1. Introduction of Machining Technology

The material removal processes are a family of shaping operations (Figure 1) in which excess material is removed from a starting workpiece so that what remains is the desired final geometry.

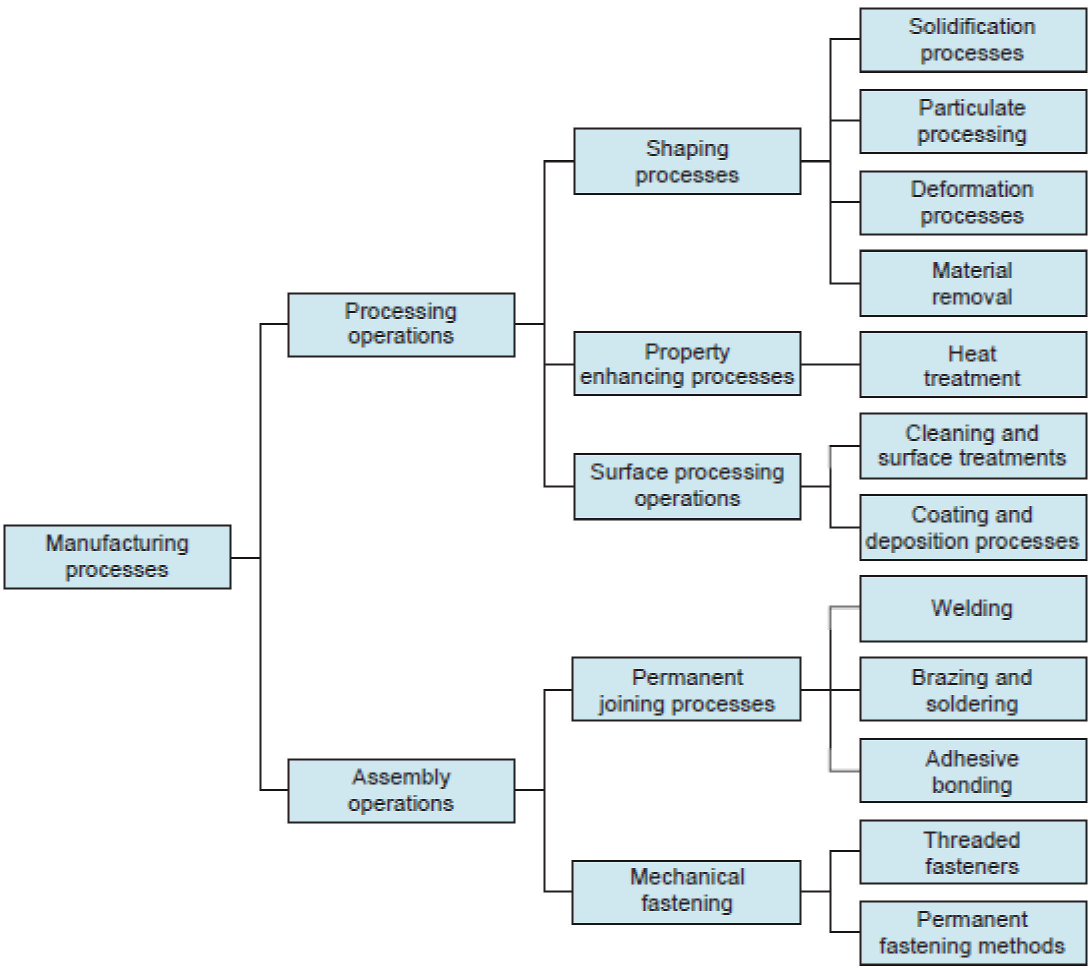

Figure 1: Classification of manufacturing processes.

The ‘‘family tree’’ is shown in Figure 2. The most important branch of the family is conventional machining, in which a sharp cutting tool is used to mechanically cut the material to achieve the desired geometry.

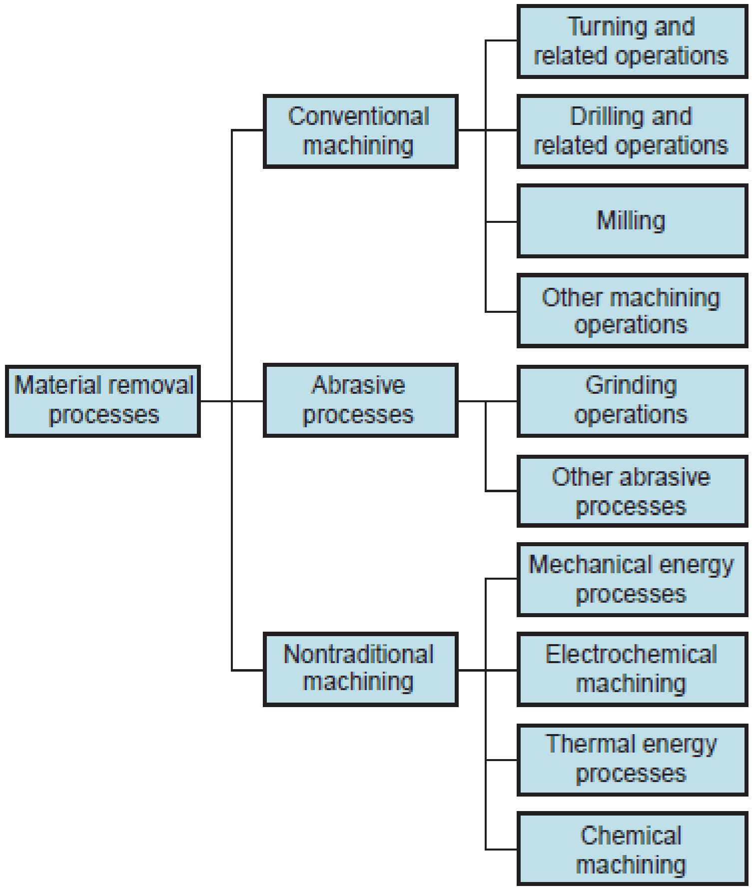

Figure 2: Classification of material removal processes.

Another group of material removal processes is the abrasive processes, which mechanically remove material by the action of hard, abrasive particles. This process group, which includes grinding. The ‘‘other abrasive processes’’ in Figure 2 include honing, lapping, and superfinishing. Finally, there are the nontraditional processes, which use various energy forms other than a sharp cutting tool or abrasive particles to remove material. The energy forms include mechanical, electrochemical, thermal, and chemical.

Machining is a manufacturing process in which a sharp cutting tool is used to cut away material to leave the desired part shape. The predominant cutting action in machining involves shear deformation of the work material to form a chip; as the chip is removed, a new surface is exposed. Machining is most frequently applied to shape metals. The process is illustrated in the diagram of Figure 3.

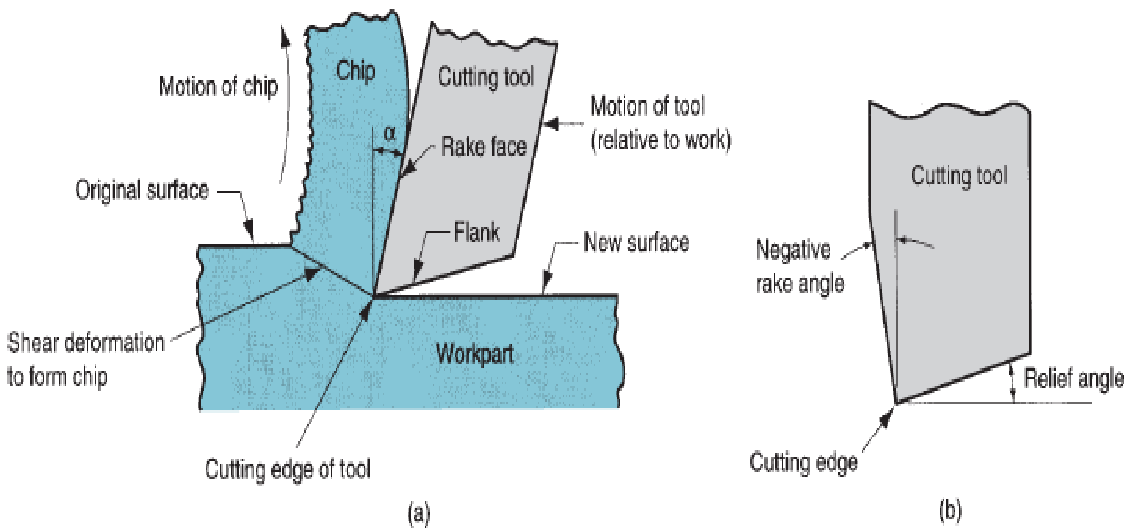

Figure 3: (a) A cross-sectional view of the machining process. (b) Tool with negative rake angle; compare with positive rake angle in (a).

Machining is important commercially and technologically for several reasons:

1. Machining can be applied to a wide variety of work materials.
2. Machining can be used to create any regular geometries, such as flat planes, round holes, and cylinders.
3. Machining can produce dimensions to very close tolerances.
4. Machining is capable of creating very smooth surface finishes. Roughness values less than 0.4 microns.

On the other hand, certain disadvantages are associated with machining and other material removal processes:

1. Machining is inherently wasteful of material.
2. Machining operation generally takes more time to shape a given part than alternative shaping processes such as casting or forging.

Note: Machining is generally performed after other manufacturing processes such as casting or forging, bar drawing.

2. Basic motions

To perform machining operations, relative motion is required between the tool and the workpiece. This relative motion is achieved in most machining operations and is a combined motion consisting of several elementary motions, such as the primary motion, called the cutting speed, and the secondary motion, called the cutting feed.

Turning is used for machining cylindrical surfaces. The basic motions of turning are shown in Figure 4. They are:

1. The primary motion is the rotary motion of the workpiece around the turning axis.
2. The secondary motion is the translational motion of the tool, known as the feed motion.

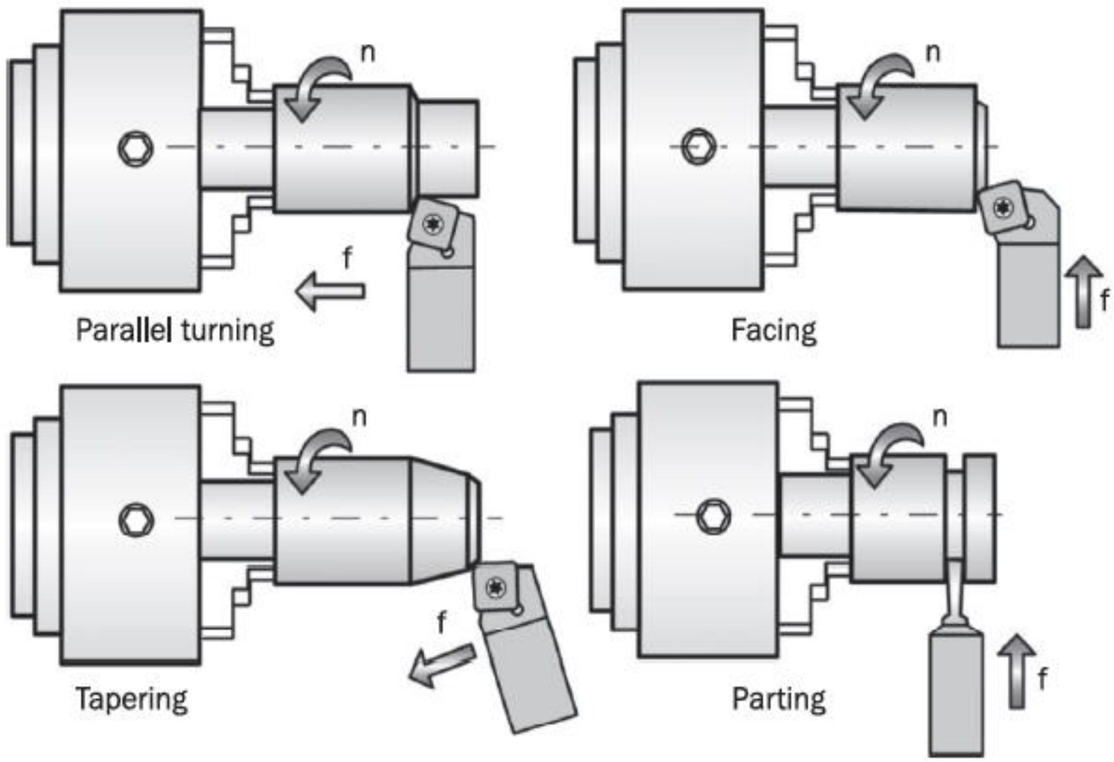

Figure 4: Basic motions in turning operations.

Most cutting tools in practice have more complex geometries than those in Figure 3. There are two basic types, examples of which are illustrated in Figure 5: (a) single-point tools and (b) multiple-cutting-edge tools.

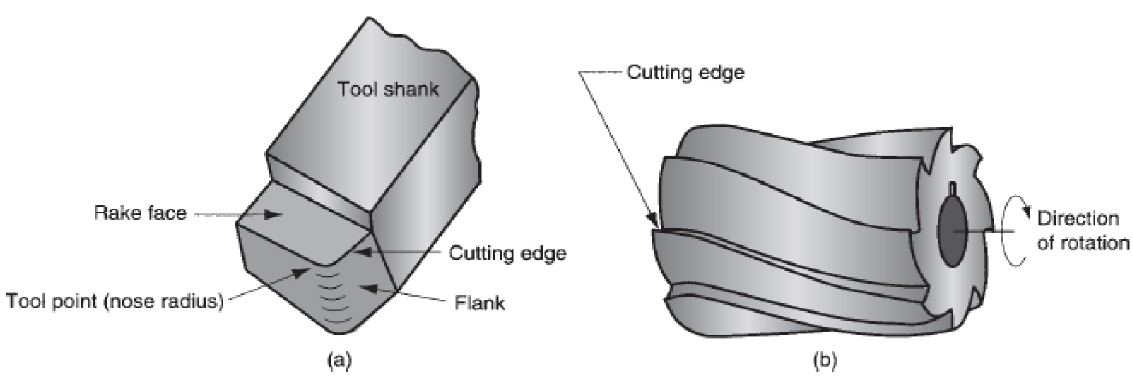

Figure 5: (a) A single-point tool showing rake face, flank, and tool point; and (b) a helical milling cutter, representative of tools with multiple cutting edges.

A *single-point tool* has one cutting edge and is used for operations such as turning. In addition to the tool features shown in Figure 3, there is one tool point from which the name of this cutting tool is derived. During machining, the point of the tool penetrates below the original work surface of the part. The point is usually rounded to a certain radius, called the nose radius. *Multiple-cutting-edge tools* have more than one cutting edge and usually achieve their motion relative to the workpart by rotating.

Drilling and milling use rotating multiple-cutting-edge tools. Figure 5(b) shows a helical milling cutter used in peripheral milling. Although the shape is quite different from a single point tool, many elements of tool geometry are similar. Single-point and multiple-cutting edge tools and the materials used in them are discussed in more detail in the next lecture.

3. Cutting Conditions

Relative motion is required between the tool and workpiece to perform a machining operation. The primary motion is accomplished at a certain ***cutting speed*** *(v)*. In addition, the tool must be moved laterally across the workpiece. This is a much slower motion, called the ***feed rate*** *(f)*. The remaining dimension of the cut is the penetration of the cutting tool below the original work surface, called the ***depth of cut*** *(d)*. Collectively, speed, feed, and depth of cut are called the ***cutting conditions***. They form the three dimensions of the machining process, and for certain operations (e.g., most single-point tool operations) they can be used to calculate the material removal rate for the process:

$MRR = v \times f \times d$ ……………………………………………….……………….. (1)

Where

MRR = material removal rate, mm^3/ min;

v = cutting speed, m/ min.,

f = feed rate, mm/rev.

d = depth of cut, mm.

The cutting conditions for a turning operation are depicted in Figure 6. Typical units used for cutting speed are (m/min). Feed in turning is expressed in (mm/rev), and depth of cut is expressed in (mm). In other machining operations, interpretations of the cutting conditions may differ. For example, in a drilling operation, depth is interpreted as the depth of the drilled hole.

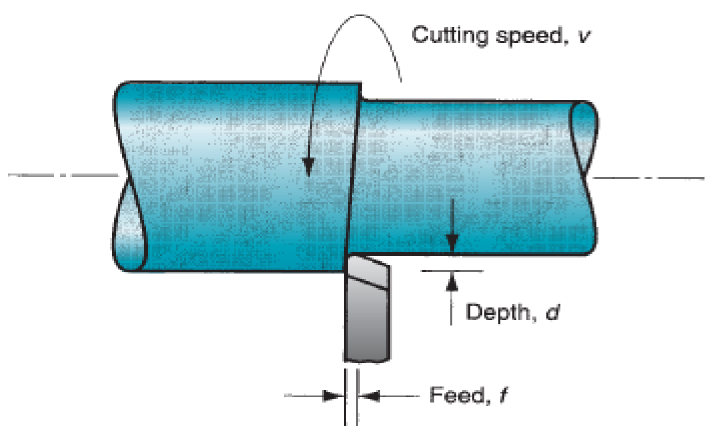

Figure 6: Cutting speed, feed, and depth of cut for a turning operation.