科技英语丛书

English for Mechanics

机械专业英语

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中国科学技术大学出版社

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内 容 简 介

本书为专业英语教材，详细介绍了机械相关专业所涉及的金属材料及热加工、金属切削机床与切削原理、几何公差与配合、机械电子、液压传动、CAD/CAE/CAPP/CAM、先进制造技术、机械工程文献介绍及英文写作等内容，力求使读者既能全面地了解到重要的专业知识，又能切实地提高其专业英语的阅读和应用水平。

本书可作为高等院校机械工程、机械设计制造及自动化、机电一体化、工业工程、材料成型及控制工程等专业的本科生和研究生学习机械专业英语的教材，也可以作为工厂企业从事机械设计、机械制造工作的工程技术人员或管理者的英语学习教材或参考书。

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前　言

本书为科技英语系列教材之一。全书共分为7个单元，每个单元包含4～6课，每课供2个学时使用。各专业可以适当节选内容，以满足各自不同的教学要求。教材内容主要涉及金属材料及热加工、金属切削机床与切削原理、几何公差与配合、机械电子、液压传动、CAD/CAE/CAPP/CAM、先进制造技术、机械工程文献介绍及英文写作等。

本书资料新颖，内容涵盖面广，既可作为高等院校机械工程、机械设计制造及自动化、机电一体化、工业工程、材料成型及控制工程等专业的研究生和本科生学习机械专业英语的教材，也可作为工厂企业从事机械设计、机械制造工作的工程技术人员和管理者的英语学习教材或参考书。

本书课文全部节选自欧美文献原著。为保持原著的语言风格，编者对选材一般只作删节，不作改写。对原著中采用的各种计量单位及图样标注均不作改动。本书原稿曾作为“机械专业英语”选修课校内讲义供高年级本科生和工程硕士生使用了多年，在听取了有关老师和学生的意见和建议后，我们对书稿又作了较大的增删与修改，直至成书。

本书由安徽工业大学汪永明任主编，对全书各章节进行了多次审稿、改稿和统稿。本书的 Unit 1、Unit 2 (Lesson 8)、Unit 5 (Lesson 17～18)、Unit 6 和 Unit 7 由汪永明编写，Unit 2 (Lesson 5～7) 由单建华编写，Unit 3 由叶晔编写，Unit 4 由邓克编写，Unit 5 (Lesson 19～20) 由俞金众编写。全书由安徽工业大学余晓流教授主审，他对教材的编写大纲、编写内容及特点等方面提出了许多宝贵的意见。

本书在编写过程中得到了安徽工业大学机械工程学院领导和同仁的大力支持和帮助，参考了国内外学者、专家的有关文献。在此，谨向他们表示衷心感谢。

限于编者的水平，书中不足或错误之处在所难免，恳请读者批评指正。

编　者

2011 年 9 月

Contents

Unit 1 Metallic Material & Hot Working

Lesson 1 Metallic Material

1 Introduction

1.1 Historical Perspective

Materials are so important in the development of civilization that we associate Ages with them. In the origin of human life on earth, the Stone Age, people used only natural materials, like stone, clay, skins, and wood. When people found copper and how to make it harder by alloying, the Bronze Age started about 3000 BC. The use of iron and steel, a stronger material that gave advantage in wars started at about 1200 BC. The next big step was the discovery of a cheap process to make steel around 1850, which enabled the railroads and the building of the modern infrastructure of the industrial world.

1.2 Materials Science and Engineering

Understanding of how materials behave like they do, and why they differ in properties was only possible with the atomistic understanding allowed by quantum mechanics, that first explained atoms and then solids starting in the 1930s. The combination of physics, chemistry, and the focus on the relationship between the properties of a material and its microstructure is the domain of Materials Science. The development of this science allowed designing materials and provided a knowledge base for the engineering applications (Materials Engineering).

Structure:

- At the atomic level: arrangement of atoms in different ways. (Gives different properties for graphite than diamond both forms of carbon.);
- At the microscopic level: arrangement of small grains of material that

can be identified by microscopy. (Gives different optical properties to transparent vs. frosted glass.)

Properties are the way the material responds to the environment. For instance, the mechanical, electrical and magnetic properties are the responses to mechanical, electrical and magnetic forces, respectively. Other important properties are thermal (transmission of heat, heat capacity), optical (absorption, transmission and scattering of light), and the chemical stability in contact with the environment (like corrosion resistance).

Processing of materials is the application of heat (heat treatment), mechanical forces, etc., to affect their microstructure and, therefore, their properties.

1.3 Why Study Materials Science and Engineering?

- To be able to select a material for a given use based on considerations of cost and performance;
- To understand the limits of materials and the change of their properties with use;
- To be able to create a new material that will have some desirable properties.

All engineering disciplines need to know about materials. Even the most "immaterial", like software or system engineering depend on the development of new materials, which in turn alter the economics, like software-hardware trade-offs. Increasing applications of system engineering are in materials manufacturing (industrial engineering) and complex environmental systems.

1.4 Classification of Materials

Like many other things, materials are classified in groups, so that our brain can handle the complexity. One could classify them according to structure, or properties, or use. The one that we will use is according to the way the atoms are bound together:

Metals: Valence electrons are detached from atoms, and spread in an "electron sea" that "glues" the ions together. Metals are usually strong, conduct electricity and heat well and are opaque to light (shiny if polished). Such as aluminum, steel, brass, gold.

Semiconductors: The bonding is covalent (electrons are shared between atoms). Their electrical properties depend extremely strongly on minute proportions of contaminants. They are opaque to visible light but transparent to the infrared. Such as Si, Ge, Ga, As.

Ceramics: Atoms behave mostly like either positive or negative ions, and are bound by Coulomb forces between them. They are usually combinations of metals or semiconductors with oxygen, nitrogen or carbon (oxides, nitrides, and carbides). Such as glass, porcelain, many minerals.

Polymers: They are bound by covalent forces and also by weak Van der Waals forces, and usually based on H, C and other non-metallic elements. They decompose at moderate temperatures (100℃ ~ 400℃), and are lightweight. Other properties vary greatly. Examples: plastics (nylon, teflon, polyester) and rubber.

Other categories are not based on bonding. A particular microstructure identifies composites, made of different materials in intimate contact (Such as fiberglass, concrete, wood) to achieve specific properties. Biomaterials can be any type of material that is biocompatible and used, for instance, to replace human body parts.

1.5 Advanced Materials

Materials used in "High-Tec" applications, usually designed for maximum performance, and normally expensive. Examples are titanium alloys for supersonic airplanes, magnetic alloys for computer disks, special ceramics for the heat shield of the space shuttle, etc.

1.6 Modern Material's Needs

- Engine efficiency increases at high temperatures: requires high temperature structural materials;
- Use of nuclear energy requires solving problem with residues, or advances in nuclear waste processing;
- Hypersonic flight requires materials that are light, strong and resist high temperatures;
- Optical communications require optical fibers that absorb light negligibly;

- Civil construction-materials for unbreakable windows;
- Structures: materials that are strong like metals and resist corrosion like plastics.

2 Metallic Material

It is known that metals are very important in our life. Metals have the greatest importance for industry. All machines and other engineering constructions have metal parts, some of them consist only of metal parts.

There are two large groups of metals:

(1) Simple metals — more or less pure chemical elements;

(2) Alloys — materials consisting of a simple metal combined with some other elements.

About two thirds of all elements found in the earth are metals, but not all metals may be used in industry[1]. (see Appendix of Lesson 30) Those metals which are used in industry are called engineering metals. The most important engineering metal is iron (Fe), which in the form of alloys with carbon (C) and other elements, finds greater use than any other metals. Metals consisting of iron combines with some other elements are known as ferrous metals[2], all the other metals are called nonferrous metals. The most important nonferrous metals are copper (Cu), aluminum (Al), lead (Pb), zinc (Zn), tin (Sn), but all these metals are used much less than ferrous metals, because the ferrous metals are much cheaper.

Engineering metals are used in industry in the form of alloys because the properties of alloys are much better than the properties of pure metals. Only aluminum may be largely used in the form of a simple metal. Metals have such a great importance because of their useful properties or their strength, hardness, and plasticity.

Different metals are produced in different ways, but almost all the metals are found in the form of metals ore (iron ore, copper ore, etc.).

The ore is a mineral consisting of a metal combined with some impurities. In order to produce a metal from some metal ore, we must separate these impurities from the metal that is done by metallurgy.

There are many different material types to choose from when undertaking a project. For the purposes of our discussion, the materials are grouped roughly into two categories, these being "Non-metallic" and "Metallic". In respect to metallic materials these are then subsequently grouped into two groups being ferrous and non-ferrous. Each of the materials has their own characteristics and requires different machining techniques. Careful consideration needs to be given to the correct material selection for its application. (Definition: ferrous as in containing iron, e. g. , steel Non-ferrous as in not containing iron, e. g. , aluminum, copper.) A simple test for ferrous/non-ferrous materials is to use magnet as a magnet will sick to ferrous materials due to its iron content.

2.1 Aluminum Alloy

There are many kinds of alloys to choose from but often, aluminum is chosen as it is lightweight (about 2700 kg/m^3 density), it is comparatively soft and its process-ability is good. From a machining viewpoint pure aluminum (JIS A1000) greatly differs from Al-Cu alloy (JIS A2000).

Pure aluminum is easy to bend but it is difficult to process as it is too soft and easily clogs cutting tools. On the other hand, the Al-Cu alloy, such as A2011 or A2017 (as shown in Fig. 1. 1) is easy to handle and cut with several of the grades having strength similar to that of steel. However, one of the drawbacks of aluminum is that it is difficult to weld, solder and bend.

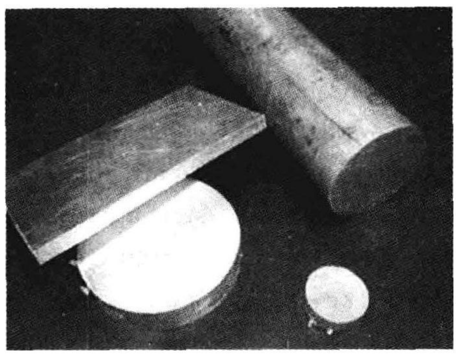

Fig. 1. 1 Aluminum Alloy (JIS A2017)

It is very difficult to distinguish between the pure aluminum, the Al-Cu alloy, etc. When they are cutting with a machine, we may recognize the material.

2.2 Stainless Steel

A typical stain less steel is JIS SUS304, as shown in Fig. 1. 2. The benefits of stainless steel is that it has high strength, great heat-resistance, and it resists staining e. g. rust. Due to its high resistance to heat it makes an ideal material for mechanical parts that are subjected to heating such as a heater of a stirling engine. Also, due to the materials resistance to rusting, it is ideal for use where

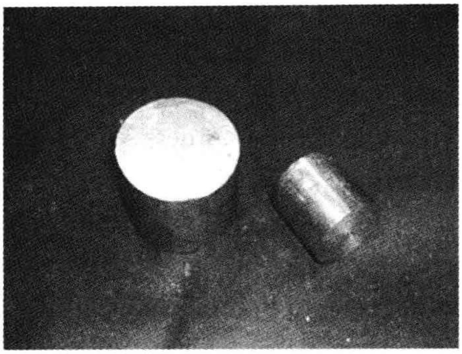

Fig. 1.2　Stainless Steel(JIS SUS304)

it is exposed to water. Other examples of its use is in drive shafts where both strength and corrosion resistance is needed.

Stainless steel tends to be a bit sticky in respect to cutting and machining and as it is a relatively hard material it tends to shorten the life of the cutting tools being used. Such cutting tools need to be sharpened often particularly in prolonged cutting operations. Stainless steel can usually be identified by its glossy silver colour.

2.3　Carbon Steel

Typical carbon steel materials are JIS S45C (as shown in Fig. 1. 3) and JIS SS400. They are very cheap, excelling in weld ability, and they can be subjected to various heat treatments. Since many machine tools are designed to cut mild steel material, it is very rare to encounter problems while machining.

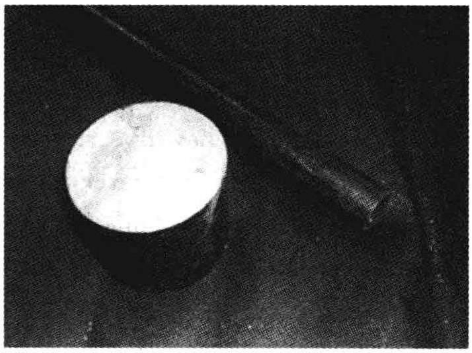

Fig. 1.3　Carbon Steel (JIS S45C)

I hardly use mild steel apart from cases where welding is required as I mostly make experimental models as therefore issues such as low manufacturing costs are not a consideration in the work that I do.

Generally, mild steel has a black surface and this surface is very hard, if possible, this surface should be left intact as it offers additional protection.

2.4　Brass

Brass is an alloy which is made from a combination of copper and zinc as the main ingredients, as shown in Fig. 1. 4. In compared with carbon steel or stainless steel, the machine-ability of brass is good, and it also has good soldering properties.

Brass is very heavy due to its high density so it is ideal for heavy parts, such as a flywheel or balance weight for model engines.

Brass is prized for the highly polished finish it can produce however, since brass surface will oxidise when exposed to the elements, it preferable to apply a clear lacquer protective coating.

Brass is very expensive when compared to other materials so it is used very selectively.

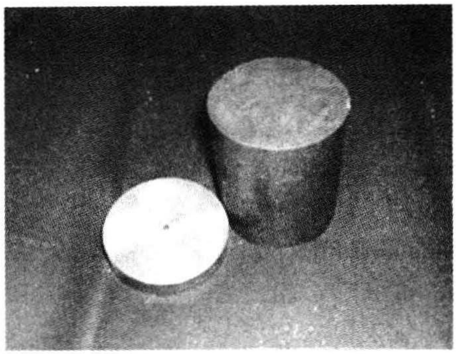

Fig. 1.4 Brass (JIS C2800)

3 Material Identification

Usually, a billet (column) of material is sold in unit lengths of 1 to 2 meters (or more). These billets typically carry the material identification written on the end of the billet as seen in the photos on the right, as shown in Fig. 1. 5. As the billet is usually cut to provide the work piece, take care to cut from the end opposite the markings so as to leave the markings for subsequent identification.

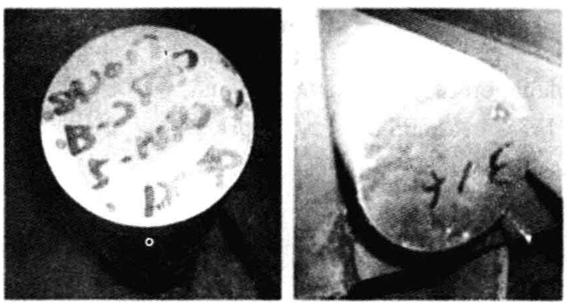

Fig. 1.5 Material Indication

Vacabulary

metal ['metəl] n. 金属

construction [kən'strʌkʃən] n. 结构

combine ... with　把……和……结合(起来)
iron [ˈaiən]　n. 铁
carbon [ˈkɑːbən]　n. 碳;石墨
ferrous [ˈferəs]　adj. 亚铁的;铁的，含铁的
ferrous metals　黑色金属
non-ferrous metals　有色金属
copper [ˈkɔpə]　n. 铜
aluminum [əˈljuːminəm]　n. 铝
lead [liːd]　n. 铅
zinc [ziŋk]　n. 锌
tin [tin]　n. 锡
metallurgical [ˌmetəˈləːdʒik, -kəl]　adj. 冶金的;冶金学的
strength [streŋθ]　n. 强度;实力
hardness [hɑːdnis]　n. 硬度
plasticity [plæsˈtisiti]　n. 塑性，可塑性;适应性;柔软性
ore [ɔː]　n. 矿;矿沙(石)
impurity [imˈpjuərəti]　n. 杂质;不纯
mineral [ˈminərəl]　adj. 矿物的;矿质的　n. 矿物;(英)矿泉水;无机物
brass [brɑːs, bræs]　n. 黄铜;黄铜制品;铜管乐器;厚脸皮

Notes

[1]　About two thirds of all elements found in the earth are metals 中，found in the earth 是过去分词短语，作 all elements 的后置定语，可译为:地球上发现的各种元素。而 two thirds 是指“三分之二”，故全句可译为:在地球上发现的各种元素中大约三分之二是金属元素，但并不是所有的金属都能够用于工业上。

[2]　Metals consisting of iron combined with some other elements are known as ferrous metals 中，consisting of 是短语动词的现在分词形式，与其后面的宾语组成现在分词短语，作 metals 的后置定语。本句的短语动词是 are know as。因此本句可译为:由铁跟某种其他元素相结合组成的金属称为黑色金属。

Exercises

1. Give an explanation of the following terms:
   oxidise　　brass　　mild steel　　work piece
2. List the classification of materials.
3. List the types of metal.
4. What is the difference between non-ferrous metal and ferrous metal?

Lesson 2　Mechanical Properties of Metallic Material

1　Kinds of Steel

There are two general kinds of steels: carbon steel and alloy steel. Carbon steel contains only iron and carbon, while alloy steel contains some other alloying elements such as nickel, chromium, manganese, molybdenum, tungsten, vanadium, etc.

(1) Carbon steels

① Low carbon steel containing from 0.05 to 0.15 percent carbon; this steel is also known as machine steel.

② Medium carbon steel containing from 0.15 to 0.60 percent carbon.

③ High carbon steel containing from 0.6 to 1.50 percent carbon, which is sometimes called "tool steel".

(2) Alloy steels

① Special alloy steel, such as nickel steel, chromium steel.

② High speed steel also known as self-hardening steel[1].

Carbon steels are the most common steels used in industry. The properties of these steels depend only on the percentage of carbon they contain. Low carbon steels are very soft and can be used for bolts and for machine parts that do not need strength.

Medium carbon steel is a better grade and stronger than low carbon steel. It is also more difficult to cut than low carbon steel.

High carbon steel may be hardened by heating it to a certain temperature and then quickly cooling in water. The more carbon the steel contains and the quicker the coolingis, the harder it becomes[2]. Because of its high strength and hardness this grade of steel may be used for tools and working parts of machines.

But for some special uses, for example, for gears, bearings, springs, shafts and wire, carbon steels cannot be always used because they have no properties needed for these parts.

2 Mechanical Properties of Metals

2.1 Introduction

Often materials are subject to forces (loads) when they are used. Mechanical engineers calculate those forces and material scientists how materials deform (elongate, compress, twist) or break as a function of applied load, time, temperature, and other conditions.

Materials scientists learn about these mechanical properties by testing materials. Results from the tests depend on the size and shape of material to be tested (specimen), how it is held, and the way of performing the test. That is why we use common procedures, or standards, which are published by the ASTM (American Society for Testing Material).

2.2 Concepts of Stress and Strain

To compare specimens of different sizes, the load is calculated per unit area, also called normalization to the area. Force divided by area is called stress. In tension and compression tests, the relevant area is that perpendicular to the force. In shear or torsion tests, the area is perpendicular to the axis of rotation.

$s=F/A_0$ tensile or compressive stress

$t=F/A_0$ shear stress

The unit is the Megapascal = 10^{+} Newtons/m^2.

There is a change in dimensions, or deformation elongation, DL as a result of a tensile or compressive stress. To enable comparison with specimens of different length, the elongation is also normalized, this time to the length L. This is called strain, e.

$$e=DL/L$$

The change in dimensions is the reason we use A_0 to indicate the initial area since it changes during deformation. One could divide force by the actual area, this is called true stress.

For torsional or shearstress, the deformation is the angle of twist, q and the shear strain is given by:

$$g=\tan q$$

2.3 Stress—Strain Behavior

Elastic Deformation. When the stress is removed, the material returns to the dimension it had before the load was applied. Valid for small strains (except the case of rubbers).

Deformation is *reversible*, *non permanent*.

Plastic Deformation. When the stress is removed, the material does not return to its previous dimension but there is a *permanent*, irreversible deformation.

In tensile tests, if the deformation is *elastic*, the stress-strain relationship is