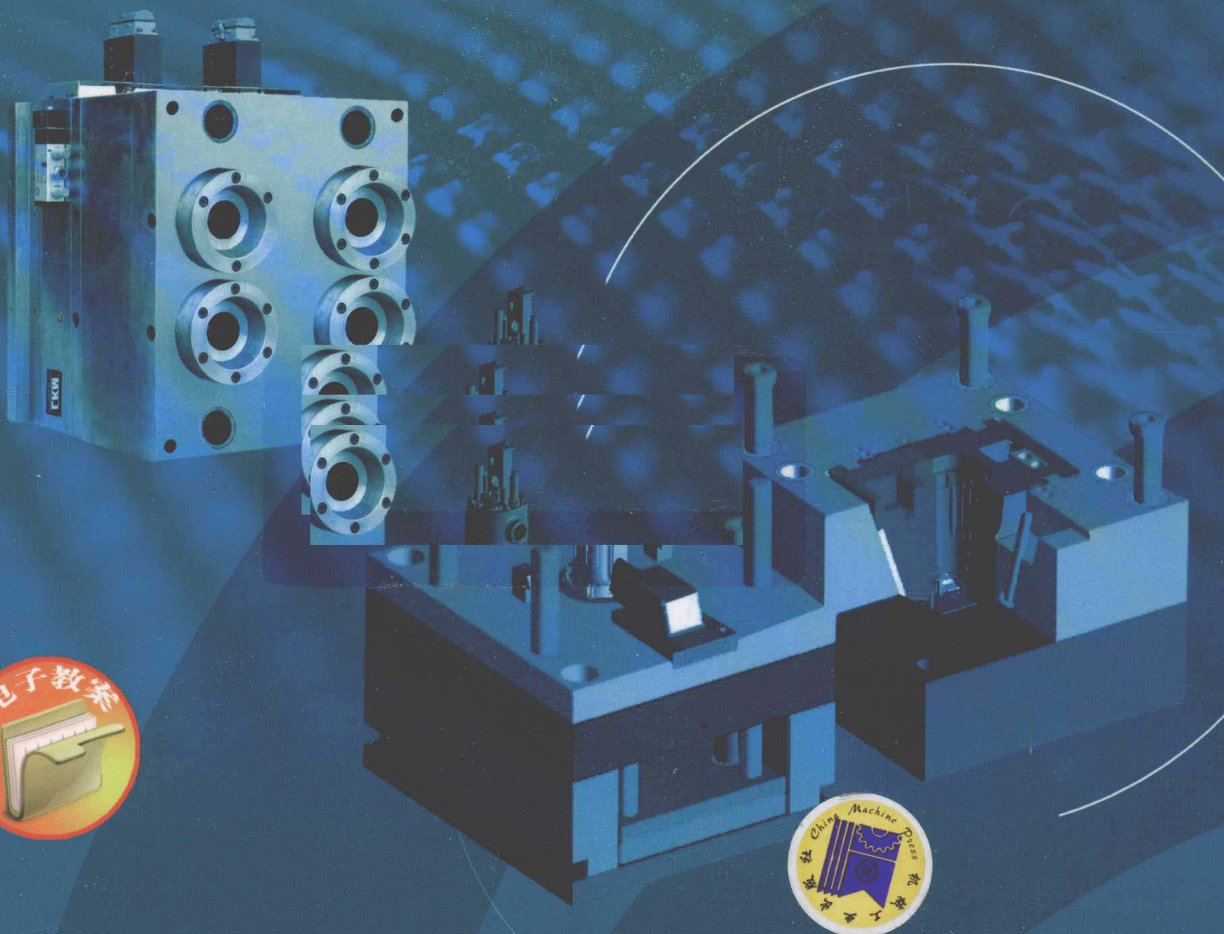
职业教育院校重点专业规划教材
模具设计与制造专业教学用书

模具专业英语

MUJU ZHUANYE YINGYU

钱晓琳　唐妍　主编



配电子教案

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本书是本着先进、实用、简明、系统的组织原则，从职业教育的实际出发，结合多年的专业英语教学实践编写的。本书内容均选自英、美国家的专业教材及专业刊物的原文，内容涉及机械基础、冷冲压工艺及模具、塑料模具、模具成形机械、模具制造技术、CAD/CAM 等，基本涵盖了模具设计与制造专业所需的技术知识。本书在内容上注重选材的实用性，英语表达地道，力求兼顾知识的基础性和专业性，可以作为高职、高专模具设计与制造专业的英语教材，也可以作为工程技术人员的参考书。

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前　言

在快速发展的模具设计与制造领域，大量的原版英文技术资料和国外最新的技术信息与动态，对于专业技术的学习和提高有着举足轻重的作用。目前，我国很多职业院校的模具专业都将“模具专业英语”作为一门专业知识拓展课程。

本书是以提高学生对专业英语的阅读、理解能力，扩展和深化学生对模具设计和制造领域关键技术的认知，为学生职业生涯的可持续发展搭建平台为目的，本着先进、实用、简明、系统的组织原则，从高职教育以实践为主的实际出发，结合多年的专业英语教学实践来编写的。

本书的内容均选自英、美国家专业教材及专业刊物的原文，共 8 个单元，27 篇课文，27 篇阅读材料。全书内容涉及机械基础（材料及热处理、传统加工）、冷冲压工艺及模具、塑料模具、模具成形机械、模具制造技术（数控加工、特种加工）、CAD/CAM、模具寿命和失效的相关内容以及模具常用术语，基本涵盖了模具设计与制造专业所需的技术知识。本书可以作为高职、高专模具设计与制造专业的英语教材，也可以作为工程技术人员的自学参考书。

在编写过程中，本书力求体现下列特点：

1）面向广大高职、高专教育对象，重点在于扩充学生的专业英语词汇量，提高读者对科技英语的阅读、理解能力。

2）以培养模具设计与制造专业能力为主线来选取文章，单元模块式的结构组织便于教师的灵活选用。

3）在内容上注重选材的实用性，在形式上注重图文并茂，正文中生词均斜体加粗，疑难句有注释，便于读者阅读。

4）文章均为原版英文文献，英语表达地道，力求兼顾知识的基础性与专业性，同时反映专业发展的新趋势。

5）在精讲课文内设有引导阅读的小问题，便于教师组织教学。

本书的参考学时为 30～60 个学时，教师可根据教学计划对内容作适当增减。

本书由南京交通职业技术学院钱晓琳、唐妍任主编。具体编写分工如下：钱晓琳编写第 1～3 单元，并负责全书的统稿；唐妍编写第 4、6 单元及专业术语词汇表；李东君编写第 5、8 单元；范英铭编写第 7 单元。南京交通职业技术学院贾俐俐教授和加拿大圣克莱尔学院 Marko Jovanovic 教授审阅了全书，并提出许多宝贵意见，在此深表感谢！

职业院校的专业教学改革是一项长期又艰苦的工作，模具专业英语的教学正处于教学改革的探索阶段。如果本书能对模具专业的学生在学习和工作上有一些帮助，那将是我们最大的欣慰。由于编者水平和经验有限，书中可能存在一些疏漏和错误，恳请教师和读者批评指正，以便修订时改进。所有意见和建议请发至：jdgcx@njci.cn或 qianxiaolin76@sohu.com。需要教材电子资料的教师和读者亦可发信至上述信箱。联系电话：025-86115081　钱老师。

编　者

目　录

Unit One

Basic Knowledge of Die or Mold

学习目标：本单元介绍模具的概念和模具材料的基础知识。通过本单元的学习，使学生掌握模具分类、模具材料和热处理方面的专业词汇，提高学生阅读、理解科技英语的能力。

Lesson 1 What Is Die or Mold?

Text

Die is a device used for cutting out, forming, or ***stamping*** material (Fig. 1-1),[①] especially:

(1) An ***engraved*** metal piece used for impressing a design onto a softer metal, as in ***coining*** money.

(2) A part on a machine that ***punches*** shaped holes in, cuts, or forms ***sheet metal***, ***cardboard***, or other ***stock***.

(3) A metal block containing small ***conical*** holes through which plastic, metal, or other ***ductile*** material is ***extruded*** or ***drawn***.

Mold is a shaped ***hollow container*** into which a liquid material is ***poured*** so that it can set in a particular shape when it hardens (Fig. 1-2).[②]

想一想

What are the main differences between a die and a mold?

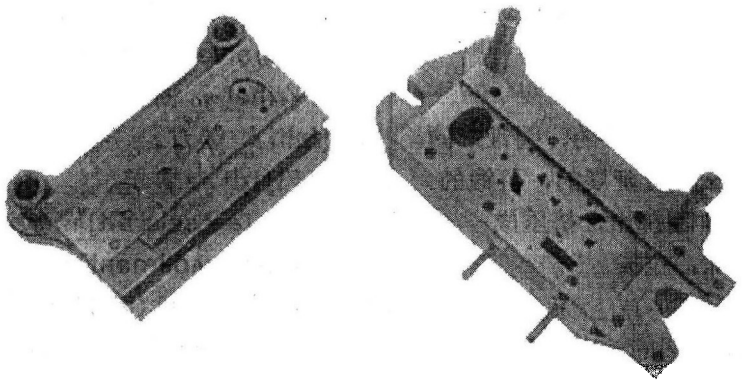


Fig. 1-1 A ***progressive die*** with ***scrap strip*** and stampings

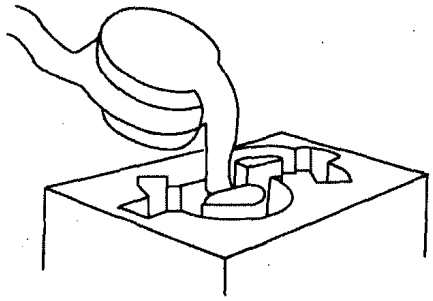


Fig. 1-2 A casting mold

Die is used for ***drawing wire***, and for ***blanking***, ***bending***, cutting, machine ***forging***, and ***embossing***. Dies used for striking, or stamping, coins and medals are cut in ***intaglio***, one for the front, another for the back, of the coin. Diemaking, formerly entirely a hand process in which the ***graver*** (a cutting tool), ***riffler*** (a ***file***), and ***chisel*** were employed, has been ***accelerated*** in modern times by the use of diemaking machines ***supplemented*** by hand finishing.[③] Sheet metal or other material is blanked out, shaped, or embossed between the dies by ***power-operated levers*** or ***drop hammers***, or by ***die-casting***. The die used for drawing wire or extruding ***rods*** is made of hard metal with a hole or a series of ***progressively*** smaller holes through which the metal is forced. For making ***screws*** or ***threading*** pipe, a hollow hard metal die with ***internal*** threading is used.

Today the demand for dies used in metal forming, die casting, and plastic molding is filled by tool- and die-making shops.

New Words

die [dai] *n.* 冲模，钢型，硬模
stamp [stæmp] *v.* 压印，压花，冲压
n. (*pl.*) 落料件，冲压件
engrave [in'greiv] *v.* 雕刻
coin [kɔin] *v.* 冲制，模压，压花纹
punch [pʌntʃ] *v.* 冲孔，打孔
sheet metal 金属板（片），钣金件
cardboard 纸板
stock [stɔk] *n.* 原料，材料
conical ['kɔnikəl] *adj.* 圆锥的，圆锥形的
ductile ['dʌktail] *adj.* 可延展的，可锻的
extrude [eks'tru:d] *v.* 挤出，挤压成
draw [drɔ:] *v.* 拉深，拉拔
mold [məuld] *n.* 模具
hollow ['hɔləu] *adj.* 凹的，中空的
container [kən'teinə] *n.* 容器，箱
pour [pɔ:] *v.* 灌注，倾倒
drawing wire 金属拉丝
blank [blæŋk] *v.* 冲裁，下料，冲切
bend [bend] *v.* 弯曲
forge [fɔ:dʒ] *v.* 锻造，锤炼
emboss [im'bɔs] *v.* 压纹，轧花，浮雕
intaglio [in'tæliəu] *v.* 凹雕，阴雕
graver ['greivə] *n.* 雕刻师，雕刻刀
riffler ['riflə] *n.* 曲锉（用来雕模）
file [fail] *n.* 锉刀
chisel ['tʃizl] *n.* 錾子
accelerate [æk'seləreit] *v.* 加速，促进
supplement ['sʌplimənt] *v.* & *n.* 补充，补足
power-operated 机(电/自)动的，动力驱动的
lever ['li:və ,'levə] *n.* 杆，控制杆，杠杆
drop hammer 落锤，吊锤，打桩锤

die-casting 压(模)铸法，压(模)铸件
rod [rɔd] *n.* 杆，棒
progressively [prə'gresivli] *adv.* 渐进地
screw [skru:] *n.* 螺钉，螺旋，螺杆，螺孔
thread ['θred] *n.* 螺线 *v.* 攻螺纹，套螺纹
internal [in'tə:nl] *adj.* 内在的，内部的
progressive die 级进模
scrap strip 废料板

Notes

① Die is a device used for cutting out, forming, or stamping material (Fig. 1-1).

模具是一种用于切割材料、使材料成形或冲压材料的装置，如图 1-1 所示。

“die”通常指冲压模具、锻造模具、挤压模具和压铸模具。这类模具工作时，要借助外力把材料压成所需的形状。

② Mold is a shaped hollow container into which a liquid material is poured so that it can set in a particular shape when it hardens (Fig. 1-2).

模具是一种具有特定形状的中空容器。将液态材料倾倒入其型腔内，当液态材料凝固变硬后，就获得了相应的形状，如图 1-2 所示。

“mold”通常指塑料模具和铸造模具，它的工作特点是把材料加热熔融后灌入模膛。

③ Diemaking, formerly entirely a hand process in which the graver (a cutting tool), riffler (a file), and chisel were employed, has been accelerated in modern times by the use of diemaking machines supplemented by hand finishing.

最初，模具制造完全是个手工活，加工过程中使用像刻刀（切削刀具）、曲锉（一种锉刀）和錾子之类的工具。现在，借助模具制造机械并辅以最后的手工精加工，模具的生产效率得到了提高。

“formerly entirely a hand process...were employed”是“diemaking”的同位语，其中“in which the graver...were employed”又是“a hand process”的定语从句，说明在加工中使用的工具有哪些。

Glossary of Terms

forming die 成形模
blanking die 冲裁模
piercing die 冲孔模
compound die 复合模
drawing die 拉深模
bending die 弯曲模
injection mold 注射模，注塑模
transfer mold 传递模，压注模
compression mold 压缩模
blow molding 吹塑成型
die-casting die 压铸模
forging die 锻造模，锻模

Reading Materials

(1) The Definition of a Die

A die is a specialized tool used in manufacturing industries to cut, shape and form a wide variety of products and components. Like molds and templates, dies are generally customized

and uniquely matched to the product they are used to create. Products made with dies range from simple paper clips to complex pieces used in advanced technology.

(2) Blanking Die

A blanking die produces a flat piece of material by cutting the desired shape in one operation. The finish part is referred to as a blank. Generally, a blanking die may only cut the outside contour of a part, often used for parts with no internal features.

Three benefits to die blanking are:

(1) Accuracy. A properly sharpened die, with the correct amount of clearance between the punch and die, will produce a part that holds close dimensional tolerances in relationship to the parts edges.

(2) Appearance. Since the part is blanked in one operation, the finish edges of the part produces a uniform appearance as opposed to varying degrees of burnishing from multiple operations.

(3) Flatness. Due to the even compression of the blanking process, the end result is a flat part that may retain a specific level of flatness for additional manufacturing operations.

Lesson 2 Die and Mold Steels

Text

A set of die may contain 10 or more different steels plus several ***non-ferrous metals*** and special ***heat resisting alloys***.① The specific material selected for a particular die or mold is normally determined by the ***mechanical properties*** necessary for the proper operation of the dies and molds.② These materials should be selected only after a careful study and evaluation of the functions and requirements of the ***proposed*** tool. In most applications, more than one type of material will be satisfactory, and a final choice will normally be governed by the requirements from customers, such as ***performance*** and economic considerations.

The principal materials used for dies and molds can be divided into two major ***categories***: cold work tool (die) steel and hot work tool (mold) steel.③ For example, ***carbide steel***, alloy tool steel, carbon tool steel, high-speed steel, high alloy steel, high carbon steel, low carbon steel, shock resistance tool steel and so on.

Parts of the die which merely act as ***bearings*** can be made of non-ferrous metals such as ***phosphor bronze***, or ***medium carbon steel***. The ***mechanisms*** for moving the ***ejectors*** and ***cores*** must work smoothly in the ***constantly*** changing temperature of a die. The box sections, ejector plates and ***sprue puller*** are made of ***mild steel***, with about 0.15% carbon. The ***guide pillars*** and

试一试

Can you translate the materials in this paragraph into Chinese?

ejector stops, which is to support and guide the die, and endure shock loading, are made of ***case hardened*** mild steel; occasionally case hardened ***nickel*** steels are used for increased strength.④ ***Bolsters*** undergo mechanical impact and stress but not a great deal of thermal shock and are often made of medium carbon steel; ***alternatively*** these parts are steel castings or they may be of a ***spheroidal graphite cast iron***. Normally the ***bushes*** are made of ***carburized*** steel.

The die ***inserts***, the cores and the ***cavities***, which have to withstand the impact and high temperature of the ***molten*** material, are made of alloy steel given a ***nitride*** or other treatment to resist wear and heat.

New Words

non-ferrous metal 有色金属
heat resisting alloy 耐热合金
mechanical properties 力学性能
propose [prə'pəuz] *v.* 计划，打算，提议
performance [pə'fɔ:məns] *n.* 性能，成绩
category ['kætigəri] *n.* 种类，范畴
carbide steel 硬质(合金)钢
bearing ['bɛəriŋ] *n.* 轴承，轴套
phosphor ['fɔsfə] *n.* 磷(P)
bronze [brɔnz] *n.* 青铜
medium carbon steel 中碳钢
mechanism ['mekənizəm] *n.* 机构，机制
ejector [i'dʒektə] *n.* 顶料或推料设备
core [kɔ:] *n.* 型芯
constantly ['kɔnstəntli] *adv.* 经常地
sprue [spru:] *n.* 浇口，直浇道，主流道
sprue puller 拉料杆
mild steel 低碳钢(low carbon steel)
pillar ['pilə] *n.* 柱子，栋梁
guide pillar 导柱
ejector stop 止推销(挡板)
case hardened 表面硬化
nickel ['nikl] *n.* 镍
bolster ['bəulstə] *n.* 垫板，支撑板
alternatively [ɔ:l'tɜ:nətivli] *adv.* 可选择地
spheroidal ['sfiərɔidəl] *adj.* 类似球体的
graphite ['græfait] *n.* 石墨
spheroidal graphite cast iron 球墨铸铁
bush [buʃ] *n.* 衬套
carburize ['kɑ:bjuraiz] *v.* 渗碳
insert [in'sə:t] *n.* 嵌件，镶件 *v.* 嵌入，插入
cavity ['kæviti] *n.* 型腔
molten ['məultən] *adj.* 熔化的，熔融的
nitride ['naitraid] *n.* 氮化物

Notes

① A set of die may contain 10 or more different steels plus several non-ferrous metals and special heat resisting alloys.

一副模具可能含有十种或更多种类的钢，以及一些有色金属和特种耐热合金。

② The specific material selected for a particular die or mold is normally determined by the mechanical properties necessary for the proper operation of the dies and molds.

选择何种材料用于特定的冲压或塑料模具，通常是由冲压或塑料模具正常工作时所必需的力学性能来决定的。

此句主干为“The specific material is normally determined by the mechanical properties.”。“selected for a particular die or mold”是过去分词短语作后置定语，修饰“the specific

material"；"necessary for the proper operation of the dies and molds"是形容词短语作后置定语，修饰"the mechanical properties"。

③ The principal materials used for dies and molds can be divided into two major categories: cold work tool (die) steel and hot work tool (mold) steel.

用于冲压与塑料模具的主要材料可分为以下两大类型：冷作模具钢（用于冲压模具）和热作模具钢（用于塑料模具）。

④ The guide pillars and ejector stops, which is to support and guide the die, and endure shock loading, are made of case hardened mild steel; occasionally case hardened nickel steels are used for increased strength.

支承和引导模具，并且承受冲击载荷的导柱和止推销由低碳钢经表面硬化制成；有时为获得更大的强度也用镍钢经表面硬化制成。

Glossary of Terms

non-ferrous metal 有色金属（铝、铜等）
cold/hot work tool steel 冷/热作模具钢
carbon steel 碳素钢
alloy steel 合金钢
carbide (tool) steel 硬质合金（工具）钢
free cutting steel 易切削钢
high speed steel 高速钢
shock resisting steel 耐振钢
mild steel (low carbon steel) 低碳钢
medium/ high carbon steel 中/高碳钢
high/low alloy steel 高/低合金钢
cast steel 铸钢
cast iron 铸铁
white iron 白口铸铁
gray iron 灰铸铁
ductile iron（spheroidal/nodular graphite iron）球墨铸铁
malleable iron 可锻铸铁

Reading Materials

Engineering Materials' Categories and Properties

The principal engineering materials can be divided into three major categories: ferrous materials, non-ferrous materials and non-metallic materials. Ferrous materials have iron as a base metal and include tool steel, alloy steel, carbon steel and cast iron. Non-ferrous materials have a base metal other than iron and include aluminum, magnesium, zinc, lead, bismuth, copper and a variety of alloys. Non-metallic materials are those materials such as woods, plastic, rubbers, epoxy resins, ceramics and diamonds that do not have a metallic base.

To properly select a material, there are several physical and mechanical properties you should understand to determine how the material you select will affect the function and operation.

Physical and mechanical properties are those characteristics of a material which control how the material will react under certain condition. Physical properties are those properties which are natural in the material and cannot be permanently altered without changing the material itself. These properties include weight, color, thermal and electrical conductivity, rate of thermal expansion and

melting point. The mechanical properties of a material are those properties which can be permanently altered by thermal or mechanical treatment. These properties include strength, hardness, ductility, wear resistance, toughness, brittleness, plasticity, malleability and modulus of elasticity. In most applications, more than one type of material will be satisfactory and a final choice will normally be governed by material availability and economic considerations.

New Words

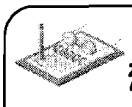
aluminum [ə'lju:minəm] *n.* 铝(Al)
magnesium [mæg'ni:zjəm] *n.* 镁(Mg)
zinc [ziŋk] *n.* 锌(Zn)
lead [li:d] *n.* 铅(Pb)
bismuth ['bizməθ] *n.* 铋(Bi)
copper ['kɔpə] *n.* 铜(Cu)
rubber ['rʌbə] *n.* 橡胶，橡皮
epoxy resin 环氧树脂
ceramics [si'ræmiks] *n.* 陶器；陶瓷制品
mechanical [mi'kænikl] *adj.* 机械的
function ['fʌŋkʃən] *n.* 功能，活动，运行
characteristic [ˌkæriktə'ristik] *n.* 特性，特征
permanently ['pə:mənəntli] *adv.* 永久地
alter ['ɔ:ltə] *v.* 改变
heat treatment *n.* 热处理
strength [streŋθ] *n.* 强度；力，力量
thermal ['θə:məl] *adj.* 热的，热量的
conductivity [ˌkɔndʌk'tiviti] *n.* 传导性
expansion [iks'pænʃən] *n.* 扩充，膨胀
melting point 熔点
hardness ['hɑ:dnis] *n.* 硬度
ductility [dʌk'tiliti] *n.* 塑性，韧性，柔软
wear resistance 耐磨性
toughness ['tʌfnis] *n.* 刚性，韧性
brittleness ['britlnis] *n.* 脆性，脆度；脆弱性
plasticity [plæs'tisiti] *n.* 塑性，可塑性
malleability [ˌmæliə'biliti] *n.* (金属的)可锻性
modulus ['mɔdjuləs] *n.* 模数，系数
elasticity [ilæs'tisiti] *n.* 弹性，弹力
availability [əˌveilə'biliti] *n.* 可利用性

Lesson 3 Heat Treatment of Steel

Text

The role of heat treatment in modern mechanical engineering cannot be ***overestimated***. The purpose of heat treatment is to control the properties of a metal through the ***alteration*** of the structure of the metal by heating it to definite temperatures and cooling at various rates. This combination of heating and controlled cooling determines not only the nature and ***distribution*** of the ***microconstituents***, which in turn determine the properties, but also the ***grain*** size.[①]The changes in the properties of metals due to heat treatment are of extremely great ***significance***.

Heat treating should improve the alloy or metal for the service intended. Some of the various



想一想

Which is the key factor in heat treating: heating temperature, heating rate, or cooling rate?

purposes of heat treating are follows:

(1) To remove ***strains*** after cold working such as forging, ***rolling***.

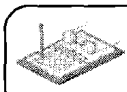
(2) To remove internal ***stresses*** such as those produced by drawing, bending, or ***welding***.

(3) To improve or change properties of a material, such as the hardness, wearing resistance, ***corrosion resistance***, heat resistance, or others as required.

(4) To improve ***machinability*** and the ***comprehensive*** performance of a material on purpose, such as ***normalizing***.②

(5) To soften the material, such as ***annealing***.

Heat treatment conditions' characteristics ***parameters*** are: heating temperature, time of holding at the heating temperature, heating rate, and cooling rate. In general, 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. Heat treatment of ferrous materials involves several important operations which are ***customarily*** referred to under various names, such as normalizing, annealing, ***hardening***, ***tempering***, ***case hardening***, ***spheroidizing***, and ***stress relieving***.



想一想

What methods are there in heat treating?

New Words

overestimate ['əuvə'estimeit] *v.* 过高评价
alteration [ˌɔ:ltə'reiʃən] *n.* 改变，变更
distribution [ˌdistri'bju:ʃən] *n.* 分布，分发
constituent [kən'stitjuənt] *n.* 要素，组分
microconstituent 微观组织，微观成分
grain [grein] *n.* 晶粒，谷物，细粒
significance [sig'nifikəns] *n.* 意义，重要性
strain [strein] *n.* 应变，变形，应力
rolling ['rəuliŋ] *n.* 轧制，辊轧
stress [stres] *n.* 应力
welding ['weldiŋ] *n.* 焊接
corrosion resistance 耐腐蚀性
machinability [məʃi:nə'biliti] *n.* 可加工性
comprehensive [ˌkɔmpri'hensiv] *adj.* 综合的
normalizing ['nɔ:məlaiziŋ] *n.* 正火
annealing [æ'ni:liŋ] *n.* 退火
parameter [pə'ræmitə] *n.* 参数，参量
critical ['kritikəl] *adj.* 临界的，批判的
customarily ['kʌstəmərili] *adv.* 通常
hardening ['hɑ:dəniŋ] *n.* 淬火
tempering ['tempəriŋ] *n.* 回火
case hardening 表面硬化
spheroidize ['sfiərɔidaiz] *v.* 球化处理
stress relieving 去应力处理

Notes

① This combination of heating and controlled cooling determines not only the nature and distribution of the microconstituents, which in turn determine the properties, but also the grain size.

加热和被控制的冷却相结合，不仅决定了微观组织的性质和分布，还决定了晶粒的大小。而微观组织的性质和分布又决定了材料的性能。

句中谓语动词“determines”的宾语由“not only...but also”连接，一个是“the nature and distribution of the microconstituents”，另一个是“the grain size”。

在第一个动词宾语“the nature and distribution of the microconstituents”后，是由“which”引导的非限制性定语从句，修饰说明“微观组织的性质和分布又决定了材料的性能”。

② To improve machinability and the comprehensive performance of a material on purpose, such as normalizing.

根据预期的要求，改善材料的可加工性能和综合性能，如正火。

Glossary of Terms

heat treatment/treating 热处理
normalizing 正火
annealing 退火
hardening 淬火（quenching）
tempering 回火（drawing）
case hardening 表面硬化
stress relieving 去应力
critical range 临界（温度）范围
hardenability 淬透性
hardness profile 硬度分布，硬度剖面图
isothermal annealing 等温退火
partial annealing 不完全退火
overheated structure 过热组织
spheroidized structure 球化组织
cementite 渗碳体
pearlite 珠光体
ferrite 铁素体
austenite 奥氏体
martensite 马氏体

Reading Materials

Common Methods in Heat Treatment

The primary purpose of **annealing** is to soften hard steel so that it maybe machined or cold worked. Full annealing 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 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.

Annealing may not be the most suitable treatment for low carbon steels, which after fully annealed are too soft and relatively weak, offering little resistance to cutting, but usually having sufficient ductility and toughness that a cut chip tends to pull and tear the finished surface, leaving a comparatively poor surface quality that results in a poor machinability. However, the machinability of most of high carbon steels and alloy steels can usually be greatly improved by annealing, as they are often too hard and strong to be easily cut at any but their softest condition. Tool steel is generally purchased in the annealed condition. Sometimes it is necessary to rework a tool that has been hardened, and the tool must then be annealed. For maximum softness and ductility the cooling rate should be as

slow as allowing the parts to cool down with the furnace. The higher the carbon content, the slower cooling rate must be.

Spheroidizing is a form of annealing, which in the process of heating and cooling steels produces a rounded or globular form of carbide-the hard constitute in steel, 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, then cooling slowly in the furnace, this structure will be obtained, which gives improved machinability to the steel, especially to tool steels.

The purpose of **normalizing** is usually to refine grain structures that have been coarsened in forging. With most of the medium carbon forging steels, alloyed and unalloyed, normalizing is highly recommended after forging and before machining to produce more homogeneous structures, and in most cases, improved machinability. Most commercial steels are normalized after rolled and cast. But high alloy air-hardened steels are never normalized, since to do so would cause them to harden and defeat the primary purpose. Normalizing involves heating the metal to a temperature of about 55-100℃ above the critical range and cooling in still air.

Hardening, also called **quenching**, is the oldest and most effective process to hardening metals, whose purpose is to produce martensite. The four common cooling mediums, arranged in order of decreasing cooling ability, are the following: brine, water, light and heavy oil, and air. High temperature gradients contribute to high stresses that cause distortion and cracking, so the quench only produces the necessary desired structure. Care must be exercised in quenching that heat is removed uniformly to minimize thermal stresses. Two special types of quenching are conducted to minimize quenching stresses and decrease the tendency for distortion and cracking. In both, the 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 the products having certain desired physical properties.

Steel that has been hardened by rapid quenching is brittle and not suitable for most use. By **tempering**, 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. 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 dose not soften the steel to the extent that annealing would. The final structure obtained from tempering a fully hardened steel is called tempered martensite. The magnitude of the structural changes and the change of properties caused by tempering depend upon the temperature to which the steel is reheated. The higher the temperature, the greater the effect, so the choice of temperature will generally depend on willingness to sacrifice hardness and strength to gain ductility and toughness.

The addition of carbon to the surface of steel parts and the subsequent hardening operations are important processes in heat treating, called **case hardening**. The process may involve the use of molten sodium cyanide mixture, pack carburizing with activated solid materials such as charcoal or coke, gas or oil carburizing, and dry cyaniding.

New Words

primary ['praiməri] *adj.* 主要的，最初的
accomplish [ə'kɔmpliʃ] *v.* 完成，达到，实现
approximately [ə'prɔksimitli] *adv.* 大约
refine [ri'fain] *v.* 精炼，细化
purchase ['pə:tʃəs] *v.* 购买
coarsen ['kɔ:sn] *v.* 变粗糙
recommend [rekə'mend] *v.* 推荐
homogeneous [ˌhɔməu'dʒi:njəs] *adj.* 均匀的
still [stil] *adj.* 静止的
martensite ['mɑ:tənzait] *n.* 马氏体
medium['mi:diəm] *n.* 媒介 *adj.* 中间的
brine[brain] *n.* 盐溶液
gradient ['greidiənt] *n.* 变化率，梯度
distortion [dis'tɔ:ʃən] *n.* 扭曲，变形，曲解
cracking ['krækiŋ] *n.* 开裂，裂纹，裂痕
tendency ['tendənsi] *n.* 倾向，趋向
salt bath 盐浴（炉，槽）
austempering [ˌɔ:s'tempəriŋ] *n.* 等温淬火
martempering ['mɑ:ˌtempəriŋ] *n.* 分级淬火
tensile ['tensail] *adj.* 可拉长的，拉力的
tensile strength 抗拉强度
sacrifice ['sækrifais] *n.* 牺牲 *v.* 牺牲，献出
subsequent ['sʌbsikwənt] *adj.* 随后的，后来的
sodium ['səudjəm] *n.* 钠
cyanide ['saiənaid] *n.* 氰化物，碳氮共渗
dry cyaniding 干法碳氮共渗
carburizing ['kɑ:bjuraiziŋ] *n.* 渗碳剂
activated ['æktiveitid] *adj.* 有活性的