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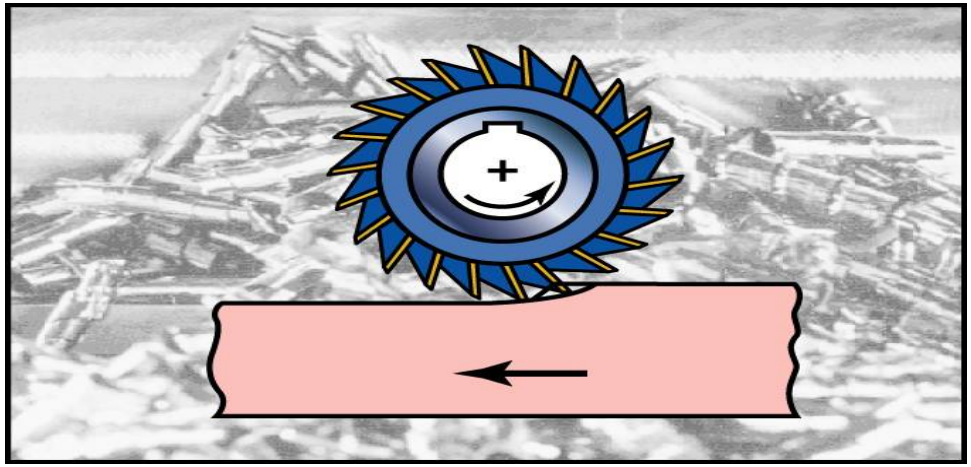
Ch-4
Milling Machine



Subject:- MP **Code:-3141908**	**Prepared by:** **Asst.Prof.Harin Prajapati** **(Mechanical Department,ACET)**	AMIRAJ COLLEGE OF ENGINEERING & TECHNOLOGY

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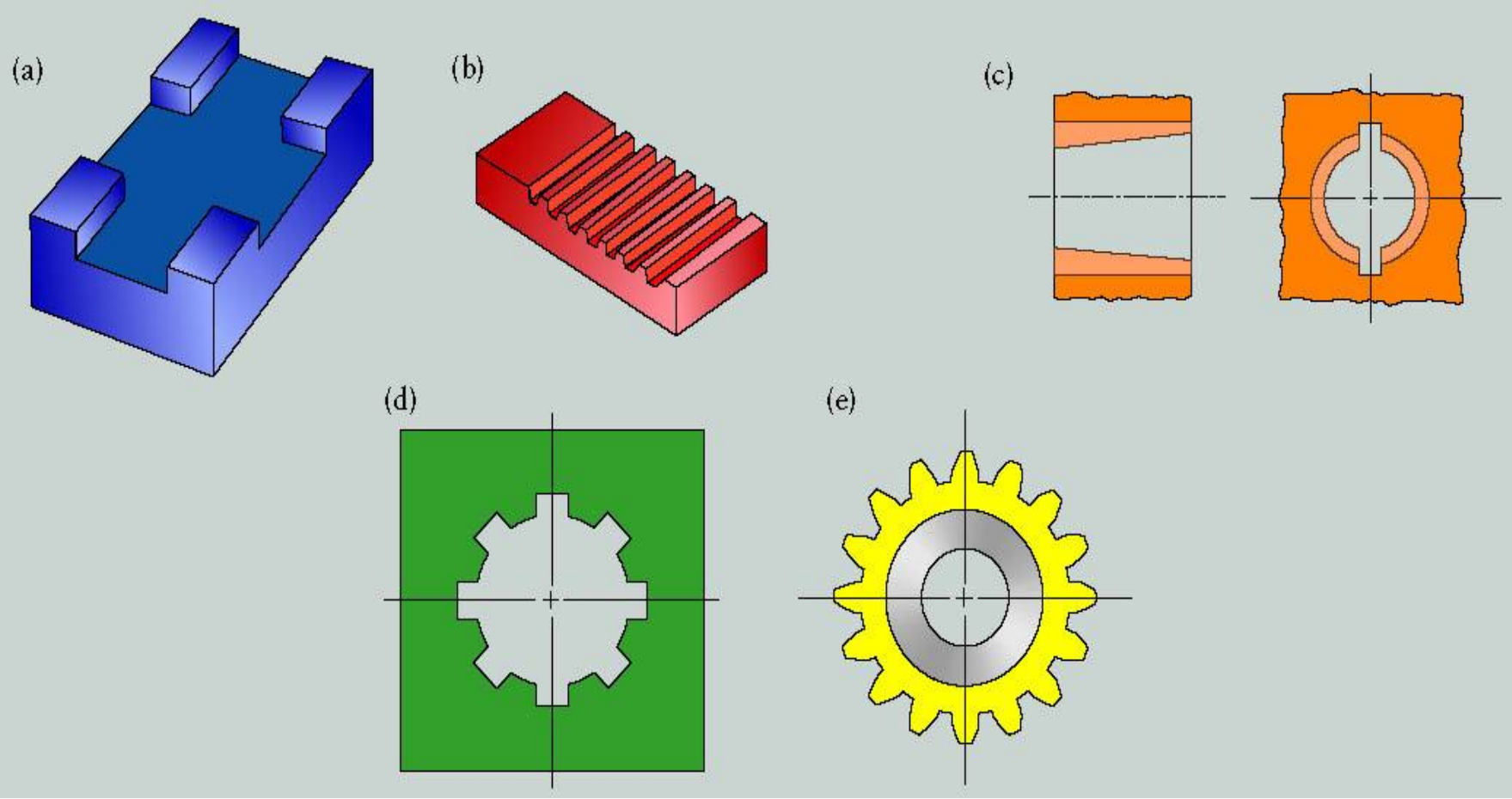
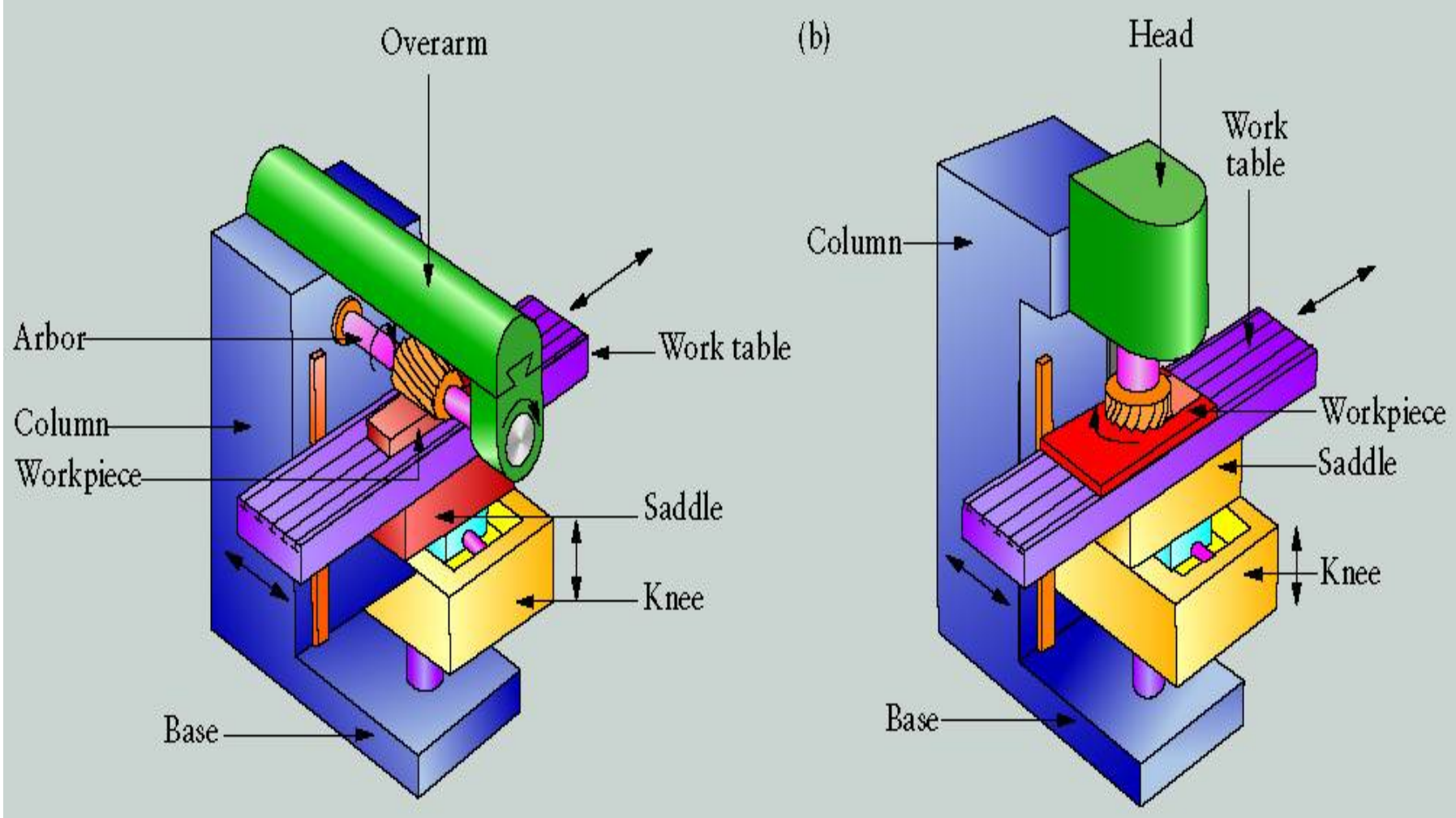
What is milling?

- Milling: a process in which a rotating multi-tooth cutter removes material while traveling along various axes with respect to the workpiece.
- Machining operation in which work is fed past a rotating tool with multiple cutting edges
  - Axis of tool rotation is perpendicular to feed direction
  - Usually creates a planar surface; other geometries possible either by cutter path or cutter shape
  - Other considerations and terms:
    - Milling is an *interrupted cutting* operation
    - Cutting tool called a *milling cutter,* cutting edges called "teeth"
    - Machine tool called a *milling machine*

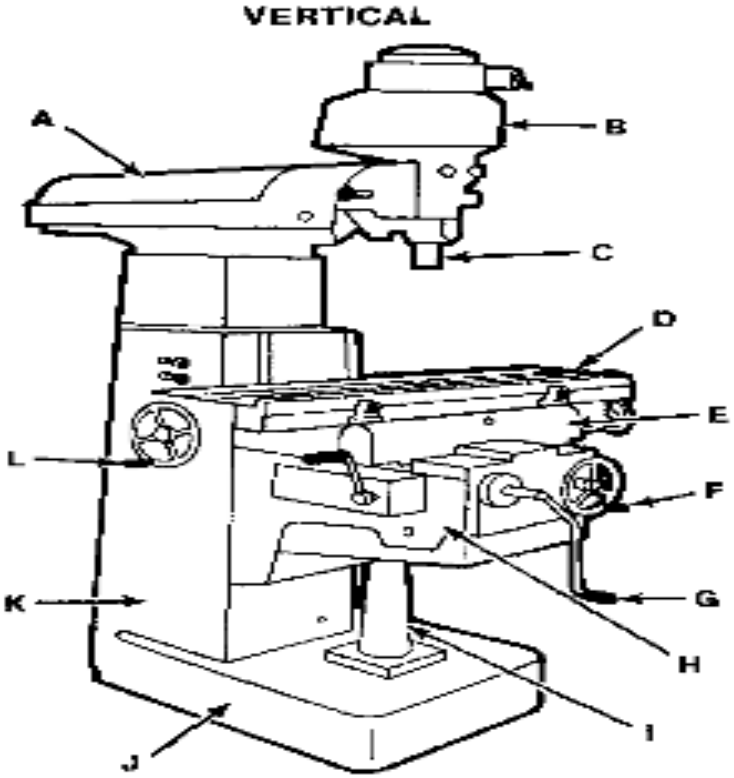
Parts and shape produce by milling

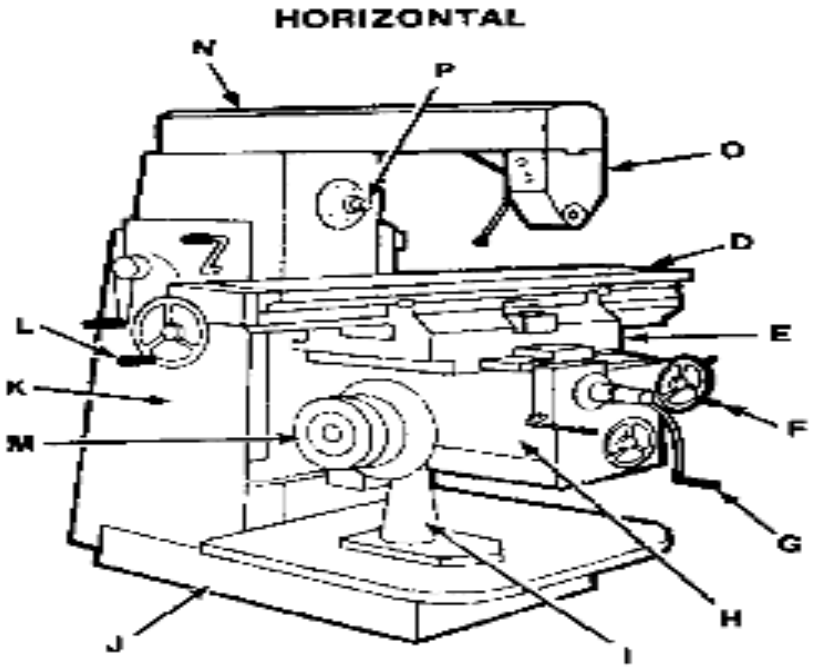


Schematic illustration of milling machines



Milling machines

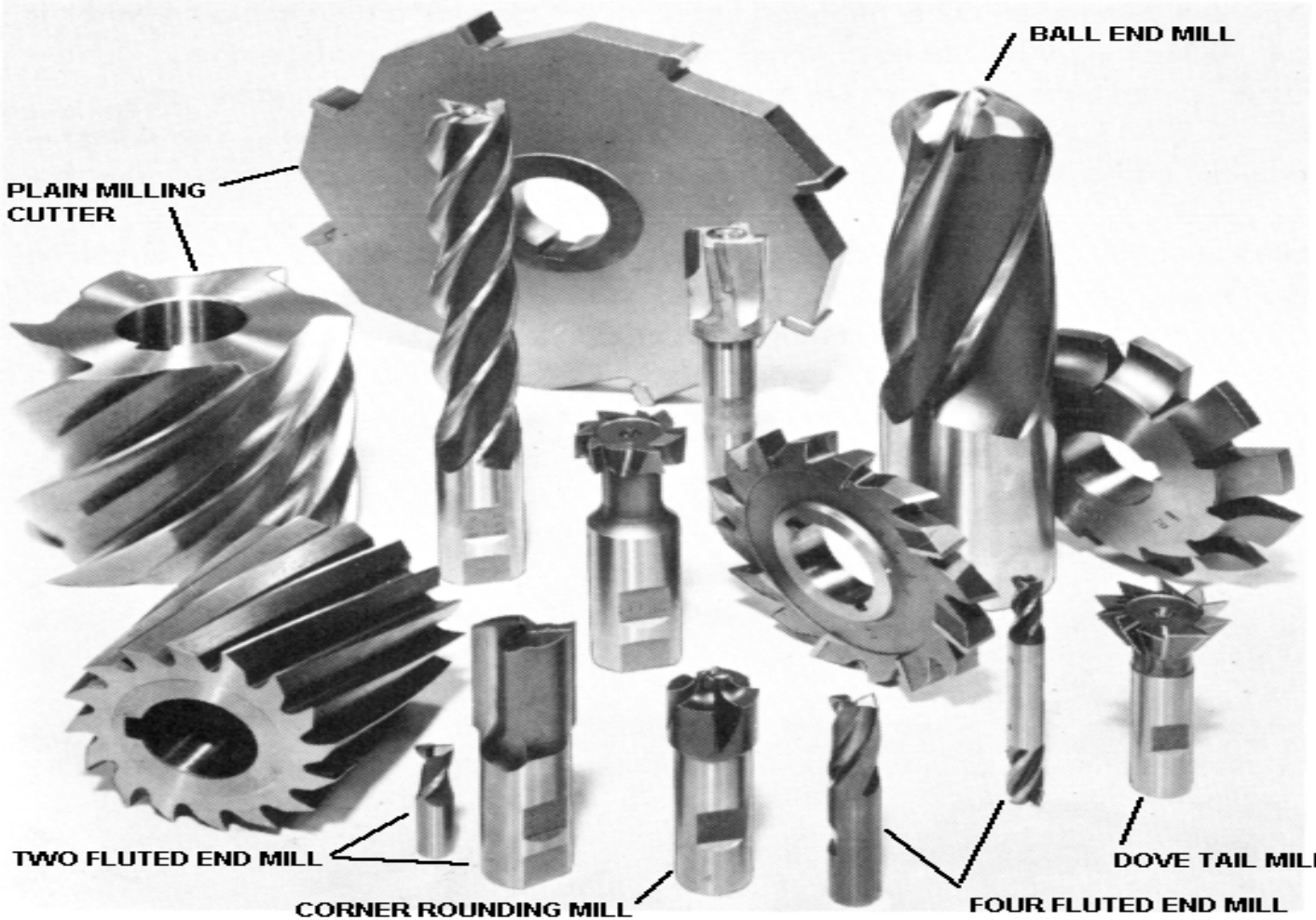




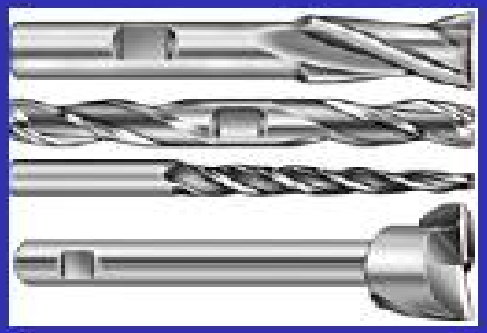
A RAM
B VERTICAL HEAD
C QUILL
D TABLE
E SADDLE
F CROSSFEED HANDLE
G VERTICAL FEED CRANK
K KNEE

I VERTICAL POSITIONING SCREW
J BASE
K COLUMN
L TABLE HANDWHEEL
M TABLE TRANSMISSION
N RAM TYPE OVERARM
O ARBOR SUPPORT
P SPINDLE

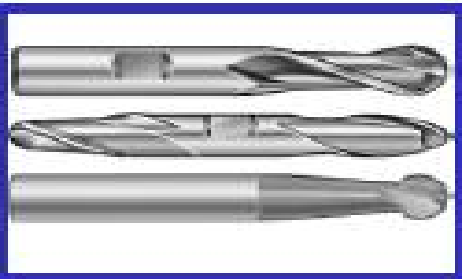
Milling Tool



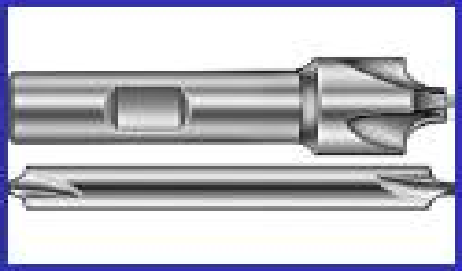
Milling Tool



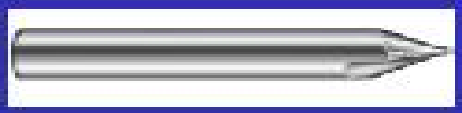
Flat end-mills for:
- pockets
- slots
- edge trim
- facing



Ball-end mills make rounded pockets or spherical pockets; also fillets



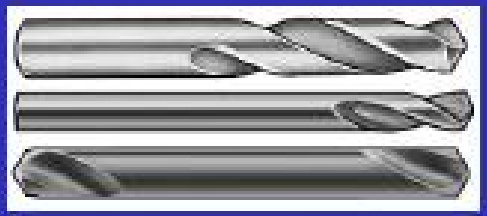
Corner-rounders form rounded comers!



Conical end-mill for chamfers

Milling Tool

standard **drill**: will flex/walk, follow pilot



stub drill for less walk/greater rigidity

center drill establishes hole position with no walk

reamers (straight or spiral)
finish off hole (last several thousandths)
precise hole diameter
for insertion of dowel pins, bearings, etc.
plunge while spinning, extract still

countersink: for screw heads & deburring hole

Milling Cutters and Milling Operations

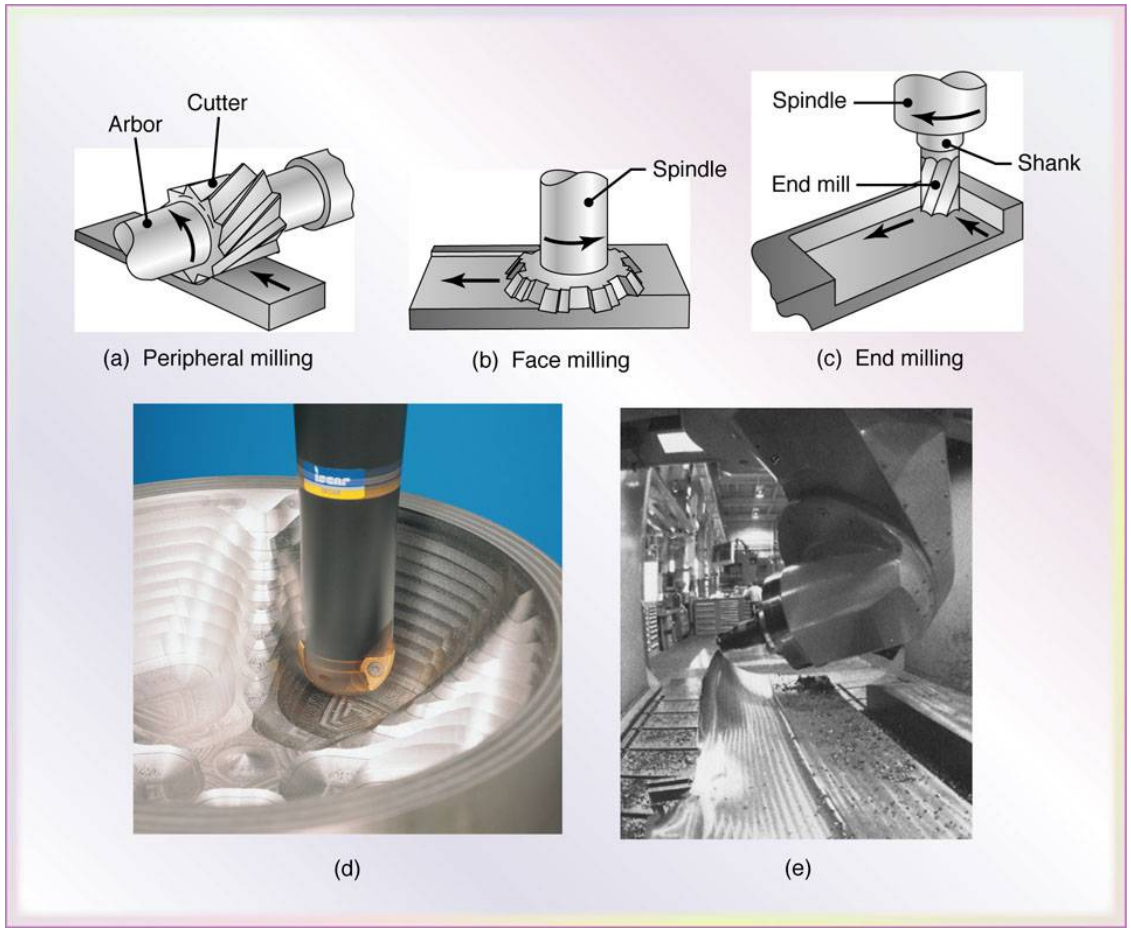


Figure :Some basic types of milling cutters and milling operations. (a) Peripheral milling. (b) Face milling. (c) End milling. (d) Ball-end mill with indexable coated-carbide inserts machining a cavity in a die block. (e) Milling a sculptured surface with an end mill, using a five-axis numerical control machine. *Source*: (d) Courtesy of Iscar. (e) Courtesy of The Ingersoll Milling Machine Co.

Milling Operations

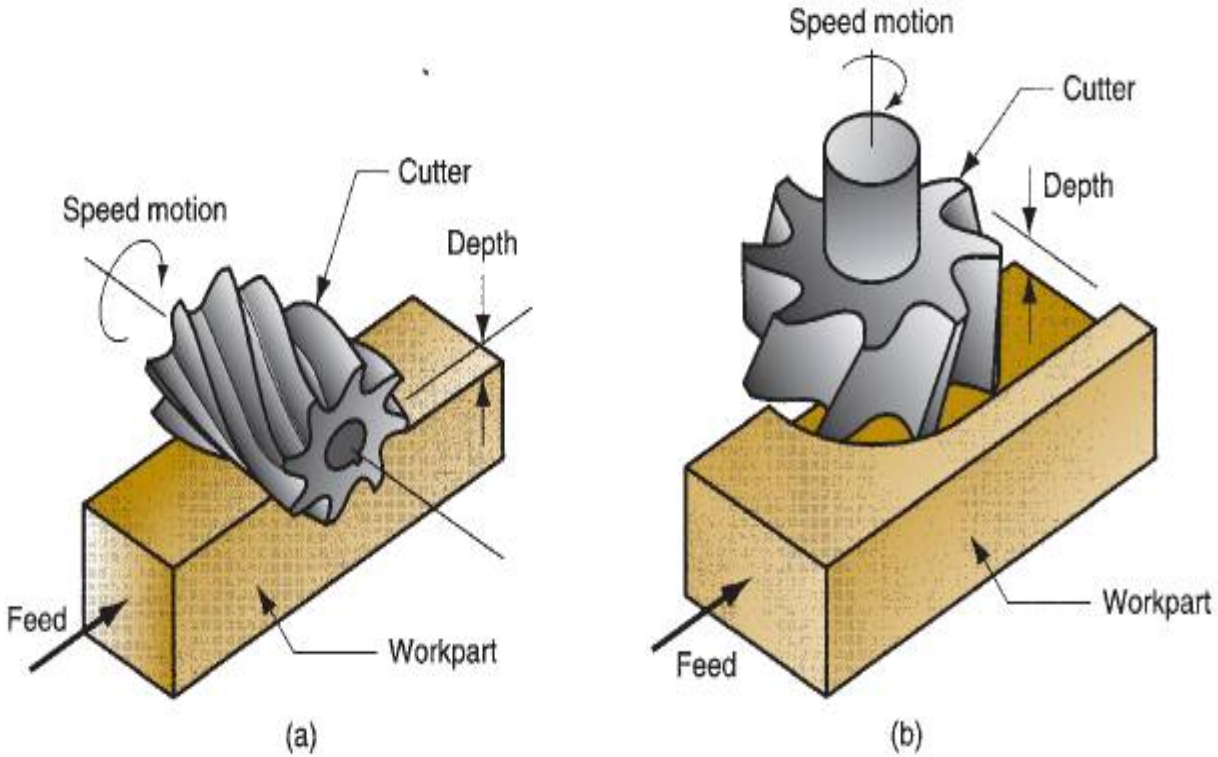


FIGURE 21.17
Two basic types of milling operations: (a) peripheral or plain milling and (b) face milling.

TYPES OF MILLING OPERATIONS

Peripheral Milling

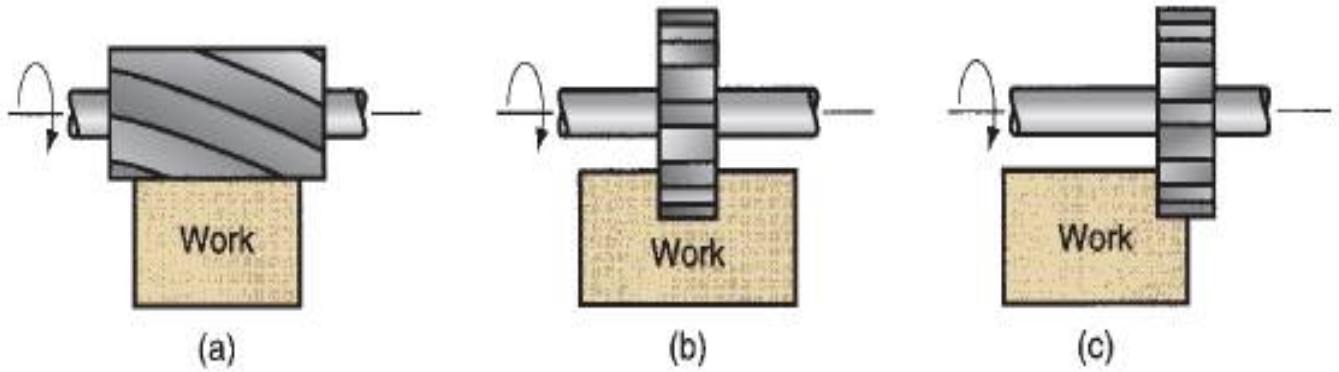


FIGURE 21.18
Peripheral milling:
(a) slab milling,
(b) slotting,
(c) side milling,
(d) straddle milling, and
(e) form milling.

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TYPES OF MILLING OPERATIONS

Peripheral Milling

- In peripheral milling, also called *plain milling*, *the axis of the tool* is parallel to the surface being machined, and the operation is performed by cutting edges on the outside periphery of the cutter. Several types of peripheral milling are
- shown in Figure (a) **slab milling,** the basic form of peripheral milling in whichthe cutter width extends beyond the workpiece on both sides; (b) **slotting**, also called slot milling, in which the width of the cutter is less than the workpiece width, creating a slot in the work—when the cutter is very thin, this operation can be used to mill narrow slots or cut a work part in two, called saw milling; (c) **side milling**, in which the cutter machines the side of the workpiece; (d**) straddle milling,** the same as side milling, only cutting takes place on both sides of the work; and (e) **form milling**, in which the milling teeth have a special profi le that determines the shape of the slot that is cut in the work.

TYPES OF MILLING OPERATIONS

Direction of Cutter Rotation

- In peripheral milling, the direction of cutter rotation distinguishes two forms of milling: up milling and down milling, illustrated in Figure 21.19. In **up milling, also** called **conventional milling, the direction of motion of the cutter teeth is opposite** the feed direction when the teeth cut into the work. It is milling "against the feed." In **down milling, also called climb milling, the direction of cutter motion is the same as** the feed direction when the teeth cut the work. It is milling "with the feed."

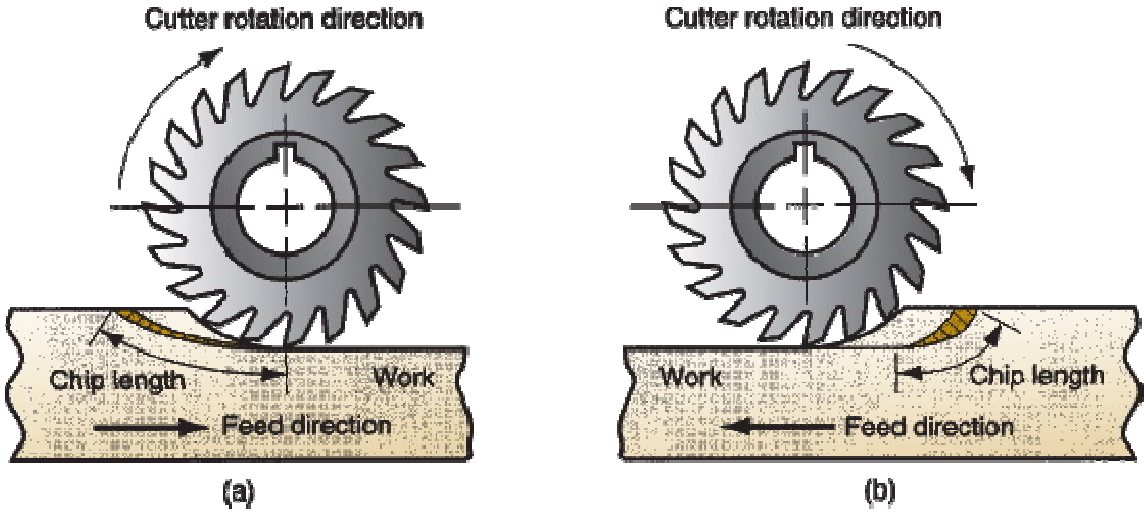


FIGURE 21.19 Two forms of peripheral milling operation with 20-tooth cutter: (a) up milling, and (b) down milling.

TYPES OF MILLING OPERATIONS

Direction of Cutter Rotation

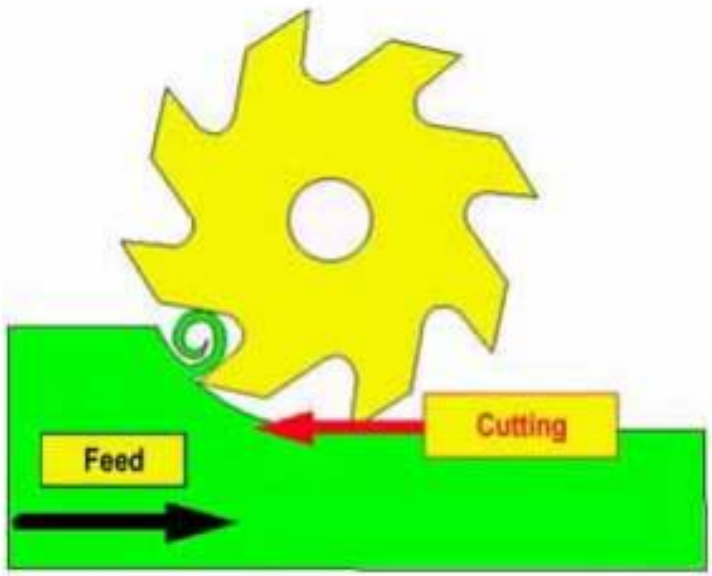


Figure 14. Up Cut Milling

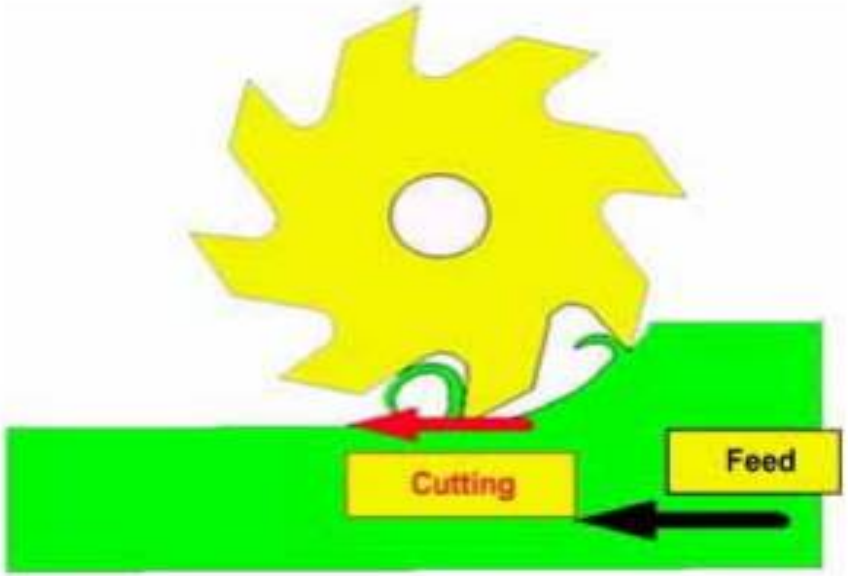


Figure 15. Down Cut Milling

TYPES OF MILLING OPERATIONS

Face Milling

- In face milling, the axis of the cutter is perpendicular to the surface being milled, and machining is performed by cutting edges on both the end and outside periphery of the cutter. As in peripheral milling, various forms of face milling exist, several of which are shown in Figure

(a) **conventional face milling,** in which the diameter of the cutter is greater than the work part width, so the cutter overhangs the work on both sides;

(b) **partial face milling,** where the cutter overhangs the work on only one side;

(c) **end milling,** in which the cutter diameter is less than the work width, so a slot is cut into the part;

(d) **profile milling,** a form of end milling in which the outside periphery of a fl at part is cut;

(e) **pocket milling,** another form of end milling used

TYPES OF MILLING OPERATIONS

Face Milling

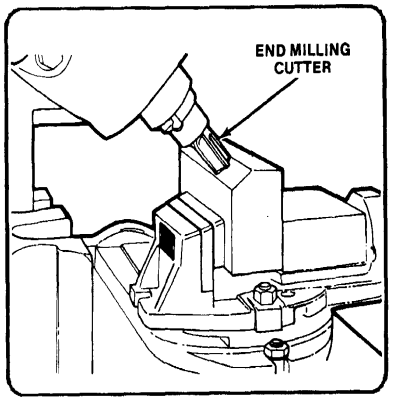


Figure 8-31. Angular face milling.

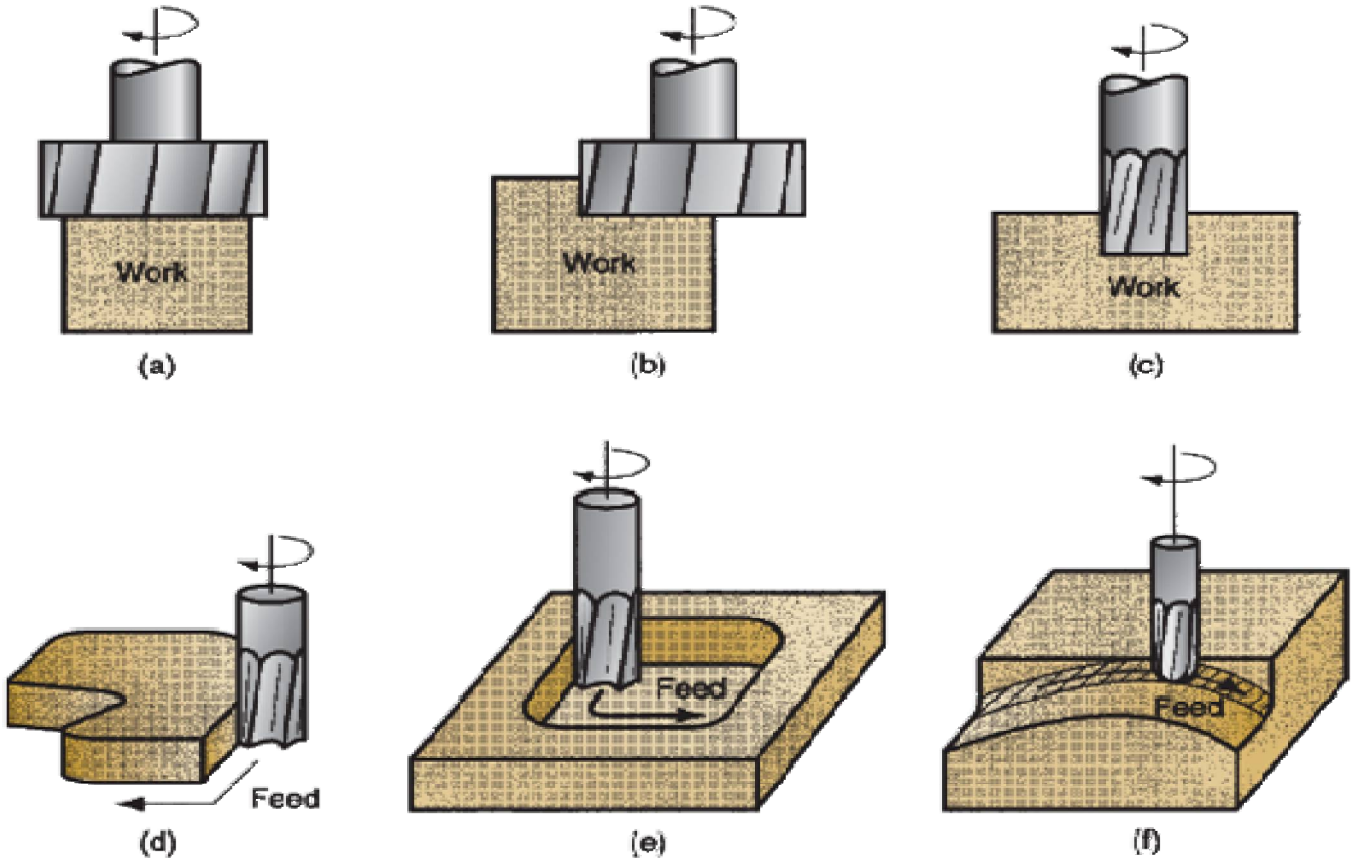


FIGURE 21.20 Face milling: (a) conventional face milling, (b) partial face milling, (c) end milling, (d) profile milling, (e) pocket milling, and (f) surface contouring.

TYPES OF MILLING OPERATIONS

Plain Milling

- Plain milling is the milling of a flat surface with the axis of the cutter parallel to the machining surface. It can be carried out either on a horizontal machine or a vertical machine as shown in figure .

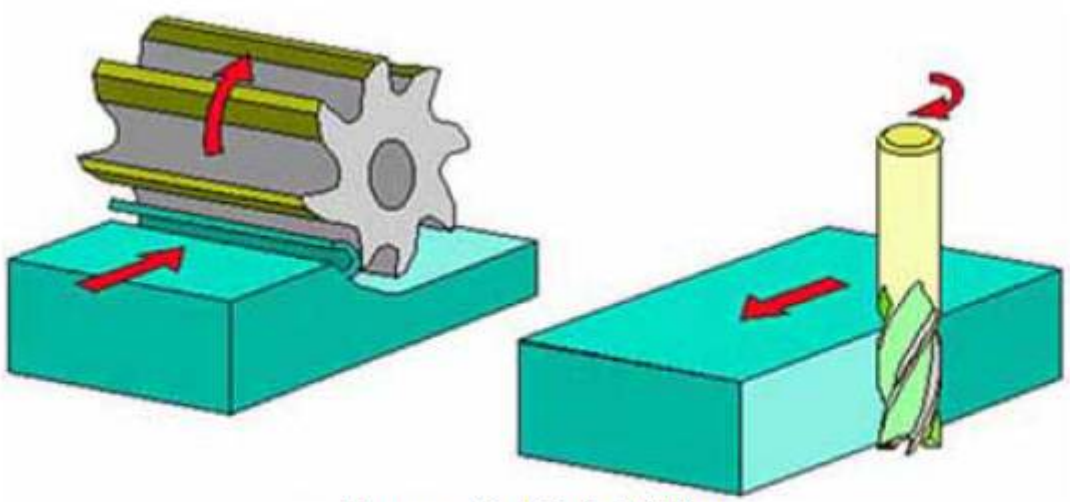


Figure 16. Plain Milling

TYPES OF MILLING OPERATIONS

End Milling

- End Milling is the milling of a flat surface with the axis of the cutter perpendicular to the machining surface as shown in figure

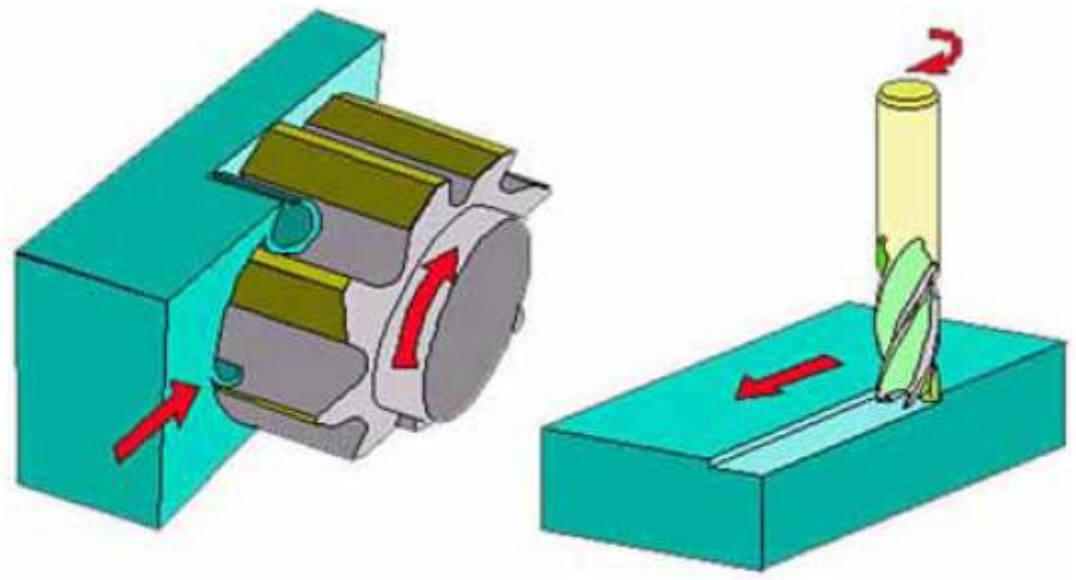
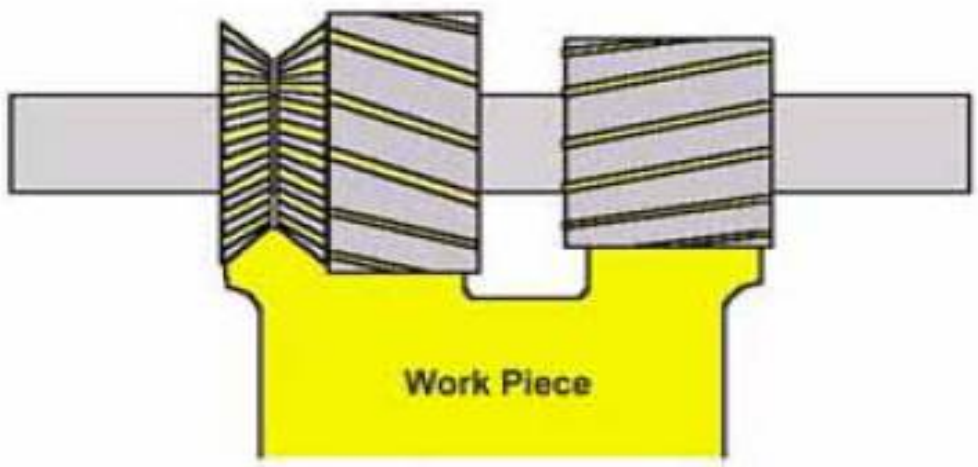


Figure 17. End Milling

TYPES OF MILLING OPERATIONS

Gang Milling

- Gang milling is a horizontal milling operation that utilises three or more milling cutters grouped together for the milling of a complex surface in one pass. As illustrated in figure ,
- Different type and size of cutters should be selected for achieving the desire profile on the workpiece.



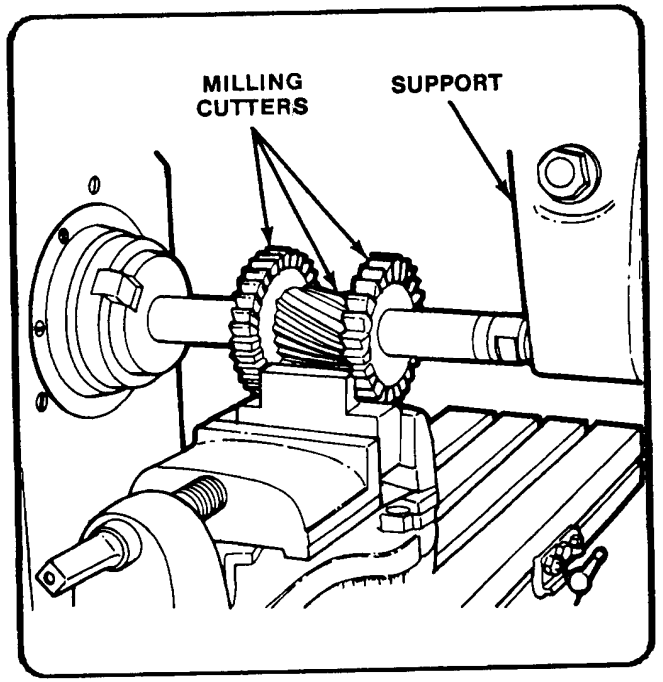
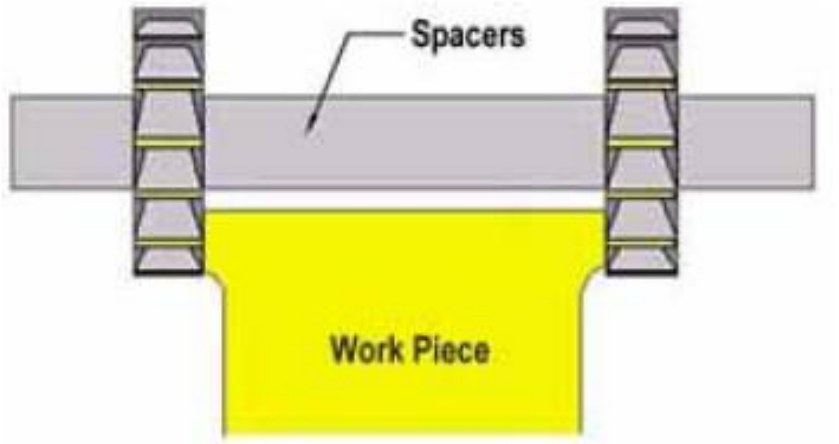


Figure 8-32. Gang milling.

TYPES OF MILLING OPERATIONS

Straddle Milling

- In straddle milling, a group of spacers is mounted in between two side and face milling cutters on the spindle arbor as shown in figure . for the milling of two surfaces parallel to each other at a given distance.



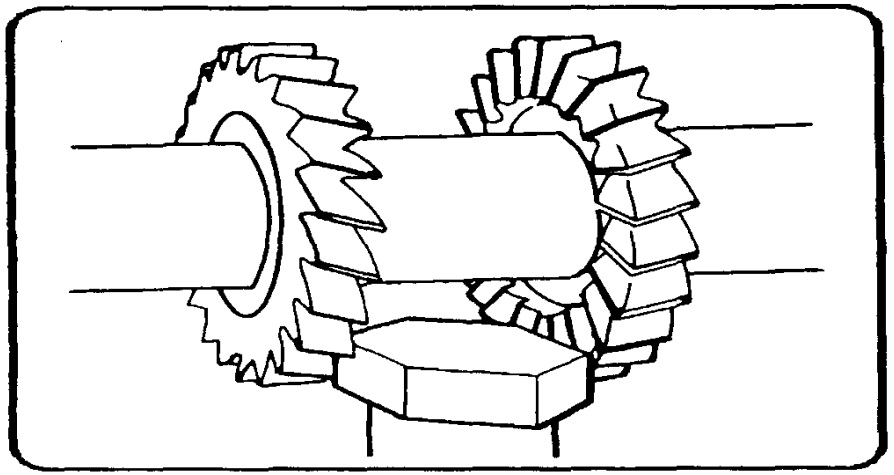
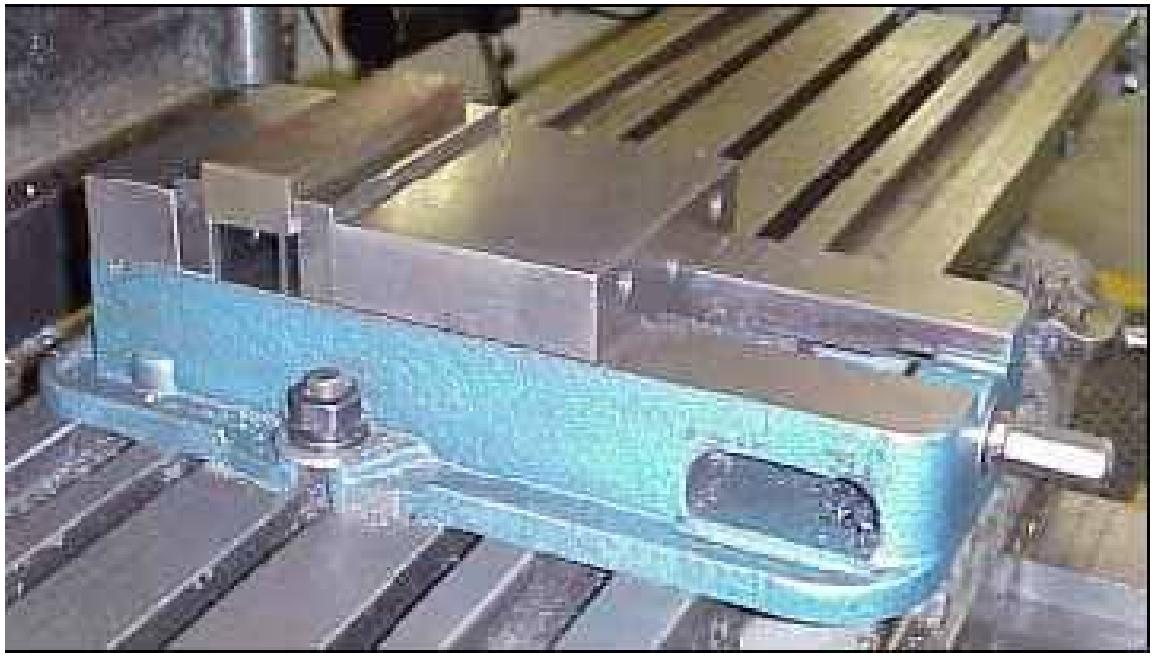


Figure 8-29. Straddle milling.

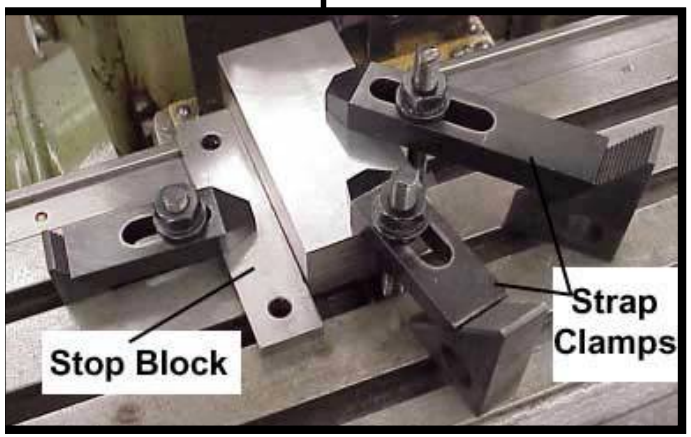
Work-Holding for milling operations

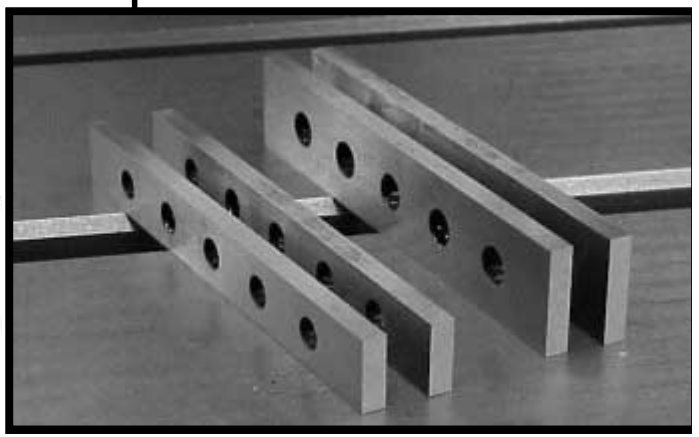
- Several types of fixtures are commonly used to hold parts while milling them. The most common is a vise.

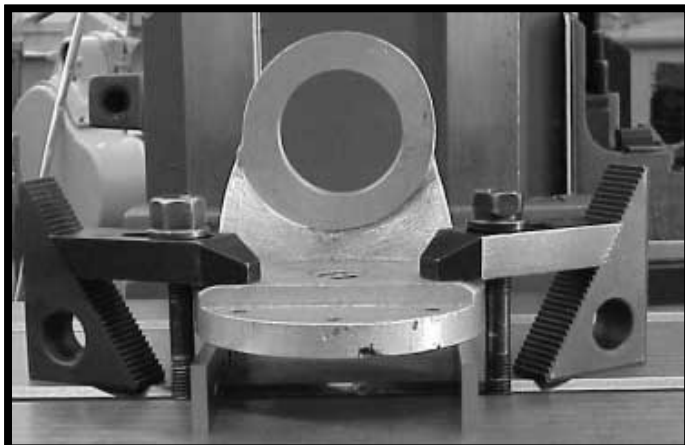


Work-Holding for milling operations

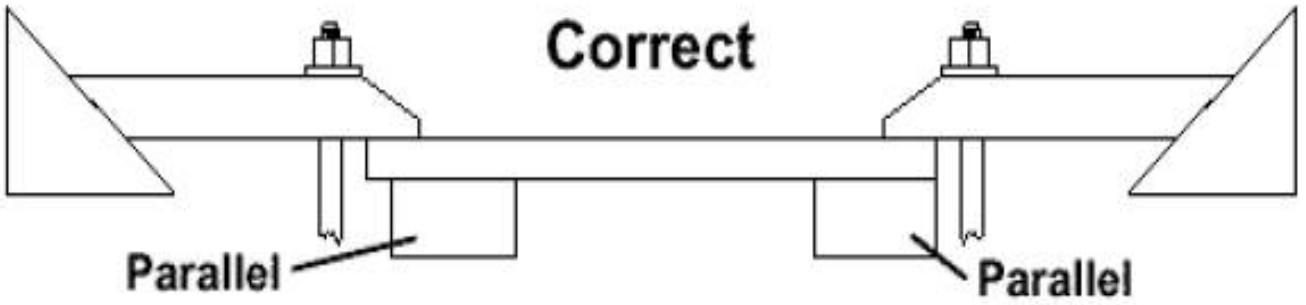
- Another common alternative is to clamp the part directly to the machine table using clamps. Therefore all milling machine tables have T-slots along the length to allow placement of the clamps.



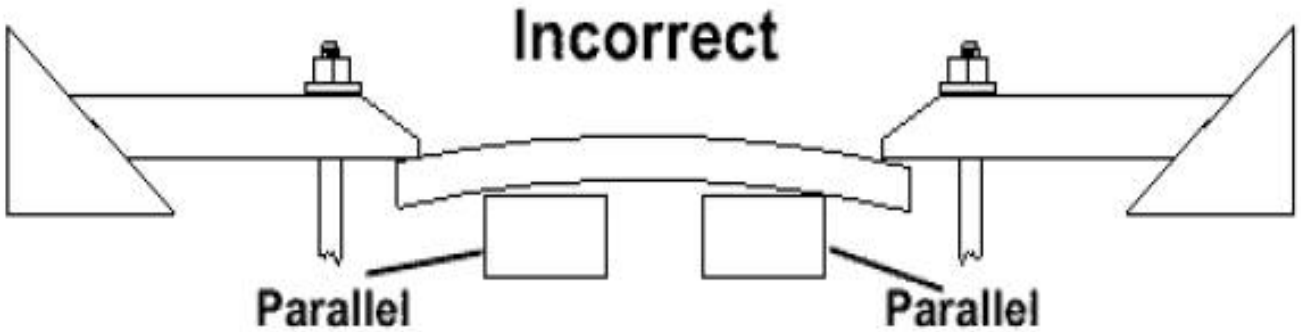




Work-Holding for milling operations



Place support parallels directly under clamps.

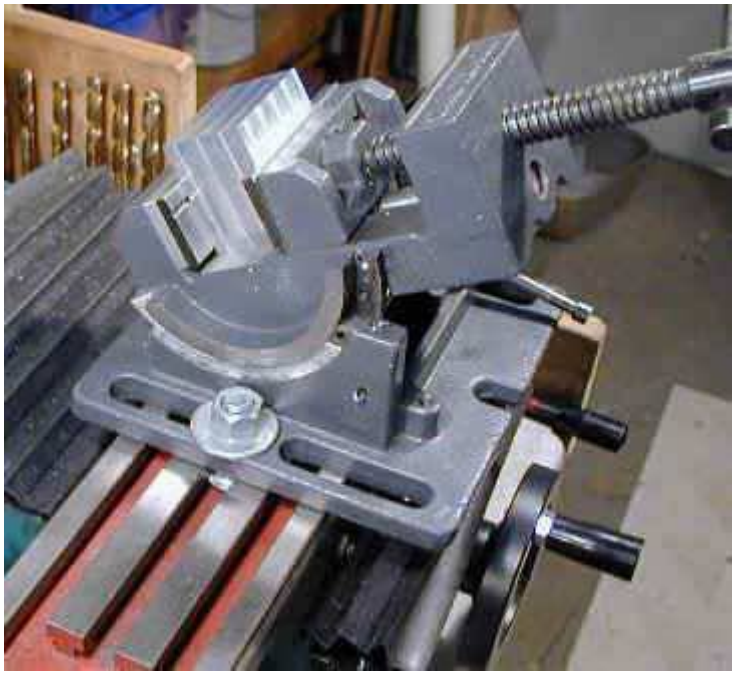


The spring caused by improper parallel placement will cause the part to bow.

Figure 15: Correct and Incorrect Clamping Practices

Work-Holding for milling operations

- Another common work-holding method is an indexed vise, which allows the part to be rotated so as to expose a different surface to the milling tool quickly.



Machining Calculations: Milling

- Spindle Speed - N (rpm)
  - **v = cutting speed**
  - **D = cutter diameter**

$$N = \frac{v}{\pi \quad D}$$

- Feed Rate - f_r (mm/min -or- in/min)
  - **f = feed per tooth**
  - **n_t = number of teeth**

$$f_r = N \quad n_t \quad f$$

- Machining Time - T_m (min)
  - **Slab Milling:**
    - **L = length of cut**
    - **d = depth of cut**

$$T_m = \frac{L + \sqrt{d(D-d)}}{f_r}$$

  - **Face Milling:**
    - **w = width of cut**
    - **2nd form is multi-pass**

$$T_m = \frac{L + 2\sqrt{w(D-w)}}{f_r}$$

- Mat'l Removal Rate - MRR (mm^3/min -or- in^3/min)

$$MRR = w\, d\, f_r$$

ARBORS

- Milling machine arbors are made in various lengths and in standard diameters of 7/8,1,1 1/4, and 1 1/2 inch. The shank is made to fit the taper hole in the spindle while the other end is threaded.
- Arbors are supplied with one of three tapers to fit the milling machine spindle: the Standard Milling Machine taper, the Brown and Sharpe taper, and the Brown and Sharpe taper with tang in Figure .

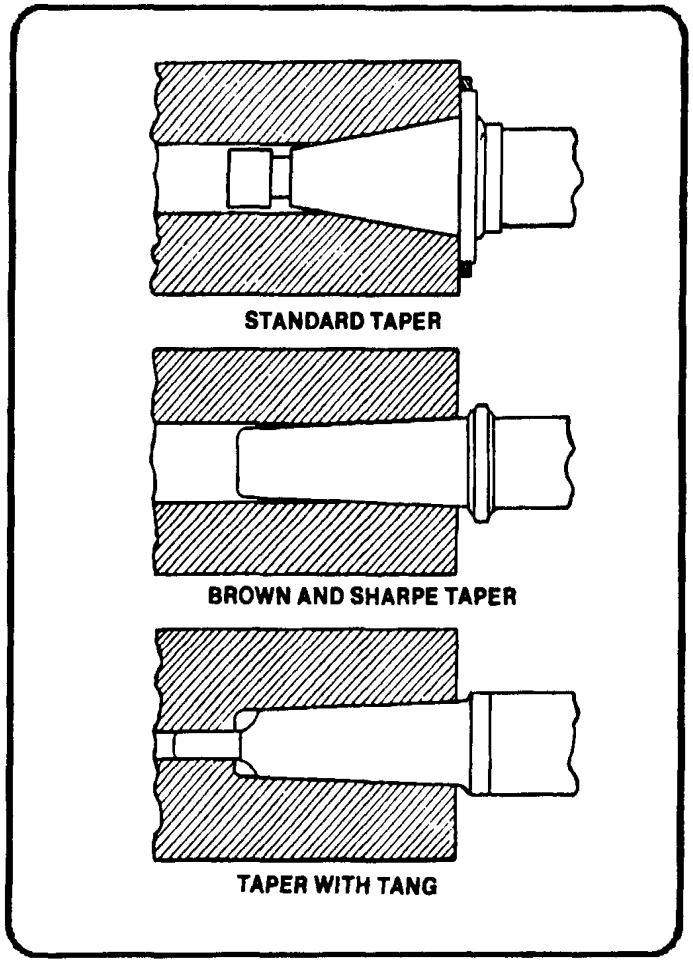


Figure 8-10. Tapers used for milling machine arbors.

ARBORS

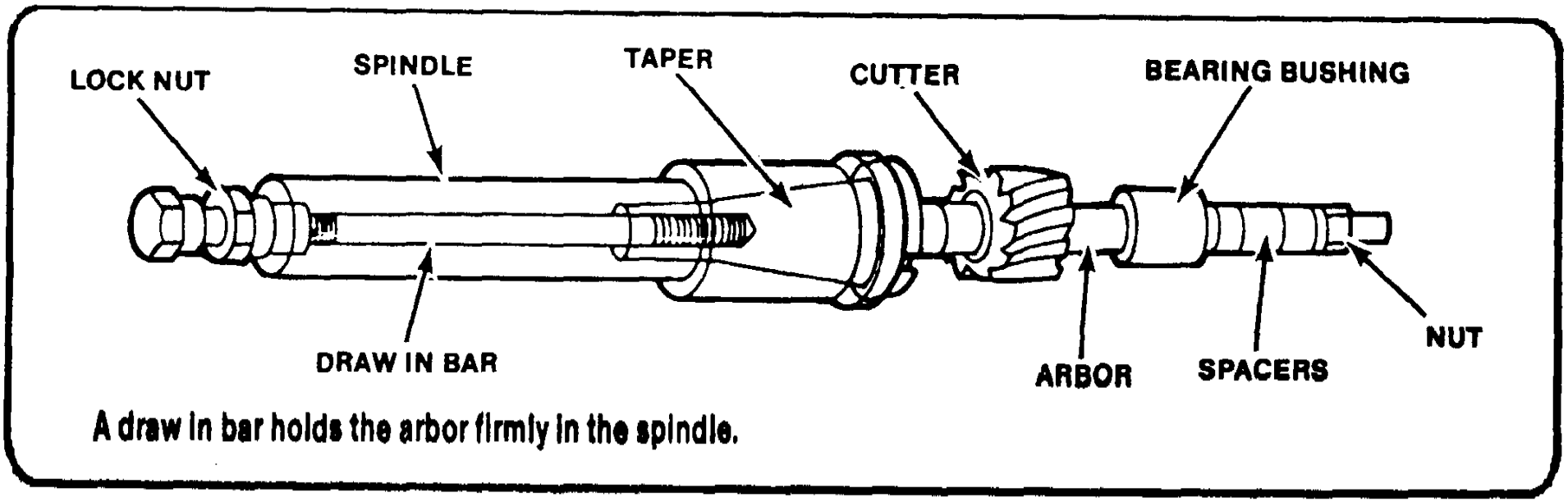


Figure 8-11. Standard

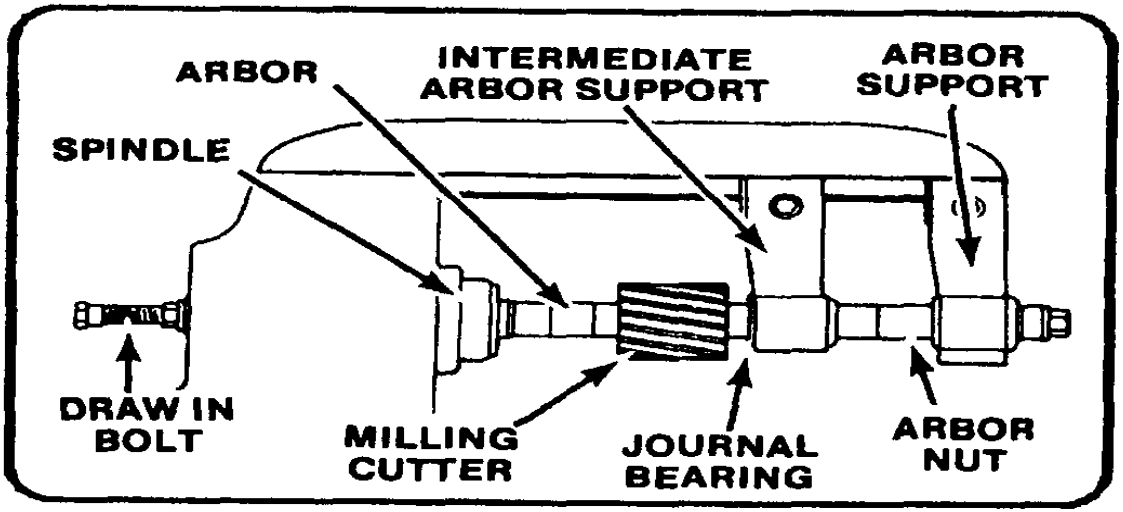


Figure 8-12. Arbor installation.

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Indexing

- Indexing is the process of evenly dividing the circumference of a circular workpiece into equally spaced divisions, such as in cutting gear teeth, cutting splines, milling grooves in reamers and taps, and spacing holes on a circle.
- The index head of the indexing fixture is used for this purpose.

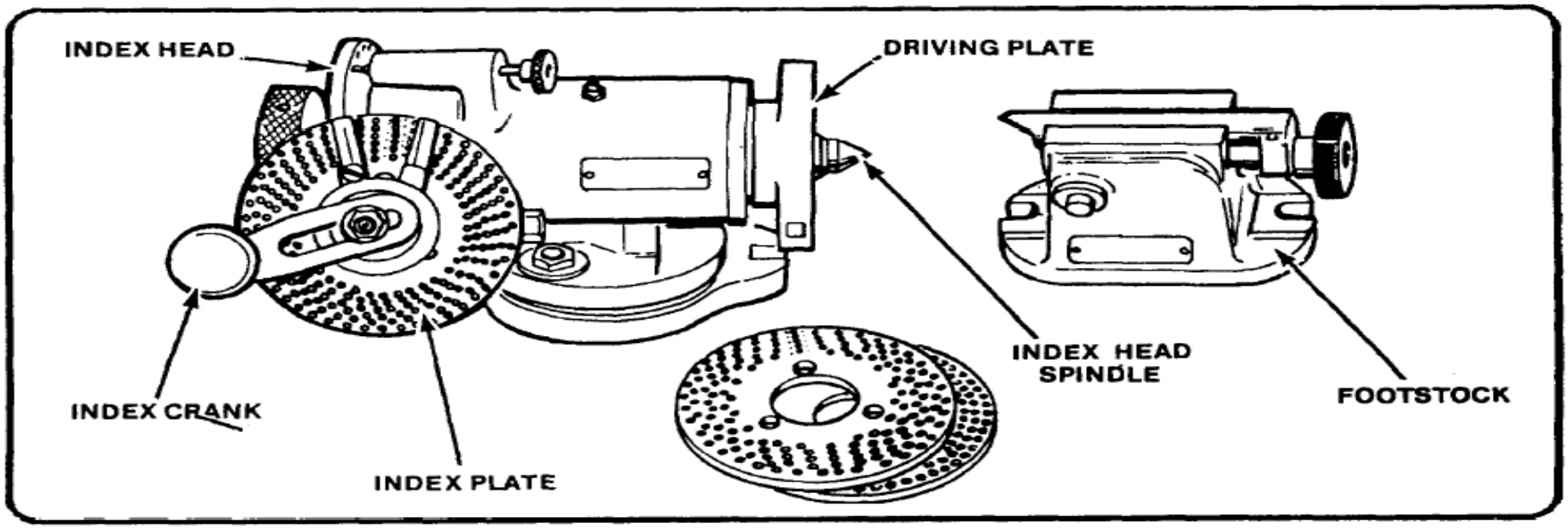

Figure 8-19. Indexing fixture.

Index Plate

- The indexing plate (Figure) is a round plate with aeries of six or more circles of equally spaced holes; the index pin on the crank can be inserted in any hole in any circle.
- With the interchangeable plates regularly furnished with most index heads, the spacing necessary for most gears, boltheads, milling cutters, splines, and so forth can be obtained. The following sets of plates are standard equipment.

Brown and Sharpe type consists of 3 plates of 6 circles each drilled as follows:

Plate I -15, 16, 17, 18, 19, 20 holes

Plate 2-21, 23, 27, 29, 31, 33 holes

Plate 3-37, 39, 41, 43,47,49 holes

Cincinnati type consists of one plate drilled on both sides with circles divided as follows:

First side -24, 25, 28, 30, 34, 37,38, 39,41,42,43 holes

Second side -46, 47, 49, 51, 53, 54, 57, 58, 59, 62, 66 holes

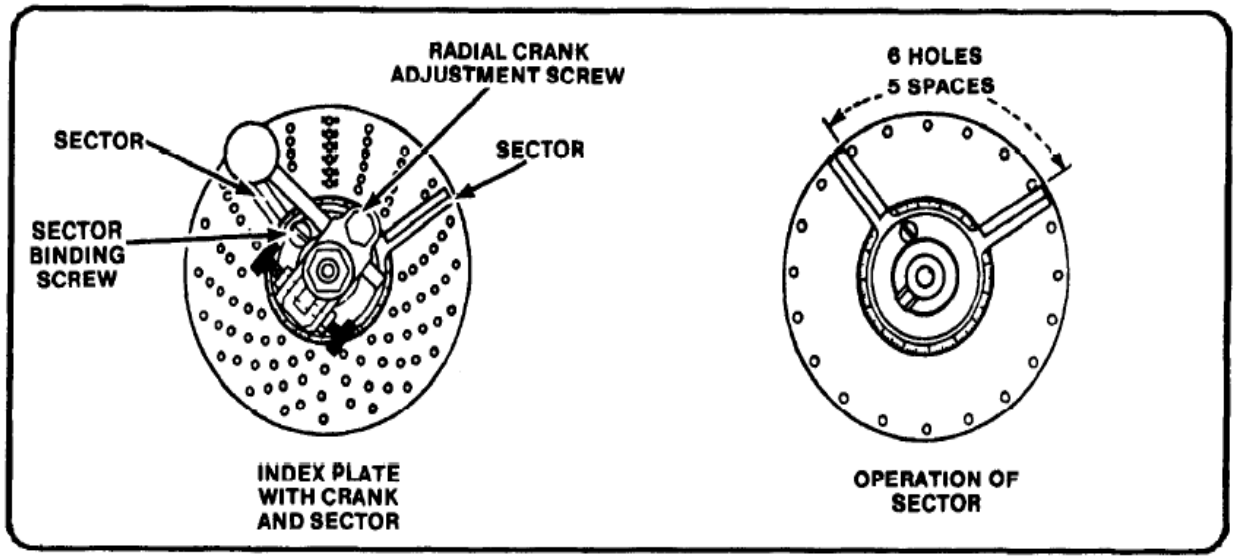

Figure 8-25. Index plate and sector.

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