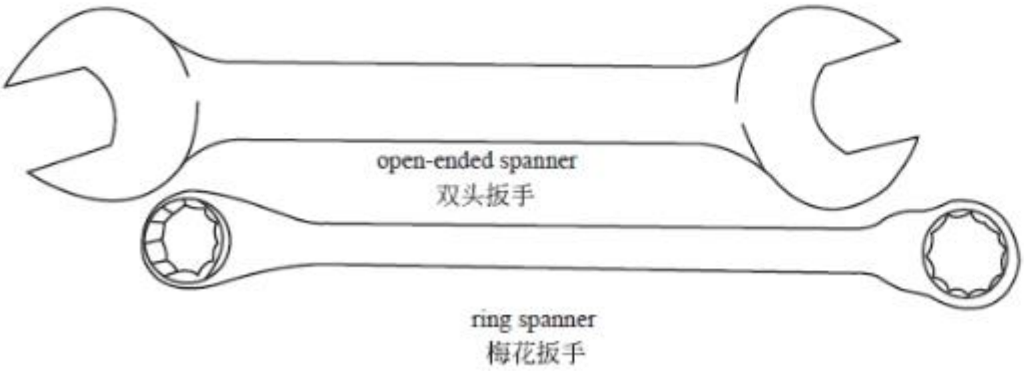


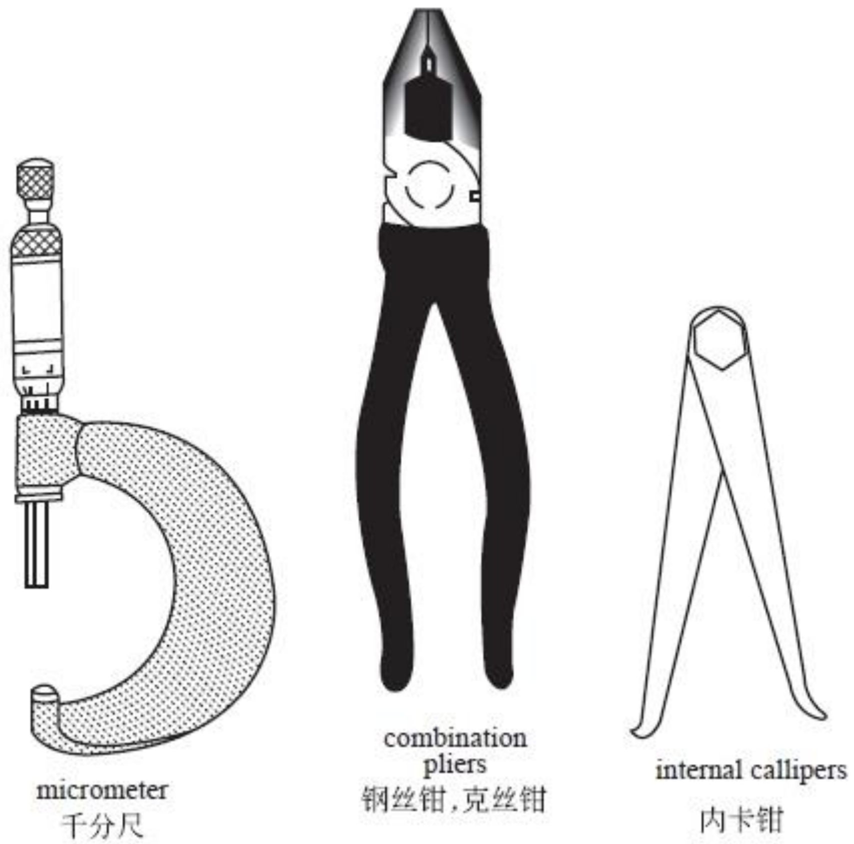
steel rule
钢尺

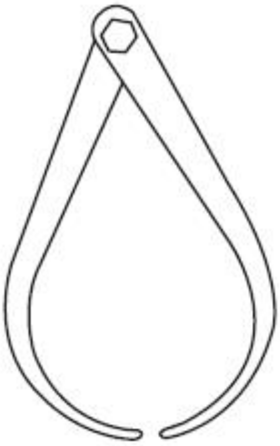


set squares
三角板

2.4 Tools for Metalwork



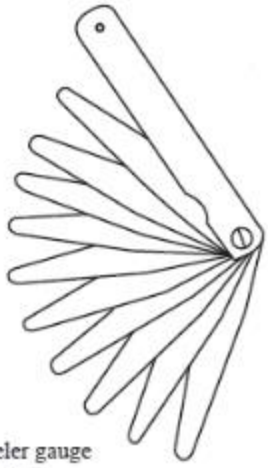




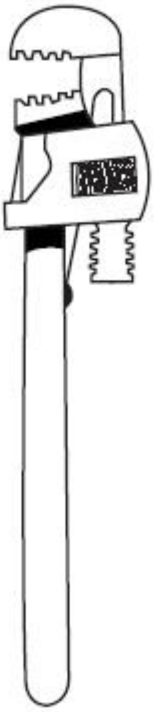
external callipers
外卡钳

ball-peen hammer
钳工锤，圆头锤

screwdrivers
螺钉旋具，
改锥，螺丝刀



feeler gauge
塞尺



pipe wrench
管子钳

水管钳
Groove Joint Pliers

斜嘴钳
Diagonal cutting pliers

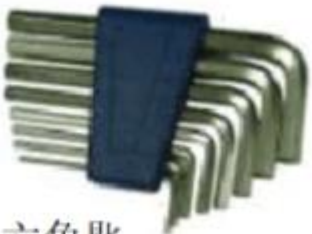
尖嘴钳
Long Nose Pliers

鲤鱼钳
Slip Joint Pliers

电线钳
Wire Crimper

五金柄界刀
Knife

塑胶柄界刀
Plastic Knife



六角匙
Hex Key

磁性螺丝批柄
Magnetic
Screwdriver Handle

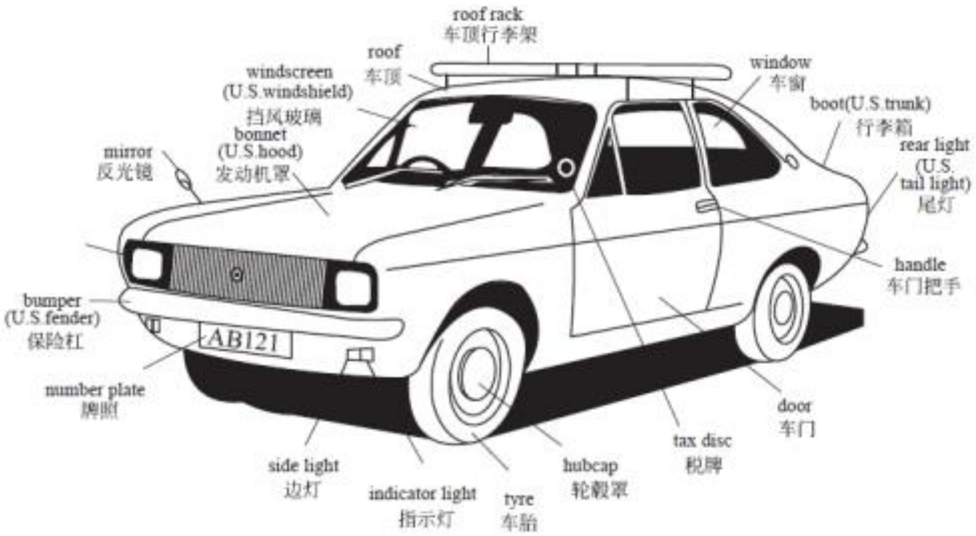
罗卜头螺丝批
Screwdriver Handle

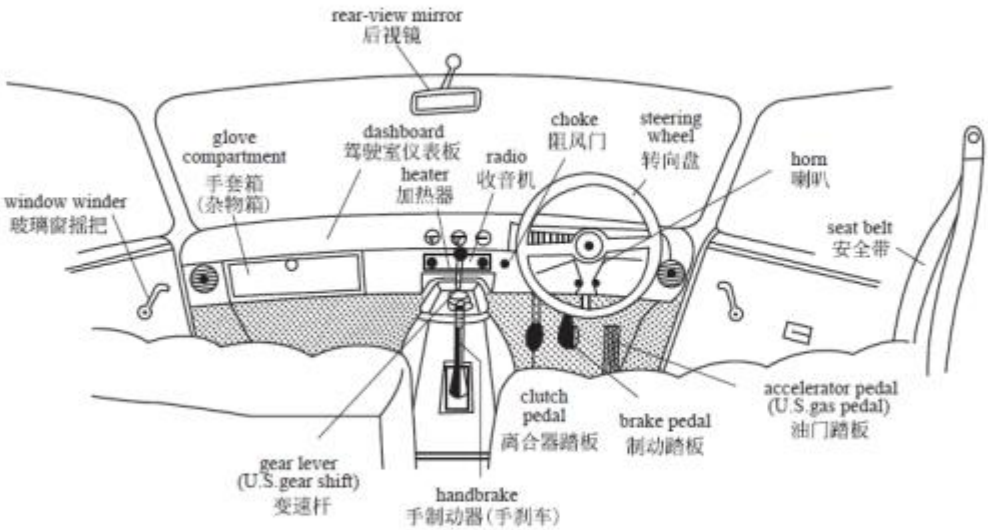
“T”型螺丝批
T-Bar Ratchet
Handle

精密螺丝批
Precision
Screwdriver Handle

卷尺
Tape Measure

2.5 Components of automobile





［思考与练习题］

1. 列出 5 种书中没有出现的工具的名称?

2. 列出 5 种书中没有出现的机械结构或者配件的名称?

［本章小结］

本章主要介绍了常用五金工具和常用的机械配件的通俗叫法。

Unit3 knowledge of machine drawing

［Target］

本章节的教学目的是了解机械制图的基础知识，介绍机械制图的相关知识，包括现在制图的主要分类、工程制图的相关标准和基本知识。

3.1 Engineering drawing

Drawing (just like photography) is one of the basic forms of visual communication. Drawing is used to record objects and actions of everyday life in an easily recognizable manner. There are two major types of drawings: artistic drawings and technical drawings.

Artistic drawings

These are a form of freehand representation that makes use of pictures to provide a general impression of the object being drawn. There are no hard rules or standards in the preparation of artistic drawings. They are simply drawn by artists, based more or less on one's talent and skills. Although these drawings are often very attractive, they find very limited use in the world of science.[1]

Technical drawings

These are detailed drawings drawn accurately and precisely. They are pictures that have been prepared with the aid of mathematical instruments in order to record and transmit technical information. They provide an exact and complete description of things that are to be built or manufactured.

1、Technical drawings do not portray the objects the way they directly appear to the eye

2、They make use of many specialized symbols and conventions in order to transmit technical information clearly and exactly.

3、To understand and correctly interpret technical drawings, one needs to acquaint oneself with the fundamentals of technical drawing – hence the purpose of this course.

Presentation of engineering drawings

(1)Axonometric (pictorial) projections

These are drawings in which the object is drawn in three dimensions (3-D), i.e. three sides of the object appear in one drawing. Normally only one drawing is prepared/used.

1、They are used extensively in artistic drawing.

2、A three dimensional view (i.e. shows length, width and height of the object simultaneously).

3、Provides only a general impression of the shape of the object by allowing the observer to see three of its sides as well as its three overall dimensions.

4、 An exact and complete description of its shape, particularly as applied to its slots on the underside is lacking. Two standards are currently used for axonometric projections: diametric projection and isometric projection.

Dimetric Projection:

In diametric projection, all dimensions along two axes are drawn to TRUE SIZE. The dimensions along the third axis are HALVED. This projection is preferred when one view of the object is to be emphasized than the other two views (i.e. when that one view is of more interest than the other views).

Example: A cube of length L

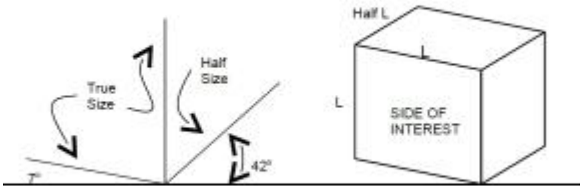


Fig.2. 1

Isometric Projection

In isometric projection, all dimensions along all the three axes are drawn to TRUE SIZE. Isometric projection is preferred when the three views of the object are of equal importance for accurate presentation of the object.

Example: Cube of length L

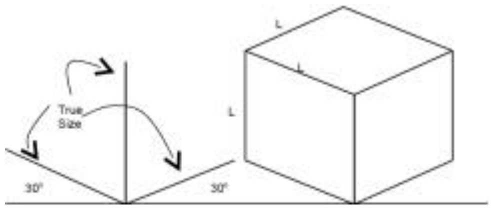


Fig.2. 2

(2) Orthographic projections

To present an object in a unique way, generally more views (and sometimes sections) are required. In orthographic projection, the views are seen in directions that make right angles (i.e. 90o) with each other. The number of views needed should be sufficient to represent the object completely and conveniently, but it should be kept to the minimum. For most purposes, three views are usually sufficient.

1、Engineering (Technical) drawings usually utilize orthographic views (OV) rather than pictorial views.

2、Orthographic (OV) help to record the shapes of objects exactly and completely.

3、OV is a two-dimensional (2-D) drawing. It shows only one side of an object and two of its overall dimensions.

4、A minimum of two OV is required to show the three dimensions of any object and therefore to describe its shape completely Some features of the object that do not directly appear on viewing the object from any specific direction (known as hidden details) are shown on the drawing as dotted lines.

Naming of Views

In orthographic projection, three views are normally drawn. The three chosen views may be any of the six hypothetical faces of the object. These views are named as shown below.

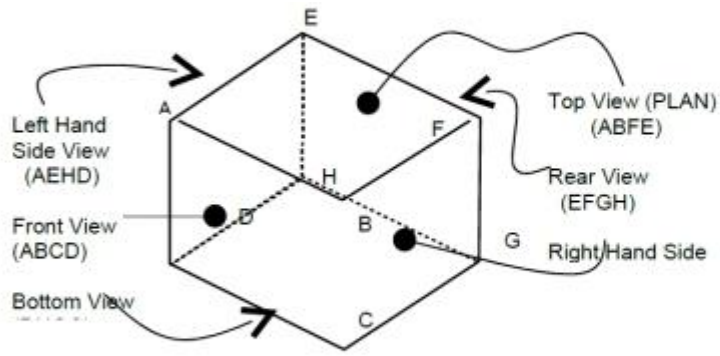


Fig.2. 3

The Front View (ABCD) – abbreviated as FV, is that view of utmost importance in representing the object (normally the most complicated of all the views) as seen when the object is placed directly in front of the viewer. This view generally serves to represent the object (e.g. a work piece) in the most common position in which it is used. It is normally the first view to be drawn – other views following thereafter. The Rear View – RV (EFGH) is directly opposite the FV at the back of the object. The Right hand Side View – RHSV (BFGC) and the Left Hand Side View – LHSV (AEHD) appear on the right and left sides of the object, respectively. The Top (ABFE) and Bottom (DCGH) Views are at the top and bottom sides of the FV. As you must have noted, these six views are at right angles to one another.

Standard Orthographic Projections.

Two standards are commonly in use in orthographic projection of drawings; the First Angle Projection. (European projection) and the Third Angle Projection (American projection). It should be noted that corresponding views are identical in both methods of projection except for their relative positions on the drawing paper.

The First Angle Projection

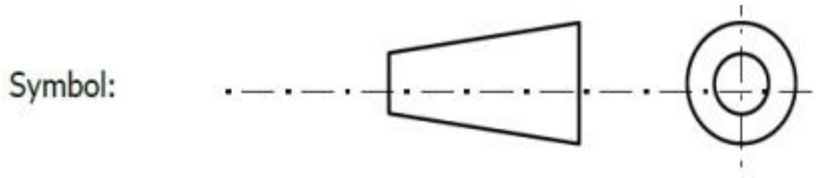


Fig.2. 4

In here, the front view (A) is the basis (reference) and the other views are drawn as ‘shadows’ of that view. That is, the left hand side view for instance is drawn on the right side of the front view. Similarly the top view (plan) is drawn at the bottom of the front view, etc.

The Third Angle Projection

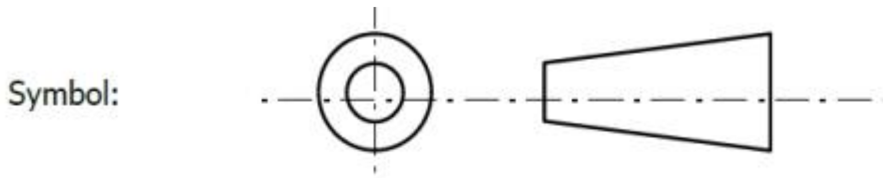


Fig.2. 5

In here, the front view is the basis (just as before) but the other views are drawn as ‘reflections’ of that view. The left hand side view is drawn on the left hand side of the front view. Similarly, the top view (plan) is drawn at the top of the front view.

Example: The Front View (FV), Left Hand Side View (LHSV) and Top View (PLAN) of the given object.

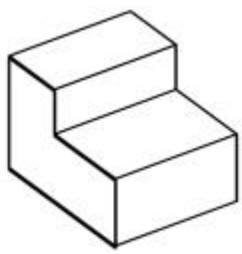
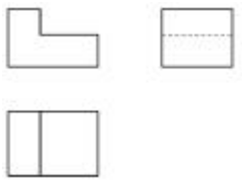


Fig.2. 6

SOLUTION － I

First Angle Projection



SOLUTION － II

Third Angle Projection

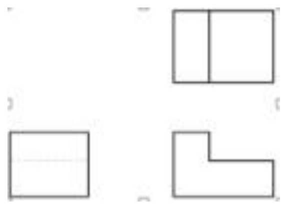


Fig.2. 7

3.2 Engineering drawing standards

Engineering drawings, being one of the many forms of technical communication, have to fulfill some accepted standards. There are various national, multinational and international standards, but the current trend in most countries is to adhere (adopt) the ISO standards. Thus for the purpose of this course, we will adhere to the ISO standards. [2]

(1)Paper sizes and folding

The ISO most recommended paper sizes for technical drawings are known as A-FORMATS. Other series, like the B-Series, are of lesser importance. In the A-Format series, the largest size is A0. The size of an A1 paper is half the size of A0 while A2 is half the size of A1 and so forth. Note that a higher order paper size (which is always smaller in size) is obtained by simply halving the preceding size along its longer side. For technical drawings A4 is considered to be the smallest paper size. Smaller-sized A-Format papers (i.e. A5, A6, etc) are very rarely used for technical drawings.

The A-Format Paper Sizes

Format	Cut Sheet (mm)
A0	841 X 1189
A1	594 X 841
A2	420 X 594
A3	297 X 420
A4	210 X 297
....	....

Fig.2. 8

NOTES:

1、When a format smaller than A4 is needed, it is obtained by simply halving A$ along its longer side. For instance A5 has 210-mm as its longer side and (297/2 = 148mm) as its shorter side.

2、Format A4 is exclusively used in an upright position. The other formats (which are lager in size than A4) may be used in an upright position or horizontal position.

(2) The drawing scales

The objects we encounter in our day-to-day life are usually either too large or too small to be drawn to their true size. For instance a car or a building can be drawn to its true size if, and only if, we use a piece of paper that is large enough to accommodate the true dimensions of that car or building. But as we have noted above, the largest size of paper (under ISO standard) is A0 (841-mm X 1189-mm), which is a lot smaller than these objects. The discrepancy between the actual sizes of objects and the size of the papers we use for drawing necessitates us to prepare drawings that are either smaller or bigger in size than the actual objects. This is only possible through the use of scales.

1、A scale is simply the ratio of the linear dimension appearing on the drawing compared to the corresponding linear dimension on the object

2、A scale has no units as it is simply a ratio (i. e. dimension on drawing : dimension on object).

3、Scales are used either for enlargements or reductions.

The recommended scales in Engineering Drawing are:

True Size	1:1		
Scales for Reduction	1:2 1:20 1:200	1:5 1:50 1:500	1:10 1:100 1:1000
Scales for Enlargement	2:1 20:1 200:1	5:1 50:1 500:1	10:1 100:1 1000:1

Fig.2. 9

The scale of 1:1 (read as one-to-one) implies the object has been drawn to true size. A scale of say 2:1 (read as two-to-one) implies that the object has been enlarged twice its true size. A scale of 1:2 (read as one-to-two) implies that the object has been reduced to its half size, etc.

(3) The drawing Lines and Lettering

Lines

In Engineering Drawing, we make use of different lines and line styles to convey the desired message. These lines differ in (i) thickness and (ii) style. Typical uses of these lines are summarized below.

Type of Line and Designation	Applications	Recommended line thickness [mm] PAPER SIZE	
		A4/A3/A2	A1/A0
A: A continuous thick line	1. Object line	0.5	0.7
B: A continuous thin line	1. Dimensioning line 2. Projection or extension lines *(used to project points from one view to another)* 3. Hatching 4. Outlines of adjacent parts 5. Outline of revolved views or revolved sections 6. Leaders for notes 7. Imaginary outlines	0.25	0.35
C: A continuous wavy line	1. Break line of part views and part sections when break lines are not center lines	0.25	0.35
D: A short thin dashes	1. Non-visible outline (hidden) *(3 – 4-mm strokes, 1 – 2-mm spaces)*	0.25	0.35

Fig.2. 10

E: A thin chain line	1. Center lines and pitch circles 2. path lines for indicating movement and/or extreme positions 3. oulines positioned in front of a section 4. Folding edges in developments	0.25	0.35
F: A thin chain line with thick extremities	1. Cutting or viewing planes	0.5/0.25	0.7/0.35
G: A thick chain line	1. indication of surfaces with supplementary or different treatments	0.5	0.7

Fig.2. 11

Hidden Lines

- Each end of a hidden line should touch the object line.

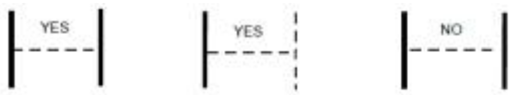


Fig.2. 12

• A hidden line should not touch an object line if it is an extension of the surface the object line represents.

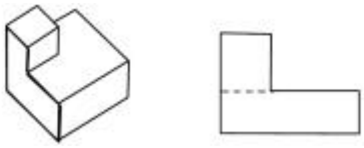


Fig.2. 13

• The strokes of parallel hidden lines that are relatively close together should be staggered.

Fig.2. 14

• Corners of hidden lines should be solid.

Fig.2. 15

(4)The drawing Title Blocks and Parts Lists

Title Block

In every engineering drawing, a Title Block is included at the bottom right-hand corner. The Title Blocks are locally standardized but should be designed in such a way that it can be easily understood. The information needed in any standard Title Block is normally:

1、Name of the Firm/School/College.

2、Name of the Object (Work piece).

3、Number of the drawing (particularly useful for reference where more than one drawing are concerned --- typically in assembly drawings).

4、Format of the paper used (paper size).

5、Scale used.

6、Dimensioning unit (usually millimeters --- mm).

7、Symbol for the method of projection used.

8、Date when the drawing was finished.

9、Name of the draftsman (draughtsman) --- e.g. student name if it is a normal class exercise.

10、Name of the person who checked the drawing.

11、Remarks.

The Title Block used at the then Faculty of Engineering (University of Dar es Salaam) is shown below. For the purpose of this course, we will adopt the same.

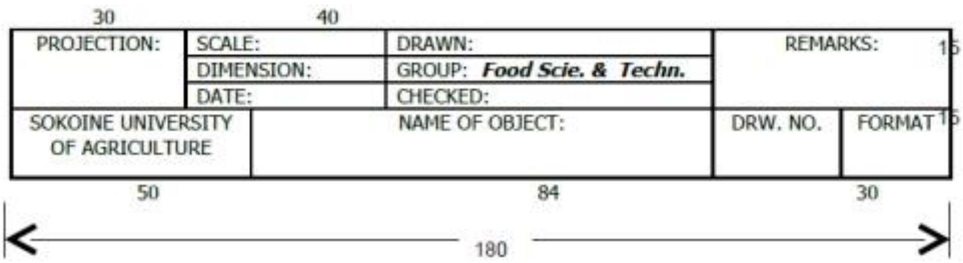


Fig.2. 16

Parts List

The Parts List is an essential component in any assembly drawing. It is usually drawn on top of the Title. Block. The Parts Lists usually have the same width as the Title Block, i.e.180-mm. The height depends on the number of items to be included. The following information is usually included in the Parts List;

A --- Part reference number.

B --- Name of the part.

C --- Number of parts required in an assembly.

D --- Material used to manufacture the part.

E --- Indication of standard or dimension.

F --- Drawing number.

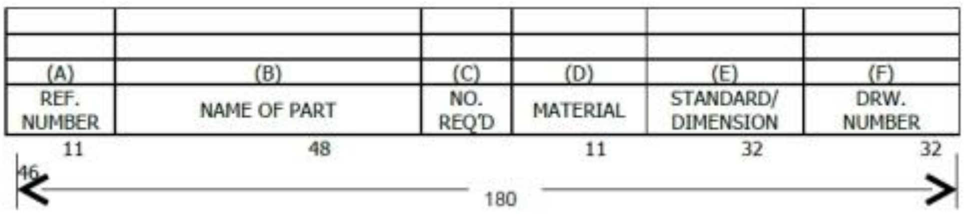


Fig.2. 17

3.3 Preparing detail drawings

3.3.1 Sectioning

For complex components with a number of hidden details, external views may not be enough to enable machining of such components. In such cases, sectioning is recommended.

Sectioning is achieved by assuming an imaginary cutting/sectioning plane (or several planes) passing through the detail of interest. The "cut section", as it would appear, is drawn. The position of the cutting plane is indicated by a thin, long chain, line with thick extremities (Line Type F1, pg. 14). This chain line is labeled with capital letters with the direction of viewing indicated by arrows. The capital letters are placed behind the arrows in the direction of viewing. The layout of sections and the designation/naming of sectional views is the same as for the corresponding ordinary external views.

General Hints

- Sometimes, only a small portion of the component is sectioned to indicate the feature of interest.

Parts (features) behind the sectioning plane are not shown, except when clarity requires this.

Hatch the solid part of the component that is "cut through" by the sectioning plane. Hatching lines are thin, parallel lines usually drawn at an angle of 45o to the outlines or the center lines of the object. The spacing of these lines depend on the size of the drawing.

Some standard parts/features are usually not sectioned (e.g. shafts, bolts, nuts, rivets, keys, pins, ridges, ribs, etc).

For symmetrical components/features, only half of the component is sectioned along the line of symmetry.

Sections through two intersecting cutting planes are drawn as if these sections were in one plane.

EXAMPLE:

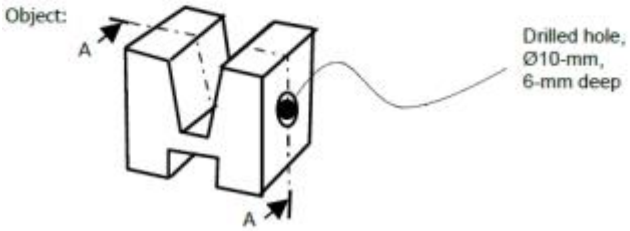


Fig.2. 18

SOLUTION

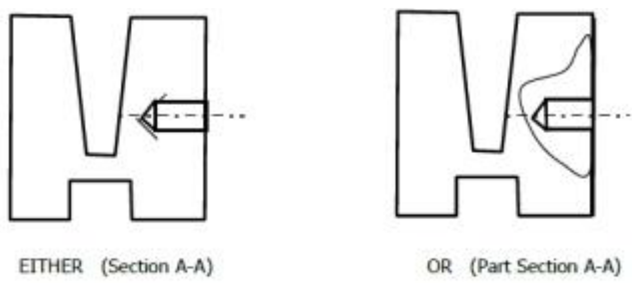


Fig.2. 19

3.3.2 Dimensioning

To enable productions of machine parts/components, all the relevant dimensions have to appear on the drawing. The practice is that any dimension is shown only once in that view in which it appears more explicitly. For this reason, it is not surprising that most of the important dimensions appear in the front view. Repetitions are discouraged unless clarity necessitates this. To keep the drawing clean, it is advised to put all the dimensions outside the drawing, except where and when this is unavoidable.

There are three types of dimensions; Functional Dimensions (FD), Non-Functional Dimensions (NFD) and Auxiliary Dimensions (AD).

Functional Dimensions (FDs)

These are dimensions, which directly dictate the functioning of the component. That is a FD is a dimension defined on the basis of the function of the product and the method of locating it in any assembly of which it may form part of, e.g. the diameter of a shaft, the length of a bolt, etc.

Non-Functional Dimensions (NFDs)

These are dimensions, which do not directly affect the functioning of the component but have to be specified to enable production of that component, e.g. the size of a bolt head.

Auxiliary Dimensions (ADs).

These are dimensions which should not necessarily appear on the drawing but are sometimes included to avoid calculations or when they would provide additional/useful information. ADs are usually written in brackets.

EXAMPLE: A bolt

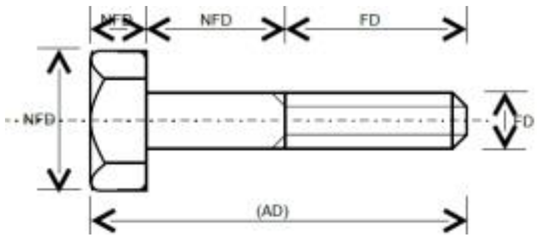


Fig.2. 20

General Hints on Dimensioning

- NOTE that all “rules” on dimensioning are just guidelines. Use common sense depending on circumstances (i.e. there are no strict rules/regulations on dimensioning).
- In metric system, all linear dimensions are considered to be in millimeters.
- Show full size dimensions regardless of the scale used in the drawing.

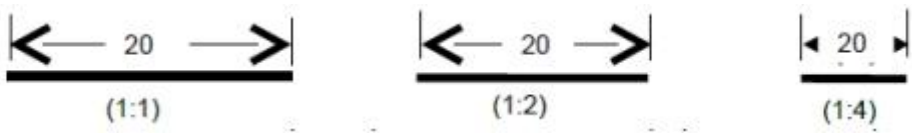


Fig.2. 21

- Dimension in a manner that makes it unnecessary to calculate any required size information.

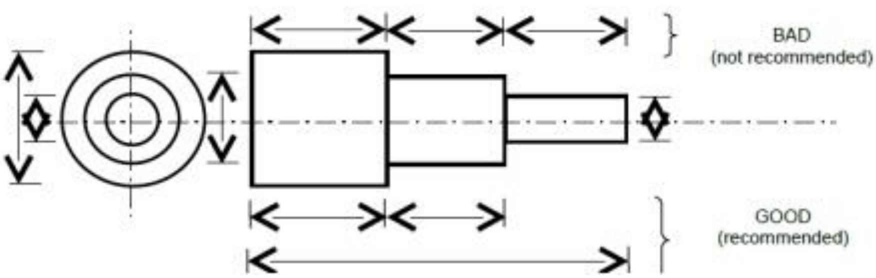


Fig.3. 22

- For any feature, place the dimensions where the feature appears most explicitly.

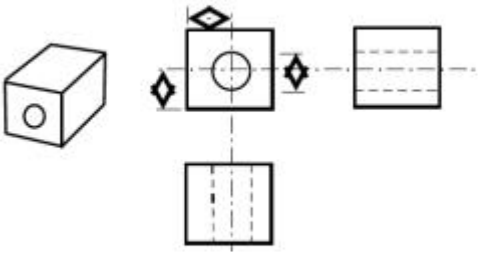


Fig.3. 23

- Dimension any feature only once (i.e. no repetitions are allowed).
- Dimension obviously identical features only once.

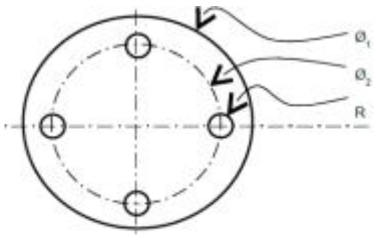


Fig.3. 24

3.3.3 Some special features

Some features that we encounter are either too difficult to draw as they appear or they appear too often such that simplified symbols are commonly used in their place. They are may such features, but for our purpose we will consider just a few of them that are relatively more common. These will include; threaded parts, machined holes, chaufers, countersinks and specially treated surfaces.[3]

Threaded Parts

Threads are machined according to different standards. However, the trend nowadays is to machine threads (and other standard features) according to ISO standards. A letter “M” followed by a number designates the size of the threads. The “M” stands for metric and the number that follows thereafter indicates the diameter (in mm) of the shaft upon which the threads have been machined. Male threads (e.g. on a bolt) and female threads (e.g. on a nut) of the same size are designated by the same M-number.

This number actually specifies not only the size of the threaded part but also the size of the bolt head and the size of the nut (if all are made in accordance to the ISO standard). NOTE that by specifying the thread size (the M-number) automatically covers such details as; the nominal diameter, the pitch, the pitch diameter, the minor diameter, the major diameter, the various radii etc.

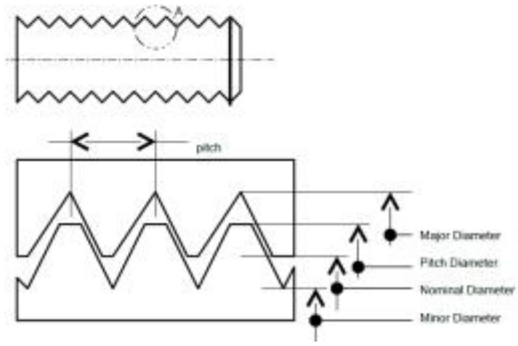


Fig.3. 25

EXAMPLE: M10 – Male and Female threads

SOLUTION:

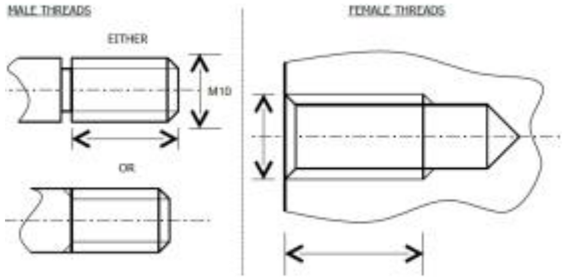


Fig.3. 26

Machines Holes (Drilled and Milled holes).

Drilled Holes.

Drilled holes are distinguished from holes machined by other methods by their characteristic tapered end. The shape of the drill bit brings about the tapered end.

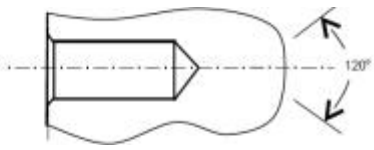


Fig.3. 27

Milled Holes

Unlike drilled holes, milled holes have a flat end.

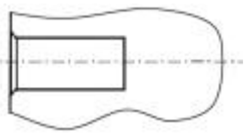


Fig.3. 28

Chamfers and Countersinks

At the end of each shaft or any drilled/machined hole, a small tapered end is machined just to eliminate the sharp edge. This is important because.

- The sharp edge may hurt people during handling and/or on assembling.
- The sharp edge wears and tears fast.

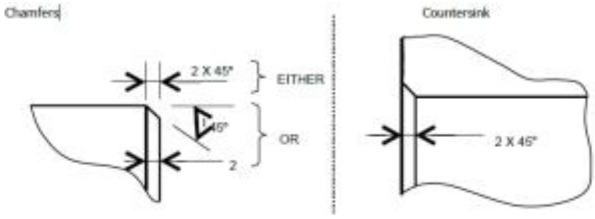


Fig.3. 29

Specially Treated Surfaces

If the surface demands special treatments (e.g. to be covered by wear resistance material, special lacquer etc), this has to be shown on the drawing. This is indicated on the drawing as follows:

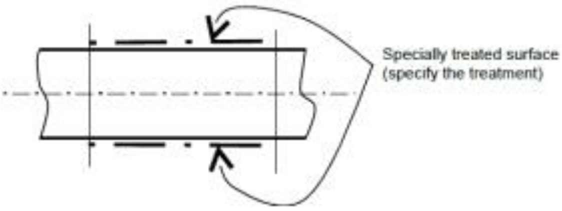


Fig.3. 30

3.3.4 Tolerances and fits

- Tolerance is simply defined as “the degree (extent) of acceptable inaccuracy”.
- It describes dimensional accuracy/inaccuracy.
- Tolerance is necessary under mass production.
- Absolute size (nominal size) is only theoretical/hypothetical.
- Tolerance specifies the acceptable upper and lower limits for a given nominal size.
- Usually two extreme conditions are of interest: tight fit and loose fit.

EXAMPLES

1: PIN and RING

You may need a tight fit or a loose fit between a pin and a ring – depending on circumstances.

SOLUTION

(A) Tight Fit (B) Loose Fit

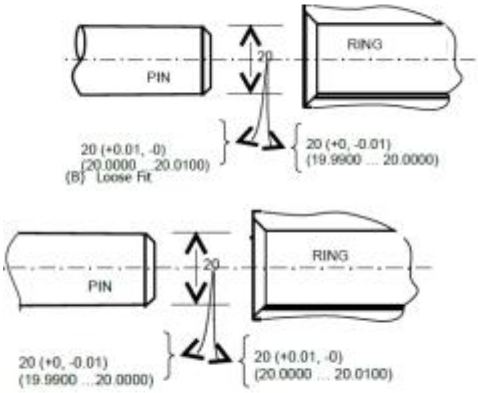


Fig.3. 31 Fig.3. 32

2: LOCOMOTIVE TYRE AND WHEEL

A very Tight Fit

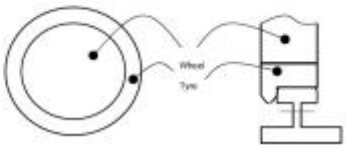


Fig.3. 33

3.4 Assembly drawings

As the name indicates, assembly drawings are nothing more but a collection of detail drawings (each of which forms part of that assembly) put together in a logical way. The drawing serves someone who is to assemble the individual parts so as to get a single unit in its working condition.

NOTES:

1、Only the external extreme dimensions of the assembly are indicated.

2、Each component is identified by its part reference number. This number is used in the parts list (where details of that part are indicated e.g. the drawing number for its detail drawing).

3、Sectional views are in most cases preferred as they show in a detailed form how the parts interact in an assembly.

4、Only one view is normally drawn, unless where the unit is so complex such that the interaction of all parts can't be clearly presented in one view.

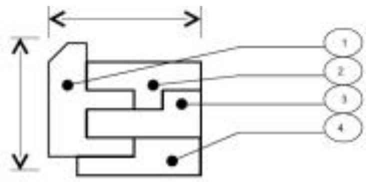


Fig.3. 34

5、If the unit has one or more moving parts, the extreme positions of the moving part are indicated in dotted lines (and the dimensions). This allows for consideration on space limitation during installation.

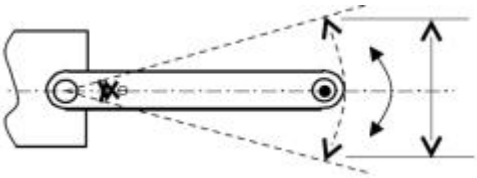


Fig.3. 35

6、Detail specifications of the individual parts are never shown on an assembly drawing (as they already appear on the respective detail drawing of the respective part).

EXAMPLE:

Draw an assembly of two stainless steel plates (SS 306) held together by a bolt and a nut (SS 318).

SOLUTION

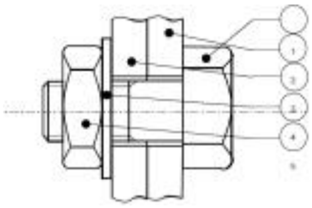


Fig.3. 36

5	Nut	1	SS 318	M10	005
4	Washer	1	SS 318	M10	004
3	Plate # 2	1	SS 306	–	003
2	Plate # 1	1	SS 306	–	002
1	Bolt	1	SS 318	M10	001
REF. NUMBER	NAME OF PART	NO. REQ'D	MATERIAL	STANDARD/ DIMENSION	DRW. NUMBER

Fig.3. 37

3.5 The machine drawing’s tool “Auto-CAD”

CAD (computer-aided design) is a technique of using a computer to create, modify, and refine a design. It, normally used in engineering departments, has greatly changed these departments. Drawings used to be made on paper with pencil or pen and instruments. The drawings were very time-intensive to produce. They were then copied, and the copies were sent to the floor for the production. The originals were stored in large drawers. Even a small job shop could have thousands large blueprints on file. If changes is necessary, engineering would get the original out of the file drawer, make the changes, copy it, and sent the new print to the floor. Nowadays the computer also allows for rapid and easy modifications.

The engineering and designer first draw the part on the screen of computer. This part drawing is actual part geometry. The sizes and locations are all correct so that the information can be used later to create a program to machine the part. Actually, you can also draw the geometry of a workpiece with CAD software on a computer. You may create the design model by applying graphics commands stored in the computer. You have complete freedom to zoom and view the model at different orientation and the represent the design as a set of points, lines, arcs, and so on by using basic CAD software. Actually, graphics editing commands allow for easy modifications as required.

Fig.3. 38

AutoCAD is a computer-aided (CAD) program used by just about every engineering and design office in the world. When you start AutoCAD, the AutoCAD window will open. The window is actually your design work space. How to create a new drawing with AutoCAD? Firstly, you choose “New” from the “File” menu. The dialogue box will appear in the command window underside of the AutoCAD window. Secondly, you can choose “Start from Scratch”. Under “Select Default Setting” select “English” or “Metric”, and then choose “OK”. In this way, the drawing opens with default AutoCAD settings. Finally choose “Save As” from the “File” menu and enter a file name, then you can save the drawing.

The AutoCAD interface has several different components, each of which provides different information of command options for the user.

Translate

[1] 这些是徒手画像的一种形式，利用图片来提供被画物体的总体印象。在艺术绘画的准备中没有严格的规则或标准。它们简单地由艺术家绘制，或多或少基于一个人的才能和技能。虽然这些图纸通常非常有吸引力，但它们在科学界的使用非常有限

[2] 工程图纸是许多形式的技术交流之一，必须满足一些公认的标准。 有各种国家，跨国和国际标准，但目前大多数国家的趋势是遵守（采用）ISO 标准。 因此，为了这个目的，我们将遵守 ISO 标准。

[3] 我们遇到的某些功能要么太难以在它们出现时绘制，要么它们看起来太频繁，以至于通常在它们的位置使用简化符号。它们可能具有这样的特征，但出于我们的目的，我们将仅考虑其中一些相对更常见的特征。 这些将包括;螺纹部件，机加工孔，埋头孔和特殊处理表面。

Glossary:

Projections [prə'dʒɛkʃən] n. 预测；投影；发射，规划

Scale [skeil] n. 规模；比例；刻度；天平； vi. 衡量； vt. 测量；攀登；刮鳞；依比例决

Assembly [ə'sembli] n. 装配；集会，集合

Tolerance ['tɔlərəns] n. 公差；宽容；容忍；公差

Threaded [θ'redid] adj. 有线状图案装饰的 v. 穿过；穿线于（thread 的过去分词）

Hint [hint] n. 暗示；线索 vt. 暗示；示意 vi. 示意

Hidden ['hɪdn] adj. 隐藏的 v. 隐藏，躲藏（hide 的过去分词）

EXERCISE:

1、Translate the last section with Chinese

2、Drawing a simple machine paper

本章小结

本章节对机械制图的分为三个部分进行了讲解，分别为机械制图的分类、机械制图过程中的规则和对机械制图工具 CAD 进行了介绍。

Unit 4 Engineering Material and Heat Treatment

［**Target**］

本章节的主要教学目的是了解工程材料及热处理，对常用的工程材料进行介绍，包括性能、特点等；并介绍金属材料热处理原理、过程及现代热处理技术等相关知识。

4.1 The kinds of engineering materials

For industrial purposes, material can be divided into engineering materials and non-engineering materials. Engineering materials are those used in manufacturing and will become part of products through definition processing. In generally, engineering material maybe further subdivided into metals, ceramics and polymers.

Metals. Common metals are gold, silver, copper, iron, nickel, aluminum and titanium, etc. Among these metals, gold and silver (also platinum) are precious metals; iron and nickel are magnetic materials (they are subject to the action of magnetic force); aluminum, magnesium and titanium are commonly called light metals. Of course, metal materials are seldom used in their pure states but in alloy states. Alloy containmore than metallic element. Their properties can be modified by changing the element contents present. Examples of alloys include stainless steel which are alloys of Fe, Ni and Cr; and brass which is an alloy of Cu and Zn. In addition, metal materials can also be broadly divided into two group, i.e. ferrous metals and nonferrous metals. Ferrous metals oftenrefer to iron alloys (iron and steel materials) and nonferrous metals include all other metallic materials.

Ceramics. It seems that there hasn't been an exact and complete definition about advanced ceramics so far, but from a viewpoint of modern engineering and technology,advanced ceramics (differentiating from traditional household ceramic) may be defined as the new engineering materials composed of some special kinds of metallic oxides (e.g. alumina or corundum and zirconia) or carbides or nitride of metallicand nonmetallic elements (e.g. tungsten carbide, silicon carbide, boron nitride, silicon nitride, etc.). They have some unique properties such as high-temperature strength; hardness to chemicals, food, and environment; resistance to wear and corrosion; and low electrical and thermal conductivity. So they are widely used in turbine, automobile, aerospace component, heat exchangers, semiconductors and cutting tools.

Polymers. The word polymer was first used in 1866. In essence, they are organic macromolecular compounds. And in 1909, the word plastics was employed as a synonym for "polymer". Plastic is from s Greek word plastikos, meaning "able to be molded and shaped". Plastics are one of numerous polymeric materials and have extremely large molecules. Because of their many unique and diverse properties, polymers have increasingly replaced metallic components in applications as automobiles, civilian and military air craft, sporting goods toys, appliances, and office equipment.

Fig.4. 1

Composite material. Among the major developments in material in recent years are composite materials, In fact, composites are now one of the most important classes of engineered materials, because the offer several outstanding properties as compared with conventional materials. A composite material is a combination of two or more chemically distinct and insoluble phases; its properties and structural performance are superior to those of the constituents acting independently.

Nanomaterials refer to those materials, at least one of whose three dimensions in at the nono-scale(1-100nm) and hence we may have nono-powders, nano-fibers and nano-lilms. They were first investigated in the early 1980s. However, we can‘t classify them in nature as distinct from other four common engineering materials, i. e metals, ceramics, composite and macromolecular materials, because various nano-materials developed so far are all composed of one or combination of the above four materials. Nevertheless, when the size of some common materials are reduced to the nano-scale, they will possess some special properties superior to traditional and commercially available materials.These properties can include strength, hardness, ductility, wear resistance and corrosion resistance suitable for structural (load-bearing) and nonstructural applications, in combinations with unique electrical, magnetic, and optical properties. For example, nano-powders have very large specific surface area, up to hundreds even thousands of square meters per gram, making them become highly active adsorbents and catalysts with wide application prospect in organic synthesis and environmental protection.

Carbon steels are generally classified by their proportion (by weight) of carbon content.

1、Low-carbon steel, also called mild steel, has less than 0.30% carbon. It is generally. Used for common industrial products, such as bolts, nuts, sheet, plate, and tubes, and formachine components that do not require high strength.

2、Medium-carbon steel has 0.30% to 0.60% carbon. It is generally used in applications requiring higher strength than is available in low-carbon steels, such as in machinery, in automotive and agricultural equipment parts (gears, axles, connecting rods, crankshafts), in railroad equipment, and in parts for metalworking machinery.

3、High-carbon steel has more than 0.60% carbon. It is generally used for parts requiring strength, hardness, and wear resistance, such as cutting tools, cable, music string, springs, and cutlery. After being manufactured into shapes, the parts are usually heat treater and tempered. The higher the carbon content of the steel, the higher is its hardness, strength, and wear resistance after heat treatment.

Alloy steels contain significant amounts of alloying elements. Structural-grade alloy steels, as identified by ASTM specifications, are used mainly in the construction and transportation industries, because of their high strength. Other alloy steels are used in applications where strength, hardness, creep and fatigue resistance, and toughness are required. These steels may also have been heat treated, in order to obtain the desired properties.

Stainless steels are characterized primarily by their corrosion resistance, high strength and ductility, and high chromium content. They are called stainless because in the presence of oxygen (air) they develop a thin, hard adherent film of chromium oxide that protects the metal from corrosion (passivation). This protective film builds up again in the event that the surface is scratched. For passivation to occur, the minimum chromium content should be 10% to 12% by weight. In addition to chromium, other alloying elements in stainless steels typically are nickel, molybdenum, copper, titanium, silicon, manganese, columbium, aluminum, nitrogen, and sulfur.

Tool and die steels are specially alloyed steels. They are designed for high strength, impact toughness, and wear resistance at room and elevated temperatures. They are commonly used in forming and machining of metals.

High-speed steels (HSS) are the most highly alloyed tool and die steels. First developed in the early 1900s, they maintain their hardness and strength at elevated operating temperatures. There are two basic types of high-speed steels: the molybdenum type (M series) and the tungsten type (T series).

Hot-work steels are designed for use at elevated temperatures. They have high toughness as well as high resistance to wear and cracking. The alloying elements are generally tungsten, molybdenum, chromium, and vanadium.

Cold-work steels are used for cold-working operations. They generally have high resistance to wear and cracking. These steels are available as oil-hardening or air-hardening types.

Shock-resisting steels are designed for impact toughness and are used in applications such as header dies, punches, and chisels. Other properties of these steels depend on the particular composition.

Aluminum (Al). Typical example of the applications of nonferrous metals and alloys are aluminum for cooking utensil and aircraft bodies, copper wire for electricity, copper tubing for residential water supply, zinc for galvanized sheet metal for car bodies, titanium for jet-engine turbine blades and for orthopedic implants.

The principle uses of aluminum and its alloys are in containers and packaging, in buildings and other types of construction, in transportation, in electrical applications, in consumer durables. Nearly all high-voltage transmission wiring is made of aluminum. In its structural components, 82% of a Boeing 747 aircraft is aluminum.

Porous Aluminum. Blocks of aluminum have recently been produced that are 37%lighter than solid aluminum and have uniform permeability. This characteristic allows their use in applications where a vacuum or differential pressure has to be maintained. Examples are the vacuum holding of fixtures for assembly and automation and the vacuum forming or thermoforming of plastics. These blocks are 70% to 90% aluminum power; the rest is epoxy resin. They can be machined with relation ease and can be joined together using adhesives.

Magnesium (Mg) is the lightest engineering metal available, and it has good vibration-damping characteristics. Its alloys are used in structural and nonstructural applications wherever weight is of primary importance. Magnesium is also an alloying element in various nonferrous metals. A variety of magnesium alloys have good casting, forming, and machining characteristics. Typical uses of magnesium alloys are in aircraft and missile components, material-handling equipment, portable power tools, ladders, luggage, bicycles, sporting goods, and general lightweight components.

Copper (Cu). Its alloys has good properties somewhat similar to those of aluminum. In addition, they are among the best conductors of electricity and heat, and they have good corrosion resistance. They can be processes easily by various forming, machining, casting, and joining techniques. Copper alloys are often attractive for application where a combination of electrical, mechanical, nonmagnetic, corrosion-resistant, thermally conductive, and were-resistant qualities are required. Application include electrical and electronic components; springs; cartridges for small arms; plumbing; heat exchangers marine hardware goods, such as cooking utensils, jewelry, and other decorative objects.

Titanium (Ti) named after the giant Greek god Titan, was discovered in 1791, but it was not produced commercially until the 1950s. Although it's expensive that high strength-to- weight ratio and its corrosion resistance at room and elevated temperatures make it attractive for many applications, submarine hulls, and biomaterials, such as orthopedic implants. Titanium alloys have been developed for service at 550℃ for long periods of time and at up to 750℃ for shorter periods. The properties and characteristics of Titanium alloys are extremely sensitive to small variations in both alloying and residual elements. These elements cause embrittlement of Titanium and, consequently, reduce toughness and ductility.

4.2 Heat treatment about engineering materials

4.2.1 Introduce the heat treatment technology

Heat treatment is a metal thermal processing process in which a metal material is heated, insulated, and cooled in a certain medium to control its properties by changing the metallographic structure of the surface or interior of the material.

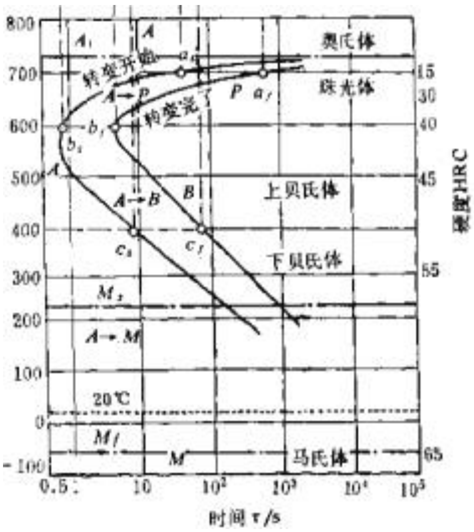


Fig.4. 2

Metal heat treatment is one of the important processes in mechanical manufacturing. Compared with other processing methods, heat treatment generally does not change the shape and overall chemical composition of the workpiece, but changes the microstructure inside the workpiece or changes the chemical composition of the surface of the workpiece. , to give or improve the performance of the workpiece. It is characterized by improved intrinsic quality of the workpiece, which is generally not visible to the naked eye.

In order to make the metal workpiece have the required mechanical properties, physical properties and chemical properties, in addition to the rational selection of materials and various forming processes, heat treatment processes are often essential. Steel is the most widely used material in the machinery industry. The microstructure of steel is complex and can be controlled by heat treatment. Therefore, the heat treatment of steel is the main content of metal heat treatment. In addition, aluminum, copper, magnesium, titanium, and the like can also be modified by heat treatment to obtain different mechanical properties, physical properties, and chemical properties. [1]

4.2.2 The definition of heat treatment term

Ferrite 铁素体

A gap solid solution of carbon in α-Fe (body-centered cubic structure of iron).

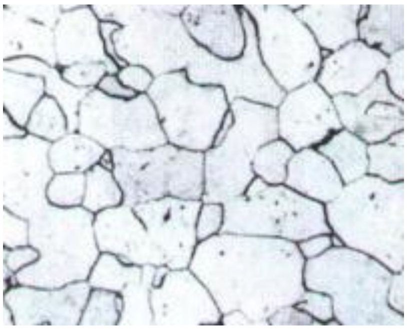


Fig.4. 3

Austenite 奥氏体

A gap solid solution of carbon in γ-Fe (face-centered cubic iron).

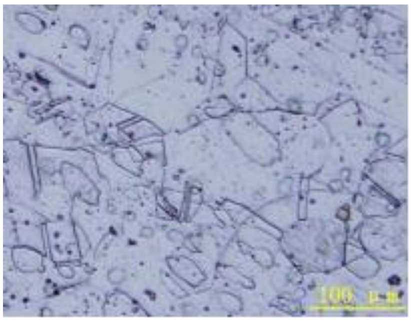


Fig.4. 4

Cementite 渗碳体

A stable compound (Fe_3C) formed by carbon and iron.

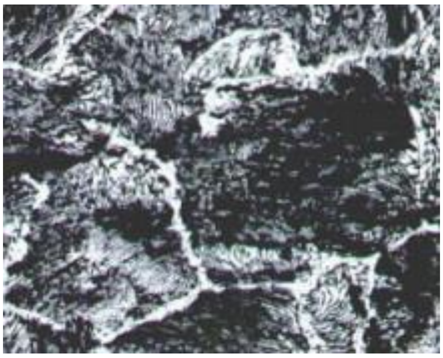


Fig.4. 5

Pearlite 珠光体

A mechanical mixture of ferrite and cementite (Fe + Fe3C contains 0.77% carbon).

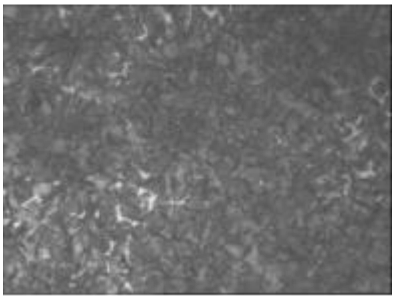


Fig.4. 6

Leysite 莱氏体

A mechanical mixture of cementite and austenite (4.3% carbon).

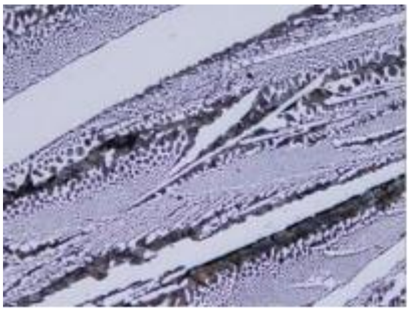


Fig.4. 7

Normalizing 正火

The steel or steel is heated to a suitable temperature above the critical point AC3 or ACM for a certain period of time and then cooled in the air to obtain a heat treatment process of the pearlite-like structure.

Annealing 退火

The sub-eutectoid steel workpiece is heated to a temperature of 20-40 degrees above AC3, and after heat preservation for a period of time, the furnace is slowly cooled (or buried in sand or lime) to a heat treatment process of cooling below 500 degrees in air.

Hot melt treatment 热熔固处理

The alloy is heated to a high temperature single-phase zone constant temperature maintenance, the excess phase is sufficiently dissolved into the solid solution, and then rapidly cooled to obtain a heat treatment process of the supersaturated solid solution.

Aging 老化

The phenomenon that the alloy changes its properties over time after solution heat treatment or cold plastic deformation at room temperature or slightly above room temperature.

Solution treatment 固溶处理

The various phases in the alloy are fully dissolved, the solid solution is strengthened, the toughness and corrosion resistance are improved, stress and softening are eliminated, and the molding is continued.

Aging treatment 老化处理

The temperature of the strengthening phase is heated and kept warm, and the strengthening phase is precipitated to be hardened to increase the strength.

Quenching 淬火

The steel is austenitized and then cooled at an appropriate cooling rate to cause a heat treatment process in which the workpiece undergoes an unstable structural transformation such as martensite in all or a certain range in the cross section.

Temper 回火

The quenched workpiece is heated to a suitable temperature below the critical point AC1 for a certain period of time and then cooled by a satisfactory method to obtain a desired heat treatment process for the structure and properties.

Carbonitriding of steel 钢的碳氮共渗

Carbonitriding is the process of simultaneously infiltrating carbon and nitrogen into the surface of steel. It is customary for carbonitriding, also known as cyanidation. At present, it is widely used in medium temperature gas carbonitriding and low temperature gas carbonitriding (ie, gas soft nitriding). The main purpose of carbon monoxide in medium temperature gas is to increase the hardness, wear resistance and fatigue strength of steel. Low temperature gas carbonitriding is mainly nitriding, and its main purpose is to improve the wear resistance and seizure resistance of steel.

Quenching and tempering 调质处理

It is generally customary to combine the quenching and high temperature tempering heat treatment as quenching and tempering treatment. Quenching and tempering treatment is widely used in a variety of important structural parts, especially those that work under alternating loads, such as connecting rods, bolts, gears and shafts. After the quenching and tempering treatment, the tempered sorbite structure is obtained, and its mechanical properties are superior to the normal-fired sorbite structure of the same hardness. Its hardness depends on the high temperature tempering temperature and is related to the tempering stability of the steel and the cross-sectional dimensions of the workpiece, generally between HB200 and 350.[2]

Brazing 钎焊

A heat treatment process in which two workpieces are bonded together using a solder.

4.2.3 The process of heat treatment

The heat treatment process generally includes three processes of heating, heat preservation and cooling, and sometimes only two processes of heating and cooling.

Heating is one of the important processes of heat treatment. There are many heating methods for metal heat treatment. The first use of charcoal and coal as a heat source, and then the use of liquid and gaseous fuels. Electrical applications make heating easy to control and environmentally friendly. These heat sources can be used for direct heating, or by indirect heating of molten salts or metals, or floating particles.

When the metal is heated, the workpiece is exposed to the air, and oxidation and decarburization (ie, the carbon content on the surface of the steel part) often occur, which has a detrimental effect on the surface properties of the parts after the heat treatment. Thus, the metal should generally be heated in a controlled or protective atmosphere, in a molten salt and in a vacuum, or protected by a coating or packaging process.

Heating temperature is one of the important process parameters of heat treatment process. Selecting and controlling heating temperature is the main problem to ensure the quality of heat treatment. The heating temperature varies depending on the metal material to be treated and the purpose of the heat treatment, but is generally heated above the phase transition temperature to obtain a high temperature structure. In addition, the transformation takes a certain time, so when the surface of the metal workpiece reaches the required heating temperature, it must be kept at this temperature for a certain period of time, so that the internal and external temperatures are uniform, and the microstructure is completely transformed. This period of time is called the holding time. When high-energy density heating and surface heat treatment are used, the heating rate is extremely fast, and generally there is no holding time, and the heat treatment time of the chemical heat treatment tends to be long.

Cooling is also an indispensable step in the heat treatment process. The cooling method varies from process to process, mainly to control the cooling rate. Generally, the annealing rate is the slowest, the normalizing cooling rate is faster, and the quenching cooling rate is faster. However, there are different requirements depending on the type of steel. For example, an empty hard steel can be hardened at the same cooling rate as a normal fire.

4.2.4 The kinds of heat treatment

Metal heat treatment processes can be roughly divided into three categories: overall heat treatment, surface heat treatment and chemical heat treatment. Depending on the heating medium, heating temperature and cooling method, each category can be divided into several different heat treatment processes. The same metal uses different heat treatment processes to obtain different microstructures and thus different properties. Steel is the most widely used metal in the industry, and the steel microstructure is also the most complex, so there are many kinds of steel heat treatment processes. The overall heat treatment of steel has four basic processes: annealing, normalizing, quenching and tempering. [3]

(1) Annealing 退火

Annealing is to heat the workpiece to the appropriate temperature, using different holding time according to the material and the size of the workpiece, and then slowly cooling, in order to achieve or close to the equilibrium of the internal structure of the metal, to obtain good process performance and performance, or to further quench Prepare for organization.

There are many types of annealing processes for steel. According to the heating temperature, they can be divided into two categories: one is annealing above the critical temperature (Ac1 or Ac3), also known as phase change recrystallization annealing, including complete annealing, incomplete annealing, and ball. Annealing and diffusion annealing (homogeneous annealing), etc.; the other is annealing below the critical temperature, including recrystallization annealing and stress relief annealing. According to the cooling method, the annealing can be classified into isothermal annealing and continuous cooling annealing.

1. Complete annealing and isothermal annealing 完全退火和等温退火

Complete annealing, also known as recrystallization annealing, is generally referred to as annealing. It is to heat steel or steel to Ac3 above 20~30 ℃, and keep it for a long time, so that the microstructure is completely austenitized and then slowly cooled to obtain near equilibrium. Heat treatment process of the tissue. This type of annealing is mainly used for casting, forging and hot-rolled profiles of various carbon steels and alloy steels of the hypoeutectoid composition, and sometimes for welded structures. It is often used as a final heat treatment for some non-heavy workpieces or as a pre-heat treatment for certain workpieces.

2. Spheroidizing annealing 球化退火

Spheroidizing annealing is mainly used for hypereutectoid carbon steel and alloy tool steels (such as steel grades used in the manufacture of cutting tools, gauges, and molds). Its main purpose is to reduce hardness, improve machinability, and prepare for later quenching.

3. Stress relief annealing 去应力退火

Stress relief annealing, also known as low temperature annealing (or high temperature tempering), is mainly used to eliminate residual stresses in castings, forgings, welded parts, hot rolled parts, cold drawn parts, and the like. If these stresses are not eliminated, it will cause deformation or cracking of the steel after a certain period of time or during subsequent cutting operations.

4. Incomplete annealing 不完全退火

Incomplete annealing is to heat the steel between Ac1~Ac3 (hypoeutectoid steel) or Ac1~ACcm (hypereutectoid steel), and then slowly cool after heat preservation to obtain a heat treatment process close to the equilibrium structure.

(2) Normalizing 正火

Normalizing is to cool the workpiece to a suitable temperature and then cool it in the air. The effect of normalizing is similar to annealing, but the resulting structure is finer, which is often used to improve the cutting performance of materials, and sometimes used for some less demanding parts. As the final heat treatment.

(3) Quenching 淬火

Quenching is the rapid cooling of the workpiece after heating and holding it in a quenching medium such as water, oil or other inorganic salts or organic aqueous solutions. After quenching, the steel becomes hard but becomes brittle at the same time. When quenching, the most common cooling media are brine, water and oil. The salt-quenched workpiece is easy to obtain high hardness and smooth surface. It is not easy to produce hard spots that are hard to quench, but it is easy to deform the workpiece seriously and even crack. The use of oil as a quenching medium is only suitable for the quenching of some alloy steels or small-sized carbon steel workpieces with relatively high stability of supercooled austenite.

(4) Tempering 回火

In order to reduce the brittleness of the steel, the quenched steel is heat-treated for a long time at a suitable temperature above room temperature and below 650 °

C, and then cooled. This process is called tempering.

1. Low temperature tempering (150-250 degrees)低温回火（150－250 度）

The structure obtained by low temperature tempering is tempered martensite. The purpose is to reduce the internal stress and brittleness of the quenched steel under the premise of maintaining the high hardness and high wear resistance of the quenched steel, so as to avoid cracking or premature failure during use. It is mainly used for various high carbon cutting tools, measuring tools, cold stamping dies, rolling bearings and carburizing parts. The hardness after tempering is generally HRC58-64.

2. Medium temperature tempering (250-500 degrees)中温回火（250－500 度）

The tissue obtained by medium temperature tempering is tempered troostite. Its purpose is to achieve high yield strength, elastic limit and high toughness. Therefore, it is mainly used for the treatment of various springs and hot working dies, and the hardness after tempering is generally HRC35-50.

3. High temperature tempering (500-650 degrees)高温回火（500－650 度）

The structure obtained by high temperature tempering is tempered sorbite. Conventionally, the heat treatment combined with quenching and high temperature tempering is called quenching and tempering treatment, and the purpose is to obtain comprehensive mechanical properties with good strength, hardness, plasticity and toughness. Therefore, it is widely used in important structural parts of automobiles, tractors, machine tools, etc., such as connecting rods, bolts, gears and shafts. After tempering, the hardness is generally HB200-330.

The "four fires" evolved different heat treatment processes with different heating temperatures and cooling methods. In order to obtain a certain strength and toughness, the process of combining quenching and high-temperature tempering is called quenching and tempering. After quenching some alloys to form a supersaturated solid solution, it is kept at room temperature or a slightly higher temperature for a longer period of time to increase the hardness, strength or electrical magnetic properties of the alloy. Such a heat treatment process is called aging treatment.

The method of effectively and tightly combining pressure processing deformation with heat treatment to obtain a good strength and toughness of the workpiece is called deformation heat treatment; the heat treatment in a vacuum atmosphere or vacuum is called vacuum heat treatment, which can not only make The workpiece is not oxidized, does not decarburize, keeps the surface of the workpiece smooth after treatment, improves the performance of the workpiece, and can also be subjected to chemical heat treatment by using an infiltrant.

Surface heat treatment is a metal heat treatment process that only heats the surface layer of the workpiece to change its surface mechanical properties. In order to heat only the surface layer of the workpiece without excessive heat being introduced into the interior of the workpiece, the heat source used must have a high energy density, that is, to give a large amount of heat energy to the workpiece per unit area, so that the surface layer or local portion of the workpiece can be short-time or instantaneous. Reach high temperatures. The main methods of surface heat treatment include flame quenching and induction heating heat treatment, commonly used heat sources such as aerobic acetylene or oxypropane, induction current, laser and electron beam.

Chemical heat treatment is a metal heat treatment process that changes the chemical composition, structure and properties of the surface of the workpiece. The difference between chemical heat treatment and surface heat treatment is that the latter changes the chemical composition of the surface layer of the workpiece. Chemical heat treatment is to heat the workpiece in a medium (gas, liquid, solid) containing carbon, nitrogen or other alloying elements for a long time, so that the surface of the workpiece penetrates into carbon, nitrogen, boron and chromium. After infiltration of the elements, other heat treatment processes such as quenching and tempering are sometimes performed. The main methods of chemical heat treatment are carburizing, nitriding and metalizing.

Heat treatment is one of the important processes in the manufacturing process of mechanical parts and tooling. In general, it can guarantee and improve various properties of the workpiece, such as wear resistance and corrosion resistance. It also improves the microstructure and stress state of the blank to facilitate various cold and hot processing. [4]

4.3 The modern heat treatment technology

Heat treatment technology is the processing technology used to improve the mechanical properties of metal materials during processing. In order to make the metal workpiece have the required mechanical properties, physical properties and chemical properties, in addition to the rational selection of materials and various forming processes, heat treatment processes are often essential. An improper surface treatment will make the products in the process make all the processing done in the process become a bubble, which invisibly reduces the productivity and quality of the products and increases the cost of manufacturing, and relatively reduces the competitiveness of the industry. We introduce several modern heat treatment technologies for your reference application.

1. Vacuum heat treatment technology

Method: Vacuum heat treatment is a technique in which a metal workpiece is placed in an evacuated vessel and then subjected to various repeated heating and cooling operations for the desired purpose. Uses or advantages: the surface of the workpiece is bright, the workpiece is less deformed, the workpiece is not oxidized and decarburized or carburized, no corrosion and pollution problems, quality is stable, etc. It is suitable for heat treatment of tools or molds, and is the mainstream of future heat treatment technology.

2. Sub-zero processing technology

Method: Sub-zero treatment is a heat treatment method in which a metal workpiece is placed in a low-temperature environment to force the metal workpiece to change the material properties. The conventional sub-zero treatment is usually performed after the steel material is quenched to effectively reduce the residual Osda. The iron content can make the steel material dimensional stability and improve the wear resistance characteristics, especially the high carbon content tool steel, the best effect. Use or advantage: The application of sub-zero treatment will be applied to non-ferrous metals such as super-hard alloys and copper alloys to improve the residual application of the workpiece, so as to increase the life of the workpiece more than twice.

3. Ion nitriding technology

Method: first place the metal workpiece in a vacuum container, then pass nitrogen gas, treat the container itself as the anode, the workpiece as the cathode, and then pass the high-voltage direct current to force the nitrogen to dissociate into positively charged nitrogen ions, which is extremely high. A surface heat treatment technique that rushes toward the cathode metal workpiece to instantaneously nitride the surface of the metal workpiece. Use or advantage: Effectively improve the wear resistance, fatigue resistance and corrosion resistance of metal materials. In addition, it also has the characteristics of small deformation, no pollution and energy saving. Widely used in the nitriding of various steel workpieces and non-ferrous metal workpieces.

4. Low pressure nitriding technology Method: The low pressure nitriding technology is carried out by injecting nitrogen, such as NH3, N2O and N2, under the action pressure of about 300 mba, and further adding CH4 for gas nitriding and carbonization. The treatment temperature is about 400~600 ℃. Low pressure nitriding and nitriding carbonization can obtain a higher hardness nitriding layer on the surface of the workpiece, increase the surface compressive stress of the workpiece, improve its wear resistance and fatigue resistance; the nitriding speed is fast, and the nitriding layer structure can be selected as pure The diffusion layer or the dense white layer can be nitrided deep hole slit, the surface of the workpiece is clean, the mass production is good, the labor is saved, the gas energy is saved, the working environment is excellent, and the application is increasingly wide. Use or advantage: Because low pressure nitriding can obtain a uniform hardened layer for complex shapes and deep-hole workpieces, wear resistance for die-casting molds, forging dies, aluminum extrusion dies, and rollers, dies, nozzles, engine cylinders, etc. The fatigue-resistant workpiece is very suitable.

5. Salt bath carbonitriding technology Method:

The salt bath carbonitriding technology is to treat the workpiece in a soft nitride bath to form a wear-resistant diffusion nitride layer on the surface of the workpiece, and then quickly move the workpiece into the oxide salt. Oxidation treatment, the outer surface of the workpiece is further formed with an abrasion resistant oxide layer. Use or advantage: The operation using salt bath is simple and easy, the deformation of the workpiece is small, and the mechanical properties such as wear resistance, fatigue resistance and corrosion resistance of the workpiece can be effectively improved, and it can be applied to tools and various mechanical components.

6. Physical evaporation technology

Method: The physical vapor deposition method is to coat a surface of a substrate with a ceramic film in a high vacuum. The hardness of the film is harder than that of the tungsten carbide alloy, and has the advantages of high corrosion resistance, wear resistance, adhesion and low friction coefficient. . At present, there are two kinds of physical vapor deposition systems of cathode electric plasma and unbalanced magnetron sputtering. TiN, TiCN, CrN, CrCN, TiAIN and amorphous carbon films have been developed and applied. Use or advantage: The physical vapor deposition temperature is about 100~500℃, which is lower than the tempering temperature of high speed steel and die steel. Therefore, the workpiece will not soften and deform, and it can be applied to super hard alloy, high speed steel, die steel, stainless steel, about titanium alloys and aluminum alloys. When the tool vapor-deposited ceramic film can reduce the edge melting phenomenon, reduce the knife edge wear rate and improve the tool life by 2~7 times; the mold can increase the mold release, wear resistance, reduce the adhesive wear and burn through the evaporation process. The phenomenon can effectively increase the life of the mold several times, not only reduce the production cost, but also increase the competitiveness of the product.

Translate:

［1］为使金属工件具有所需要的力学性能、物理性能和化学性能，除合理选用材料和各种成形工艺外，热处理工艺往往是必不可少的。钢铁是机械工业中应用最广的材料，钢铁显微组织复杂，可以通过热处理予以控制，所以钢铁

的热处理是金属热处理的主要内容。另外，铝、铜、镁、钛等及其合金也都可以通过热处理改变其力学、物理和化学性能，以获得不同的使用性能。

［2］一般习惯将淬火加高温回火相结合的热处理称为调质处理。调质处理广泛应用于各种重要的结构零件，特别是那些在交变负荷下工作的连杆、螺栓、齿轮及轴类等。调质处理后得到回火索氏体组织，它的机械性能均比相同硬度的正火索氏体组织为优。它的硬度取决于高温回火温度并与钢的回火稳定性和工件截面尺寸有关，一般在 HB200—350 之间。

［3］金属热处理工艺大体可分为整体热处理、表面热处理和化学热处理三大类。根据加热介质、加热温度和冷却方法的不同，每一大类又可区分为若干不同的热处理工艺。同一种金属采用不同的热处理工艺，可获得不同的组织，从而具有不同的性能。钢铁是工业上应用最广的金属，而且钢铁显微组织也最为复杂，因此钢铁热处理工艺种类繁多。钢铁整体热处理大致有退火、正火、淬火和回火四种基本工艺。

［4］化学热处理是通过改变工件表层化学成分、组织和性能的金属热处理工艺。化学热处理与表面热处理不同之处是后者改变了工件表层的化学成分。化学热处理是将工件放在含碳、氮或其它合金元素的介质(气体、液体、固体)中加热，保温较长时间，从而使工件表层渗入碳、氮、硼和铬等元素。渗入元素后，有时还要进行其它热处理工艺如淬火及回火。化学热处理的主要方法有渗碳、渗氮、渗金属。

Glossary:

Alumina [ə'lju:minə] n. [无化] 氧化铝；矾土

Cartridge ['kɑ:tridʒ] n. 弹药筒，弹药；笔芯；一卷软片;支座

Catalyst ['kætəlist] n. [物化] 催化剂；刺激因素

Compacted ['kɔmpæktid] adj. 压实的；压紧的

Graphite ['græfait] n. 石墨；黑铅

Iron ['aiən] n. 熨斗；烙铁；坚强 vt. 熨；用铁铸成 adj. 铁的；残酷的；刚强的

Embrittlement [em'britəlmənt] n. [材] 脆化；[材] 脆裂

Ferrous ['ferəs] adj. [化学] 亚铁的；铁的，含铁的

Metal ['metəl] n. 金属；合金 vt. 以金属覆盖 adj. 金属制的

Galvaniz ['gælvənaiz] vt. 镀锌；通电；刺激

Hardenability [,hɑ:dənə'biləti] n. 可硬化性；淬硬性

Macromolecular [,mækrəuməu'lekjulə]adj. [化学] 大分子的

Compound ['kɔmpaund, kəm'paund] vt. 合成；混合；和解妥协；搀合 vi. 和解；妥协 n. [化学] 化合物；混合物；复合词 adj. 复合的；混合的

Malleable ['mæliəbl] adj. 可锻的；可塑的；有延展性的；易适应的

Passivation [pæsi'veiʃən] n. [化学] 钝化；钝化处理

Austenite ['ɔstinait] n.奥氏体

Ferrite ['ferait] n. 铁酸盐, 铁素体

Cementite [si'mentait]n. [材] 渗碳体，碳

Pearlite ['pə:lait]n. [材] 珠光体；[地质] 珍珠岩

Normalizing ['nɔ:məlaiziŋ] n. [冶] 正火；正常化；[数] 规格化

Anneal [ə'ni:l] vt. 使退火，韧炼；锻炼 n. 退火；锻炼，磨练

Melt [melt] vi. 熔化，溶解 vt. 使融化；使熔化；使软化；使感动 n. 熔化；熔化物

Solution [sə'lju:ʃən] n. 解决方案；溶液；溶解；解答

Aging ['edʒɪŋ] n. 老化；陈化，熟

Treatment ['tri:tmənt] n. 治疗，疗法；处理；对待

Quench [kwentʃ] vt. 熄灭，[机] 淬火；解渴；结束；冷浸 vi. 熄灭；平息

Temper ['tempə] n. 脾气；（钢等）回火；性情；倾向 vt. 使回火；锻炼；调和；使缓和 vi. 回火；调和

本章小结

本章节的教学主要针对工程材料的分类进行了介绍，包括及性能等；还对热处理技术进行了介绍，包括热处理的原理，过程中各个阶段的作用；最后对现代热处理工艺进行了介绍。

EXERCISE:

1. Translate the section for Chinese

Quenching is the rapid cooling of the workpiece after heating and holding it in a quenching medium such as water, oil or other inorganic salts or organic aqueous solutions. After quenching, the steel becomes hard but becomes brittle at the same time. When quenching, the most common cooling media are brine, water and oil. The salt-quenched workpiece is easy to obtain high hardness and smooth surface. It is not easy to produce hard spots that are hard to quench, but it is easy to deform the workpiece seriously and even crack. The use of oil as a quenching medium is only suitable for the quenching of some alloy steels or small-sized carbon steel workpieces with relatively high stability of supercooled austenite.

2. Describe the engineering material’s characteristic by self.

Unit 5 Machining Parts and Industrial Robots

［**Target**］

（1）了解常见机械配件的功能作用

（2）了解常见工业机器人的控制方法和功能

5.1 Parts, Components

1. **A belt drive** is a mechanical transmission that utilizes a flexible belt that is tensioned on a pulley for motion or power transmission. According to the different transmission principle, there is a friction type belt transmission which is driven by friction between the belt and the pulley, and a timing belt transmission which is driven by the belt and the teeth on the pulley.

The belt drive has the advantages of simple structure, stable transmission, buffering vibration absorption, transmission of power between large shaft spacing and multiple shafts, low cost, no lubrication, easy maintenance, etc., and is widely used in modern mechanical transmission. Friction type belt drive can overload and slip, low running noise, but the transmission ratio is not accurate (sliding rate is below 2%); synchronous belt transmission can ensure the transmission synchronization, but the absorption capacity for load changes is slightly poor, and the high-speed operation is noisy. In addition to transmitting power, the belt drive is sometimes used to transport materials, perform integral parts, and so on.

The belt drive usually consists of a drive wheel, a driven wheel and an endless belt that is tensioned on the two wheels.

Fig.5. 1

2. **Gear transmission** refers to the device that transmits motion and power from the gear pair. It is the most widely used mechanical transmission method in modern equipment. Its transmission is more accurate, high efficiency, compact structure, reliable operation and long service life.

Among the various transmission forms, gear transmission is the most widely used in modern machinery. This is because the gear transmission has the following characteristics:

1) High transmission accuracy. As mentioned above, the belt drive cannot guarantee an accurate gear ratio, and the chain drive cannot achieve a constant instantaneous gear ratio. However, the transmission ratio of the modern involute gear is theoretically accurate and constant. This is not only a key requirement for precision machinery and instruments, but also an important condition for reducing dynamic loads and achieving smooth transmission under high speed and heavy load.

2) Wide application range. The power transmission of the gear transmission is extremely wide, from 0.001W to 60,000 kW; the peripheral speed can be as low as 150m/s, and the belt drive and chain drive are difficult to compare.

3) It is possible to realize the transmission between any two axes of parallel axis, intersecting axis, staggered axis, etc., which is also impossible for belt drive and chain drive.

4) Reliable work and long service life.

5) The transmission efficiency is high, generally 0.94 to 0.99.

6) The manufacturing and installation requirements are high and the cost is also high.

7) The environmental conditions are stricter. Except for a few cases of low speed and low precision, it is generally required to be placed in the box cover to prevent dust and scale, and also to pay attention to lubrication.

8) Not applicable to transmissions with two axes that are far apart.

9) Vibration damping and impact resistance are not as good as flexible transmissions such as belt drives.

There are many types of gear transmissions, which can be divided into different types according to different classification methods.

By gear ratio

According to whether the gear ratio of a pair of gear transmission is constant, it can be divided into fixed gear ratio and variable ratio gear transmission. The gear of the variable ratio gear transmission is generally non-circular, so it is also called non-circular gear transmission, which is mainly used in some machines with special requirements. The gears in the fixed gear ratio gear mechanism are all circular, so they are also called circular gear transmission.

There are many types of gear ratio transmissions. According to whether the main and driven wheel rotation axes are parallel, they can be divided into two types, namely, face gear transmission and space gear transmission.

According to the shape of the tooth profile

According to the shape of the tooth profile curve, it can be divided into involute gear transmission, cycloidal gear transmission, arc gear transmission and parabolic gear transmission. Among them, involute gear transmission is the most widely used.

By working conditions

According to different working conditions of gear transmission, it can be divided into closed gear transmission, open gear transmission and semi-open gear transmission. In the open gear transmission, the teeth are exposed, and the dust is easy to fall on the tooth surface; in the closed gear transmission, the gear teeth are enclosed in the box body, which can ensure good working conditions and is widely used; the semi-open gear transmission is faster than the open gear transmission working condition. Fortunately, the large gear is partially immersed in the pumping tank and has a simple protective cover, but there is still foreign matter intrusion.

Tooth surface hardness

According to the different hardness of the tooth surface, it is divided into soft tooth surface gear transmission and hard tooth surface gear transmission. When the tooth surface hardness of two wheels (or one of them) is ≤350HBW, it is called soft tooth surface transmission. When the tooth surface hardness of both wheels is >350HBW, it is called hard tooth surface transmission. The soft-toothed gear transmission is often used for general medium- and low-speed gear transmissions that do not require high precision. Hard-toothed gear transmissions are often used for gear transmissions that require strong bearing capacity and compact structure.

Although there are many types of gear transmissions, the involute spur gear transmission is the simplest and most basic type.

Failure form

The gear transmission works by the meshing of the teeth and the teeth. The gear teeth are the parts in which the gears directly participate in the work, so the failure of the gears mainly occurs on the gear teeth. The main failure modes are gear fracture, tooth surface pitting, tooth surface wear, tooth surface gluing and plastic deformation.

1. Broken tooth

There are two cases of gear fracture: one is fatigue fracture due to repeated bending stress and stress concentration; the other is overload fracture due to sudden severe overload or impact load. In particular, gears made of brittle materials (cast iron, hardened steel, etc.) are more susceptible to gear breakage. Both fractures start on the side of the tooth that is subjected to tensile stress. Increase the root radius of the root transition, improve the mechanical properties of the material, reduce the surface roughness to reduce the stress concentration, and strengthen the root (such as shot peening, rolling extrusion), etc. Anti-breaking ability.

2. Tooth surface pitting

When the gear teeth work, the front meshing portion is subjected to repeated repeated stresses, and several small cracks are generated on the tooth surface near the pitch line. As the crack expands, it will cause the small piece of metal to peel off. This phenomenon is called tooth surface pitting. Continued expansion of the tooth surface pitting will affect the smoothness of the transmission and generate vibration and noise, resulting in the gear not working properly. Pitting is a common form of failure for a well-closed closed gear drive. Increasing the hardness of the tooth surface and reducing the surface roughness value can improve the pitting resistance of the tooth surface and the open gear transmission. Since the tooth surface wears faster, no pitting occurs.

3. Tooth surface wear

When the teeth are engaged, the surface of the teeth is worn due to the relative sliding, especially when the external hard particles enter between the meshing working surfaces. After the tooth surface is gradually worn, the tooth surface will lose the correct tooth shape. In severe cases, the tooth teeth will be too thin and broken. The tooth surface wear is the main failure mode of the open gear transmission. In order to reduce wear, important gear drives should be closed and pay attention to lubrication.

4. Tooth surface gluing

In high-speed and heavy-duty gear transmission, the pressure on the tooth surface is large, the temperature rises, and the lubrication effect is poor. When the instantaneous temperature is too high, the two tooth surfaces will be partially melted and the metal will adhere to each other. When the two tooth surfaces are in relative motion. When the stuck place is torn, the belt surface or the large area of the scar is formed along the sliding direction on the tooth surface, and the low speed and heavy load transmission is not easy to form an oil film. Although the friction heat is not large, it may also be due to heavy load. Cold glue appears. The use of lubricating oil with high viscosity or good anti-gluing property can reduce the surface roughness to form good lubrication conditions; increase the hardness of the tooth surface can enhance the anti-adhesive ability of the tooth surface.

5. Tooth surface plastic deformation

For soft toothed gears with low hardness, at low speed and heavy load, the tooth surface pressure is too large, and under the action of friction, the tooth surface metal plastically flows and loses the original tooth shape. Increasing the hardness of the tooth surface and using a higher viscosity lubricant help to prevent or reduce the plastic deformation of the tooth surface.

Fig.5. 2

3. **The chain drive** is a transmission method in which the movement and power of a drive sprocket having a special tooth shape is transmitted to a driven sprocket having a special tooth shape through a chain.

The chain drive has many advantages. Compared with the belt drive, it has no elastic sliding and slipping phenomenon, the average transmission ratio is accurate, the work is reliable, and the efficiency is high. The transmission power is large, the overload capability is strong, and the transmission size under the same working condition is small; The tightening force is small, the pressure acting on the shaft is small; it can work in harsh environments such as high temperature, humidity, dust, and pollution.

The main disadvantages of the chain drive are: only can be used for transmission between two parallel shafts; high cost, easy to wear, easy to stretch, poor transmission stability, additional dynamic load, vibration, shock and noise during operation, not suitable for rapid Reverse drive.

The chain drive is the meshing drive and the average gear ratio is accurate. It is a mechanical transmission that utilizes the meshing of the chain with the sprocket teeth to transmit power and motion.

Chain

The chain length is expressed in number of links. The number of links is preferably taken as an even number so that when the chain is connected in a ring shape, it is just that the outer link plate is connected to the inner link plate, and the joint can be locked by a spring clip or a split pin. If the number of links is an odd number, a transition link is required. When the chain is pulled, the transition links are subject to additional bending loads and should generally be avoided. The toothed chain is hinged by a plurality of stamped toothed chain plates. In order to avoid the chain breakage during the engagement, the chain should have a guide plate (divided into an inner guide and an outer guide). The two sides of the toothed chain plate are straight sides, and the side edges of the chain plate are engaged with the tooth profile of the sprocket during operation. The hinge can be made into a sliding pair or a rolling pair, and the roller type can reduce friction and wear, and the effect is better than that of the bearing. Compared with the roller chain, the toothed chain runs smoothly, has low noise, and has high ability to withstand impact loads. However, the structure is complicated, expensive, and heavy, so its application is not as extensive as the roller chain. Toothed chains are often used for high speed (chain speeds up to 40 m/s) or transmissions with high motion accuracy requirements. The national standard only specifies the maximum and minimum values of the radius of the tooth surface of the roller chain sprocket, the radius of the groove arc and the angle of the groove (see GB1244-85 for details). The actual face profile of the various sprockets should be between the maximum and minimum cogging shapes. This treatment gives the sprocket tooth profile design a great deal of flexibility. However, the tooth shape should ensure that the chain energy-saving smoothly enters and exits the meshing and is easy to process. There are a variety of face profile curves that meet the above requirements. The most commonly used tooth profile is the "three arcs straight line", that is, the face tooth shape is composed of a three-section arc and a straight line.

Sprocket

The sprocket shaft teeth are arcuate on both sides to facilitate the entry and exit of the links. When the tooth profile is machined with a standard tool, it is not necessary to draw the face tooth shape on the sprocket work diagram, but the sprocket shaft face tooth shape must be drawn so that the turning sprocket hair is broken. The specific dimensions of the shaft profile are given in the relevant design manual. The sprocket teeth should have sufficient contact strength and wear resistance, so the tooth surface is often heat treated. The small sprocket has more meshing times than the large sprocket, and the impact force is also large, so the material used should generally be superior to the large sprocket. Commonly used sprocket materials are carbon steel (such as Q235, Q275, 45, ZG310-570, etc.), gray cast iron (such as HT200). The important sprocket can be made of alloy steel. The small diameter sprocket can be made into a solid type; the medium diameter sprocket can be made into an orifice plate type; the larger diameter sprocket can be designed as a combination, and if the gear teeth fail due to wear, the ring gear can be replaced. The size of the sprocket hub portion can be referred to the pulley.

Compared with the belt drive, the chain drive has no elastic sliding and slipping, and can maintain an accurate average transmission ratio; the required tension is small, the pressure acting on the shaft is also small, and the friction loss of the bearing can be reduced; the structure is compact; Work in harsh environmental conditions such as high temperatures and oil. Compared with the gear transmission, the chain drive has lower requirements for manufacturing and installation accuracy; when the center distance is large, the transmission structure is simple. The instantaneous chain speed and instantaneous transmission ratio are not constant, so the transmission is less stable and there is a certain impact and noise in the work. The average transmission ratio of the chain drive is accurate, the transmission efficiency is high, the distance between the shafts is large, and it can be used in an environment with high temperature and high humidity. However, the chain drive can only be used as a parallel shaft transmission, and its instantaneous transmission the transmission noise is larger than the fluctuation. Since the links are rigid, there is a polygonal effect (i.e., motion non-uniformity) that changes the instantaneous gear ratio of the chain drive and causes additional dynamic loads and vibrations that must be considered when selecting the chain drive parameters. Chain drives are widely used in transportation, agriculture, light industry, mining, petroleum and machine tool industries.

Fig.5. 3

5.2 Industrial Robots

There are a variety of definitions of the term industrial robot. Depending on the definition used, the number Industrial robot installations worldwide varies widely. Numerous single-purpose machines are used in manufacturing plants that might appear to be robots. These machines can only perform a single function and cannot be reprogrammed to perform a different function. Such single-purpose machines do not fit the definition for industrial robots that is becoming widely accepted.

An industrial robot is defined by the Intentional Organization for Standardization (ISO) as an automatically controlled, reprogrammable, multipurpose manipulator, programmable in three or more axes, which may be either fixed in place or mobile for use in industrial automation applications.

There exist several other definitions too, given by other societies, e.g.by the Robot Institute of America (RIA), British Robot Association (BRA), and others. The definition developed by RIA is:

A robot is a reprogrammable multifunctional manipulator designed to move material, parts, tools, or specialized devices through variable programmed motions for the performance of a variety of tasks.

All definitions have two points in common. They all contain the words reprogrammable and multifunctional. It is these two characteristics that separate the true industrial robot from the various single-purpose machines used in modern manufacturing firms.

The term “reprogrammable” implies two things: The robot operates according to a written program, and this program can be rewritten to accommodate a variety of manufacturing tasks.

The term “multifunctional” means that the robot can, through reprogramming and the use of different end-effectors, perform a number of different manufacturing tasks. Definitions written around these two critical characteristics have become the accepted definitions among manufacturing professionals.

The first articulated am came about in 1951 and was used by the U. S Atomic Energy Commission. In 1954, the first industrial robot was design by George C. Devol. It was an unsophisticated programmable materials handling machine.

The first commercially produced robot was developed in 1959. In 1962, the first industrial robot to be used on a production line was installed in the General Motors Corporation. It was used to lift red-hot door handles and other such car parts from die casting machines in an automobile factory in New Jersey, USA. Its most distinctive feature was a gripper that eliminated the need for man to touch car parts just made from molten metal. It had five degrees of freedom (DOF). This robot was produced by Unimation.

A major step forward in robot control occurred in 1973 with the development of the T industrial robot by Cincinnati Milacron. The T robot was the first commercially produced industrial robot controlled by a minicomputer.

Since then robotics has evolved in a multitude of directions, starting from using them in welding, painting, in assembly, machine tool loading and unloading, to inspection.

Over the last three decades automobile factories have become dominated by robots. A typical factory contains hundreds of industrial robots working on fully automated production lines. For example, on an automated production line, a vehicle chassis on a conveyor is welded, painted and finally assembled at a sequence of robot stations.

Mass-produced printed circuit boards (PCBS) are almost exclusive assembled by pick-and-place robots, typically with SCARA manipulators, which pick tiny electronic components, and place them on to PCBS with great accuracy. Such robots can place tens of thousands of components per hour, far surpassing a human in speed, accuracy, and reliability.

A major reason for the growth in the use of industrial robots is their declining cost. Since 1970s, the rapid inflation of wages has tremendously increased the personnel costs of manufacturing firms. In order to survive, manufacturers were forced to consider any technological developments that could help improve productivity. It became imperative to produce better products at lower costs in order to be competitive in the global market economy. Other factors such as the need to find better ways of performing dangerous manufacturing tasks contributed to the development of industrial robots. However, the fundamental reason has always been and is still, improved productivity.

One of the principal advantages of robots is that they can be used in setting that are dangerous to humans. Welding and parting are examples of applications where robots can be used more safely than humans. Most industrial robots of today are designed to work in environments which are not safe and very difficult for human workers. For example, a robot can be designed to handle a very hot or very cold object that the human hand cannot handle safely.

Even though robots are closely associated in the workplace, they can, in themselves, be dangerous. Robot workspaces should be accurately calculated and a danger zone surrounding the workspace clearly marked off. Barriers can be used to keep human workers out of a robots workspace. Even with such precautions it is still a good idea to have an automatic shutdown system in situations where robots are used. Such a system should have the capacity to sense the need for an automatic shutdown of operations.

Fig.5. 4

Basic Components of an Industrial Robot

To appreciate the functions of robot components and their capabilities, we might simultaneously observe the flexibility and capability of diverse movements of our arm, wrist, hand, and fingers in reaching for, and grabbing an object from a shelf, or in using a hand tool, or in operating a machine. Described next are the basic components of an industrial robot.

Manipulator. The manipulator is a mechanical unit that provides motions similar to those of a human am and writ. A manipulator is formed of links, and joints normally connected in series, as for the robots. For a typical six degrees of freedom root, the first three links and joints form the arm, and the last three joints make the wrist. The function of an arm is to place an object in certain location in the Three-dimensional space, where the wrist orients it.

End Effector. End effectors are devices mounted on the end of the manipulator of a robot. It is equivalent to the human hand. Depending on the tape of operation, conventional end effectors may be any of the following:

(1)Grippers, electromagnets, and vacuum cups, for material handling;

(2)Spray guns, for painting;

(3)Welding devices, for spot and are welding;

(4)Power tools, such as electrical drills;

(5)Measuring instruments.

End effectors are generally custom-made to meet special requirements. Mechanical grippers are the most commonly used and are equipped with two or more fingers, A two-fingered gripper can only hold simple objects, whereas a multi-fingered gripper can perform more complex tasks, The Selection of an appropriate end effector for a specific application depends on such factors as the payload, environment, reliability, and cost.

Actuator. Actuators are like the “muscles” of a robot, they provide motion to the manipulator and the end effector. They are, classified as pneumatic, hydraulic or electric, based on their principle of operation.

Pneumatic actuators utilize compressed air provided by a compressor and transform it into mechanical energy by means of pistons or air motors. Pneumatic actuators have few moving parts making them inherently reliable and reducing maintenance costs. It is the cheapest form of all actuators. But Pneumatic actuators are not suitable for moving heavy loads under precise control due to the compressibility of air.

Hydraulic actuators utilize high-pressure fluid such as oil to transmit force to the point of application desired. A hydraulic actuator is very similar in appearance to that of pneumatic actuator. Hydraulic actuators are designed to operate at much higher pressure (typically between 7 and 17 MPa). They are suitable for high power applications. Hydraulic robots are more capable of withstanding shock loads than electric robots.

Electric motors are the most popular actuator for manipulators. Direct current (DC) motors can achieve very high torque-to-volume ratios. They are also capable of high precision, fast acceleration, and high reliability. Although they don’t have the power-to-weight ratio of hydraulic actuators or pneumatic actuators, their controllability makes them attractive for small and medium-sized manipulators.

Alternating current (AC) motor and stepper motors have been used infrequently in industrial robots. Difficulty of control of the former and low torque ability of the latter have limited their use.

Sensor. Sensors convert one form of signal to another.fo. For example, the human eye converts light pattern into electrical signals. Sensors fall into one of the several types: vision, touch, position, force, velocity, acceleration etc.

Digital Controller. The digital controller is a special electronic device that has a CPU, memory, and sometimes a hard disk. In robot systems. These components are kept inside a sealed box referred to as a controller. It is used for controlling the movements of the manipulator and the end effector. Since a computer has the same characteristics as those of a digital controller.

Analog-to-digital Converter. An analog-to-digital converter (abbreviated ADC) is an electronic device that converts analog signals to digital signals. This electronic device interfaces with the sensors and the robots controller. Typically, an ADC converts an input analog voltage (or current) to a digital number proportional to the magnitude of the voltage or current. For example, the ADC converts the voltage signal developed due to the strain in a strain gage to a digital signal, so that the digital robot controller can processes this information.

Digital-to-analog Converter (DAC). A DAC converts the digital signal from the robot controller into an analog signal to activate the actuators. In order to actually drive the actuators, e. g. a DC electric motor, the digital controller

Is also coupled with a DAC to convert its signal back to an equivalent analog signal, i. e, the electric voltage for the DC motors.

Amplifier. Generally, an amplifier is any device that changes, usually increases the amplitude of a signal. Since the control commands from the digital controller converted to analogue signals by the DAC are very weak, they need amplification to really drive the electric motors of the robot manipulator.

Translate:

5. 1 常见的机械零部件

1. 皮带传动是一种机械传动装置，利用柔性皮带张紧在皮带轮上进行运动或动力传递。根据不同的传动原理，存在由皮带和皮带轮之间的摩擦驱动的摩擦型皮带传动装置，以及由皮带和皮带轮上的齿驱动的同步带传动装置。

皮带传动具有结构简单，传动平稳，缓冲振动吸收，大轴间距与多轴间动力传递，成本低，无润滑，易维护等优点，广泛应用于现代机械传动。摩擦式皮带传动可以过载和滑动，运行噪音低，但传动比不准确（滑动率低于 2%）；同步带传动可以保证传动同步，但负荷变化的吸收能力稍差，高速运转有噪声。除了传输动力之外，皮带传动器有时用于运输材料，执行整体部件等。

皮带传动装置通常包括驱动轮，从动轮和在两个轮子上张紧的环形皮带。

2. 齿轮传动是指从齿轮副传递运动和动力的装置。它是现代设备中使用最广泛的机械传动方法。其传动更精确，效率更高，结构紧凑，运行可靠，使用寿命长。

在各种传动形式中，齿轮传动是现代机械中最广泛使用的。这是因为齿轮传动具有以下特征：

1）传输精度高。如上所述，皮带传动不能保证精确的齿轮比，并且链传动不能实现恒定的瞬时传动比。然而，现代渐开线齿轮的传动比在理论上是准确和恒定的。这不仅是精密机械和仪器的关键要求，也是降低动态载荷，实现高速，重载下平稳传动的重要条件。

2）适用范围广。齿轮传动的动力传递非常宽，从 0.001W 到 60,000kW;圆周速度可低至 150m / s，皮带传动和链传动很难比较。

3）可以实现平行轴，交叉轴，交错轴等任意两个轴之间的传动，这对于皮带传动和链传动也是不可能的。

4）工作可靠，使用寿命长。

5）传输效率高，一般为 0.94 至 0.99。

6）制造和安装要求高，成本也高。

7）环境条件更加严格。除少数低速和低精度的情况外，通常需要将其放置在箱盖中以防止灰尘和水垢，并且还要注意润滑。

8）不适用于两个相距很远的轴的变速箱。

9）减振和抗冲击性不如皮带传动装置等柔性传动装置。

有许多类型的齿轮传动装置，根据不同的分类方法可以分为不同的类型。

按齿轮比

根据一对齿轮传动的齿轮比是否恒定，可分为固定齿轮比和变速齿轮传动。可变比齿轮传动装置的齿轮通常是非圆形的，因此也称为非圆齿轮传动装置，主要用于某些有特殊要求的机器。固定齿轮比齿轮机构中的齿轮都是圆形的，因此它们也被称为圆齿轮传动装置。

有许多类型的齿轮比传动装置。根据主轮和从动轮的旋转轴是否平行，它们可以分为两种类型，即平面齿轮传动和空间齿轮传动。

根据齿形的形状

根据齿廓曲线的形状，可分为渐开线齿轮传动，循环齿轮传动，圆弧齿轮传动和抛物线齿轮传动。其中，渐开线齿轮传动是最广泛使用的。

按工作条件

根据齿轮传动的不同工况，可分为闭式齿轮传动，开式齿轮传动和半开式齿轮传动。在开式齿轮传动装置中，齿露出，灰尘容易落在齿面上。在闭式齿轮传动装置中，齿轮齿封在箱体内，可以保证良好的工作状态，应用广泛;半开式齿轮传动比开式齿轮传动工况更快。幸运的是，大型齿轮部分浸没在泵送罐中并具有简单的保护盖，但仍然存在异物侵入。

齿面硬度

根据齿面硬度的不同，分为软齿面齿轮传动和硬齿面齿轮传动。当两个轮子（或其中一个轮子）的齿面硬度≤350HBW 时，它被称为软齿面传动。当两个车轮的齿面硬度> 350HBW 时，称为硬齿面传动。软齿轮传动装置通常用于不需要高精度的一般中速和低速齿轮传动装置。硬齿轮传动装置通常用于需要强大承载能力和紧凑结构的齿轮传动装置。

虽然有许多类型的齿轮传动装置，但渐开线直齿轮传动装置是最简单和最基本的类型。

失败形式

齿轮传动通过齿和齿的啮合起作用。齿轮齿是齿轮直接参与工作的部件，因此齿轮的失效主要发生在齿轮齿上。主要的失效模式是齿轮断裂，齿面点蚀，齿面磨损，齿面粘合和塑性变形。

1. 断牙

齿轮断裂有两种情况：一种是由于反复弯曲应力和应力集中引起的疲劳断裂;另一种是由于突然的严重过载或冲击载荷引起的过载断裂。特别是，由脆性材料（铸铁，硬化钢等）制成的齿轮更容易受到齿轮断裂的影响。两个骨折都始于受到拉应力的牙齿侧面。增加根部过渡半径，提高材料的力学性能，降低表面粗糙度，减少应力集中，强化根部（如喷丸，滚压挤压）等抗破碎能力。

2. 牙齿表面凹陷

当齿轮齿工作时，前啮合部分经受反复的重复应力，并且在俯仰线附近的齿表面上产生几个小裂缝。随着裂纹扩展，它将导致小块金属剥落。这种现象称为牙齿表面凹陷。齿面点蚀的持续膨胀会影响传动装置的平稳性并产生振动和噪音，导致齿轮不能正常工作。对于闭合良好的闭式齿轮传动装置来说，点蚀是一种常见的失效形式。增加齿面的硬度和降低表面粗糙度值可以改善齿面和开式齿轮传动的耐点蚀性。由于牙齿表面磨损较快，因此不会发生点蚀。

3. 齿面磨损

当齿啮合时，齿的表面由于相对滑动而磨损，特别是当外部硬颗粒进入啮合工作表面之间时。在牙齿表面逐渐磨损后，牙齿表面将失去正确的牙齿形状。在严重的情况下，牙齿会太薄而且破损。齿面磨损是开式齿轮传动的主要失效模式。为了减少磨损，应关闭重要的齿轮传动装置并注意润滑。

4. 牙齿表面胶合

在高速和重载齿轮传动中，齿面压力大，温度升高，润滑效果差。当瞬时温度过高时，两个齿面将部分熔化，金属将相互粘附。当两个齿面相对运动时。当卡住位置被撕裂时，沿着齿面上的滑动方向形成带表面或疤痕的大面积，并且低速和重载传递不容易形成油膜。虽然摩擦热量不大，但也可能是由于负载

过重。出现冷胶水。使用高粘度或良好的抗粘性的润滑油可以降低表面粗糙度，形成良好的润滑条件;增加牙齿表面的硬度可以增强牙齿表面的抗粘连能力。

5. 齿面塑性变形

对于低硬度，低速和重载的软齿轮，齿面压力过大，在摩擦力作用下，齿面金属塑性流动，失去原有的齿形。增加牙齿表面的硬度并使用较高粘度的润滑剂有助于防止或减少牙齿表面的塑性变形。

链传动是一种传动方法，其中具有特殊齿形的驱动链轮的运动和动力通过链传递到具有特殊齿形的从动链轮。

链传动具有许多优点。与皮带传动相比，它没有弹性滑动和滑动现象，平均传动比准确，工作可靠，效率高。传输功率大，过载能力强，在相同工作条件下的传输尺寸小;紧固力小，作用在轴上的压力小;它可以在恶劣的环境中工作，如高温，潮湿，灰尘和污染。

链传动的主要缺点是：只能用于两个平行轴之间的传动;成本高，易磨损，易拉伸，传动稳定性差，附加动态负载，振动，冲击和运行时噪音，不适合快速反向驱动。

链传动是啮合驱动，平均传动比是准确的。它是一种机械传动装置，利用链条与链轮齿的啮合来传递动力和运动。

链

链长以链接数表示。链节的数量优选地被视为偶数，使得当链条以环形连接时，外链板仅连接到内链板，并且接头可以通过弹簧夹锁定或者一个分裂针。如果链接数是奇数，则需要转换链接。拉动链条时，过渡连杆会承受额外的弯曲载荷，一般应避免使用。齿链由多个冲压齿形链板铰接。为了避免在接合过

程中链条断裂，链条应具有导板（分为内导板和外导板）。齿形链板的两侧是直边，并且链板的侧边缘在操作期间与链轮的齿形轮廓啮合。铰链可以制成滑动副或滚动副，滚轮类可以减少摩擦和磨损，效果优于轴承。与滚子链相比，齿链运行平稳，噪音低，并且具有很高的承受冲击载荷的能力。然而，该结构复杂，昂贵且重，因此其应用不如滚子链那样广泛。齿链通常用于高速（链速高达 40m/s）或具有高运动精度要求的变速箱。国家标准仅规定了滚子链轮的齿面半径的最大值和最小值，槽弧的半径和槽的角度（详见 GB1244-85）。各种链轮的实际表面轮廓应在最大和最小齿槽形状之间。这种处理使链轮齿形设计具有很大的灵活性。但是，齿形应确保链节能顺利进出啮合并易于加工。有各种面轮廓曲线满足上述要求。最常用的齿形是“三弧直线”，即，面齿形状由三段弧和直线组成。如果齿轮齿由于磨损而失效，则可以更换齿圈。链轮毂部分的尺寸可以称为滑轮。

与皮带传动相比，链传动没有弹性滑动和滑动，可以保持精确的平均传动比;所需的张力小，作用在轴上的压力也小，轴承的摩擦损失可以减小;结构紧凑;在恶劣的环境条件下工作，如高温和油。与齿轮传动相比，链传动对制造和安装精度要求较低;当中心距离大时，传动结构简单。瞬时链速和瞬时传动比不是恒定的，因此传动不太稳定，工作中存在一定的冲击和噪音。链传动的平均传动比准确，传动效率高，轴间距离大，可用于高温高湿环境。但是，链传动只能用作平行轴传动，其瞬时传动噪声大于波动。由于连杆是刚性的，因此存在多边形效应（即，运动不均匀性），其改变链传动装置的瞬时传动比并且引起在选择链传动参数时必须考虑的额外动态载荷和振动。链传动广泛用于运输，农业，轻工，采矿，石油和机床工业。

5.2 工业机器人

有许多关于工业机器人的定义。采用不同的定义，全世界各地工业机器人装置的数量就会发生很大的变化。在制造工厂中使用的许多单用途机器可能会看起来像机器人。这些机器只具有单一的功能，不能通过重复编程的方式去完成不同的工作。这种单一用途的机器不能满足被人们日益广泛接受的关于工业机器人的定义。

国际标准化组织（ISO）对工业机器人的定义为：一种能够实现自动控制、可重复编程、多用途的操作机，可以对三个或三个以上轴进行编程，它可以是固定式的也可以是移动式的，应用于工业自动化领域。

其他的一些协会，例如美国机器人协会（RIA），英国机器人协会（BRA）等都对工业机器人提出了他们各自的定义。由美国机器人协会提出的定义为：

机器人是一种用于移动材料、零件、工具或者专用装置的，通过可编程序动作来执行多种任务并具有可重复编程能力的多功能操作机。

在所有的这些定义中有两个共同点。它们是“可重复编程”和“多功能”这两个词。正是这两个特征将真正的机器人与现代制造工厂中使用的各种单一用途的机器区分开来。

“可重复编程”这个词意味着两件事：机器人根据编写的程序工作，以及可以通过重新编写程序来使其适应不同种类的制造工作的需要。

“多功能”这个词意味着机器人能通过重复编程和使用不同的末端执行器，来完成不同的制造工作。围绕着这两个关键特征所撰写的定义已经变成了被制造业的专业人员所接受的定义。

第一个关节式手臂于 1951 年被研制出来，供美国原子能委员会使用。在 1954 年，第一个可以编程的机器人由乔治 C．德沃尔设计出来。它是一个不复杂的，可以编程的物料搬运机器人。

第一个商业化生产的机器人在 1959 年研制成功。通用汽车公司在 1962 年安装了第一个用于生产线上的工业机器人。它在位于美国新泽西州的一家汽车厂中被用来从压铸机中取出红热的车门拉手以及诸如此类的汽车零件。它最显著的特点是通过采用夹持器，避免由人去接触那些刚刚由熔化的金属形成的汽车零件。它有五个自由度。它是由万能自动化公司（ Unimation）生产的。

在 1973 年，辛辛那提·米拉克龙(Milacron)公司研制出下工业机器人，在机器人的控制方面取得了重大的进展。T 机器人是第一个商业化生产的采用小型计算机控制的机器人。

从那时起，机器人技术在很多方面都得到了发展，这包括焊接、喷漆、装配、机床上下料和检测。

在过去的三十年中，机器人在许多汽车制造厂中占据了主要地位。在一个工厂中，通常有数以百计的工业机器人工作在全自动生产线上。例如，在一条自动生产线中，车辆底盘装在输送机上，在通过一连串的机器人工作站时进行诸如焊接、喷漆和最后的装配等项工作。

在印刷电路板的大批量生产过程中，装配工作几乎完全都是采用抓一放型机器人进行的。通常采用平面关节型装配机器人（ SCARA)，它可以抓取微小的电子元器件并以非常高的精度将其放到印刷电路板上。这类机器人每小时可以放置成千上万个元器件，其速度、精度和可靠性都远远超过了人类。

工业机器人成本的降低是促进它们的使用量增长的一个主要原因。从 20 世纪 70 年代开始，工资的快速增长大大增加了制造业中的人工费用。为了生存，制造厂家被迫考虑采用任何能够提高生产率的技术。为了在全球性市场经济的环境中具有竞争能力，制造厂家必须以比较低的成本，生产出质量更好的产品。其他的因素，诸如寻找更好的方式来完成带有危险性的制造工作，也促

进了工业机器人的发展。但是，其根本原因一直是，而且现在仍然是提高生产率。

机器人的主要优点之一是它们可以在对于人类来说是危险的环境中工作。采用机器人进行焊接和切断工作是比由人工来完成这些工作更为安全的例子大部分现代机器人被设计用在对人类来说是不安全和非常困难的环境中工作。例如，可以设计一个机器人来搬运非常热或非常冷的物体，而这些物体如果用人工搬运，会存在不安全因素。

尽管机器人与工作地点的安全密切相关，它们本身也可能是危险的。应该精确地计算出机器人的工作空间，并且在这个工作空间的四周清楚地标示出危险区域。可以通过设置障碍物来阻止工人进入机器人的工作空间。即使有了这些预防措施，在使用机器人的场地中设置一个自动停止工作的系统仍然不失为一个好主意。这个系统应当具有能够检测出是否有需要自动停止工作的要求的能力。

工业机器人的基本组成部分

为了评价机器人各个组成部分的功能和性能，我们可以同时观察在从货架上抓取物体时，使用手工工具时或者是操纵机器时，我们的手臂、手腕、手和手指的各种运动的灵活性和能力。工业机器人的基本组成如下所述：

操作机 操作机是一个能够提供类似人的手臂和手腕运动的机械装置。操作机通常由杆件（它们的功能类似于人体中的骨头）和关节（也被称为“运动副”）以串联的方式连接而成。对于一个典型的六自由度机器人，前三个杆件和关节构成了手臂，而后三个关节构成了手腕。手臂的功能是将一个物体放在三维空间中的某一位置，手腕的功能是确定此物体的方位。

末端执行器 末端执行器是安装在机器人的操作机端部的装置。它相当于

人的手。根据其用途，常见的末端执行器有以下几种：

（1）用于物料搬运的夹持器、电磁铁和真空吸盘

（2）用于喷涂的喷枪；

（3）进行点焊和弧焊的焊接装置；

（4）诸如电钻等类的电动工具；

（5）测量仪器。

末端执行器通常是按照客户的特殊要求定做的。最常用的末端执行器是机械式夹持器，它们有二个或多个手指。具有二个手指的夹持器只能抓取形状简单的物体，具有多个手指的夹持器则能够完成更为复杂工作。为某一特定的用途选择末端执行器时，应该考虑诸如承载能力，环境，可靠性和成本等项因素。

驱动器 驱动器就像机器人的肌肉，它们为操作机和末端执行器提供运动根据其工作原理，可以将它们分为气动、液压和电气驱动器。气动驱动器利用活塞或气动马达将由压缩机提供的压缩空气转换为机械能。气动动器只有极少数运动部件，这决定了它们具有较高的可靠性和只需要较低的维修费用。在所有的驱动器中，它是价格最便宜的。但是，由于空气的可压缩性，气动驱动器不适合应用于搬运重物并且需要精确控制的场合。

液压驱动器利用油等高压流体将力传到需要的作用点。液压驱动器在外观上很像气动驱动器。二者相比，液压驱动器的工作压力要高很多（通常为7-1Mm）。它们适合用于需要大功率的场合。与电气驱动的机器人相比，液压驱动的机器人具有更强的承受冲击载荷的能力。

作为操作机的驱动器，电动机的使用数量最多。直流（DC）电动机具有很高的扭矩体积比。它们还具有高精度、高加速度和高可靠性。尽管它们的功率重量比不如气动动器和液压驱动器，其可控制性使得它们适用于中小型操作机。

交流（AC）电动机和步进电机在工业机器人中并不常用。前者难于控制和后者只能产生较低的扭矩都限制了它们的应用。

传感器 传感器可以将一种信号转换为另一种信号。例如，人眼可以将光图像转换为电信号。传感器可以分为几种类型：视觉、触觉、位置、力觉、速度、加速度等。

数字控制器 数字控制器是一种专用的电子装置，它有中央处理器（CPU），存储器，有时还会有硬盘。在机器人系统中，这些元器件被装在一个叫做控制器的密封盒子里。它被用来控制操作机和末端执行器的运动。由于计算机具有与数字控制器相同的特性，它也可以被用来作为机器人的控制器。

模数转换器 模数转换器（简称 ADC）是一个将模拟信号转换为数字信号的电子器件。这种电子器件与传感器和机器人控制器相连接。通常，模数转换器将输入的模拟电压（或电流）转换成与电压或电流成正比的数值。例如，模数转换器（ADC）可以将由于应变片的应变而产生的电压信号转换为数字信号，使得机器人的数字控制器能够处理这个信息。

数模转换器（DAC）数模转换器（DAC）把从机器人控制器中获得的数字信号转换为模拟信号，以启动驱动器。为了使驱动器（例如，一台直流电动机）工作，与数字控制器相连接的数模转换器（DAC）要把它的数字信号转换回模拟信号，也就是，直流电动机的电压。

放大器 一般说来，放大器是一种能够改变，通常是增大信号幅值的装置。由数字控制器中发出的指令通过数模转换器后生成的模拟信号很弱，只有将它们放大之后才能驱动机器人操作机中的电动机。

Glossary

Ream [ri:m] vt. 榨取（果汁等）；扩展；挖 n. 令（纸张的计数单位）；大量

Headstock ['hedstɔk] n. 主轴承

Tailstock ['teilstɔk] n.尾座

Rod [rɔd] n. 棒；惩罚；枝条；权力

Schematic [ski:'mætik] adj. 图解的；概要的 n. 原理图；图解视图

Bar [bɑ:] n. 条，棒；酒吧；障碍 vt. 禁止；阻拦 prep. 除…

Quill [kwil] n. 活动套筒，衬套

Swing [swɪŋ] n. 最大回转直径

Bench [bentʃ] n. 长凳；工作台；替补队员；vt. 给…以席位；为…设置条凳

Symmetrical [si'metrikəl] adj. 匀称的，对称的

Flute [flu:t] n. 容屑槽

Twist [twist] vt. 捻；拧；扭伤；编织；使苦恼 n. 扭曲；拧；扭伤 vi. 扭动；弯曲

Drill [drɪl] n. 训练；钻孔机；钻子；播种机 vi. 钻孔；训练 vt. 钻孔；训练；条

Edge [edʒ] n. 边缘；优势；刀刃；锋利 vt. 使锐利；将…开刃；给…加上边 vi. 缓缓移动；侧着移动

Cemented [si'mentid] adj. 渗碳的；注水泥的；粘合的 v. 巩固；接合；粘合（cement 的过去分词形式）

Dovetail ['dʌvteil] vt. 用鸠尾榫接合；与…吻合 vi. 吻合 n. 楔形榫头

Groove [gru:v] n. [建] 凹槽，槽；最佳状态；惯例 vt. 开槽于 vi. 形成沟槽

Exercise:

1. List some common machining equipments.
2. List some common transmissions.
3. What is the basic components of an industrial robot.
4. What is the function of a sensor in a robot.

Unit 6 Conventional Machining Processes

6.1 Introduction

Conventional machining is the group of machining operations that use single- or multi-point tools to remove material in the form of chips. Metal cutting involves removing metal through machining operations. Machining traditionally takes place on lathes, drill presses, and milling machines with the use of various cutting tools. Most machining has very low set-up cost compared with forming, molding, and casting processes. Machining is necessary where tight tolerances on dimensions and finishes are required.

6.2 Turning and Lathe

Turning is one of the most common of metal cutting operations. In turning, a workpiece is rotated about its axis as single-point cutting tools are fed into it, cutting away excess material and creating the desired cylindrical surface. Turning can occur on both external and internal surfaces to produce an axially-symmetrical contoured part. Parts ranging from pocket watch components to large diameter marine propeller shafts can be turned on a lathe.

Apart from turning, several other operations can also be performed on a lathe.

Boring and internal turning. Boring and internal turning are performed on the internal surfaces by a boring bar or suitable internal cutting tools. If the initial workpiece is solid, a drilling operation must be performed first. [1] The drilling tool is held in the tailstock, and the latter is then fed against the workpiece. When boring is done in a lathe, the work is usually held in a chuck or on a face plate. Holes may be bored straight, tapered, or to irregular contours. Boring is essentially internal turning while feeding the tool parallel to the rotation axis of the workpiece.

Facing. Facing is the producing of a flat surface as the result of a tool's being fed across the end of the rotating workpiece. Unless the work is held on a mandrel, if both ends of the work are to be faced, it must be turned around after the first end is completed and then the facing operation repeated. [2] The cutting speed should be determined from the largest diameter of the surface to be faced. Facing may be done either from the outside inward or from the center outward. In either case, the point of the tool must be set exactly at the height of the center of rotation. Because the cutting force tends to push the tool away from the work, it is usually desirable to clamp the carriage to the lathe bed during each facing cut to prevent it from moving slightly and thus producing a surface that is not flat. In the facing of casting or other materials that have a hard surface, the depth of the first cut should be sufficient to penetrate the hard material to avoid excessive tool wear.

Parting. Parting is the operation by which one section of a workpiece is severed from the remainder by means of a cutoff tool. Because cutting tools are quite thin and must have considerable overhang, this process is less accurate and more difficult. The tool should be set exactly at the height of the axis of rotation, be kept sharp, have proper clearance angles, and be fed into the workpiece at a proper and uniform feed rate.

Threading. Threading can be considered as turning since the path to be travelled by the cutting tool is helical. However, there are some major differences between turning and threading. While in turning, the interest is in generating a smooth cylindrical surface, in threading the interest is in cutting a helical thread of a given form and depth which can be calculated from the formulae. There are two basic requirements for thread cutting. An accurately shaped and properly mounted tool is needed because thread cutting is a form-cutting operation. The resulting thread profile is determined by the shape of the tool and its position relative to the workpiece. The second requirement is that the tool must move longitudinally in a specific relationship to the rotation of the workpiece, because this determines the lead of the thread. This requirement is met through the use of the lead screw and the split unit, which provide positive motion of the carriage relative to the rotation ofthe spindle.

Many type of lathes are used for production turning. According to purposes and construction, lathe-type machine tools can be classified as follows:

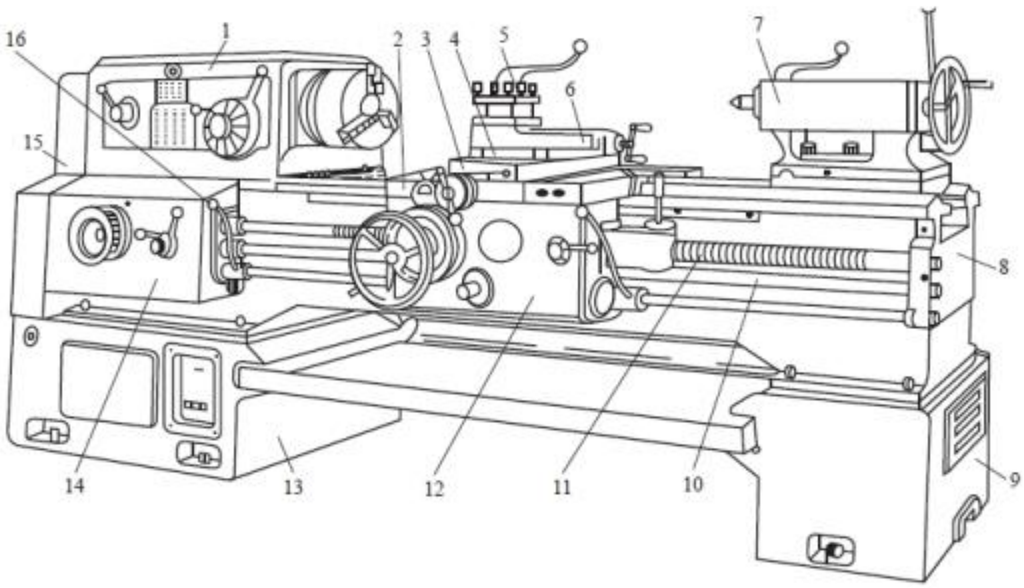
1. Engine lathes;
2. Vertical lathes;
3. Turret lathes;
4. Single- or multiple-spindle automatic or semi-automatic lathes;
5. Contouring lathes;
6. Universal lathes;
7. Special-purpose lathes such as crankshaft lathes, camshaft lathes, car wheel lathes and backing-off lathes, etc.

The engine lathe is the most representative member of the lathe family and is the most widely used, so there is a description of each of the main elements of an engine lathe, which is shown in Fig.6.1.

Lathe bed is the foundation of the engine lathe, which is a heavy, rugged casting made to support the working parts of the lathe. The size and mass ofthe bed give the rigidity necessary for accurate engineering tolerances required in manufacturing. On top of the bed are machined slideways that guide and align the carriage and tailstock, as they move from one end of the lathe to the other.

Headstock is clamped atop the bed at the left-hand end of the lathe and contains the motor that drives the spindle whose axis is parallel to the guideways through a series of gears housed within the gearbox. The function of gearbox is to generate a number of different spindle speeds. A spindle gear is mounted on the rear of the spindle to transmit power through the change gears to the feeding box that distributes the power to the lead screw for threading or to the feed rod for turning. [3]

Fig.6.1



Layout of a general purpose horizontal lathe 卧式车床外形

1－headstock 主轴箱 2－saddle(carriage)床鞍(大拖板) 3－cross-slide 中拖板 4－rotary plate 转盘 5－tool post 方刀架 6－small slide 小拖板 7－tailstock 尾座 8－bed 床身 9－right base 右床脚 10－feed rod 光杆 11－leadscrew 丝杠 12－slide box(apron)溜板箱 13－left base 左床脚 14－feed change gear box 进给箱 15－change gear box 挂轮架 16－handle 操作手柄

The spindle has a through hole extending lengthwise through which bar stocks can be fed if continuous production is used. The hole can hold a plain lathe center by its tapered inner surface and mount a chuck, a face plate or collet by its threaded outer surface.

Carriage assembly is actually an H-shaped block that sits across the guideways and in front of the lathe bed. The function of the carriage is to carry and move the cutting tool longitudinally. It can be moved by hand or by power and can be clamped into position with a locking nut. The carriage is composed of the cross slide, compound rest, tool saddle, and apron.

The cross slide is mounted on the dovetail guideways on the top of the saddle and is moved back and forth at 90^o to the axis of the lathe by the cross slide lead screw. The lead screw can be hand or power activated.

The compound rest is mounted on the cross slide and can be swiveled and clamped at any angle in a horizontal plane. The compound is typically used for cutting chamfers or tapers, but must also be used when cutting threads. The compound rest can only be fed by hand. There is no power to the compound rest. The cutting tool and tool holder are secured in the tool post which is mounted directly to the compound rest.

The tool saddle is an H-shaped casting mounted on top of the guideways and houses the cross slide and compound rest. It makes possible longitudinal, cross and angular feeding of the tool bit.

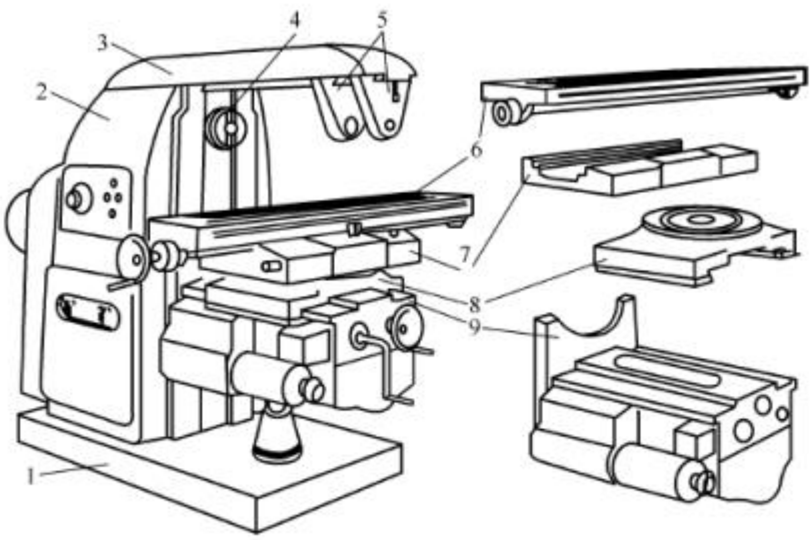
The apron is attached to the front of the carriage and contains the gears and feed clutches which transmit motion from the feed rod or lead screw to the carriage and cross slide. When cutting screw threads, power is provided to the gearbox of the apron by the lead screw. In all other turning operations, it is the feed rod that drives the carriage.

Tailstock is composed of a low base and the movable part of the tail-stock proper, the transverse adjustments being made with a cross screw furnished with a square head. The two parts are held together by the holding-down bolts which secure the tailstock to the bed. The tailstock is located on the opposite end of the lathe from the headstock. It supports one end of the work when machining between centers, supports long pieces held in the chuck, and holds various forms of cutting tools, such as drills, reamers, and taps.

6.3 Milling and Milling Machine

Milling machines are basically classified as vertical or horizontal according to the orientation of their spindle axes. A vertical milling machine spindle axis is vertical and the horizontal milling machine spindle axis is horizontal. In addition, the vertical milling machine has a machine table that moves perpendicular to the spindle axis of rotation and the horizontal milling machine has a worktable that moves parallel to the spindle axis of rotation. These machines are also classified as column and knee Wrpe, ram-type, manufacturing or bed type, and planer-type.

Fig.6.2



Horizontal knee and column type milling machine 卧式升降台铣床

1－base 基座　2－vertical column 立柱　3－overarm 悬梁
4－spindle 主轴　5－support frame 支架　6－T slot table T 槽工作台　7－rotary base 回转座
8－saddle 床鞍　9－knee 升降台

6.4 Drilling and Drill Press

Drill can be defined as a rotary end cutting tool having one or more cutting lips, and having one or more helical or straight flutes for the passage of chips and the admission of a cutting fluid. There are several hole-making operations carried out on the drill press as follows:

Drilling. Drilling involves selecting the proper twist drill or cutter for the job, properly installing the drill into the machine spindle, setting the speed and feed, drilling a smaller pilot hole, and drilling the hole to specifications within the prescribed tolerance. Drilled holes are always slightly oversized, or slightly larger than the diameter of the drill's original designation.

Reaming. Reaming can be performed on a drilling machine. It is difficult, if not impossible, to drill a hole to an exact standard diameter. When great accuracy is required, the holes are first drilled slightly undersized and then reamed to size. Reaming can be done on a drilling machine by using a hand reamer or using a machine reamer. When you must drill and ream a hole, it is best if the setup is not changed.

Tapping. Tapping is cutting a thread in a drilled hole. Tapping is accomplished on the drilling machine by selecting and drilling the tap drill size, then using the drilling machine chuck to hold and align the tap while it is turned by hand. The drilling machine is not a tapping machine, so it should not be used to power tap. To avoid breaking taps, ensure the tap aligns with the center axis of the hole, keep tap flutes clean to avoid jamming, and clean chips out of the bottom of the hole before attempting to tap.

Counterboring. Counterboring is the process of using a counterbore to enlarge the upper end of a hole to a predetermined depth and machine a recess at that depth. [6] Counterbored holes are primarily used to recess socket head cap screws and similar bolt heads slightly below the surface.

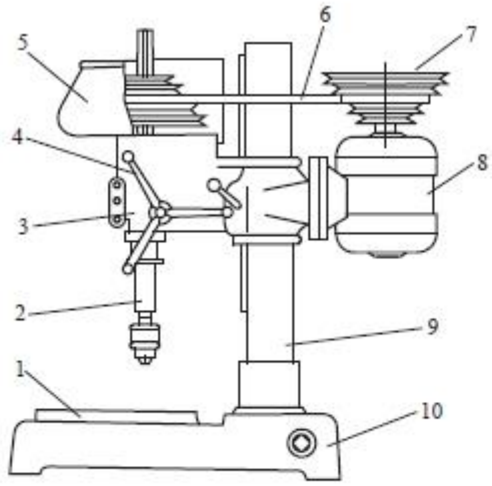
Countersinking. Countersinking is an operation in which a cone-shaped enlargement is cut at the top of a hole to form a recess below the surface. A conical cutting tool is used to produce this chamfer. When countersinking, the cutter must be properly aligned with the existing hole. Countersinking is useful in removing burrs from edges of holes, as well as accommodating the countersunk screw head.

Spot-facing. Spot-facing is basically the same as counterboring, using the same tool, speed, feed, and lubricant. Spot-facing is the smoothing off and squaring of a rough or curved surface around a hole to permit level seating of washers, nuts, or bolt heads .The operation of spot-facing is slightly different in that the spot-facing is usually done above a surface or on a curved surface. [7] When rough surfaces, castings, and curved surfaces are not at right angl to the cutting tool, great strain may occur on the pilot hole and counterbore, which can lead to broken tools. Both counterboring and spot-facing can be accomplished with standard counterbore cutters.

Boring. Boring is conducted when a straight and smooth hole is needed occasionally which is too large or odd sized for drills or reamers. A boring tool can be inserted into the drilling machine and bore any size hole into which the tool holder will fit. A boring bar with a tool bit installed is used for boring on the larger drilling machines. To bore accurately, the setup must be rigid, machine must be sturdy, and power feed must be used. Boring is not recommended for hand-feed drilling machines. Hand feed is not smooth enough for boring and can be dangerous, because the tool bit could catch the workpiece and throw it back to the operator.

There are many different types or configurations of drill presses, but most drill presse will fall into four broad categories: sensitive bench type, upright type, radial type, and special purpose type. [8]

Rigid and accurate construction of drilling machines is important to obtain proper results with the various cutting tools used. The sensitive drilling machine construction features are discussed in this section because its features are common to most other drilling machines (Fig. 6.3).



Drill press used on bench 台式钻床

1－table 工作台 2－spindle 主轴 3－spindle box 主轴箱 4－feed hand wheel 进给手轮 5－safety cover 安全护罩 6－V-belt 三角带 7－pulley 皮带轮 8－motor 电动机 9－vertical column 立柱 10－base 底座

Fig.6.3

Notes

[1] If the initial workpiece is solid, a drilling operation must be performed first.

句意：如果工件毛坯是实心的，首先要钻孔。

[2] Unless the work is held on a mandrel, if both ends of the work are to be faced, it must be tumed around after the first end is completed and the facing operation repeated.

句意：除非工件固定在心轴上，如果工件两端都要车端面，必须在一端加工完成后，将工件倒过来，重复进行车端面加工。

[3] A spindle gear is mounted on the rear of the spindle to transmit power through the change gears to the feeding box that distributes the power to the lead screw for threading or to the feed rod for turning.

句意：主轴齿轮安装在主轴尾部，通过齿轮把动力传递到进给箱。如果是

车螺纹，进给箱就将动力分配到丝杆上；如果是车削，就将动力分配到光杆上。

[4] In peripheral (or slab) milling, the milled surface is generated by teeth located on the periphery of the cutter body.

句意：在圆周（平面）铣削中，铣削表面是分布在刀体周围的刀加工完成的。

[5] Knee is the casting that supports the table and the saddle that gives the table vertical movements for adjusting the depth of cut.

句意：升降台是一个铸件，用来支撑工作台和床鞍，它可以实现工作台的垂直移动以调整切深。

[6] Counterboring is the process of using a countcrbore to enlarge the upper end of a hole to a predetermined depth and machine a recess at that depth.

句意：锪沉头孔加工就是利用平底扩孔钻，将孔的上端部扩至预定深度，从而加工出一个凹窝（以便螺栓头的埋入)。

[7] The operation of spot facing is slightly different in that the spot facing is usually done above a surface or on a curved surface.

句意：锪凸台加工稍微有所不同，它通常是在平面上或曲面上进行的。

[8] There are many different types or configurations of drill presses, but most drill presses will fall into four broad categories: sensitive bench type, upright type, radial type, and special purpose type.

句意：钻床有很多类型，但多数钻床都分成四大类：台式钻床、立式钻床、摇臂式钻床和专用钻床。

Translate:

6.1 简介

传统加工是一组加工操作，使用单点或多点工具以芯片的形式重新移动材料。金属切削涉及通过机加工操作去除金属。传统上，加工使用各种切削工具在车床，钻床和铣床上进行。与成型，模塑和铸造工艺相比，大多数加工的设

置成本非常低。在需要严格的尺寸和表面公差的情况下，加工是必要的。

6.2 车削和车床

车削是最常见的金属切削操作之一。在车削时，工件围绕其轴线旋转，因为单点切削工具被送入其中，切除多余的材料并形成所需的圆柱形表面。可以在外表面和内表面上进行车削以产生轴对称的轮廓部件。从怀表部件到大直径船用螺旋桨轴的零件可以在车床上打开。

除了车削外，还可以在车床上执行其他几项操作。

镗孔和内部车削。通过镗杆或合适的内部切削工具在内表面上进行镗孔和内部车削。如果初始工件是实心的，则必须首先进行钻孔操作。[1]钻具保持在尾架中，然后将后者送到工件上。当在车床中进行镗孔时，工件通常保持在卡盘或面板上。孔可以是直的，锥形的或不规则的轮廓。镗孔基本上是内部车削，同时平行于工件的旋转轴进给工具。

端面加工是由于工具被送过旋转工件的末端而产生的平坦表面。除非工作在心轴上，如果要面对工件的两端，必须在第一端完成后转动，然后重复面对操作。[2]切割速度应根据要面对的表面的最大直径确定。面向可以从外侧向内或从中心向外进行。在任何一种情况下，工具的尖端必须精确地设置在旋转中心的高度。因为切割力倾向于将工具推离工件，所以通常希望在每次面对切割期间将托架夹紧到床身上以防止其稍微移动并因此产生不平坦的表面。在铸件或具有硬表面的其他材料的表面中，第一切口的深度应足以穿透硬质材料以避免过度的工具磨损。

分离加工是通过切割工具将工件的一个部分与其余部分切断的操作。由于切削刀具非常薄并且必须具有相当大的悬伸，因此该过程不太准确且更难以实现。刀具应精确地设定在旋转轴的高度，保持锋利，具有适当的后角，并以适

当和均匀的进给速率送入工件。

螺纹加工由于切削工具要行进的路径是螺旋形的，因此可以认为螺纹是转动的。但是，车削和螺纹加工之间存在一些主要差异。在转弯时，感兴趣的是产生光滑的圆柱形表面，在穿线时，人们关注的是切割给定形状和深度的螺旋形螺纹，其可以从公式计算出来。螺纹切削有两个基本要求。由于螺纹切削是一种形状切削操作，因此需要精确成形且正确安装的刀具。得到的螺纹轮廓由工具的形状及其相对于工件的位置决定。第二个要求是工具必须以与工件旋转的特定关系纵向移动，因为这决定了螺纹的导程。通过使用导螺杆和分离单元来满足该要求，该导螺杆和分离单元提供托架相对于主轴旋转的正向运动。

许多类型的车床用于生产车削。根据目的和结构，车床式机床可分为以下几类：

1. 卧式车床;普通车床

2. 立式车床;

3. 转塔车床;

4. 单轴或多轴自动或半自动车床;

5. 轮廓车床;

6. 万能车床;

7. 专用车床，如曲轴车床，凸轮轴车床，车轮车床和后退车床等。

卧式机车床是车床系列中最具代表性的成员，也是使用最广泛的车床，所以对卧式车床的每个主要元素进行了描述，如图 6.1 所示。

车床是发动机车床的基础，这是一种重型坚固的铸件，用于支撑车床的工作部件。床的尺寸和质量给出了制造所需的精确工程公差所需的刚性。在床的顶部是机加工的滑道，当车辆从车床的一端移动到另一端时，引导并对齐车架

和尾座。

主轴箱夹在车床左侧的床顶上，并包含驱动主轴的电机，主轴的轴线通过齿轮箱内的一系列齿轮平行于导轨。 变速箱的功能是产生许多不同的主轴转速。 主轴齿轮安装在主轴的后部，以通过变速齿轮将动力传递到进给箱，该进给箱将动力分配到导螺杆用于螺纹或用于转动的进给杆。[3]

主轴有一个纵向延伸的通孔，如果使用连续生产，可以通过该通孔进给。该孔可通过其锥形内表面固定普通车床中心，并通过其螺纹外表面安装卡盘，面板或夹头。

托架组件实际上是一个 H 形块，横跨导轨并位于车床前面。滑架的功能是纵向移动和移动切割工具。它可以用手或动力移动，并可以用锁紧螺母夹紧到位。滑架由十字滑块，复合支架，工具鞍座和挡板组成。

十字滑块安装在鞍座顶部的燕尾导轨上，并通过十字滑动导螺杆以 90°前后移动到车床轴线。导螺杆可以手动或动力激活。

复合支架安装在十字滑台上，可以在水平面上以任何角度旋转和夹紧。该化合物通常用于切割倒角或锥度，但在切割螺纹时也必须使用。复合休息只能手工喂养。复合休息没有力量。切削工具和刀架固定在刀架中，刀架直接安装在复合支架上。

工具鞍座是一个安装在导轨顶部的 H 形铸件，内置十字滑块和复合支架。它使刀头的纵向，横向和角度进给成为可能。

挡板连接在滑架的前部，并包含齿轮和进给离合器，它们将动作从进给杆或导螺杆传递到滑架和横向滑块。当切割螺纹时，通过导螺杆为挡板的齿轮箱提供动力。在所有其他车削操作中，驱动滑架的是进给杆。

尾座由低底座和尾座的可移动部分组成，横向调节由带有方头的十字螺丝

制成。这两个部件通过固定螺栓固定在一起，固定螺栓将尾座固定在床上。尾架位于车床的与主轴箱相对的一端。它支持工件的一端，在中心之间进行加工，支撑夹头中的长件，并且可以容纳各种形式的切削工具，例如钻头，铰刀和丝锥。

6.3 铣床和铣床

根据主轴的方向，铣床基本上分为垂直或水平。 立式铣床主轴为垂直，卧式铣床主轴为水平轴。 此外，立式铣床具有垂直于主轴旋转轴线移动的机床工作台，并且卧式铣床具有平行于主轴旋转轴线移动的工作台。 这些机器还分为柱式和膝式，柱塞式，制造型或床型，以及刨床型。

6.4 钻孔和钻床

钻头可以被定义为具有一个或多个切削唇的旋转端部切削工具，并且具有一个或多个螺旋或直槽，用于切屑的通过和切削液的进入。在钻床上进行了几次制孔操作如下：

钻孔。钻孔包括为工作选择合适的麻花钻或刀具，将钻头正确安装到机床主轴，设置速度和进给，钻一个较小的导孔，以及在规定的公差范围内钻孔。钻孔总是略微过大，或略大于钻头原始名称的直径。

绞孔。可以在钻孔机上进行铰孔。如果不是不可能的话，很难钻一个精确的标准直径的孔。当需要很高的精度时，首先钻孔略微未破裂，然后扩孔至尺寸。可以使用手动铰刀或使用机器铰刀在钻孔机上进行铰孔。必须钻孔并钻孔时，最好不要更改设置。

攻螺纹。攻丝是在钻孔中切割螺纹。通过选择和钻孔自来钻尺寸在钻孔机上完成攻丝，然后使用钻孔机夹头在手动转动时保持并对齐丝锥。钻孔机不是攻丝机，因此不应用于给水龙头供电。为避免分开，请确保龙头与孔的中心轴

对齐，保持龙头槽清洁以避免卡住，并在尝试敲击之前清除孔底部的切屑。

锪孔。 锪孔是一种操作，其中在孔的顶部切割锥形扩大部以在表面下方形成凹部。锥形切削工具用于生产该倒角。 锪孔时，切刀必须与现有孔正确对齐。反钻可用于从孔的边缘重新移动毛刺，以及容纳埋头螺钉头。

锪锥孔。使用相同的工具，速度，进给和润滑剂，点对面基本上与镗孔相同。点对面是孔周围粗糙或弯曲表面的平滑和平整，以允许垫圈，螺母或螺栓头的水平安置。点面操作略有不同，因为通常在上方进行点面操作表面或曲面。[7]当粗糙表面，铸件和曲面与切削工具不成直角时，导向孔和反作用孔可能会产生很大的应变，从而导致工具损坏。可以使用标准沉头孔切割机完成平衡和面向现场。

镗孔。当偶尔需要直的和光滑的孔时进行镗孔，这对于钻头或铰刀来说太大。可以将钻孔工具插入钻孔机中并钻出任何尺寸的孔，刀架将装配到该孔中。安装有刀头的镗杆用于在较大的钻孔机上钻孔。为了准确钻孔，设置必须是刚性的，机器必须坚固，并且必须使用供电。不建议将镗孔用于手动钻孔机。手动进给不够平滑以进行镗孔并且可能是危险的，因为刀具可以抓住工件并将其扔回操作员。

钻床有许多不同类型或配置，但大多数钻机都分为四大类：敏感台式，直立式，径向型和特殊用途型。[8]

钻孔机的刚性和精确构造对于使用各种切削工具获得适当的结果是重要的。 本节将讨论敏感钻孔机的结构特征，因为其功能与大多数其他钻孔机相同（图 6.3）。

Glossary

External [ik'stə:nəl] adj. 外部的，表面的

Propeller [prəu'pelə] n. 螺旋桨

Rotation [rəu'teiʃən] n. 旋转；循环

Axis ['æksis] n. 轴；轴线

Engine ['endʒin] n. 引擎；发动机

Foundation [faun'deiʃən] n. 基础；地基

Gearbox ['giəbɔks] n. 变数箱；齿轮箱

Drill [drɪl] n. 钻孔机

Tapping ['tæpiŋ] n. 开孔

Socket ['sɔkit] n. 插座

Insert [in'sə:t, 'insə:t] vt. 插入；嵌入

Feature ['fi:tʃə] n. 特色；特征

Sensitive ['sensitiv] n. 敏感的；灵敏的

Milling ['miliŋ] n.铣削

Movement ['mu:vmənt] n. 活动；运转

Conventional [kən'venʃənəl] adj. 符合习俗的，传统的；常见的；惯例的

Exercise:

1. List some conventional machining processes.
2. What is the foundation of the engine lathe.

Unit7 Nontraditional Machining Processes

7.1 Introduction

Traditional or conventional machining, such as turning, milling, and grinding etc., uses mechanical energy to shear metal against another substance to create holes or remove material. Nontraditional machining processes are defined as a group of processes that remove excess material by various techniques involving mechanical, thermal, electrical or chemical energy or combinations of these energies but do not use a sharp cutting tool as it is used in traditional manufacturing processes. [1]

Extremely hard and brittle materials are difficult to be machined by traditional machining processes. Using traditional methods to machine such materials means increased demand for time and energy and therefore increases in costs; in some cases traditional machining may not be feasible. Traditional machining also results in tool wear and loss of quality in the product owing to induced residual stresses during machining. Nontraditional machining processes, also called unconventional machining process or advanced manufacturing processes, are employed where traditional machining processes are not feasible, satisfactory or economical due to special reasons as outlined below:

1. Very hard fragile materials difficult to clamp for traditional machining;
2. When the workpiece is too flexible or slender;
3. When the shape of the part is too complex;
4. Parts without producing burrs or inducing residual stresses.

Traditional machining can be defined as a process using mechanical (motion) energy. Nontraditional machining utilizes other forms of energy; the three main forms of energy used in nontraditional machining processes are as follows:

1. Thermal energy;
2. Chemical energy;
3. Electrical energy.

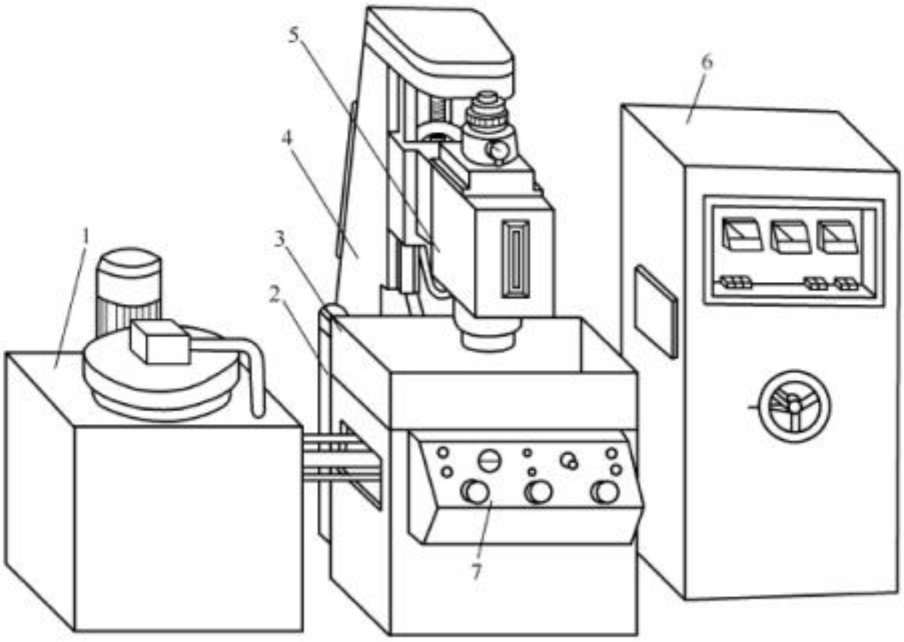
Several types of nontraditional machining processes have been developed to meet extra required machining conditions. When these processes are employed properly, they offer many advantages over traditional machining processes. The common nontraditional machining processes are described in the following section.

7.2 Electrical Discharge Machining (EDM)

Electrical discharge machining (EDM) sometimes is colloquially referred to as spark machining, spark eroding, burning, die sinking or wire erosion. It is one of the most widely used nontraditional machining processes. The main attraction of EDM over traditional machining processes such as metal cutting using different tools and grinding is that this technique utilizes thermoelectric process to erode undesired materials from the workpiece by a series of rapidly recurring discrete electrical sparks between workpiece and electrode. [2]

The traditional machining processes rely on harder tool or abrasive material to remove the softer material whereas nontraditional machining processes such as EDM uses electrical spark or thermal energy to erode unwanted material in order to create desired shapes. So, the hardness of the material is no longer a dominating factor for EDM process.

Fig.7.1



Electro discharge machine 电火花机床

1－hydraulic pump and oil tank 液压泵油箱 2－bed 床身
3－dielectric collector 工作液箱 4－column 立柱 5－spindle 主轴
6－pulse power supply 脉冲电源 7－control panel 控制板

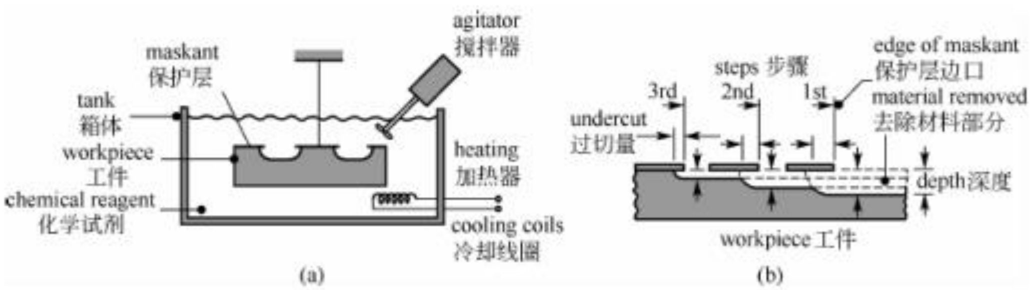
EDM removes material by discharging an electrical current, normally stored in a capacitor bank, across a small gap between the tool (cathode) and the workpiece (anode) typically in the order of 50 volts/10amps. As shown in Fig.7.1, at the beginning of EDM operation, a high voltage is applied across the narrow gap between the electrode and the workpiece. This high voltage induces an electric field in the insulating dielectric that is present in the narrow gap between electrode and workpiece. This causes conducting particles suspended in the dielectric to concentrate at the points of strongest electrical field. When the potential difference between the electrode and the workpiece is suffcicntly high, the dielectric breaks down and a transient spark discharges through the dielectric fluid, removing small amount of material from the workpiece surface. The volume of the material removed per spark discharge is typically in the range of 10-5 to10-6 mm3. The gap is only a few thousandths of an inch, which is maintained at a constant value by the servomechanism that actuates and controls the tool feed.

7.3 Chemical Machining (CM)

Chemical machining (CM) is a well known non-traditional machining process in which metal is removed from a workpiece by immersing it into a chemical solution. The process is the oldest of the nontraditional processes and has been used to produce pockets and contours and to remove materials from parts having a high strength-to-weight ratio. Moreover, the chemical machining method is widely used to produce micro-components for various industrial applications such as microelectromechanical systems (MEMS) and semiconductor industries. [3]

In CM material is removed from selected areas of workpiece by immersing it in a chemical reagents or etchants, such as acids and alkaline solutions. Material is removed by microscopic electrochemical cell action which occurs in corrosion or chemical dissolution of a metal. Special coatings called maskants protect areas from which the metal is not to be removed. This controlled chemical dissolution will simultaneously etch all exposed surfaces even though the penetration rates of the material removal may be only 0.0025~0.1 mm/min. The basic process takes many forms: chemical milling of pockets, contours, overall metal removal, chemical blanking for etching through thin sheets; photochemical machining (pcm) for etching by using of photosensitive resists in microelectronics; chemical or electrochemical polishing where weak chemical reagents are used (sometimes with remote electric assist) for polishing or deburring and chemical jet machining where a single chemically active jet is used. A schematic of chemical machining process is shown in Fig.7.2a. Because the etchant attacks the material in both vertical and horizontal directions, undercuts may develop (as shown by the areas under the edges of the maskant in Fig.7.2b). Typically, tolerances of ±10% of the material thickness can be maintained in chemical blanking. In order to improve the production rate, the bulk of the workpiece should be shaped by other processes (such as by machining) prior to chemical machining. Dimensional variations can occur because of size changes in workpiece due to humidity and temperature. This variation can be minimized by properly selecting etchants and controlling the environment in the part generation and the production area in the plant.

Fig.7.2



Chemical process 化学加工

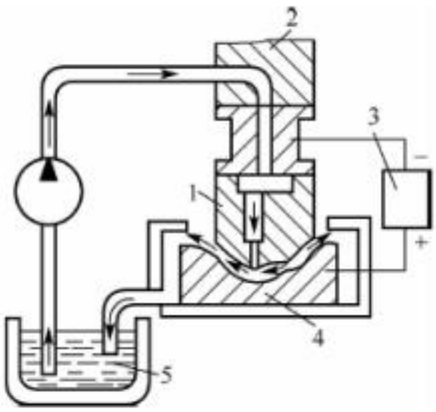
7.4 Electrochemical Machining (ECM)

Electrochemical metal removal is one of the more useful nontraditional machining processes. Although the application of electrolytic machining as a metal-working tool is relatively new, the basic principles are based on Faraday laws. Thus, electrochemical machining can be used to remove electrically conductive workpiece material through anodic dissolution. No mechanical or thermal energy is involved. This process is generally used to machine complex cavities and shapes in highstrength materials, particularly in the aerospace industry for the mass production of turbine blades, jet-engine parts, and nozzles, as well as in the automotive (engines castings and gears) and medical industries.[4] More recent applications of ECM include microachining for the electronics industry.

Electrochemical machining (ECM), shown in Fig.7.3, is a metal-removal process based on the principle of reverse electroplating. In this process, particles travel from the anodic material (workpiece) toward the cathodic material (machining tool). Metal removal is effected by a suitably shaped tool electrode, and the parts thus produced have the specified shape, dimensions, and surface finish. ECM forming is carried out so that the shape of the tool electrode is transferred onto, or duplicated in, the workpiece. The cavity produced is the female mating image of the tool shape. For high accuracy in shape duplication and high rates of metal removal, the process is operated at very high current densities of the order 10~ 100 A/cm2 , at relative low voltage usually from 8 to 30 V, while maintaining a very narrow machining gap (of the order of 0.1 mm) by feeding the tool electrode with a feed rate from 0.1 to 20 mm/min. Dissolved material, gas, and heat are removed from the narrow machining gap by the flow of electrolyte pumped through the gap at a high velocity (5 ~50 m/s), so the current of electrolyte fluid carries away the deplated material before it has a chance to reach the machining tool.

Being a non-mechanical metal removal process, ECM is capable of machining any electrically conductive material with high stock removal rates regardless of their mechanical properties.[5] In particular, removal rate in ECM is independent of the hardness, toughness and other properties of the material being machined. The use of ECM is most warranted in the manufacturing of complex-shaped parts from materials that lend themselves poorly to machining by other, above all mechanical methods. There is no need to use a tool made of a harder material than the workpiece, and there is practically no tool wear. Since there is no contact between the tool and the work, ECM is the machining method of choice in the case of thin-walled, easily deformable components and also brittle materials likely to develop cracks in the surface layer.

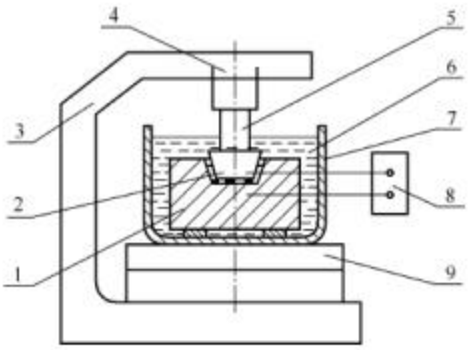
Fig.7.3



Principle of electrolysis(electrochemical machining) 电解(电化学)加工原理

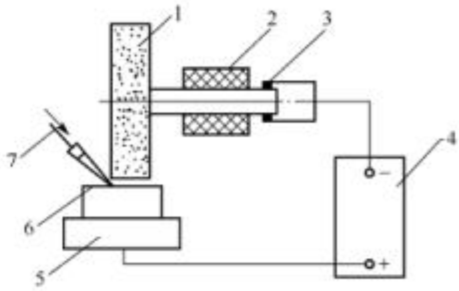
1－tool cathode 工具电极(阴极) 2－feed set 进给机构 3－DC power 直流电源 4－workpiece (anode)工件(阳极) 5－electrolyte 电解液

Fig.7.5 Fig.7.4



Schematic diagram of electrochemical polishing 电化学抛光示意图

1 – workpiece(anode)工件(阳极) 2 – tool (cathode)工具(阴极) 3 – support 支架 4 – servo 伺服机构 5 – feed spindle 进给主轴 6 – electrolyte 电解液 7 – electrolyte tank 电解液槽 8 – DC power 直流电源 9 – table 工作台



Schematic diagram of an electrochemical grinding operation 电解(电化学)磨削示意图

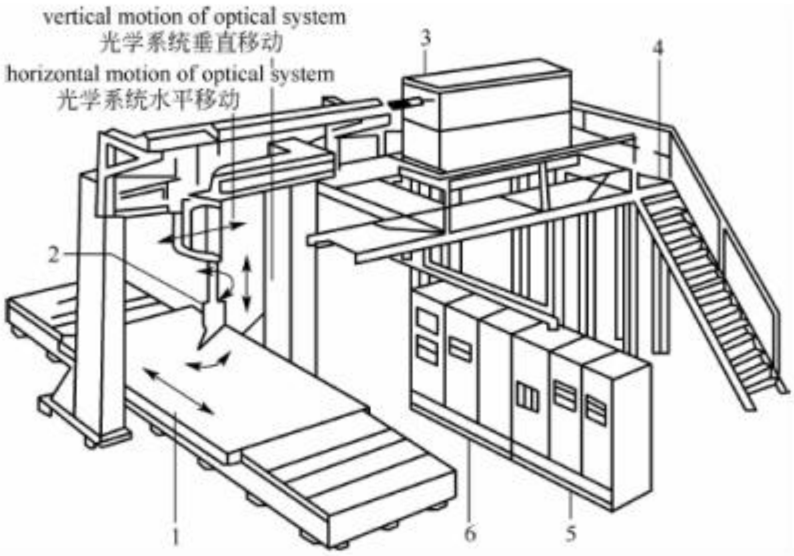
1 – electrically conducting grinding wheel 导电砂轮 2 – insulating bushing 绝缘套 3 – electricity conducting ring 电导环(电刷) 4 – DC power 直流电源 5 – table 工作台 6 – workpiece 工件 7 – electrolyte 电解液

7.5 Laser Beam Machining (LBM)

LASER is an acronym for Light Amplification by Stimulated Emission of Radiation. Although the laser is used as a light amplifier in some applications, its principal use is as an optical oscillator or transducer for converting electrical energy into a highly collimated beam of optical radiation. [6] The light energy emitted by the laser has several characteristics which distinguish it from other light sources: spectral purity, directivity and high focused power density.

Laser machining is the material removal process accomplished through laser and target material interactions. Generally speaking, these processes include laser drilling, laser cutting, laser welding, and laser grooving, marking or scribing.

Fig.7.6 Laser machining (Fig.7.6) is localized, non-contact machining and is almost reacting-force free. [7] This process can remove material in very small amount and is said to remove material "atom by atom". For this reason, the kerf in laser cutting is usually very narrow, the depth of laser drilling can be controlled to less than one micron per laser pulse and shallow permanent marks can be made with great flexibility. In this way material can be saved, which may be important for precious materials or for delicate structures in micro-fabrications. The ability of accurate control of material removal makes laser machining an important process in micro-fabrication and micro-electronics, Also laser cutting of sheet material with thickness less than 20 mm can be fast, flexible and of high quality, and large holes or any complex contours can be efficiently made through trepanning.



Laser beam machine 激光加工机

1 – moving table 移动工作台 2 – cutting head 切割头 3 – laser head 激光头
4 – platform 平台 5 – power 电源 6 – NC system 数控系统

Heat Affected Zone (HAZ) in laser machining is relatively narrow and the re-solidified layer is of micron dimensions. [8] For this reason, the distortion in laser machining is negligible. LBM can be applied to any material that can properly absorb the laser irradiation. It is difficult to machine hard materials or brittle materials such as ceramics using traditional methods, laser is a good choice for solving such difficulties.

Laser cutting edges can be made smooth and clean, no further treatment is necessary. High aspect ratio holes with diameters impossible for other methods can be drilled using lasers. Small blind holes, grooves, surface texturing and marking can be achieved with high quality using LBM. Laser technology is in rapid progressing, so do laser machining processes. Dross adhesion and edge burr can be avoided, geometry accuracy can be accurately controlled. The machining quality is in constant progress with the rapid progress in laser technology.

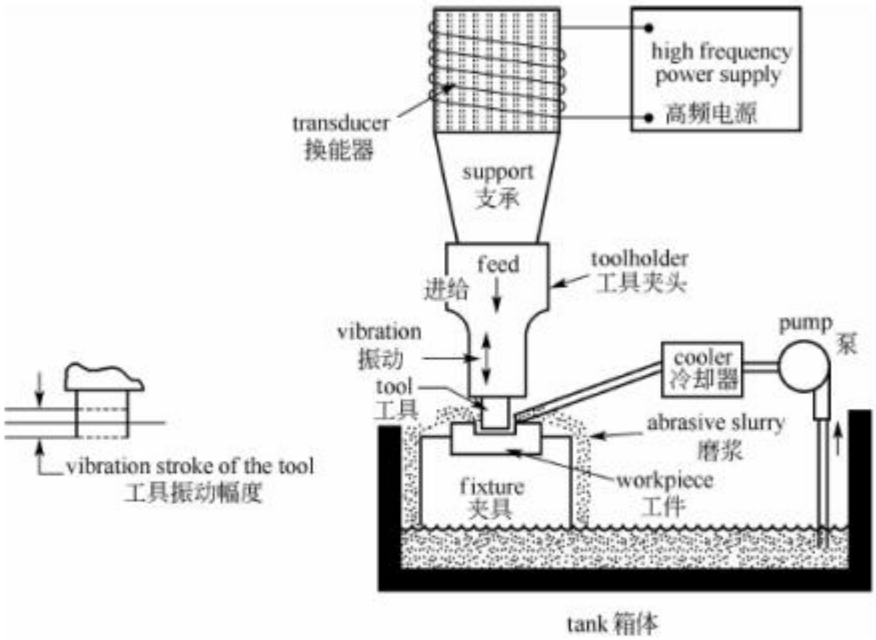
7.6 Ultrasonic Machining (USM)

Ultrasonic machining offers a solution to the expanding need for machining brittle materials such as single crystals, glasses and polycrystalline ceramics, and for increasingly complex operations to provide intricate shapes and workpiece profiles. This machining process is non-thermal, non-chemical, creates no change in the microstructure, chemical or physical properties of the workpiece and offers virtually stress-free machined surfaces. It is therefore used extensively in machining hard and brittle materials that are difficult to cut by other traditional methods. The actual cutting is performed either by abrasive particles suspended in a fluid, or by a rotating diamond-plated tool. These variants are known respectively as stationary (conventional) ultrasonic machining and rotary ultrasonic machining (RUM).

Conventional ultrasonic machining (USM) accomplishes the removal of material by the abrading action of a grit-loaded slurry, circulating between the workpiece and a tool that is vibrated with small amplitude. The form tool itself does not abrade the workpiece; the vibrating tool excites the abrasive grains in the flushing fluid, causing them to gently and uniformly wear away the material, leaving a precise reverse form of the tool shape. The uniformity of the sonotrode-tool vibration limits the process to forming small shapes typically under 100 mm in diameter.

The USM system includes the sonotrode-tool assembly, the generator, the grit system and the operator controls. The sonotrode is a piece of metal or tool that is exposed to ultrasonic vibration, and then gives this vibratory energy in an element to excite the abrasive grains in the slurry.[9] A schematic representation of the USM set-up is shown in Fig.7.7. The sonotrode-tool assembly consists of a transducer, a booster and a sonotrode. The transducer converts the electrical pulses into vertical stroke. This vertical stroke is transferred to the booster, which may amplify or suppress the stroke amount. The modified stroke is then relayed to the sonotrode-tool assembly. The amplitude along the face of the tool typically falls in a 20 to 50 μm range. The vibration amplitude is usually equal to the diameter of the abrasive grit used.

Fig.7.7



Schematic diagram of an ultrasonic machining operation 超声加工原理图

The grit system supplies a slurry of water and abrasive grit, usually silicon or boron carbide, to the cutting area. In addition to providing abrasive particles to the cut, the slurry also cools the sonotrode and removes particles and debris from the cutting area.

Notes

[1] Nontraditional manufacturing processes is defined as a group of processes that remove excess material by various techniques involving mechanical, thermal, electrical or chemical energy or combinations of these energies but do not use a sharp cutting tools as it needs to be used for traditional manufacturing processes.

句意：特种加工是指这样一组加工工艺，他们通过各种涉及机械能、热能、电能、化学能或及其组合形式的技术，而不使用传统加工所必须的尖锐刀具来去除工件表面的多余材料。

[2] The main attraction of EDM over traditional machining processes such as metal cutting using different tools and grinding is that this technique utilizes thermoelectric process to erode undesired materials from the workpiece by a series of rapidly recurring discrete electrical sparks between workpiece and electrode.

句意：相比于利用不同刀具进行金属切削和磨削的常规加工，电火花加工更为吸引人之处在于它利用工件和电极间的一系列快速重复产生的（脉冲）离散电火花所产生的热电作用，从工件表面通过电腐蚀去除多余的材料。

[3] The chemical machining method is widely used to produce micro-components for various industrial applications such as microelectromechanical systems (MEMS) and semiconductor industries.

句意：化学加工广泛用于为多种工业应用（如微机电系统和半导体行业）制造微型零件。

[4] This process is generally used to machine complex cavities and shapes in

high-strength materials, particularly in the aerospace industry for the mass production of turbine blades, jet-engine parts, and nozzles, as well as in the automotive (engines castings and gears) and medical industries.

句意：这个加工过程一般用于在高强度材料上加工复杂型腔和形状，特别是在航空业中如加工涡轮机叶片、喷气发动机零件和喷嘴，以及在汽车业（发动机铸件和齿轮）和医疗卫生业中相关零件的加工。

[5] Being a non-mechanical metal removal process, ECM is capable of machining any electrically conductive material with high stock removal rates regardless of their mechanical properties.

句意：作为一种非机械式金属去除加工方法，ECM 可以以高切削量加工任何导电材料而无须考虑材料的机械性能。

[6] LASER is an acronym for Light Amplification by Stimulated Emission of Radiation. Although the laser is used as a light amplifier in some applications,its principal use is as an optical oscillator or transducer for converting electrical energy into a highly collimated beam of optical radiation.

句意：LASER 是英文 Light Amplification by Stimulated Emission of Radiation 的缩写词。意思是“通过受激光发射光放大”或“光的受激发射”，简称激光。虽然激光在某些应用场合可以用来作为放大器，但它的主要用途是光激射振荡器，或者是作为将电能转变为具有高度准直性光束的换能器。

[7] Laser machining is localized, non-contact machining and is almost reacting-force free.

句意：激光加工可以实现局部的非接触加工，因此对加工件几乎没有作用力。

[8] Heat Affected Zone (HAZ) in laser machining is relatively narrow and the re-solidified layer is of micron dimensions.

句意：激光机工中的热影响区相对较窄，其重凝固层厚度只有几微米。

[9] The sonotrode is a piece of metal or tool that is exposed to ultrasonic vibration, and then gives this vibratory energy in an element to excite the abrasive grains in the slurry.

句意：音极是暴露在超声波振动中的一小块金属或工具，它将振动能传给某个元件，从而激励浆料中的磨粒。

Translate:

7.1 前言

传统加工如车削、铣削和磨削等，是利用机械能将金属从工件上剪切掉，以加工成孔或去除余料。特种加工是指这样一组加工工艺，它们通过各种涉及机械能、热能、电能、化学能或组合形式的技术，而不使用传统加工所必需的尖锐刀具来去除工件表面的多余材料。

传统加工如车削、钻削、刨削、铣削和磨削，都难以加工特别硬的或脆性材料。采用传统方法加工这类材料就意味着对时间和能量要求有所增加，从而导致成本增加。在某些情况下，传统加工可能行不通。由于在加工过程中会产生残余应力，传统加工方法还会造成刀具磨损，损坏产品质量。基于以下各种特殊理由，特种加工工艺或称为先进制造工艺，可以应用于采用传统加工方法不可行，不令人满意或者不经济的场合：

1. 对于传统加工难以夹紧的非常硬的脆性材料；
2. 当工件柔性很大或很薄时；

3. 当零件的形状过于复杂时；

4. 要求加工出的零件没有毛刺或残余应力。

传统加工可以定义为利用机械（运动）能的加工方法，而特种加工利用其他形式的能量，主要有如下三种形式：

1. 热能；

2. 化学能；

3. 电能。

为了满足额外的加工条件的要求，已经开发出了几类特种加工工艺。恰当地使用这些加工工艺可以获得很多优于传统加工工艺的好处。常见的特种加工工艺描述如下。

7.2 电火花加工

电火花加工是使用最为广泛的特种加工工艺之一。相比于利用不同刀具进行金属切削和磨削的常规加工，电火花加工更为吸引人之处在于它利用工件和电极间的一系列重复产生的 （脉冲）离散电火花所产生的热电作用，从工件表面通过电腐蚀去除掉多余的材料。

传统加工工艺依靠硬质刀具或磨料去除较软的材料，而特种加工工艺如电火花加工，则是利用电火花或热能来电蚀除余料，以获得所需的零件形状。因此，材料的硬度不再是电火花加工中的关键因素。

电火花加工是利用存储在电容器组中的电能（一般为 50V/10 A 量级）在工具电极（阴极）和工件电极（阳极）之间的微小间隙间进行放电来去除材料的。如图 7.1 所示，在 EDM 操作初始，在工具电极和工件电极间施以高电压。这个高电压可以在工具电极和工件电极窄缝间的绝缘电介质中产生电场。这就会使悬浮在电介质中的导电粒子聚集在电场最强处。当工具电极和工件电极之

间的势能差足够大时，电介质被击穿，从而在电介质流体中会产生瞬时电火花，将少量材料从工件表面蚀除掉。每次电火花所蚀除掉的材料量通常在10-5~10-6mm^{3}范围内。电极之间的间隙只有千分之几英寸，通过伺服机构驱动和控制工具电极的进给量使该值保持常量。

7.3 化学加工

化学加工是众所周知的特种加工工艺之一，它将工件浸人化学溶液通过腐蚀溶解作用将多余材料从工件上去除掉。该工艺是最古老的特种加工工艺，主要用于凹腔和轮廓加工，以及从具有高的比刚度的零件表面去除余料。化学加工广泛用于为多种工业应用（如微机电系统和半导体行业）制造微型零件。

化学加工将工件浸人到化学试剂或蚀刻剂中，位于工件选区的材料通过发生在金属溶蚀或化学溶解过程中的电化学微电池作用被去除掉。而被称为保护层的特殊涂层所保护下的区域中的材料则不会被去除。不过，这种受控的化学溶解过程同时也会蚀除掉所有暴露在表面的材料，尽管去除的渗透率只有0.0025~0.1 mm/min。该工艺采用如下几种形式：凹坑加工、轮廓加工和整体金属去除的化学铣，在薄板上进行蚀刻的化学造型，在微电子领域中利用光敏抗蚀剂来完成蚀刻的光化学加工（PCM），采用弱化学试剂进行抛光或去毛刺的电化学抛光，以及利用单一化学活性喷射的化学喷射加工等。如图 7.2（a）所示的化学加工示意图，由于蚀刻剂沿垂直和水平方向开始蚀除材料，钻蚀（又称为淘蚀）量进一步加大，如图 7.2（b）所示的保护体边缘下面的区域。在化学造型中最典型的公差范围可保持在材料厚度的±10%左右。为了提高生产率，在化学加工前，毛坯件材料应采用其他工艺方法（如机械加工）进行预成形加工。湿度和温度也会导致工件尺寸发生改变。通过改变蚀刻剂和控制工件加工环境，这种尺寸改变可以减小到最小。

7.4 电化学加工

电化学金属去除方法是一种最有用的特种加工方法。尽管利用电解作用作为金属加工手段是近代的事，但其基本原理是法拉第定律。利用阳极溶解，电化学加工可以去除具有导电性质工件的材料，而无须机械能和热能。这个加工过程一般用于在高强度材料上加工复杂形腔和形状，特别是在航空工业中如涡轮机叶片、喷气发动机零件和喷嘴，以及在汽车业（发动机铸件和齿轮）和医疗卫生业中。最近，还将电化学加工应用于电子工业的微加工中。

图 7.3 所示的是一个去除金属的电化学加工过程， 其基本原理与电镀原理正好相反。 在电化学加工过程中，从阳极（工件）上蚀除下的粒子移向阴极（加工工具）。 金属的去除由一个合适形状的工具电极来完成，最终加工出来的零件具有给定的形状、尺寸和表面光洁度。在电化学加工过程中，工具电极的形状逐渐被转移或复制到工件上。型腔的形状正好是与工具相匹配的阴模的形状。为了获得电化学过程形状复制的高精度和高的材料去除率，需要采用高的电流密度（范围为 10~100 A/cm2 ） 和低电压 （范围为 8~30V)。通过将工具电极向去除工件表面材料的方向进给，加工间隙要维持在 0.1mm 范围内，而进给率一般为 0.1~20mm/min 左右。 泵压后的电解液以高达 5~50 m/s 的速度通过间隙，将溶解后的材料、气体和热量带走。因此，当被蚀除的材料还没来得及附着到工具电极上时，就被电解液带走了。

作为一种非机械式金属去除加工方法，ECM 可以以高切削量加工任何导电材料，而无须考虑材料的机械性能。特别是在电化学加工中，材料去除率与被加工件的硬度、韧性及其他特性无关。对于利用机械方法难于加工的材料，电化学加工可以保证将该材料加工出复杂形状的零件，这就不需要制造出硬度高于工件的刀具，而且也不会造成刀具磨损。由于工具和工件间没有接触，电化

学加工是加工薄壁、易变形零件及表面容易破裂的脆性材料的首选。

7.5 激光束加工

LASER 是英文 Light Amplification by Stimulated Emission of Radiation 各单词头一个字母所组成的缩写词。虽然激光在某些场合可用来作为放大器，但它的主要用途是光激射振荡器，或者是作为将电能转换为具有高度准直性光束的换能器。由激光发射出的光能具有不同于其他光源的特点：光谱纯度好、方向性好及具有高的聚焦功率密度。

激光加工就是利用激光和靶材间的相互作用去除材料。简而言之，这些加工工艺包括激光打孔、激光切割、激光焊接、激光刻槽和激光刻划等。

激光加工（见图 7．6）可以实现局部的非接触加工，而且对加工件几乎没有作用力。这种加工工艺去除材料的量很小，可以说是 “逐个原子’’ 地去除材料。 由于这个原因，激光切割所产生的切口非常窄。激光打孔深度可以控制到每个激光脉冲不超过 1μm, 且可以根据加工要求很灵活地留下非常浅的永久性标记。采用这种方法可以节省材料，这对于贵重材料或微加工中的精密结构而言非常重要。可以精确控制材料去除率使得激光加工成为微制造和微电子技术中非常重要的加工方法。厚度小于 20mm 的板材的激光切割加工速度快、柔性好、质量高。另外，通过套孔加工还可有效实现大孔及复杂轮廓的加工。

激光加工中的热影响区相对较窄，其重铸层只有几微米。基于此，激光加工的变形可以不予考虑。激光加工适用于任何可以很好地吸收激光辐射的材料，而传统加工工艺必须针对不同硬度和耐磨性的材料选择合适的刀具。采用传统加工方法，非常难以加工硬脆材料如陶瓷等，而激光加工是解决此类问题的最好选择。

激光切割的边缘光滑且洁净，无须进一步处理。激光打孔可以加工用其他

方法难以加工的高深径比的孔。激光加工可以加工出高质量的小盲孔、槽、表面微造型和表面印痕。激光技术正处于高速发展期，激光加工也如此。激光加工不会挂渣，没有毛边，可以精确控制几何精度。随着激光技术的快速发展，激光加工的质量正在稳步提高。

7.6 超声加工

超声加工为日益增长的对脆性材料如单晶体、玻璃、多晶陶瓷材料的加工需求及不断提高的工件复杂形状和轮廓加工提供了解决手段。这种加工过程不产生热量、无化学反应，加工出的零件在微结构、化学和物理特性方面都不发生变化，可以获得无应力加工表面。因此，超声加工被广泛应用于传统加工难以切削的硬脆材料。在超声加工中，实际切削由液体中的悬浮磨粒或者旋转的电镀金刚石工具来完成。超声加工的变型有静止（传统）超声加工和旋转超声加工。

传统的超声加工是利用作为小振幅振动的工具与工件之间不断循环的含有磨粒的浆料的磨蚀作用去除材料的。成形工具本身并不磨蚀工件，是受激振动的工具通过激励浆料液流中的磨料不断缓和而均匀地磨损工件，从而在工件表面留下与工具相对应的精确形状。音极工具振动的均匀性使超声加工只能完成小型零件的加工，特别是直径小于 100mm 的零件。

超声加工系统包括音极组件、超声发生器、磨料供给系统及操作人员的控制。音极是暴露在超声波振动中的一小块金属或工具，它将振动能传给某个元件，从而激励浆料中的磨粒。超声加工系统的示意图如图 7.7 所示。音极/工具组件由换能器、变幅杆和音极组成。换能器将电脉冲转换成垂直冲程，垂直冲程再传给变幅杆进行放大或压抑。调节后的冲程再传给音极/工具组件。此时，工具表面的振动幅值为 20~50μm。工具的振幅通常与所使用的磨粒直径大致相

等。

磨料供给系统将由水和磨粒组成的浆料送至切削区，磨粒通常为碳化硅或碳化硼。另外，除了提供磨粒进行切削外，浆料还可对音极进行冷却，并将切削区的磨粒和切屑带走。

Glossary

Shear [ʃiə] vt. 剪，修剪

Substance ['sʌbstəns] n. 物质；实质

Thermal ['θə:məl] adj. 热的；热量的

Flexible ['fleksibl] adj. 灵活的；柔韧的

Residual [ri'zidjuəl, -dʒu-] n. 剩余；残渣

Erosion [i'rəuʒən] n. 侵蚀；腐蚀

Dielectric [,daii'lektrik] n. 绝缘体；电介质

Amplification [,æmplifi'keiʃən] n. 放大；扩大

Laser ['leizə] n.激光

Ultrasonic [,ʌltrə'sɔnik] adj. 超声的

Crystal ['kristəl] n. 结晶；晶体

Abrasive [ə'breisiv] adj. 粗糙的

Generator ['dʒenəreitə] n. 发电机；发生器

Amplitude ['æmplitju:d] n. 振幅；丰富；充足

Exercise:

1. List some nontraditional machining processes .

2. What are The USM system include.

Unit8 常见工程文档编写要求

［Target］

（1）了解工作报告的誊写规范

（2）了解常用说明书的誊写规范

（3）了解生产工艺 SOP 的誊写规范

8.1 工作报告演示文稿设计要求

使用电子演示文稿可以帮助演讲者清楚地表达和传递信息，因此在确定了工作报告的内容和结构之后，就需要开始着手电子演示文稿（以下简称“演示文稿”）的设计。设计演示文稿时要从演讲者和听众两个角度考虑。对于演讲者来说，演示文稿要起到提纲和提醒的作用，帮助演讲者流畅、顺利地完成报告；对于听众来说，演示文稿要清晰、简洁、易读、容易理解。再具体设计演示文稿时，应该达到以下要求：

1 整体风格统一

演示文稿整体上应具备统一的风格，即页面的尺寸和纵横比例、版式、颜色组合、字号和字体等，在整体上要连贯、协调，避免选取多个不同风格的模板来简单地拼凑和组合。

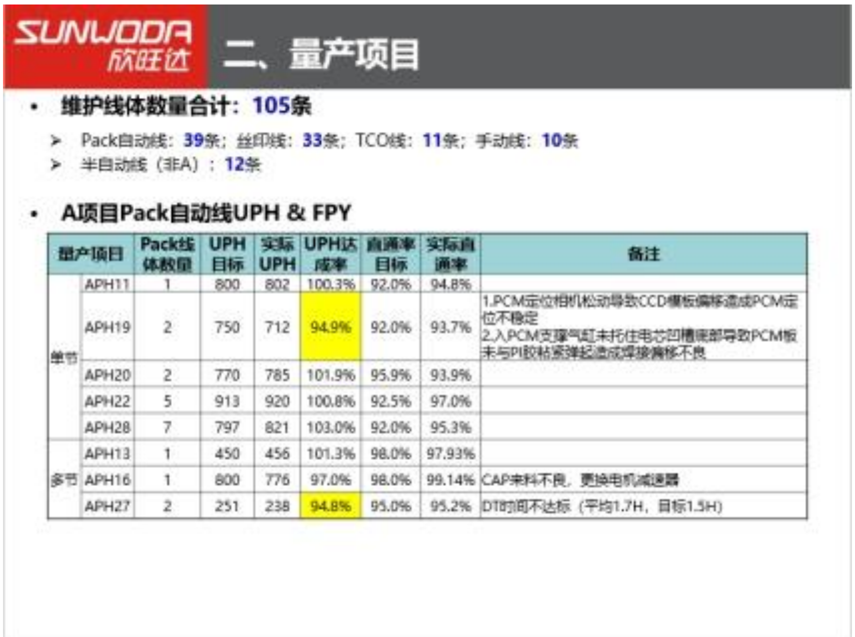


图8.1

2 文字表述简明、准确

各页面中的题目应尽可能简洁、有效地指出该页的主题，各标题用词结构尽量对称，如都是名词短语或动宾短语等。演示文稿的文字应清楚、协调、正确，避免错别字或英文拼写错误，以免使听众认为演讲者没有认真准备；切忌使用大段文字，一方面读者没有足够的时间去阅读，另一方面会使演示文稿枯燥乏味。对于纯文字的演示文稿，正文文字每页最多 6～8 行，行距不小于 1.2 倍，每行用简洁的文字表达明确的意思或观点。由于小写字母比全部大写字母更容易阅读，因此建议在标题和正文中均尽量采用首词的首字母大写、其余均小写的形式。

3 颜色使用协调

（ 1 ） 同一页面不宜采用太多颜色 演示文稿中颜色使用十分重要，在同一页面使用不同的色彩可达到强调重点、增强层次的效果，但同时也要注意色彩不宜太多、太杂，否则很可能会令人眼花缭乱，不知所云。在通常情况下，同一页面中的颜色不宜超过 3 种（图片除外）。

（ 2 ）背景和字体颜色搭配 背景色和字体颜色的色彩搭配一定要协调、 美观，且要保证背景色与字体颜色有足够的对比度，以使演示文稿内容清晰可见、易于分辨，尤其对于显示效果较差的场合，更需要注意这个问题。通常深色背景（黑色、深蓝色、深褐色、大红色、深绿色等）衬托浅色字体（白色、浅黄色等），或浅色背景衬托深色字体，切忌深色字体配以深色背景。推荐使用公司统一模板。

图8.2

4 字体和字号设置得当

合适的字体、字号是演示文稿页面简明清楚的前提。英语中无衬线字体（ 如 Arial,Tahoma）、衬线字体（ 如 Times New Roman） 在屏幕上更容易阅读； 中文字体应优先采用宋体、华文中宋、楷体等字体；黑体字更容易阅读，尤其适用于大屏幕和大量听众的场合；一般情况下同一种语言字体不超过 3 种。

采用不同的字号有利于明确文字性质，大标题、小标题、正文的字号要依次减小。

标题部分的字号应大于 32 号字，正文的字号应不小于 24 号，否则后排听众很难辨认。特殊情况下也可用小于 24 号的文字（如引用的文献、图题、表头以及次要内容等）。

5 多用图表，增加生动性和可读性

使用图来表达时，需要注意几个方面：折线图或曲线图中尽量用符号而不是颜色来区分不同线条，相关的图例或标记要尽量直接标注在线条旁边；不见的缩写或简称在第一次出现时一定要注明全称；坐标图中要做到坐标轴的标注明晰、各变量的含义明确、图例清楚；在图的下方尽量附有图题；采用的图应具有自明性。

表格设计要注意几个方面：设计简单、合理，内容一目了然；字号适中，可以辨认；各列数据纵向对齐，量和单位的符号要清晰明了；表格填充颜色和文字颜色需与演示文稿版式协调；可采用的不同填充或文字颜色标注出解释重点；文字、填充颜色和演示文稿背景之间要保证合适的对比度，以清晰显示。

放在演示文稿中的图表都需说明问题，不要只是为了装饰而放置很多的图片，甚至是与主题毫不相关，否则会分散观众的注意力，扰乱思路。

6 多用流程图和框图

为了避免演示文稿上出现大量的文字，并且清晰地展现演讲者的思路，使观众更容易理解，起到内容承上启下的作用，应提倡多用流程图或框图来表达有一定逻辑关系的内容，如分类、顺序、因果等关系。在讲述技术路线、工艺流程、编程策略等内容时，尤其适合采用流程图和框图的形式。

APH31/32/33 MCTQ进度流程图

MCTQ操作流程图	计划开始时间	计划完成时间	完成状态
MCTQ 关键尺寸定义	2018/12/01	2018/12/10	APH31/32/33 Done
MCTQ 3D评审	2019/01/04	2019/01/12	APH31/32/33 Done
MCTQ 标准块检验	2019/02/26	2019/02/28	APH31/32/33 Done
自动线调试数据收集	2019/03/01	2019/03/25	1）APH31数据收集3/29完成；2）APH32/33自动线试产Delay，3/27才开始Mini build，预计4月中旬完成数据收集
MCTQ 阶段性评审--修正	2019/03/26	2019/03/30	
MCTQ 关键尺寸更新	2019/04/01	2019/04/07	
MCTQ 第二版3D评审	2019/04/11	2019/04/13	
MCTQ 第二版标准块检验	2019/05/11	2019/05/15	
复制线推广使用--确定	2019/05/16	2019/07/06	

图8.3

7 单页演示文稿布局合理

单页演示文稿上各种形式应布局合理，避免充满页面、拥挤的文字或单一、单调的图表，最好是图文并茂。同时，为了不干扰听众的注意力，要尽量避免移动的图像、哗众取宠的图片或带纹饰的边框等。

8 演示文稿的播放

播放演示文稿时要注意以下几方面： 根据演讲时间确定演示文稿的页数 ，每张演示文稿的展演时间为 45～120 秒，避免快速掠过；确保演讲的总体时间不超过会议所规定的时间，如果因时间不够需要中止讲演，应快速切换到结论部分并简要阐述；页面的演示要力求顺畅，不同页面的切换要与相关的讲述同步，如需要链接另外的文件（数据库、模拟动画等），一定要简洁、快速；对于讲演中需要重复演示的页面，可采用两页同样的片子以免在演讲中回溯翻页，破坏连贯性。

另外，设置一定的动画效果可以使演示文稿内容根据演讲者需要连续出现 ，但是动画效果一定要简单，慎用慢速动画和声音。如果采用花样迭出的效果展示和强调内容，如从各个方向闪入、字母和汉字逐个跳出、转圈闪入等，会使观众眼花缭乱、冲淡信息传递效果，甚至降低演讲的水平。

8.2 设备说明书的设计要求

说明书，是以应用文体的方式对某事或物来进行相对的详细描述，方便人们认识和了解某事或物。说明书要实事求是，有一说一、有二说二，不可为达到某种目的而夸大产品作用和性能。说明书要全面的说明事物，不仅介绍其优点，同时还要清楚地说明应注意的事项和可能产生的问题。产品说明书、使用说明书、安装说明书一般采用说明性文字。说明书可根据情况需要，使用图片、图表等多样的形式，以期达到最好的说明效果。

产品使用说明书是介绍产品安装、调试、使用、维修保养的应用文本。它是一种有关产品知识和使用须知的科技应用文体。一般按照用户的认知习惯和认知程度，按照一定次序准确阐述。 它广泛地使用在各类产品上，它是科技应用文中使用范围最广、适用面最大的一种文体。不同类型的产品，对产品说明书的要求也不一样，生活用产品及部分医药品的说明书内容简单，篇幅较短，具有广告色彩；生产、科研用产品、专用产品、仪器设备产品的说明书内容较为详细，具有一定格式。

产品使用说明书如何写：

1、标题。通常是产品名称后面加上说明书三个字，如《VCD 说明书》。如果有些是侧重介绍使用方法，称为使用说明书，即产品名称加上使用说明，如 vcd 使用说明。

2、正文。正文要详细介绍产品的有关知识：产地、原料、功能、特点、原理、规格、使用方法、注意事项、维修保养等知识。当然，不同产品，其说明书侧重的内容也不同。

一般的产品说明书分为⑴家用电器类。⑵日用生活品类。⑶食品药物类。⑷大型机器设备类。⑸设计说明书。

3、附文。附文一般包括厂名、地址、电话、电挂、电传、联系人和生产日期等。出口产品在外包装上要写明生产日期、中外文对照。

一、什么是产品说明书

所谓产品说明书，就是对商品的性能、用途、使用和保养方法以及注意事项等作书面介绍的文书。又可叫做商品说明书。

二、产品说明书的作用

除了能够帮助和指导消费者正确地认识商品、使用和保养商品，同时还具有宣传商品的作用。

三、产品说明书的特点

1、说明性。对产品进行介绍说明，是主要功能和目的。

2、实事求是性。必须客观、准确反映产品。

3、指导性。还包含指导消费者使用和维修产品的知识。

4、形式多样性。表达形式可以文字式，也可以配图。

四、产品说明书的分类

1、根据内容和用途的不同：可分为民用产品说明书、专业产品说明书、技术说明书等。

2、根据表达形式的不同：可分为条款式说明书、文字图表说明书等。

3、根据传播方式的不同，可分为：包装式：即直接写在产品的外包装上。内装式：将产品说明书专门印制，甚至装订成册，装在包装箱（盒）内。

具体内容参考见书末附件。

8.3 工序 SOP 的编写技巧

“制造”就是以规定的成本、规定的工时、生产出品质均匀、符合规格的产品。要达到上述目的，如果制造现场之作业如工序的前后次序随意变更，或作业方法或作业条件随人而异有所改变的话，一定无法生产出符合上述目的的产品。

因此，必须对作业流程、作业方法、作业条件加以规定并贯彻执行，使之标准化。

标准有以下四大目的：

技术储备， 提高效率；防止再发， 教育训练。

标准化的作用主要是把企业内的成员所积累的技术、经验，通过文件的方式来加以保存，而不会因为人员的流动，整个技术、经验跟着流失。达到个人知道多少，组织就知道多少，也就是将个人的经验转化为企业的财富。

更因为有了标准化，每一项工作即使换了不同的人来操作，也不会因为不同的人，在效率与品质上出现太大的差异。如果没有标准化，老员工离职时，他将所有曾经发生过问题的对应方法、作业技巧等宝贵经验装在脑子里带走后，新员工可能重复发生以前的问题，即便在交接时有了传授，但凭记忆很难完全记住。

没有标准化，不同的师傅将带出不同的徒弟，其工作结果的一致性可想而知。

所谓 SOP，是 Standard Operation Procedure 三个单词中首字母的大写 ，即标准作业程序。就是将某一事件的标准操作步骤和要求以统一的格式描述出来，用来指导和规范日常的工作。

SOP 的精髓，就是将细节进行量化，用更通俗的话来说，SOP 就是对某一程序中的关键控制点进行细化和量化。

是以文件的形式描述作业员在生产作业过程中的操作步骤和应遵守的事项;

是作业员的作业指导书;

是检验员用于指导工作的依据。

SOP 的作用

将企业积累下来的技术、经验记录在标准文件中,以免因技术人员的流动而使技术流失;

使操作人员经过短期培训,快速掌握较为先进合理的操作技术;

根据作业标准，易于追查不良品产生的原因;

树立良好的生产形象，取得客户信赖与满意;

实现生产管理规范化、生产流程条理化、标准化、形象化、简单化;

是企业最基本、最有效的管理工具和技术资料。

SOP 的特征：SOP 是一种程序。

SOP 是对一个过程的描述，不是一个结果的描述。同时，SOP 不是制度，也不是表单，是流程下面某个程序中关控制点如何来规范的程序。

SOP 是一种作业程序

SOP 首是一种操作层面的程序，是具体可操作的，不是理念层次上的东西。如果结合 ISO9000 体系的标准，SOP 是属于三阶文件，即作业性文件。

所谓标准，有最优化的概念，即不是随便写出来的操作程序都可以称做 SOP，而一定是经过不断实践总结出来的，在当前条件下可以实现的最优化的操作程序设计。

说得更通俗一些，所谓的标准，就是尽可能地将相关操作步骤进行细化、量化和优化，细化、量化和优化的度就是在正常条件下大家都能理解又不会产生歧义。

SOP 不是单个的，是一个体系。

虽然我们可以单独地定义每一个 SOP，但真正从企业管理来看，SOP 不可能只是单个的，必然是一个整体和体系，也是企业不可或缺的,而且这个标准作业程序一定是要做到细化和量化。

举例：（1）麦当劳作业手册

图8.4

大家都熟悉的麦当劳，它有许多分店，但是口味却是一样的美味？他们的工作标准有 560 页！

（2）肯德基的炸鸡：

图8.5

KFC 的炸鸡翅肯定好吃吧？他们规定炸好之后要放在滤油网上，不能多于七秒，因为这样太干燥了，不能少于三秒，否则就会太油了。

SOP 编写指南

1. SOP 编写流程：

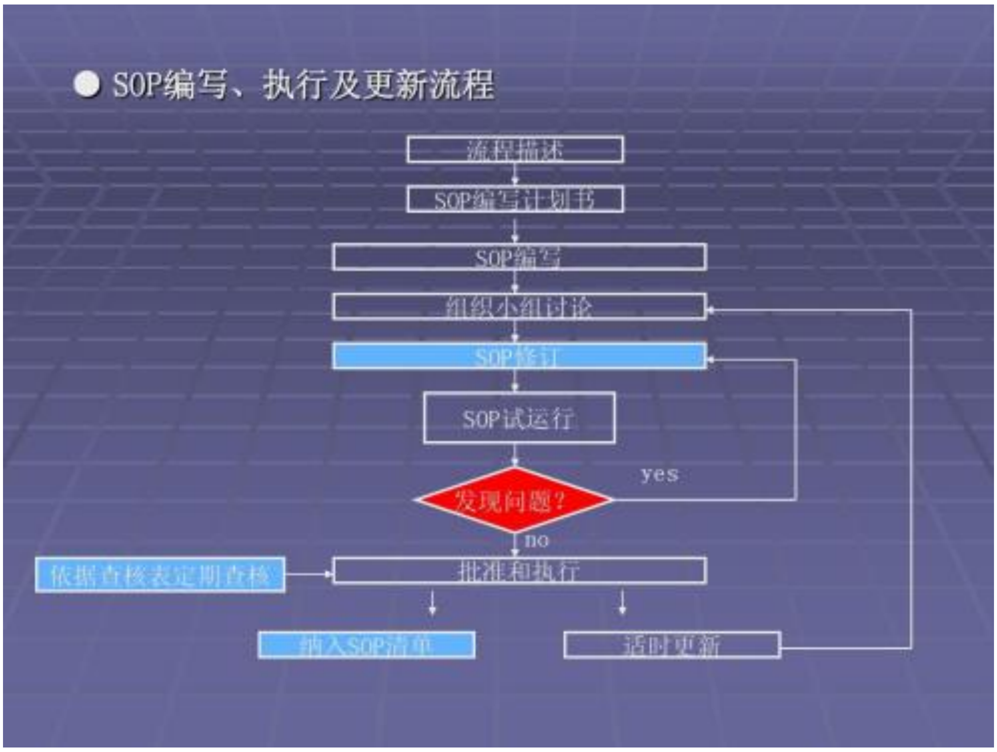


图8.6

2. SOP 编写计划书：

明确 SOP 的编号、工序名称、编写人、初稿完成时间、小组讨论时间及最终的定稿时间。

3. SOP 编写人员要求：

操作好，有经验，有一定写作基础的一线员工；

沟通，打消编写人员的顾虑；

培训；

给予支持:专门的时间、提供相关资料等；

编写小组要有团队精神。

4. SOP 的讨论修订：

统一认识，达成共识；

SOP 讨论会参与人员；

操作员、设备员（维修人员）、工艺员、体系管理员、编写组负责人及 1-2 名与本岗位无关的人员；

讨论会要作到互相挑战,各抒己见；

必要时可进行现场确认。

5. SOP 的试运行：

目的：通过实践来检验 SOP 的合理性和可操作性。

6. SOP 的定稿、批准和执行：

建立与 SOP 相应的查核表（工段长、工艺工程师两级查核)；

定期查核；

CPCPR（Critical Process Control PointReview)：关键工序控制点回顾，关键工序是对产品质量起重要、关键作用的工序，通过建立关键工序控制点并实施严格的质量控制，以提高产品质量的过程控制能力。

7. 适时更新：

当工艺要求、设备状况等发生改变，一些操作方法的改进时，要对 SOP 进行评审和更新；

定期回顾；

确定回顾时间及参加人员；

将回顾结果纳入更新内容；

将正式发布的 SOP 列入 SOP 清单。

SOP 六要素

>>>物料名称及数量<<<

在生产前须确认好本工位所需的物料和准备的物料是否一致、数量是否正确，物料

是否经过 IQC 检验。当全部确认无误后方能上线生产。

生产过程中绝不接受不良品，绝不生产不良品，绝不传递不良品。

>>>工装夹具<<<

每天上班前对夹具进行校准检查，确认工装夹具是否能够正常使用。

>>>设备名称及参数<<<

设备操作工必须经培训合格后方能上岗操作机器，在设备开启前先仔细阅读设备使用说明书及设备各参数的设定值，然后按照使用说明书对机器进行操作，且确定设定的各参数值与要求的参数值相同。

>>>作业步骤<<<

操作步骤是 SOP 内容中的重点，必须简洁、明了，让人一看就懂，一看就知道怎么操作。SOP 需要达到的效果是一个新人一来就可以独立操作且产品质量合格，这也是 SOP 的最高境界。

>>>人员配置<<<

SOP 中各工位须确定人员，这样可以避免每天上班需要班组长对人员进行分配。这样每天上线前员工知道自己要做什么准备，并且可以让他们更熟练本工位工作。工位定员的话既可以节约时间，又可以保证质量。

>>>安全因素<<<

任何操作都有可能导致产品的质量问题，所以我们在 SOP 中必须包含操作的注意事项、检查项目和一些人员安全须知。

图8.7

SOP 的编写要点

编写总要求：

条理化，规范化，形象化；

逻辑性；

正确性，精确性；

可操作性；

SOP 的编写要条理化、规范化、形象化：

语句和结构；条理清晰。

文章前后有关联，指向分明。

规范化要求：

使用祈使句（尽量避免使用被动句）：

例如　正确：　按下 STOP 按钮；

不正确：　STOP 按钮被按下。

在此基础上可以添加地点或工具的条件状语

	条件从句	行动动词	宾语
正确的	使用扭力扳手	上紧	排空管到 50in.lb
不正确的	现在你可以将排空管上紧到 50in.lb		

统一使用精确的行动动词；

例如有几个动词都可以用来描述旋开关到一个定位：

“旋开”，“定位”，或“调节”等；

悬着一个动词并统一使用它（所有 SOP）；

名称固定化：红色制动开关----红色制动按钮

词语要简单、固定

限定行动次数

每个步骤只能指出一个行动或最多 3 个相关的行动

行动次数由步骤中的动词数决定

确定责任人

SOP 的默认使用者是操作员，没有必要再步骤描述中再指出，如“操作员打开…”等

但是，如果有其他工作人员涉及到执行步骤，应该提到这些工作人员，例如：

正确的　　让一个质检员检查坩埚是否正确摆放在石墨地板中间位置

不正确的　　检查坩埚是否正确摆放在石墨地板中间位置。

设备名称正确完整。例如：对阀门，泵等物品要进行编号，竖直列出多个对象

不正确：　打开阀门 E1-A,E2-A,　E4-B,和 E5-5

正确：　　打开阀门

E1-A

E2-A

E4-B

E5-5

编写 SOP 的六要素（5W1H）

WHAT:需要执行的任务;

HOW：　执行次任务所需要的详细步骤;

WHEN：步骤的先后顺序；说明某一具体步骤需要的具体时间；要进行下一步所需满足的特定条件;

WHO:　表明程序的执行人及所涉及到的其他人员;

WHERE:指明使用的仪器、设备所在的位置;

WHY：　解释进行此步骤和任务的原因。

例如：

当某操作人员受伤或机器出现问题时，关闭机器。

当某操作人员受伤或及其出问题时，按下“紧急制动按钮”来关闭机器。

当某操作人员受伤或及其出问题时，按下位于操作控制面板的右上角的紧急制动按钮来关闭机器。

SOP 不但要正确更要精确。

例：某一个喷涂操作 SOP 的准备工作

正确的：保持喷枪离所需喷表面垂直距离适中。

精确的：保持喷枪离所需喷表面垂直距离为 30-40cm。

运用具体的量化的衡量标准，避免正常的，适当的，安全的，正确的，有效的……

例：某一个喷涂操作的 SOP

不正确表述：将进气压力，喷枪的喷射压力、气动泵压力调至正确值

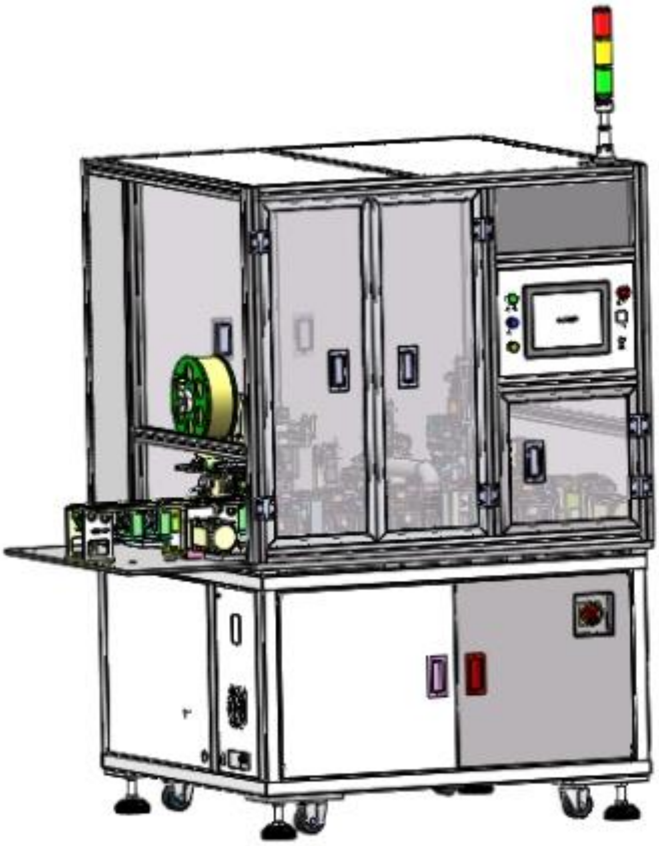
正确表述：　将进气压力、喷枪的喷射压力、气动泵压力调至正确值：

进气压力调至 75~85PSI

喷枪的喷射压力调至 20~40PSI

气动泵压力调至 27~30PSI

附录 1.设备说明书实例



APH29 自动线　贴凹槽胶纸机说明书

APH29 Automatic line--Taping terrace tape machine equipment manual

地址：深圳市光明新区塘家南十八号科裕路欣旺达工业园 B 栋

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前　　言

Foreword

为了确保您正确地使用该设备，发挥该设备的最大效能，在操作设备之前，务必熟读此说明书！

In order to ensure that you use the device correctly and to use it for maximum performance, be sure to read this manual thoroughly before operating the device!

该设备实现载具和 CELL 输送、贴凹槽胶纸、凹槽胶纸整形、撕离型纸、二次折弯和自动排不良品等功能，使用运送皮带运输 CELL 和载具，从而达到贴胶纸、撕胶纸、二次折弯以及排除不良品目的，具体说明见下文。

The equipment realizes the functions of carrier and CELL conveying, grooved adhesive tape, grooved tape shaping, tear-off type paper, secondary bending and automatic discharging of defective products, and uses transport belts to transport CELLs and carriers so as to achieve The purpose of adhesive tape, tear tape, secondary bending, and elimination of defective products is described below.

目　　录

CONTENTS

一. 设备结构说明及主要技术参数

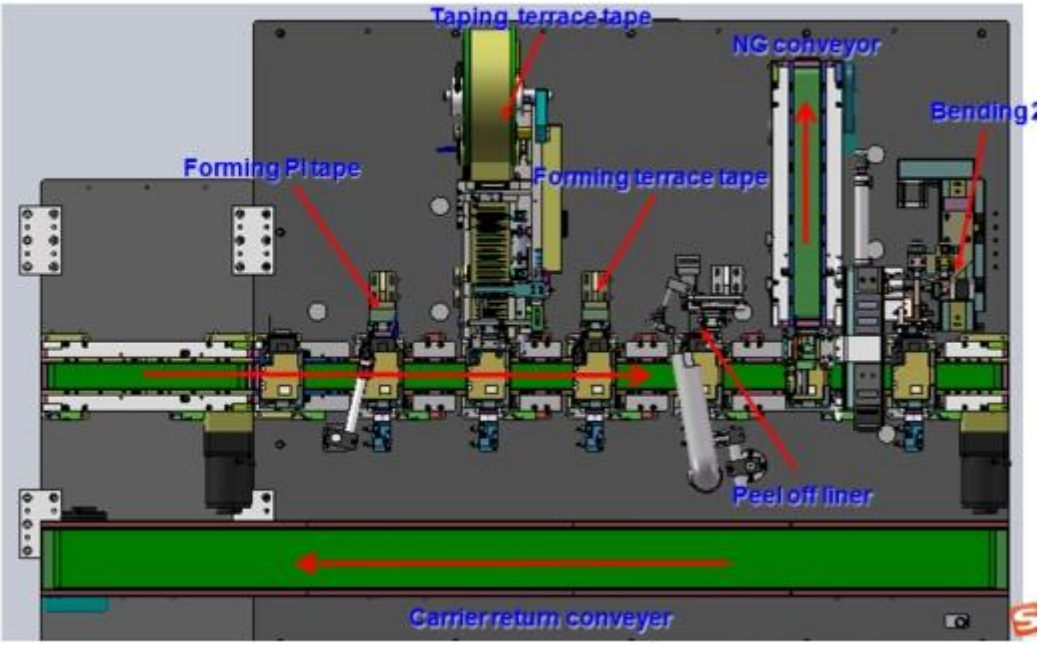
1. Equipment structure description and main technical parameters

设备主要结构和工作原理

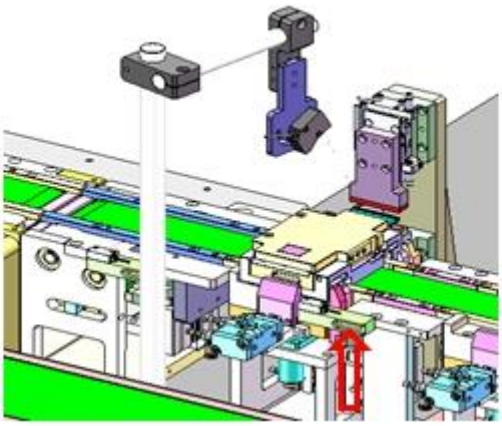
1.1 The main equipment structure and working principle

1.1.1 主要结构：

1.1.1 The main structure:

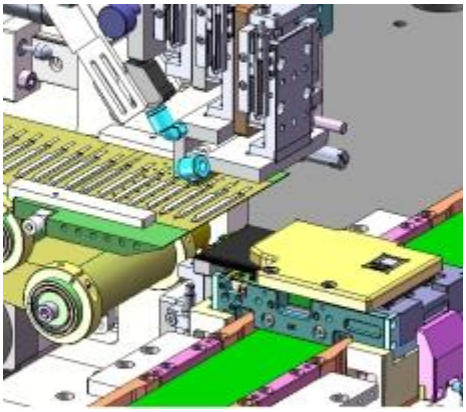


镍片整形工位：对贴防水胶电池进行镍片整形。



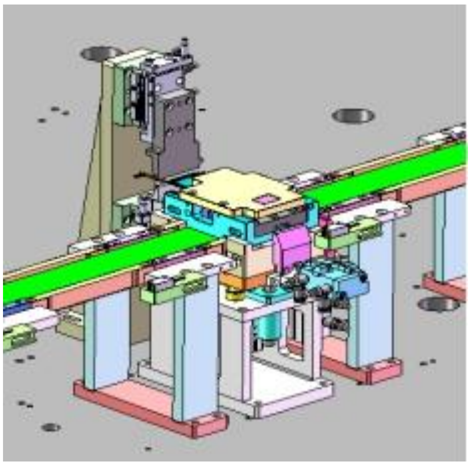
贴凹槽胶纸工位：对OCV测试OK产品，头部贴入凹槽胶纸。

Taping terrace tape station: For OCV test OK products, the head is taped with terrace tape



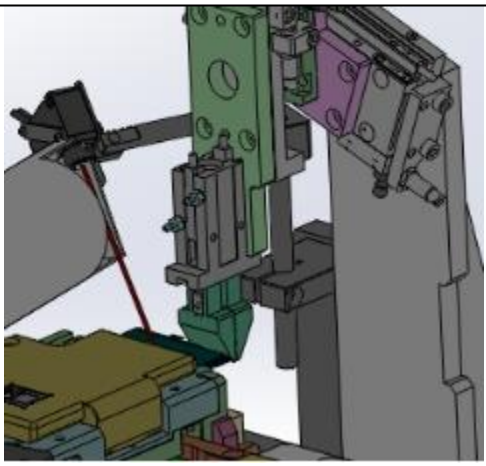
胶纸整形工位：使用整形块对贴完凹槽胶的产品进行整形，使胶纸能贴紧凹槽内。

Forming terrace tape station：The product that sticks terrace tape to form use plastic piece, make tape can stick close terrace inside.



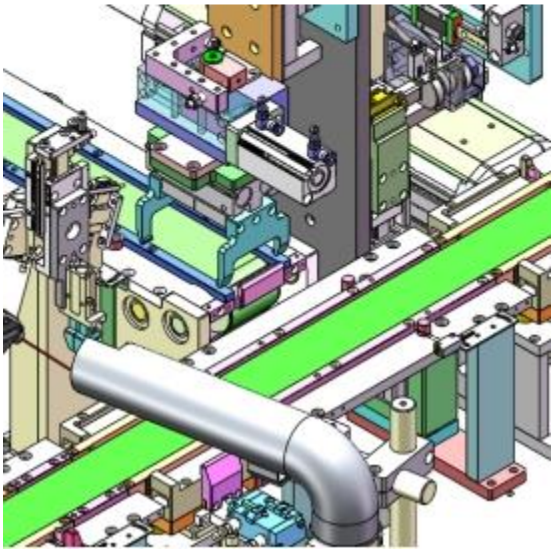
撕标工位：利用夹爪撕掉胶纸上面的离型纸。

Tear-off station: Use the jaws to tear off the release paper above the tape.



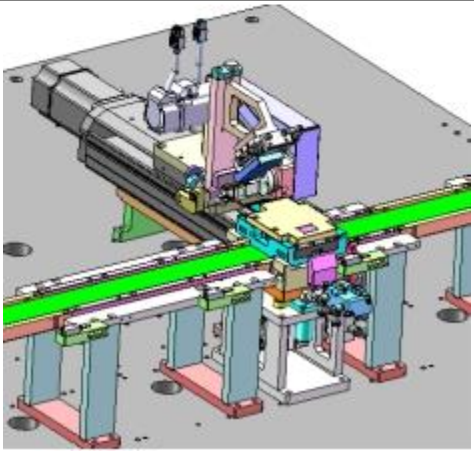
排不良工位：对 NG 产品，用机械手夹取移至不良排出皮带，排除。

Bad Discharge station: For NG products, use robot gripper to move to bad discharge belt and remove.



折弯二工位：贴完凹槽胶纸的产品，对 PCM 进行折弯。

Bending 2 station: Finish the product of terrace tape and bend the PCM.



1.1.2 工作原理

1.1.2 working principle

使用运送皮带机构实现载具和CELL运输，头部贴入凹槽胶纸，自动排除不良品，二次折弯。

The use of a conveyor belt mechanism to achieve carrier and CELL transport, the head paste into the groove tape, automatically eliminate defective products, the second bend.

1.2设备主要技术参数

1.2 The main technical parameters of the equipment

工作电压：AC220V/50HZ

Working voltage: AC220V/50HZ

设备规格：1670*1200*1900（mm)

Equipment specification: 1670*1200*1900(mm)

消耗功率：1.75KW

Power consumption: 1.75KW

气源压力：0.5MPa～0.7MPa

Air source pressure: 0.5MPa to 0.7MPa

设备效率：900 PCS /H

Equipment efficiency: 900 PCS /H

二．操作说明

2. Instructions

2.1人机界面操作说明

2.1 Man-machine interface operation instructions

2.1.1开机

2.1.1 Boot

②设备开机，在确认系统处于安全的状况下，将电源旋钮旋转至闭合位置，系统进入初始画面，点击“进入主画面”按键系统进入主控制画面，初始画面如下。

Device is turned on, the system is in a safe condition confirmation, the power knob to the closed position, the system enters the initial screen, click on "the home screen" button into the main system control screen as an initial screen.

2.1.2画面介绍

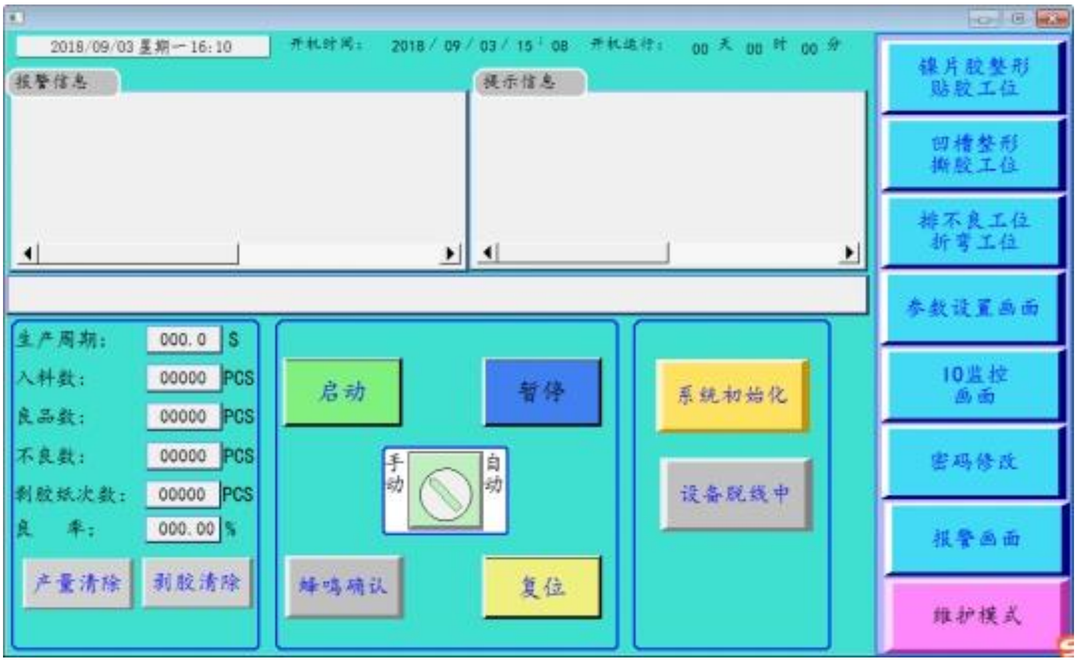
2.1.2 Screen introduction

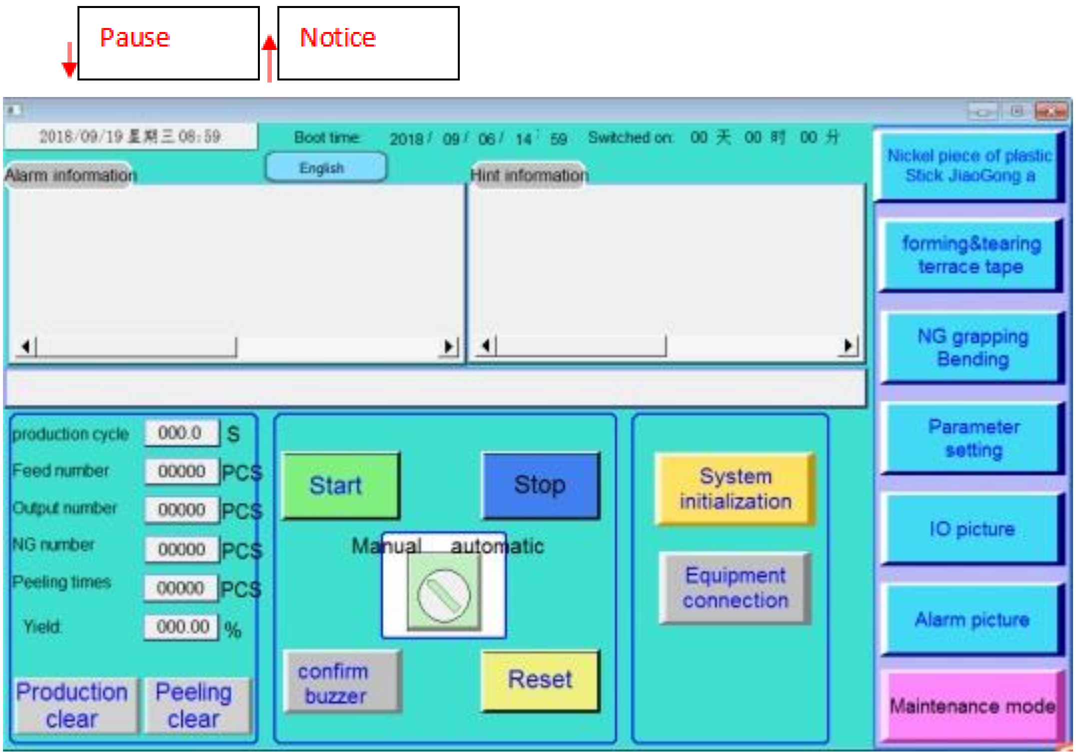
①主画面

main screen

设备主控画面

Device master screen

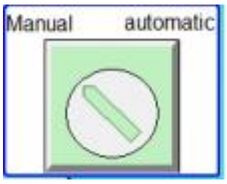




下面对主控画面做详细的操作说明：

The detailed operation instructions for the main control screen are as follows:

此按键用来切换手动、自动两种操作模式。



This button is used to switch between manual and automatic modes of operation.

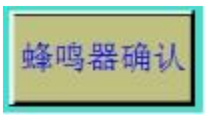
当提示栏提示“设备初始化完成”或者设备处于运行暂停中，在自动模式下按此按键可运行设备。

When the prompt 

“Device Initialization Completed” or the device is in a running pause is indicated in the prompt bar, the device can be operated by pressing this button in automatic mode.

设备自动运行中，按此按键，暂时停止设备动作。

During automatic operation of the device, press this button to temporarily stop the device.

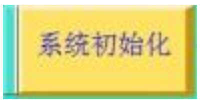


设备报警状态下，可通过屏蔽蜂鸣器，关闭蜂鸣声音。

In the alarm state of the device, the buzzer can be turned off and the buzzer sound can be turned off.

按此按键，可对当前已排除的报警异常信号进行复位。

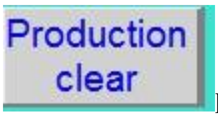
Press this button to reset the current alarm exception signal that has been eliminated.



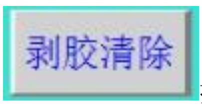
急停以后，手动模式下，按下此按键 3s 以上，设备将自动初始化，回到初始位置;正常情况下，请勿系统复位。

After an emergency stop, in manual mode, press this button for more than 3s, the device will automatically initialize and return to the initial position; under normal circumstances, do not reset the system.

按下此按键 1s(其他的机台 2S,3S,需要统一)以上，总产量、不良品和良率数据将归零。

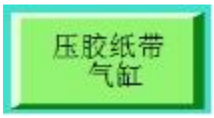


Pressing this button for more than 1 s will return the total output, defective product, and yield data to zero.



按下此按键 1s 以上，剥胶次数将置 0。

Press this button for more than 1s, the number of peeling will be set to 0.

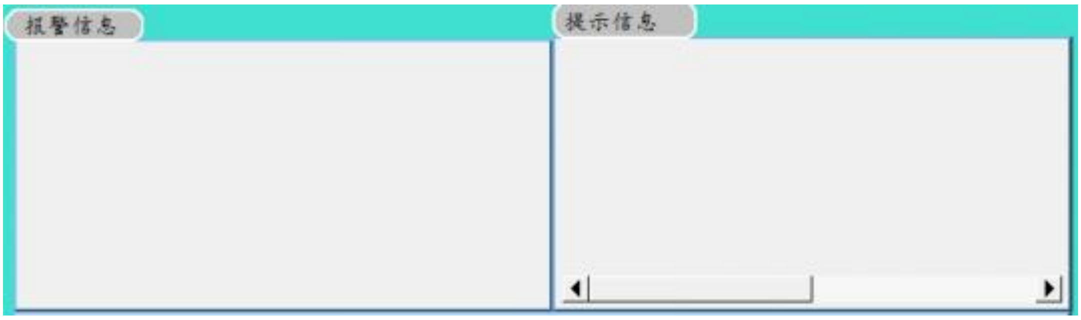


当胶纸用完以后,点此气缸进行更换胶纸。

When the tape is used up, point the cylinder to change the tape.

设备提示栏，提示设备信号屏蔽状况以及其它相关信息。

The device prompt box indicates the device signal shielding status and other related information.

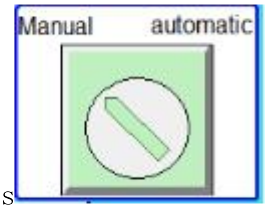


异常报警提示框，信息提示框,当前设备的异常报警状况和屏蔽状态。

Abnormal alarm message box, message box, abnormal alarm status and masking status of the current device.

注：当设备运行中出现报警状况，请按

切换至手动操作模式，切换画面至手动画面对(报警)气缸进行操作（只能对当前报警的气缸操作，没有出现报警的气缸将自动锁住）；排除异常后，切换至自动操作模式，按“启动”按键或按钮继续运行设备。

Note: When an alarm condition occurs during the operation of the equipment, press

to switch to the manual operation mode, switch the screen to the manual screen to operate the cylinder (can only operate the current alarm cylinder, the cylinder will not automatically alarm when there is no alarm); eliminate abnormal After that, switch to the automatic operation mode and press the start button or button to continue the operation of the device.

设备运行过程中遇到不可解除的异常状况，请长按“系统复位”3s 以上，设备回到初始状态。

During the operation of the device, an irremovable abnormal condition is encountered. Press and hold “System Reset” for more than 3 seconds to return the device to the initial state.

正常运行状态请勿随意按急停按钮；急停按钮用于紧急情况，急停按下伺服释放，设备需“系统复位”才能再启动。

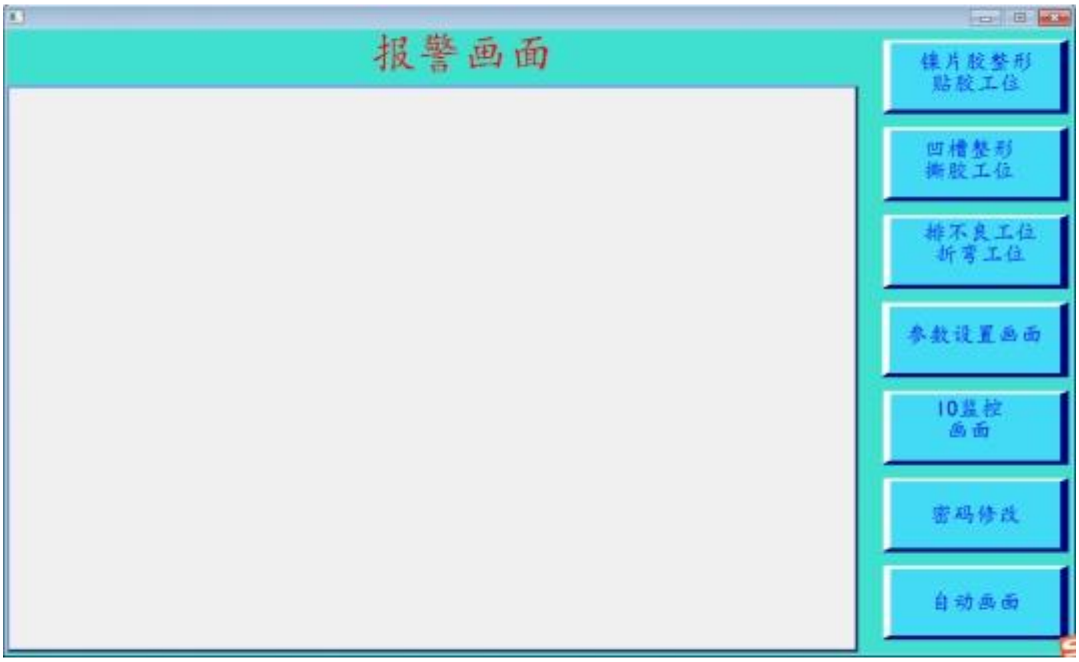
In normal operation, do not press the emergency stop button at will; the emergency stop button is used for emergencies, and the emergency stop presses the servo to release. The device must be "system reset" to start again.

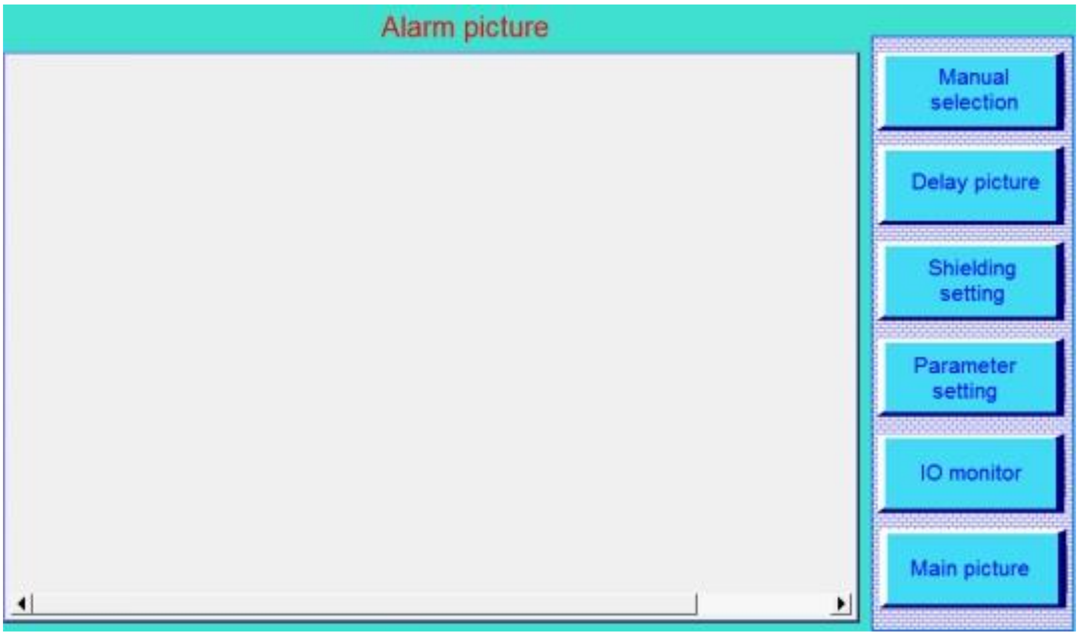
2.报警画面

2. Alarm screen

该画面包括实时报警和历史报警。实时报警提示当前设备的异常信息；历史报警存储该设备上电后的所有报警信息（断电后历史报警将自动清除）。

This screen includes real-time alarms and historical alarms. The real-time alarm prompts the current device's abnormal information; the historical alarm stores all the alarm information after the device is powered on (the historical alarm will be cleared automatically after the power off).





3.手动画面

3. manual screen

手动画面包括工位操作画面、马达控制画面；当设备处于手动模式，可在工位操作画面进行操作。下面对画面操作做相关说明：

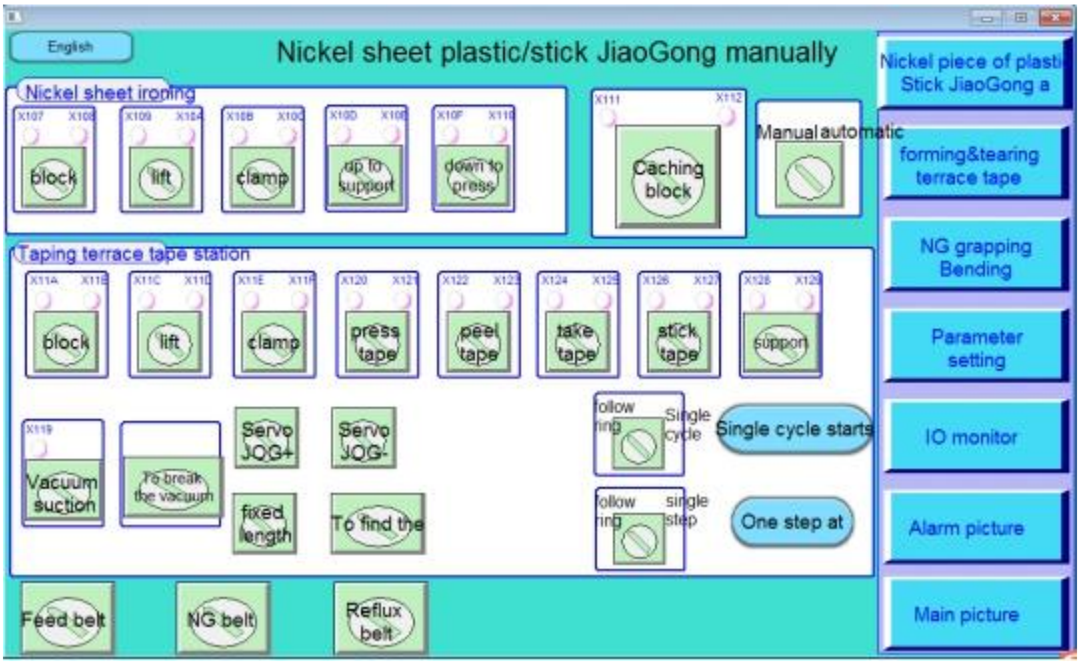
The manual screen includes the station operation screen and the motor control screen; when the device is in the manual mode, operations can be performed on the station operation screen. The following describes the screen operation:

工位操作画面包括入料镍片整形画面、贴凹槽胶、凹槽胶整形撕胶纸、胶纸检测排不良、折弯二画面。

(1) The station operation screen includes the input buffer screen, paste groove adhesive, groove plastic reshaping tear tape, adhesive tape detection defect, bend two screens.

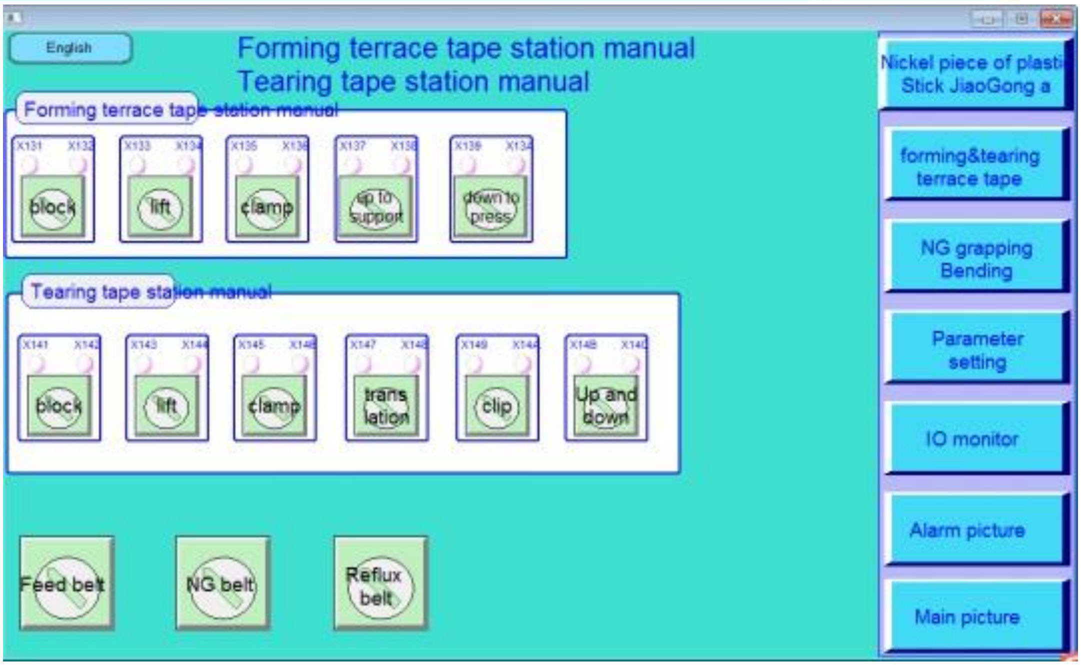
镍片整形&贴凹槽胶

镍片整形&Groove adhesive



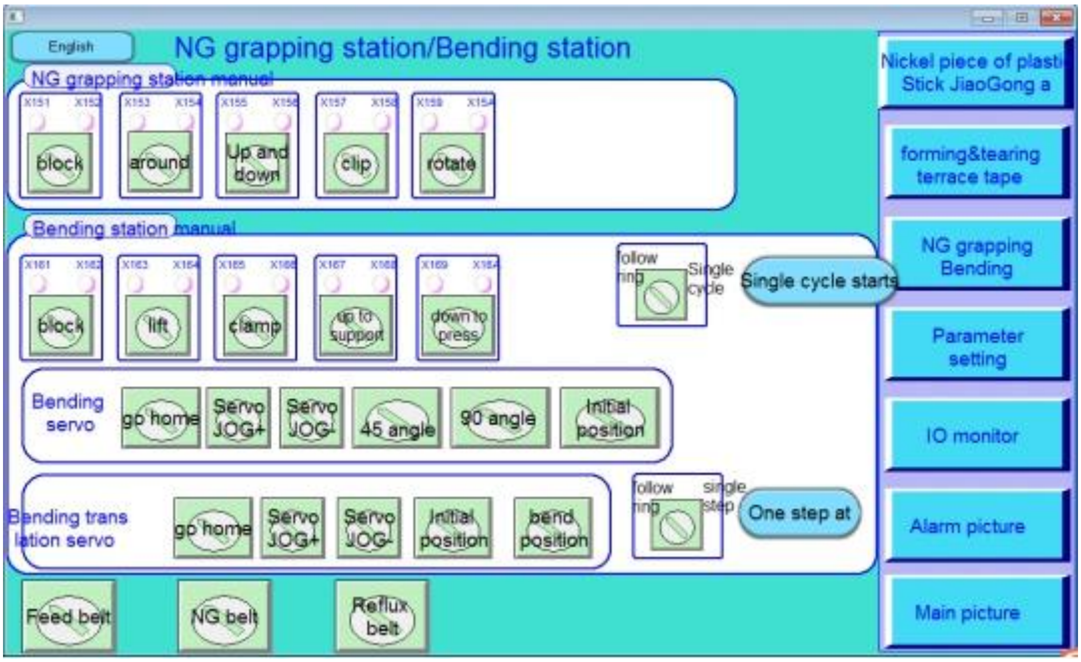
凹槽胶整形撕胶纸

Groove plastic plastic tearing tape



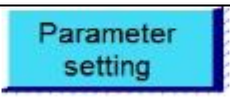
胶纸检测排不良& Bending2

Bad adhesive tape detection & Bending2



单击

均会跳转到权限登录画面

Click 

to jump to the permission login screen

操作员登录密码为：1，技术员登录密码为：2，管理员登录密码为 268888

The operator login password is: 1, the technician login password is: 2, and the administrator login password is 268888

登录失败提示

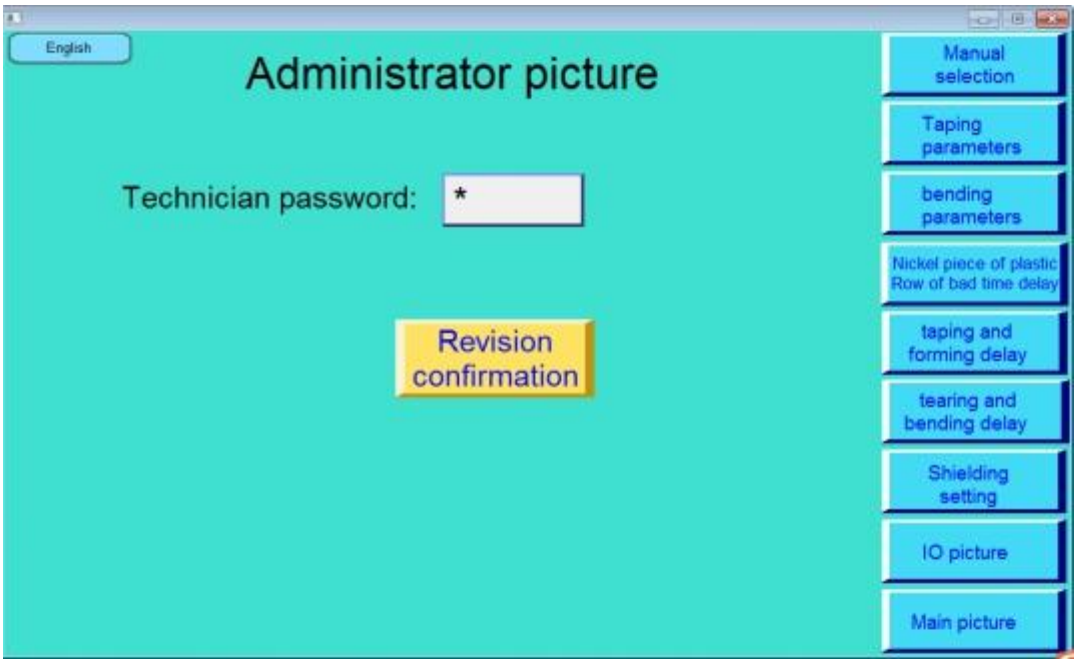
输入错误，需重新输入修改参数权限需要技术员以上权限才能登录进入，若要修改技术员登录密码，则在管理员界面登录 268888，单击

进入如下页面

Login Failure Prompt Input error

, need to re-enter modify the parameter permissions need more than the technician to log in to enter, to modify the technician login password, log in to the administrator interface 268888, click

to enter the following page



输入新密码，单击修改确认即可修改技术员登录密码。

Enter the new password and click Modify Confirm to modify the technician login password.

以下对工位操作画面进行介绍

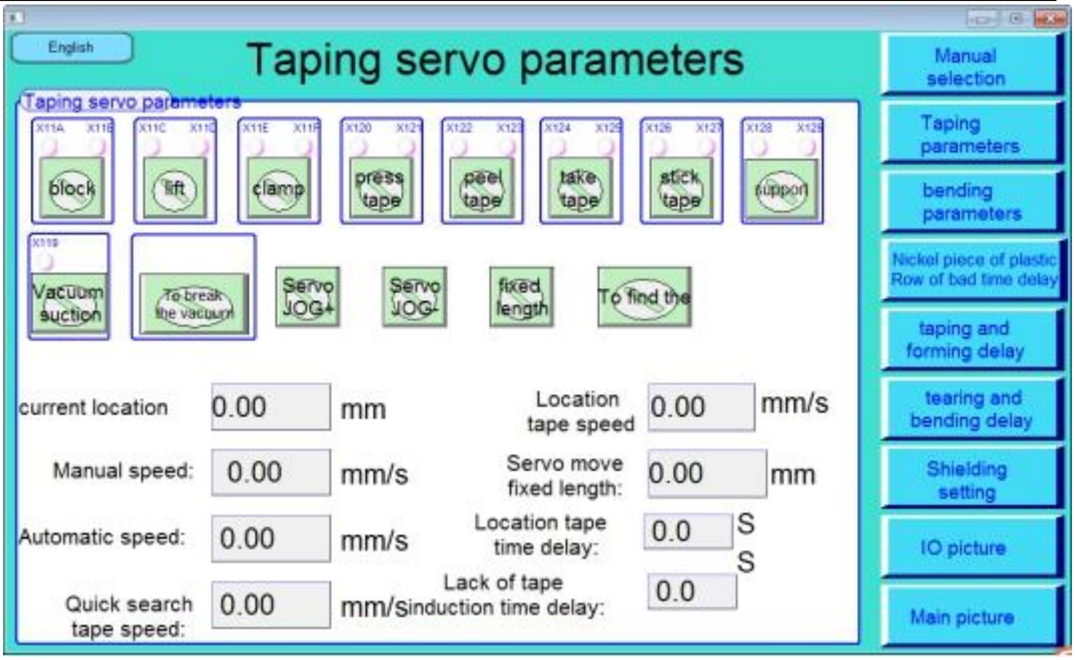
The following describes the station operation screen

马达控制画面包括贴胶伺服画面以及折弯伺服。

(2) The motor control screen includes a sticker servo screen and a bending servo.

贴胶伺服画面

Paste servo screen



点击该按键，马达进行激磁与释放切换，释放状态，马达可用手推动。

Click this button 

, the motor is switched between excitation and release to release the state, and the motor can be pushed by hand.

马达激磁状态点击该按键，进行点动前后操作。

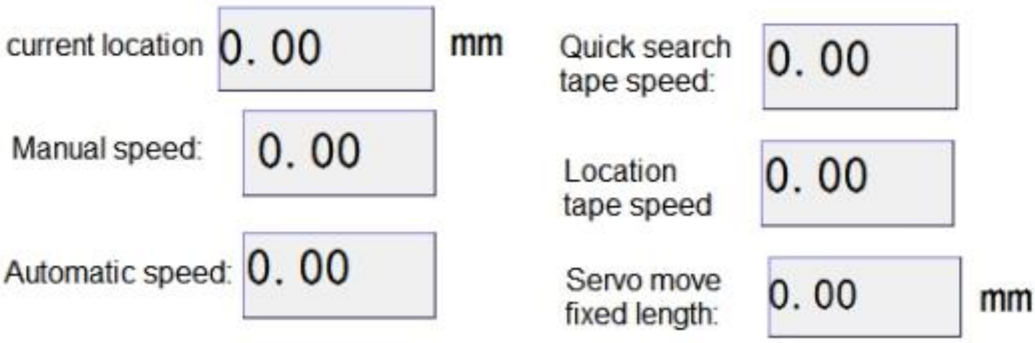
Motor Excitation Status Click this button

to perform jog operation before and after.

马达激磁状态且胶纸和色标感应器正常时，在手动模式下，单击可进行一次找胶。

When the motor is energized and the tape and color sensor are normal, in manual mode, click to search for glue.

设置伺服自动、手动速度以及快速找胶速度、对胶速度和伺服走定长度。



Set the servo auto, manual speed and quick find glue speed, glue speed and servo length.

快速找胶速度：在缺胶纸或者胶纸中间缺少部分时，以快速找胶速度进行快速找胶。

Quickly find the speed of glue: When there is a missing part in the lack of adhesive tape or adhesive tape, quickly find the glue with a quick look for glue speed.

伺服走定长：在找到胶纸前边缘后，伺服以自动速度进行定长走位。

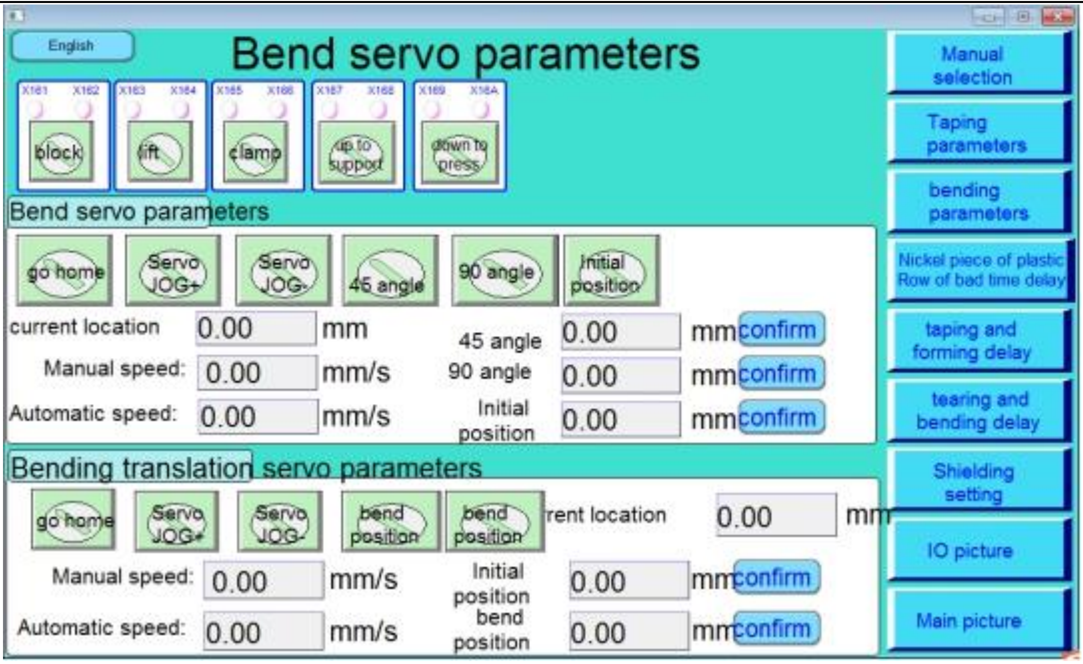
Servo length: After finding the front edge of the tape, the servo takes a fixed length walk at the automatic speed.

对胶速度：伺服走完定长后，将接近胶纸后边缘，此时以对胶速度，慢速找到胶纸后边缘。

The speed of the glue: After the servo runs for a certain length, it will be close to the back edge of the adhesive tape. At this time, the rear edge of the adhesive tape is found at the speed of the glue.

折弯伺服

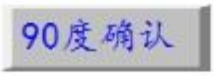
Bending servo

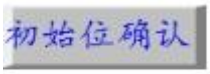


设置折弯旋转伺服和折弯平移伺服自动速度和手动速度，单击

和

进行回原点操作。长按

进行位置调节，单击



和

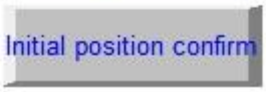
进行位置写入并保存。

Set Brake Rotation Servo and Bending Shift Servo Auto Speed and Manual Speed, click 

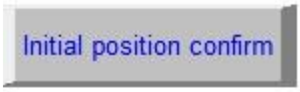
and 

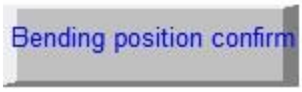
to perform home operation. Press and hold 

for position adjustment, click 



and

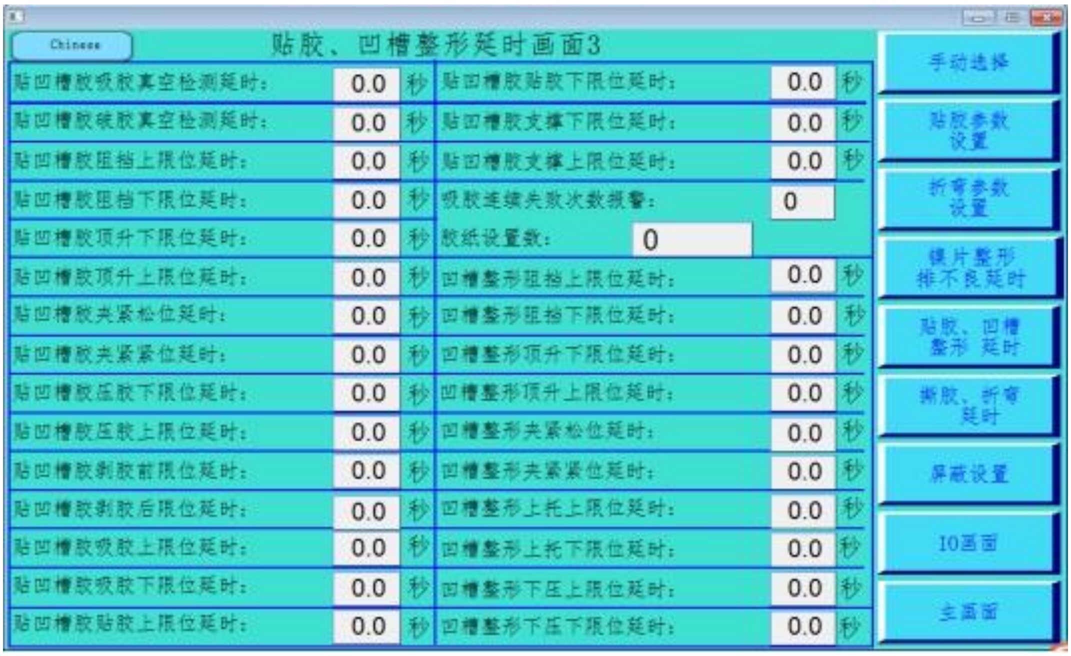




to write position and save.

延时设置画面

Delay setting screen



冻结设置画面。

Freeze the settings screen.

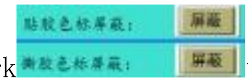
冻结设置针对调试使用的画面，正常生产情况下请勿“关闭”冻结设置，所有信号处于“打开”状态。下面对设置画面操作做相关说明：

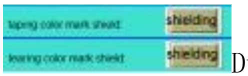
参数设置画面

Freeze setting For the screen used for debugging, do not "close" the freeze setting under normal production conditions. All signals are in the "open" state. The following describes the settings screen operation:

Parameter setting screen

设备运行过程中，工位处于状态，该工站正常工作；工位处于状态，该工站不工作。

During the operation of the equipment, the station is in the state and the station is working normally; the station is in the state and the station does not work设备运行过程中，信号处于”状态，设备识别该信号；信号处于状态，设备忽略该信号。

During operation of the equipment, the signal is in the ″state″ and the equipment recognizes the signal; the signal is in the state and the equipment ignores the signal.

当设备处于自动模式时，旋转至“点动”(单动）模式，设备运行过程中，按一次启动按键/按钮，设备向前推进一个动作，直至该周期完成；当设备处于自动模式时。此两信号只用于调试设备，正常生产请处于“循环”模式。

When the device is in automatic mode, rotate to “jog” mode. During the operation of the device, press the start button/button once. The device advances one action until the cycle is completed; when the device is in automatic mode. The two signals are only used to debug the equipment. For normal production, please use the "cycle" mode.

当设备处于自动模式时，此两信号只用于调试设备，当旋转至“单动”模式，每按一次启动按键/按钮，设备按预设程序动作一次，直至该周期完成；正常生产请处于“循环”模式。

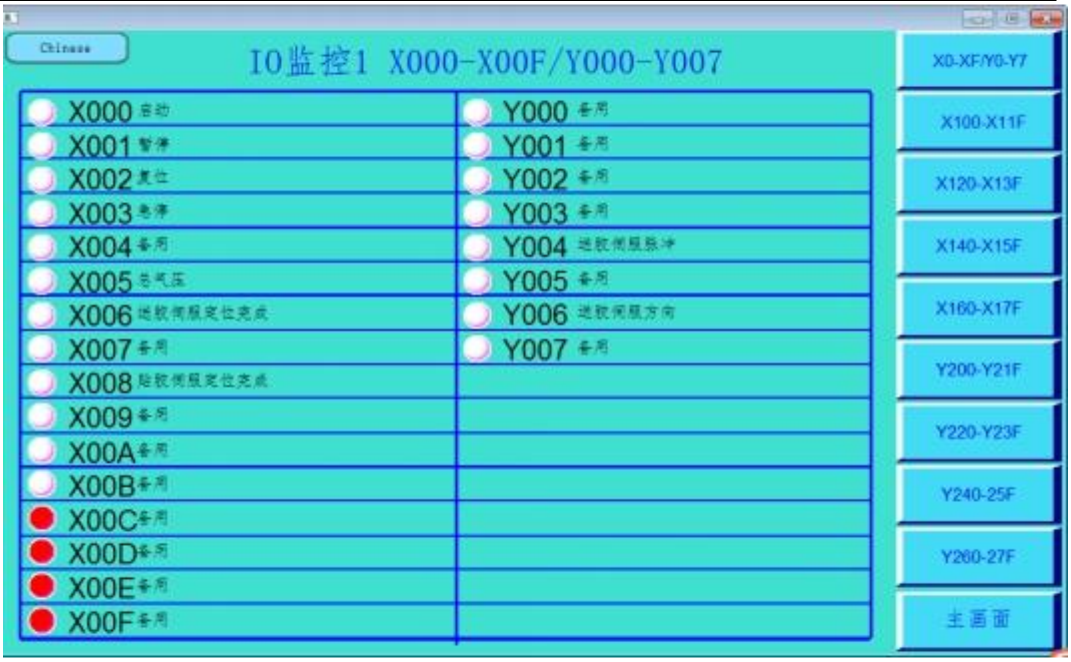
When the equipment is in automatic mode, these two signals are only used for debugging the device. When rotating to "single action" mode, each time you press the start button/button, the equipment operation once follow the preset program until the cycle is completed. Normal production should be in "cycle" mode.

注意：设备正常生产中，请将所有信号处于“屏蔽”状态；工位处于“停止屏蔽”状态该工位关闭不运行，测试工位“停止屏蔽”默认为该工位测试 OK（）。

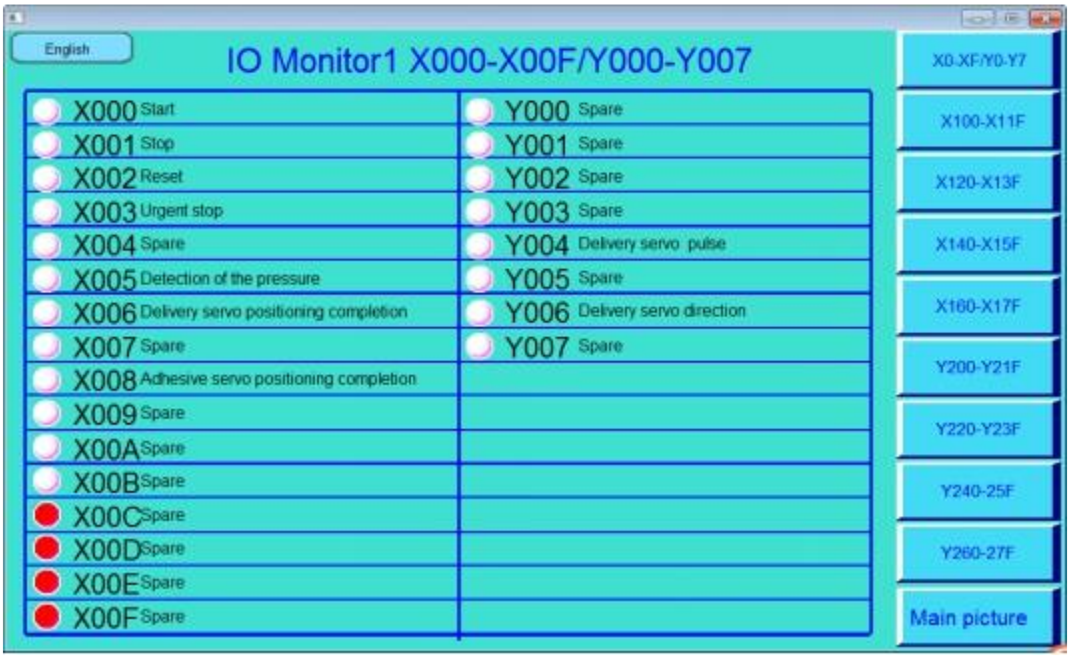
Note: In the normal production of the equipment, please put all the signals in the "shielded" state; the station is in the "stop shielding" state, the station is closed and does not run, and the test station "stop shielding" defaults to the station test OK.

④I/O 画面

4. I/O screen



Emergency stop | Pause



本设备画面实时监控 PLC 输入输出的变化，画面中输入输出点指示红色为代表有信号输入，白色代表无信号输入。

The equipment screen monitors the PLC input and output changes in real time. The input and output points on the screen indicate for signal input and white for no signal input.

三．安全、操作、维护保养注意事项

3. Safety, operation and maintenance precautions

⊙轻拿轻放，小心损坏产品；

⊙ gently, careful to damage to the product;

⊙设备运行机器人动作时，禁止用手去接触设备动作的部分；

⊙ When the robot is operated by the equipment, it is forbidden to touch the parts of the equipment by hand;

⊙设备运行时，请及时更换 CELL 物料，以免影响设备正常生产；

⊙When the equipment is running, please repalce cell material in time to avoid to impact normal production;

⊙非本部门人员或者未授权修理人员,不得自行修理或者改造本设备;

⊙ No personnel of this department or unauthorized repair personnel shall repair or modify the equipment by themselves;

⊙长时间不使用时，请拔掉电源插头。

⊙ Unplug the power plug when it is not used for a long time.

⊙电源线老化、插头损坏应立即停止使用，必须由本部门人员或类似专职人员来更换。

⊙ power cable aging, should immediately stop using the plug is damaged it must be replaced by the full-time staff department personnel or the like.

⊙如工作期间长时间不需使用该设备,请将设备暂时切断电源，并保持通风良好。

⊙ such a long time without the use of the device during operation, connect the device to temporarily cut off the power, and maintain good ventilation.

⊙工作参数由 PE 设定，严禁其他人员擅自调整参数。

⊙ The working parameters are set by PE. It is forbidden for other personnel to adjust the parameters without authorization.

⊙丝杆与直线轨道每三个月进行加油润滑维护

⊙ screw and linear tracks lubrication maintenance every three months

四. 常见故障与排除方法

4. Common faults and troubleshooting

气缸异常—检查气缸磁性开关位置是否合适或损坏，设备机构是否卡料；

Cylinder abnormality - check whether the magnetic switch position of the cylinder is appropriate or damaged, and whether the device mechanism is stuck;

感应信号故障—物料状况异常,产品满料,感应器损坏都会出现感应信号故障提示;

Induction signal failure - Abnormal material conditions, product full of material, sensor damage will appear inductive signal failure prompts;

马达异常—检查线路是否短路，马达有没有卡住或者超出极限限位开关位置;

Motor abnormality - check if the circuit is short-circuited, the motor is stuck or the limit limit switch position is exceeded;

机器人故障—长按复位按钮或主画面按键，如无法解除异常机器人从新上电，出现不可排除异常请联系维护人员检修。

Robot fault—Press and hold the reset button or the main screen button for a long time. If it fails to release the error, if the robot is powered on again, an unresolvable error occurs. Contact the maintenance personnel for repairs.

五. 附件

5. Accessories

5.1 设备主要标准件/易损件清单

5.1 List of main standard parts/consumables of equipment

序号 No.	物料名称/规格 Material name/specification	单位 unit	供应商 supplier	易损等级 Vulnerability level	备注 Note
1	开关电源 Switching power supply	PCS	明纬 Ming Wei	★	
2	电磁阀 The electromagnetic valve	Pcs	SMC	★★	
3	启动按钮 start up button	Pcs	APT	★★★	
4	感应光纤线 Induction fiber optic cable	Pcs	基恩士/欧姆龙 Keynece/Omron	★★★	

注：1.螺丝、垫片等连接件，电线、端子、线耳等电气常规易损件不在此列。

Note: 1. Screws, gaskets and other connectors, electrical wires, terminals, wire ears and other electrical consumables are not included in this list.

2.易损等级说明如下：

2. The vulnerability level is as follows

：不会损坏，与设备同期寿命，易损因素可以不考虑；

★ : Will not be damaged, with the same period of equipment life, vulnerable factors can not be considered

★★:基本不会损坏,但频繁拆装调整可能会造成损坏,正常情况下可以不做备用;

★ ★: basically will not be damaged, but frequent disassembly adjustment may cause damage, under normal circumstances can not do standby;

★★★：随着使用环境的恶劣（脏污、高温、振动、摩擦、高频率作动等）会影响其使用寿命，可做适当备用品；

★ ★ ★: With the harsh environment of use (dirty, high temperature, vibration, friction, high frequency operation, etc.) will affect its useful life, you can make appropriate spare parts;

★★★★：消耗品，本身就是一种消耗，需定期做备品；

★★★★: Consumables are themselves a kind of consumption and they need to be prepared on a regular basis;

★★★★★：容易损坏，易破碎，需长期做备品。

★ ★ ★ ★ ★: easy to damage, easy to break, need to do long-term spare parts.

5.2 售后及其它

5.2 After-sales and other

售后热线：*********** ******

After-sale hotline: *********** ******

附录 2.欣旺达常用缩略词

缩写	全称	中文
ANSI	American National Standard Institute	美国国家标准协会
AQL	Acceptance Quality Level	可接受的质量标准/抽样检验标准
APE	Automation Planning Engineering	自动化规划部
AW	Artwork	艺术字体
AVL	approve vendor list	已通过供应商名单
AOI	Automated Optical Inspection	自动光学检验
BD	Barcode	二维码
BMU	battery monitor unit	电池管理单元
CQP	Commodity Quality Plan	产品质量计划
C/T	Cycle time	节拍时间
CPK	Process Capability Index	制程能力指数
CM	Contract Manufacture. Companies assembling Apple products	代工.苹果产品组装企业
CT	Contamination	脏污

CTQ	Critical To Quality	关键质量特性
CCTV	closed circuit television	闭路电视
CCD	charge-coupled device	CCD 图像传感器
COS	continue of supply	持续供应
CQR	component qualification report	组件认证报告
CTB	clear to build	净产出
CTF	critical to function	重要功能尺寸
DPPM	Defective parts per Million	每百万产品中的不良数
DFMEA	design process failure mode effection analysis	设计失效模式分析
DRI	Directly Responsible Individual	直接负责人
DVT	Design Validation Testing	设计验证测试
DT	Down time	停机时间
DT(D)	Dent（dot）	凹点
DT(L)	Dent（line）	凹痕
DC	Discoloration	变色
DF	Deformation	变形
DT(H)	Dent(hollow)	头部凹陷
DOE	Design Of Experiments	实验设计

DFM	Design For Management	设计管理/电子产品可制造性设计
ERS/D	Engineering Requirement Spec/ Document	工程需求规格/文件
EM	Exposed Metal	漏铝
EVT	Engineering Validation Testing	工程验证测试
EG	Excess Glue	溢胶
ES	Edge Shine	边缘发亮
ETA	Estimated Time of Arrival	估计到达时间
ESD	electro-static discharge	静电放电
ETD	estimated time of departure	预计出发日期
FPY	First Pass Yield	一次通过率
FAI	First Article Inspection	首件检验
FATP	Final Assembly Test & Pack	总装测试及打包
FA/CA	Failure Analysis and Corrective Action	不良分析及改善动作
FYI	For Your Information	供参考
FA	failure analysis	不良分析
FPC	flexiable printed circuit	软性印刷电路板
GRR	Gauge Repeatability & Reproducibility	量具的重复性及在线线性
HEV	hybrid electrical vehicle	混合动力汽车
IPQC	input process quality control	制程检验

IMS	Integrated Measurement System	综合测量系统
IR	Infrared Radiation	红外线发射
IQC	Incoming Quality Control	来料质量控制
KPI	key performance indicator	关键业绩指标
LWL/LPL/LOL/LC	Label Wrinkle/Peel/Overlap/Crack	头部胶褶皱/剥落/重叠/破损
MIH	Make In House	到场
MP	Mass Production	批量生产
MIL	Main issue List	设备问题列表
MCO	Mechanical Control Outline	机械控制概要
MSA	Measurement System Analysis	测量系统分析
NDA	non-disclosure agreement	保密协议
NTC	negative temperature coefficient	负温度系数
NL	No Label	无头部胶
NPI	New Product Introduction	新产品引进
OQC	Outgoing Quality Control	出货质量控制
ORT	Ongoing Reliability Test	可靠性测试
OBA	Out Of Box Audit	开箱检测
OK2use	OK to use	可以使用
Ok2 mini	OK to mini build	可以小批量生产

OK2 main	OK to main	主要的
Ok2s end	OK to send	可以送达
OIM	Optical Inspection Method	光学检查方法
OMM	Optical Measurement Method	光学测量方法
OEE	Overall Equipment Effectiveness	设备综合效率
OPL	One's point Lesson	个人经验
OOO	out of office	休假
OPA C	online public access catalog	联机公共检索目录
OPO	opening purshase order	开放订单数量
OQC	output quality control	出料检验
ORT	ongoing reliability test	产品可靠性测试
PVT	Production Validation Testing	生产验证测试
PMP	Process Management Plan	过程管理计划
PT（D)	Protrusion(dot)	凸点
PT(L)	Protrusion(line)	凸痕
PPG	Parallel Plate Gauge	平行金属板测量器
PCB	Printed circuit board	印刷电路板
PCM	protective circuit modul	保护电路模块
PFM	process failure mode and effection	过程失效模式分析

EA	analysis	
PHEV	plug-in hybrid electrical vehicle	插电式混合动力车
PO	purchase order	请购单
PPM	parts per million	百万分之…
PTC	possitive temperature coefficient	正温度系数
QAE	Quality Audit Engineer	质量审核工程师
QRD	Quality Requirements Document	质量要求文件
RCCA	Root Cause Corrective Action	根因及改善动作
ROI	Return on Investment	投资回报率
RP	Ramp	爬坡
RZ	Realize	实现
RF	Refine	精调
RFI	request for information	信息需求书
RFP	request for proposal	需求建议书
RFQ	request for quotation	报价需求书
RPN	risk priority number	风险优先系数
RSOC	rate state of charge	剩余电量百分比
RT	room temperature	室温
SPC	Statistical Process Control	统计过程控制
SOP	Standard Operating Procedure	标准作业程序

SQE	Supplier Quality Engineer	供应商质量工程师
SC	Scratch	划痕
SDI	systems documentation incorporated	全球服务与解决方案供应商
SEA	social and environmental acccountability	社会和环境责任
SIP	standard inspection procedure	产品检验规范
SOC	state of charge	剩余电量
SQM	supplier quality management	供应商品质管理
TPM	Technical Program Manager	项目技术管理
TBC	To Be Confirmed	待确定
TBD	To Be Determined	待决定
UPH	Unit Per Hour	单位时间产量
URL	uniform resource locator	全球资源定位器
VHB	very high bond	非常高强度的胶结
VMI	vendor managed inventory	供应商管理仓库

附录 3.机构设计及生产常用专业英语单词

assembly line 组装线

layout 布置图

conveyer 流水线物料板

screw driver 起子

OOBA 开箱检查

fit together 组装在一起

fasten 锁紧(螺丝)

fixture 夹具(治具)

pallet 栈板

fuse together 熔合

repair 修理

cosmetic inspect 外观检查

inner parts inspect 内部检查

thumb screw 大头螺丝

sheet metal parts 冲件

trolley 台车

sub-line 支线

punching machine 冲床

robot 机械手

hydraulic machine 油压机

lathe 车床

planer 刨床

miller 铣床

grinder 磨床

driller 钻床

linear cutting 线切割

electrical sparkle 电火花

welder 电焊机

riveting machine 铆合机

to apply oil 擦油

to file burr 锉毛刺

final inspection 终检

to connect material 接料

to reverse material 翻料

wet station 沾湿台

Tiana 天那水

cleaning cloth 抹布

to load material 上料

to unload material 卸料

to return material/stock to 退料

scraped 报废

scrape 刮削

oxidation 氧化

scratch 刮伤

dents　压痕

defective upsiding down　抽芽不良

defective to staking　铆合不良

embedded lump　镶块

feeding is not in place　送料不到位

stamping-missing　漏冲

proposal improvement　提案改善

spare parts=buffer 备件

forklift　叉车

trailer=long vehicle　拖板车

compound die　合模

die locker 锁模器

pressure plate=plate pinch 压板

bolt　螺栓

forklift　叉车

bridge crane　行车

缺陷

excessive defects　过多的缺陷

critical defect极严重缺陷

major defect　主要缺陷

minor defect 次要缺陷

not up to standard 不合规格

dimension/size is a little bigger 尺寸偏大(小)

cosmetic defect外观不良

slipped/slippery screw head 螺丝滑头

speckle 斑点

mildewed=moldy=mouldy 发霉

rust 生锈

deformation 变形

burr(金属)flash(塑件)毛边

poor staking 铆合不良

excessive gap 间隙过大

grease/oil stains 油污

inclusion 杂质

scratch 划伤

polishing/surface processing 表面处理

exposed metal/bare metal 金属裸露

material change, stock change 材料变更

feature change 特性变更

evaluation 评估

parameters 参数

rotating speed, revolution 转速

manufacture management 制造管理

abnormal handling 异常处理

production unit生产单位

lots of production 生产批量

steel plate钢板

roll material 卷料

automation 自动化

to stake/staking/riveting 铆合

add lubricating oil 加润滑油

argon welding 氩焊

冲压常词汇 vocabulary for stamping

stamping/press 冲压

punch press/dieing out press 冲床

feeder 送料机

rack/shelf/stack 料架

cylinder 油缸

robot 机械手

taker 取料机

conveyer belt 输送带

transmission rack 输送架

top stop 上死点

bottom stop下死点

one stroke 一行程

inch 寸动

to continue/cont. 连动

to grip(material) 吸料

location lump/locating piece/block stop 定位块

reset 复位

dent 压痕

scratch 刮伤

deformation 变形

filings 铁削

to draw holes 抽孔

abrasion 磨损

reverse angle /chamfer 倒角

to take apart a die 卸下模具

to load a die 装上模具

to tight a bolt 拧紧螺栓

to looser a bolt 拧松螺栓

to move away a die plate 移走模板

easily damaged parts 易损件

standard parts 标准件

breaking/(be)broken/(be)cracked 断裂

to lubricate 润滑

模具工程常用词汇（common vocabulary for die engineering)

die　　模具

punched hole　　冲孔

panel board镶块

to cut edges/side cut/side scrap　切边

to bending 折弯

to pull, to stretch　　拉伸

Line stretching/line pulling　线拉伸

spring 弹簧

bolt　　螺栓

plate　电镀

mold　　成型

steel/rolled steel 钢材

wire EDM　　线割

torch-flame cut火焰切割

stock locater block　　定位块

under cut=scrap chopper　　清角

male die　　公模

female die 母模

heat dissipation　　热传递

rack　　上料

degrease　　脱脂

Anodize 阳性处理

molding 成型

thermocouple　热电偶

sand blasting　喷沙

grit　砂砾

derusting machine　除锈机

degate　打浇口

concave 凸

convex　凹

nick　缺口

speck　瑕疵

检验量测工具用语

calibration　校准

caliper gauge　卡规

cylinder square　圆筒直尺

dial snap gauge　卡规

inside calipers　内卡钳

leveling block　平台

monometer　压力计

nonius　游标卡尺

passimeter　内径仪

protractor 分角器

radius 半径

ring gauge 环规

sine bar 正弦量规

snap gauge 卡模

square master 直角尺

模具钢材

alloy tool steel 合金工具钢

aluminium alloy 铝合金钢

bearing alloy 轴承合金

blister steel 浸碳钢

carbon tool steel 碳素工具钢

forging die steel 锻造模用钢

galvanized steel sheet 镀锌铁板

hard alloy steel 超硬合金钢

hot work die steel 热锻模用钢

molybdenum high speed steel 钼系高速钢

molybdenum steel 钼钢

nickel chromium steel 镍铬钢

prehardened steel 顶硬钢

silicon steel sheet 矽钢板

stainless steel 不锈钢

表面处理关连用语

age hardening 时效硬化

ageing 老化处理

air hardening 气体硬化

air patenting 空气韧化

annealing 退火

anode effect 阳极效应

anodizing 阳极氧化处理

austempering 奥氏体等温淬火

austenite 奥斯田体/奥氏体

bainite 贝氏体

carbide 炭化物

coarsening 结晶粒粗大化

decarburization 脱碳处理

decarburizing 脱碳退火

diffusion 扩散

diffusion annealing 扩散退火

full annealing 完全退火

gaseous cyaniding 气体氧化法

cementite 渗碳体

grain size 结晶粒度

hardening 硬化

heat treatment 热处理

low temperature annealing 低温退火

malleablizing 可锻化退火

martensite 马氏体/硬化铁炭

pearlite 珠光体组织

precipitation 析出

quench hardening 淬火

quenching stress 淬火应力

reconditioning 再调质

recrystallization 再结晶

residual stress 残留应力

retained austenite 残留奥氏体

segregation 偏析

stress relieving annealing 应力消除退火

supercooling 过冷

surface hardening 表面硬化处理

tempering 回火

tempering crack 回火裂痕

thermal refining 调质处理

thermoechanical treatment 加工热处理

vacuum hardening 真空淬火

vacuum heat treatment 真空热处理

vacuum nitriding 真空氮化

water quenching 水淬火

焊接用语

acetylene 乙炔

ampere 电流安培

angle welding 角焊

arc 电弧

argon arc welding 氩弧焊接

filler rod 焊条

fillet weld 填角焊接

hand face shield 手握面罩

metal electrode insert gas welding MIG 熔接

nugget 点焊熔核

overlaying 堆焊

pressure welding 压焊

seam 焊缝

spark 火花

spot welding 点焊接

stud arc welding 电弧焊接

weld line 焊接纹

weld mark　焊接痕

welding　　焊接

welding flux　　焊剂

caulking compound　填隙料

cell　　气孔

nozzle　喷嘴

模具常用刀具与工作法用语

adjustable spanner　　活动扳手

angle cutter　　角铣刀

buffing　　抛光

chamfering machine　　倒角机

chamfering tool　　去角刀具

chuck　　夹具

concave cutter 凹面铣刀

convex cutter　凸形铣刀

drill stand　　钻台

edge file　刃用锉刀

file　　锉刀

grinder　　砂轮机

hatching　　剖面线

hexagon headed bolt　　六角头螺栓

hexagon nut 六角螺帽

jack 千斤顶

nose angle 刀角

pinchers 钳子

plug 柱塞头

polisher 磨光器

punch 冲头

sand paper 砂纸

scraper 刮刀

screw driver 螺丝起子

scribing 划线

spanner 扳手

square 直角尺

square trowel 直角度

T-slot T 形槽

tool for lathe 车刀

tool point angle 刀刃角

tool post 刀架

tosecan 划线盘

trimming 去毛边

waffle die flattening 压纹效平

wiper 脱模钳

wrench 螺旋扳手

模具加工方法

barrel 滚筒(加工)

centering 定中心

cutting 切削

cylindrical lathe cutting 外圆车削

facing 面车削

filing 锉刀修润

hand finishing 手工修润

hemming 卷边加工

hobbing 滚齿加工

joggling 摇动加工

lapping 抛光/研磨修润

lathe cutting 车床车削

planning 刨削加工

polishing 抛亮光

reaming 铰孔修润

rough machining粗切削

rounding 圆形加工

sawing 锯削

scaling 清除钢碇缺陷

shaping 成形加工

skiving 表面研磨

slotting 切缝切削

taper turning 锥度车削

thread cutting 螺纹切削

ultrasonic machining 超音波加工

up cut milling 逆铣加工

学理实验与试验用语

air permeability test 透气性试验

Brinell hardness 布耐内尔硬度

Brinell hardness test 布氏硬度试验

Charpy impact test 夏比冲击试验

dart drop impact test 落锤冲击试验

fatigue test 疲劳试验

hot bend test 热弯试验

Rockweel hardness test 洛氏硬度试验

Rockweel hardness 洛氏威尔硬度

scratch hardness 抗刮硬度

shore hardness 萧氏硬度

tensile impact test 拉伸冲击试验

tensile strength 抗拉强度

thermal shock test 冷热剧变试验

torsion test　扭曲试验

Vicat indentation test　维卡针压陷试验

Vickers hardness test　维氏硬度试验

warpage test　翘曲试验

砂轮用语

abrasive　砂轮

Al203　氧化铝

bond　结合

buffing wheel　抛光布轮

dresser　砂轮整修机

endless grinding belt　循环式研磨带

finishing allowance　加工余量

grain　磨粒

grinding disc　研磨盘

mesh　网筛目

parameter　参数

slitting　切缝量

vitrified　陶瓷的

wheel　旋转

机械设计及周边其他用语

assembly drawing 装配图

auto tool change cycle 自动换刀时间周期

beam 横梁

bending moment 弯矩

bending stress 弯曲应力

bottoming 底靠

buckling 纵弯曲

chamfering 去角斜切

channel 凹槽

chattering 颤动

check point 查核点

chip 切屑

chip conveyor 排屑输送机

coefficient of friction 摩擦系数

cooling pipe 冷却管

distortion 扭曲变形

draft taper 拔模锥度

draw out 拉拔

fit tolerance 配合公差

flexible rigidity 弯曲刚性

gas vent 气孔

hatching 剖面线

heater cooler 加热器冷却装置

hook cavity　　钩穴

inching　　寸动

lug　　凸缘

maintenance　　维修保固

notch effect　　切口效果

out of roughness　　真圆度

performance　　动作性能

pit 坑 plane strain　　倒角应力

repeated load　重覆载荷

sand paper 砂纸

shift　偏移

shrinkage hole 缩孔

sinking　　凹陷

sketch 草图

spalling　　剥落

straightness　　直度

submarine　深陷式

surface roughness　表面粗度

tapping　　攻螺丝

thermocouple　　热电耦

torsion load　　扭转载荷

toughness　韧性

tracing　　描图

under cut　凹割

图纸常用词汇

nozzle　接管　喷嘴

Orientation　方位

lifting lug　吊耳

Name plate　铭牌

Grinding for smooth transition 打磨圆滑过渡

Eradicate　根除

Polish　磨光

Flange　法兰

Overlay　补堆

Shell　壳体

Reactor　反应器

pre-assemble　预组装

Catalyst　催化剂

Base template　基础模板

Solution outlet screen　出口过滤器

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