普通高等教育机电类规划教材

Mechanical Engineering

ENGLISH READINGS

机械工程英语

华南理工大学　陈统坚　主编

机械工业出版社

普通高等教育机电类规划教材

Mechanical Engineering

ENGLISH READINGS
机 械 工 程 英 语

主　编　陈统坚

编　者　陈统坚　孙厚芳　叶邦彦
沈　康　毛军红　唐一平

主　审　郦　明

机 械 工 业 出 版 社

本教材是按全国机械制造专业教学指导委员会1991年会议制定的出版计划组织有关高等院校集体编写的。本书在选材方面既注意结合机械制造专业的基础理论，又强调现代制造技术方面的发展与动向，内容安排由浅入深循序渐进，既有工程材料、基本加工方法、公差及技术测量、机械设计、液压传动和特种加工技术等专业基础知识，又有数控技术(CNC)、机器人技术(ROBOTICS)、成组技术(GT)、计算机辅助设计与制造(CAD/CAM)、柔性加工技术(FMS)、计算机集成制造(CIMS)等现代制造技术。本书所载文章均选自欧美原著，对其中一些难句作了注释或给出参考译文。本书还提出较多的工程技术应用文体范例及一些常用文体的写作指南，以满足读者提高写作能力的需要。

本书内容丰富，题材广泛，可作为大专院校学生和有关科技人员的专业英语教材或阅读材料。全书收入单词和词组约1700条，书末还附有机械工程领域的世界著名学术机构名称、常见缩略语和参考文献。

Mechanical Engineering
ENGLISH READINGS
机械工程英语
华南理工大学　陈统坚　主编
*
责任编辑：王世刚　邓海平　版式设计：王　颖
封面设计：肖　晴　陈统坚　责任校对：陈统坚
责任印制：路　琳
*
机械工业出版社出版(北京市百万庄大街22号)
邮政编码：100037
(北京市书刊出版业营业许可证出字第117号)
北京机工印刷厂印刷
新华书店北京发行所发行・新华书店经售
*
开本787mm×1092mm 1/16・印张16.5・字数402千字
1999年10月第1版・第4次印刷
印数 14001-18000　定价：21.50元
*
ISBN 7-111-05039-8/TB・231（课）

前　言

本教材是按照全国机械制造专业教学指导委员会1991年会议提出的教材出版计划组织编写的。

本教材可供机械工程系高年级学生作专业英语阅读使用。全书分为两篇，第一篇为基础篇，内容包括工程材料及其处理、加工方法、公差、工夹具、机械原理、机械零件、液压传动、热加工、特种加工等。第二篇为计算机化制造技术，内容主要涉及制造领域的现代先进科技，如数控技术、工业机器人、计算机辅助设计与制造、柔性制造、质量控制、计算机集成制造、制造业的未来发展等。每篇的最后一个单元给出一些常用的工程技术文体范例，包括说明书、广告、报价单、售货合同、文摘、动态、科技论文、摘要及概要的写作指南等，以提高教材的实用性。全书约100 000个英语词，每篇含16个单元，按每周一单元进度恰好为一个学期的阅读量，全书供两个学期使用。

编者对教材内容的选择与安排，本着由浅入深循序渐进的原则，通过第一篇，阅读掌握科技领域对事物的英语表达方式和常用词汇，在第二篇中收集了较多的现代科技信息。由于现代工程技术的飞速发展，很多高新技术知识一时还难于通过设置新课程的方法向学生传授，而本教材内容的选取将能有效地帮助学生了解机械工程高新科技的发展情况，是对目前专业课程设置、更新赶不上形势发展要求的一种补偿。

本书所载文章全部取自欧美文献原著，为保持原著的语言风格，编者对原文只作删节，不作改写。在每单元末处对正文中某些疑难句子的语法现象、翻译技巧等给出注释或给出句子的参考译文。教材附有机械工程领域世界性著名学术机构名称、与机械自动化有关的常见缩略语、参考文献（在每单元之后用方括号标出文献编号），及适用于教材内容的词汇表（约1 700个单词及词组）。

本书由华南理工大学、北京理工大学、西安理工大学、西安交通大学联合编写，华南理工大学陈统坚主编，中国科技大学郦明主审。华南理工大学陈澄洲教授、邵汝椿教授、杨南祥教授对教材编写的组织工作给予了热忱的指导和支持，在此特向他们致以衷心的谢意。

本书编写时间尚不够充分，不足或错漏之处在所难免，望读者给予批评指正。

编　者

1995年11月

CONTENTS

PART I

FUNDAMENTALS OF MACHINE MANUFACTURING

Unit 1

ENGINEERING MATERIALS

TYPES OF MATERIALS

Materials may be grouped in several ways. Scientists often classify materials by their state: solid, liguid, or gas, They also separate them into organic (once living) and inorganic (never living) materials.

For industrial purposes, materials are divided into engineering materials or nonengineering materials. Engineering materials are those used in manufacture and become parts of products. Nonengineering materials are the chemicals, fuels, lubricants, and other materials used in the manufacturing process which do not become part of the product.

This grouping is not exact. Engineering materials may be further subdivided into: ①Metals. ②Polymers. ③Ceramics. A fourth type of material sometime listed is called a composite. Materials in this group are made up of two or more materials from the engineering groups, Each of the materials in a composite retains its original characteristics. Examples of composites include **wood-, concrete-, glass-reinforced** polyester, and graphite polymer advanced composites.

COMMON METALS

Pure metals are seldom used in common industrial products. pure copper is used in electrical applications, in automotive radiators, and gaskets. Pure aluminum has applications in the chemical and electrical industries. However, most metals are alloys (combinations of two or more elements). There are over 25,000 different iron-carbon alloys (steels) and over 200 standard copper alloys including a number of brasses, bronzes, and nickel silvers. Each of these alloys are identified by a code number.

Steel is an alloy of iron and carbon with other elements added to produce specific properties. The various types of steel can be grouped under two major headings:

(1) Carbon steel. A steel in which the main alloying element is carbon. Carbon steels are further divided into three groups.

a. Low carbon steel. This steel has a carbon content of less than 0. 30 percent. It is the most common type and is often called mild steel. It is relatively inexpensive, ductile, soft, and is easily machined and forged. Mild steel cannot be heat-treated (hardened). Low carbon steel is a general purpose steel.

b. Medium carbon steel. This steel has a carbon content between 0. 30 percent and 0. 80 percent. Harder and stronger than mild steel, it can be hardened by heat treating. Medium carbon steel is most commonly used for forgings, castings, and machined parts for automobiles, agricultural equipment, machines, and aircraft.

c. High carbon steel. This type of steel is easily heat-treated to produce a strong, tough part. The material has a carbon content above 0. 80 percent. It finds wide use in hand tools, cutting tools, springs, and piano wire.

(2)High alloy steel. These steels contain significant amounts of other elements in addition to carbon. The common high alloy steels are:

a. Stainless steel which is produced by using chromium as a significant alloying element along with nickel and other metals. The result is a tough, hard, corrosion-resistant metal.

b. Tool steel which is a special group of high carbon steels produced in small quantities to high quality specifications. Tool steels are used for a wide range of cutting tools and forming dies.

c. Manganese steel which is an alloy containing 12 precent manganese and one percent carbon. This metal is used in mining, railroad, and construction equipment because of its high tensile strength.

PROPERTIES OF MATERIALS

All materials have their own properties or characteristics. These properties may be arranged into major groups which include:

Physical properties.

Mechanical properties.

Chemical properties.

Thermal properties.

Electrical and Magnetic properties.

Optical properties.

Acoustical properties.

1. Physical Properties

Physical properties, for this discussion, are restricted to those which describe the basic features of the material. These features are measured or observed without the use of extensive scientific experiments. The common physical properties are size, shape, density, and porosity.

Size is the overall dimensions of the object. These dimensions, for most materials, are given as thickness, width, and length or as diameter and length.

Shape is the contour or outline of the object. Contour is given to an object by curved, notched, sloped, or other irregular surfaces.

Density or specific gravity measures the mass of an object. The measurement is by weight for a unit or a certain volume. Typically, density is measured by pounds per cubic foot or kilograms per cubic meter of material. Density allows the mass of one material to be compared with that of other materials.

Porosity is a measure of voids (open pores)in the material. It is generally described as a ratio of open pore volume to total volume of a material. This ratio is expressed as a percentage. Porosity will provide a measure of liquid-holding power, or the ability of air or gas to move through the material.

2. Mechanical Properties

Mechanical properties mean a material's ability to carry or resist the application of mechanical forces and loads. The material's reaction to these forces is usually either deformation (shape change) or fracture.

Mechanical properties are probably the most important to manufacturing processing. They determine the extent to which a material may be formed, sheared, or machined.

Typical forces which are applied to a material are tension, compression, shear, and torsion, These forces are used to form and shape materials. Furthermore, materials must withstand excess amounts of these forces in product applications. Since screws are used to assemble wood parts, they must absorb torsion forces. Rods holding suspended fixtures must withstand excess tension forces. The head of a hammer must absorb compression forces.

(1) Stress-strain. The stress-strain relationship is often used to study many mechanical properties. Stress is force applied to material. It is usually measured in either pounds per square inch or kilograms per square centimeter. Strain is the change in the length of a material which is under stress. The strain measurements are given in terms of the amount of elongation (increased length) of the material per unit of length. Strain is given in thousandths of an inch per inch of material or millimeters (or smaller units) per centimeter of material. For most materials, the elongation of a material under stress is quite small.

A stress-strain diagram, like the one shown in Fig. 1. 1, is widely used to chart stress-strain relationships. The stress (force per unit area) is plotted on the vertical axis while the strain (elongation of each unit of length) is plotted on the horizontal axis.

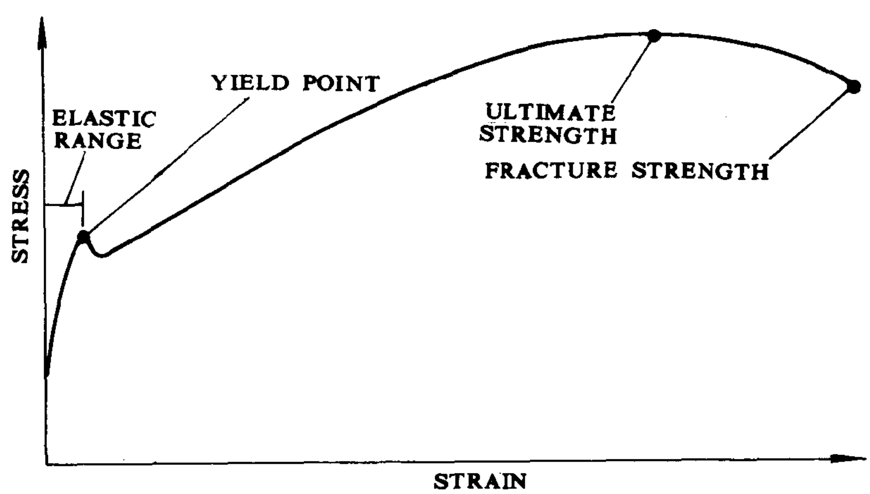

Fig. 1. 1 Stress-strain charts are used to show the relationship of forces and how they act on a certain material

As stress is applied, the material first resists permanent deforming. This area is in the material's elastic range. This is a range in which the material will return to its original length when the force is released.

Applying additional stress (force) will bring the material to its yield point. At this point, additional strain (elongation) occurs without additional force (stress) being applied. Strain above this point is produced with smaller amounts of force. The force also produces permanent changes in the length of the material.

This elongation which is above the material's elastic limit (point at which the material will not return to its original length) is called plastic deformation.

As stress is increasingly applied above the yield point, additional strain occurs. Finally, a maximum strain is reached and the material begins to fail. Its internal structure begins to come apart. This point is called the material's ultimate strength or tensile strength. Additional stress may cause a reduction in cross-sectional area (necking) and will finally cause fracture.

(2) Mechanical strengths. A material can be subjected to a number of different types of forces. They may be tension, shear, torsion, compression, or a combination of these forces. Each possible force causes a material to respond in a different way. A material, therefore, has several different mechanical strengths. The strength depends on the force applied.

The most common mechanical strengths are:

a. Tensile strength —— the maximum tension load a material can withstand before fracturing. Tensile strength is the easiest strength to measure and, therefore, is widely used.

b. Compression strength —— the ability to resist forces which tend to squeeze the material into a new shape. It is basically the opposite of tensile strength. Excessive compression force will cause the material to rupture (buckling and splitting).

c. Shear strength —— the ability to resist fracture under shear forces. The shear force is caused by offset forces applied in opposite directions. These forces cause the grains or molecules of the material to slide by one another and eventually fracture.

d. Torsion strength —— the ability to resist twisting forces. Forces which exceed the torsion strength (modulus of rupture) will cause the material to rupture.

e. Flexure (bending) strength —— the ability of a material to resist the combination of tensile and compression forces. As seen in Fig. 1. 2, when a material is bent, the material on the inside of the bend must compress while that on the outside portion must stretch. A material must have flexure strength to undergo bending processes.

f. Fatigue strength —— the ability to resist forces which vary in direction and/or magnitude. Typical of forces which cause fatigue are constant bending back and forth (plastic hinge), applying and releasing tension forces (coil spring), or torsion forces (automobile torsion bar).

g. Impact strength —— the ability to resist a rapidly applied load. This is a more specific measure of tension or compression strengths. Impact strength determines the ability to absorb a tension or compression load which is quickly applied. Impact strength is often called toughness. The action of a hammer on a nail applies such impacts. Forging dies must have high impact strength.

(3) Plastic flow of materials. In addition to the mechanical properties involving

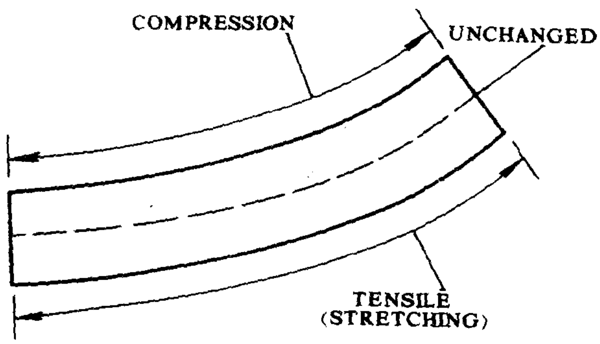

Fig. 1. 2 Flexure force creates compression on one surface and stretching on the opposite surface of a material

strength, materials have characteristics that govern their behavior during the plastic defomation stage. These properties are usually called ductility and creep.

Ductility is the plastic flow characteristic of a material under normal temperature. The higher the ductility of a material the greater is its ability to be formed without fracturing. Highly ductile materials can be easily bent, drawn into wire, or extruded.

Creep is the movement or plastic flow of material under load over an extended period of time. Creep of a material is affected by the stress level (force applied), temperature of the material, and the length of time over which the stress is applied. Also different types of material have different creep characteristics. Wood creeps very little. Metal experiences slight amounts of creep. Glass and plastic are more likely to experience significant amounts of creep.

(4) Hardness. Hardness is the resistance of a material to penetration or scratching. It accounts for abrasion resistance as well as resistance to denting. Hardness is also directly related to strength. The harder a material the stronger it is. Metallic and ceramic materials are almost always harder and stronger than polymeric materials. A number of different testers have been designed to test the hardness of a variety of materials.

3. Chemical Properties

All materials are used in some types of environment. All environments, except a pure vacuum, contain chemicals. These chemicals may be gases (oxygen, hydrogen, chlorine, nitrogen), liquids (water, acids, oils) or solids (other engineering materials). The reactions between the chemicals and a material in an environment is called corrosion.

These reactions are complex and require a knowledge of chemistry for a full understanding. In general, there are several types of chemical reactions. These include:

(1) Oxidation——corrosion caused by a reaction between the material and oxygen in the air. Iron oxidizes to form iron oxide (rust). Some polymers are weakened and destroyed by a combination of sunlight and oxygen. Rubber is particularly prone to oxidation which is called aging. As rubber ages it loses its flexibility (elasticity) and strength.

(2)Electrochemical corrosion——corrosion caused by electrical currents set up in a material in a liquid or moist environment. Electrical current flows from one point on the material (anodic area)to another part (cathodic). The current removes materials from the anodic area and deposits it at the cathodic area. This action is similiar to the operation of the storage battery.

(3)Water absorption——the tendency of polymers and ceramic materials to absorb water. This action increases the material's weight and volume. water absorption will cause many materials to warp and swell,and lose desirable mechanical and electrical properties.

4. Thermal properties

All materials are subjected to thermal(heat)energy. Heat may cause the material to change its physical form(melt,evaporate),to change in size,or to change in temperature. Heat may also change the internal structure of the material.

The important thermal properties to materials are:

(1)Heat resistance,the ability of a material to remain stable with changes in temperature. Ceramic materials have high heat resistance ratings.

(2)Thermal conductivity,the ability of a material to transfer heat energy along its length, width,or thickness. The rate of heat transfer for a material is called its coefficient of thermal conductivity. Metals have high coefficients of thermal conductivity. Ceramics and polymers have low conductivity rates. They are therefore good heat insulators.

(3)Thermal expansion,the rate of size change per unit of heat applied. Almost all engineering materials expand as they are heated. The rate of expansion is called the coefficient of linear expansion. The rate of expansion varies greatly among materials.

The varying rates of thermal expansion are the basis of the bimetal thermostat. The metal stripe of the thermostat have greatly different thermal expansion coefficients. When they are bonded together and heated,the metal with the high expansion rate elongates much more than the other strip. This causes the strips to bend and touch the contact point. This action closes an electric circuit which could start a furnace,turn on a cooling fan,or light a warning light.

5. Electrical and Magnetic Properties

Electrical and magnetic properties are similar. The electrical properties describe the behavior of a material carrying an electrical current. Magnetic properties involve the behavior of materials in an electromagnetic field. These properties include:

(1)Electrical conductivity——the ability to conduct an electric current. Engineering materials are classified as conductors (easily carry electrical current)and insulators(resist carrying electrical current). Other materials are called semiconductors and are the foundation of the computer and data processing industry.

The opposite of electrical conductivity is electrical resistivity (resistance to conducting current). If resistivity is an important property,it is often discussed as the dielectric property or strength. The dielectric strength is a specific measure of a material's electrical insulating qualities. Metals generally are considered conductors of electricity while ceramics and polymers are insulators (have high dielectric constants).

(2) Magnetic properties—the ability to be magnetized by an external electromagnetic force. Materials with high magnetic properties are said to be permeable or have high permeability. Iron, nickel, and cobalt which are called ferromagnetic materials have high permeability. They are easily magnetized.

6. Optical Properties

Optical properties govern the material's reaction to light. These properties include:

(1) Opacity—the degree to which a material obstructs visible light. Materials with high opacity are said to be opaque. Low-opacity materials are called transparent.

(2) Color—the appearance of the material which depends on the spectrum of light it reflects to the human eye.

(3) Transmittance—the measure of the amount of light transmitted by a material. The opposite of transmittance is reflectance. Window glass has high transmittance while polished aluminum has high reflectance.

7. Acoustical Properties

Acoustical properties describe a material's reaction to sound waves. The most important acoustical property is the sound insulating or absorbing quality of the material. This is the ability of the material to absorb sound and is called its sound absorption coefficient. Most ceiling tile has high sound absorption coefficients to reduce echoes in a room.

Unit 2

HEAT TREATMENT OF METALS

The understanding of heat treatment is embraced by the broader study of metallurgy. Metallurgy is the physics, chemistry, and engineering related to metals from ore extraction to the final product. Heat treatment is the operation of heating and cooling a metal in its solid state to change its physical properties. According to the procedure used, steel can be hardened to resist cutting action and abrasion, or it can be softened to permit machining. With the proper heat treatment internal stresses may be removed, grain size reduced, toughness increased, or a hard surface produced on a ductile interior. The analysis of the steel must be known because small percentages of certain elements, notably carbon, greatly affect the physical properties.

Alloy steels owe their properties to the presence of one or more elements other than carbon, namely nickel, chromium, manganese, molybdenum, tungsten, silicon, vanadium, and copper. [1] Because of their improved physical properties they are used commercially in many ways not possible with carbon steels.

The following discussion applies principally to the heat treatment of ordinary commercial steel known as plain-carbon steels. With this process the rate of cooling is the controlling factor, rapid cooling from above the critical range results in hard structure, whereas very slow cooling produces the opposite effect.

A SIMPLIFIED IRON-CARBON DIAGRAM

If we focus only on the materials normally known as steels, a simplified diagram is often used. Those portions of the iron-carbon diagram near the delta region and those above 2% carbon content are of little importance to the engineer and are deleted. [2] A simplified diagram, such as the one in Fig. 2. 1 focuses on the eutectoid region and is quite useful in understanding the properties and processing of steel.

The key transition described in this diagram is the decomposition of single-phase austenite (γ) to the two-phase ferrite plus carbide structure as temperature drops. Control of this reaction, which arises due to the drastically different carbon solubilities of austenite and ferrite, enables a wide range of properties to be achieved through heat treatment.

To begin to understand these processes, consider a steel of the eutectoid composition, 0. 77% carbon, being slow cooled along line x-x′ in Fig. 2. 1. At the upper temperatures, only austenite is present, the 0. 77% carbon being dissolved in solid solution with the iron. When the steel cools to 727°C (1341°F), several changes occur simultaneously. The iron wants to change from the fcc austenite structure to the bcc ferrite Structure, but the ferrite can only contain 0. 02% carbon in solid solution[3]. The rejected carbon forms the carbon-rich cementite intermetallic with composition Fe_3C. In essence, the net reaction at the eutectoid is

$$\underset{0.77\%C}{\text{austenite}} \rightarrow \underset{0.02\%C}{\text{ferrite}} + \underset{6.67\%C}{\text{cementite}}$$

Since this chemical separation of the carbon component occurs entirely in the solid state, the re-

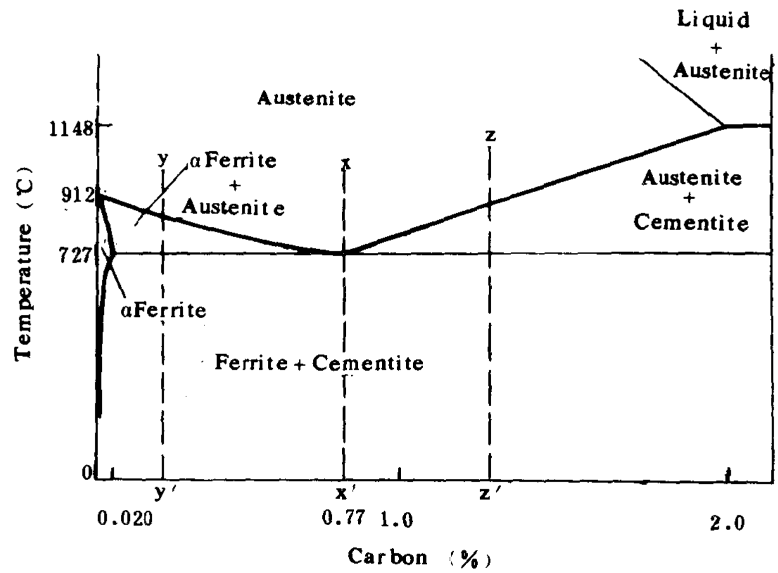

Fig. 2. 1 Simplified iron-carbon diagram

sulting structure is a fine mechanical mixture of ferrite and cementite. Speciments prepared by polishing and etching in a weak solution of nitric acid and alcohol reveal the lamellar structure of alternating plates that forms on slow cooling. This structure is composed of two distinct phases, but has its own set of characteristic properties and goes by the name pearlite, because of its resemblance to mother-of-pearl at low magnification. [4]

Steels having less than the eutectoid amount of carbon(less than 0. 77%)are known as hypoeutectoid steels. Consider now the transfomation of such a material represented by cooling along line y-y′ in Fig. 2. 1. At high temperatures, the material is entirely austenite, but upon cooling enters a region where the stable phases are ferrite and austenite. Tie-line and lever-law calculations show that low-carbon ferrite nucleates and grows, leaving the remaining austenite richer in carbon. [5] At 727℃ (1341℉), the austenite is of eutectoid composition(0. 77% carbon)and further cooling transforms the remaining austenite to pearlite. The resulting structure is a mixture of primary or proeutectoid ferrite (ferrite that formed above the eutectoid reaction) and regions of pearlite.

Hypereutectoid steels are steels that contain greater than the eutectoid amount of carbon. When such a steel cools, as in z-z′ of Fig. 2. 1 the process is similar to the hypoeutectoid case, except that the primary or proeutectoid phase is now cementite instead of ferrite. As the carbon-rich phase forms, the remaining austenite decreases in carbon content, reaching the eutectoid composition at 727℃ (1341℉). As before, any remaining austenite transforms to pearlite upon slow cooling through this temperature.

It should be remembered that the transitions that have been descibed by the phase diagrams are for equilibrium conditions, which can be approximated by slow cooling. With slow heating, these transitions occur in the reverse manner. However, when alloys are cooled rapidly, entirely different results may be obtained, because sufficient time is not provided for the normal phase reactions to occur, In such cases, the phase diagram is no longer a useful tool for engineering analysis.

HARDENING

Hardening is the process of heating a piece of steel to a temperature within or above its critical range and then cooling it rapidly. If the carbon content of the steel is known, the proper temperature to which the steel should be heated may be obtained by reference to the iron-iron carbide phase diagram. However, if the composition of the steel is unknown, a little preliminary experimentation may be necessary to determine the range. A good procedure to follow is to heat-quench a number of small specimens of the steel at various temperatures and observe the results, either by hardness testing or by microscopic examination. When the correct temperature is obtained, there will be a marked change in hardness and other properties.

In any heat-treating operation the rate of heating is important. Heat flows from the exterior to the interior of steel at a definite rate. If the steel is heated too fast, the outside becomes hotter than the interior and uniform structure cannot be obtained. If a piece is irregular in shape, a slow rate is all the more essential to eliminate warping and cracking. The heavier the section, the longer must be the heating time to achieve uniform results. Even after the correct temperature has been reached, the piece should be held at that temperature for a sufficient period of time to permit its thickest section to attain a uniform temperature.

The hardness obtained from a given treatment depends on the quenching rate, the carbon content, and the work size. In alloy steels the kind and amount of alloying element influences only the hardenability (the ability of the workpiece to be hardened to depths) of the steel and does not affect the hardness except in unhardened or partially hardened steels.

Steel with low carbon content will not respond appreciably to hardening treatments. As the carbon content in steel increases up to around 0.60%, the possible hardness obtainable also increases. Above this point the hardness can be increased only slightly, because steels above the eutectoid point are made up entirely of pearlite and cementite in the annealed state. Pearlite responds best to heat-treating operations; any steel composed mostly of pearlite can be transformed into a hard steel.

As the size of parts to be hardened increases, the surface hardness decreases somewhat even though all other conditions have remained the same. There is a limit to the rate of heat flow through steel. No matter how cool the quenching medium may be, if the heat inside a large piece cannot escape faster than a certain critical rate, there is a definite limit to the inside hardness. However, brine or water quenching is capable of rapidly bringing the surface of the quenched part to its own temperature and maintaining it at or close to this temperature. Under these circumstances there would always be some finite depth of surface hardening regardless of size. This is not true in oil quenching, when the surface temperature may be high during the critical stages of quenching.