专业英语阅读丛书

材料科学英语阅读

ENGLISH READING FOR MATERIAL SCIENCE

主编　李洪涛　费维栋

哈尔滨工业大学出版社

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内 容 提 要

本书是为提高从事材料科学专业学习和研究人员的英语阅读能力而编写的。

全书共分五大部分:第一部分是材料及其热处理工艺;第二部分是铸造工艺;第三部分是成型工艺;第四部分是焊接工艺;第五部分是包含若干短文的一般科技英语。

本书可作为有关专业的专业英语阅读教材,也可供有关人员阅读参考。

材料科学英语阅读

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前　言

本书是国家“九五”重点图书《材料科学与工程》丛书之一，是为材料科学与工程专业的三、四年级本科生使用的专业英语教材。

本书由五部分组成，第一部分是材料及其热处理工艺，第二部分是铸造工艺，第三部分是成型工艺，第四部分是焊接工艺，第五部分是包含若干短文的一般科技英语。编写本教材的目的是为了让本科生在经历了大学一、二年级的基础英语学习后，通过阅读本书，实现英语教学的不断线，使英语水平再上一个新台阶。

本书选材新颖，覆盖面广，不仅包含了材料科学领域的四门基础专业而且涉及除此之外的其他各学科的基础知识，从而开阔了学生的视野，丰富了学生的知识。

本书编排独具匠心，把一篇较长的文章人为的分成若干段落(passage)，并在每段后还提出了几个问题，供学生回答或讨论。这不仅有利于学生及时检查自己对文章的理解情况，还便于教师安排教学。书中用星号(*)把那些较生僻的词标在了段后给出汉语注释，以减少翻字典的次数，提高阅读效率。

另外，在书后的附录部分讲解了科技文章的翻译方法，选择性地摘取了有代表性的段落通过比较、分析使学生能够对所讲方法融会贯通，从而提高写作和翻译的能力。

本书由哈尔滨工业大学材料科学与工程学院李洪涛副教授和费维栋教授主编，由崔成松、刘祖岩、阎久春、孙杰等人共同编写。因编者水平所限，错误之处在所难免，敬请批评指正。

作　者

1999 年 5 月 于哈尔滨

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Unit 1 Materials and Heat Treatment

1.1 Ferrous Alloys

More than 90% by weight of the metallic materials used by human beings are ferrous alloys. This represents an immense family of engineering materials with a wide range of microstructures and related properties. The majority of engineering designs that require structural load support or power transmission involve ferrous alloys. As a practical matter, these alloys fall into two broad categories based on the carbon in the alloy composition. Steel generally contains between 0.05 and 2.0 wt% carbon. The cast irons generally contain between 2.0 and 4.5 wt% carbon . Within the steel category, we shall distinguish whether or not a significant amount of alloying elements other than carbon is used. A composition of 5 wt% total non-carbon additions will serve as an arbitrary boundary between low alloy and high alloy steels. These alloy additions are chosen carefully because they invariably bring with them sharply increased material costs. They are justified only by essential improvements in properties such as higher strength or improved corrosion resistance.

Questions:

1) How can you distinguish steel from cast iron?

2) How can you distinguish low alloy steel from high alloy steel?

1.1.1 Iron and Steel

The earth contains a large number of metals which are useful to man. One of the most important of these is iron. Modern industry needs considerable quantities of this metal, either in the form of iron or in the form of steel. A certain number of non-ferrous metals, including aluminum and zinc, are also important, but even today the majority of our engineering products are of iron or steel. Moreover, iron possesses magnetic properties, which have made the development of electrical power possible.

The iron ore* which we find on earth is not pure. It contains some impurities that must be removed by smelting. The process of smelting consists of heating the ore in a blast furnace* with coke* and limestone*, and reducing it to metal. Blasts of hot air enter the furnace from the bottom and provide the oxygen that is necessary for the reduction of the ore. The ore becomes molten, and its oxides combine with carbon from the coke. The non-metallic constituents of the ore combine with the limestone to form a liquid slag*. This floats on top of the molten iron, and passes out of the furnace through a tap*. The metal which remains is pig iron*.

We can melt this down again in another furnace—a cupola*—with more coke and limestone, and tap it out into a ladle* or directly into molds. This is cast iron. Cast iron does not have the strength of steel. It is brittle and may fracture under tension. But it possesses certain properties that make it very useful in the manufacture of machinery. In the molten state it is very fluid, therefore, it is easy to cast it into intricate shapes. Also it is easy to machine it. Cast iron contains small proportions of other substances. These non-metallic constituents of cast iron include carbon, silicon and sulphur, and the presence of these substances affects the behavior of the metal. Iron which contains a negligible quantity of carbon, for example, wrought* iron behaves differently from iron which contains a lot of carbon.

The carbon in cast iron is present partly as free graphite and partly as a chemical combination of iron and carbon which is called cementite*. This is a very hard substance, and it makes the iron hard too. However, iron can only hold about 1.5% of cementite. Any carbon content above that percentage is present of the form of a flaky* graphite. Steel contains no free graphite, and its carbon content ranges from almost nothing to 1.5%. We make wire and tubing from mild steel with a very low carbon content, and drills and cutting tools from high carbon steel.

Key words:

ore[矿]	blast furnace[高炉]	coke[焦炭]
limestone[石灰石]	slag[熔渣]	tap[口]
pig iron[生铁]	cupola[平炉]	ladle[杓子]
wrought[精炼的]	cementite[渗碳体]	flaky[片状的]

Questions:

1) How is the steel made?

2) If you want to have a high strength iron based material, what should you do?

3) What is the function of the coke when producing pig iron?

4) What is the difference between the pig iron and the cast iron?

1.1.2 Carbon and Low Alloy Steel

The majority of ferrous alloys belongs to this category. The reasons for this are straightforward. They are moderately priced due to the absence of large amounts of alloying elements, and they are sufficiently ductile* to be readily formed. The final product is strong and durable. These eminently* practical materials find applications from ball bearings to metal sheet formed into automobile bodies. For example, the 10XX, 11XX,

Mn manganese Mo molybdenum
P phosphorus Mg magnesium
Cr chromium
Ni nickel

12XX, 15XX etc. (AISI standards, in which the first two numbers give a code designating the type of alloy additions and the last two or three numbers give the carbon content in hundredths of a weight percent). As an example, the plain carbon steel with 0.40 wt% carbon is a 1040 steel, whereas a steel with 1.45 wt% Cr and 1.50 wt% carbon is a 52150 steel. One should keep in mind that chemical compositions quoted in alloy designations are approximate and will vary slightly from product to product within acceptable limits of industrial quality control.

An interesting class of alloys known as high strength low alloy (HSLA) steels has emerged in response to requirements for weight reduction of vehicles. The compositions of many commercial HSLA steels are proprietary and specified by mechanical properties rather than composition. But a typical example might contain 0.2 wt% Carbon and about 1.0 wt% or less of such elements as Mn, P, Si, Cr, Ni, or Mo. The high strength of HSLA steels is the result of optimal alloy selection and carefully controlled processing such as hot rolling (deformation at temperatures sufficiently elevated to allow some stress relief).

Key words:

ductile[延展] eminently[杰出地]

Questions:

1) What is the difference between the carbon steel and HSLA steel?
2) Why the HSLA steel is so popular?
3) How are the good properties of the HSLA steel obtained?

1.1.3 High Alloy Steel

As mentioned above, alloy additions must be made with care and justification because they are expensive. We shall now look at three cases in which engineering design requirements justify high alloy composition (i.e., total non-carbon additions greater than 5 wt%). Stainless steels require alloy additions to prevent damage from a corrosive atmosphere. Tool steels require alloy additions to obtain sufficient hardness for machining applications. So it is called "superalloys" which require alloy additions to provide stability in high temperature applications such as turbine* blades.

Stainless steels are more resistant to rusting* and staining than carbon and low alloy steels, due primarily to the presence of chromium addition. The amount of chromium is at least 4 wt% and usually above 10 wt%. Levels as high as 30 wt% Cr are sometimes used. The austenitic* stainless steels have the austenite structure retained at room temperature. The austenite has the fcc* structure and is stable above 910℃. This structure can occur at room temperature when it is stabilized by an appropriate alloy addition such as nickel. Without the high nickel content, the bcc * structure is stable, as seen in the ferritic stainless steels. For many applications not requiring the high corrosion resistance of austenitic stainless steels, these lower alloy(and less expensive) ferritic stainless steels are quite serviceable. A rapid quench heat treatment discussed later allows the formation of a more complex body centered tetragonal* crystal structure called martensite*. This crystal structure yields high strength and low ductility. As a result, these martensitic stainless steels are excellent for applications such as cutlery* and springs. Precipitation* hardening is another heat treatment. Essentially, it involves producing a multiphase microstructure from a single phase one. The result is increased resistance to dislocation* motion and, thereby, greater strength or hardness. Precipitation hardening stainless steels can be found in applications such as corrosion resistant structural members.

Tool steels are used for cutting, forming or otherwise shaping another material. Plain carbon steel can also be tool steel. For shaping operations that are not too demanding, such a material is adequate. In fact, tool steels were historically of the plain carbon variety until the mid-nineteenth century. Now high alloy additions are common. Their advantage is that they can provide the necessary hardness with simple heat treatments and retain that hardness at higher operating temperatures. The primary alloying elements used in these materials are tungsten*, molybdenum*, and chromium.

The term superalloys refers to a broad class of metals with especially high strength at elevated temperatures (even above 1 000℃). Many stainless steels serve a dual role as heat resistant alloys. Except iron based superalloys, there are also cobalt* and nickel based alloys. Most superalloys contain chromium additions for oxidation and corrosion resistance. These materials are expensive and, in some cases, extremely so. But the increasingly severe requirements of modern technology are justifying such costs. Between 1950 and 1980, the use of superalloys in aircraft turbojet engines rose from 10% to 50% by weight. At this point, our discussion of steels has taken us into closely related to non-ferrous alloys. Before going on to the general area of all other non-ferrous alloys, we must discuss the traditional and important ferrous system, the cast irons.

Key words:

turbine[涡轮机]	rust [生锈]	austenitic[奥氏体的]
fcc[面心立方]	bcc[体心立方]	tetragonal[四角的]
martensite[马氏体]	cutlery[刀具]	precipitation[沉淀]
dislocation[位错]	tungsten[钨]	molybdenum[钼]
cobalt[钴]		

Questions:

1) Generally speaking, what is the role of the elements such as

chromium, nickel and tungsten in the high alloy steel?

2) What is the main property of the superalloy steel?

3) By adding what element into steel can we obtain austenite at room temperature?

1.1.4 Cast Irons

As stated earlier, we define cast irons as the ferrous alloys with greater than 2 wt% carbon. They also generally contain up to 3 wt% silicon for control of carbide formation kinetics. Cast irons have relatively low melting temperatures and liquid phase viscosities*, do not form undesirable surface films when poured, and undergo moderate shrinkage* during solidification and cooling. The cast irons must balance good formability of complex shapes against inferior mechanical properties compared to wrought alloys.

A cast iron is formed into a final shape by pouring molten metal into a mold. The shape of the mold is retained by the solidified metal. Inferior mechanical properties result from a less uniform microstructure, including some porosity*. Wrought alloys are initially cast but are rolled or forged into final, relatively simple shapes (in fact, "wrought" simply means "worked").

There are four general types of cast irons. White iron has a characteristic white, crystalline fracture surface. Large amounts of Fe_3C are formed during casting, giving a hard, brittle material. Gray iron has a gray fracture surface with a finely faceted structure. A significant silicon content (2 to 3 wt%) promotes graphite (C) precipitation rather than cementite (Fe_3C). The sharp, pointed graphite flakes contribute to characteristic brittleness in gray iron. By adding a small amount (0.05 wt%) of magnesium* to the molten metal of the gray iron composition, spheroidal graphite precipitates rather than flakes are produced. This resulting ductile iron derives its name from the improved mechanical properties. Ductility is increased by a factor of 20, and strength is doubled. A more traditional form of cast iron with reasonable ductility is malleable* iron, which is first cast as white iron and then heat treated to produce nodular* graphite precipitates.

Key words:

viscosity[粘性]	shrinkage[收缩]	porosity[多孔]
magnesium[镁]	malleable[可锻的]	nodular[小球]

Questions:

1) The name "cast iron" derives from the fact that the composition of the cast iron is just iron. (T/F)

2) How is malleable cast iron obtained?

3) What is the function of the element of magnesium when it is added into the cast iron?

1.2 Heat Treatment of Steel

We can alter the characteristics of steel in various ways. In the first place, steel which contains very little carbon will be milder than steel which contains a higher percentage of carbon, up to the limit of about 1.5%. Secondly, we can heat the steel above a certain critical temperature, and then allow it to cool at different rates. At this critical temperature, changes begin to take place in the molecular structure of the metal. In the process known as annealing*, we heat the steel above the critical temperature and permit it to cool very slowly. This causes the metal softer than before, and much easier to be machined. Annealing has a second advantage. It helps to relieve any internal stresses which exist in the metal. These stresses are liable to occur through hammering or working the metal, or through rapid cooling. Metal which we cause to cool rapidly contracts more rapidly on the outside than on the inside. This produces unequal contractions, which may give rise to distortion or cracking. Metal which cools slowly is less liable to have these internal stresses than metal which cools quickly.

On the other hand, we can make steel harder by rapid cooling. We heat it up beyond the critical temperature, and then quench* it in water or some other liquid. The rapid temperature drop fixes the structural change in the steel and this hardened steel is more liable to fracture than normal steel. We therefore heat it again to a temperature below the critical temperature, and cool it slowly. This treatment is called tempering*. It helps to relieve the internal stresses, and makes the steel less brittle than before. The properties of tempered steel enable us to use it in the manufacture of tools which need a fairly hard steel. High carbon steel is harder than tempered steel, but it is much more difficult to work.

These heat treatments take place during the various shaping operations. We can obtain bars and sheets of steel by rolling the metal through huge rolls in a rolling mill. The roll pressures must be much greater for cold rolling than for hot rolling, but cold rolling enables the operators to produce rolls of great accuracy and uniformity, and with a better surface finish. Other shaping operations include drawing into wire, casting in molds*, and forging*.

Key words:

annealing[退火]　quench[淬火]　tempering[回火]
mold [模具]　forging[锻造]

Questions:

1) If a workpiece made of steel is too hard to work, what would you do?

2) Generally speaking, which kind of steel is softer, and which one is harder?

3) If you want a piece of steel to be harder or softer, what would you do?

1.3 Principle of Heat Treatment of Steel

Theoretical study of heat treatment steel was initiated by the discovery of the critical points in steel made by D. K. Chernov in 1868. Cheronv's assumption that the properties of steels are determined by the structure and that the latter depends on the heating temperature and rate of cooling has been generally recognized. During the decades which followed the researchers were engaged in establishing the relationships between the structure and the conditions of its formation (mainly the heating temperature and cooling rate). The principal achievements in the theory of heat treatment were, however, made in 1920's and 1930's.

Metallurgists have gradually come to the conclusion that the type of structure(its texture*, properties, etc.) is determined by the temperature of its formation. It has become clear that the processes occurring in heat treatment can be explained by studying the kinetics* of transformations at various temperatures and the factors affecting the kinetics.

These concepts formed the basis of extensive experimental work undertaken by S. S. Steinberg and co-workers in 1930 ~ 1940. They collected a vast experimental material which has constituted the basis of the modern concepts on transformations in steel and the theory of heat treatment of steel.