高等学校教材

机械设计制造及其自动化

专业英语

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
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化学工业出版社
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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作了大量工作，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 [diːfɔː'meiʃən] *n*.变形
8. crystallinity [kristə'liniti] *n*.(结)晶性，结晶度

9. constituent [kən'stitjuənt] *a*.; *n*. 组成的，构成的；成分，组分
10. dimensional [dai'menʃənəl] *a*.线(维)度的，…维的
11. orientation [ɔ:rien'teiʃən] *n*.定向，定位，排列方向
12. grain [grein] *n*.颗粒，晶粒
13. grain boundary 晶界
14. ubiquitous [ju:'bikwitəs] *a*.处处存在的，普遍存在的
15. cast irons 铸铁
16. corrosion [kə'rəuʒən] *n*.腐蚀
17. esoteric [esəu'terik] *a*.深奥的，奥秘的
18. fabricate ['fæbrikeit] *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结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 6^{th} paragraph into Chinese.
3. Put the following into Chinese.
   aluminum copper nicked 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 1725 MPa (250 ksi). Operating temperatures around 750 °C (1400 °F) are common, and in some applications temperatures as high as 1090 °C (2000 °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 (1400 °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 1400 °C, or 1670°F and 2550 °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 °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 [æz'kɑːst] *a*.铸态的
2. powder-metallurgy ['paudəme'tælədʒi] *n*.粉末冶金学
3. cast ingots [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
11. wrought [rɔːt] *a*.可锻的
12. ferritic [fə'ritik] *a*.铁素体的
13. martensitic [mɑː'tenzaitik] *a*.马氏体的
14. austenitic [ɔːstə'nitik] *a*.奥氏体的
15. oxidation [ɔksi'deiʃən] *n*.氧化
16. cryogenic ['kraiədʒenik] *a*.低温的, 深冷的

Unit 2 Polymer and Composites

Polymers and polymer composites are used in many different forms, ranging from synthetics through to structural composites in the construction industry and to the high technology composites of the aerospace and space satellite industries①.

Plastics are generally considered to be a relatively recent development. In fact, they are members of the much larger family of polymers.

Polymers are the products of combining a large number of small molecular units called monomers by the chemical process known as polymerization (which is the process by which molecules or groups of atoms are joined together) to form long-chain molecules. Natural materials such as bitumen, rubber and cellulose have this type of structure. There are two main types of polymerization. In the first type, a substance consisting of a series of long-chain polymerized molecules, called thermoplastics, is produced. All the chains of the molecules are separate and can slide over one another. In the second type, the chains become cross-linked so that a solid material is produced which cannot be softened and which will not flow. Such solids are called thermosetting polymers. These two groups classify polymer materials.

Polymers are usually made in one of two polymerization processes. In condensation polymerization the linking of molecules creates by-products, usually water, nitrogen or hydrogen gas. In addition polymerization no by-products are created.

The final property of the plastics material will be determined by the type of additive mixed with the pure polymer. Additives may be simply fillers or extenders designed to reduce the quantity of polymers used or to toughen the product. Pigments or stabilizers can be added to provide colouring for the material or to reduce degradation, and plasticizers are incorporated to alter the characteristics of the polymers. The glossary outlines the purpose of the main additives used with polymers②.

Thermoplastic polymers consist of linear molecules which are not interconnected. The chemical valency bond along the chain is extremely strong, but the forces of attraction between the adjacent chains are weak. Because of their unconnected chain structure, thermoplastics may be repeatedly softened and hardened by heating and cooling respectively; with each repeated cycle, however, the material tends to become more brittle.

The thermosetting polymer is formed by a chemical reaction. In the first stage, a substance consisting of a series of long-chain polymerized molecules, similar to those present in thermoplastics, is produced. In the second stage of the process, the chains become cross-linked; this reaction can take place either at room temperature or under the application of heat and pressure. The resultant material will not flow and cannot be softened by heating.

The mechanical properties of polymers can be greatly improved by using techniques from nature. Few natural materials consist of one substance only: most are a mixture of different components which, when combined, produce a material with enhanced properties. Bone, for example, achieves its lightness and strength by combining crystals of apatite with fibres of the protein collagen. This combination of two or more materials is known as a composite.

Polymers are often combined with fillers and/or fibres to improve their mechanical or physical properties. The fillers usually consist of wood flour, china clay, quartz powder or other powdered minerals. The filler is incorporated not only to improve the physical property of the composite but also sometimes to reduce the polymer content and hence the cost.

The use of fibres in combination with polymers enhances the latter's mechanical properties for structural use. Most fibres can be used, provided there is chemical compatibility between the two parts③.

Both thermoplastics and thermosetting polymers can be combined with fibre reinforcement. In the past, thermoplastics have been combined mainly with short fibres but these composites were unable to take full advantage of the fibre strength. However, users have taken advantage of this system's toughness property by manufacturing a range of injection mouldings. Conversely, the thermosetting composite system tends to be brittle, because of the cross-linking of the matrix. Long fibres have been utilized in the composite, to take full advantage of the strength of the fibre. This system has found application in large panels and pressure pipes and containers.

Currently, however, the traditional market areas of the thermoplastics and thermosetting polymer composites are less well defined and both long and short fibres are being used with thermoplastics and thermosetting matrices.

Selected from " Polymers and Polymer Composites in Construction", L. C. Hollaway Thomas, Telford Ltd, London, 1990.

New Words and Expressions

1. polymer ['pɔlimə] *n*.聚合物，聚合材料
2. composite [kəm'pɔzit] *n*.合成，复合，复合材料
3. monomer ['mɔnəmə] *n*.单(分子物)体，单基物
4. polymerization [pɔlimərai'zeiʃən] *n*.聚合作用，聚合反应
5. thermoplastic ['θəːməu'plæstik] *a*.; *n*.热塑性的；热塑性塑料
6. thermosetting [ˌθəːməu'setiŋ] *a*.热固(凝)的
7. thermosetting polymer 热固性塑料
8. additive ['æditiv] *n*.添加剂
9. filler ['filə] *n*.填充物，填料
10. extender [iks'tendə] *n*.填充剂，补充料
11. pigment ['pigmənt] *n*.染料，色素
12. stabilizer ['steibilaizə] *n*.稳定剂
13. degradation [degrə'deiʃən] *n*.退化，降低，劣化
14. plasticizer ['plæstisaizə] *n*.增塑剂，柔韧剂

15. adjacent [ə'dʒeisənt] *a*.相邻的，毗连的
16. brittle ['britl] *a*.易碎的，脆性的
17. enhance [in'hɑːns] *v*.提高，增强
18. quartz [kwɔːts] *n*.石英
19. compatibility [kəmpætə'biliti] *n*.相容性，可混性
20. moulding ['məuldiŋ] *n*.模塑(法)，造型(法)
21. injection moulding (塑料)注射成型
22. matrix ['meitriks] *n*.基体，基质，矩阵

Notes

① 参考译文："聚合物和聚合物复合材料用于许多不同的领域，从合成纤维织物到建筑工业的结构材料直到航天和宇航工业的高科技复合材料范围内（均有应用)"。此处 range from…through to…，意为"分布在从 ……直到 ……范围之内"。

② 参考译文："专用手册概括了用于聚合材料的主要添加剂的作用"。glossary 此处可理解成专门的添加剂手册，介词 with 表示"向"的意思。

③ 参考译文："只要二者之间有化学相容性，多数纤维均可使用"。此处 provided 是连词，完整表达其后应有 that，that 经常被省略，引导一个条件从句，作"只要"解。

Exercises

1. After reading the text above, write a summary of it.
2. Answer the following questions, according to the text.
   ① What kind of materials are polymers?
   ② Which two main types are there in the family of polymer?
   ③ Why do we add various additives to polymers?
   ④ Compare with the polymers, what advantages do the composites have?
3. Translate the 3rd paragraph into Chinese.
4. Put the following into Chinese, by reference to the text.
   long-chain cross-linked condensation by-product chemical valency component china clay toughness
5. Put the following into English.
   由……组成 结合 添加剂 机械性质 只要…… 相反地 压力管道
6. Put the following sentences into English.
   ① 热塑性塑料和热固性塑料二者均可与纤维相结合得以增强。
   ② 塑料材料的最终性能取决于加入到纯聚合物的添加剂的种类。

Reading Material 2

Ceramics

Ceramic materials are manufactured from clay compositions by moulding and subsequent burning, an intermediate drying of freshly moulded items being a frequent practice.

Universality of properties, a wide range of products, high strength, durability and reasonable cost of ceramic items underlie their wide use in the most various subassemblies of buildings and installations, such as walls, heating units, wall and floor facing materials, sewer pipes, lining materials for chemical industry apparatus and light porous aggregates for prefabricated reinforced concrete items.

Ceramic materials are manufactured from various clayey rocks. Workability of clays is improved and the manufactured items are given required physical and chemical properties by blending clays with quartz sand, chamotte (refractory clay burned at 1000～1400°C and crushed), slag, sawdust, pulverized coal.

According to one of the definitions, clay is an earthen mineral mass or fragmentary rock capable of mixing with water and forming a plastic viscous mass, which on drying retains the shape it was given and after burning acquires the strength of stone.

Burning is a process which takes place when the temperature is raised above the 800 °C mark; in the process, the easy-fusing clay components melt, spread out and envelop particles that are still solid; when cooled, the molten mass solidifies and cements the particles. Burning of clay transforms it into stone. The partial melting of clay and the action of surface tension of the molten mass bring the particles closer together and cause a reduction in its volume, the phenomenon being known as the "fire shrinkage". If the temperature is raised still further, the clay melts.

Despite the wide range of ceramic items, the great variety of their shapes and of the physical and mechanical properties of raw materials, the basic production steps are common to all the items and involve the following operations: mining of raw materials; preparation of raw paste; moulding of items; drying; burning of items; finishing of items (trimming, glazing, etc.) and packing.

Plants for manufacturing ceramic materials are generally built near deposits of clay, and the quarry is an intrinsic part of such a plant. Raw materials are quarried by the open pit method with the aid of power shovels, and are transported to the plant in dump trucks or cars and by belt conveyors when the quarry is near the plant.

Preparation of raw materials involves disintegration of clay's natural structure, removal or grinding of large inclusions, mixing the clay with admixtures and water until a readily mouldable mass is obtained.

Depending on the properties of raw materials and on the kind of items produced, ceramic mass is prepared by the stiff-mud, soft-mud and slip casting methods.

In the stiff-mud method, clay is first crushed and dried, then ground and moulded at a mois-