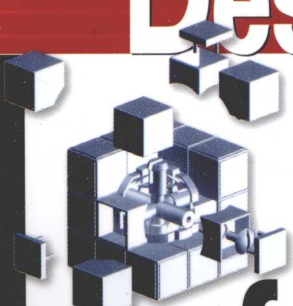
高职高专"十二五"规划教材·专业英语系列

模具设计与制造专业英语

■ 孙江 沈剑英 顾金梅 主编

English For Die & Mould Designing and Manufacturing



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内 容 简 介

《模具设计与制造专业英语》分为六个单元，每一单元由多篇课文和阅读材料组成。阅读材料提供与课文相应的知识或课文的续篇。每篇课文均对关键专业术语加以注释，对一些难懂句课后有参考译文，每课后还配有与课文内容相关的讨论题及翻译练习。课文与阅读材料均选自一些欧美原版书及欧美专业网站。主要章节有工程材料及热处理、注射成形工艺与模具设计、冲压工艺与模具设计、热锻工艺与模具设计、压铸工艺与模具设计、模具制造技术及模具CAD/CAM等。

本书内容丰富、新颖、知识面宽。不仅适合高职高专模具专业学生使用，也可作为相关专业教师及研究人员的学习参考用书。

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前　言

当今高等教育的改革非常重视学生科技创新能力和实际工作能力的培养。学好英语，不仅要学好日常英语，还须学好专业英语。专业英语是学生获取科研信息、掌握学科发展动态、参加国际学术交流的基本前提。模具技术涉及高分子材料、模具金属材料、模具结构、成形加工设备等诸多领域，这些领域都在不断发展变化，国内引进的材料成形设备及相关技术和国际合作交流很多，因此，模具专业的学生有必要熟悉模具设计制造方面的专业语汇。尽管该专业所涉及的科技英语词汇、语句等常见于各专业文献中，但无法全面、系统地反映材料、设备、工艺的内在联系，为此特编撰本书，以提高模具专业学生专业英语的素养。

本书根据模具专业所涉及的专业知识，按照内容由浅入深，循序渐进的原则编排专业英语。课程内容既有工程材料及其处理、机械加工方法、材料成形工艺、模具结构、模具设计和模具设备等常规的专业知识内容，又有一些制造领域的先进科学技术内容。主要章节有工程材料及热处理、注射成形工艺与模具设计、冲压工艺与模具设计、热锻工艺与模具设计、压铸工艺与模具设计、模具制造技术和模具 CAD/CAM 等。本书所载文章均选自欧美原著及欧美的专业网站，书中对课文中一些专业术语或难懂词汇给予了注释，并对一些难懂句在课后给出了参考译文，课后还针对课文主要内容给出了一些讨论习题和一些翻译练习题，每课后还附有一些相关阅读材料。

本书由孙江、沈剑英、顾金梅主编，王殿梁负责全书的结构、大纲编写及专业语汇的解释，孙江负责全书的组织、审核及第四、五单元的编写，沈剑英负责第一、六单元的编写，顾金梅负责第二、三单元的编写。由于水平有限，书中难免会有疏漏之处，恳请读者给予批评指正。

编　者

Contents

Unit 1 Fundamentals of Engineering Materials

Lesson 1 The Crystal Structure of Metals

Why are some metals hard and others soft? Why are some metals **brittle**, while others are **ductile** and can be shaped easily without **fracture**? Why is it that some metals can withstand high temperatures, while other cannot? We can answer these and similar questions by studying the structure of metals—that is, the **arrangement** of the atoms within metals. The structure of metals greatly influences their behavior and properties.

Knowledge of structures guides us in controlling and predicting the behavior and performance of metals in various manufacturing processes. Understanding the structure of metals also allows us to predict and evaluate their properties. This helps us make appropriate selections for specific applications under particular external and environmental conditions such as force and temperature.

In addition to atomic structure, various other factors also influence the properties and behavior of metals. Among these are the composition of the metal, **impurities** and **vacancies** in the atomic structure, grain size, grain boundaries, environment, size and surface condition of the metal, and the methods by which metals and alloys are made into useful products[1].

When metals **solidify** from a **molten state**, the atoms arrange themselves into various orderly configurations, called **crystals**. This arrangement of the atoms in the crystal is called **crystalline** structure. The smallest group of atoms showing the characteristic **lattice structure** of a particular metal is known as a unit cell. It is the building block of a crystal, and a single crystal can have many unit cells[2].

brittle 脆性的
ductile 韧性的
fracture 断裂
arrangement 排列
impurity 杂质
vacancy 孔穴
solidify 凝固
molten state 液态
crystal 晶体
crystalline 结晶
lattice structure 晶格结构

Here are three basic atomic arrangements and some of the metals that use each:

1. **body-centered cubic** (BCC)－alpha iron（α铁）, chromium（铬）, molybdenum（钼）, tantalum（钽）, tungsten（钨）, and vanadium（钒）;
2. **face-centered cubic** (FCC)－gamma iron(γ铁), aluminum(铝), copper（铜）, nickel（镍）, lead（铅）, silver（银）, gold and platinum（铂）;
3. **hexagonal close-packed** (HCP)－beryllium(铍), cadmium(镉), cobalt（钴）, magnesium, alpha titanium（钛）, zinc（锌）, and zirconium（锆）.

These structures are represented by the illustrations given in Figs.1.1-1.3. Each sphere in these **illustrations** represents an atom. The order of magnitude of the distance between the atoms in these crystal structures is 0.1nm (10^{-8}in). The models are known as hard-ball or **hard-sphere models**; they can **be likened to** tennis balls arranged in various configurations in a box. The way in which these atoms are arranged determines the properties of particular metal. We can modify these arrangements by adding atoms of some other metal or metals, known as alloying; it often improves the properties of the metal[3].

body-centered cubic 体心立方

face-centered cubic 面心立方

hexagonal closed-packed 密排六方

illustration 插图

hard-sphere model 硬球模型

be likened to 可与相比

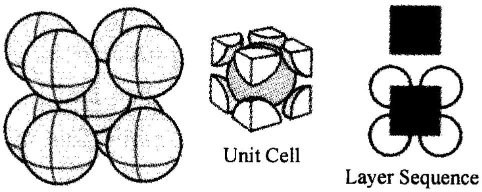


Fig. 1.1 Body-centered cubic

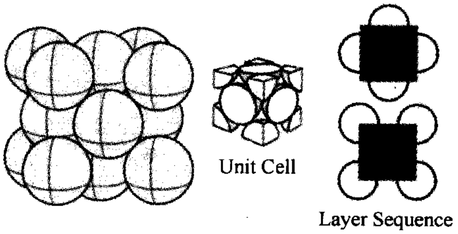


Fig. 1.2 Face-centered cubic

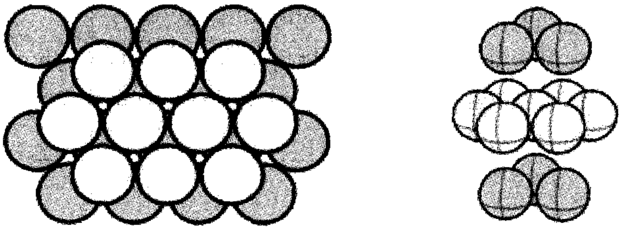


Fig. 1.3 Hexagonal close-packed

As shown in Fig.1.1, each atom in the bcc structure has eight neighboring atom. Of the three structures illustrated, the FCC and HCP crystal have the most densely packed configurations. In the HCP structure, the top and bottom planes are called **basal planes**.

basal plane 基层

The reason that metals form different crystal structures is to minimize the energy required to fit together in a regular pattern. Tungsten, for example, forms a BCC structure because that structure involves less energy than other structures do. **On the same grounds**, aluminum forms a FCC structure. At different temperatures, however, the same metal may form different structures, because of a lower energy requirement at that temperature. For example, iron forms a bcc structure (alpha iron) below 912°C (1,674°F) and above 1,394°C (2,542°F), but it forms a FCC structure (gamma iron) between 912 °C and 1,394 °C.

on the same ground 同样，同理

One important characteristic of a crystalline structure is its **atomic packing factor**. This is calculated by assuming that all the atoms are identical spheres, with a radius large enough that each sphere abuts the next[4]. The atomic packing factor is the proportion of space filled by these spheres.

atomic packing factor 原子堆积因数

Assuming one atom per lattice point, in a simple cubic lattice with cube side length *a*, the sphere size would be $a/2$ and the atomic packing factor turns out to be about 0.524 (which is quite low). Similarly, in a BCC lattice, the atomic packing factor is 0.680, and in FCC it is 0.740. The FCC value is the highest theoretically possible value for any lattice, although there are other lattices which also achieve the same value, such as HCP.

As a rule, since atoms in a solid attract each other, the more

tightly-packed arrangements of atoms tend to be more common. (Loosely packed arrangements do occur, though, for example if the orbital **hybridization** demands certain bond angles.) The BCC and FCC, with their higher densities, are both quite common in nature.	hybridization 杂交，混合（形成）

Notes

① In addition to atomic structure, various other factors also influence the properties and behavior of metals. Among these are the composition of the metal, impurities and vacancies in the atomic structure, grain size, grain boundaries, environment, size and surface condition of the metal, and the methods by which metals and alloys are made into useful products. 除了原子结构外，各种因素也会影响金属的特性和行为，如金属的组成，原子结构中杂质和空穴，晶粒心尺寸，晶粒边界，环境，金属的尺寸和表面状态以及金属和合金制成有用产品时所采用的加工方法。

② When metals solidify from a molten state, the atoms arrange themselves into various orderly configurations, called crystals. This arrangement of the atoms in the crystal is called crystalline structure. The smallest group of atoms showing the characteristic lattice structure of a particular metal is known as a unit cell. It is the building block of a crystal, and a single crystal can have many unit cells. 当金属从液态开始凝固时，原子将以各种有序的方式重新排列，我们将其称之为晶体。晶体内的这种原子排列叫做晶格结构。能体现某种金属点阵结构特征的最小原子团称为晶胞（又称单位晶格）。晶胞是构成晶体的基本单元，一颗晶粒可由很多晶胞构成。

③ We can modify these arrangements by adding atoms of some other metal or metals, known as alloying; it often improves the properties of the metal.我们能通过添加其他一种或多种金属的一些原子来改变这些排列，如我们所知的合金，它常常提高金属的性能。

④ This is calculated by assuming that all the atoms are identical spheres, with a radius large enough that each sphere abuts the next. 计算时，假设所有的原子都是相同的球体,半径足够大，能使每个球体都相连。

Exercises

1. Questions for discussion

（1）What is unit cell?

（2）What does BCC mean?

（3）How do we improve the properties of the metal?

2. Translate the following into Chinese

(1) We can answer these and similar questions by studying the structure of metals—that is, the arrangement of the atoms within metals.

(2)The reason that metals form different crystal structures is to minimize the energy required to fit together in a regular pattern.

(3) The FCC value is the highest theoretically possible value for any lattice, although there are other lattices which also achieve the same value, such as HCP.

3. Translate the following into English

晶胞 晶体结构 面心立方 原子堆积因数 凝固

Free Reading

Coordination Numbers and the Structures of Metals

The coordination numbers of the four structures of metals are summarized in Table 1.1. It is easy to understand why metals pack in hexagonal or cubic closest-packed structures. Not only do these structures use space as efficiently as possible, they also have the largest possible coordination numbers, which allows each metal atom to form bonds to the largest number of neighboring metal atoms.

Table 1.1 Coordination Numbers for Common Crystal Structures

Structure	Coordination Number	Stacking Pattern
simple cubic	6	AAAAAAAA···
body-centered cubic	8	ABABABAB···
hexagonal closest-packed	12	ABABABAB···
cubic closest-packed	12	ABCABCABC···

It is less obvious why one-third of the metals pack in a body-centered cubic structure, in which the coordination number is only 8. The popularity of this structure can be understood by referring to Fig. 1.4.

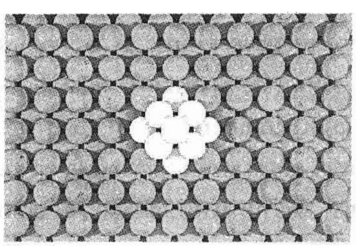


Fig. 1.4 A body-centered cubic structure

The coordination number for body-centered cubic structures given in the table above counts only the atoms that actually touch a given atom in this structure. The figure above shows that each atom also almost touches four neighbors in the same plane, a fifth neighbor two planes above, and a sixth two planes below. The distance from each atom to the nuclei of these nearby atoms is only 15% larger than the distance to the nuclei of the atoms that it actually touches. Each atom in a body-centered cubic structure therefore can form a total of 14 bonds—eight strong bonds to the atoms that it touches and six weaker bonds to the atoms it almost touches.

This makes it easier to understand why a metal might prefer the body-centered cubic structure to the hexagonal or cubic closest-packed structure. Each metal atom in the closest-packed structures can form strong bonds to 12 neighboring atoms. In the body-centered cubic structure, each atom forms a total of 14 bonds to neighboring atoms, although six of these bonds are somewhat weaker than the other eight.

Lesson 2 Properties of Metals in Different Conditions

The appearance of more than one type of crystal structure is known as **allotropism** or **polymorphism** (meaning "many shapes"). Because the properties and behavior of a metal depend greatly on its crystal structure, allotropism is an important factor in the heat treatment of metals and in metalworking and welding operations[1].

allotropism 同素异形
polymorphism 多形，多态性

Cold-, Warm-, and Hot-working

Cold working refers to **plastic deformation** that is usually, but not necessarily, carried out at room temperature. When the deformation is carried out above the **recrystallization** temperature, it is called hot-working. "Cold" and "hot" are relative terms, as we can see from the fact that deforming lead at room temperature is a hot-working process, because the recrystallization temperature of lead is at about room temperature. As the name implies, warm-working is carried out at **intermediate** temperatures. Thus warm working is a compromise between cold-and hot-working.

plastic deformation 塑性变形
recrystallization 再结晶
intermediate 中间的

The temperature ranges from these three categories of plastic deformation are given in Table 1.2. In terms of a ratio, where T is the working temperature and T_m is the **melting point** of the metal, both on the absolute scale. Although it is a **dimensionless quantity**, this ratio is known as the **homologous temperature**.

melting point 熔点
dimensionless quantity 无量纲的量
homologous temperature 对比温度

Table 1.2 Homologous temperature ranges for various processes

Process	T/T_m
Cold working	<0.3
Warm working	0.3 to 0.5
Hot working	>0.6

Working Hardening (Strain Hardening)

Although the presence of a **dislocation** lowers the shear stress required to cause **slip**, dislocations can:

1. become **entangled** and interfere with each other; and
2. be **impeded** by barriers, such as grain boundaries and impurities and **inclusions** in the material.

dislocation 错位
slip 滑移
entangle 缠结
impede 妨碍
inclusion 夹杂

Entanglements and impediments increase the shear stress required for slip. Entanglement is like moving two humps at different angles across a carpet; where they cross, the two humps interfere with each other's movement, and their combined effect is to make it more difficult to move the carpet.[2]

The effect of an increase in shear stress that causes an increase in the overall strength of the metal is known as **work hardening** or **strain hardening**. The greater the deformation, the greater the number of entanglements, hence an increase in the metal's strength. Work hardening is used extensively for strengthening metals in metalworking processes at **ambient** temperature. Typical examples are producing sheet metal for automobile bodies and **aircraft fuselages** by rolling, making the head of bolt by **forging**, and strengthening wire by reducing its cross-section by drawing it through a **die**[3].

work hardening 加工硬化
strain hardening 应变硬化
ambient 周围的
aircraft fuselage 机身
forging 锻造
die 模具

Plastic Deformation of Polycrystalline Metals

If a piece of polycrystalline metal with **uniform equiaxed grains** (having equal dimensions in all directions) is subjected to plastic deformation at room temperature (cold-working), the grains become deformed and **elongated**. The deformation process may be carried out either by compressing the metal, as is done in forging to make turbine disk or by subjecting it to **tension**, as is done in stretching sheet metal to make a car body[4].The deformation within each grain takes place by the mechanisms described in following section for a single crystal.

uniform equiaxed grain 均匀等轴的晶粒

elongate 伸长

tension 拉伸

During plastic deformation the grain boundaries remain **intact**, and **mass continuity** is maintained. The deformed metal exhibits greater strength, because of the entanglement of dislocations with grain boundaries. The increase in strength depends on the amount of deformation (strain) to which the metal is subjected; the greater the deformation, the stronger the metal becomes. Furthermore, the increase in strength is higher for metals with smaller grains, because they have a larger grain-boundary surface area per unit volume of metal.

intact 未触动的

mass continuity 整体的连续性

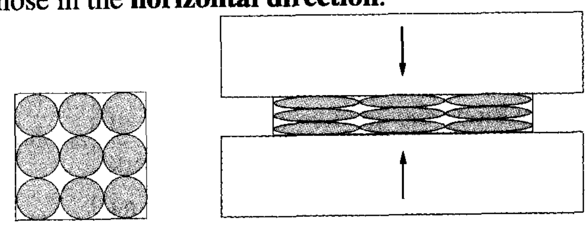
Anisotropy (Texture). Figure 1.5 shows that, as a result of plastic deformation, the grains in Fig.1.5(a) have elongated in one direction and **contracted** in the other. Consequently, this piece of metal has become anisotropic, and its properties in the **vertical direction** are different from those in the **horizontal direction**.

anisotropy 各向异性

contracted 受约束的

vertical direction 垂直方向

horizontal direction 水平方向



(a) before deformation　　(b) after deformation

Fig. 1.5 Plastic deformation

Many products develop anisotropy of mechanical properties after they have been processed by metalworking techniques. The degree of anisotropy depends on how uniformly the metal is deformed. Note, for example, that the **ductility** of the cold-rolled sheet in the **transverse**

ductility 韧性

transverse 横向

(vertical) direction is lower than that in its rolling (longitudinal) direction. Anisotropy influences both mechanical and physical properties of metals. For example, sheet steel for electrical **transformers** is rolled in such a way that the resulting deformation imparts anisotropic magnetic properties to the sheet. This arrangement reduces **magnetic-hysteresis losses** and improves the efficiency of transformers. There are two general types of anisotropy in metals: **preferred orientation** and **mechanical fibering**⑤.	transformer 变压器 magnetic-hysteresis loss 磁滞损耗 preferred orientation 择优取向 mechanical fibering 加工纤维化

Notes

① The appearance of more than one type of crystal structure is known as allotropism or polymorphism (meaning "many shapes"). Because the properties and behavior of a metal depend greatly on its crystal structure, allotropism is an important factor in the heat treatment of metals and in metalworking and welding operations. 我们把呈现出一种以上的晶体结构现象称做同素异性或同素异构（意思是多个形态）。因为金属的性能特征主要取决于晶体结构，因此同素异性在金属热处理、金属热加工和焊接过程中是一个很重要的影响金属性能的因素。

② Entanglements and impediments increase the shear stress required for slip. Entanglement is like moving two humps at different angles across a carpet; where they cross, the two humps interfere with each other's movement, and their combined effect is to make it more difficult to move the carpet. 缠结和障碍增加了（晶间）滑移所需的剪应力。缠结现象有点像两个凸峰从不同方向沿着一块地毯运动，当它们相遇时，这两个凸峰会彼此发生干涉从而使地毯更难以移动。

③ Typical examples are producing sheet metal for automobile bodies and aircraft fuselages by rolling, making the head of bolt by forging, and strengthening wire by reducing its cross-section by drawing it through a die. 典型（加工硬化）的例子如在生产汽车车体和飞机机身所用金属板时的轧制方法，生产螺栓头部时所用的锻造方法，以及为强化金属丝时所采用的拉拔方法，也就是拉拔金属丝通过模具减小金属丝的截面积。

④ The deformation process may be carried out either by compressing the metal, as is done in forging to make turbine disk or by subjecting it to **tension**, as is done in stretching sheet metal to make a car body. 变形过程即可以通过压缩金属方法，如在生产涡轮机盘时的锻造方法，也可采用拉伸方法，如在生产汽车车体的金属板所用的轧制方法。

⑤ Anisotropy influences both mechanical and physical properties of metals. For example, sheet steel for electrical transformers is rolled in such a way that the resulting deformation imparts anisotropic magnetic properties to the sheet. This arrangement reduces magnetic-hysteresis losses and improves the efficiency of transformers. There are two general types of anisotropy in metals: preferred orientation and mechanical fibering. 各向异性会影响金属材料的机械物理性能。例如，用于变压器的金属板材（硅钢片）在轧制过程中要使其变形在板材中产生各向异性的铁磁性能，这样可以减少磁滞损耗，提高变压器的效率。金属中的各向异性一般可分为两种形式：择优取向和加工纤维化。

Exercises

1. Questions for discussion

(1) What is hot-working?

(2) What does work hardening mean?

(3) Illustrate an example of work hardening.

2. Translate the following into Chinese

(1) "Cold" and "hot" are relative terms, as we can see from the fact that deforming lead at room temperature is a hot-working process, because the recrystallization temperature of lead is at about room temperature.

(2) The effect of an increase in shear stress that causes an increase in the overall strength of the metal is known as work hardening or strain hardening.

(3) The deformed metal exhibits greater strength, because of the entanglement of dislocations with grain boundaries. The increase in strength depends on the amount of deformation (strain) to which the metal is subjected; the greater the deformation, the stronger the metal becomes.

3. Translate the following into English

磁滞损耗　塑性变形　再结晶　热加工　位错

Free Reading

Solid Solutions and Intermetallic Compounds

Most of the solutions chemists work with involve a gas (such as HCl) or a solid (such as NaCl) dissolved in a liquid (such as water). It is also possible to prepare solutions in which a gas, a liquid, or a solid dissolves in a solid. The most important class of solid solutions are those in which one solid is dissolved in another. Two examples of solid solutions are copper dissolved in aluminum and carbon dissolved in iron.

The solubility of one solid in another usually depends on temperature. At room temperature, for example, copper doesn't dissolve in aluminum. At 550℃, however, aluminum can form solutions that contain up to 5.6% copper by weight. Aluminum metal that has been saturated with copper at 550℃ will try to reject the copper atoms as it cools to room temperature. In theory, the solution could reject copper atoms by forming a polycrystalline structure composed of small crystals of more or less pure aluminum interspersed with small crystals of copper metal. Instead of this, the copper atoms combine with aluminum atoms as the solution cools to form an intermetallic compound with the formula $CuAl_2$.

$CuAl_2$ is a perfect example of the difference between a mixture (such as a solution of copper dissolved in aluminum) and a compound. The solution can contain varying amounts of copper and aluminum. At 550℃, for example, the solution can contain between 0 and 5.6% copper metal by weight. The intermetallic compound has a fixed composition—$CuAl_2$ is always 49.5% aluminum by weight.

Intermetallic compounds such as $CuAl_2$ are the key to a process known as precipitation hardening. Aluminum metal packs in a cubic closest-packed structure in which one plane of atoms can slip past another. As a result, pure aluminum metal is too weak to be used as a structural metal in cars or airplanes. Precipitation hardening produces alloys that are five to six times as strong as aluminum, and make an excellent structural metal.

The first step in precipitation hardening of aluminum involves heating the metal to 550℃. Copper is then added to form a solution, which is quenched with cold water. The solution cools so fast that the copper atoms can't come together to form microcrystals of copper metal.

Comparing a solid with a brick wall has one major disadvantage. It leads one to believe that atoms can't move through the metal. This is not quite true. Diffusion through the metal can occur, although it occurs slowly. Over a period of time, copper atoms can move through the quenched solution to form microcrystals of the $CuAl_2$ intermetallic compound that are so small they are hard to see with a microscope.

These $CuAl_2$ particles are both hard and strong. So hard they inhibit the flow of the aluminum metal that surrounds them. These microcrystals of $CuAl_2$ strengthen aluminum metal by interfering with the way planes of atoms slip past each other. The result is a metal that is both harder and stronger than pure aluminum.

Copper dissolved in aluminum at high temperature is an example of a substitution solution, in which copper atoms pack in the positions normally occupied by aluminum atoms. There is another way in which a solid solution can be made. Atoms of one element can pack in the holes, or interstices, between atoms of the host element because even the most efficient crystal structures use only 74% of the available space in the crystal. The result is an interstitial solution.