



高等学校教材

机械设计制造及其自动化 专业英语

第三版

大学英语专业阅读教材编委会 组织编写

马玉录 刘东学 主编

蔡建国 主审

JIXIE SHEJI ZHIZAO
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· 北京 ·

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、材料的机械性能、材料力学、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、液压系统、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。第三版保留了第二版的风格, 对部分内容作了更换和调整, 增加了如材料力学绪论、阀门、热力学应用、控制模式等内容, 保留的内容尽可能使用最新版本的内容, 使教材的内容具有更强的时效性和适用性。

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。

图书在版编目 (CIP) 数据

机械设计制造及其自动化专业英语/马玉录, 刘东学
主编. —3 版. —北京: 化学工业出版社, 2015. 2
高等学校教材
ISBN 978-7-122-22574-0

I. ①机… II. ①马…②刘… III. ①机械制造-英语-
高等学校-教材 IV. ①H31

中国版本图书馆 CIP 数据核字 (2014) 第 298194 号



责任编辑: 高 钰
责任校对: 宋 玮

装帧设计: 史利平

出版发行: 化学工业出版社 (北京市东城区青年湖南街 13 号 邮政编码 100011)
印 装: 北京云浩印刷有限责任公司
787mm×1092mm 1/16 印张 13 $\frac{3}{4}$ 字数 337 千字 2015 年 3 月北京第 3 版第 1 次印刷

购书咨询: 010-64518888 (传真: 010-64519686) 售后服务: 010-64518899

网 址: <http://www.cip.com.cn>

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定 价: 29.00 元

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前言

Preface

《机械设计制造及其自动化专业英语》(第二版)于2009年1月出版以来,已先后重印了多次,受到了本专业和相关专业教师和学生以及专业技术人员的支持和爱护。本教材还先后获得中国石油和化学工业联合会2010年度中国石油和化学工业优秀出版物奖(教材奖)一等奖和2011年上海普通高校优秀教材奖二等奖。

根据我们的教学实践和听取其他高校在使用本教材过程中提出的宝贵意见和建议,在前一版的基础上对全书进行了修订和补充。第三版基本结构和格式上与第二版保持一致,根据教学需要更换和调整了部分内容,增加了如材料力学绪论、阀门、热力学应用、控制模式等内容,保留的内容尽可能使用最新版本的内容。这样,使教材的内容具有更强的时效性和适用性。

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,在此一并谨致以衷心的感谢。

由于作者水平有限,难免存在不足之处,敬请读者批评指正。

编者
2014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。

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。

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

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。

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《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。

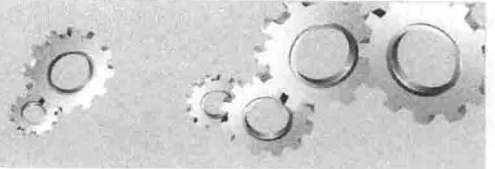
机械设计制造及其自动化专业英语（第二版）对部分内容作了更换与调整，增加了如模具设计与制造、过程控制系统状态监测、精益制造等内容，使教材适应性更广，也更加通俗易懂。

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。

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编者
2008 年 10 月

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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 atoms^①. 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 metal^②.

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 chessboard^③. 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 practice^④. 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 [nɒn'metl] *n.* 非金属
2. crystalline ['krɪstəlɪn] *a.* 结晶性的, 晶状的



3. ambient [ˈæmbiənt] *a.*; *n.* 周围的; 周围环境
4. ambient temperature 室温, 环境温度
5. opaque [əˈpeɪk] *a.* 不透明的
6. ductile [ˈdʌktaɪl] *a.* 延性的, 易变形的, 可塑的, 韧性的
7. deformation [diːfɔːmeɪʃən] *n.* 变形
8. crystallinity [ˈkrɪstəlɪnɪti] *n.* (结) 晶性, 结晶度
9. constituent [kənˈstɪtjuənt] *a.*; *n.* 组成的, 构成的; 成分, 组分
10. dimensional [daɪˈmenʃənəl] *a.* 线(维)度的, ...维的
11. orientation [ɔːriənˈteɪʃən] *n.* 定向, 定位, 排列方向
12. grain [greɪn] *n.* 颗粒, 晶粒
13. grain boundary 晶界
14. ubiquitous [juːˈbɪkwɪtəs] *a.* 处处存在的, 普遍存在的
15. cast irons 铸铁
16. corrosion [kəˈrəʊʒən] *n.* 腐蚀
17. esoteric [esəʊˈterɪk] *a.* 深奥的, 奥秘的
18. fabricate [ˈfæbrɪkeɪt] *vt.* 制造加工

Notes

① 参考译文: 最基本的定义是以围绕存在于元素原子间的键接类型以及与这些原子联系的电子某些特性为主”。

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°C (1,400°F) are common, and in some applications temperatures as high as 1090°C (2,000°F) 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°C ($1,400^{\circ}\text{F}$)] . 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°C and $1,400^{\circ}\text{C}$, or $1,670^{\circ}\text{F}$ and $2,550^{\circ}\text{F}$) 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 possi-

bilities. 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°C (1600°F). 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 [æzkɑ:st] *a.* 铸态的
2. powder-metallurgy [ˈpaʊdəmeɪtələdʒi] *n.* 粉末冶金学
3. cast ingot [kɑ:st ɪŋgət] *n.* 铸锭
4. roll [rəʊl] *v.* 轧制
5. tonnage [ˈtʌnɪdʒ] *n.* (总) 吨位
6. extrude [eksˈtru:d] *v.* 挤压
7. spin [spɪn] *v.* 旋压
8. solder [ˈsɔ:ldə] *vt.* 钎焊
9. braze [breɪz] *vt.* 铜焊
10. cladding [ˈklædɪŋ] *n.* 包层, 覆盖, (金属) 覆层
11. wrought [rɔ:t] *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 [fə'ritik] *a.* 铁素体的
17. martensitic [mɑ:'tenzaitik] *a.* 马氏体的
18. austenitic [ɔ:stə'nitik] *a.* 奥氏体的
19. oxidation [ɒksɪ'deɪʃən] *n.* 氧化
20. cryogenic [kraɪədʒenɪk] *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 three^①. 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 treating^②.