English for Die&Mould

模具专业英语

主编
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上海科学技术出版社

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内 容 提 要

本书包括 6 个单元，22 篇课文。主要内容包括：第 1 单元模具材料及热处理；第 2 单元冲压模具设计；第 3 单元塑料模设计；第 4 单元其他模具类型；第 5 单元 CAD/CAM；第 6 单元现代模具制造技术。课文后有词汇、注释、阅读材料，全书后附有课文译文。

本书既可作为高职高专模具设计与制造专业教材，也可供普通高等工科院校相关专业师生参考、使用，还可以作为模具技术人员的参考书。

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前 言

Preface

专业英语是学生获取科技信息、掌握学科动态发展及进行国际交流的基本前提。模具技术涉及材料、成形、设备等众多领域，这些领域正处于迅速发展变化之中。为能适应企业国际化发展与交流的需要，模具设计与制造专业的学生及技术人员必须具备直接阅读模具专业原版英文技术文献和资料的能力。

针对高职高专教育及应用型本科教育的特点，编者在教学实践的基础上编写了本书，在编写中以必需、够用为度，力图使读者通过使用本书，掌握和扩大专业英语词汇，提高阅读英语科技资料文献的能力。

全书内容共 6 个单元，22 篇课文，涉及模具材料及热处理、冷冲压模具设计、塑料模具、其他模具、模具 CAD/CAM、现代模具制造技术等内容，编写中在注重专业英语知识的同时，力求新颖、简洁。本书既可作为高职高专模具设计与制造专业的英语教材，也可供普通高等工科院校相关专业师生参考、使用，还可以作为企业模具技术人员的参考书。

本书由上海工程技术大学高等职业技术学院、上海市高级技工学校杨梅、黄红辉主编，上海工程技术大学高等职业技术学院杜继涛、张利华、金仁健参编。其中杨梅负责全书的组织、审核及第 1、2、5 单元的编写，黄红辉负责第 3 单元的编写，杜继涛负责第 6 单元中第 19、20 课的编写，张利华负责第 6 单元中第 21、22 课的编写，金仁健负责第 4 单元的编写。

由于编者水平有限，书中难免有疏漏和不妥之处，恳请读者批评指正。

编 者

Contents

Unit 1 Mould Materials and Heat Treatment

Lesson 1 Mechanical Properties of Metals

Mechanical properties are measures of how materials behave under applied loads. Another way of saying this is how strong a metal is when it comes in contact with one or more forces. If you know the strength properties of a metal, you can build a structure that is safe and sound. Hence strength is the ability of a metal to withstand loads (forces) without breaking down.

Strength properties are commonly referred to as tensile strength, bending strength, compressive strength, torsional strength, shear strength, fatigue strength and impact strength.

1. Stress is the internal resistance a material offers to being deformed and is measured in terms of the applied load.

2. Strain is the deformation that results from a stress and is expressed in terms of the amount of deformation per unit length.

3. Elasticity is the ability of a metal to return to its original shape after being elongated or distorted, when the forces are released. A rubber band is a good example of what is meant by elasticity. If the rubber is stretched, it will return to its original shape after you let it go. However, if the rubber is pulled beyond a certain point, it will break. Metals with elastic properties react in the same way.

4. Elastic limit is the last point at which a material may be stretched and still return to its undeformed condition upon release of the stress.

5. Modulus of elasticity is the ratio of stress to strain within the elastic limit. The less a material deforms under a given stress the higher the modulus of elasticity. By checking the modulus of elasticity the comparative stiffness of different materials can readily be ascertained. Rigidity or stiffness is very important for many machine and structural applications.

6. Tensile strength is that property which resists forces acting to pull the metal apart. It is one of the more important factors in the evaluation of a metal.

7. Compressive strength is the ability of a material to resist being crushed.

Compression is the opposite of tension with respect to the direction of the applied load. Most metals have high tensile strength and high compressive strength. However, brittle materials such as cast iron have high compressive strength but only a moderate tensile strength.

8. Bending strength is that quality which resists forces from causing a member to bend or deflect in the direction in which the load is applied. Actually a bending stress is a combination of tensile and compressive stresses.

9. Torsional strength is the ability of a metal to withstand forces that cause a member to twist.

10. Shear strength refers to how well a member can withstand two equal forces acting in opposite directions.

11. Fatigue strength is the property of a material to resist various kinds of rapidly alternating stresses. For example, a piston rod or an axle undergoes complete reversal of stresses from tension to compression. Bending a piece of wire back and forth until it breaks is another example of fatigue strength.

12. Impact strength is the ability of a metal to resist loads that are applied suddenly and often at high velocity, the higher the impact strength of a metal the greater the energy required to break it. Impact strength may be seriously affected by welding since it is one of the most structure sensitive properties.

13. Ductility refers to the ability of metal to stretch, bend, or twist without breaking or cracking. A metal having high ductility, such as copper or soft iron, will fail or break gradually as the load on it is increased. A metal of low ductility, such as cast iron, fails suddenly by cracking when subjected to a heavy load.

14. Hardness is that property in steel which resists indentation or penetration. Hardness is usually expressed in terms of the area of an indentation made by a special ball under a standard load, or the depth of a special indenter under a specific load.

New Words

property [ˈprɒpətɪ] *n*. 特性
measure [ˈmeʒə] *n*. 大小,度量
strength [streŋθ] *n*. 强度
sound [saʊnd] *adj*. 结实的,坚固的
withstand [wɪðˈstænd] *vt*. 经受,经得起
refer [rɪˈfɜː] *v*. 指,涉及,谈及
tensile [ˈtensaɪl] *adj*. 拉紧的,张紧的
bend [bend] *v*. 弯曲
compressive [kəmˈpresɪv] *adj*. 压缩的
torsional [ˈtɔːʃənəl] *adj*. 扭转的
shear [ʃɪə] *n*. 剪,切
fatigue [fəˈtiːg] *n*. 疲劳
impact [ˈɪmpækt] *n*. 冲击
stress [stres] *n*. 压力,应力
internal [ɪnˈtɜːnl] *adj*. 内部的
resistance [rɪˈzɪstəns] *n*. 阻力,抵抗
strain [streɪn] *n*. 应变
deform [dɪˈfɔːm] *v*. (使)变形
elasticity [elæˈstɪsɪtɪ] *n*. 弹性
elongate [ˈiːlɒŋgeɪt] *vt*. (使)伸长,延长

distort [dɪ'stɔːt] *vt*. (使)变形，扭曲
release [rɪ'liːs] *vt*. 释放
stretch [stretʃ] *v*. 伸展
modulus ['mɒdjʊləs] *n*. 系数
ratio ['reɪʃɪəʊ] *n*. 比，比率
ascertain [ˌæsə'teɪn] *vt*. 确定，查明
stiffness ['stɪfnɪs] *n*. 刚度
rigidity [rɪ'dʒɪdətɪ] *n*. 刚度
evaluation [ɪˌvæljʊ'eɪʃən] *n*. 评估
resist [rɪ'zɪst] *vt*. 抵抗
crush [krʌʃ] *vt*. 压碎
opposite ['ɒpəzɪt] *n*. 反面
compression [kəm'preʃən] *n*. 压缩
tension ['tenʃən] *n*. 拉紧，张紧
brittle ['brɪtl] *adj*. 易碎的
moderate ['mɒdərɪt] *adj*. 适中的
quality ['kwɒlɪtɪ] *n*. 质量
deflect [dɪ'flekt] *vt*. 使弯曲
twist [twɪst] *v*. 扭曲，扭转
various ['veərɪəs] *adj*. 不同的，各种的
rapidly ['ræpɪdlɪ] *adv*. 迅速地
piston ['pɪstən] *n*. 活塞
rod [rɒd] *n*. 杆，棒
undergo [ʌndə'gəʊ] *vt*. 经受
reversal [rɪ'vɜːsl] *n*. 反向
axle ['æksl] *n*. 轮轴，车轴
velocity [və'lɒsətɪ] *n*. 速度
seriously ['sɪərɪəslɪ] *adv*. 严重地
welding ['weldɪŋ] *n*. 焊接
sensitive ['sensɪtɪv] *adj*. 敏感的
ductility [dʌk'tɪlɪtɪ] *n*. 延展性，韧性
crack [kræk] *v*. (使)破裂，裂纹
fail [feɪl] *n*. 损坏
subject ['sʌbdʒɪkt] *vt*. 使受到
hardness ['hɑːdnɪs] *n*. 硬度
indentation [ɪnden'teɪʃən] *n*. 压痕
indenter [ɪn'dentə] *n*. 压头
penetration [penɪ'treɪʃən] *n*. 穿透

Phrases and Expressions

applied loads 作用力
in terms of 依据
in contact with 接触
break down 破坏
with respect to 相对于

Notes

1. Mechanical properties are measures of how materials behave under applied loads. Another way of saying this is how strong a metal is when it comes in contact with one or more forces.
   机械性能是材料在外加载荷作用下所表现出的特性。换句话说，机械性能是金属在一个力或几个力的作用下所具有的强度。
2. Strength properties are commonly referred to as tensile strength, bending strength, compressive strength, torsional strength, shear strength, fatigue strength and impact strength.
   强度特性通常指的是抗拉强度、抗弯强度、抗压强度、抗扭强度、抗剪强度、疲劳强度和冲击强度。
3. Elastic limit is the last point at which a material may be stretched and still return to its undeformed condition upon release of the stress.

弹性极限是材料在拉伸时,所加应力去掉后还能回到未变形前状态的最大应力。

4. Hardness is usually expressed in terms of the area of an indentation made by a special ball under a standard load, or the depth of a special indenter under a specific load.
硬度通常是用在标准载荷作用下特制钢球的压痕面积来表示,或是用在特定载荷作用下,专门的压头所形成的深度来表示。

Reading Material

The Nature of Materials Science

During the last generation we have witnessed(证明) and benefited from the development of numerous new technological systems, such as nuclear power plants, satellites, computers, lasers, etc. Each of these has been advanced by the development of materials with new and exotic(奇异的) properties. The properties of materials, have dictated nearly every design and every useful application that the engineer could devise. But with the present sophistication(复杂化) of our engineering science, it is no longer simply a question of being satisfied to design with existing materials. We are now requiring new materials with new properties to fit our designs. This search for new materials with improved properties now occupies an important position in the engineering world.

Along with the search for new materials has come the realization that effective usage of materials can be realized only when the engineer fully understands the various properties of materials. The reason for this is that practically all of the useful properties of materials are strongly dependent on their internal(内部的) structure. The rather broad term internal structure is defined as the arrangement (排列) of electrons and atoms within a material. We shall see shortly that for a material of given chemical composition, the internal structure is not constant, but can vary greatly, depending on: a. how the material was manufactured (exactly what processing conditions were involved); b. under what conditions (temperature, pressure, exposure to radiation, etc.) the material is placed into service. By altering the internal structure of a material in a controlled manner it is possible to effectively control the properties of the material. And because a single material may be treated to have different internal structures and correspondingly different properties, one maternal may be used for many applications, each calling for different physical properties.

Lesson 2 Heat Treatment

Heat treatment is a term applied to a variety of procedures for changing the characteristics of metal by heating and cooling. By proper heat treatment, it is possible to obtain certain characteristics in metal such as hardness, tensile strength (ability to resist stretching), and ductility. Heat treatment can be a simple process requiring few tools. In industry, it is a highly scientific and complicated procedure requiring much equipment.

Many of the projects or products made in the machine shop have little or no value until they are heat-treated. This chapter includes only the most elementary information about the heat treatment of steel. Heat treatment can also be done on many of the nonferrous metals such as aluminium, copper and brass. The procedures are different, however, and will not be considered here.

The procedures of heat treatment of steel include hardening, tempering, annealing, and case hardening.

Hardening is a process of heating and cooling steel to increase its hardness and tensile strength, to reduce its ductility, and to obtain a fine grain structure. The procedure includes heating the metal above its critical point or temperature, followed by rapid cooling. As steel is heated, a physical and chemical change takes place between the iron and carbon. The critical point, or critical temperature, is the point at which the steel has the most desirable characteristics. When steel reaches this temperature — somewhere between 1 400 - 1 600°F — the change is ideal to make for a hard, strong material if it is cooled quickly. If the metal cools slowly, it changes back to its original state. By plunging the hot metal into water, oil, or brine (quenching), the desirable characteristics are retained. The metal is very hard and strong and less ductile than before.

Heating is done in a furnace fired by gas, oil, or electricity. A device called a pyrometer is attached to the furnace. This accurately registers the exact temperature in the furnace (Fig. 2. 1). The temperature of the metal can also be determined by observing its color. You can make use of the colors when heat-treating simple metal parts and tools. Colors are not very accurate, however. Even the expert heat-treater will be off as much as 20°F from the true temperature.

The hardening procedure is:

1. Light the furnace, and allow it to come to the right temperature.

2. Place the metal in the furnace, and heat it to the critical temperature. For carbon tool steel, allow about 20 to 30 minutes per inch of thickness for coming up to heat. Allow about 10 to 15 minutes per inch of thickness for soaking at hardening temperature.

3. Select the correct cooling solution. Some steels can be cooled in water, and others must be cooled in oil or brine. Water is the most widely used material for quenching

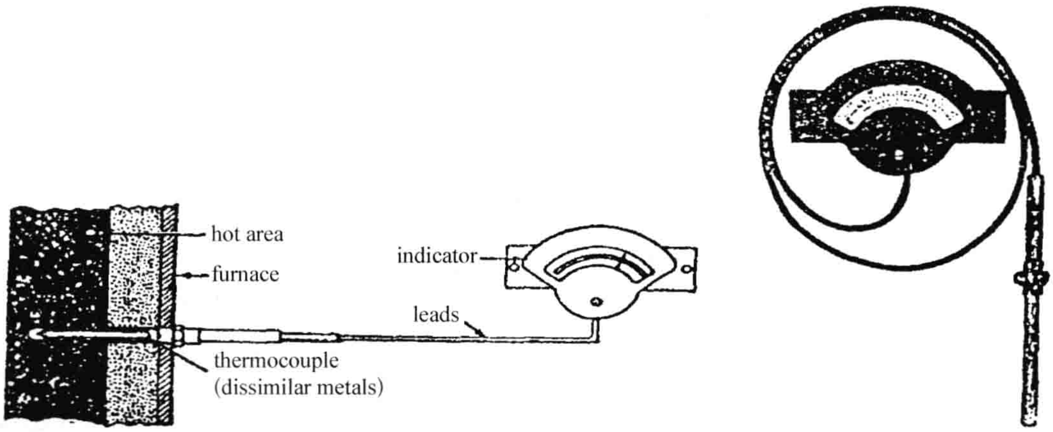

Fig. 2. 1 A pyrometer accurately tells the temperature inside the furnace

carbon steels because it is inexpensive and effective. Brine is usually made by adding about 9 percent of common salt to the water. Brine helps to produce a more uniform hardness. The brine cools the parts all over more quickly. Oil is used for a somewhat slower speed of quenching. Most oils used for quenching are mineral oils.

4. Remove the hot metal with tongs, and plunge it into the cooling solution. Agitate so that the metal cools quickly and evenly. If it is a thin piece (like a knife or blade), cut the cooling solution with the object so it won't warp. If one side cools faster than the other, there will be some warping.

5. A properly hardened piece of steel will be hard and brittle and have high tensile strength. It will also have internal strain. If left in this state, these internal strains could cause the metal to crack.

Tempering is a process of reducing the degree of hardness and strength and increasing the toughness. It removes the brittleness from a hardened piece. It is a process that follows the hardening procedure and makes the metal as hard and tough as possible. Tempering is done by reheating the metal to low or moderate temperature, followed by quenching or by cooling in air. As the metal is heated for tempering, it changes in colour. These colours are called temper colours. You can watch these colours to know when the correct heat is reached. A more accurate method, of course, is to watch the pyrometer. Many parts and projects are completely tempered. Others are tempered in one section, and the rest remains in the hardened state.

The tempering procedure is:

1. To temper the entire piece, place it in the furnace. Reheat to the correct temperature to produce the hardness and toughness you want. Remove the metal and cool it quickly.

2. To temper small cutting tools:

a. Harden the entire tool. Clean off the scale with abrasive cloth.

b. Heat a scrap piece of metal red hot.

c. Place the tool on the metal with the point extending beyond the hot piece of metal.

d. Watch the temper colours. When the correct colour reaches the point of the tool quench it.

Annealing is the process of softening steel to relieve internal strain. This makes the steel easier to machine. The metal is heated above the critical temperature and cooled slowly. The most common method is to place the steel in the furnace and heat it thoroughly. Then turn off the furnace, allowing the metal to cool slowly. Another method is to pack the metal in clay, heat it to the critical temperature, remove it from the furnace, and allow it to cool slowly.

Case hardening is a process of hardening the outer surface or case of ferrous metal. By adding a small amount of carbon to the case of the low-carbon steel, it can be heat-treated to make the case hard, at the same time the centre, or core, remains soft and ductile.

There are many methods of case hardening. In industry, molten cyanide is used (this is called cyaniding). Another industrial method is carburizing. This is a case-hardening procedure in which carbon is added to steel from the surface inward by one of the following methods: a. pack method; b. gas method; c. liquid-salt method.

This process can be done on such items as hammer heads, piston pins, and other items that must stand a good deal of shock and wear. It can never be used on anything that must be sharpened by grinding.

New Words

treatment [ˈtriːtmənt] *n.* 处理
hardness [ˈhɑːdnɪs] *n.* 硬度
tensile [ˈtensaɪl] *adj.* 拉力的，可拉伸的
complicated [ˈkɒmplɪkeɪtɪd] *adj.* 复杂的
project [prəˈdʒekt] *n.* 项目，产品
elementary [elɪˈmentərɪ] *adj.* 基本的
nonferrous [nɒnˈferəs] *adj.* 不含铁的，非铁的
aluminium [æljʊˈmɪnɪəm] *n.* 铝
brass [brɑːs] *n.* 黄铜
tempering [ˈtempərɪŋ] *n.* 回火
annealing [əˈliːlɪŋ] *n.* 退火
critical [ˈkrɪtɪkl] *adj.* 临界的
rapid [ˈræpɪd] *adj.* 迅速的
F (Fahrenheit) [ˈfærənhaɪt] *n.* 华氏温度
desirable [dɪˈzaɪrəbl] *adj.* 合适的
plunge [plʌndʒ] *v.* 投入
brine [braɪn] *n.* 盐水
quench [kwentʃ] *vt.* 淬火
retain [rɪˈteɪn] *vt.* 保持，保留
pyrometer [paɪˈrɒmɪtə] *n.* 高温计
accuracy [ˈækjʊrəsɪ] *n.* 精度，准确性
register [ˈredʒɪstə] *v.* 记录，显示，记数
observe [əbˈzɜːv] *vt.* 观察
soak [səʊk] *v.* 浸，泡，均热
solution [səˈluːʃən] *n.* 溶液
inexpensive [ɪnɪkˈspensɪv] *adj.* 便宜的
mineral [ˈmɪnərəl] *n.* 矿物，矿产
agitate [ˈædʒɪteɪt] *v.* 摇动
tong [tɒŋ] *n.* 火钳

warp [wɔːp] *v*. 翘曲
toughness [ˈtʌfnɪs] *n*. 韧性
moderate [ˈmɒdərət] *adj*. 适度的
scale [skeɪl] *n*. 硬壳
extend [ɪkˈstend] *v*. 伸展
abrasive [əˈbreɪsɪv] *adj*. 研磨的
scrap [skræp] *n*. 小片,废料
point [pɒɪnt] *n*. 刃口
relieve [rɪˈliːv] *vt*. 减轻,解除
thoroughly [ˈθʌrəlɪ] *adv*. 十分地,彻底地
case [keɪs] *n*. 壳,套
pack [pæk] *v*. 包装
clay [kleɪ] *n*. 黏土
core [kɔː] *n*. 核心
cyanide [ˈsaɪənaɪd] *n*. 氰化物
carburizing [ˈkɑːbjʊraɪzɪŋ] *n*. 渗碳

Phrases and Expressions

machine shop 车间
make use of 利用
abrasive cloth (金刚)砂布
case hardening 表面硬化

Notes

1. Heat treatment is a term applied to a variety of procedures for changing the characteristics of metal by heating and cooling.
   热处理这一术语指的是各种各样通过加热和冷却以改变金属特性的方法。
2. Colors are not very accurate, however. Even the expert heat-treater will be off as much as 20°F from the true temperature.
   然而颜色是不十分精确的。甚至熟练的热处理工人据此所观察出的温度同真正的温度之间的误差也会达20°F之多。
3. A properly hardened piece of steel will be hard and brittle and have high tensile strength.
   正常淬火的钢制工件会变硬变脆并具有很高的抗拉强度。
4. It removes the brittleness from a hardened piece. It is a process that follows the hardening procedure and makes the metal as hard and tough as possible.
   回火能消除淬火工件的脆性。它是在淬火之后采用的使金属尽可能变硬变韧的方法。
5. Place the tool on the metal with the point extending beyond the hot piece of metal.
   把切削工具放在金属上,刃部伸到这块炽热的金属之外。

Reading Material

Heat Treatment of Steels

Heat treating refers to the heating and cooling operations performed on a metal for the purpose of altering(改变) such characteristics as hardness, strength, or ductility. A tool steel intended to be machined into a punch(冲头) may first be softened so that it can be machined. After being machined to shape, it must be hardened so that it can sustain(承受) the punishment that punches receive. Most heating operations for hardening leave a scale(锈皮) on the surface, or contribute (造成) other surface defects(缺陷). The final operation must, therefore be grinding(磨) to remove surface defects and provide a suitable surface roughness(表面粗糙度).

When a steel part is to be either hardened or softened, its temperature must be taken above the critical temperature line; that is, the steel must be austenitized(奥氏体化). Usually a temperature of 50 to 109°F above the critical temperature is selected, to ensure that the steel part reaches a high enough temperature to be completely austenitized, and also because furnace temperature control is always a little uncertain.

The steel must be held at furnace temperature for sufficient time to dissolve the carbides(碳化物) in the austenite, after which the steel can be cooled. How much residence(停留) time in the furnace is required is to some degree a matter of experience with any particular steel. Usually, for a 3/4 in. bar, 20 minutes or slightly more will do. Double the time for twice the diameter. Alloy steels may require a longer furnace time; many of these steels are best preheated in a lower-temperature furnace before being charged into the hardening furnace.

When the heating time is completed, the steel must be cooled down to room temperature. The cooling method determines whether the steel will be hardened or softened. If the steel is quickly removed from the furnace and quenched into cold water, it will be hardened. If it is left in the furnace to cool slowly with the heat turned off, or cooled in air (small pieces of plain carbon steel cannot be air-softened, however), it will be softened. High-alloy steels may be hardened by air-cooling, but plain carbon steels must have a more severe quench, almost always water.

There are several softening methods for steels. Softening therefore does not indicate what softening process or purpose was used. The method of softening by slow cooling from austenite is called annealing, not softening. Annealing leaves the steel in the softest possible condition (dead soft).

To conclude, the difference between hardening and annealing is not in the heating process, but in the cooling process.

Lesson 3 Mould Materials

Depending on the processing parameters for the various processing methods as well as the length of the production run, i. e., the number of finished products to be produced, moulds must satisfy a great variety of requirements. It is therefore not surprising that, moulds can be made from a very broad spectrum of materials, including such exotic materials as paper match and plaster. However, because most processes require high pressures, and often combined with high temperatures, metals still represent by far the most important material group, with steel being the predominant metal. It is interesting in this regard that, in many cases, the selection of the mould material is not only a question of material properties and an optimum price-to-performance ratio but also that the methods used to produce the mould, and thus the entire design can be influenced.

A typical example can be seen in the choice between cast metal moulds, with their very different cooling systems, compared to machined moulds. In addition, the production technique can also have an effect. For instance, it is often reported that, for the sake of simplicity, a prototype mould is frequently machined from solid stock with the aid of the latest technology such as computer-aided design (CAD) and computer-integrated manufacturing(CIM). In contrast to the previously used methods based on the use of patterns, the use of CAD and CIM often represents the more economical solution today, not only because this production capability is available in house but also because with any other technique an order would have to be placed with an outside supplier.

Overall, although high-grade materials are often used, as a rule, standard materials are used in mould making. New, high-performance materials, such as ceramics, for instance, are almost completely absent. This may be related to the fact that their desirable characteristics, such as constant properties up to very high temperature, are not required in moulds. Whereas their negative characteristics, e. g., low tensile strength and poor thermal conductivity, having a clearly related to ceramics, such as sintered material, is found in mould making only to a limited degree. This refers less to the modern materials and components produced by powder metallurgy, and possibly by hot isostatic pressing, than to sintered metals in the sense of porous, air-permeable materials.

Removal of air from the cavity of a mould is a necessary with many different processing methods, and it has been proposed many times that this can be accomplished using porous metallic materials. The advantages over specially fabricated venting devices, particularly in areas where melt flow fronts meet, i. e., at weld lines, are as obvious as the potential problem areas: On one hand, preventing the texture of such surfaces from becoming visible on the finished product, and on the other hand, preventing the micropores from quickly becoming clogged with residues. It is also interesting in this case that completely new possibilities with regard to mould design and processing technique result from the use of such materials. The process steps of venting, cooling, and ejecting in relation to the use of sintered metals can be best illustrated with the aid of the sketches shown in Fig. 3.1.

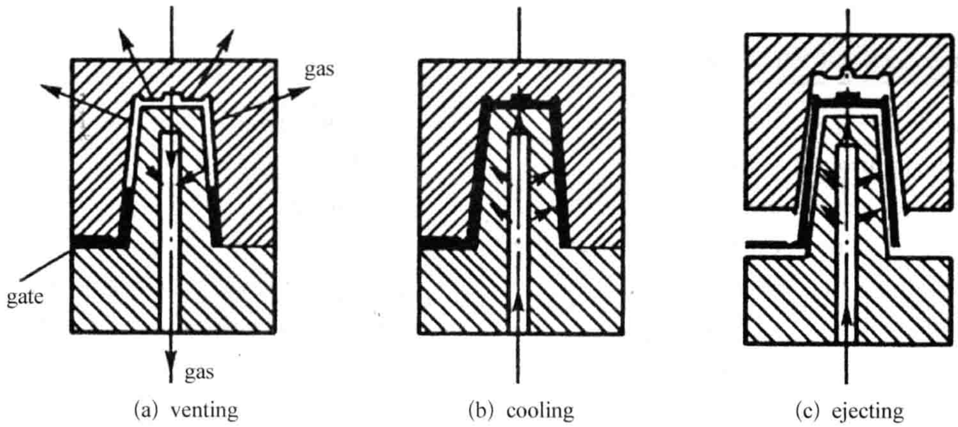

Fig. 3.1 Microporous metal ejecting in a mould

Venting of the edge-gated cavity used to produce a cup-shaped product with a complex bottom would require a great deal of technical effort to provide guaranteed removal of the air from the bottom region. By using a microporous material for the core and cavity halves, no additional measures for venting are required. Moreover, because venting takes place over the entire surface area of the cavity, filling of the cavity can occur faster, and there is, in principle, freedom in selecting the location of the gate.

It is particularly difficult to remove the necessary amount of heat in regions with long, narrow cores. In this case, it is possible to distribute cold gas via the system of micropores in the core and in this way intensify the cooling, with the possible result of achieving a shorter cycle time. Improved temperature uniformity over the mould surface can be another beneficial side effect.

It is also possible, in combination with other means (ejectors, stipper rings) or even without them, to eject the product by introducing gas at high pressure into the core half of the mould. In this way, the risk of ejector marks is reduced or eliminated, and there is no need to overcome a vacuum during ejection.

New Words

spectrum [ˈspektrəm] *n*. 范围;光谱

exotic [ɪgˈztɪk] *adj*. 奇异的,外来的

predominant [prɪˈdɒmɪnənt] *adj*. 占优势的,主要的

optimum [ˈɒptɪməm] *adj*. 最优化的

component [kəmˈpəʊnent] *n*. 零件,组件

metallurgy [ˈmɛtlˌəːdʒɪ] *n*. 冶金学,冶金术

isostatic [ˌaɪsəʊˈstætɪk] *adj*. 均衡的