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高等职业教育教学改革系列规划教材

数控模具专业英语

黄红辉 王凌云 主编
谢志江 宋放之 主审

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内 容 简 介

本书遵循“以专业为导向，以应用为目的，以必需、够用为度”的原则，强化概念，注重应用。内容包括数控机床和系统、数控操作、金属材料与加工、冲压成形与模具、注塑成形与模具、CAD/CAM等。原文选自数控与模具专业的英语版教科书籍，内容丰富，通俗易懂，较全面地反映了数控和模具两个专业知识的英语表达和英语词汇。每一课都有注释和参考译文，并有辅助阅读材料以扩充相关知识。本书可作为模具设计与制造及数控技术专业的专业英语教材，也可以作为相关专业技术人员的参考书。

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前　言

随着制造业全球化的趋势，尤其是 CAD/CAM 技术在制造业的广泛应用，生产制造行业对数控技术和模具设计与制造专业人才的专业英语能力提出了更高的要求，学生在走上岗位后，能够阅读专业英文资料、设备说明书和有关技术文件，才能更好地适应岗位要求。

《数控模具专业英语》教材遵循“以专业为导向，以应用为目的，以必需、够用为度”的原则，强调实用性，注重应用。整合数控技术和模具设计与制造两个专业的知识，注重学生岗位能力和综合能力的培养。使学生能够阅读专业英文资料、设备说明书和有关技术文件，以适应先进制造业相关岗位群的需求。为满足模具设计与制造及数控技术专业的专业英语教学需要编写的这本书，涉及数控与模具专业各主要课程的内容，如数控系统、数控机床及其制造技术、金属材料与加工、冲压成形与模具、注塑成形与模具、计算机辅助设计与制造（CAD/CAM）、模具制造工艺及特种加工等。课文均选自英美原版著作。文章风格各异，生动有趣。每篇课文后都有生词、词组解释和难句的注解。教材图文并茂，大多数单元都配有与内容相关的插图，即通过文中图例便可直观地理解各段文章大意。书后配有课文的参考译文。

通过本教材的学习，读者不仅可学到常用的模具专业术语、科技英语的一般表达方法以及阅读方法，提高英语水平，而且能获得非常有用的专业知识。初步掌握数控、模具专业英语的基本词汇与惯用表述，为日后阅读和翻译本专业的相关书籍奠定基础。

本书既可以作为专业英语教材，也可以作为相关专业技术人员的参考书。本书由上海工程技术大学的黄红辉、王凌云教授担任主编，其中黄红辉执笔了其中的注塑成形与模具、冲压成形与模具及其相关部分，其余部分由王凌云执笔，本书由谢志江、宋放之主审。

编者在此向谢志江、宋放之、郑卫、崔岩、于位灵、许文全、杨中文、皮智谋、皮杰、王志平、王荣兴、刘茂福、黄登红、汪程等专家学者致以诚挚的谢意！

由于作者水平有限，书中难免有一些不足之处，恳请广大读者批评指正！

编　者

2012 年 5 月 8 日

数控、模具类教材编委会

（排名不分先后）

CONTENTS

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 is a metal 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 centimeter.

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 the best 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 act 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 is. 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 most important factors in the evaluation of a metal.

7. Compressive strength is the ability of a material to resist to be 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 moderate tensile strength.

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

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.

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 is, the greater the energy is required to break it. Impact strength may be seriously affected by welding since it is one of the most sensitive properties of structure.

13. Ductility refers to the ability of metal to stretch, bend, or twist without breaking or cracking. A metal of 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 the 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.

15. Cryogenic properties of metals represent behavior characteristics under stress in environments of very low temperatures. In addition to being sensitive to crystal structure and processing conditions, metals are also sensitive to low and high temperatures. Some alloys which perform satisfactorily at room temperatures may fail completely at low or high temperatures. The changes from ductile to brittle failure occurs rather suddenly at low temperatures.

New Words

alloy	[ə'lɔi]	n. 合金
alternate	['ɔ:ltənit]	v. 交替，轮流
ascertain	[ˌæsə'tein]	vt. 确定，查明
axle	['æksl]	n. 轮轴，车轴
behavior	[bi'heivjə]	n. 性能
bend	[bend]	v. 弯曲
brittle	['britl]	adv. 易碎的
characteristic	[kærəktə'ristik]	n. 特性
compression	[kəm'preʃən]	n. 压缩
compressive	[kəm'presiv]	a. 压缩的
crack	[kræk]	v. （使）破裂，裂纹
crush	[krʌʃ]	vt. 压碎
cryogenic	[ˌkraiə'dʒenik]	a. 低温学的
crystal	['kristl]	a. 结晶状的
deflect	[di'flekt]	vt. 使弯曲
deform	[di'fɔ:m]	v. (使)变形

distort	[dis'tɔ:t]	vt. (使)变形，扭曲
ductility	[dʌk'tiliti]	n. 延展性，韧性
elasticity	[ilæ'stisiti]	n. 弹性
elongate	[i'lɔŋget]	vt. (使)伸长，延长
evaluation	[i'vælju,eiʃən]	n. 评估
fail	[feil]	n. 损坏
fatigue	[fə'tig]	n. 疲劳
hardness	['ha:dnis]	n. 硬度
impact	['impækt]	n. 冲击
indentation	[,inden'teiʃən]	n. 压痕
indenter	[in'dentə]	n. 压头
internal	[in'tə:nl]	a. 内部的
measure	['meʒə]	n. 大小，度量
moderate	['mɔdərit]	a. 适中的
modulus	['mɔdjuləs]	n. 系数
opposite	['ɔpəzit]	n. 反面
penetration	[peni'treiʃən]	n. 穿透
piston	['pistən]	n. 活塞
property	['prɔpəti]	n. 特性
quality	['kwaliti]	n. 质量
rapidly	['ræpidli]	adv. 迅速地
ratio	['reiʃiəu]	n. 比，比率
refer	[ri'fə:]	v. 指，涉及，谈及
release	[ri'li:s]	vt. 释放
resist	[ri'zist]	vt. 抵抗
resistance	[ri'zistəns]	n. 阻力，抵抗
reversal	[ri'və:sl]	n. 反向
rigidity	[ri'dʒiditi]	n. 刚度
rod	[rɔd]	n. 杆，棒
satisfactorily	[,sætis'fæktrili]	adv. 满意地
sensitive	['sensitiv]	a. 敏感的
seriously	['siəriəsli]	adv. 严重地
shear	[ʃiə]	n. 剪，切
sound	[saund]	a. 结实的，坚固的
stiffness	['stifnis]	n. 刚度
strain	[strein]	n. 应变
strength	[streŋθ]	n. 强度
stress	[stres]	n. 压力，应力
stretch	[stretʃ]	v. 伸展
subject	['sʌbdʒikt]	vt. 使受到

tensile	['tensl]	a. 拉紧的，张紧的
tension	['tenʃən]	n. 拉紧，张紧
torsional	['tɔ:ʃənl]	a. 扭转的
twist	[twist]	v. 扭曲，扭转
undergo	[ʌndə'gəu]	vt. 经受
various	['vɛəriəs]	a. 不同的，各种的
velocity	[vi'lɔsiti]	n. 速度
welding	['weldiŋ]	n. 焊接
withstand	[wið'stænd]	vt. 经受，经得起

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 is a metal 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呈现的特性的量度。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、抗疲劳强度和抗冲击强度。

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。

5. The changes from ductile to brittle failure occurs rather suddenly at low temperatures.

在低温下从塑性到脆性破坏，变化的发生是相当突然的。

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 is true in all fields of engineering, whether it be the mechanical engineer trying to design high-strength, light-weight casings (包装) for rocket hulls (外壳), the electrical engineer trying to design a solid state electronic device that will operate at temperatures above a few hundred degrees Celsius (摄氏的), or the nuclear engineer concerned with the materials needed to contain, control, and utilize a nuclear reaction. 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 to 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, and can vary greatly, depending on (1) how the material was manufactured (exactly what processing conditions were involved) and (2) under what conditions (temperature, pressure, exposure (暴露) 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 1400°F and 1600°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.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 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.

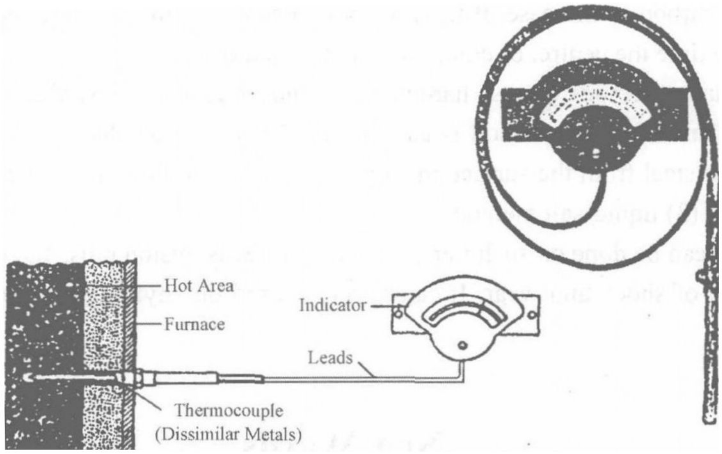

Fig.1 A pyrometer accurately tells the temperature inside the furnace

4. Remove the hot metal with tongs, and plunge it into 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 decide 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 till 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 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: (1) pack method, (2) gas method, or (3) 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

°F (Fahrenheit)	['færənhait]	n. 华氏温度
abrasive	[ə'breisiv]	a. 研磨的
accuracy	['ækjurəsi]	n. 精度，准确性
agitate	['ædʒiteit]	v. 摇动
aluminiun	[ˌælju'minjəm]	n. 铝
annealing	[ə'ni:liŋ]	n. 退火
brass	[bræs]	n. 黄铜
brine	[brain]	n. 盐水
carburizing	['ka:bjuraiziŋ]	n. 渗碳
case	[keis]	n. 壳，套
clay	[klei]	n. 黏土
complicated	['kɔmpləkeitid]	a. 复杂的
core	[kɔ:]	n. 核心
critical	['kritikl]	a. 临界的
cyanide	['saiənaid]	n. 氰化物
desirable	[di'zairəbl}	a. 合适的
elementary	[elə'mentəri]	a. 基本的
extend	[eks'tend]	v. 伸展
hardness	['ha:dnis]	n. 硬度
inexpensive	[inik'spensiv]	a. 便宜的
mineral	['minərəl]	n. 矿物，矿产
moderate	['mɔdərit]	a. 适度的
nonferrous	['nɔn'ferəs]	a. 不含铁的，非铁的
observe	[əb'zə:v]	vt. 观察
pack	[pæk]	v. 包装

plunge	[plʌndʒ]	v. 投入
point	[pɔint]	n. 刃口
project	[prə'dʒekt]	n. 项目，产品
pyrometer	[pai'rɔmitə]	n. 高温计
quench	[kwentʃ]	vt. 淬火
rapid	['ræpid]	a. 迅速的
register	['redʒstə]	v. 记录，显示，记数
relieve	[ri'li:v]	vt. 减轻，解除
retain	[ri'tein]	vt. 保持，保留
scale	[skeil]	n. 硬壳
scrap	[skræp]	n. 小片，废料
soak	[səuk]	v. 浸，泡，均热
solution	[sə'lu:ʃən]	n. 溶液
tempering	['tempəriŋ]	n. 回火
tensile	['tensail]	a. 拉力的，可拉伸的
thoroughly	['θʌrəuli]	adv. 十分地，彻底地
tong	[tɔŋ]	n. 火钳
toughness	['tɔfnis]	n. 韧性
treatment	['tri:tmənt]	n. 处理
warp	[wɔ:p]	v. 翘曲

Phrases and Expressions

machine shop	车间
make use of	利用
abrasive cloth	砂带，（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.

然而利用颜色判断不是十分精确。甚至熟练的热处理工人籍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 has 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.

它能消除淬火工件的脆性。这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，刃部伸到这块赤热的金属之外。

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 finish (表面光洁度).

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℃ 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, and the word 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 FORMING AND MACHINING

The initial step in the manufacture of a product is, of course, to produce the required shape. There are two basic processes used for this purpose: forming and machining.

Forming, by far the more important shaping operation in terms of tonnage of ceramics, plastics, rubbers, and metals brought to final shape, includes all those methods that use a combination of force and tooling to change material into the shape required. In extrusion the press supplies the required force, the dies are the tooling. Again, a sand casting is produced by using the force of gravity to fill a sand mold with molten metal.

Forming operations may be done cold, as in the bending of sheet metal, or hot, as in forging or casting. Extrusion of metals may be done hot or cold. Thermo-plastics are hot-extruded.

The alternative to forming methods is machining. In machining, a sharpened tool of suitable shape removes material in the form of chips until the desired shape is produced. The use of computer and punched-tape control of machine tools makes it possible for the machining tool to follow any complex three-dimensional path.

Machining is suited to either brittle or ductile materials, preferably the former, but not to materials too hard or too soft. Soft materials deform under tool pressure with a consequent loss of cutting action. Hard materials destroy the tool point. Inasmuch as abrasive grinding, electric discharge machining, and electrochemical machining methods extend the range of possible hardness in both directions, it is slightly difficult to define what is too hard or too soft to machine. It depends on the machining method selected.

Machining is not an economical method of producing a shape, because good raw material is converted into scrap chips. As the quality and cost of materials increase in the future and more basic knowledge about the forming methods is developed, perhaps machining methods may decline in importance. Machining has the further limitation that it is slow. Only so many cubic inches of volume can be shaped per unit time by the machining tool. Shapes that can be produced in seconds by forming methods may require minutes to produce by machining.

However, machining can be done to standards of accuracy that are currently impossible to meet in forming methods. Few forgings can be produced to final dimensions, and they must be given a machining operation to obtain the exact dimensions required. Accuracy of 0. 001 in. is possible in machining with cutter bits on metal stock. Greater accuracy is possible by grinding methods, some of which are capable of accuracy approaching a millionth of an inch.

Best surface finish is provided by machining methods, especially by grinding. Sand castings, for example, have a rough surface usually containing some sand. Such a surface must be removed in a final machining or grinding operation.