Unit 8

Section One: Reading Comprehension

Material-Removal Processes

Parts manufactured by casting, forming, and shaping processes, which were described in units 6 and 7, often require further operations before the product is ready for use. A brief review will show you that none of the processes described thus far can produce a part with such accuracy. Parts must also be produced economically. Thus critical choices have to be made about the extent of shaping and forming versus the extent of machining to be done on a workpiece to produce an acceptable part.

Although machining is the broad term used to describe removal of material from a workpiece, it covers several processes, which we usually divide into the following categories (Figure 8-1).

- Cutting generally involving single-point or multipoint cutting tools, each with a clearly defined geometry.
- Abrasive processes, such as grinding.

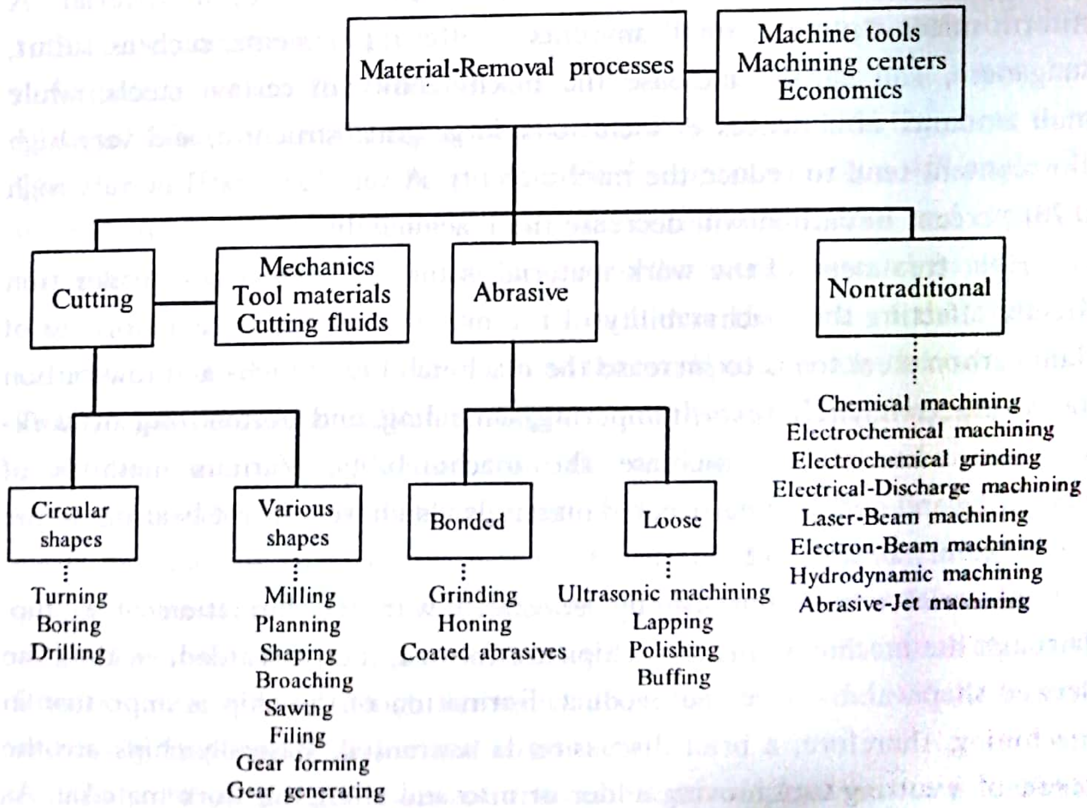

Figure 8-1. Material-Removal Processes and Machines.

• Nontraditional machining processes, utilizing electrical, chemical, thermal, and hydrodynamic methods.

The ease with which a material can be removed in planning, shaping, turning, drilling, sawing, boring, threading, broaching, and grinding is referred to as **machinability**. In addition to the ease of material removal, the quality of the resultant surface finish and life of the cutting tool are of prime importance in the concept of machinability. A number of factors influence the resultant surface finish, tool life, and ease of material removal.

Factors related to machinability can be classified by material considerations, tool design, tool type, and lubrication. Material considerations include the physical properties, internal structure, and heat treatment of the material.

Physical properties that affect machinability include hardness, tensile strength, and compressive strength. Soft materials may cause considerable drag on the tool, which causes heat generation, decreased tool life, and the potential for poor surface finish. As the material's hardness increases, the heat being produced is reduced, yielding an improved surface finish and increased tool life. However, when the material reaches a very high degree of hardness, the machinability decreases, due to abrasive wear on the tool.

Internal structure of the work material such as the grain structure, abrasive inclusions, and alloys affect the machinability of a material. A uniform micro-structure, small amounts of alloying elements, such as sulfur, manganese, and carbon increase the machinability of certain steels, while small amounts of abrasives or inclusions, large grain structure, and very high alloy content tend to reduce the machinability. A very low (0.03) or very high (0.70) percent of carbon will decrease the machinability.

Heat treatment of the work material is the final material consideration directly affecting the machinability of the material. Hot and cold working of plain carbon steel tends to increase the machinability of high- and low-carbon steels respectively. However, tempering, annealing, and normalizing of work-hardened material will increase the machinability. Various methods of quenching and cooling heat-treated materials also have a direct bearing on the machinability of the work.

Material removed is usually associated with the formation of a chip. Through the machining process, chips are formed, then discarded, yielding the desired shape and size of the product. Formation of the chip is important in machining; therefore, a brief discussion is warranted. Basically chips are the result of a cutting tool moving under or into and along the work material. As the tool moves through the work, material failure results producing a chip.

For ease in understanding the concept involved in material removal, an example using orthogonal cutting principles is used. Orthogonal cutting refers to two dimensional cutting where the tool is perpendicular to the work and direction of feed. The width of the tool is the same as the width of the material being machined.

Figure 8-2 illustrates the principle of orthogonal cutting. The tool moves at a velocity (VO) through the work material with the force of cutting action (FC) and the force of the feed (FF). As the tool moves into the work with a depth of cut (H), forces (FC) and (FF) cause the work material ahead of the

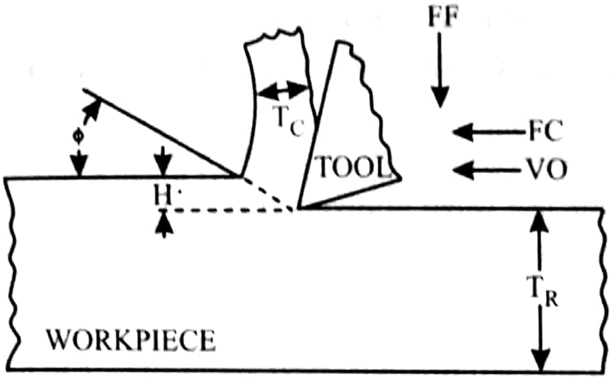

Figure 8-2. Principle of Orthogonal Cutting.

tool to be compressed. The area under compression is in a state of plastic deformation, which this area is a section referred to as the shear zone. Material failure within the shear zone occurs at a plane called the shear plane. The shear plane occurs at the shear angle ϕ, approximately a 45° angle. The work material moves up and over the face of the cutting tool and breaks off the parent material. Cutting action causes the work material in the shear plane to be compressed and move up and over the face of the tool. The deformation occurs in both the chip and the workpiece below the cutting tool. Deformation occurs at different stages in machining, depending on specific materials. Failure or separation from the workpiece occurs when a critical value is reached for any material. Cast iron, a brittle material, will fracture easily because the material's resistance to plastic deformation is high. Soft ductile materials have lower resistance to deformation and fracture. Materials with a low resistance to plastic deformation will form a continuous type chip. Brittle materials have a high resistance to deformation and will have small and easily fractured or segmented chips.

In spite of some limitations, material-removal processes and machines are indispensable to manufacturing technology. Ever since lathes were introduced in the 1700s, these processes have developed continuously. We now have available a variety of computer-controlled machines, as well as new techniques using electrical, chemical, thermal, and hydrodynamic energy sources. For technical and economic reasons, certain parts cannot be manufactured satisfactorily either by cutting or by abrasive processes. Since the 1940s, important developments have taken place in electrical, chemical, thermal, and hydrodynamic means of material removal. As a result, chemical, electrochemical, electro-discharge, laser beam, abrasive-jet, hydrodynamic, and electron-beam machining have become major manufacturing processes.

Part I. Comprehension Exercises

A. Put "T" for true and "F" for false statements. Justify your answers.

.... 1. Further operations are needed to be done before the product is ready for use when applying material-removal processes.

.... 2. The writer says that parts produced through material-removal processes are more accurate and economical than those produced through casting and forming processes.

.... 3. According to the writer, material-removal process is another name for machining process.

.... 4. The machinability can be decreased because of a very high degree of softness of the material.

.... 5. Very high alloy content can reduce the machinability while small amounts of alloying elements can increase the machinability.

.... 6. According to the text, the shear plane occurs at a plane called the shear zone.

.... 7. While machining, it is the chip and not the workpiece that will become deformed.

.... 8. Techniques such as electrical, chemical, thermal, and hydrodynamic energy sources can be classified as different types of machining.

B. Choose a, b, c, or d which best completes each item.

1. Machinability refers to removing the material by ....

a. planning, shaping, turning, and casting

b. drilling, sawing, boring, and molding

c. threading, broaching, grinding, and forging

d. sawing, planning, grinding, boring, etc.

2. Physical properties, internal structure, and heat treatment of the material are concerned with ....