6. Features at an angle to the main machining direction should be avoided as they may require special attachments or tooling, Fig. 7.9.
7. Flat-bottom drilled holes should be avoided as they involve additional operations and the use of a bottoming tool.
8. To reduce the cost of machining, machined areas should be kept to a minimum. Two examples of methods of reducing the machined area are shown in Fig. 7.10.
9. Cutting tools often require run-out space as they cannot be retracted immediately. This is particularly important in the case of grinding where the edges of the grinding wheel wear out faster than the center. Figure 7.11 gives some examples to illustrate this point.
10. Thread-cutting tools normally have a chamfer on their leading edge. This chamfer means that the first two pitches do not cut a full thread. If an external diameter ends at a shoulder, the mating screwed part cannot reach the shoulder unless an undercut or a countersink are provided, as shown in Fig. 7.12. The length of the needed undercut or countersink is usually three pitches of the thread. Similar features are needed for internal screw threads, as shown in Fig. 7.13.

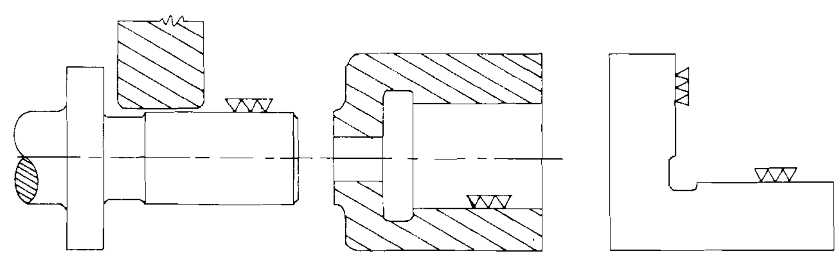


Figure 7.11 Some design details which can be introduced to give run-out space for grinding wheels.

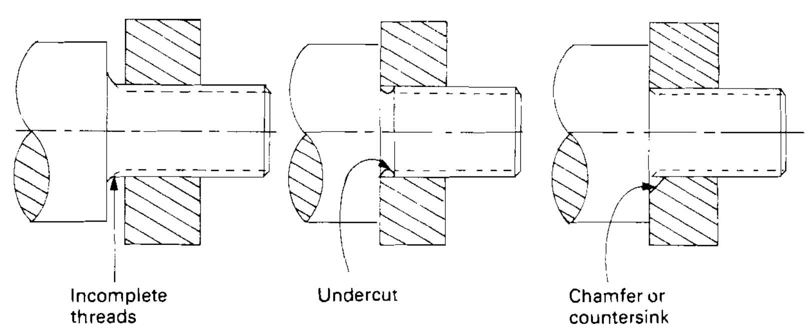
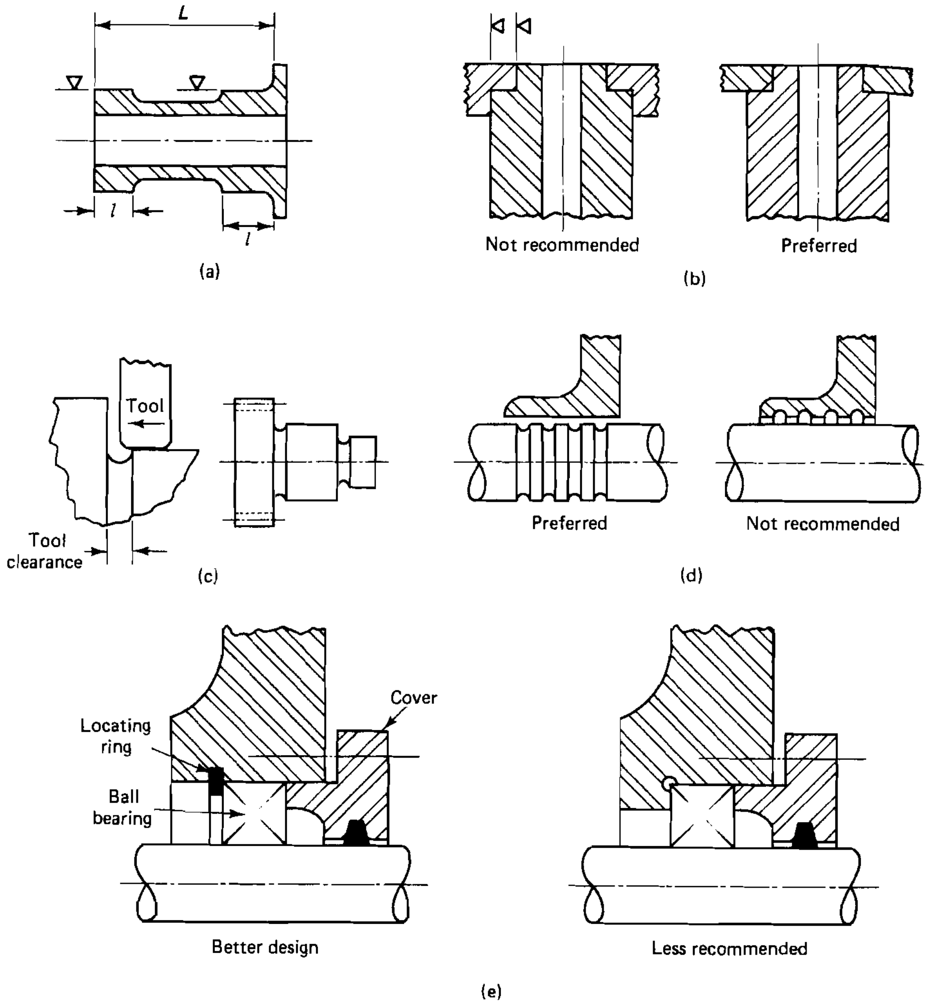


Figure 7.12 Some design details to account for the incomplete threads at the end of external screws.

FIGURE 10.25 Design considerations for turning: (a) reduce area of surface to be machined; (b) reduce number of operations required; (c) provide allowance for tool clearance; (d) opt for machining external over internal surfaces; (e) opt for through boring over alternatives



graphically depicts some design considerations for turning. Here are the guidelines to be followed:

1. Try to reduce the area of the surfaces to be machined, especially when a large number of parts is required or when the surfaces are to mate with other parts (see Figure 10.25a).
2. Try to reduce the number of operations required by appropriate changes in the design (see Figure 10.25b).
3. Provide an allowance for tool clearance between different sections of a product (see Figure 10.25c).
4. Always keep in mind that machining of exposed surfaces is easier and less expensive than machining of internal surfaces (see Figure 10.25d).

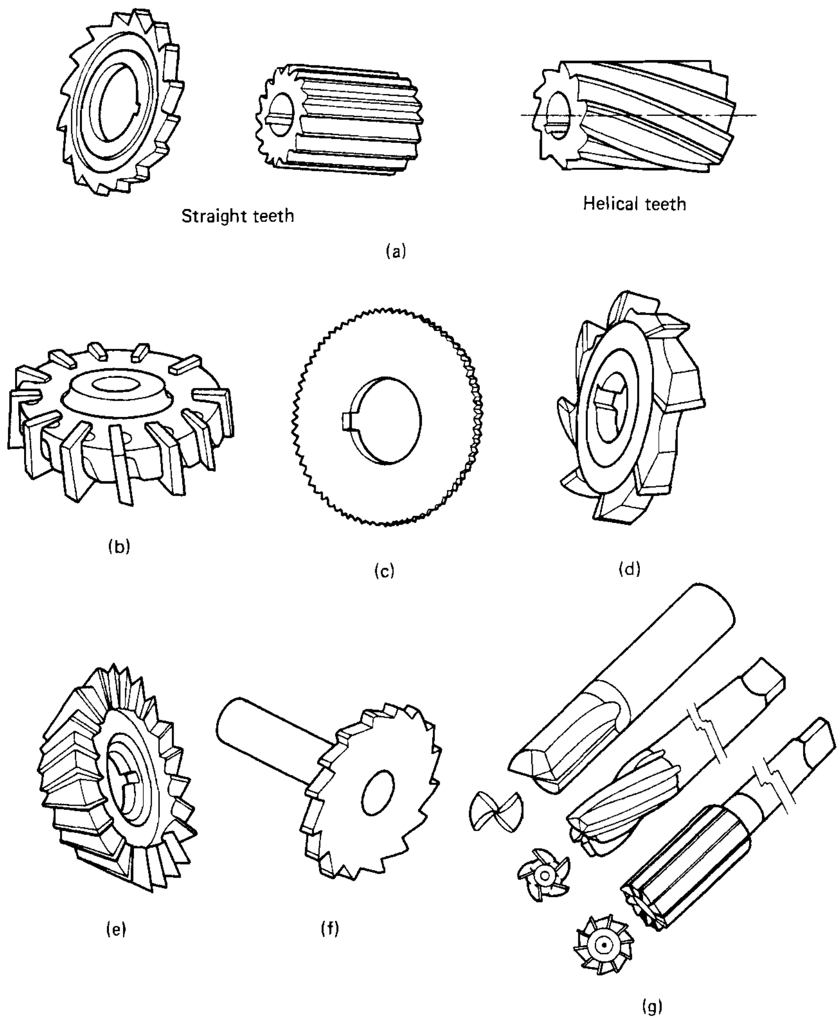


FIGURE 10.40
Types of milling cutters: (a) plain milling cutter; (b) face milling cutter with inserted teeth; (c) plain metal-slitting saw cutter; (d) side milling cutter; (e) angle milling cutter; (f) T-slot cutter; (g) end mill cutter

Plain metal-slitting saw. Figure 10.40c illustrates a plain *metal-slitting* saw cutter. Notice that it actually involves a very thin plain milling cutter.

Side milling cutter. A *side* milling cutter is used for cutting slots, grooves, and splines. As can be seen in Figure 10.40d, it is quite similar to the plain milling cutter, the difference being that this type has teeth on the sides. As is the case with the plain cutter, the cutting teeth can be straight or helical.

Angle milling cutter. An *angle* milling cutter is employed in cutting dovetail grooves, ratchet wheels, and the like. Figure 10.40e shows a milling cutter of this type.

T-slot cutter. As shown in Figure 10.40f, a *T-slot* cutter involves a plain milling cutter with an integral shaft normal to it. As the name suggests, this type of cutter is used for milling T-slots.

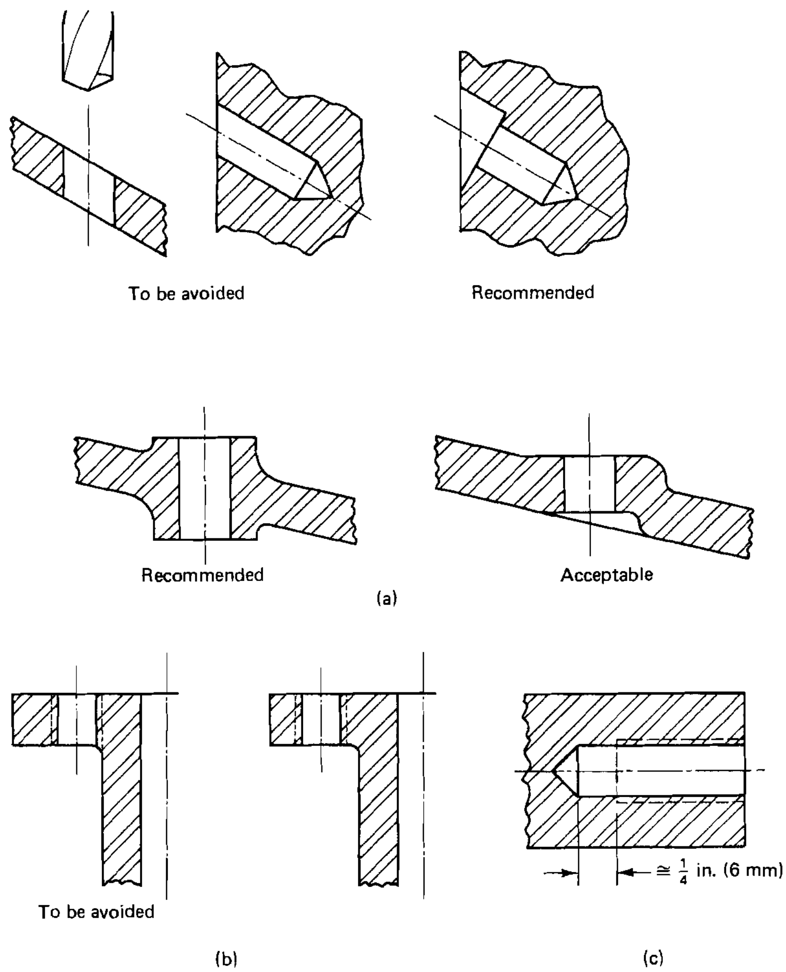


FIGURE 10.36 Design considerations for drilling: (a) set centerline of tool normal to surface to be drilled; (b) ensure tap is clear when it appears from other side; (c) provide allowance when tapping a blind hole

ering a lever handle that is designed to lower (or raise) the spindle. The spindle rotates freely inside a sleeve (which is actuated by the lever through a rack-and-pinion system) but does not rotate with the spindle.

The workpiece is mounted on the machine table, although a special vise is sometimes used to hold the workpiece. The maximum height of a workpiece to be machined is limited by the maximum gap between the spindle and the machine table.

Upright drilling machines. Depending upon the size, *upright* drilling machines can be used for light, medium, and even relatively heavy jobs. A light-duty upright drilling machine is shown in Figure 10.37. It is basically similar to a bench-type machine, the main difference being a longer cylindrical column fixed to the base. Along the column is an additional sliding table for fixing the workpiece that can be locked in position at any desired height. The power required for this type of machine is greater than that for a bench-type drilling machine as this type is employed in performing medium-duty jobs.

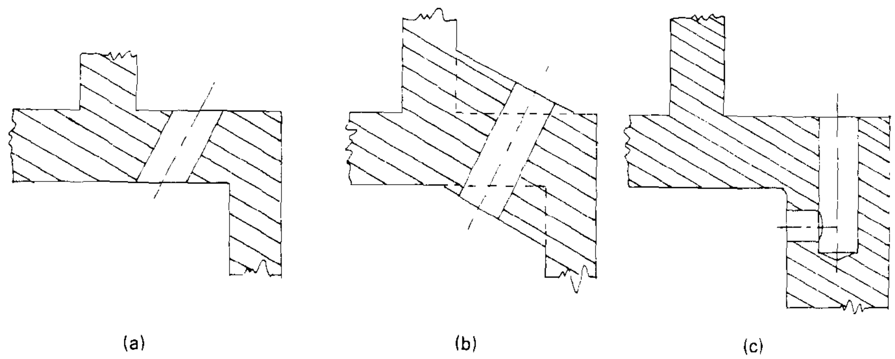


Figure 7.9 Design of drilled part. (a) Poor design as drill enters and exits at an angle to the surface. (b) Better design, but drilling the hole needs a special attachment. (c) Best design.

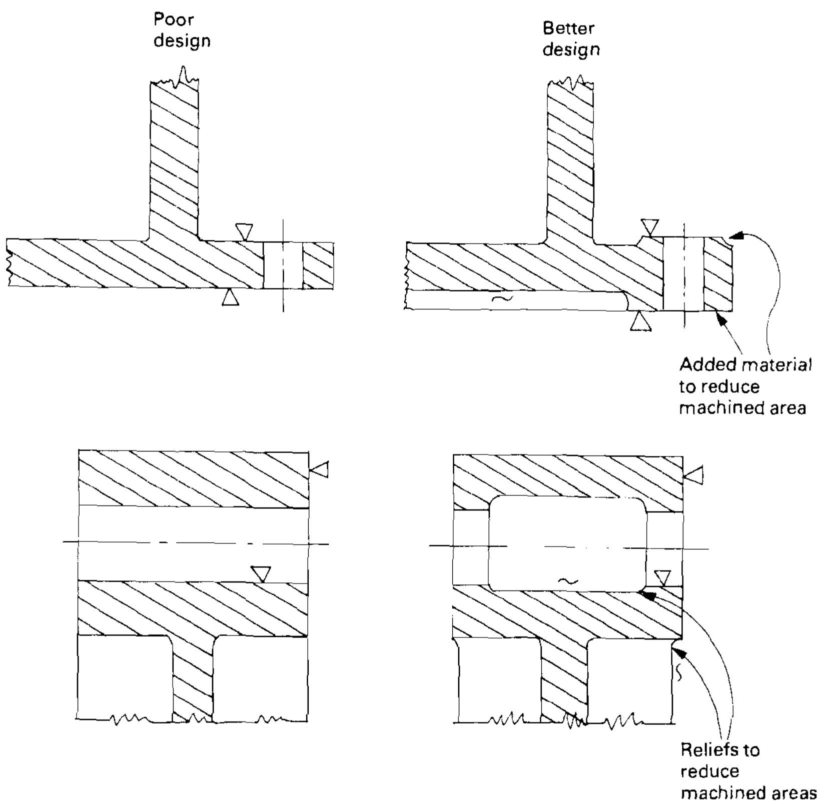


Figure 7.10 Some design details which can be introduced to reduce machining cost.