普通高等教育“十一五”国家级规划教材

机械工业出版社精品教材

模具设计与制造专业英语

第3版

王晓江◎主编

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机械工业出版社
CHINA MACHINE PRESS

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模具设计与制造专业英语

A NEW ENGLISH BOOK FOR DIE OR MOLD DESIGN AND MANUFACTURING

第3版

Third Edition

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机 械 工 业 出 版 社

本书内容均选自英、美等国专业教材及专业刊物中的原文，共10个单元、30课，90余篇（其中课文30篇，阅读材料60多篇）。内容涉及模具材料及热处理、机械制图与公差配合、刀具和夹具设计、冲压和塑料成型机械、冲压工艺及模具设计、塑料及塑料模具设计、压铸模具和锻模设计、常用机械加工方法、特种加工工艺、模具CAD/CAM、数控加工技术、快速成型与先进制造技术等方面。内容全面，难易适中，图文并茂，配套有课文参考译文，便于阅读和学习。

本书为高职高专模具设计与制造专业教材，同时也可作为从事模具设计与制造的企业工程技术人员自学参考书。

本书配套有电子课件，凡选用本书作为教材的教师可登录机械工业出版社教育服务网www.cmpedu.com，注册后免费下载。咨询电话：010-88379375。

图书在版编目（CIP）数据

模具设计与制造专业英语/王晓江主编．—3版．—北京：机械工业出版社，2018.6

普通高等教育“十一五”国家级规划教材　机械工业出版社精品教材

ISBN 978-7-111-60120-3

Ⅰ.①模…　Ⅱ.①王…　Ⅲ.①模具—设计—英语—高等学校—教材②模具—制造—英语—高等学校—教材　Ⅳ.①TG76

中国版本图书馆CIP数据核字（2018）第115530号

机械工业出版社（北京市百万庄大街22号　邮政编码100037）

策划编辑：于奇慧　责任编辑：于奇慧

责任校对：刘　岚　封面设计：马精明

责任印制：李　昂

北京宝昌彩色印刷有限公司印刷

2018年8月第3版第1次印刷

184mm×260mm·13.5印张·324千字

0001—1900册

标准书号：ISBN 978-7-111-60120-3

定价：35.00元

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第3版前言

本书为全国机械职业教育模具类专业教学指导委员会规划教材、普通高等教育“十一五”国家级规划教材。自2008年第2版出版以来，先后重印了11次，受到许多院校师生的欢迎。本次修订是在第2版的基础上，依据部分使用本书的院校师生和模具企业工程技术人员的意见和建议，对教材编排顺序、内容做了适当的修订。主要有以下几个方面：

1）对原来的课文次序进行了重新调整和编排。

2）对原教材部分课后阅读材料内容进行了适当的删减。

3）在保持原教材内容和体系的基础上，增编了Lesson 12 、Lesson 13 两课内容。

4）适当添加了部分示图、专业术语等。

5）本次修订还增加了Appendix B　Tables of Weights and Measures。

修订后的教材分10个单元、共30课。建议60学时完成。各校在组织教学时，可根据本校和学生的具体情况，不受教材编排顺序和内容限制，进行适当的删减和调整。

本书在修订过程中得到了机械工业出版社的大力支持和帮助，陕西工业职业技术学院肖春艳、杨燕老师对教材提出了宝贵的修改建议，谨向他们表示衷心的感谢。

由于编者水平所限，书中难免有不少缺点和错误，敬请读者批评指正。

编　者

第2版前言

本书是普通高等教育“十一五”国家级规划教材、全国机械职业教育模具设计与制造专业教学指导委员会规划教材、高等职业教育机电类规划教材。

本书第1版自2001年出版以来，先后重印10余次，深受广大高职院校师生的欢迎和好评。此次修订，是在第1版的基础上，依据模具设计与制造技术发展对高技能人才的需求，征求了部分院校师生的意见，并听取了模具企业工程技术人员的建议，对原书内容做了适当的更新和扩充。主要进行了以下几个方面的修订工作：

1. 在保持第1版教材内容和结构体系的基础上，新增了2个单元共4篇有关机械制图、第三角画法、公差配合、先进制造技术、快速成形技术等内容的文章（第25~28课），同时还补充了部分课后阅读材料。

2. 为方便读者学习，增加了第1~28课课文的参考译文。

3. 对第1版教材的部分课后阅读材料做了适当的删减。

修订后的教材共12个单元28课。各校在组织教学时，可根据本校学生的实际情况进行适当的删减和调整，不必受教材编排顺序和内容的限制。

王晓江任本书主编，选编并翻译了第25~28课课文，史铁樑翻译了第16~24课课文，陈永兴翻译了第5~10课课文，南欢、董海东、孙慧、王建军、周勋、杨新华等翻译了其他课文。

本书在编写过程中，得到了王明哲、刘航、殷铖、胡占军等老师的大力支持，在此谨向他们表示衷心的感谢。刘宝兴老师对教材提出了许多宝贵的修改意见，在此深表感谢。

由于编者水平所限，书中难免有不少缺点和错误，敬请读者批评指正。

编　者

第1版前言

本书是根据教育部“关于加强高职高专教育教材建设的若干意见”和国家机械工业局教材编辑室“关于组织新编高职高专模具专业教材的原则”以及“模具设计与制造专业英语”课程教学大纲编写的。

其目的是为了更好地帮助模具专业学生进一步适应国际、国内模具专业发展的需要，提高直接阅读原文和翻译有关专业英语书刊的能力，学习和借鉴国外先进的模具设计和制造技术，特别是模具CAD/CAM应用软件等，从而大力推进我国模具行业和模具产品的快速发展。

本书内容均选自英、美等国专业教材及专业刊物中的原文，共80篇（其中课文25篇，阅读材料55篇），分10个单元，24课。内容比较全面，涉及模具材料及热处理、刀具和夹具、冲压和塑压成型机械、冲压工艺及模具设计、塑料及塑料模具设计、压铸模具及锻模设计、常用冷加工方法、特种加工工艺、模具CAD/CAM和数控加工技术等方面。

本书可供高职高专模具设计与制造专业学生作为教材使用，教学中可根据各校的实际情况，调整授课顺序或删减有关内容。同时也可供有关模具设计与制造企业的工程技术人员参考。

本书由陕西工业职业技术学院王晓江主编，参加编写的人员有无锡工业职业技术学院吴斌、福建职业技术学院林涵、江西省机械工业学校钱泉森、成都市工业学校史铁樑、张家界航空工业学校卢端敏。在编写过程中得到了夏克坚、赵居礼、戴勇、翁其金等同志的大力支持。

本书由陕西工业职业技术学院王兆奇主审，陕西工业职业技术学院澳大利亚籍教师Jared Morise审阅了全书，参加审稿的有刘全胜、朱燕清、徐政坤、彭雁、包杰、武友德、陈勇、刘航等老师。他们对本书提出了许多宝贵的修改意见，在此表示衷心的感谢。

由于编者水平有限，加上时间紧迫，经验不足，书中难免会有缺点和错误，欢迎读者批评指正。

编　者

CONTENTS

Unit One

Lesson 1 Tool Materials

Text

The specific material selected for a particular tool is normally determined by the mechanical properties necessary for the proper operation of the tool. These materials should be selected only after a careful study and ***evaluation*** of the function 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 material ***availability*** and economic considerations.

The principal materials used for tools can be divided into three major ***categories***: ferrous materials, nonferrous materials, and nonmetallic materials. Ferrous tool materials have iron as a base metal and include tool steel, alloy steel, carbon steel, and cast iron. Nonferrous materials have a base metal other than iron and include aluminum, magnesium, zinc, lead, bismuth, copper, and a variety of alloys. Nonmetallic materials are those materials such as woods, plastics, rubbers, ***epoxy*** resins, ceramics, and diamonds that do not have a metallic base. To properly select a tool material, there are several physical and mechanical properties you should understand to determine how the materials you select will affect the function and operation of the tool[1].

Physical and mechanical properties are those characteristics of a material which control how the material will react under certain conditions. 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, wear resistance, ***toughness***, ***brittleness***, plasticity, ductility, ***malleability***, and ***modulus*** of elasticity.

From a use ***standpoint***, tool steels are utilized in working and shaping basic materials such as metals, plastics, and wood into desired forms. From a composition standpoint, tool steels are carbon alloy steels which are capable of being hardened and tempered. Some desirable properties of tool steels are high wear resistance and hardness, good heat resistance, and ***sufficient strength*** to work the materials. In some cases, ***dimensional stability*** may be very important. Tool steels also must be economical to use and be capable of being formed or machined into the desired shape for the tool.

Since the property requirements are so special, tool steels are usually melted in electric furnaces using careful ***metallurgical*** quality control. A great effort is made to keep ***porosity***, ***segregation***, ***impurities***, and nonmetallic inclusions to as low a level as possible[2]. Tool steels are subjected to careful ***macroscopic*** and ***microscopic inspections*** to ensure that they meet strict "tool steel" specifications.

Although tool steels are a relatively small percentage of total steel production, they have a strategic position in that they are used in the production of other steel products and engineering materials. Some applications of tool steels include drills, deepdrawing dies, shear ***blades***, punches, extrusion dies, and cutting tools.

For some applications, especially where extremely high-speed cutting is important, other tool materials such as sintered ***carbide*** products are a more economical alternative to tool steels. The exceptional tool performance of sintered carbides results from their very high hardness and high ***compressive*** strength. Other tool materials are being used more and more often industrially.

Questions

1. What is meant by the term "physical properties of a material"?
2. What are the mechanical properties of a material?
3. What makes a material either ferrous or nonferrous?
4. What are some applications of tool steels?

New Words and Expressions

1. evaluation/iˌvælju'eiʃən/*n.* 评价，估价，鉴定，计算
2. satisfactory/sætis'fæktəri/*a.* 满意的，符合要求的
3. availability/əˌveilə'biliti/*n.* 存在，具备，有效性，利用率
4. category/'kætigəri/*n.* 种类，范畴，类型
5. epoxy/e'pɔksi/*a.* 环氧的
6. thermal/'θəːməl/*a.* 热（量）的，由热造成的；*n.* 上升暖气流
7. toughness/'tʌfnis/*n.* 韧性，韧度，塑性，刚度
8. brittleness/'britlnis/*n.* 脆性，脆度，脆弱性
9. malleability/mæliə'biliti/*n.* 可锻性，延展性，展性
10. modulus/'mɔdjuləs/*n.* 模量，模数，系数
11. standpoint/'stændpɔint/*n.* 观点，立场
12. sufficient/sə'fiʃənt/*a.* 充分的，足够的
13. strength/streŋθ/*n.* 力（量），强度
14. dimensional/di'menʃənl/*a.* 尺寸的，量纲的
15. stability/stə'biliti/*n.* 稳定（性），安定度
16. metallurgical/metə'ləːdʒikəl/*a.* 冶金（学）的
17. porosity/pɔː'rɔsiti/*n.* 多孔（性），孔隙度，疏松（度）
18. segregation/segri'geiʃən/*n.* 分离，分开，隔离，偏析
19. impurity/im'pjuəriti/*n.* 杂质
20. macroscopic/mækrə(u)'skɔpik/*a.* 宏观的，肉眼可见的
21. microscopic/maikrə'skɔpik/*a.* 显微镜的，微观的，微小的
22. inspection/in'spekʃən/*n.* 检查，调查，

参观，视察

23. bladĕ/bleid/*n.* 刀口，刀片，刀身

24. carbide/ˈkɑːbaid/*n.* 碳化物，电石，碳化钙

25. compressive/kəmˈpresiv/*a.* 压缩的，有压缩力的

26. epoxy resins 环氧树脂

27. (be) subjected to 曾受到，使受到

28. in some cases 有时，在有些情况下

Notes

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

为了选择工具材料，你应当掌握材料的一些物理性能和力学性能，以便确定所选材料对工具的功能和操作会有何影响。

不定式 to properly select a tool material 放在句首用作目的状语；you select 为定语从句修饰前面的 the materials。

[2] A great effort is made to keep porosity, segregation, impurities, and nonmetallic inclusions to as low a level as possible.

（对于工具钢的冶炼，）要最大限度地降低钢中的气孔、偏析、杂质以及非金属夹杂物等的含量。

这里的 a great effort is made 是 make a great effort 的被动形式，意为“尽一切力量”。

Glossary of Terms

1. carbide tool 硬质合金刀具
2. alloy tool steel 合金工具钢
3. alloy cast iron 合金铸铁
4. carbon steel 碳素钢
5. carbon tool steel 碳素工具钢
6. cast iron 铸铁
7. cast steel 铸钢
8. die block steel 模具钢
9. die material 模具材料
10. free cutting steel 易切削钢
11. high alloy steel 高合金钢
12. high carbon steel 高碳钢
13. low alloy steel 低合金钢
14. low carbon steel 低碳钢
15. shock resistant tool steel 抗冲击工具钢
16. cold work tool (die) steel 冷作工具（模具）钢
17. hot work tool (die) steel 热作工具（模具）钢
18. nodular graphite iron 球墨铸铁
19. malleable cast iron 可锻铸铁
20. mottled cast iron 麻口铸铁
21. high-speed steel 高速钢
22. white cast iron 白口铸铁
23. compacted graphite cast iron 蠕墨铸铁
24. powder metallurgy (P/M) 粉末冶金

Reading Materials

Carbon Steels

Carbon steels are used extensively in tool construction. Carbon steels are those steels which only contain iron and carbon, and small amounts of other alloying elements. Carbon steels are the most common and least expensive type of steel used for tools. The three principal types of carbon steels used for tooling are low carbon, medium carbon, and high carbon steels. Low carbon steel contains carbon between 0.05% and 0.3%. Medium carbon steel contains carbon between 0.3% and 0.7%. And high carbon steel contains carbon between 0.7% and 1.5%. As the carbon content is increased in carbon steel, the strength, toughness, and hardness are also increased when the metal is heat treated.

Low carbon steels are soft, tough steels that are easily machined and welded. Due to their low carbon content, these steels cannot be hardened except by case hardening. Low carbon steels are well suited for the following applications: tool bodies, handles, die shoes, and similar situations where strength and wear resistance are not required.

Medium carbon steels are used where greater strength and toughness is required. Since medium carbon steels have a higher carbon content, they can be heat treated to make parts such as studs, pins, axles, and nuts. Steels in this group are more expensive as well as more difficult to machine and weld than low carbon steels.

High carbon steels are the most hardenable type of carbon steel and are used frequently for parts where wear resistance is an important factor. Other applications where high carbon steels are well suited include drill bushings, locators, and wear pads. Since the carbon content of these steels is so high, parts made from high carbon steel are normally difficult to machine and weld.

Alloy Steels

Alloy steels are basically carbon steels with additional elements added to alter the characteris-tics and bring about a predictable change in the mechanical properties of the alloyed metal. Alloy steels are not normally used for most tools due to their increased cost, but some have been found favor for special applications. The alloying elements used most often in steels are manganese, nickel, molybdenum and chromium.

Another type of alloy steel frequently used for tooling applications is stainless steel. Stainless steel is a term used to describe high chromium and nickel-chromium steels. These steels are used for tools which must resist high temperatures and corrosive atmospheres. Some high chromium steels can be hardened by heat treatment and are used where resistance to wear, abrasion, and corrosion are required. Typical applications where a hardenable stainless steel is sometimes preferred are plastic injection molds. Here the high chromium content allows the steel to be highly polished and prevents deterioration of the cavity from heat and corrosion.

Die Steels

The die material is relevant directly to the die life as well as die cost. Recently, the commonly used die steel for cold blanking is as follows:

The carbon tool steel T8A, T10A, T12A are the cheapest and the most widely used. Its hardness after annealing is lower than that of the alloy steel. It has good machining property, and the process of forging, annealing and quenching is easy to be mastered. It is suitable to manufacture the working parts of the blanking die with small size and simple shape. But its hardenability and abrasion-resistant are bad, its quench distortion is large and its working life is short.

The low alloy tool steel, such as CrWMn, 9CrSi, 9Mn2V etc, can be quenched by oil, therefore it has a good hardenability and a small quench distortion. Comparing with T10A, 9Mn2V has a higher hardness and abrasion-resistance, and also has a good machining property.

High-carbon high-chrome die steel, such as Cr12, Cr12Mo, Cr12MoV etc, has a high strength, good hardenability and abrasion-resistance and small quench distortion. The carbon content of Cr12 is a bit higher. The distribution of carbide is nonuniform severely, which results in a decrease in the strength as well as hardness.

High-carbon medium-chrome die steel includes Cr6WV, Cr4W2MoV etc. Cr6WV is advantageous in small chrome content, better strength and impact toughness as compared with Cr12. Due to the small content of carbon and chrome, its abrasion-resistance and hardenability is not as good as Cr12, but its quench distortion is small. Its life expectancy is almost the same as Cr12. Cr4W2MoV is a new brand of die steel for cold forming to substitute Cr12. As compared with Cr12, it is characterized in finer size and more uniform distribution of eutectic carbide, therefore its hardenability, hardening-quenching capacity, mechanical property and abrasion-resistance are a bit higher. The alloy elements, such as W, Mo and V etc, improve the stability of the steel and make the die undergoing possible, chemical heat treatment possible.

Lesson 2 Heat Treating of Tool Steels

Text

The purpose of heat treatment is to control the properties of a metal or alloy through the ***alteration*** of the structure of the metal or alloy 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 micro***constituents***, which in turn determine the properties, but also the ***grain*** size[1].

Heat treating should improve the alloy or metal for the service intended. Some of the various purposes of heat treating are as follows:

1. To remove ***strains*** after cold working.
2. To remove internal stresses such as those produced by drawing, bending, or welding.
3. To increase the hardness of the material.
4. To improve machinability.
5. To improve the cutting capabilities of tools.
6. To increase wear-resisting properties.
7. To soften the material, as in ***annealing***.
8. To improve or change properties of a material, such as ***corrosion*** resistance, heat resistance, ***magnetic*** properties, or others as required.

Treatment of Ferrous Materials. Iron is the major constituent in the steels used in tooling, to which carbon is added in order that the steel may harden. Alloys are put into steel to enable it to develop properties not possessed by plain carbon steel, such as the ability to harden in oil or air, increased wear resistance, higher toughness, and greater safety in hardening.

Heat treatment of ferrous materials involves several important operations which are ***customarily*** referred to under various headings, such as normalizing, ***spheroidizing***, stress relieving, annealing, hardening, tempering, and case hardening.

Normalizing involves heating the material to a temperature of about 100 ~ 200 °F (55 ~ 100℃) above the critical range and cooling in still air. This is about 100°F (55℃) over the regular hardening temperature.

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[2].

High-alloy air-hardened steels are never normalized, since to do so would cause them to harden and defeat the primary purpose.

Spheroidizing is a form of annealing which, in the process of heating and cooling steel, produces a rounded or ***globular*** form of carbide—the hard constituent in steel.

Tool steels are normally spheroidized to improve machinability. This is accomplished by heating to a temperature to 1380 ~ 1400°F (749 ~ 760℃) for carbon steels and higher for many alloy tool steels, holding at heat one to four hours, and cooling slowly in the furnace.

Stress Relieving. This is a method of relieving the internal stresses set up in steel during forming, cold working, and cooling after welding or machining. It is the simplest heat treatment and is accomplished merely by heating to 1200 ~ 1350°F (649 ~ 732℃) followed by air or furnace cooling.

Large dies are usually roughed out, then stress-relieved and finish-machined. This will minimize change of shape not only during machining but during subsequent heat treating as well. Welded sections will also have locked-in stresses owing to a combination of differential heating and cooling cycles as well as to changes in cross section. Such stresses will cause considerable movement in machining operations.

Annealing. The process of annealing consists of heating the steel to an ***elevated*** temperature for a definite period of time and, usually, cooling it slowly. Annealing is done to produce homogenization and to establish normal equilibrium conditions, with corresponding characteristic properties.

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 this type of anneal, the steel is heated slightly above its critical range and then cooled very slowly.

Hardening. This is the process of heating to a temperature above the critical range, and cooling rapidly enough through the critical range to ***appreciably*** harden the steel.

Tempering. This is the process of heating quenched and hardened steels and alloys to some temperature below the lower critical temperature to reduce internal stresses set up in hardening.

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

Questions

1. What process is used to remove the internal stresses created during a hardening operation?
2. What heat treating process makes the metallic carbides in a metal form into small rounded globules?
3. What are the main purposes of heat treating?
4. How many heat treating processes are involved in ferrous materials?

New Words and Expressions

1. alteration/ɔːltəˈreiʃən/*n.* 改变，变更
2. nature/ˈneitʃə/*n.* 本性，性质，自然界
3. distribution/distriˈbjuːʃən/*n.* 分配，分布
4. constituent/kənˈstitjuənt/*n.* 成分，分量，

要素；*a.* 组成的

5. grain/grein/*n.* 晶粒，粒度；*vt.* 使结晶，使成细粒；*vi.* 形成粒状
6. strain/strein/*vt.* *n.* 应变，张力，变形，弯曲
7. annealing/əˈniːliŋ/*n.* 退火，韧化，缓冷
8. corrosion/kəˈrəuʒən/*n.* 腐蚀，侵蚀，锈，铁锈
9. magnetic/mægˈnetik/*a.* 磁的，磁化的，有吸引力的
10. customarily/ˈkʌstəmərili/*ad.* 通常，习惯上
11. spheroidizing/sfiəˈrɔidaiziŋ/*n.* 球化处理
12. coarsen/ˈkɔːsn/*vt.* 使粗，粗化；*vi.* 变粗
13. homogeneous/hɔməˈdʒiːnjəs/*a.* 同种的，同性的，均匀的
14. globular/ˈglɔbjulə/*a.* 球状的，有小球的，世界范围的
15. elevate/ˈeliveit/*vt.* 抬起，举起，使升高
16. appreciable/əˈpriːʃiəbl/*a.* 可估计的，明显的，可观的
17. cyanide/ˈsaiənaid/*n.* 氰化物
18. carburize/ˈkɑːbjuraiz/*vt.* 渗碳
19. grain size 晶粒尺寸
20. cold working 冷加工
21. internal stress 内应力
22. corrosion resistance 耐腐蚀
23. heat resistance 耐热
24. magnetic property 磁性能
25. (be) referred to 把……归因于，参考，认为……由于
26. critical range 临界范围

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.

(在热处理过程中，) 加热与冷却控制相结合的方法不仅决定了材料中微观组织的分布和性质（进而决定了该材料的性能），而且也决定了材料内部晶粒的大小。

句中第一个 and 连接的是 heating 和 controlled cooling，第二个 and 连接的是 nature 和 distribution，而 which in turn determine the properties 为非限定性定语从句，修饰 the nature and distribution。

[2] 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.

对于大多数中碳锻钢来说，不管是否合金化，在锻造后和机械加工前通常推荐采用正火处理工艺，这样有利于形成更均匀的组织，并且在大多数情况下可改善材料的切削加工性能。

句首的介词 with 短语意为“对……来说”；in most cases 可译为“在大多数情况下”。

Glossary of Terms

1. hardenability 淬透性
2. hardenability curve 淬透性曲线
3. hardening capacity 淬硬性（硬化能力）
4. case hardening 表面硬化，渗碳

5. hardness profile　硬度分布（硬度梯度）
6. heat treatment procedure　热处理规范
7. heat treatment installation　热处理设备
8. heat treatment furnace　热处理炉
9. heat treatment cycle　热处理工艺周期
10. heat time　加热时间
11. heat system　加热系统
12. heating up time　升温时间
13. heating curve　加热曲线
14. high temperature carburizing　高温渗碳
15. high temperature tempering　高温回火
16. isothermal transformation　等温转变
17. isothermal annealing　等温退火
18. interrupted ageing treatment　分级时效处理
19. local heat treatment　局部热处理
20. overheated structure　过热组织
21. pack carburizing　固体渗碳
22. oxynitrocarburizing　氧氮碳共渗
23. partial annealing　不完全退火
24. spheroidized structure　球化组织
25. recrystallization temperature　再结晶温度

Reading Materials

Heat Treatment of Die Steels

Although alloy steels contain elements such as chromium, molybdenum and vanadium, two constituents are essential for heat treatment: iron, termed ferrite in metallography, and carbon, which combines with iron to form cementite, the hard intermetallic compound Fe_3C. These two constituents form a eutectoid structure known as pearlite when the steel is cooled slowly enough to reach equilibrium, but by rapid cooling the steel is hardened. When such a quenched steel is tempered, structures with mechanical properties intermediate between those of the slowly cooled and the quenched conditions are formed.

In recent years there has been a greater understanding of the complex structural changes taking place during heat treatment, with the help of phase transformation diagrams. Use of these diagrams can lead to better control of the heat treatment cycle which in turn will ensure that optimum properties and maximum die life are achieved.

Surface Treatments for Steels

During the past 20 years, several processes have been introduced to obtain enhanced surface hardness of steels. Some of them have developed from case carburizing and nitriding, to obtain shorter processing times with better environmental control and improved properties. Various salt bath processes have been used and now a wide range of new methods is available.

In the die casting industry surface treatments are applied to steels to improve the properties of