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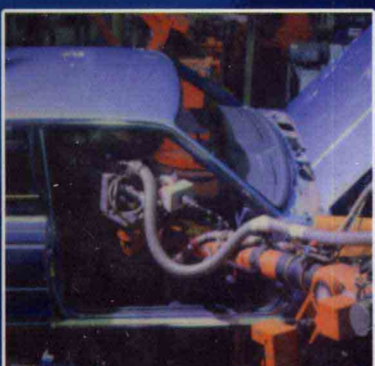
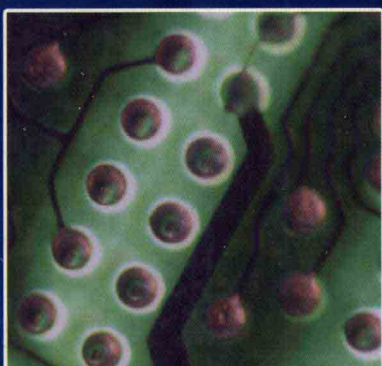
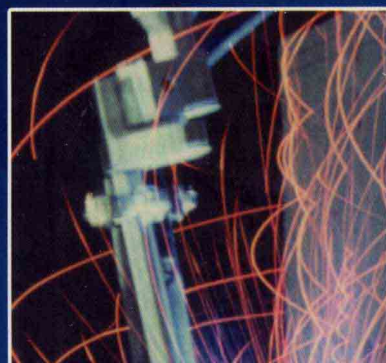
制造工程与技术(机加工)学习辅导

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机械工业出版社
CHINA MACHINE PRESS

制造工程与技术（机加工）（英文版）及学习辅导

下　册

制造工程与技术（机加工）学习辅导

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机　械　工　业　出　版　社

机械工业出版社的影印教材《Manufacturing Engineering and Technology — Machining Process》取自原版英文教材《Manufacturing Engineering and Technology》(PRENTICE HALL 2001，第4版，ISBN 0－201－36131－0)中的部分篇章，内容涵盖切削基础，刀具材料与切削液，回转体与非回转体加工，加工中心、机床结构及机加工经济性，磨削与光整加工，先进加工方法与纳米制造，制造工艺过程自动化，计算机集成制造系统和制造的竞争性。

《制造工程与技术（机加工）学习辅导》是为上述影印原版教材配套而编写的，内容包括影印教材各章节目录、INTRODUCTION、SUMMARY、TRENDS和KEY TERMS的对照中文翻译以及各章中疑难句子的中文翻译。本书可作为机械工程类的本、专科学生学习英文原版教材的辅导材料，也可随原版教材一起作为工程技术人员的参考资料及涉外企业员工的培训教材。

机械工业出版社（北京市百万庄大街22号 邮政编码100037）
责任编辑：高文龙　版式设计：霍永明　责任校对：全燕鸣
封面设计：鞠　杨　责任印制：施　红
三河市宏达印刷有限公司印刷·新华书店北京发行所发行
2004年3月第1版第1次印刷
787mm×1092mm 1/16 · 29.25印张 · 721千字
定价：41.00元（上、下册）

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前 言

按照教育部高校教材建设的发展规划，本科院校，尤其是重点院校，部分课程逐步采用外语教学和外文教材已是势在必行，许多学校正在计划让一部分基础课和主干专业课在这方面先行一步。考虑到外语教学对教师和学生都必须有一个循序渐进的过程，目前大多数院校的师资和生源尚达不到直接使用原版外文教材并同时用外语授课的水平，故编写和使用英汉双语教材，视教师和生源情况灵活采用双语授课不失为当前适应形势发展需要的好办法。

许多学校的机械学院（系）都已经按大专业招生，砍去原先的小专业和小专业课程。“材料成形基础”和“机械制造工程学”是按机械工程大学科专业招生后本科生的主干专业课程，所用的是为适应教学体系改革而编写的综合性教材。“材料成形基础”涵盖了原先铸造、压力加工、焊接三个专业的原理、工艺、设备等多门课程的主要内容，“机械制造工程学”由原先机械制造专业的“机械制造工艺学”、“金属切削原理”、“金属切削刀具”、“机床概论”、“夹具设计”、“机床设计”等6门课程整合而成。近年陆续有类似教材面世，但都是中文版。几年来这些讲义（书）已为历届学生所使用并收到了一定效果，但是随着形势的发展和改革的深入，也逐渐出现了一些亟待解决的问题：

1. 制造技术日新月异，特别是近年来，以计算机、信息技术为代表的高新技术的发展，使制造技术的内涵和外延发生了革命性的变化。作为培养高层次人才所用的大学教材理所当然地应该及时反映这些发展。但是现用讲义内容已显陈旧，即便是国内新出的同类教材，其取材也基本上还是来自旧教材，虽有点滴新技术介绍，也比国外教材慢了若干节拍。因此，该课程所用教材急需更新，而直接引进国外同类新教材是解决此问题的好途径。

2. 对于现在要拓宽学生适应面，培养复合型人才的教学计划安排而言，授课学时不够安排是各校都头痛的问题。各校近年虽然都在强调外语教学的重要性，除公共外语以外，都还开设专业外语课程，但苦于课时不够安排，专业外语课时只好被一再压缩。实际上学生学习专业外语的时间太少，以致于毕业找工作时常因此抱憾。而机械类大专业学生的专业外语教材主要内容正是“材料成形基础”和“机械制造工程学”所涵盖的范围。如果这两门课程使用外语或双语教学，完全可以将其与专业外语课程合并，这样既利于课时安排，又提高了学生的专业外语水平。

原版英文教材《Manufacturing Engineering and Technology》（Copyright 2001，1148pp，ISBN 0-201-36131-0，Serope Kalpakjian，Steven R. Schmid，The University Of Nitre Dame）是全球最大的教育出版集团 PRENTICE HALL 2001 年最新出版的第4版本科生教材，被许多国家著名院校广为采用，作为机械工程类本科生的教科书。该书共有40章，长达1148页，幅面为260×210mm，内容涵盖工程材料、机加工、热加工、特种加工、表面工程和先进制造技术。此原版教材引入中国尚属首次，机械工业出版社获得其影印版权。考虑到原书篇幅太长，而我国院校教学计划中尚难设置太长的课时来开设一门课程，并且我国学生也难以为一本书支付太高价格，经原作者和原出版社同意，现将其中铸造工艺与设备（第10~12章）、压力成形工艺与设备（第13~16章）、金属冶金及陶瓷、玻璃和超导体加工工艺（第17章）、塑料

与复合材料成形（第18章）、快速成形工艺（第19章）和连接工艺与设备（第27~30章）取出，合成《制造工程与技术（热加工）》影印出版；将其中金属去除工艺与机床（第20~25章）、先进加工方法和纳米制造（第26章）、制造工艺过程自动化（第38章）、计算机集成制造系统（第39章）和制造的竞争环境（第40章）取出，合成《制造工程与技术（机加工）》影印出版；另外配套编辑对应的学习辅导随同影印书出版发行。学习辅导的内容包括：对照翻译原版书各章的目录、简介（INTRODUCTION）、小结（SUMMARY）、发展趋势（TRENDS）和关键术语（KEY TERMS），另外摘取各章中的疑难句子作了注释。

《制造工程与技术（热加工）》、《制造工程与技术（机加工）》的主要应用对象是机械工程类的本、专科学生，各校可根据自身需要和实际课时灵活选用授课内容和双语形式。这两本书也可作为工程技术人员的参考书及涉外企业员工的培训教材。

随同这两本英文影印教材出版的两本学习辅导书由华南理工大学机械学院的教师编写，其中《制造工程与技术（热加工）学习辅导》的第一篇由全燕鸣编写，第二篇由袁宁和全燕鸣编写，第三篇由高岩编写；《制造工程与技术（机加工）学习辅导》第一篇的第20章由全燕鸣、刘旺玉编写，第21和25章由陈秉均编写，第22和24章由林颖编写，第23和26章由刘旺玉编写，第二篇由全燕鸣编写。两本学习辅导书均由全燕鸣主编。

采用外文原版教材进行双语教学是一种教学改革，为此编写学习辅导也是一种尝试。由于编者的水平和时间所限，书中难免有谬误之处，敬请读者批评指正。

编　者

2003年10月于广州

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Part IV Material-Removal Processes and Machines
第一篇（原版 Part IV） 金属去除工艺与机床

Chapter 20 Fundamentals of Cutting
第 20 章 切削基础

20.1 Introduction 简介
20.2 The Mechanics of Chip Formation 切屑形成机理
20.3 The Types of Chips Produced in Metal-Cutting 金属切屑的类型
20.4 The Mechanics of Oblique Cutting 斜刃切削机理
20.5 Cutting Forces and Power 切削力与功率
20.6 Temperature in Cutting 切削中的温度
20.7 Tool Life: Wear and Failure 刀具寿命：磨损与失效
20.8 Surface Finish and Integrity 表面粗糙度与完整性
20.9 Machinability 可机加工性

INTRODUCTION 简介

Cutting processes remove material from the surface of a workpiece by producing chips. And though these processes will be described in Chapters 22 and 23 in greater detail, some of the more common cutting processes are illustrated in Fig. 20.1.

切削加工通过产生切屑而从工件表面切除材料。这些加工方法将会在第 22 和 23 章中更详细地讲述。图 20.1 表示出了一些普通的切削方法。

In the turning operation (Fig. 20.1a) the workpiece is rotated and a cutting tool removes a layer of material as it moves to the left; 20.1b shows a cutting-off operation, where the cutting tool moves radially inward and separates the right piece from the bulk of the blank; 20.1c shows a slab-milling operation, in which a rotating cutting tool removes a layer of material from the surface of the workpiece; and 20.1d shows an end-milling operation, in which rotating cutter travels along a certain depth in the workpiece and produces a cavity.

在车削加工中（图 20.1a)，工件旋转而切削刀具在向左的移动行程中切除一层材料；图 20.1b 表示切断加工，刀具径向切入，将坯件右段切离；图 20.1c 表示平面铣削，旋转着的刀具从工件表面切除一层材料；图 20.1d 表示立铣加工，旋转着的铣刀在工件中沿一定深度移动而产生一空腔。

One of the most common processes is turning, illustrated in Fig. 20.2. The cutting tool is set at a certain depth of cut (measured in mm or in.) and travels to the left with a certain velocity as the workpiece rotates. The feed or feed rate is the distance the tool travel per unit revolution of the workpiece (mm/rev or in. /rev). As a result of this action, a chip is produced which moves up the face of the tool.

最普通的切削加工方法是车削，如图 20.2 所示。在工件旋转的同时，切削刀具被设定以一定切削深度（以 mm 或 in 计）、以一定速度向左移动。进给量或进给速率是指对应工件每转刀具移动的距离（mm/r 或 in/r)。这样运动的结果，就是产生切屑并沿前刀面向上移动。

In order to analyze this process in detail, a two-dimensional model of it is presented in Fig. 20.3. In his idealized model, a cutting tool moves to the left along the workpieces at a constant velocity, V, and depth of cut, t_0. A chip is produced ahead of the tool by the forming and shearing the material continuously along the shear plane.

为了详尽地分析这个加工过程，用到一个二维模型，如图 20.3 所示。在这个理想化的模型中，切削刀具以恒定速度 V 和切削深度 t_0 沿工件向左移动。通过连续地沿剪切面成形和剪切材料而在刀具前面产生切屑。

FIGURE 20.1 Examples of cutting processes.
图 20.1 切削加工的例子

FIGURE 20.2 Basic principle of the turning operation.
图 20.2 车削加工的基本原理

FIGURE 20.3 Schematic illustration of a two-dimensional cutting process, also called orthogonal cutting. Note that the tool shape and its angles, depth of cut, t_0, and the cutting speed, V, are all independent variables.

图 20.3 二维切削也称正交切削的示意图。注意刀具的形状和角度、切削深度 t_0、切削速度 V 都是独立变量。

TABLE 20.1 Factors Influencing Cutting Processes

Parameter	Influence and interrelationship
Cutting speed, depth of cut, feed, cutting fluids	Force, power, temperature rise, tool life, type of chip, surface finish.
Tool angles	As above; influence on chip flow direction; resistance to tool chipping.
Continuous chip	Good surface finish; steady cutting forces; undesirable in automated machinery.
Built-up edge chip	Poor surface finish; thin stable edge can protect tool surfaces.
Discontinuous chip	Desirable for ease of chip disposal; fluctuating cutting forces; can affect surface finish and cause vibration and chatter.
Temperature rise	Influences tool life, particularly crater wear, and dimensional accuracy.
Tool wear	Influences surface finish, dimensional accuracy, temperature rise, forces and power.
Machinability	Related to tool life, surface finish, forces and power.

表 20.1 影响切削加工的因素

参量	影响和相互关系
切削速度、切削深度、进给量、切削液	力、功率、温升、切屑类型、表面粗糙度
刀具角度	同上；影响切屑流动方向、刀具崩裂抗力
连续切屑	小的表面粗糙度；稳定的切削力；自动加工机床上不希望产生
积屑瘤切屑	大的表面粗糙度；细薄而稳定的积屑瘤能保护刀具表面
非连续切屑	有利于排屑；波动的切削力；会影响表面粗糙度，引起振动与颤振
温度升高	影响刀具寿命和尺寸精度，特别是造成月牙洼磨损
刀具磨损	影响表面粗糙度、尺寸精度、温升、力和功率
机加工性能	与刀具寿命、表面粗糙度、力和功率有关

In comparing Figs. 20.2 and 20.3, note that the feed in turning is now equivalent to t_0, and the depth of cut in turning is equivalent to the width of cut (dimension perpendicular to the page) in the idealized model. These relationships can be visualized by rotating Fig. 20.3 clockwise by 90°.

比较图 20.2 与图 20.3，注意到在车削中当前进给量等于 t_0，而切削深度等于理想化模型中的切削宽度（垂直于纸面）。把图 20.3 顺时针转 90°就可看清这些关系。

Table 20.1 outlines the factors that influence a cutting process. The major independent variables in the cutting process are as follows:

表 20.1 概略列出了影响切削加工的因素。切削加工中主要的独立变量如下：

- Tool material, coatings, and tool condition.
  刀具材料、涂层和刀具状态。
- Tool shape, surface finish, and sharpness.
  刀具形状、表面光洁程度和锐利程度。
- Workpiece material, condition, and temperature.
  工件材料、状态和温度。
- Cuuting parameters, such as sped, feed, and depth of cut.
  切削参数，如速度、进给量和切削深度。
- Cutting fluids.
  切削液。
- The characteristics of the machine tool, such as its stiffness and damping.
  机床特性，如刚性和阻尼。
- Workholding and fixturing.
  工件装夹条件。

Dependent variables—those that are influenced by changes in the independent variables—are the following:

非独立变量——那些因独立变量变化而受影响的变量，有：

- Type of chip produced.
  所产生的切屑类型。

- Force and energy dissipated in the cutting process.
  在切削加工中耗散的力和能量。
- Temperature rise in the workpiece, the chip, and the tool.
  工件、切屑和刀具的温升。
- Wear and failure of the tool.
  刀具的磨损与失效。
- Surface finish produced on the workpiece after machining.
  加工后工件的表面粗糙度。

When unacceptable conditions result from machining operations, the manufacturing engineer must ask questions to determine the cause of the problem.

当机加工引起不良状况，制造工程师必须提出问题，以确定问题的原因。

If, for example, the surface finish of the workpiece being cut is poor and unacceptable, which of the independent variables should be changed first? The angle of the tool? If so, should it be increased or decreased?

a. 例如，如果正在加工的工件表面粗糙度过大，哪么应该首先改变哪个独立变量呢？改变刀具角度？若是，应该加大还是减小它？

If the cutting tool wears and rapidly becomes dull, should the cutting speed, the depth of cut, or the tool material be changed?

b. 如果刀具磨损和迅速变钝，则应改变切削速度、切削深度还是刀具材料呢？

If the tool and the machine begin to vibrate, what should be done to eliminate or reduce vibrations?

c. 如果刀具和机床出现振动，则应该采取什么措施以消除或减轻振动？

This chapter describes the mechanics of chip formation; chip types; force and power requirements; temperature rise caused by the cutting action; tool life; surface finish; and machinability. With this knowledge, we can plan efficient and economical machining operations and can select the proper equipment and tooling.

本章讲述切屑形成机理、切屑类型、力和功率要求、切削作用引起的温升、刀具寿命表面粗糙度和切削加工性。有了这些知识，我们就能有效和经济地安排机加工和选择适当的设备及工装。

SUMMARY 小结

- Material-removal processes are often necessary in order to impart the desired dimensional accuracy, geometric features, and surface finish characteristics to components, particularly those with complex shapes that cannot be produced economically or with other shaping techniques. On the other hand, these processes generally take longer, waste some material in the form of chips, and may have adverse effects on surfaces produced.

  为了使零件达到所要求的尺寸精度、几何形状与表面粗糙度，尤其是对于那些具有复杂形状而不能采用其它工艺经济地成形的零件，采用材料切除法进行加工通常是必要的。另一方面，这类加工方法通常耗时长、浪费材料（产生切屑），并可能对已加工表面产生不利影响。

- Commonly observed chip types are continuous; built-up edge; discontinuous; and serrated. Important process variables in machining are tool shape and material; cutting conditions such as speed, feed, and depth of cut; use of cutting fluids; and the characteristics of the workpiece material and the machine tool. Parameters influenced by these variables are forces and power consumption; tool wear; surface finish and integrity; temperature; and dimensional accuracy of the workpiece.

通常观察到的切屑类型有连续切屑、积屑瘤、非连续切屑和锯齿状切屑。加工过程中重要的加工变量有刀具几何形状与材料、切削条件（如速度、进给量和切深)、切削液的使用情况以及工件材料和机床的特性。受上述变量影响的参数有切削力与功耗、刀具磨损、表面粗糙度与表面完好性、温度以及工件的尺寸精度。

- Temperature rise is an important consideration, since it can have adverse effects on tool life as well as on the dimensional accuracy and surface integrity of the machined part.

温升是一个需关注的重要现象，因为它对刀具寿命、被加工零件的尺寸精度和表面完整性可能有不利影响。

- Two major types of tool wear are flank wear and crater wear. Tool wear depends on workpiece and tool material characteristics; on cutting speed, feed, depth of cut, and cutting fluids; and on machine-tool characteristics.

刀具磨损的两种主要形式是后刀面磨损与月牙洼磨损。刀具磨损状况取决于工件与刀具材料特性、切削速度、进给量、切削深度，以及切削液和机床特性。

- Surface finish of machined components can adversely affect product integrity. Important variables are the geometry and condition of the cutting tool, the type of chip produced, and process variables.

已加工零件的表面粗糙度对产品的完好性可能有不利影响。重要的变量有刀具的几何形状和状态、切屑类型和工艺参数。

- Machinability is usually defined in terms of surface finish, tool life, force and power requirements, and chip control. Machinability of materials depends not only on their intrinsic properties and microstructure, but also on proper selection and control of process variables.

通常，零件的可机加工性能是根据以下因素来定义的：表面粗糙度、刀具寿命、切削力和功率需求以及切屑控制。材料的可机加工性能不仅取决于其内在特性和微观结构，而且也依赖于工艺参数的适当选择与控制。

TRENDS 发展趋势

- Studies of cutting processes are continuing, particularly for new metallic and nonmetallic materials (as well as engineered materials), to find better ways of machining.

对切削工艺方法的研究在继续进行，尤其是对于新的金属和非金属材料（以及工程材料)，要开发更好的加工方法。

- Because of their importance in computer-controlled manufacturing and in planning tool changes, reliable tool-life-testing techniques and accurate prediction of tool life continue to be investigated.

正在继续进行可靠的刀具寿命测试技术和刀具寿命的精确预报研究，因为这对于计算机控制制造以及在换刀安排方面有重要性。

- On-line tool-wear monitoring techniques and devices for computer-controlled machine tools are being developed and are currently in use.

数控加工机床的在线刀具磨损监控技术与装置正被开发并且目前已得到应用。

- Control of chip flow and disposal, particularly in high-production machining, is being investigated.

正在对切屑流动与处理的控制，尤其是对高生产率加工中切屑的流动与处理控制进行研究。

KEY TERMS 关键术语

Acoustic emission 声发射
Allowable wear land 许用磨损带宽度
Build-up edge 积屑瘤
Chip 切屑
Chip breaker 断屑器，断屑槽
Chip curl 卷屑
Chipping of tool 崩刀
Clearance angle 后角
Continuous chip 连续切屑
Crater wear 月牙洼磨损
Cutting force 切削力
Cutting ratio 切削比
Depth-of-cut line 切深边界
Diffusion 扩散
Discontinuous chip 非连续切屑
Feed marks 进给刀痕
Flank wear 后刀面磨损
Friction angle 摩擦角
Hot machining 热机加工
Inclination angle 倾角
Machinability 可加工性，机加工性
Machinability ratings 机加工率
Machine tool 机床
Machining 机加工，切削加工
Notch wear 边界磨损
Oblique cutting 斜刃切削，非正交切削
Orthogonal cutting 正交切削
Primary shear zone 第一剪切区
Rake angle 前角
Relief angle 后角
Rephosphorized steel 二次磷化钢
Resulfurized steel 二次硫化钢

Secondary shear zone　第二剪切区
Serrated chip　锯齿状切屑
Shaving　剃削，刮削
Shear angle　剪切角
Shear plane　剪切平面
Skiving　切片，刮，削
Specific energy　比能
Surface finish　表面光洁性，表面粗糙度
Surface integrity　表面完整性
Taytor equation　泰勒方程式
Thermally-assisted machining　热辅助加工，加热切削
Thrust force　轴向力
Tool-condition monitoring　刀具状态监控
Tool life　刀具寿命
Turning　车削
Wear land　磨损带

疑难句子注释

1. Note from Fig. 20.4a that the shearing process in chip formation is similar to the motion of cards in a deck sliding against each other. The dimension d in the figure is highly exaggerated to show the mechanism involved; in reality, this dimension is only on the order of 10^{-2} to 10^{-3} mm (10^{-3} to 10^{-4} in.).

（P537 第 5 段第 2 行）从图 20.4a 看出，在切屑形成中的剪切过程类似于在台面上相互滑动的卡片的运动。图中尺寸 d 是夸大了的，为的是便于说明其机理；实际上，该尺寸只不过在 10^{-2} ~ 10^{-3}mm（10^{-3} ~ 10^{-4}in）的数量级。

2. The reciprocal of r is known as the chip compression ratio and is a measure of how thick the chip has become compared to the depth of cut. Thus the chip compression ratio is always greater than unity.

（P537 正文倒数第 1 段第 2 行）r 的反商被称为切屑压缩比，被作为对比切削深度而言切屑有多厚的一种度量。因此，切屑压缩比总是大于整数 1。

3. A built-up edge (BUE), consisting of layers of material from the workpiece that are gradually deposited on the tool (hence the term built-up), may form at the tip of the tool during cutting (Fig. 20.5d).

（P540 正文倒数第 2 段第 1 行）积屑瘤（BUE）由一层层的工件材料构成，它们逐渐地沉积在刀具上（因此而得名），加工中可在刀尖部位形成（图 20.5d）。

4. Although BUE is generally undesirable, a thin, stable BUE is usually regarded as desirable because it reduces wear by protecting the rake face of the tool.

（P541 正文第 1 段第 2 行）虽然通常不希望出现积屑瘤，但是，细小而稳定的积屑瘤还是可以让其存在的，因为它保护前刀面而减少了刀具磨损。

5. In general, the higher the affinity (tendency to form a bond) of the tool and workpiece materials,

the greater the tendency for BUE formation. In addition, a cold-worked metal generally has less tendency to form BUE than one that has been annealed.

（P541 倒数第 4 段第 1 行）一般而言，刀具与工件材料的亲和性（形成粘结的倾向）越高，形成积屑瘤的倾向越大。此外，通常冷变形金属比退火金属形成积屑瘤的倾向更小。

6. Serrated chips (also called segmented or nonhomogeneous chips) are semicontinuous chips with zones of low and high shear strain (Fig. 20.5e). Metals with low thermal conductivity and strength that decreases sharply with temperature, such as titanium, exhibit this behavior. The chips have a sawtoothlike appearance.

（P541 倒数第 3 段第 5 行）锯齿状切屑（也叫节状或非均匀切屑）是半连续切屑，有低和高的剪切应变区（图 20.5e)。具有低热传导性和强度随温度而急剧降低的金属，例如钛，就表现出这种行为，其切屑有锯齿般的形貌。

7. Process variables, as well as material properties, also affect chip curl. Generally, the radius of curvature decreases-the chip becomes curlier-as depth of cut decreases; this increases the rake angle, and decreases friction at the tool-chip interface.

（P542 倒数第 5 段第 1 行）工艺变量以及材料特性也影响切屑卷曲。通常，随切削深度的减小，曲率半径减小，切屑更卷曲；这增大了前角，减小了刀—屑界面摩擦。

8. This situation is especially troublesome in high-speed automated machinery and in untended machining cells using computer numerically controlled machines (Chapter 24 and 39). If all the independent machining variables are under control, the usual procedure employed to avoid such a situation is to break the chip intermittently with a chip breaker.

（P542 倒数第 4 段第 3 行）在高速自动机床上和应用计算机数控机床的加工单元中（但加工单元一直未受到人们的重视，见第 24 和 39 章)，这种情形特别棘手。如果所有的独立加工变量是可控的，避免这种情形的常用方法是采用断屑器来间歇地打断切屑。

9. In oblique cutting, the cutting edge is at an angle i, called the inclination angle (Fig. 20.9b). Note the lateral direction of chip movement in oblique cutting. This situation is similar to an angled snow-plow blade, which throws the snow sideways.

（P544 正文第 2 段第 1 行）在斜切削中，切削刃呈一个角度 i（被称为斜角，图 20.9b）。注意斜切削中侧向上的切屑运动。这种情形类似于一把有角度的刨雪刀片，将积雪向侧面抛投。

10. A typical single-point turning tool used on a lathe is shown in Fig. 20.10a. Note the various angles involved, each of which has to be properly selected for efficient cutting.

（P544 倒数第 3 段第 1 行）车床上使用的典型单尖车刀如图 20.10a 所示。注意有关的各种角度，为了有效地切削，每个角度都应适当选择。

11. Cutting tools are now widely available as inserts (Fig. 20.10b), which are mounted on tool holders with various angles.

（P544 倒数第 2 段第 1 行）目前切削刀具广泛使用镶嵌式结构（图 20.10b)，即刀片以各种角度安装在刀夹上面。

12. Thin layers of material can be removed from straight or curved surfaces by a process similar to the use of a plane to shave wood. Shaving is particularly useful in improving the surface finish and

dimensional accuracy of sheared parts and punched slugs (Fig. 16.9).

(P544 倒数第 1 段第 1 行) 通过一种类似于用刨刀刨木头的方法，可以从平直的表面或曲面上切除薄层材料。剃刮加工对于改善剪切件和冲压件 (图 16.9) 的表面粗糙度和尺寸精度特别有效。

13. The sharpness of the tool tip also influences forces and power. Because it rubs against the machined surface and makes the deformation zone ahead of the tool larger, duller tools require higher forces and power.

(P548 正文第 2 段第 1 行) 刀头的锐利性也影响力和功率。由于它与已加工表面摩擦并使得刀具前方的变形区增大，所以较钝的刀具需要更大的切削力和功率。

14. Taking $n = 0.15$, $x = 0.15$, and $y = 0.6$ as typical values encountered in practice, it can be seen that cutting speed, feed rate, and depth of cut are of decreasing importance.

(P552 正文第 4 段第 2 行) 从生产实际中常见的取值 $n = 0.15$、$x = 0.15$ 和 $y = 0.6$，可见切削速度、进给速率和切削深度对刀具寿命的影响程度依次减轻。

15. Tool-life curves are plots of experimental data obtained by performing cutting tests on various materials under different conditions and with varying process parameters, such as cutting speed, feed, depth of cut, tool material and geometry, and cutting fluids.

(P553 正文第 2 段第 1 行) 刀具寿命曲线是根据对各种材料在不同的条件下和采用不同的工艺参数，如切削速度、进给量、切削深度、刀具材料和几何形状以及切削液，进行切削实验而得到的数据绘出的曲线。

16. Tool-life curves, from which the exponent n can be determined (Fig. 20.17), are generally plotted on log-log paper. These curves are usually linear over a limited range of cutting speeds but are rarely so over a wide range.

(P553 正文倒数第 1 段第 1 行) 刀具寿命曲线通常采用双对数坐标绘制，从刀具寿命曲线可确定指数 n (图 20.17)。这些曲线在对应一个有限的切削速度范围内通常是线性的，但对应很宽的速度范围则很少是线性的。

17. Crater wear has been described in terms of a diffusion mechanism, that is, the movement of atoms across the tool-chip interface. Since diffusion rate increases with increasing temperature, crater wear increases as temperature increases.

(P556 正文第 2 段第 1 行) 月牙洼磨损已根据扩散机理讲述过，即原子穿越刀—屑界面。因为扩散速率随温度升高而加大，故月牙洼磨损也随温度升高而加大。

18. The wear groove or notch on cutting tools (Fig. 20.18) has been attributed to the fact that this region is the boundary where the chip is no longer in contact with the tool. This boundary, also known as the depth-of-cut (DOC) line, oscillates because of inherent variations in the cutting operation and accelerates the wear process.

(P557 正文第 6 段第 1 行) 切削刀具上产生磨损沟槽或凹口 (图 20.18) 是因为该区域是边界，过了此处切屑不再与刀具接触。该边界 (也被称为切深线) 由于切削加工中固有的变化而颤动，加速了磨损过程。

19. One important development is the acoustic emission (AE) technique, which utilizes a piezoelectric transducer attached to a tool holder. The transducer picks up acoustic emissions (typically

above 100 kHz) that result from the stress waves generated during cutting.

(P558 第 3 段第 2 行) 一个重要的发展是声发射 (AE) 技术，它利用了附装在刀夹上的压电传感器。传感器拾取切削中产生的应力波所引起的声发射 (一般高于 100kHz)。

20. Surface finish influences not only the dimensional accuracy of machined parts, but also their properties. Whereas surface finish describes the geometric features of surfaces (Chapter 31), surface integrity pertains to properties, such as fatigue life and corrosion resistance, which are influenced strongly by the type of surface produced.

(P558 倒数第 2 段第 1 行) 表面粗糙度不仅影响已加工零件的尺寸精度，还影响它们的特性。虽然表面粗糙度描述表面的几何特征 (第 31 章)，而表面完整性与性能有关，例如疲劳寿命和腐蚀抗力，这些性能强烈地受表面类型的影响。

21. Sulfur in steels forms manganese sulfide inclusions (second-phase particles), which act as stress raisers in the primary shear zone. As a result, the chips produced break up easily and are small; this improves machinability. The size, shape, distribution, and concentration of these inclusions significantly influence machinability. Elements such as tellurium and selenium, which are both chemically similar to sulfur, act as inclusion modifiers in resulfurized steels.

(P561 第 2 段第 1 行) 硫在钢中形成硫化锰夹杂物 (第二相粒子)，这些夹杂物在第一剪切区引起应力。其结果是使切屑容易断开而变小，从而改善了可加工性。这些夹杂物的大小、形状、分布和集中程度显著地影响可加工性。化学元素如碲和硒，其化学性质与硫类似，在二次硫化钢中起夹杂物改性作用。

22. A high percentage of leads in steels solidifies at the tip of manganese sulfide inclusions. In non-resulfurized grades of steel, lead takes the form of dispersed fine particles.

(P561 第 4 段第 1 行) 钢中高含量的铅在硫化锰夹杂物尖端析出。在非二次硫化钢中，铅呈细小而分散的颗粒。

23. Precipitation-hardening stainless steels are strong and abrasive, requiring hard and abrasion-resistant tool materials.

(P561 倒数第 1 段第 5 行) 经沉淀硬化的不锈钢强度高、磨蚀性强，因此要求刀具材料硬而耐磨。

24. In selecting various elements to improve machinability, we should consider the possible detrimental effects of these elements on the properties and strength of the machined part in service. At elevated temperatures, for example, lead causes embrittlement of steels (liquid-metal embrittlement, hot shortness; see Section 1.4.3), although at room temperature it has no effect on mechanical properties.

(P562 第 4 段第 1 行) 选择各种元素以改善可加工性时，我们应该考虑到这些元素对已加工零件在使用中的性能和强度的不利影响。例如，当温度升高时，铅会使钢变脆 (液体—金属脆化，热脆性，见 1.4.3 节)，尽管其在室温下对力学性能没有影响。

25. Fiber tearing, pulling and edge delamination are significant problems.

(P563 倒数第 4 段第 2 行) 纤维的撕裂、拉出和边界分层是非常严重的问题。