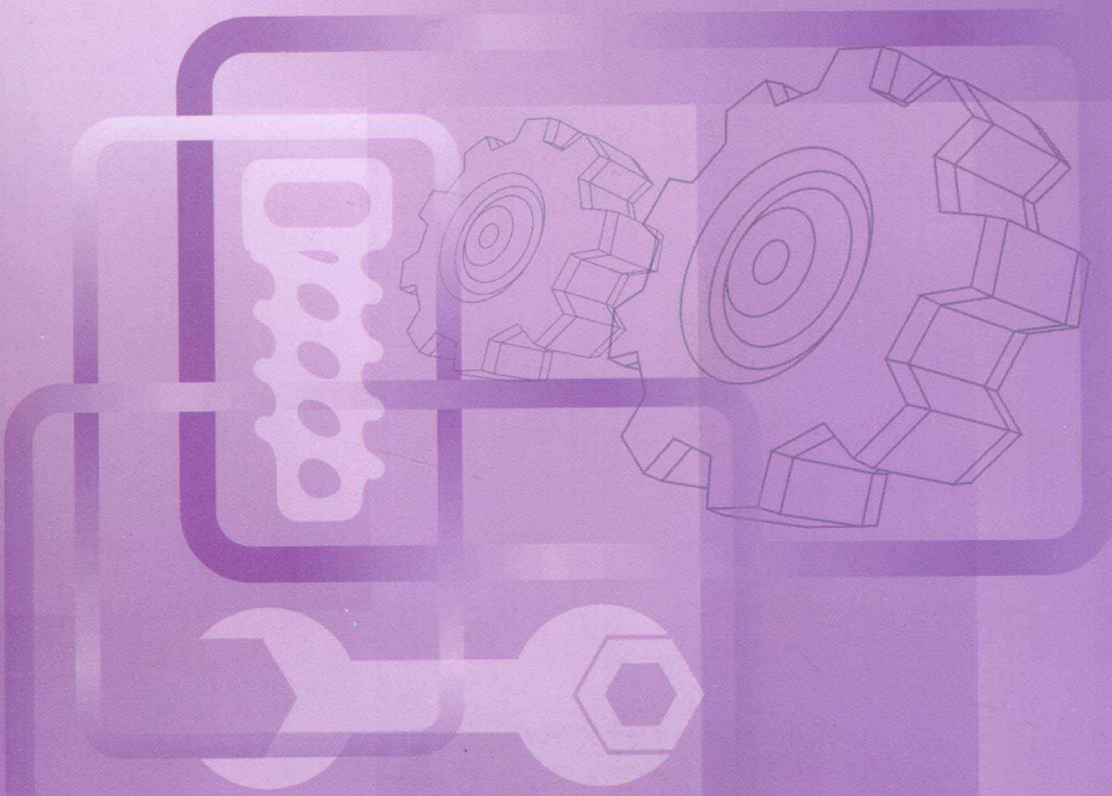
21世纪高等学校规划教材

专业英语（机械类）

ENGLISH FOR SPECIALIZED SCIENCE AND TECHNOLOGY (MECHANICAL)

秦志钰　郝兴明　容幸福　编著



兵器工業出版社

内 容 简 介

本书为普通高等院校机械类本科《专业英语》课程规划教材，全书包括4篇12章共60个单元。概括介绍了工程材料及测试、钢的热处理，金属毛坯成型常用方法、机械原理和零件设计的基本知识，金属切削基本知识以及机床、车床、组合机床及自动化、CNC、CAD/CAM、CIFM和AAC等基础内容。

本书可作为普通高等院校机械类各专业高年级相关专业基础课程的教材，可供普通高等工科院校机械工程类、近机械类专业以及其他工程类专业使用，还可以供高等职业技术学院、高等工业专科学校以及相关技术人员使用。

图书在版编目（CIP）数据

专业英语：机械类/秦志钰，郝兴明，容幸福编著．
北京：兵器工业出版社，2009.8
ISBN 978-7-80248-372-9

Ⅰ．专… Ⅱ．①秦…②郝…③容… Ⅲ．机械工程—英语
Ⅳ．H31

中国版本图书馆CIP数据核字（2009）第111799号

出版发行：兵器工业出版社
发行电话：010-68962596，68962591
邮　　编：100089
社　　址：北京市海淀区车道沟10号
经　　销：各地新华书店
印　　刷：北京市北中印刷厂
版　　次：2009年8月第1版第1次印刷
印　　数：1—2050

责任编辑：陈红梅　孙永德
封面设计：李　晖
责任校对：郭　芳
责任印制：赵春云
开　　本：787×1092　1/16
印　　张：16.25
字　　数：366千字
定　　价：28.00元

前 言

当前，我国的机械工业正向着高速、自动、精密方向迅速发展，且相应的国际交流和国际化程度越来越高。因此，根据教育部国家教改委颁布的“大学英语教学大纲”，把专业英语列为必修课并纳入英语教学计划，强调通过四年不断线的英语教学措施，使学生能够达到自如阅读专业英语书刊文献及用英语相互交流。《专业英语》（机械类）课程正是为实现这一目标而设置的。

从该课程体系、教育和教学改革发展趋势以及新世纪对培养现代工程技术人才目标和要求出发，专业英语教学已经成为高等学校教学水平和质量的评估条件。根据我国普通高等教育重点教材建设规划，为培养和提高高等学校机械类专业高年级学生阅读专业英语书刊文献及用英语相互交流的能力，我们编著了本教材。

全书包括 4 篇 12 章共 60 个单元。第 1 篇为工程材料，共 3 章 20 个单元，概括介绍了工程材料及测试，钢铁材料及钢的热处理、表面处理，合金钢及有色金属材料等。第 2 篇为铸造、锻压和焊接，共 3 章 17 个单元，介绍了金属毛坯成型的常用方法以及一些现代成型工艺和方法。第 3 篇为机械原理和零件设计，共 2 章 9 个单元，主要介绍了机械原理中的自由度、机构等基本概念及知识，以及凸轮和齿轮机构基本原理和知识；还介绍了零件设计中的基本步骤和要求，如紧固件和轴承等机械零件设计的基本原理、步骤和要点。第 4 篇为金属机加工，共 4 章 14 个单元，重点介绍了金属、切削基本知识，机床、车床、组合机床及自动化、CNC 以及 CAD/CAM、CIFM 和 AAC 等基础内容。

本教材具有以下特点：

1. 符合国家教改委强调的四年不断线英语教学过程中专业英语课程教学目标要求。

2. 本书采用全英文编著，以区别于现行专业英语教材中沿用基础英语教材

中惯用的英文单词、术语以及长句或难句用汉语注解。这有利于该课程的计划与安排，根据实际教学课时、教师以及授课对象可灵活合理地选择重点内容并组织和实施教学。

3. 在介绍机械设计、制造及其自动化基本原理和知识的基础上，注重扩展新材料、新技术和新工艺的内容。

4. 内容深入浅出、宽精适度、侧重新颖适用和通俗易懂。

5. 注重培养高年级学生英语阅读、自习和交流的能力；强调实际、实用和实践，为学生今后持续学习现代科技和工程英语奠定基础。

本书由太原理工大学秦志钰、郝兴明和容幸福编著。第 1 章由容幸福编著，第 2 ~ 3 章和第 5 ~ 12 章由秦志钰编著，第 4 章由郝兴明编著。全书经编著者互审，最后由容幸福统稿。

本书在编著过程中，得到有关同志和同仁的热忱帮助和支持，在此谨表示衷心的感谢。由于我们教学及实践经验有限，书中可能有欠妥之处，恳切希望广大读者提出宝贵意见，以便再版、重印时予以修订。

编著者

2009 年 6 月于太原

Contents

PART I ENGINEERING MATERIALS

Chapter 1 Engineering Materials and Testing

Unit 1 Engineering Materials

Metal and Alloy. If there is a typical engineering material that is associated with modern engineering practice, it is structural steel. This versatile construction material has several characteristics, or properties, that we consider metallic:

(1) It is strong and can be readily formed into practical shapes.

(2) Its extensive, permanent deformability, or ductility, is an important asset in permitting small amounts of yielding to sudden and severe loads.

(3) A freshly cut steel surface has a characteristic metallic luster.

(4) A steel bar shares a fundamental characteristic with other metals: it is a good conductor of electrical current.

An alloy is a metal composed of more than one element. Engineering alloys include the cast-irons and steels, aluminum alloys, magnesium alloys, titanium alloys, nickel alloys, zinc alloys and copper alloys. For example, brass is an alloy of copper and zinc.

Rarely do we find metallic elements in the "free" state. Society gets its metals from an ore, not from the natural element found in nature. Ores are often a combination of the metallic element and a non-metallic element. Consider, for example, Galena, PbS, is a common and popular mineral for rock hounds. Its characteristic cubes, distinctive cleavage and high density make it easy to identify. The structure of Galena is identical to that of halite, NaCl. The two minerals have the same crystal shapes, symmetry and cleavage. Some Galena may contain up to 1% silver in place of lead. The large volume of Galena that is processed for lead produces enough silver as a by product in the production of Galena, the leading ore of silver.

The basic oxygen furnace is just one method for producing steel. One way to make something useful is to pour the liquid metal directly into a crucible or mold and let it solidify. However, there are alternative processes such as the condensation of evaporated metallic elements; or the consolidation of micron-size particles.

The aluminum alloy used in the production of beverage cans contains manganese and is highly hardenable. This means that when worked (or hammered!), the aluminum becomes harder or "more resistant" to further deformation. The all aluminum-can is one of the most convenient and cost-effective containers ever developed for delivering beverages to consumers.

A materials engineer (or mechanical engineer with materials expertise) would be involved with the following issues regarding the design and fabrication of advanced bicycle spokes:

(1) What alloy should be used?

(2) What are the fabrication steps to make this unique blade-shape?

(3) At what times and temperatures should the alloy be heat-treated?

(4) What are the appropriate surface-finish operations?

(5) What fatigue life is predicted for the spoke?

(6) Do mechanical tests confirm strength and fatigue life requirements?

There is a class of alloys called shape memory alloys (SMA). These alloys provide the engineer a means of restoring a bent metal wire to some trained alternate shape. These SMA's have applications ranging from frames for optical glasses to repair parts for the human body. For example, fine NiTi (containing approximate equal parts of nickel and titanium) shape memory or superelastic wires can be woven into cylindrical shapes for various applications. One such application is vascular stents to reinforce blood vessels in the human body. The stent is crushed and inserted through a cannula into the proper location in the blood vessel. Upon warming above its transformation temperature, the stent returns to its trained cylindrical shape and provides reinforcement to the walls of the blood vessel.

Ceramics. Ceramic materials are inorganic, nonmetallic materials. Most ceramics are compounds between metallic and nonmetallic elements for which the interatomic bonds are either totally ionic or predominantly ionic but having some covalent character. The term ceramic comes from the Greek word keramikos, which means burnt stuff, indicating that desirable properties of these materials are normally achieved through a high-temperature heat treatment process called firing.

Ceramic materials are important in today's society. Consider the ceramic engine and what advantages it offers in terms of fuel economy, efficiency, weight savings and performance. What about fabricating a ceramic turbine in the millimeter range for some very, very small engine of the future? It is part of a new technology for producing micro-electromechanical systems, termed MEMS. The entire device, complete with an integrated electric generator, is expected to weigh in at just 1 gram.

You may think that copper is a good conductor of electricity. It is pretty good, really. But do you realize that a ceramic can be a better conductor of electricity than copper!? This is true of the recently discovered, high-temperature superconducting ceramic materials. At 100 degrees Kelvin and below, these materials offer no resistance to conduction of electrons. In addition, these materials reject magnetic flux lines (the Meissner effect) so that a magnet can be suspended in the space above the superconductor.

Polymers. The word polymer literally means "many parts". A polymeric solid material may be considered to be one that contains many chemically bonded parts or units which themselves are bonded together to form a solid. Two industrially important polymeric materials are plastics and elastomers. Plastics are a large and varied group of synthetic materials which are processed by forming or molding into shape. Just as we have many types of metals such as aluminum and copper, we have many types of plastics such as polyethylene and nylon. Plastics can be divided into two classes, thermoplastics and thermosetting plastics, depending on how they are structurally and chemically bonded. Elastomers or rubbers can be elastically deformed a large amount when a force is applied to them and can return to their original shape (or almost) when the force is released.

We are all pretty aware of the various plastic/polymer products in our life. We see recognizable applications of polymers: modern telecommunications equipment and the ski boot. The basic building block of a plastic is the polymer molecule, a long chain of covalent-bonded atoms. Secondary bonds then hold groups of polymer chains together to form the polymeric material.

Engineers the world over use heat-shrinkable tubing instead of standard approaches to insulation, such as taping or molding in place. The tubing comes in a wide range of sizes, colors, and materials. When heated, it shrinks to conform to the size and shape of the underlying material, making installation fast and easy.

Do you know that recent technological developments have lead to electrically conductive polymers? Semiconductor behavior is now possible using polymeric systems. For example, semiconducting polymers, sandwiched between two electrodes, can generate light of any color. This technology will lead to OLED (organic light-emitting diode), flat panel displays.

Polymers are materials comprised of long molecular chains. Most polymers are carbon based and have relatively low melting points. Polymers have a very wide range of properties which allow for their extensive use in society. Uses include: car parts, food storage, electronic packaging, optical components, and adhesives.

Synthetic fabrics are man-made copies of natural fabrics. Synthetic fibers do not occur in nature as themselves but are usually derivatives of petroleum products. Examples of common synthetic fabrics are polyester, spandex, rayon, and velcro.

We are all familiar with liquid crystal display (LCD) devices. Do you realize liquid crystals are polymeric materials? A liquid crystal is, as the name suggests, a state of matter intermediate between a "normal" liquid and a solid. Liquid crystal phases are formed from geometrically anisotropic molecules—usually this means they are cigar shaped, though other shapes are possible. In a liquid crystal phase, the polymer molecules have a certain degree of order. In the simplest case, the nematic phase, the molecules generally point in the same direction but still move around with respect to one another as would be expected in a liquid. Under the influence of an applied electric field, alignment of the polymer molecules gives rise to light absorption.

Composites. Composites are combinations of two materials in which one of the materials, called the reinforcing phase, is in the form of fibers, sheets, or particles, and is embedded in the other materials called the matrix phase. The reinforcing material and the matrix material can be metal, ceramic, or polymer. Typically, reinforcing materials are strong with low densities while the matrix is usually a ductile, or tough, material. If the composite is designed and fabricated correctly, it combines the strength of the reinforcement with the toughness of the matrix to achieve a combination of desirable properties not available in any single conventional material. The downside is that such composites are often more expensive than conventional materials. Examples of some current application of composites include the diesel piston, brake-shoes and pads, tires and so on.

Recreational equipment is heavily dependent on materials technology. For example, consider a snowboard. It is stiff and torsionally rigid so one can rail them at high speed and launch and land the hugest airs.

Various structural composite articles consist of glass fibers incorporated in a polymeric resin matrix. When the resin cures to a hard state, it is strengthened by the reinforcement. The shape of the finished part is dependent on a mold, die or other tooling that controls the geometry of the composite during processing. A structural composite often begins with lay-up of prepreg. The choice of fiber will influence the basic tensile and compressive strength and stiffness, electrical and thermal conductivity, and thermal expansion of the final prepreg material. The cost of the composite is also strongly influenced by the fiber selected.

The strength of the resin/fiber composite depends primarily on the amount, arrangement and type of fiber (or particle) reinforcement in the resin. Typically, the higher the reinforcement content, the greater the strength. In some cases, glass fibers are combined with other fibers, such as carbon or aramid, to create a "hybrid" composite that combines the properties of more than one reinforcing material. In addition, the composite is often formulated with fillers and additives that change processing or performance parameters.

A mountain bike is another piece of recreational equipment that is dependent on advanced material's technology. The mountain bike utilizes composite materials; but it also is an integration of a number of other structural materials (i.e., metals, elastomers, etc). It is, thus, a composite system. These bikes can weigh less than 16 pounds and still meet the rigors of the sport.

Unit 2 Materials Characterization

Materials characterization represents many different disciplines depending upon the background of the user. These concepts range from that of the scientist, who thinks of it in atomic terms, to that of the process engineer, who thinks of it in terms of properties, procedures, and quality assurance, to that of the mechanical engineer, who thinks of it in terms of stress distributions and heat transfer. The definition selected for the ASM-International Materials Characterization Handbook is as follows: "Characterization describes those features of composition and structure (including defects) of a material that are significant for a particular preparation, study of properties, or use, and suffice for reproduction of the material." This definition limits the characterization methods included in the Handbook to those that provide information about composition, structure, and defects and excludes those methods that yield information primarily related to materials properties, such as thermal, electrical, and mechanical properties.

An important component of the materials engineering methodology involves knowledge of the structure of materials. Typical structure is necessarily viewed through a microscope—an optical microscope, the electron microscope (imaging of electrons passed through a thin specimen in the transmission electron microscope (TEM)); or imaging by collecting electrons emitted from the surface of the material of interest in the scanning electron microscope (SEM).

This is a scanning electron micrograph (Fig. 1) of a dendrite. When solid metal grows from the liquid state, a tree-like feature grows which is called a dendrite. The dendrite is, essentially, a single crystal feature. The growth of dendrites occurs when liquid metals solidify, and the phenomenon is analogous to the process of formation of ice crystals from supersaturated water vapor.

This is a polycrystalline array of grains in an aluminum metallization line on an integrated circuit. It is a color photomicrograph (Fig. 2). Each colored grain is a single crystal of aluminum, oriented differently with respect to its neighbors.

Photomicroscopy is an important tool in the characterization of engineering materials.

The scanning electron micrograph (Fig. 3) shows a typical TiC coating of 150 micrometers on a graphite. These TiC coatings feature both an equiaxed structure adjacent to the coating-substrate interface, and columnar grains away from the interface. Additionally, these coatings adhere well to their graphite substrates even after fracture. Thicknesses for these coatings can be controlled from a few micrometers to 250 micrometers.

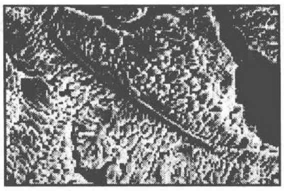


Fig. 1

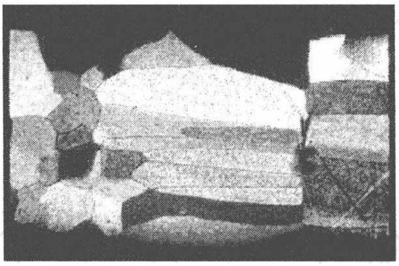


Fig. 2

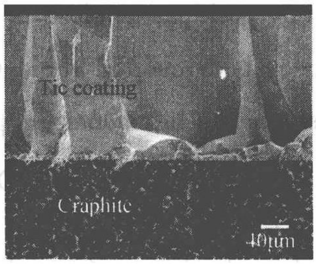


Fig. 3

The Concept of Structure. The structure of a material may be divided into four levels: atomic structure, atomic arrangement, microstructure, and macrostructure.

Atomic structure influences how the atoms are bonded together, which in turn helps one to categorize materials as metals, ceramics, and polymers and permits us to draw some general conclusions concerning the mechanical properties and physical behavior of these three classes of materials.

A crystalline state is characterized primarily by an ordered regular arrangement of atoms in space. The crystal structure of a material or the arrangement of atoms in a crystal structure can be described in terms of its unit cell (Fig. 4). The unit cell is a tiny box containing one or more motifs, a spatial arrangement of atoms. The unit cells stacked in three-dimensional space describes the bulk arrangement of atoms of the crystal. The crystal structure has a three dimensional shape. The unit cell is given by its lattice parameters, the length of the cell edges and the angles between them, while the positions of the atoms inside the unit cell are described by the set of atomic positions (x_i, y_i, z_i) measured from a lattice point. Crystals of metals are usually small in size, so that a metallic article consists of a very large number of crystals. Such a structure is called poly-crystalline. Such crystals of irregular shape are called *grain* or *crystallite*.

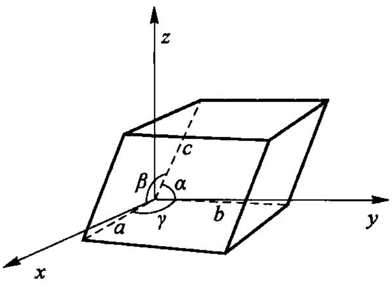
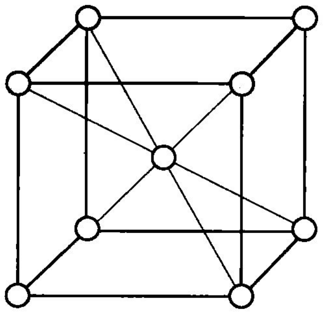


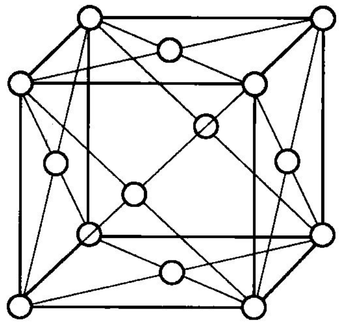
Fig. 4

The Structure of Metals. Metals are giant structures of atoms held together by metallic bonds. "Giant" implies that large but variable numbers of atoms are involved—depending on the size of the bit of metal. Most metals are close packed—that is, they fit as many atoms as possible into the available volume. The structures of pure metals are easy to describe because the atoms that form these metals can be thought of as identical perfect spheres. Atoms tend to occupy positions as close as possible as to one another and thus form other types of crystal lattice: body-centred cubic (b. c. c., Fig. 5), face-centred cubic (f. c. c., Fig. 6) and close-packed hexagonal (c. p. h., Fig. 7).



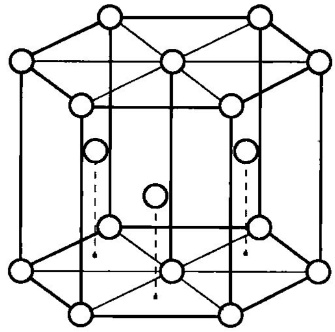
b.c.c.

Fig. 5



f.c.c.

Fig. 6



c.p.h.

Fig. 7

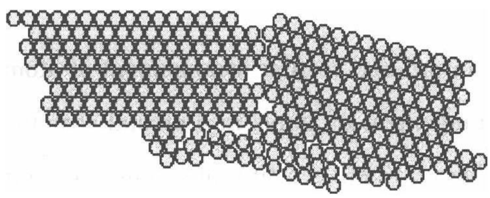


Fig. 8

It would be misleading to suppose that all the atoms in a piece of metal are arranged in a regular way. Any piece of metal is made up of a large number of "crystal grains", which are regions of regularity. At the grain boundaries atoms have become misaligned (Fig. 8).

With the introduction above, the reader may appreciate that there are, must necessarily be, defects associated with crystals. Defects too define structure. For example, consider the boundaries between individual crystals (or grains). Since these crystalline aggregates grow together with "random" orientation, grain-boundaries necessarily exist, and they are defects as the atomic order along them is disrupted from that within individual grains. These planar structures certainly must have something to do with, for example, how the aggregate will break apart if struck by a hammer blow. The source of this discoloration is impurity particles. Iron sulfide and iron/copper sulfide grow on (and then into) the lead-sulfide crystals. These sulfides have different color properties than the lead-sulfide. It is indeed