吴隆 程军红 编著

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（机械工程类）

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内容提要

本书是作者总结多年的英语教学经验，结合国内外的教学方法编著的一部能使机械工程类的大学生较快提高专业英语阅读能力的教科书。

全书共24课，主要内容为：金属材料及热处理，各种机械加工方法，机械设计，公差与测量，液压传动，特种加工以及各种计算机化的现代制造技术。每课附有相对应的阅读材料及单词，书后附录内容丰富，具有很强的实用性和知识延伸性。

本书可作为高等院校机械工程类学生和有关科技人员的专业英语教材或阅读材料。

前 言

本书是作者在多年从事专业英语教学实践的基础上，尝试编写的，供机械工程专业高年级学生及相关工程技术人员专业英语阅读使用。

全书共24课，涉及的主要内容为：金属材料及热处理、各种机加工方法、公差与配合、夹具设计、机械设计、液压传动、热加工、特种加工、数控技术、计算机辅助设计与制造、成组技术、计算机辅助工艺规程的制订、柔性制造系统、计算机集成制造系统、机械加工史等，每课还附有与课文相呼应的阅读材料和单词。

本书既有机械工程的基础、专业、选修课的内容，又有计算机化的现代制造技术的内容，全书注重提高学生阅读专业书刊、翻译引进设备技术文件、用英语撰写专业论文等方面的能力。

本书由中原工学院吴隆、程军红任主编，董秀洁、史光远、张济洲任副主编，李力教授主审。

参加本书编写的人员有：吴隆（18、21单元），程军红（7、9、17单元），董秀洁（1、16单元），史光远（19、20单元），张济洲（6、14、15单元），张太超（8、11、24单元），沈晓来（2、3、22单元），张洪（4、12、13单元），刘英（5、10、附录2），陈旭（23单元），李学新（附录1），张素香（附录3，附录4）。

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编者

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Contents

Unit 1

Heat Treatment of Metals

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 influence 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.

Tempering

Steel that has been hardened by rapid quenching is brittle and not suitable for most uses. By tempering or drawing, the hardness and brittleness may be reduced to the desired point for service conditions. As these properties are reduced there is also a decrease in tensile strength and an increase in the ductility and toughness of the steel. The operation consists of reheating quench-hardened steel to some temperature below the critical range followed by any rate of cooling. Although this process softens steel, it differs considerably from annealing in that the process lends itself to close control of the physical properties and in most cases does not soften the steel to the extent that annealing would. The final structure obtained from tempering a fully hardened steel is called tempered martensite.

Tempering is possible because of the instability of the martensite, the principal constituent of hardened steel. Low-temperature draws, from 300°F to 400°F (150° ~ 205℃), do not cause much decrease in hardness and are used principally to relieve internal strains. As the tempering temperatures are increased, the breakdown of the martensite takes place at a faster rate, and at about 600°F (315℃) the change to a structure called tempered martensite is very rapid. The tempering operation may be described as one of precipitation and agglomeration or coalescence of cementite. A substantial precipitation of cementite begins at 600°F (315℃), which produces a decrease in hardness. Increasing the temperature causes coalescence of the carbides with continued decrease in hardness.

In the process of tempering, some consideration should be given to time as well as to temperature. Although most of the softening action occurs in the first few minutes after the temperature is reached, there is some additional reduction in hardness if the temperature is maintained for a prolonged time. Usual practice is to heat the steel to the desired temperature and hold it there only long enough to have it uniformly heated.

Two special processes using interrupted quenching are a form of tempering. In both, the hardened steel is quenched in a salt bath held at a selected lower temperature before being allowed to cool. These processes, known as austempering and martempering, result in products having certain desirable physical properties.

Annealing

The primary purpose of annealing is to soften hard steel so that it may be machined or cold worked. This is usually accomplished by heating the steel to slightly above the critical temperature, holding it there until the temperature of the piece is uniform throughout, and then cooling at a slowly controlled rate so that the temperature of the surface and that of the center of the piece are approximately the same. This process is known as full annealing because it wipes out all trace of previous structure, refines the crystalline structure, and softens the metal. Annealing also relieves internal stresses previously set up in the metal.

The temperature to which a given steel should be heated in annealing depends on its composition; for carbon steels it can be obtained readily from the partial iron-iron carbide equilibrium diagram. The heating rate should be consistent with the size and uniformity of sections, so that the entire part is brought up to temperature as uniformly as possible. When the annealing temperature has been reached, the steel should be held there until it is uniform throughout. This usually takes about 45min for each inch (25mm) of thickness of the largest section. For maximum softness and ductility the cooling rate should be very slow, such as allowing the parts to cool down with the furnace. The higher the carbon content, the slower this rate must be.

Normalizing and Spheroidizing

The process of normalizing consists of heating the steel about 50°F to 100°F (10 ~ 40℃) above the upper critical range and cooling in still air to room temperature. This process is principally used with low-and medium carbon steels as well as alloy steels to make the grain structure more uniform, to relieve internal stresses, or to achieve desired results in physical properties. Most commercial steels are normalized after being rolled or cast.

Spheroidizing is the process of producing a structure in which the cementite is in a spheroidal distribution. If a steel is heated slowly to a temperature just below the critical range and held there for a prolonged period of time, this structure will be obtained. The globular structure obtained gives improved machinability to the steel. This treatment is particularly useful for hypereutectoid steels that must be machined.

Surface Hardening

1. Carburizing

The oldest known method of producing a hard surface on steel is case hardening or carburizing. Iron at temperatures close to and above its critical temperature has an affinity for carbon. The carbon is absorbed into the metal to form a solid solution with iron and converts the outer surface into a high-carbon steel. The carbon is gradually diffused to the interior of the part. The depth of the case depends on the time and temperature of the treatment. Pack carburizing consists of placing the parts to be treated in a closed container with some carbonaceous material such as charcoal or coke. It is a long process and used to produce fairly thick cases of from 0.030 to 0.160in, (0.76 ~ 4.06mm) in depth.

Steel for carburizing is usually a low-carbon steel of about 0.15% carbon that would not in itself respond appreciably to heat treatment. In the course of the process the outer layer is converted into a high-carbon steel with a content ranging from 0.9% to 1.2% carbon.

A steel with varying carbon content and, consequently, different critical temperatures requires a special heat treatment. Because there is some grain growth in the steel during the prolonged carburizing treatment, the work should be heated to the critical temperature of the core and then cooled, thus refining the core structure. The steel should then be reheated to a point above the transformation range of the case (Ac_1) and quenched to produce a hard, fine structure. The lower heat-treating temperature of the case results from the fact that hypereutectoid steels are normally austenitized for hardening just above the lower critical point, A third tempering treatment may be used to reduce strains.

2. Carbonitriding

Carbonitriding, sometimes known as dry cyaniding or nicarbing, is a case-hardening process in which the steel is held at a temperature above the critical range in a gaseous atmosphere from which it absorbs carbon and nitrogen. Any carbon-rich gas with ammonia can be used. The wear-resistant case produced ranges from 0.003 to 0.030in. (0.08 ~ 0.76mm) in thickness. An advantage of carbonitriding is that the hardenability of the case is significantly increased when nitrogen is added, permitting the use of low-cost steels.

3. Cyaniding

Cyaniding, or liquid carbonitriding as it is sometimes called, is also a process that combines the absorption of carbon and nitrogen to obtain surface hardness in low-carbon steels that do not respond to ordinary heat treatment. The part to be case hardened is immersed in a bath of fused sodium cyanide salts at a temperature slightly above the Ac_1 range, the duration of soaking depending on the depth of the case. The part is then quenched in water or oil to obtain a hard surface. Case depths of 0.005 to 0.015in. (0.13 ~ 0.38mm) may be readily obtained by this process. Cyaniding is used principally for the treatment of small parts.

4. Nitriding

Nitriding is somewhat similar to ordinary case hardening, but it uses a different material and treatment to create the hard surface constituents. In this process the metal is heated to a temperature of around 950°F (510°C) and held there for a period of time in contact with ammonia gas. Nitrogen from the gas is introduced into the steel, forming very hard nitrides that are finely dispersed through the surface metal.

Nitrogen has greater hardening ability with certain elements than with others; hence, special nitriding alloy steels have been developed. Aluminum in the range of 1% to 1.5% has proved to be especially suitable in steel, in that it combines with the gas to form a very stable and hard constituent. The temperature of heating ranges from 925°F to 1050°F (495 ~ 565°C).

Liquid nitriding utilizes molten cyanide salts and, as in gas nitriding, the temperature is held below the transformation range. Liquid nitriding adds more nitrogen and less carbon than either cyaniding or carburizing in cyanide baths. Case thicknesses of 0.001 to 0.012 in. (0.03 ~ 0.30mm) are obtained, whereas for gas nitriding the case may be as thick as 0.025in. (0.64mm).

In general the uses of the two nitriding processes are similar.

Nitriding develops extreme hardness in the surface of steel. This hardness ranges from 900 to 1100 Brinell, which is considerably higher than obtained by ordinary case hardening. Nitriding steels, by virtue of their alloying content, are stronger than ordinary steels and respond readily to heat treatment. It is recommended that these steels be machined and heat-treated before nitriding, because there is no scale or further work necessary after this process. Fortunately, the interior structure and properties are not affected appreciably by the nitriding treatment and, because no quenching is necessary, there is little tendency to warp, develop cracks, or change condition in any way. The surface effectively resists corrosive action of water, saltwater spray, alkalies, crude oil, and natural gas.

Words and Expressions

1. hardening *n*.淬火
2. carbide *n*.碳化物、硬质合金
3. quench *v*.淬火
4. eutectoid *n* 共析合金
5. pearlite *n*.珠光体
6. cementite *n*.碳化三铁
7. anneal *v*.退火
8. hardenability *n* 淬透性、淬硬性
9. tempering *n*.回火
10. brittle *a*.脆的
11. ductility *n*.塑性
12. toughness *n* 韧性
13. martensite *n*.马氏体
14. draw *n*.退火
15. coalescence *n*.聚合
16. austempering *n*.奥氏体回火
17. martempering *n*.马氏体回火
18. normalizing *n*.正火、调质
19. spheroidizing *n*.使球状化的正火处理
20. hypereutectoid *a*.亚共析的、低碳的
21. carburizing *n*.渗碳
22. charcoal *n*.炭
23. carbonitriding *n*.碳氮共渗
24. cyaniding *n*.氰化
25. nicarbing *n*.碳氮共渗

26. ammonia　　n. 氨
27. nitriding　　n. 渗氮
28. nitrogen　　n. 氮
29. carbonaceous　　a. 含碳的
30. fuse　　n. 保险丝，v. 溶解
31. sodium　　n. 钠
32. Brinell　　n. 布氏(硬度)
33. alkali　　n. 碱

Reading Materials

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. A simplified diagram, such as the one in Fig. 1.1 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. 1.1. 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℃ (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. The rejected carbon forms the carbon-rich cementite intermetallic with composition Fe_3C. In essence, the net reaction at the eutectoid is

austenite → ferrite + cementite
0.77%C　0.02%C　6.67%C

Since this chemical separation of the carbon component occurs entirely in the solid state, the resulting 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.

Steels having less than the eutectoid amount of carbon (less than 0.77%) are known as hypoeutectoid steels. Consider now the transformation of such a material represented by cooling along line y-y′ in Fig.1.1. 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. 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.

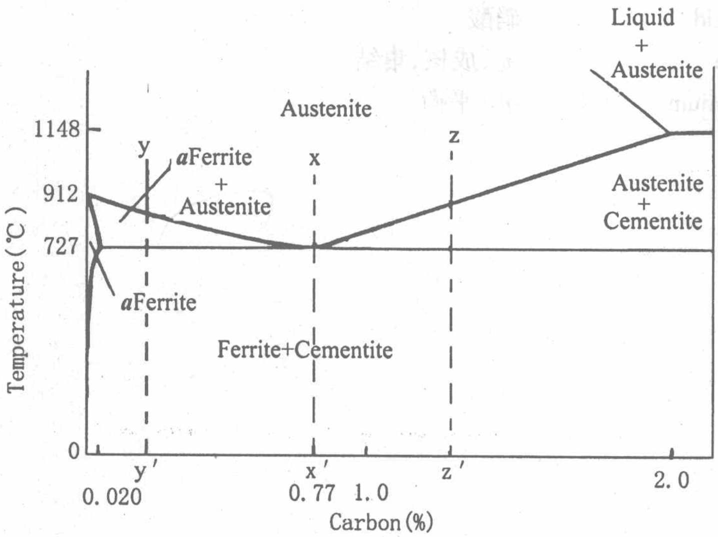


Fig.1.1 Simplified iron-carbon diagram

Hypereutectoid steels are steels that contain greater than the eutectoid amount of carbon. When such a steel cools, as in z-z′ of Fig.1.1 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 described 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.

Words and Expressions

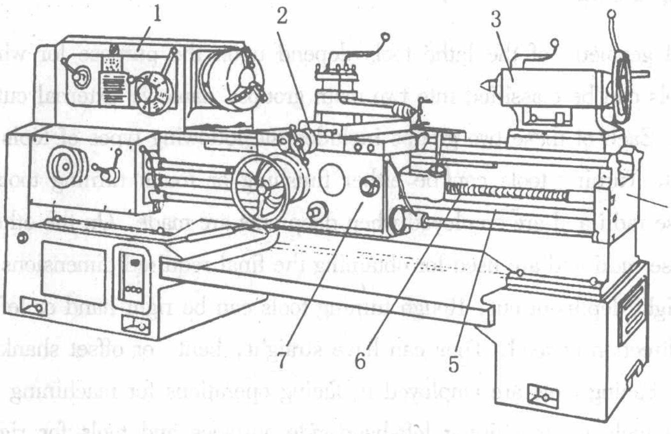
1. iron-carbon diagram 铁-碳图
2. delta *n*.铁素体
3. austenite *n*.奥氏体
4. solubility *n*.溶解度
5. lamellar *a*.层状的
6. proeutectoid *a*.先共析的
7. decomposition *n*.分解
8. nitric acid 硝酸
9. nucleate *v*.成核,集结
10. equilibrium *n*.平衡

Unit 2

The Lathe and Turning

Lathe

The lathe is one of most useful and versatile machines in the workshop, and is capable of carrying out a wide variety of machining operations. The main components of the lathe are the headstock and tailstock at opposite ends of a bed, and a tool-post between them which holds the cutting tool. The tool-post stands on a cross-slide which enables it to move sidewards across the saddle or carriage as well as along it, depending on the kind of job it is doing. The ordinary center lathe can accommodate only one tool at a time on the tool-post, but a turret lathe is capable of holding five or more tools on the revolving turret. The lathe bed must be very solid to prevent the machine from bending or twisting under stress(see Fig.2.1).



1 – Headstock; 2 – Tool-post; 3 – Tailstock; 4 – Bed;
5 – Feed-shaft; 6 – Lead-screw; 7 – Carriage

Fig.2.1 Lathe

The headstock incorporates the driving and gear mechanism, and a spindle which holds the workpiece and causes it to rotate at a speed which depends largely on the diameter of the workpiece. A bar of large diameter should naturally rotate more slowly than a very thin bar, the cutting speed of the tool is what matters. Tapered centres in the hollow nose of the spindle and of the tailstock hold the work firmly between them. A feed-shaft from the headstock drives the tool-post along the saddle, either forwards or backwards, at a fixed and uniform speed. This enables the operator to make accurate cuts and to give the work a good finish. Gears between the spindle and the feed-shaft control the speed of rotation of the shaft, and therefore the forward or backward movement of the tool-post. The gear which the operator will select depends on the type of metal which he is cutting and the amount of metal he has to cut off. For a deep or roughing cut the forward movement of the tool should be less than for a finishing cut.

Centres are not suitable for every job on the lathe. The operator can replace them by various types of chucks, which hold the work between jaws, or by a front-plate, depending on the shape of the work and the particular cutting operation. He will use a chuck, for example, to hold a short piece of work, or work for drilling, boring or screw-cutting. A transverse movement of the tool-post across the saddle enables the tool to cut across the face of the workpiece and give it a flat surface. For screw-cutting, the operator engages the leadscrew, a long screwed shaft which runs along in front of the bed and which rotates with the spindle. The lead-screw drives the tool-post forwards along the carriage at the correct speed, and this ensures that the threads on the screw are of exactly the right pitch. The operator can select different gear speeds, and this will alter the ratio of spindle and leadscrew speeds and therefore alter the pitch of the threads. A reversing lever on the headstock enables it to reverse the movement of the carriage and so bring the tool back to its original position.

Lathe Cutting Tools

The shape and geometry of the lathe tools depend upon the purpose for which they are employed. Turning tools can be classified into two main groups, namely, external cutting tools and internal cutting tools. Each of these two groups includes the following types of tools.

Turning tools. Turning tools can be either finishing or rough turning tools. Rough turning tools have small nose radii and are employed when deep cuts are made. On the other hand, finishing tools have larger nose radii and are used for obtaining the final required dimensions with good surface finish by making slight depths of cut. Rough turning tools can be right-hand or left-hand types, depending upon the direction of feed. They can have straight, bent, or offset shanks.

Facing tools. Facing tools are employed in facing operations for machining plane side or end surfaces. There are tools for machining left-hand-side surfaces and tools for right-hand-side surfaces. Those side surfaces are generated through the use of the cross feed, contrary to turning operations, where the usual longitudinal feed is used.

Cutoff tools. Cutoff tools, which are sometimes called parting tools, serve to separate the workpiece into parts and/or machine external annual grooves.

Thread-cutting tools. Thread-cutting tools have either triangular, square, or trapezoidal cutting edges, depending upon the cross section of the desired thread. Also, the plane angles of these tools must always be identical to those of the thread forms. Thread-cutting tools have straight shanks for external thread cutting and are of the bent-shank type when cutting internal threads.

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