Mechanical Design,
Manufacturing and Automation English
Second edition

高等学校教材

机械设计制造及其自动化
专业英语

第二版

大学英语专业阅读教材编委会组织编写

马王录 刘东学 主编

蔡建国 主审

化学工业出版社

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·北京·

本教材的内容覆盖了机械设计制造及其自动化专业的基本内容。各单元之间，既有一定的内在联系，又独立成章，可根据不同学时数灵活选用。第二版保留了第一版的风格，对部分内容作了更换与调整，增加了如模具设计与制造、过程控制系统状态监测、精益制造等内容，使教材适应性更广，也更加通俗易懂。

本教材共分为三部分（Part），30 个单元（Unit）。第一部分为机械设计与制造的基本知识，包括金属材料、非金属材料、材料的力学性能、选材、金属材料热处理、机械及机械零件设计、制造工艺、加工设备、模具设计与制造、数控机床、热力学、流体力学、化工机器、质量保证与控制等。第二部分为自动控制的基本知识，其中包括控制原理、控制系统类型、反馈控制原理、过程控制、测量系统、传感器及信号转换、系统状态监测等。第三部分为现代先进制造技术，主要介绍机电一体化、计算机数控、机器人、计算机辅助制造、柔性制造系统、计算机集成制造、自动组装、敏捷制造、精益制造、大批量定制生产、虚拟制造、绿色产品制造等。

本教材可供机械工程及相关专业本科生使用，也可作为同等程度的专业技术人员的自学教材。

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第二版前言

出版系列专业英语教材是许多院校师生多年来共同的愿望。为满足面向21世纪高等教育改革的需要，化学工业出版社及时与原化工部教育主管部门和全国化工类相关专业教学指导委员会协商，组织全国十余所院校成立了大学英语专业阅读教材编委会。在经过必要的调研后，根据学校需求，编委会优先从各高校教学（交流）讲义中确定选题，同时组织力量开展编审工作。本套教材涉及的专业主要包括机械工程、化学工程与工艺、信息工程、工业自动化、应用化学及精细化工、生物工程、环境工程、材料科学与工程、制药工程等。

根据“全国部分高校化工类及相关专业大学英语专业阅读教材编审委员会”的要求和安排编写的《机械设计制造及其自动化专业英语》教材，可供机械工程及相关专业本科生使用，也可作为同等程度的专业技术人员的自学教材。

本教材共分为三部分（Part），30个单元（Unit）。第一部分为机械设计与制造的基本知识；第二部分为自动控制的基本知识；第三部分为提高部分，主要介绍现代先进制造技术。每个单元由主课文、主课文词汇表、课文注释、练习作业、阅读材料和阅读材料词汇表组成。书后还附有词汇总表。

本教材的内容覆盖了机械设计制造及其自动化专业的基本内容。材料均选自近年原版英文著作、教材、科技报告和专业期刊，并兼顾多种体裁以及英美的不同文风。各单元之间，既有一定的内在联系，又独立成章，可根据不同学时数灵活选用。

《机械设计制造及其自动化专业英语》教材自2001年5月出版以来，一直得到同行以及广大师生的支持和爱护。几年来，我们不断征求大家对本教材的意见和建议，根据调研情况以及我们的教学实践，修订了本教材。

机械设计制造及其自动化专业英语（第二版）对部分内容作了更换与调整，增加了如模具设计与制造、过程控制系统状态监测、精益制造等内容，使教材适应性更广，也更加通俗易懂。

本教材的修订工作主要由华东理工大学马玉录、周邵萍、李琳、洪瑛参加。上海交通大学蔡建国教授在教材的编写过程中给予了许多指导，提出了宝贵意见并审阅了全书，在此一并致以衷心的感谢。

限于作者水平，难免存在不足之处，我们热诚希望使用本书的广大师生提出宝贵意见。

编　者

2008年10月

第一版前言

出版系列专业英语教材是许多院校师生多年来共同的愿望。为满足面向21世纪高等教育改革的需要，化学工业出版社及时与原化工部教育主管部门和全国化工类相关专业教学指导委员会协商，组织全国十余所院校成立了大学英语专业阅读教材编委会。在经过必要的调研后，根据学校需求，编委会优先从各高校教学（交流）讲义中确定选题，同时组织力量开展编审工作。本套教材涉及的专业主要包括机械工程、化学工程与工艺、信息工程、工业自动化、应用化学及精细化工、生物工程、环境工程、材料科学与工程、制药工程等。

根据“全国部分高校化工类及相关专业大学英语专业阅读教材编审委员会”的要求和安排编写的《机械设计制造及其自动化专业英语》教材，可供机械工程及相关专业本科生使用，也可作为同等程度的专业技术人员的自学教材。

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本教材由华东理工大学马玉录和大连理工大学刘东学主编。第一部分由大连理工大学刘东学、谢洪勇、李惠荣、李惠玲、银建中编写，第二部分和第三部分由华东理工大学马玉录、周邵萍、李琳、洪瑛编写。上海交通大学的蔡建国教授审阅了全书，并提出了宝贵意见。在本书的编写过程中得到了大学英语专业阅读教材编委会、华东理工大学教务处和大连理工大学教务处的大力支持，华东理工大学研究生金彦、何晓薇、关建生、本科生郭永征在本书的录入过程中做了大量工作，在此一并谨致以衷心的感谢。

限于作者水平，难免存在不足之处，热诚希望使用本书的广大师生提出宝贵意见。

编　者

2001年5月

CONTENTS

PART Ⅰ FUNDAMENTALS OF MACHINE DESIGN & MANUFACTURING

Unit 1 Metals

The use of metals has always been a key factor in the development of the social systems of man. Of the roughly 100 basic elements of which all matter is composed, about half are classified as metals. The distinction between a metal and a nonmetal is not always clear cut. The most basic definition centers around the type of bonding existing between the atoms of the element, and around the characteristics of certain of the electrons associated with these atoms①. In a more practical way, however, a metal can be defined as an element which has a particular package of properties.

Metals are crystalline when in the solid state and, with few exceptions (e. g. , mercury), are solid at ambient temperatures. They are good conductors of heat and electricity and are opaque to light. They usually have a comparatively high density. Many metals are ductile——that is, their shape can be changed permanently by the application of a force without breaking. The forces required to cause this deformation and those required finally to break or fracture a metal are comparatively high, although, the fracture forces is not nearly as high as would be expected from simple considerations of the forces required to tear apart the atoms of the metal②.

One of the more significant of these characteristics from our point of view is that of crystallinity. A crystalline solid is one in which the constituent atoms are located in a regular three-dimensional array as if they were located at the corners of the squares of a three-dimensional chessboard③. The spacing of the atoms in the array is of the same order as the size of the atoms, the actual spacing being a characteristic of the particular metal. The directions of the axes of the array define the orientation of the crystal in space. The metals commonly used in engineering practice are composed of a large number of such crystals, called grains. In the most general case, the crystals of the various grains are randomly oriented in space. The grains are everywhere in intimate contact with one another and joined together on an atomic scale. The region at which they join is known as a grain boundary.

An absolutely pure metal (i. e. , one composed of only one type of atom) has never been produced. Engineers would not be particularly interested in such a metal even if it were to be produced, because it would be soft and weak. The metals used commercially inevitably contain small amounts of one or more foreign elements, either metallic or nonmetallic. These foreign elements may be detrimental, they may be beneficial, or they may have no influence at all on a particular property. If disadvantageous, the foreign elements tend to be known as impurities. If advantageous, they tend to be known as alloying elements. Alloying elements are commonly added deliberately even in substantial amounts in engineering materials. The result is known as an alloy.

The distinction between the descriptors "metal" and "alloy" is not clear cut. The term "metal" may be used to encompass both a commercially pure metal and its alloys. Perhaps it can be said that the more deliberately an alloying addition has been made and the larger the amount of the addition, the more likely it is that the product will specifically be called an alloy. In any event, the chemical composition of a metal or an alloy must be known and controlled within certain limits if consistent performance is to be achieved in service. Thus chemical composition have to be taken into account when developing an understanding of the factors which determine the properties of metals and their alloys.

Of the 50 or so metallic elements, only a few are produced and used in large quantities in engineering practice. The most important by far is iron, on which are based the ubiquitous steels and cast irons (basically alloys of iron and carbon). They account for about 98% by weight of all metals produced. Next in importance for structural uses (that is, for structures that are expected to carry loads) are aluminum, copper, nickel, and titanium. Aluminum accounts for about 0.8% by weight of all metals produced, and copper about 0.7%, leaving only 0.5% for all other metals. As might be expected, the remainder are all used in rather special applications. For example, nickel alloys are used principally in corrosion-and heat-resistant applications, while titanium is used extensively in the aerospace industry because its alloys have good combinations of high strength and low density. Both nickel and titanium are used in high-cost, high-quality applications, and, indeed, it is their high cost that tends to restrict their application.

We cannot discuss these more esoteric properties here. Suffice it to say that a whole complex of properties in addition to structural strength is required of an alloy before it will be accepted into, and survive in, engineering practice④. It may, for example, have to be strong and yet have reasonable corrosion resistance; it may have to be able to be fabricated by a particular process such as deep drawing, machining, or welding; it may have to be readily recyclable; and its cost and availability may be of critical importance.

Selected from "Metals Engineering A Technical Guide", Leonard E. Samuels, Carnes Publication Services, Inc., 1988.

New Words and Expressions

1. nonmetal [nɔn'metl] *n.* 非金属
2. crystalline ['kristəlain] *a.* 结晶性的，晶状的
3. ambient ['æmbiənt] *a.*；*n.* 周围的；周围环境
4. ambient temperature 室温，环境温度
5. opaque [əu'peik] *a.* 不透明的
6. ductile ['dʌktail] *a.* 延性的，易变形的，可塑的

7. deformation [diːfɔːˈmeiʃən] *n.* 变形
8. crystallinity [kristəˈliniti] *n.* （结）晶性，结晶度
9. constituent [kənˈstitjuənt] *a.*；*n.* 组成的，构成的；成分，组分
10. dimensional [daiˈmenʃənəl] *a.* 线（维）度的，…维的
11. orientation [ˌɔːrienˈteiʃən] *n.* 定向，定位，排列方向
12. grain [grein] *n.* 颗粒，晶粒
13. grain boundary 晶界
14. ubiquitous [juːˈbikwitəs] *a.* 处处存在的，普遍存在的
15. cast irons 铸铁
16. corrosion [kəˈrəuʒən] *n.* 腐蚀
17. esoteric [ˌesəuˈterik] *a.* 深奥的，奥秘的
18. fabricate [ˈfæbrikeit] *vt.* 制造加工

Notes

① 参考译文："最基本的定义集中在元素原子间存在的连接形式和与这些原子相关联的电子的确定特性"。这里 associated with 的意思是"与……有关系"。

② 参考译文："引起永久变形所需的力和最终使金属断裂所需的力相当大，尽管发生断裂所需的力没有像所预期的撕开金属原子所需的力那么大"。

③ 参考译文："结晶固体是这样一种结构，组成它的原子定位在规则的三维排列中，仿佛位于三维棋盘的方格的角上"。此句的时态表达是因由 as if 引导的从句要求的虚拟语句所致。

④ 参考译文："在合金材料被采用和应用于工程实际之前，除需要掌握其结构强度外，还需知道它的综合性质就够了"。Suffice it to say that，意思为："（只要）说……就够了"。

Exercises

1. Answer the following questions according to the text.

① How many basic elements are classified as metal?

② What is a crystalline solid?

③ Which metallic elements are produced and used in large quantities in engineering practice?

④ What requirements are met before an alloy will survive in engineering practice?

2. Translate the 6th paragraph into Chinese.

3. Put the following into Chinese.

aluminum　copper　nickel　titanium　structural strength　deep drawing

4. Put the following into English.

定义　力　轴　非金属　结构　载荷　用途　性质

5. Put the following sentences into English.

① 金属和非金属的差异一般很难界定。

② 即使绝对纯金属可以生产出来，工程师们对它并不特别感兴趣。

③ 在50种左右的金属元素里，工程实践中只有少数金属被大量生产和使用。

Reading Material 1

Stainless Steels

Stainless steels do not rust in the atmosphere as most other steels do. The term "stainless" implies a resistance to staining, rusting, and biting in the air, moist and polluted as it is, and generally defines a chromium content in excess of 11% but less than 30%. And the fact that the stuff is "steel" means that the base is iron.

Stainless steels have room-temperature yield strengths that range from 205 MPa (30 ksi) to more than 1,725 MPa (250 ksi). Operating temperatures around 750℃ (1,400℉) are common, and in some applications temperatures as high as 1090℃ (2,000℉) are reached. At the other extreme of temperature some stainless steels maintain their toughness down to temperatures approaching absolute zero.

With specific restrictions in certain types, the stainless steels can be shaped and fabricated in conventional ways. They can be produced and used in the as-cast condition; shapes can be produced by powder-metallurgy techniques; cast ingots can be rolled or forged (and this accounts for the greatest tonnage by far). The rolled product can be drawn, bent, extruded, or spun. Stainless steel can be further shaped by machining, and it can be joined by soldering, brazing, and welding. It can be used as an integral cladding on plain carbon or low alloy steels.

The generic term "stainless steel" covers scores of standard compositions as well as variations bearing company trade names and special alloys made for particular applications. Stainless steels vary in their composition from a fairly simple alloy of, essentially, iron with 11% chromium, to complex alloys that include 30% chromium, substantial quantities of nickel, and half a dozen other effective elements. At the high-chromium, high-nickel end of the range they merge into other groups of heat-resisting alloys, and one has to be arbitrary about a cutoff point. If the alloy content is so high that the iron content is about half, however, the alloy falls outside the stainless family. Even with these imposed restrictions on composition, the range is great, and naturally, the properties that affect fabrication and use vary enormously. It is obviously not enough to specify simply a "stainless steel" .

The various specifying bodies categorize stainless steels according to chemical composition and other properties. For example, the American Iron and Steel Institute (AISI) lists more than 40 approved wrought stainless steel compositions; the American Society for Testing and Materials (ASTM) calls for specifications that may conform to AISI compositions but additionally require certain mechanical properties and dimensional tolerances; the Alloy Casting Institute (ACI) specifies compositions for cast stainless steels within the categories of corrosion-and heat-resisting alloys; the Society of Automotive Engineers (SAE) has adopted AISI and ACI compositional specifications. Military specification MIL-HDBK-5 lists design values. In addition, manufacturers' specifications are used for special purposes or for proprietary alloys. Federal and military specifications and manufacturers' specifications are laid down for special purposes and sometimes acquire a general acceptance.

However, all the stainless steels, whatever specifications they conform to, can be conveniently classified into six major classes that represent three distinct types of alloy constitution, or structure. These classes are ferritic, martensitic, austenitic, manganese-substituted austenitic, duplex austenitic-ferritic, and precipitation-hardening.

Ferritic Stainless steel is so named because the crystal structure of the steel is the same as that of iron at room temperature. The alloys in the class are magnetic at room temperature and up to their Curie temperature [about 750℃ (1,400°F)]. Common alloys in the ferritic class contain between 11% and 29% chromium, no nickel, and very little carbon in the wrought condition. The 11% ferritic chromium steels, which provide fair corrosion resistance and good fabrication at low cost, have gained wide acceptance in automotive exhaust systems, containers, and other functional applications. The intermediate chromium alloys, with 16%～17% chromium, are used primarily as automotive trim and cooking utensils, always in light gages, their use somewhat restricted by welding problems. The high-chromium steels, with 18% to 29% chromium content, have been used increasingly in applications requiring a high resistance to oxidation and, especially, to corrosion. These alloys contain either aluminum or molybdenum and have a very low carbon content.

The high-temperature form of iron (between 910℃ and 1,400℃, or 1,670°F and 2,550°F) is known as austenite (Strictly speaking the term austenite also implies carbon in solid solution). The structure is nonmagnetic and can be retained at room temperature by appropriate alloying. The most common austenite retainer is nickel. Hence, the traditional and familiar austenitic stainless steels have a composition that contains sufficient chromium to offer corrosion resistance, together with nickel to ensure austenite at room temperature and below. The basic austenitic composition is the familiar 18% chromium, 8% nickel alloy. Both chromium and nickel contents can be increased to improve corrosion resistance, and additional elements (most commonly molybdenum) can be added to further enhance corrosion resistance.

The justification for selecting stainless steel is corrosion and oxidation resistance. Stainless steels possess, however, other outstanding properties that in combination with corrosion resistance contribute to their selection. These are the ability to develop very high strength through heat treatment or cold working; weldability; formability; and in the case of austenitic steels, low magnetic permeability and outstanding cryogenic mechanical properties.

The choice of a material is not simply based on a single requirement, however, even though a specific condition (for example, corrosion service) may narrow the range of possibilities. For instance, in the choice of stainless steel for railroad cars, while corrosion resistance is one determining factor, strength is particularly significant. The higher price of stainless steel compared with plain carbon steel is moderated by the fact that the stainless has about twice the allowable design strength. This not only cuts the amount of steel purchased, but by reducing the dead weight of the vehicle, raises the load that can be hauled. The same sort of reasoning is even more critical in aircraft and space vehicles.

But weight saving alone may be accomplished by other materials, for examples, the high-strength low-alloy steels in rolling stock and titanium alloys in aircraft. Thus, the selection of a material involves a careful appraisal of all service requirements as well as a consideration of the ways in which the required parts can be made. It would be foolish to select material on the basis of its predicted performance if the required shape could be produced only with such difficulty that cost skyrocketed.

The applicability of stainless steels may be limited by some specific factor, for example, an embrittlement problem or susceptibility to a particular corrosive environment. In general terms, the obvious limitations are:

① In chloride environments susceptibility to pitting or stress-corrosion cracking requires careful appraisal. One cannot blindly assume that a stainless steel of some sort will do. In fact, it is possible that no stainless will serve.

② The temperature of satisfactory operation depends on the load to be supported, the time of its application, and the atmosphere. However, to offer a round number for the sake of marking a limit, we suggest a maximum temperature of 870℃ (1600℉). Common stainless steels can be used for short times above this temperature, or for extended periods if the load is only a few thousand pounds per square inch. But if the loads or the operating periods are great, then more exotic alloys are called for.

Selected from "Stainless Steel", R. A. Lula, American Society for Metals, 1986.

New Words and Expressions

1. as-cast [æz'kɑːst] *a.* 铸态的
2. powder-metallurgy ['paudəme'tælədʒi] *n.* 粉末冶金学
3. cast ingot [kɑːst iŋgət] *n.* 铸锭
4. roll [rəul] *v.* 轧制
5. tonnage ['tʌnidʒ] *n.* （总）吨位
6. extrude [eks'truːd] *v.* 挤压
7. spin [spin] *v.* 旋压
8. solder ['sɔːldə] *vt.* 钎焊
9. braze [breiz] *vt.* 铜焊
10. cladding ['klædiŋ] *n.* 包层，覆盖，（金属）覆层
11. wrought [rɔːt] *a.* 可锻的
12. American Iron and Steel Institute (AISI) 美国钢铁学会
13. American Society for Testing and Materials (ASTM) 美国材料试验学会
14. Alloy Casting Institute (ACI) 合金铸造学会
15. Society of Automotive Engineers (SAE) 美国汽车工程师学会

16. ferritic [fəˈritik] *a.* 铁素体的
17. martensitic [mɑːˈtenzaitik] *a.* 马氏体的
18. austenitic [ˌɔːstəˈnitik] *a.* 奥氏体的
19. oxidation [ɔksiˈdeiʃən] *n.* 氧化
20. cryogenic [ˈkraiədʒenik] *a.* 低温的，深冷的

Unit 2 Selection of Construction Materials

There is not a great difference between "this" steel and "that" steel; all are very similar in mechanical properties. Selection must be made on factors such as hardenability, price, and availability, and not with the idea that "this" steel can do something no other can do because it contains 2 percent instead of 1 percent of a certain alloying element, or because it has a mysterious name. A tremendous range of properties is available in any steel after heat treatment; this is particularly true of alloy steels.

Considerations in Fabrication

The properties of the final part (hardness, strength, and machinability), rather than properties required by forging, govern the selection of material. The properties required for forging have very little relation to the final properties of the material; therefore, not much can be done to improve its forgeability. Higher-carbon steel is difficult to forge. Large grain size is best if subsequent heat treatment will refine the grain size.

Low-carbon, nickel-chromium steels are just about as plastic at high temperature under a single 520ft • lb (1ft • lb = 1. 355,82J) blow as plain steels of similar carbon content. Nickel decreases forgability of medium-carbon steels, but has little effect on low-carbon steels. Chromium seems to harden steel at forging temperatures, but vanadium has no discernible effect; neither has the method of manufacture any effect on high-carbon steel.

Formability

The cold-formability of steel is a function of its tensile strength combined with ductility. The tensile strength and yield point must not be high or too much work will be required in bending; likewise, the steel must have sufficient ductility to flow to the required shape without cracking. The force required depends on the yield point, because deformation starts in the plastic range above the yield point of the steel. Work-hardening also occurs here, progressively stiffening the metal and causing difficulty, particularly in the low-carbon steels.

It is quite interesting in this connection to discover that deep draws can sometimes be made in one rapid operation that could not possibly be done leisurely in two or three①. If a draw is half made and then stopped, it may be necessary to anneal before proceeding, that is, if the piece is given time to work-harden. This may not be a scientific statement, but it is actually what seems to happen.

Internal Stresses

Cold forming is done above the yield point in the work-hardening range, so internal stresses can be built up easily. Evidence of this is the springback as the work leaves the forming operation and the warpage in any subsequent heat treatment. Even a simple washer might, by virtue of the internal stresses resulting from punching and then flattening, warp severely during heat treating②.

When doubt exists as to whether internal stresses will cause warpage, a piece can be checked by heating it to about 1,100°F and then letting it cool. If there are internal stresses, the piece is likely to deform. Pieces that will warp severely while being heated have been seen, yet the heat-treater was expected to put them through and bring them out better than they were in the first place.

Welding

The maximum carbon content of plain carbon steel safe for welding without preheating or subsequent heat treatment is 0.30%. Higher-carbon steel is welded every day, but only with proper preheating. There are two important factors: (1) the amount of heats that is put in; (2) the rate at which it is removed.

Welding at a slower rate puts in more heat and heats a large volume of metal, so the cooling rate due to loss of heat to the base metal is decreased. A preheat will do the same thing. For example, SAE 4,150 steel, preheated to 600°F or 800°F, can be welded readily. When the flame or arc is taken away from the weld, the cooling rate is not so great, owing to the higher temperature of the surrounding metal, and slower cooling results. Even the most rapid air-hardening steels are weldable if preheated and welded at a slow rate.

Machinability

Machinability means several things. To production men it generally means being able to remove metal at the fastest rate, leave the best possible finish, and obtain the longest possible tool life③. Machinability applies to the tool-work combination.

It is not determined by hardness alone, but by the toughness, microstructure, chemical composition, and tendency of a metal to harden under cold work. In the misleading expression "too hard to machine", the work "hard" is usually meant to be synonymous with "difficult" . Many times a material is actually too soft to machine readily. Softness and toughness may cause the metal to tear and flow ahead of the cutting tool rather than cut cleanly. Metals that are inherently soft and tough are sometimes alloyed to improve their machinability at some sacrifice in ductility. Examples are use of lead in brass and of sulfur in steel.

Machinability is a term used to indicate the relative ease with which a material can be machined by sharp cutting tools in operations such as turning, drilling, milling, broaching, and reaming.

In the machining of metals, the metal being cut, the cutting tool, the coolant, the process and type of machine tool, and the cutting conditions all influence the results. By changing any one of these factors, different results will be obtained. The criterion upon which the ratings listed are based is the relative volume of various materials that may be removed by turning under fixed conditions to produce an arbitrary fixed amount of tool wear.

Selected from "Modern Manufacturing Process Engineering", Benjamin W. Niebel, *et al.* , McGraw-Hill Publishing Company, 1989.

New Words and Expressions

1. availability [əˌveiləˈbiliti] *n.* 可用性，有效性，可得性

2. fabrication [ˌfæbriˈkeiʃən] *n.* 制造
3. forgeability [ˈfɔːdʒəˈbiliti] *n.* 可锻性
4. nickel [ˈnikl] *n.* 镍
5. chromium [ˈkroumjəm] *n.* 铬
6. vanadium [vəˈneidiəm] *n.* 钒
7. discernible [diˈsəːnəbl] *a.* 可辨别得出的，可看出的
8. ductility [dʌkˈtiliti] *n.* 延（展）性
9. cracking [ˈkrækiŋ] *n.* 开裂，裂纹，裂缝
10. work-harden 加工硬化，冷作硬化
11. anneal [əˈniːl] *n.*；*v.* 退火
12. warp [wɔːp] *v.* 翘曲，变形
13. preheat [priːˈhiːt] *v.* 预热
14. microstructure [ˈmaikrəuˈstrʌktʃə] *n.* 显微结构
15. mislead [misˈliːd] *vt.* 使……误解
16. ream [riːm] *vt.* （用铰刀）铰孔
17. arbitrary [ˈɑːbitrəri] *a.* 任意的

Notes

① in this connection 意思为在这方面。deep draws，深度拉伸。参考译文：“在这方面，相当有趣的是你将发现有时可通过一次快速加载完成深度拉伸，但以缓慢的方式两三次加载却不能实现。”

② 参考译文：“即使是一个简单的垫圈，由于打孔和随后的平整加工中产生内应力，也会在热处理中呈现严重的翘曲。”

③ 参考译文：“对于（机械加工）工人来说，可加工性通常意味着能够以最快的速度切削工件，获得最好的表面光洁度，并使刀具保持最长的使用寿命。”

Exercises

1. After reading the text above, write a summary of it.
2. Answer the following questions.

① What basic concepts assist the production-design engineer in the selection of steel?

② What is the most important factor in selection of material when a series of manufacturing process is needed?

③ Which mechanical property or behavior is most important for the formability of the materials?

④ How can a piece of steel be checked to determine whether internal stresses will cause warpage?

3. Translate the 1st paragraph into Chinese.
4. Put the following into Chinese