23.1 Introduction

This chapter describes machining processes with the capability of producing parts that basically are round in shape. Typical products made are as small as miniature screws for the hinges of eyeglass frames, and as large as turbine shafts for hydroelectric power plants and rolls for rolling mills.

One of the most basic machining processes is **turning**, meaning that the part is rotated while it is being machined. The starting material is generally a workpiece that has been made by other processes, such as casting, forging, extrusion, drawing, or powder metallurgy, as described in Parts II and III. Turning processes, which typically are carried out on a **lathe** or by similar *machine tools*, are outlined in Fig. 23.1 and Table 23.1. These machines are highly versatile and capable of performing several machining operations that produce a wide variety of shapes, such as:

- **Turning:** to produce straight, conical, curved, or grooved workpieces (Figs. 23.1a through d), such as shafts, spindles, and pins
- **Facing:** to produce a flat surface at the end of the part and perpendicular to its axis (Fig. 23.1e); parts that are assembled with other components; face grooving for such applications as O-ring seats (Fig. 23.1f)

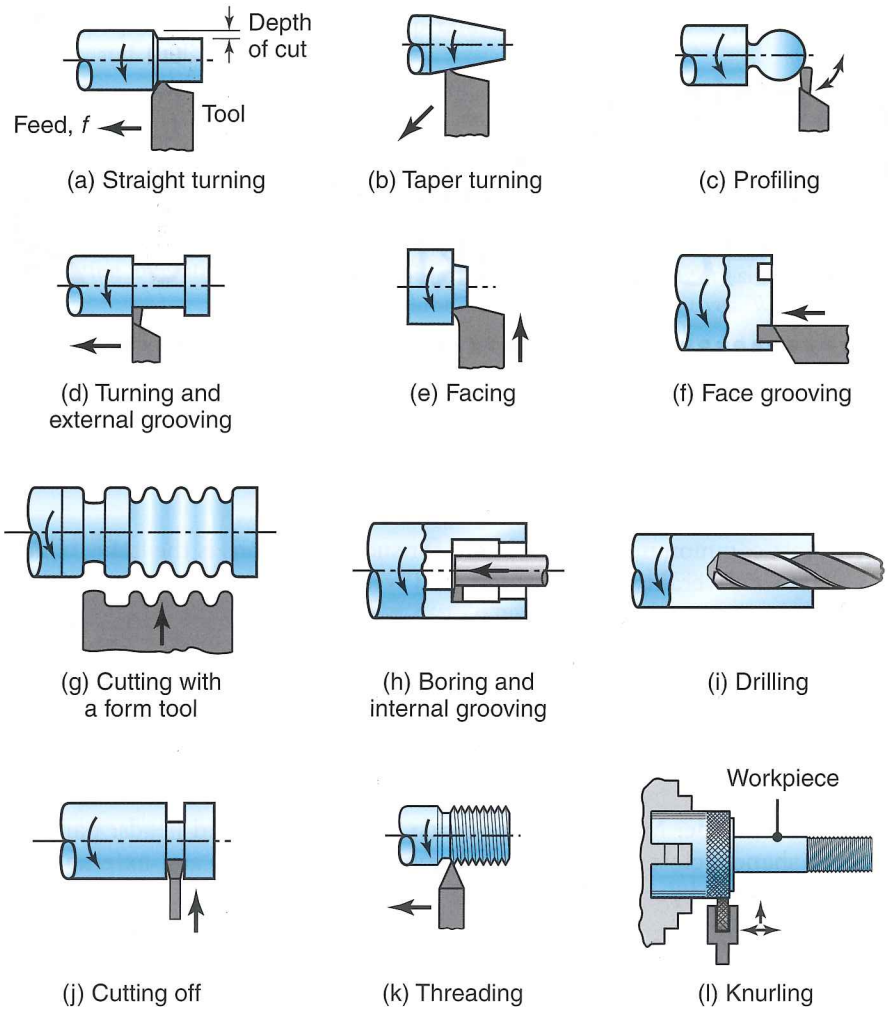


FIGURE 23.1 Miscellaneous operations that can be performed on a lathe; note that all parts are circular. The tools used, their shape, and the processing parameters are described throughout this chapter.

- **Cutting with form tools:** (Fig. 23.1g) to produce various axisymmetric shapes for functional or for aesthetic purposes
- **Boring:** to enlarge a hole or cylindrical cavity made by a previous process or to produce circular internal grooves (Fig. 23.1h)
- **Drilling:** to produce a hole (Fig. 23.1i), which then may be followed by boring it to improve its dimensional accuracy and surface finish
- **Parting:** also called **cutting off**, to remove a piece from the end of a part, as is done in the production of slugs or blanks for additional processing into discrete products (Fig. 23.1j)
- **Threading:** to produce external or internal threads (Fig. 23.1k)
- **Knurling:** to produce a regularly shaped roughness on cylindrical surfaces, as in making knobs and handles (Fig. 23.1l)

TABLE 23.1

General Characteristics of Machining Processes and Typical Dimensional Tolerances

Process	Characteristics	Typical dimensional tolerances, ±mm
Turning	Turning and facing operations on all types of materials, uses single-point or form tools; engine lathes require skilled labor; low production rate (but medium-to-high rate with turret lathes and automatic machines) requiring less-skilled labor	Fine: 0.025–0.13 Rough: 0.13
Boring	Internal surfaces or profiles with characteristics similar to turning; stiffness of boring bar important to avoid chatter	0.025
Drilling	Round holes of various sizes and depths; high production rate; labor skill required depends on hole location and accuracy specified; requires boring and reaming for improved accuracy	0.075
Milling	Wide variety of shapes involving contours, flat surfaces, and slots; versatile; low-to-medium production rate; requires skilled labor	0.13–0.25
Planing	Large flat surfaces and straight contour profiles on long workpieces, low-quantity production, labor skill required depends on part shape	0.08–0.13
Shaping	Flat surfaces and straight contour profiles on relatively small workpieces; low-quantity production; labor skill required depends on part shape	0.05–0.13
Broaching	External and internal surfaces, slots, and contours; good surface finish; costly tooling; high production rate; labor skill required depends on part shape	0.025–0.15
Sawing	Straight and contour cuts on flat or structural shapes; not suitable for hard materials unless saw has carbide teeth or is coated with diamond; low production rate; generally low labor skill	0.8

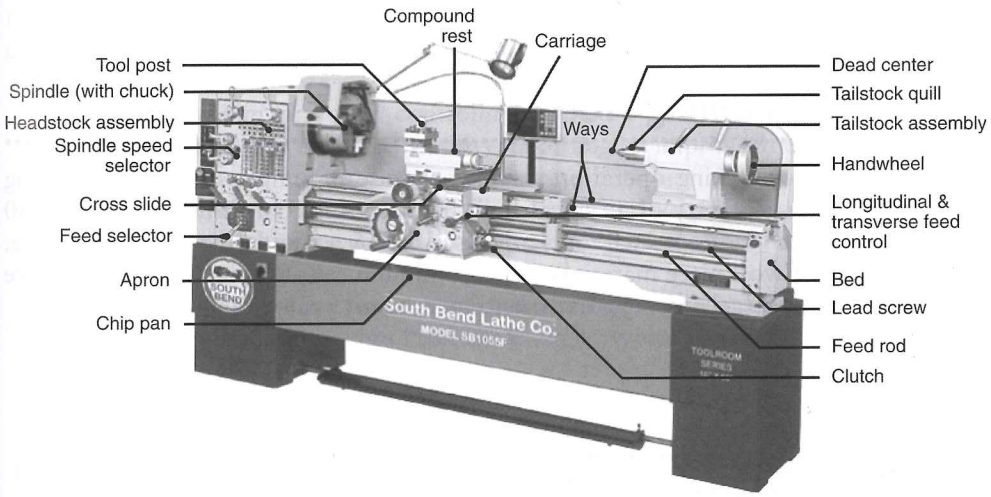
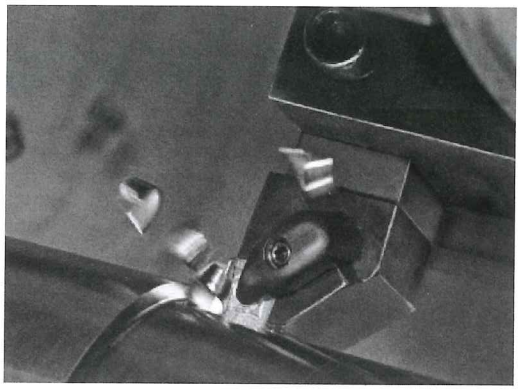
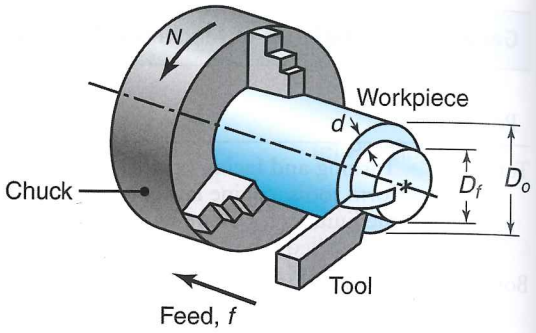


FIGURE 23.2 General view of a typical lathe, showing various components. *Source:* Courtesy of South Bend Lathe Co.

The cutting operations summarized above typically are performed on a *lathe* (Fig. 23.2), which is available in a wide variety of designs, sizes, capacities, and computer-controlled features, as described in Section 23.3 and Chapter 25. As shown in Figs. 21.2 and 23.3, turning is performed at various (a) rotational speeds, N, of the workpiece clamped in a spindle, (b) depths of cut, d, and (c) feeds, f, depending



(a)



(b)

FIGURE 23.3 (a) A turning operation, showing insert and chip removal; the machine tool is traveling from right to left in this photograph. (b) Schematic illustration of the basic turning operation, showing depth of cut, d; feed, f; and spindle rotational speed, N, in rev/min. The cutting speed is the surface speed of the workpiece at the tool tip. *Source:* (a) Courtesy of Kennametal Inc.

on the workpiece and cutting-tool materials, surface finish and dimensional accuracy required, and characteristics of the machine tool.

This chapter describes turning process parameters, cutting tools, process capabilities, and characteristics of the machine tools that are used to produce a variety of parts with round shapes. Design considerations to improve productivity for each group of processes also are outlined.