Milling and gear generating machine tools

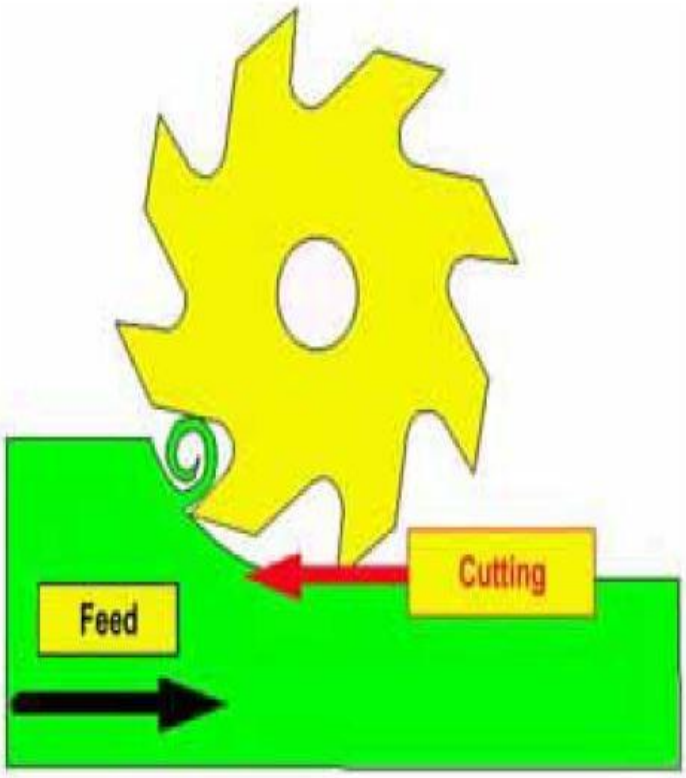
Unit IV

Milling

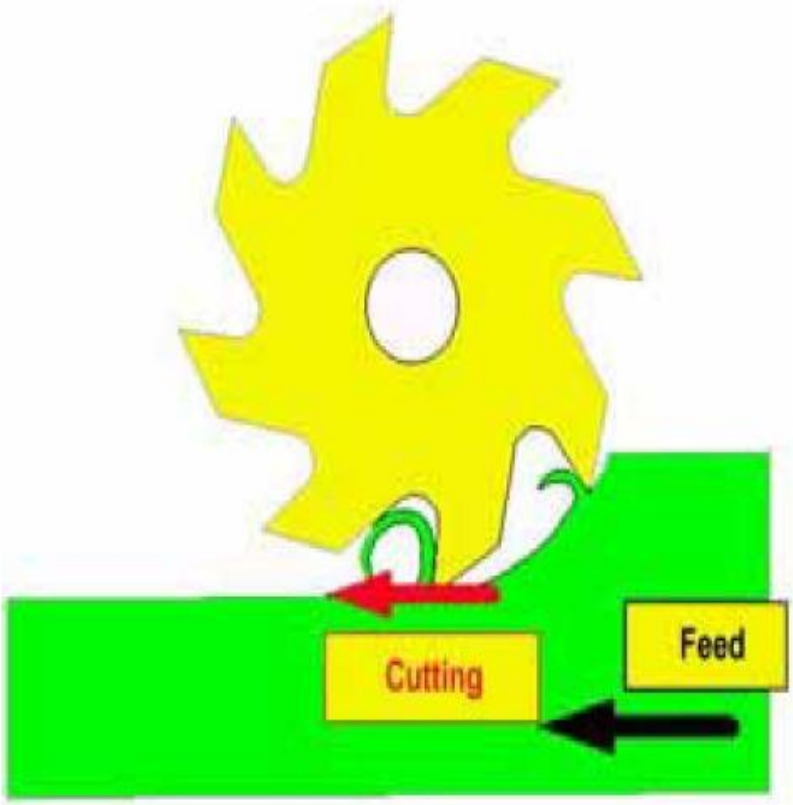
- Milling is process of removing metal from a work piece by feeding it against the multipoint cutting tool(rotary cutter) called milling cutter.
- Milling machines is used for machining flat surfaces, spiral and helixes, cutting keyways, slots, grooves, cams, gears, V-blocks and complex contours.
- Surface finish and accuracy produced by milling is superior than other machines.

Milling process- Method of milling

Upmilling or conventional milling



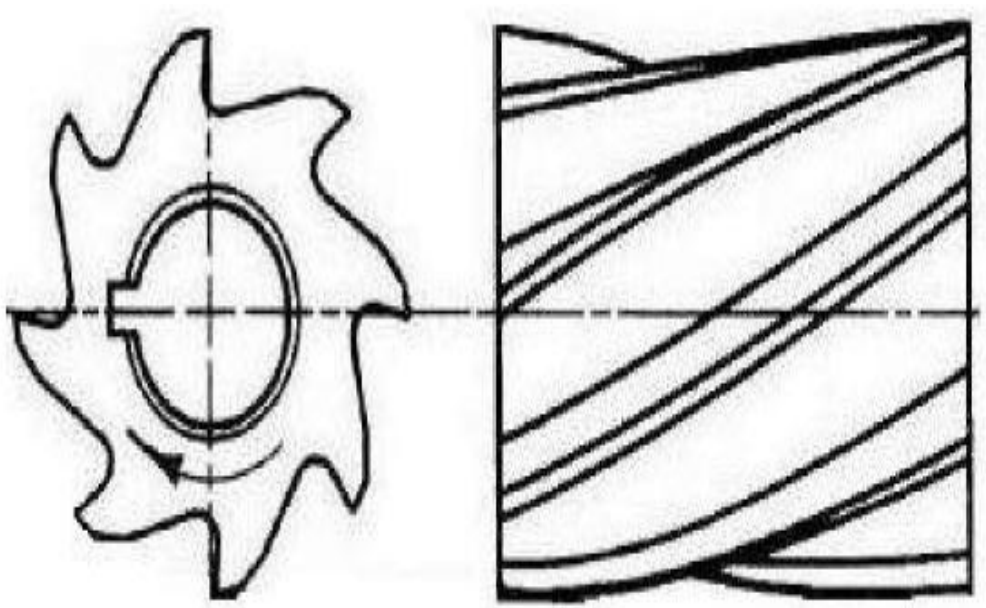
Down milling or climb or incut milling



Milling cutter types

- Plain milling cutter and Slab milling cutter
- Slitting saw
- Side milling cutter and Staggered teeth side milling cutter
- Single angle and double angle milling cutter.
- End mill
- Face mill cutter
- T- slot milling cutter
- Fly cutter
- Form cutter

Plain milling cutter



Side milling cutter

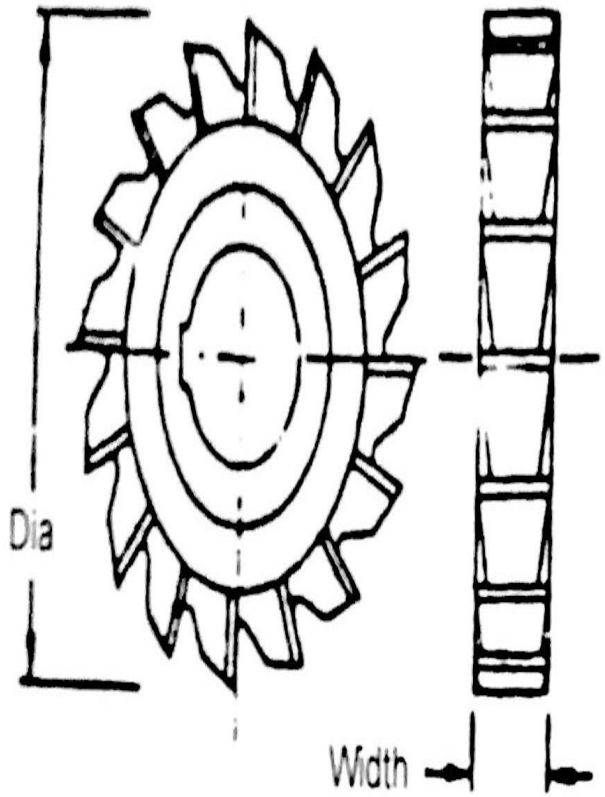


Figure 4.18(a) Side milling cutter

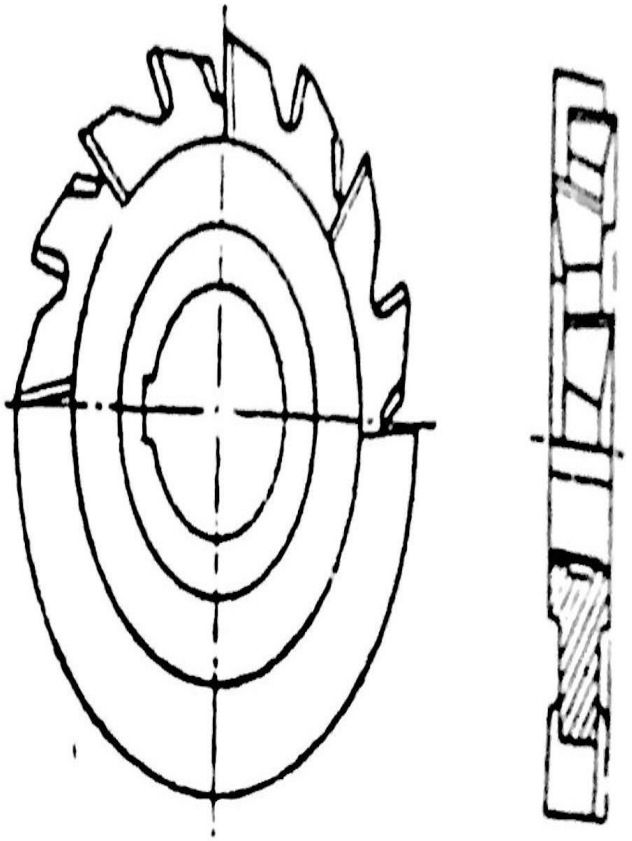
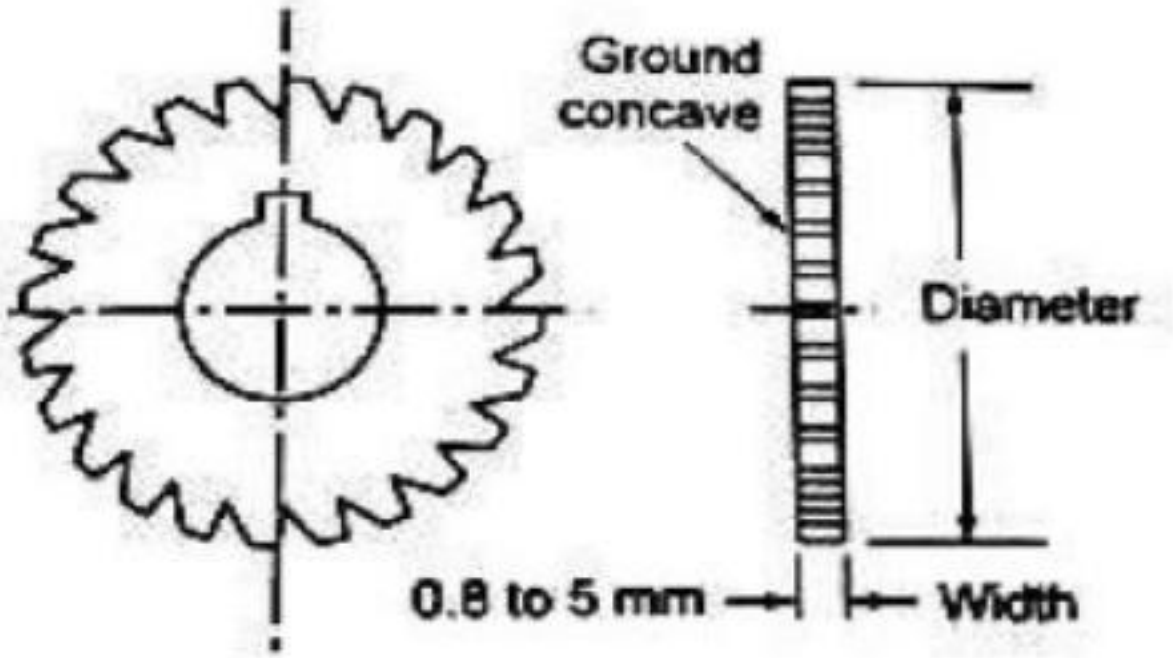


Figure 4.18(b) Staggered teeth side milling cutter

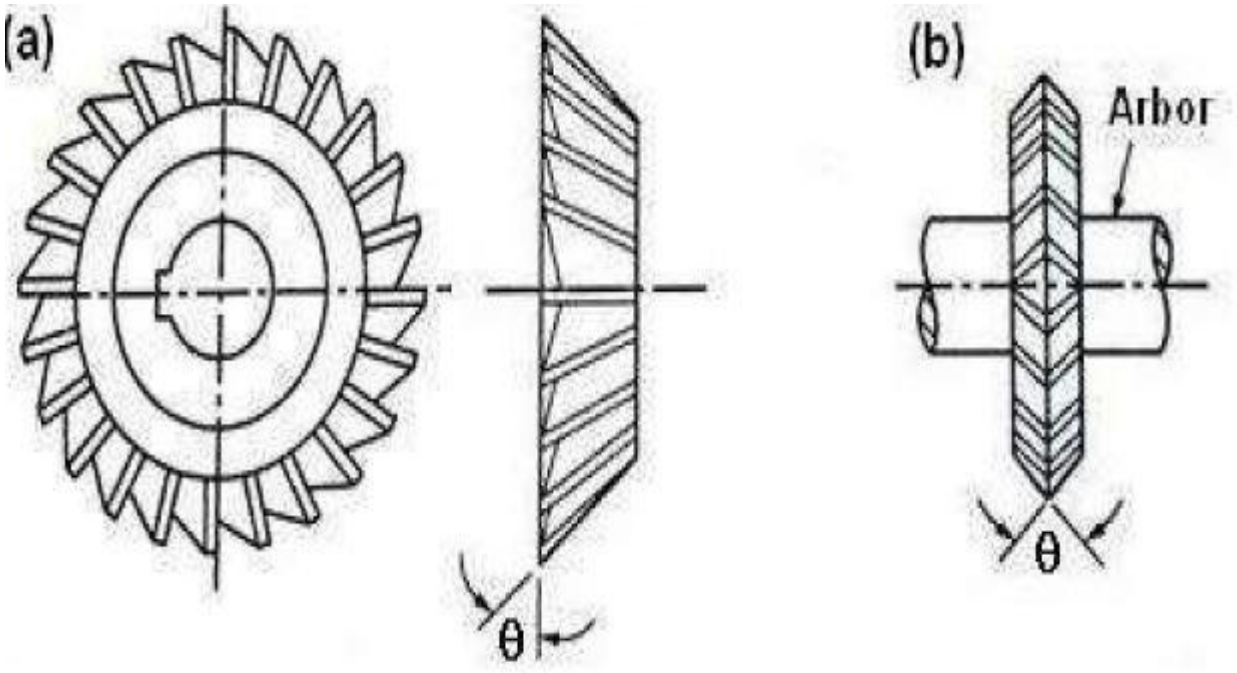
Slitting saw



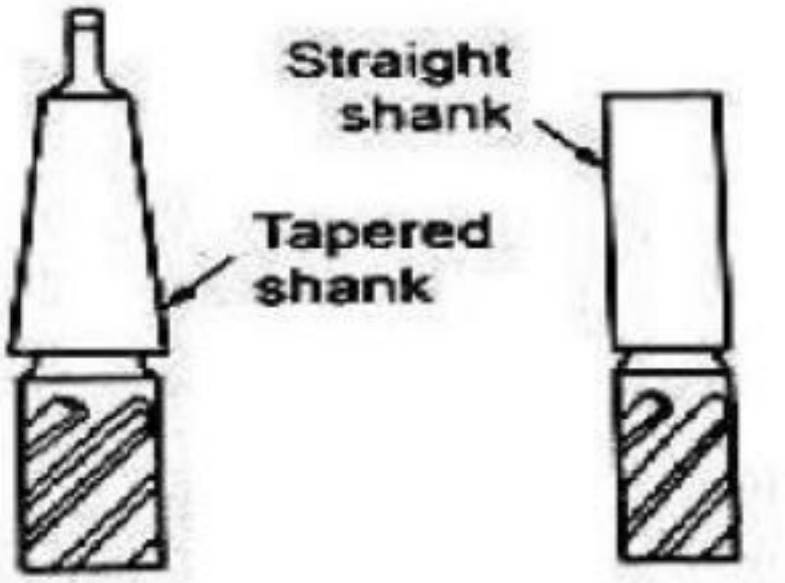
Angle milling cutters

a. SINGLE ANGLE MILLING CUTTER

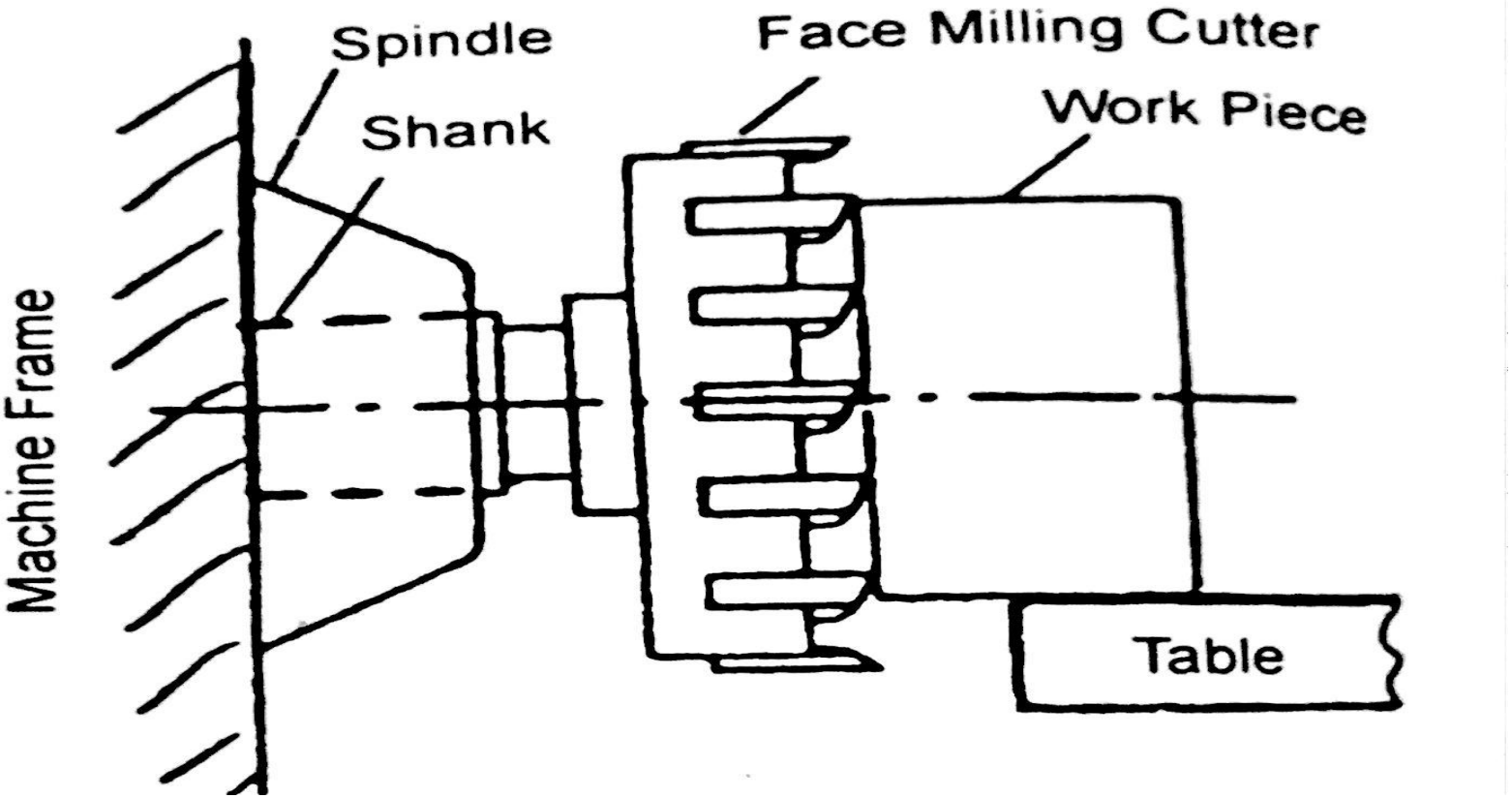
b. Double angle milling cutter



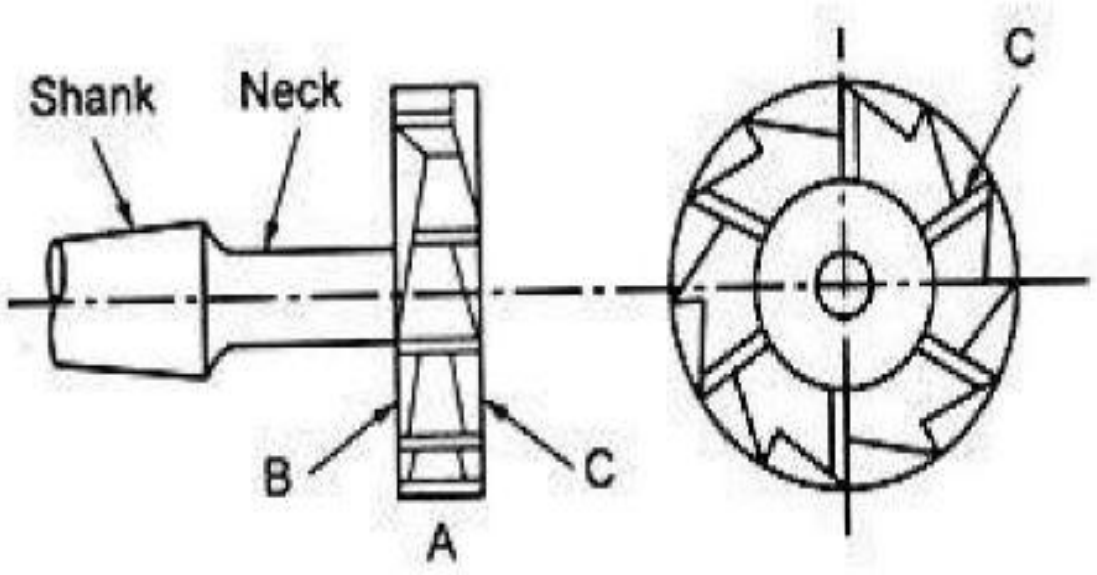
End milling cutter



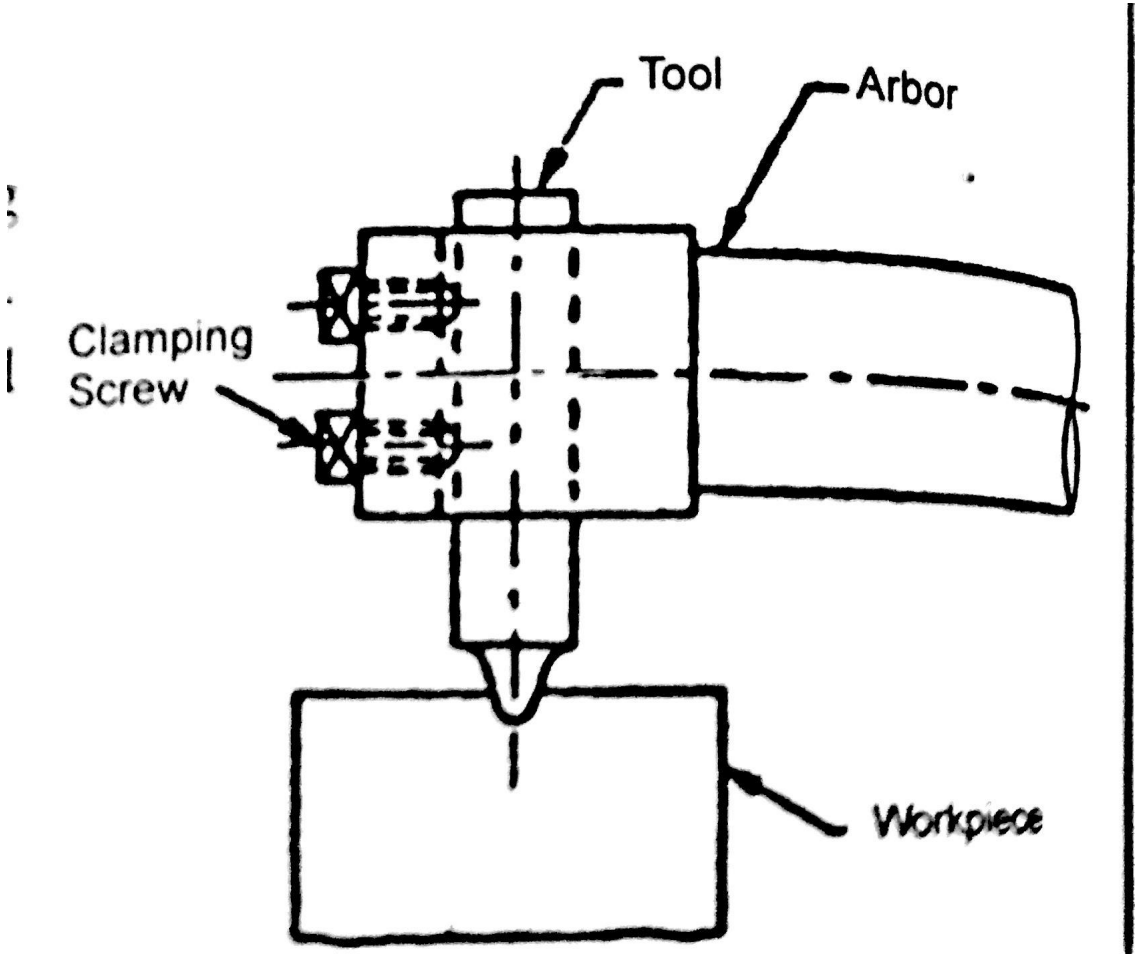
Face milling cutter



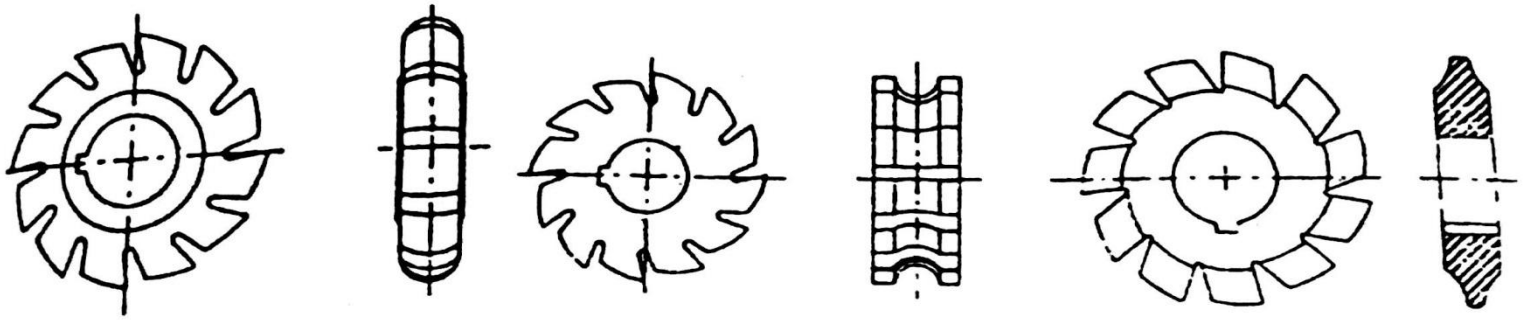
Slot milling cutter



Fly cutter



Form cutter



(a) Convex Cutter (b) Concave Cutter (c) Involute Gear Tooth CUtter

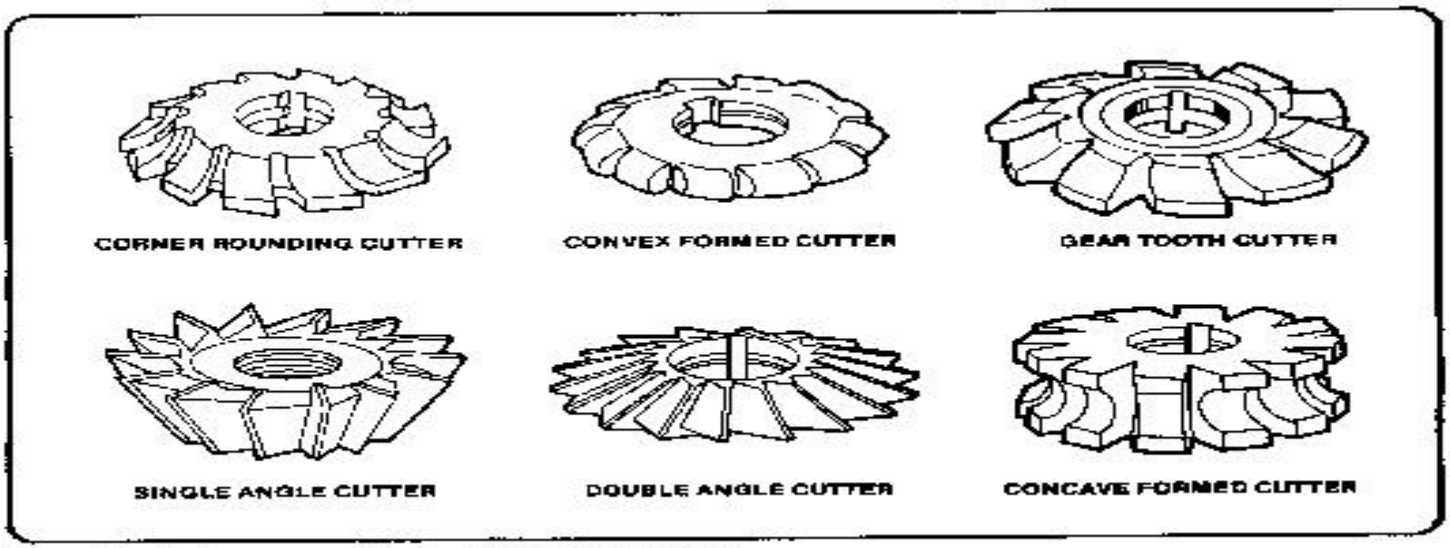


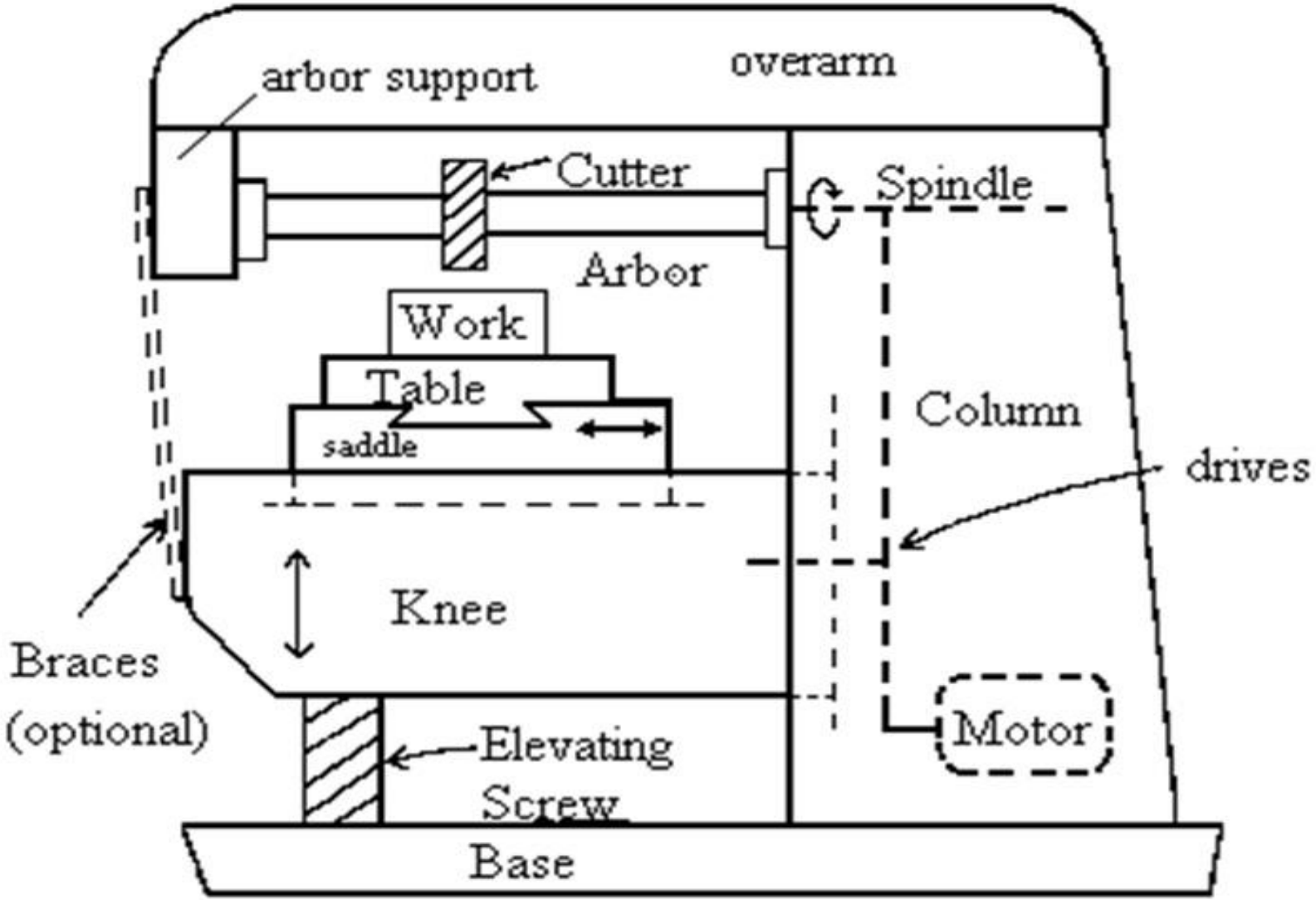
Figure 8-8. Angle, concave, convex, corner, and gear cutters.

Types of milling machine

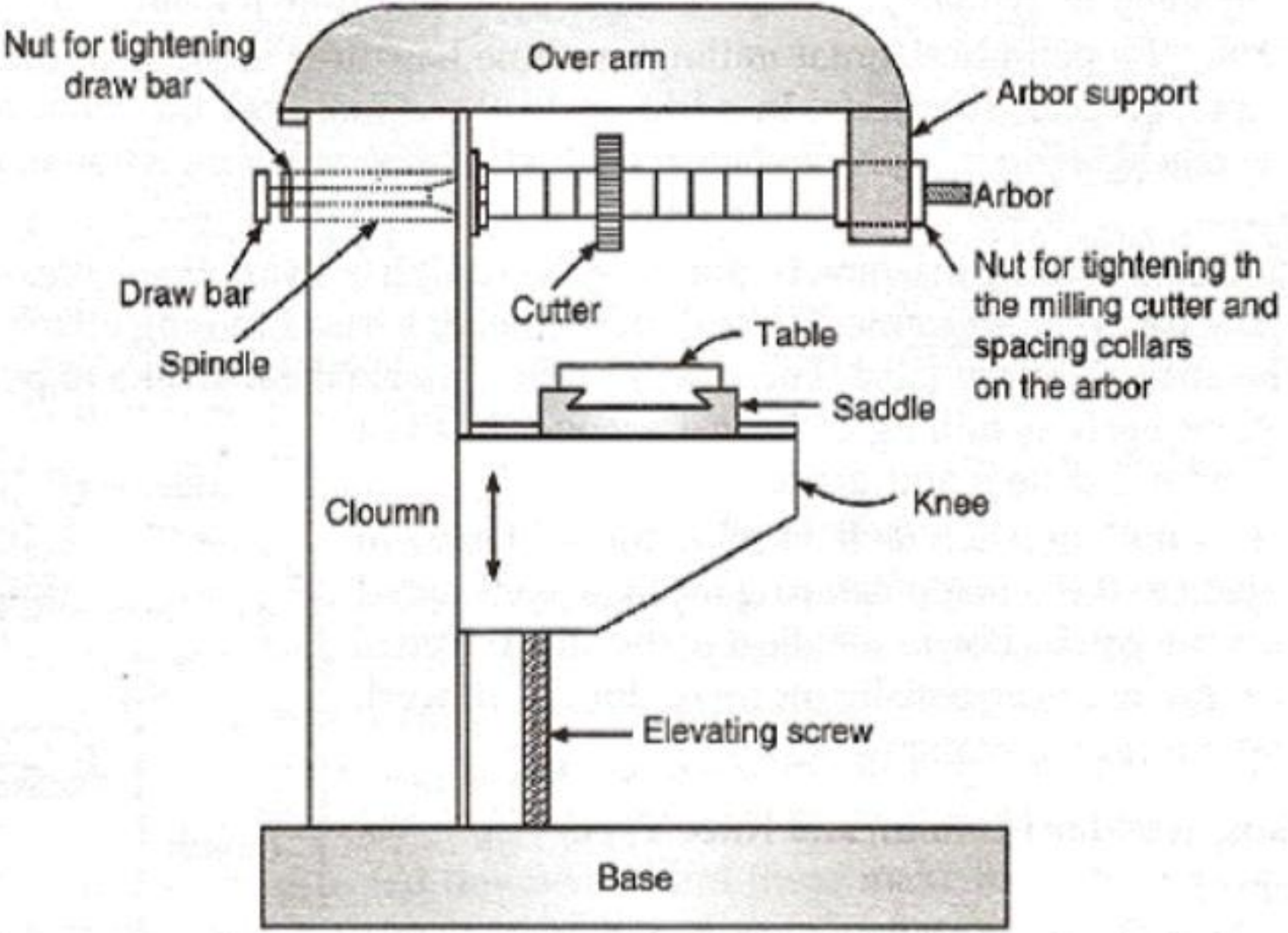
- Column and knee type milling machine
  - Plain or horizontal milling machine
  - Vertical milling machine
  - Universal milling machine
  - Omniversal milling machine
- Bed type milling machine
  - Simplex milling machine
  - Duplex milling machine
  - Triplex milling machine
- Planer type milling machine
- Special purpose milling machine
  - Cam milling machine
  - Planetary milling machine
  - Profile milling machine
  - Drum milling machine
  - Duplicating milling machine

Horizontal or plain milling machine

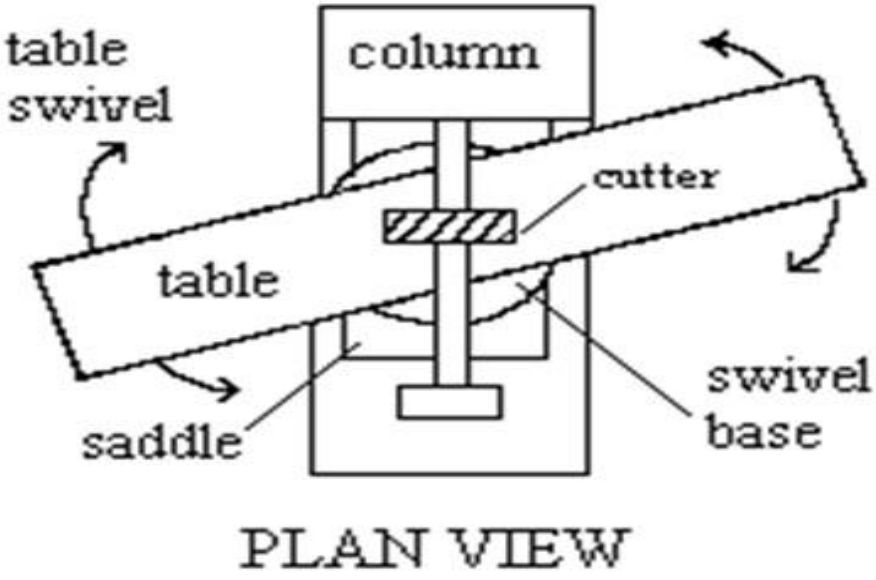
- Main parts
  - Base
  - Column
  - Knee
  - Saddle
  - Over arm
  - Spindle
  - Arbor
  - Table



Horizontal Milling machine

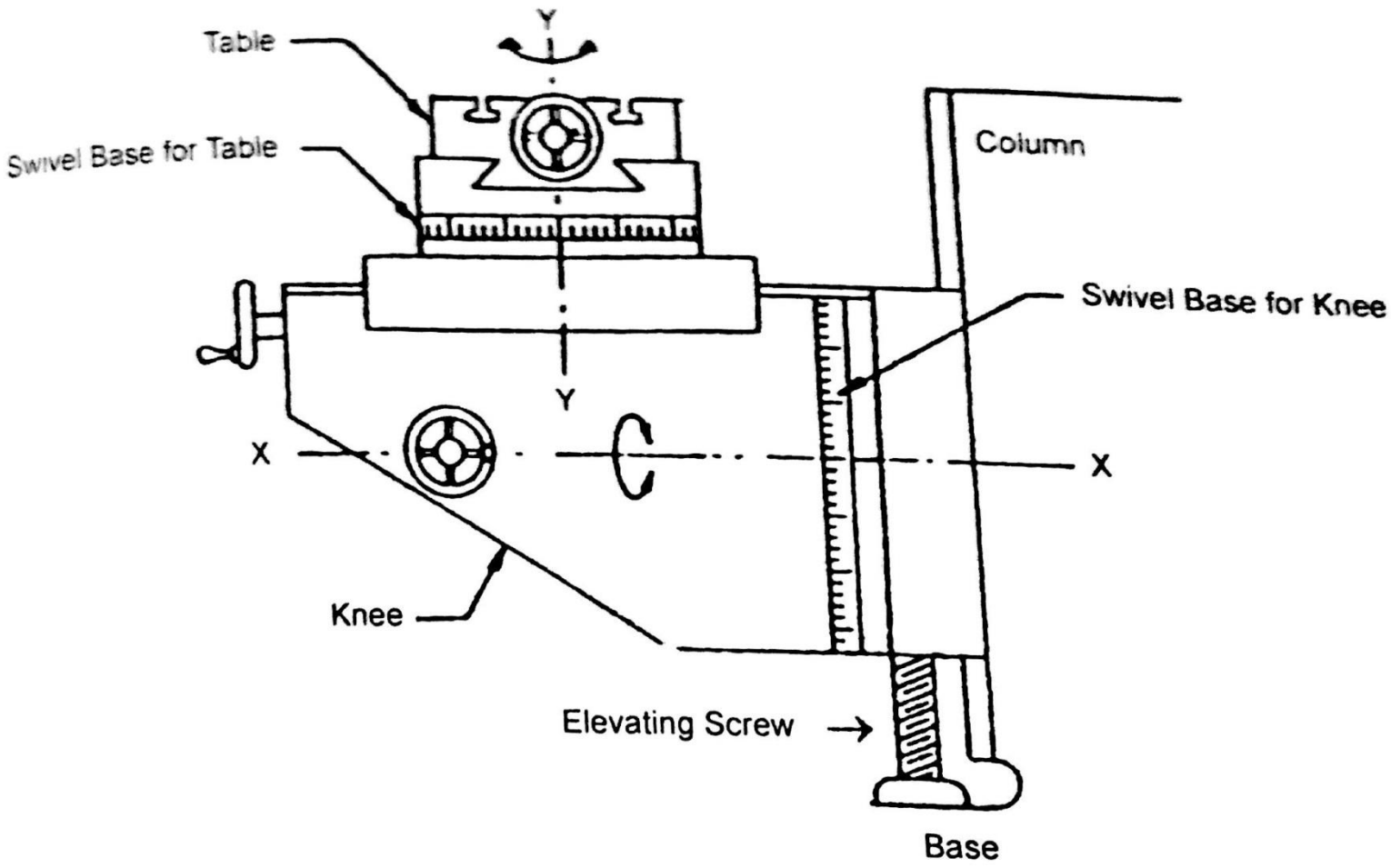

Nut for tightening draw bar
Over arm
Arbor support
Arbor
Nut for tightening th the milling cutter and spacing collars on the arbor
Draw bar
Spindle
Cutter
Table
Saddle
Knee
Cloumn
Elevating screw
Base

Universal milling machine

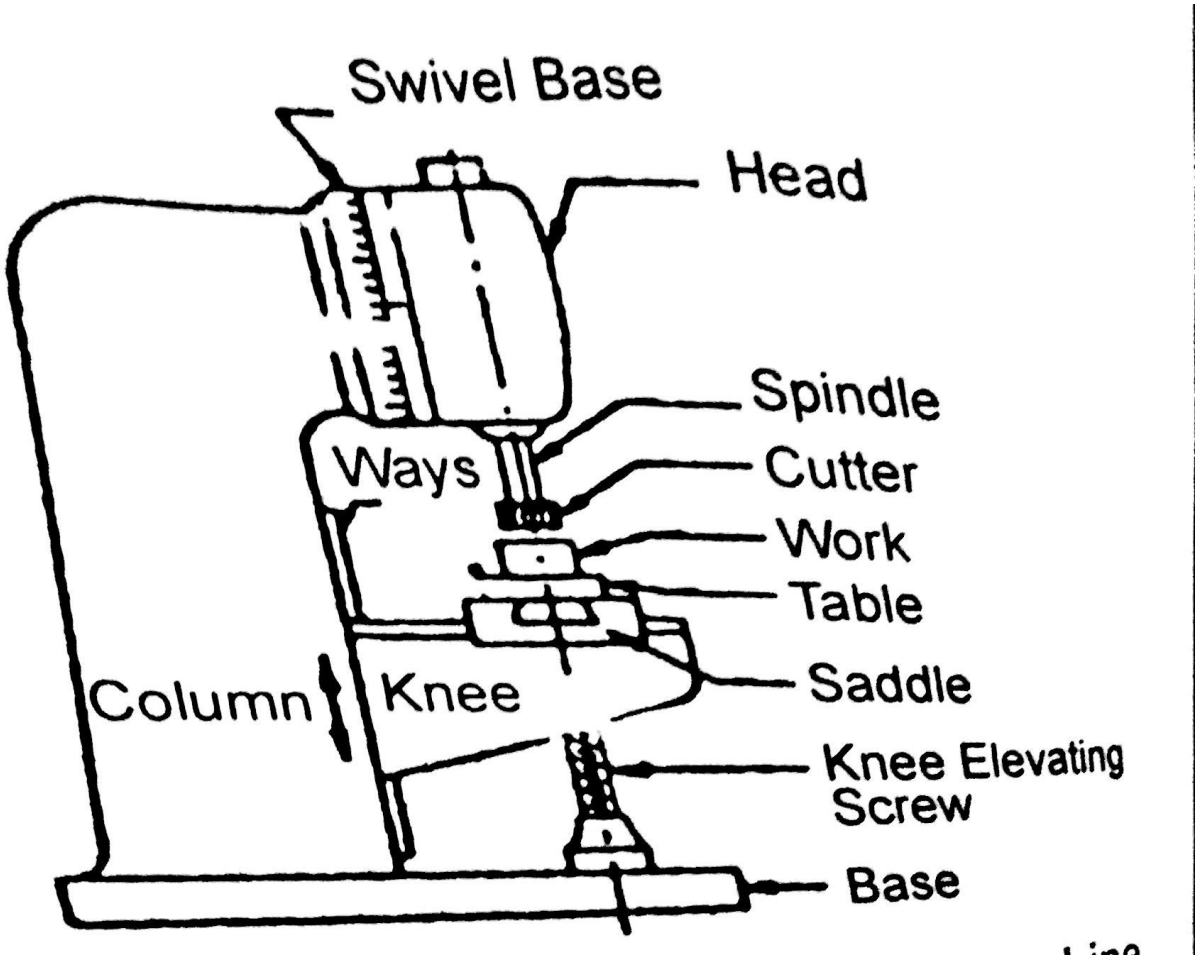


Universal Milling Machine

Omniversal milling machine



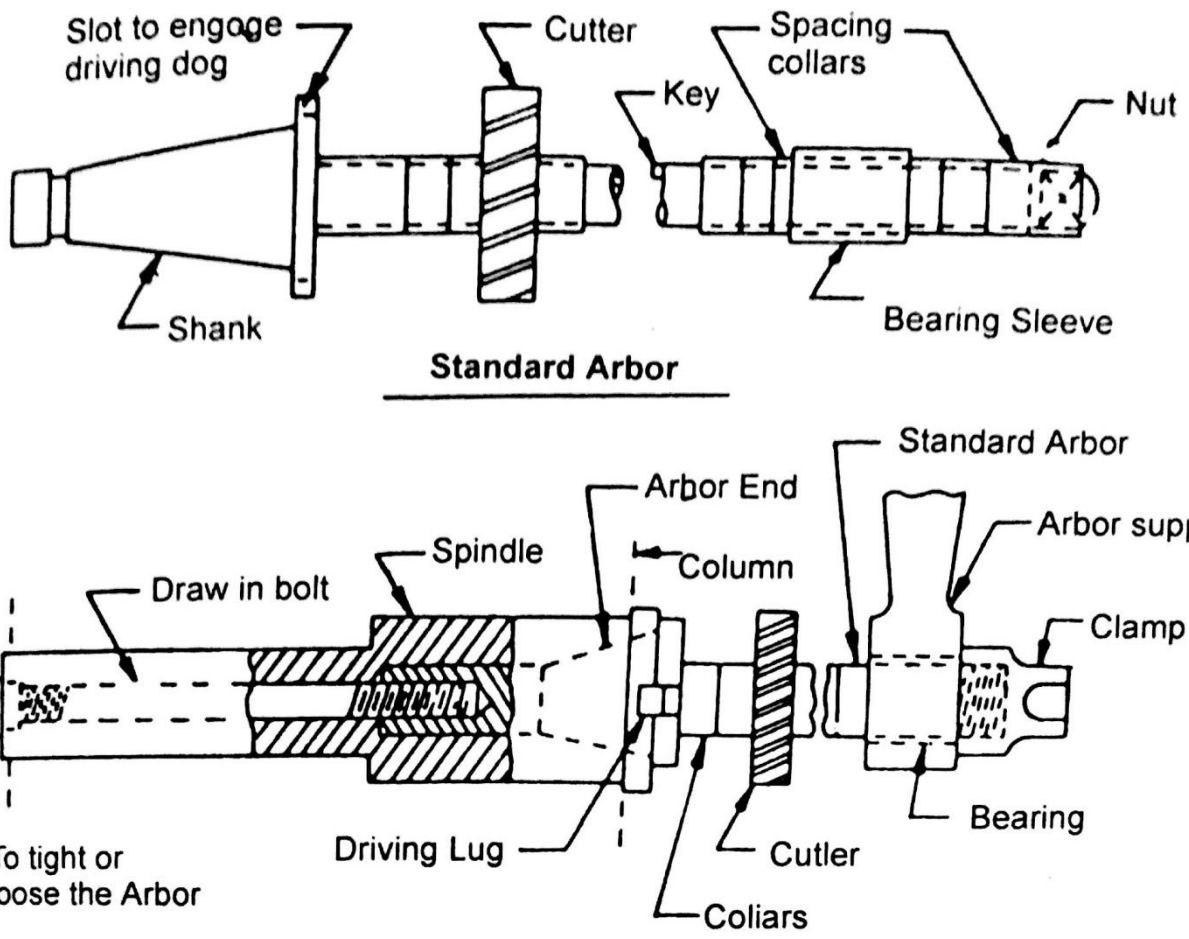
Vertical milling machine



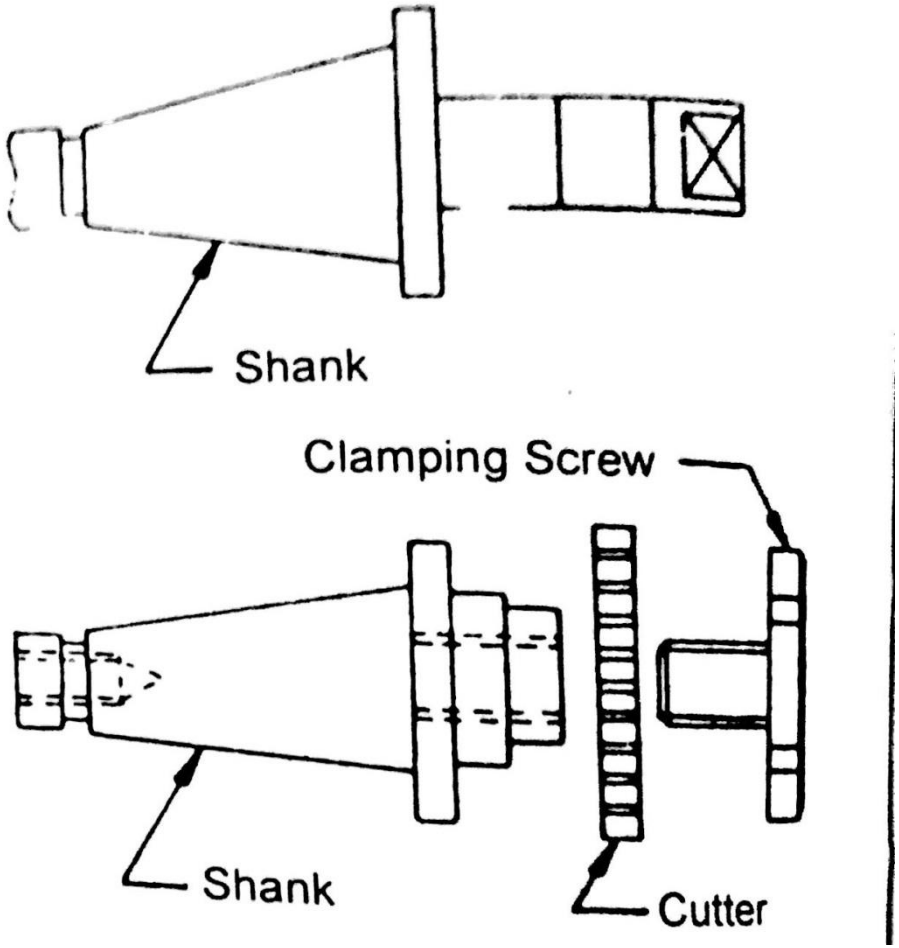
Cutter holding devices

- Arbors
  - Standard arbor
  - Stub arbor
- Adapters
- Spring collets
- Bolting system
- Screwed on cutters

Arbors
standard arbor



Stub arbor



Collet and adapter

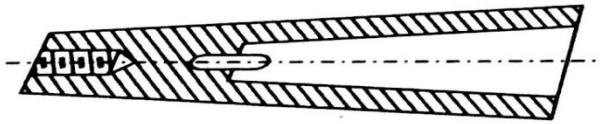
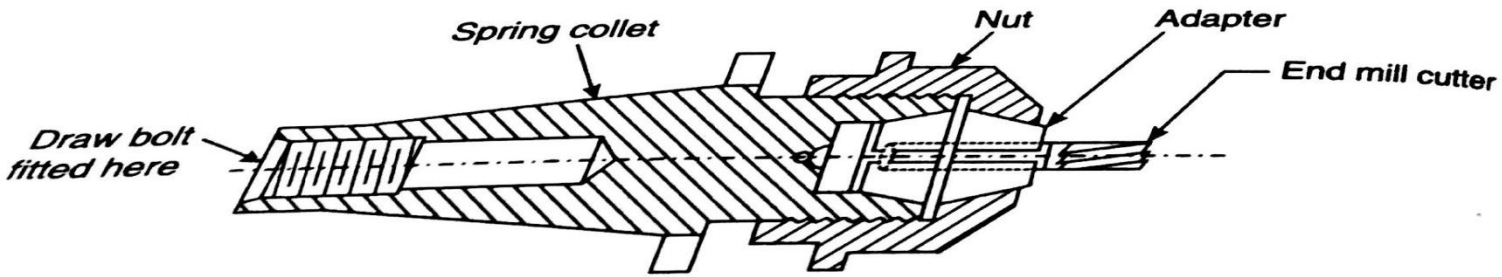


Fig. 6.127(a) Milling machine collet.



(b) Spring collet. The nose end of adapter is split by three slots to give spring action

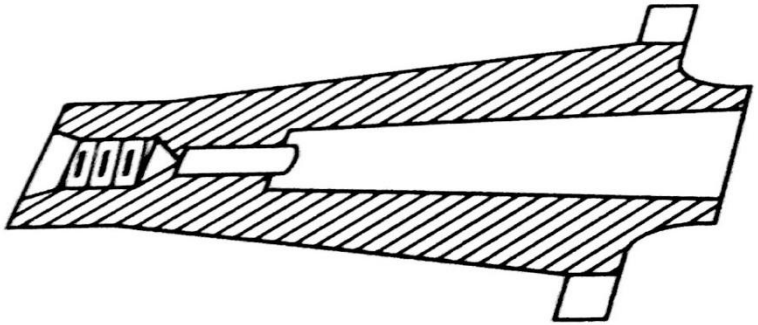


Fig. 6.128 Milling machine adapter.

Bolting system

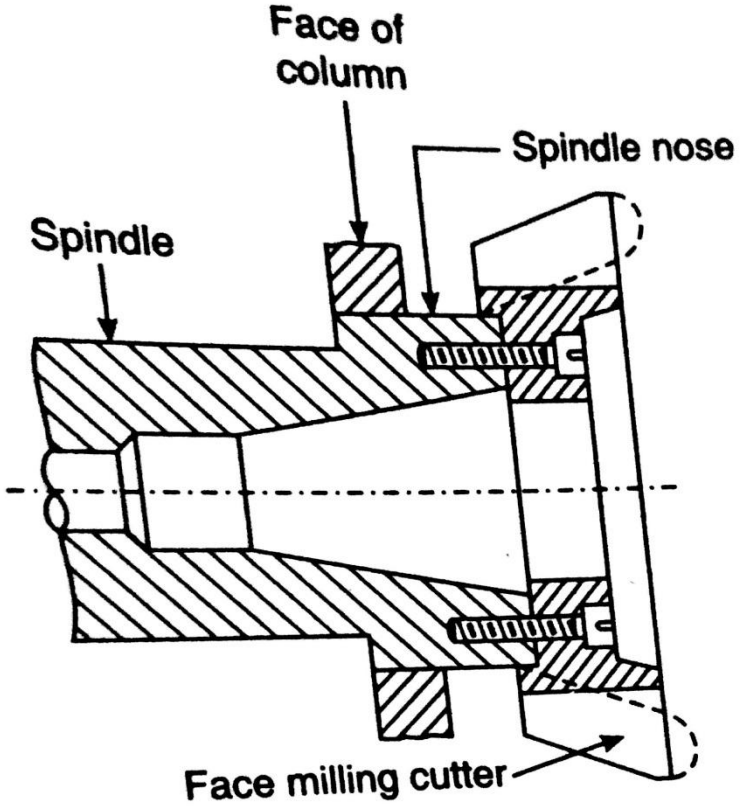


Fig. 6.129 Milling cutter bolted with spindle nose.

Workholding devices

- Plain vise
- Swivel vise
- Universal vise
- Indexing head
- Milling fixture

Nomenclature of plain milling cutter

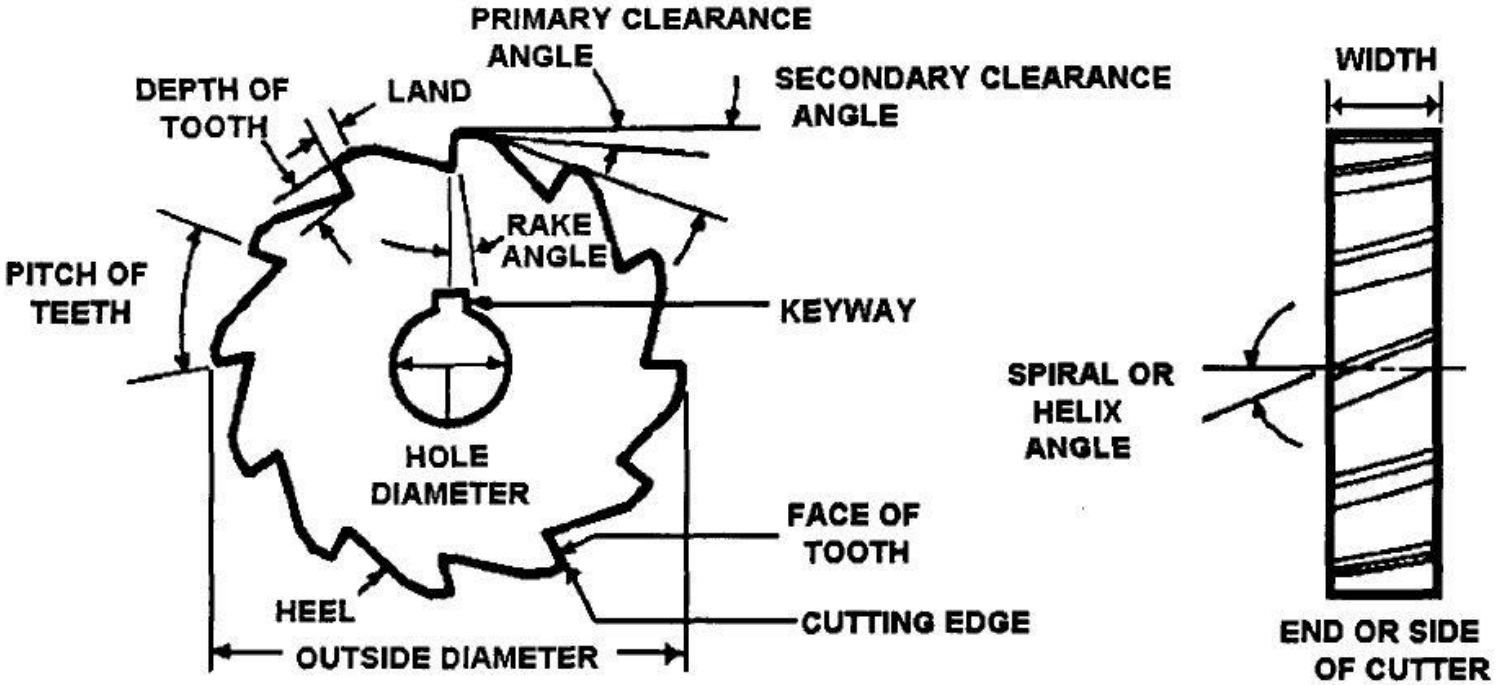
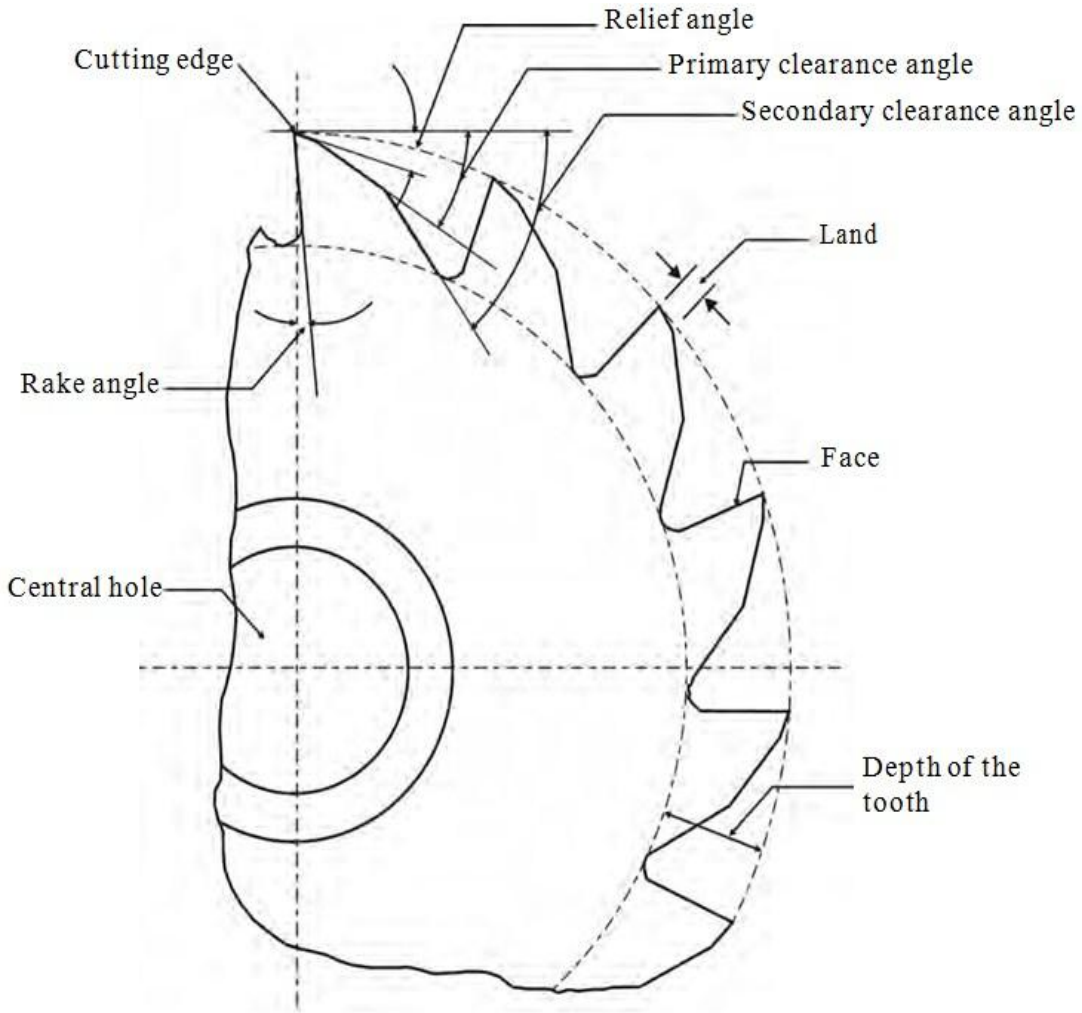


Figure 8-3. Milling cutter nomenclature.



Nomenclature of a Plain Milling Cutter

- Body of cutter
- Face
- Land
- Cutting edge
- Gash
- Fillet
- Outside diameter
- Root diameter
- Relief angle
- Primary clearance angle
- Secondary clearance angle
- Rake angle
- Lip angle

Nomenclature of plain milling cutter

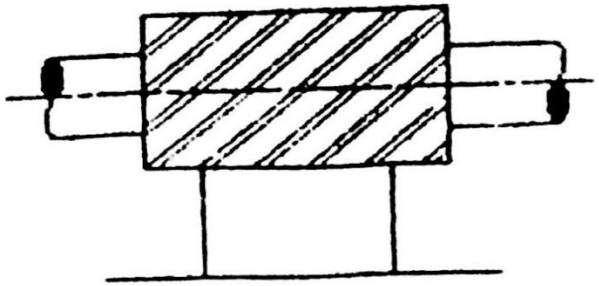
- **Body of cutter-**Part of cutter excluding from teeth portion
- **Land-**Part of back of tooth adjacent to cutting edge
- **Cutting edge-**Edge formed by intersection of face and land
- **Face -**Front portion of tooth. The chip removed during cutting impinges on face.
- **Gash-**Space between back of one tooth and face of next tooth.
- **Fillet** – curved surface at bottom of gash.
- **Outside diameter-** diameter of circle passing through peripheral cutting edge.
- **Root diameter-** diameter of circle passing through bottom of fillet.
- Cutter angle
- **Relief angle-** angle between land of tooth and tangent to outside diameter of cutter at cutting angle.

- **Primary clearance angle-** angle formed by back of tooth with a line drawn tangent to periphery of cutter at cutting edge.
- **Secondary clearance angle-** angle formed by secondary clearance surface of tooth with a line drawn tangent to periphery of cutter at cutting angle.
- **Rack angle(radial)-** angle measured in diametral plane between face of tooth and a radial line passing through tooth cutting edge.
- **Lip angle-** Included angle between land and face of tooth.

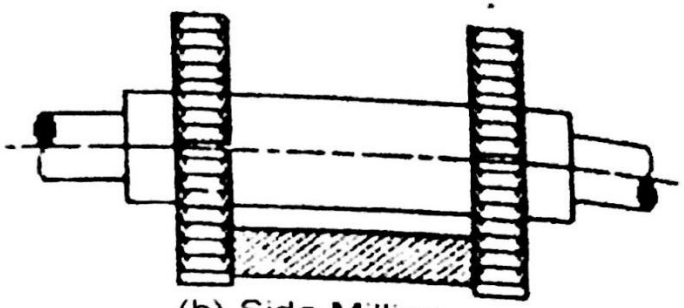
Operation in milling machine

- Plain milling
- Side milling
- Angular milling
- Gang milling
- Form milling
- Keyway milling
- Straddle milling

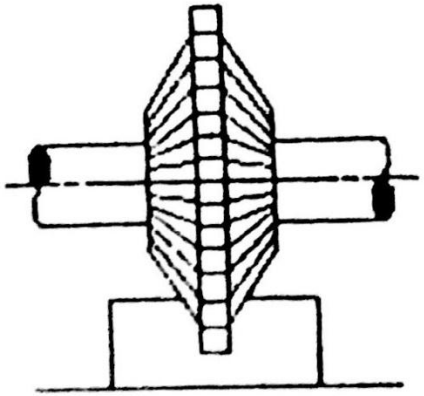
Slab



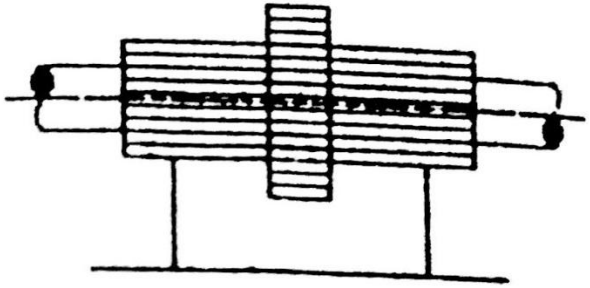
(a) Plain Milling



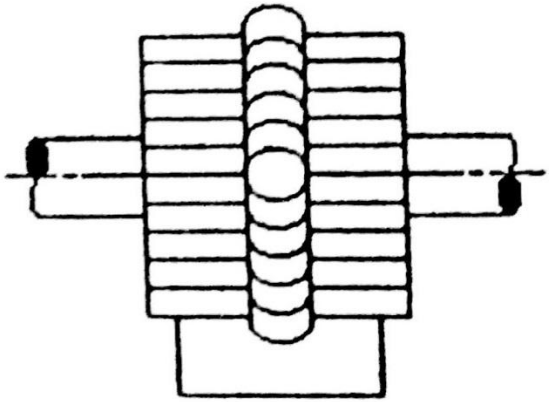
(b) Side Milling



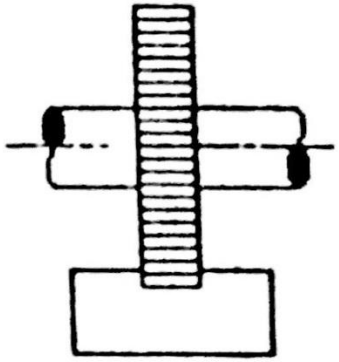
(c) Angular Milling



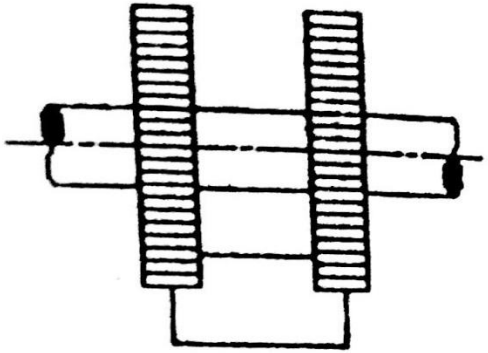
(d) Gang Milling



(e) Form Milling



(f) Keyway Milling



(g) Straddle Milling

Indexing

- Operation of dividing periphery of a work into any number of equal parts.
- Indexing is accomplished by special attachments known as dividing heads.
- Dividing heads
  - Plain or simple dividing heads
  - Universal dividing heads

Universal dividing head

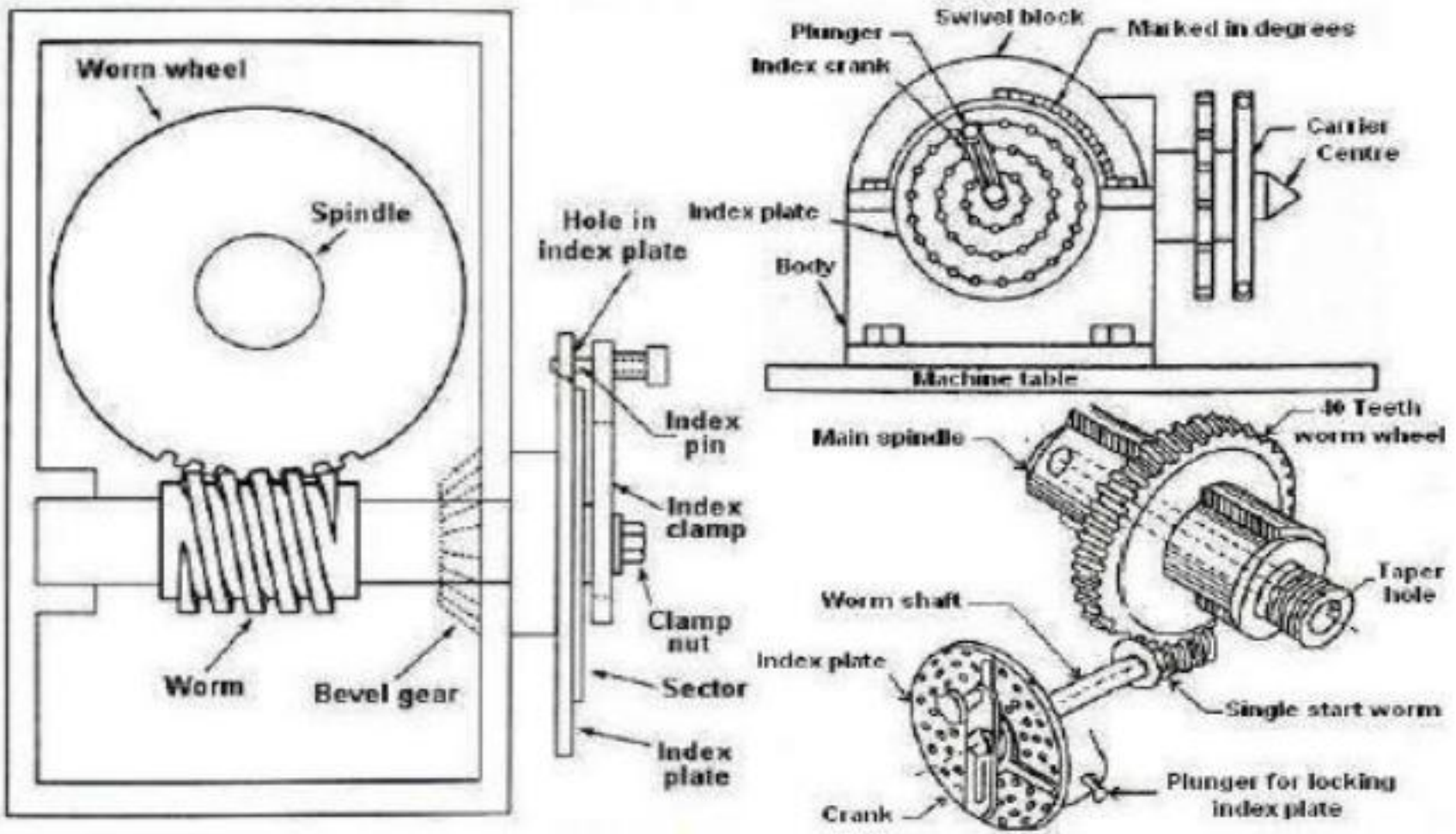


Fig. 3.67 Dividing head

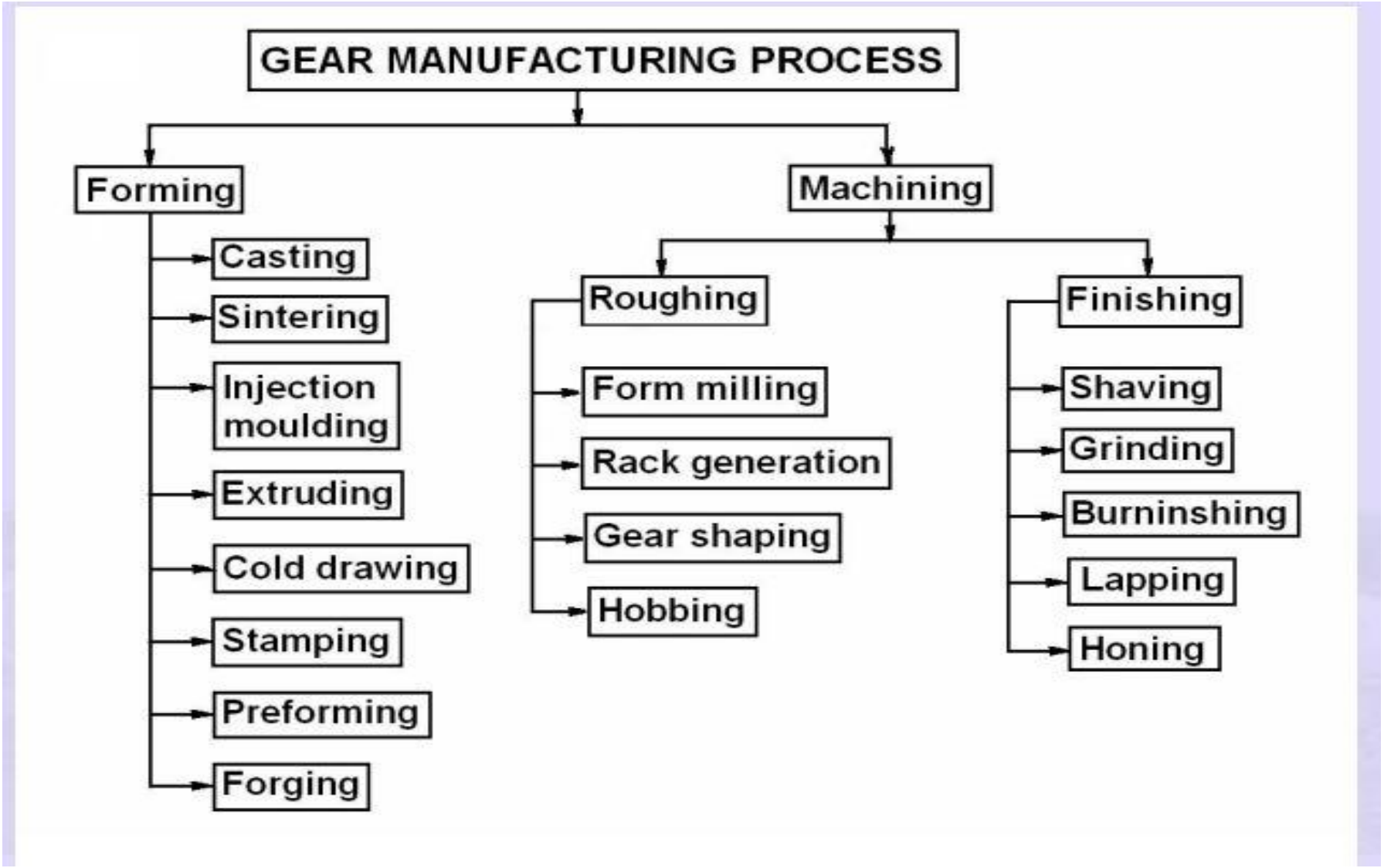
Methods of indexing

- Direct or rapid indexing
- Plain or simple indexing
- Differential indexing
- Angular indexing.

Specification of milling machine

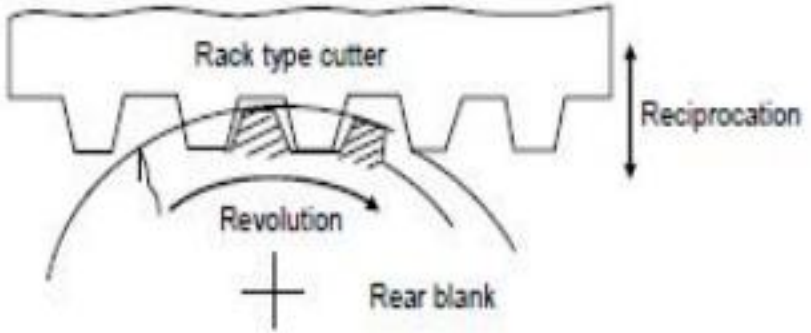
- Table length and width
- Maximum longitudinal cross and vertical travel of table
- Number of spindle speeds and feeds
- Power of driving motor
- Standard taper hole size of spindle
- Net weight of machine
- Distance from spindle nose to table surface.

Gear manufacturing methods



Gear generation process

- Gear shaping
- Gear planning or rack cutter generation process.
- Gear hobbing



Gear shaping

- Shaper cutter generating process

gear teeth. A gear shaper

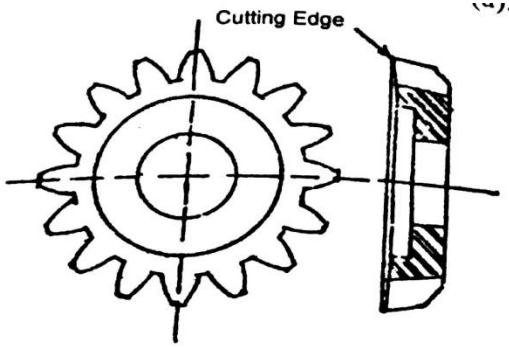


Figure 4.47(a) Gear Shaper Cutter

The figure 4.47(b) shows the setup and operation of a gear shaper cutter.

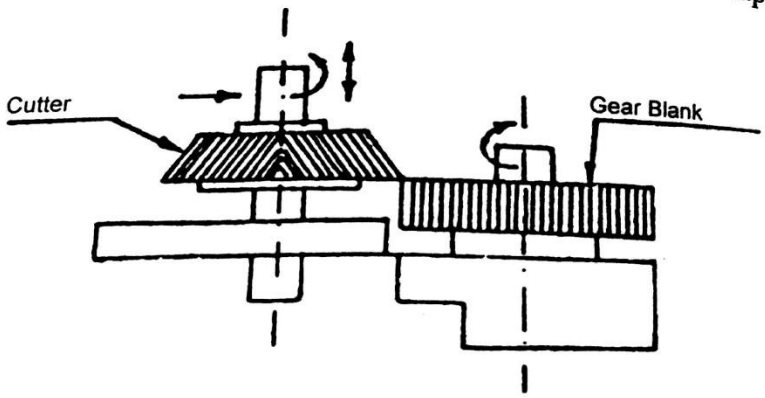


Figure 4.47(b) Setup of Shaper Cutter Gear Generating Process

- Pinion cutter generating process

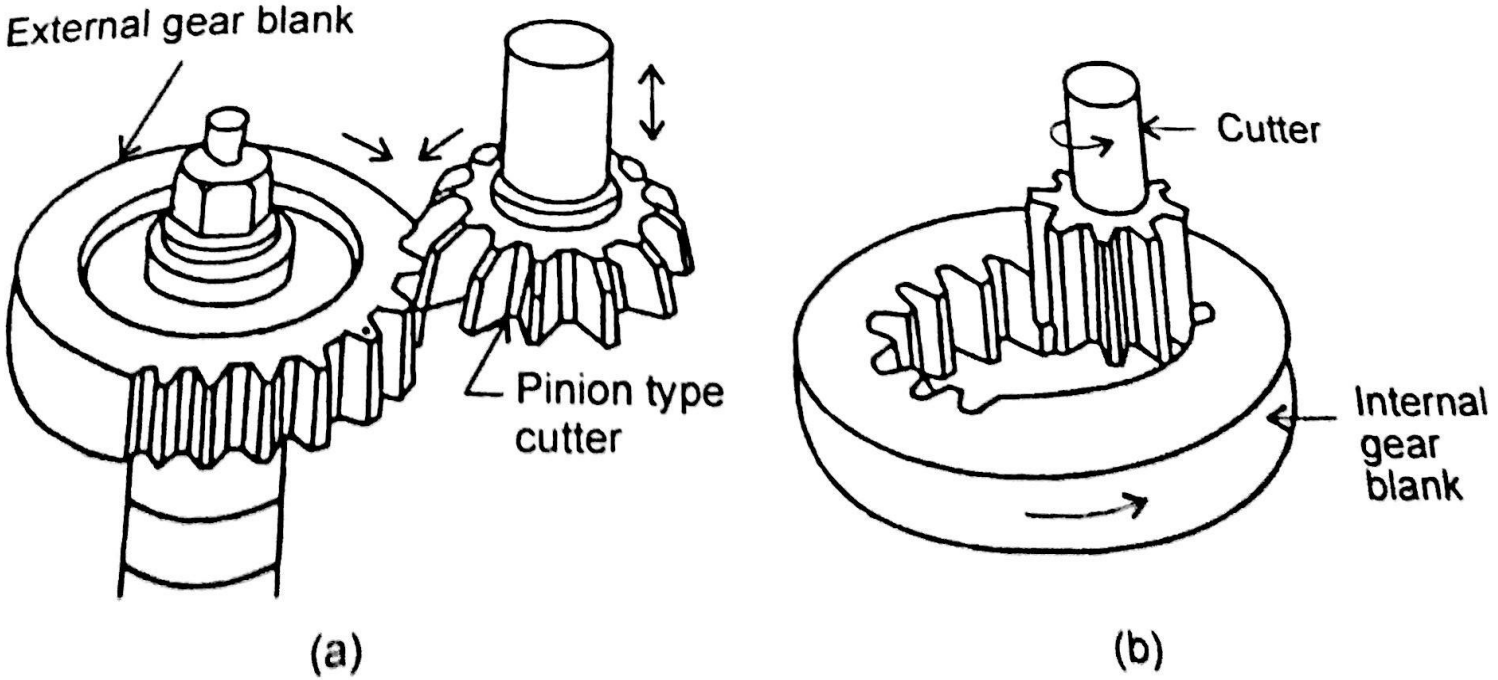
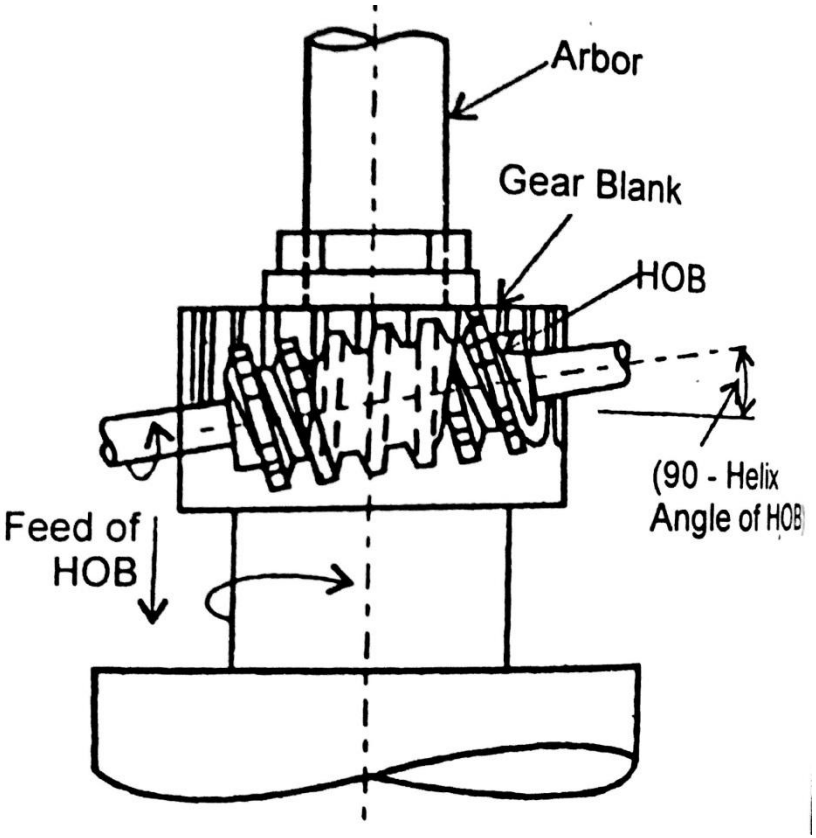
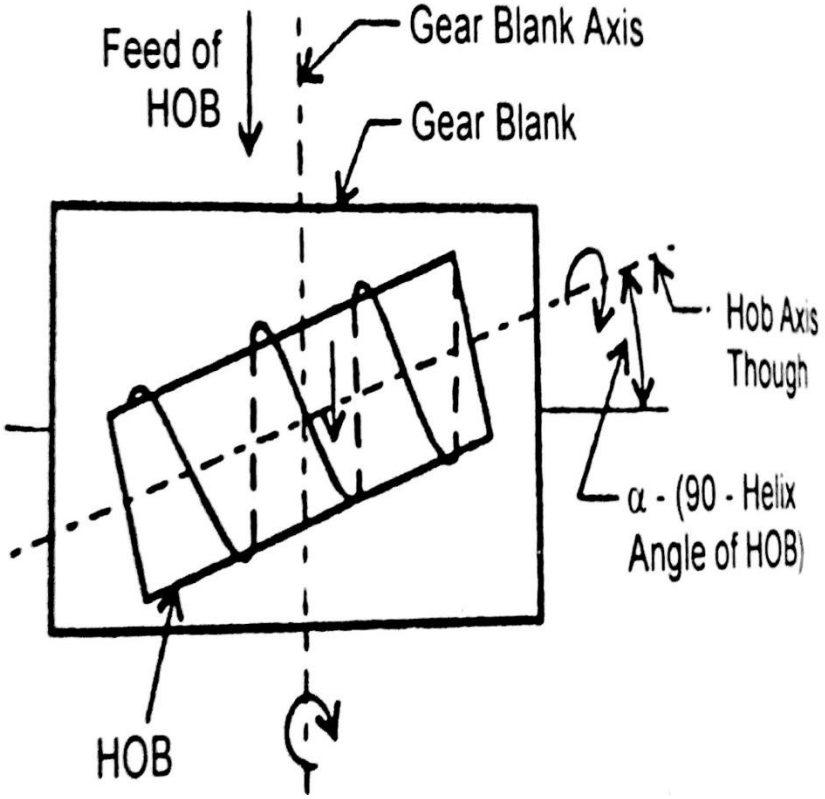


Figure 4.48 Pinion Cutter Generating Process

Gear hobbing



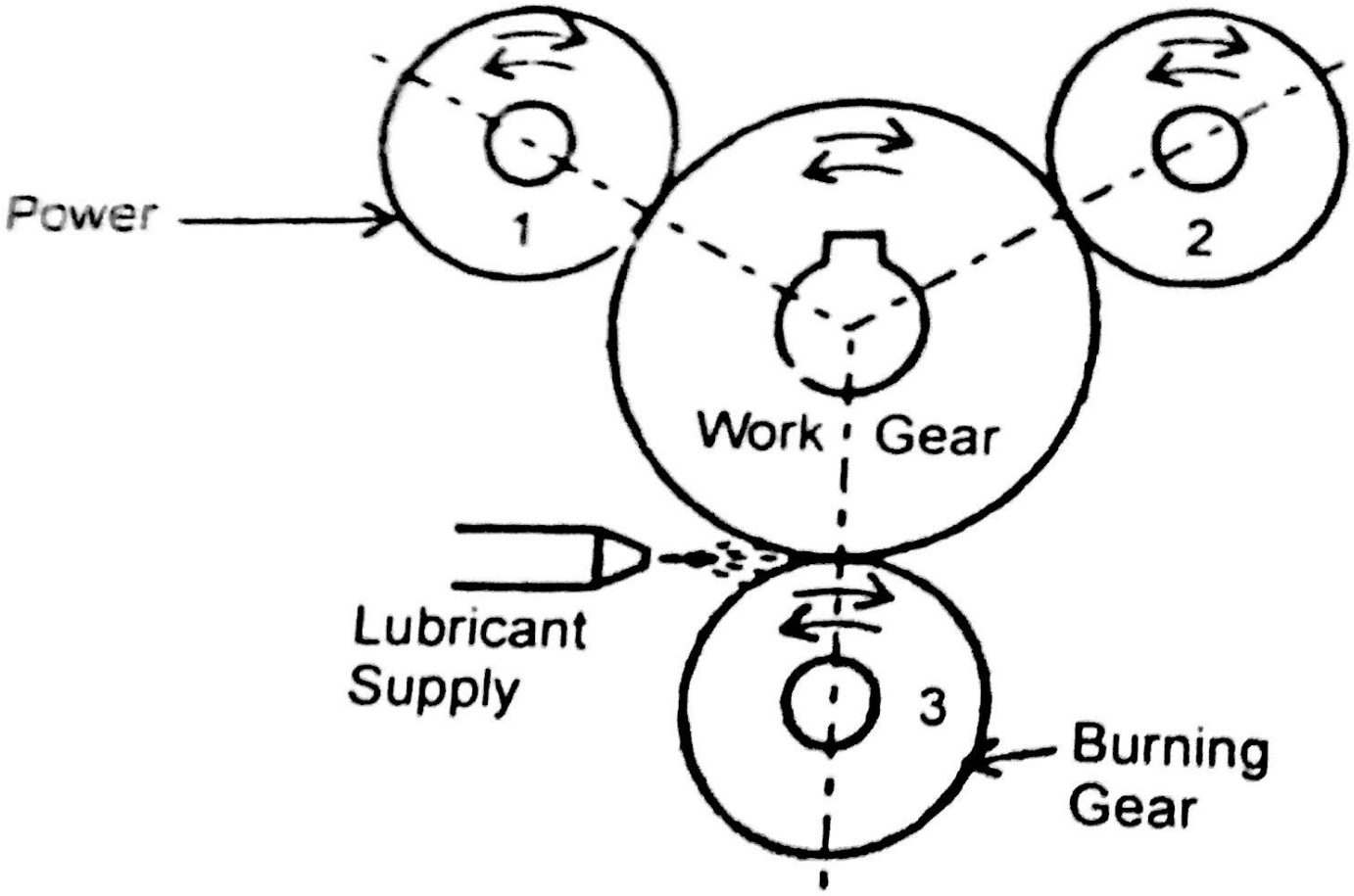


- **Application**
- Generating spur, helical and worm gears.
- **Advantages**
- A single hob with given module can be used for generating gear with any number of teeth of same module.
- The same hob can be used for spur and helical gears.
- Operation is continuous. So very fast rate of production.
- Perfect tooth shape is obtained.
- Process is automatic and so less skilled operator is sufficient.
- Worm gears are generated only by hobbing.
- Multiple blanks can be cut at a time. Hence high rate of production.

Gear finishing process

- For gears not hardened
  - Gear burnishing
  - Gear shaving
- For gears which are hardened
  - Gear grinding
    - Formed wheel grinding
    - Generation gear grinding
  - Gear lapping

Gear burnishing

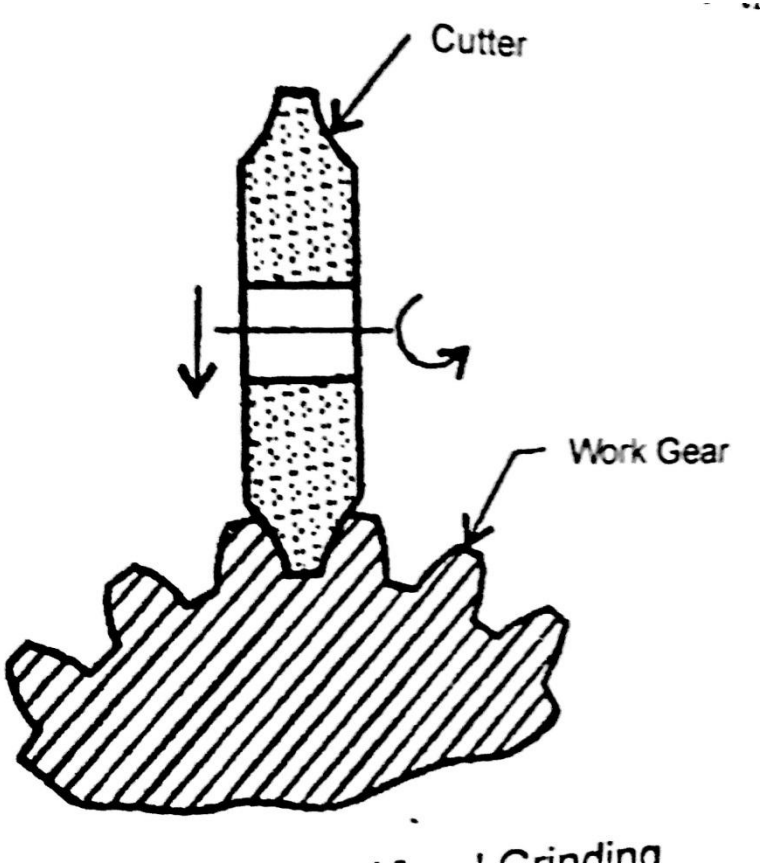


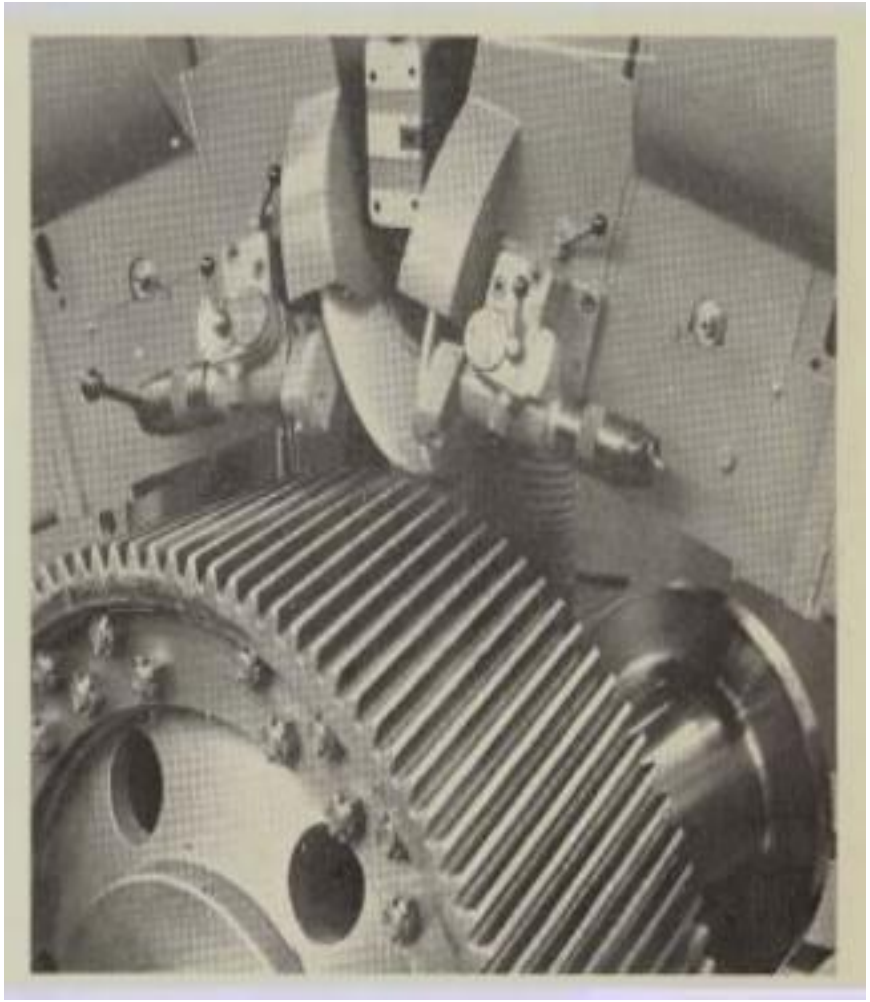
GEAR SHAVING

Gear shaving is a process of finishing of gear tooth by running it at very high rpm in mesh with a gear shaving tool. A gear shaving tool is of a type of rack or pinion having hardened teeth provided with serrations. These serrations serve as cutting edges which

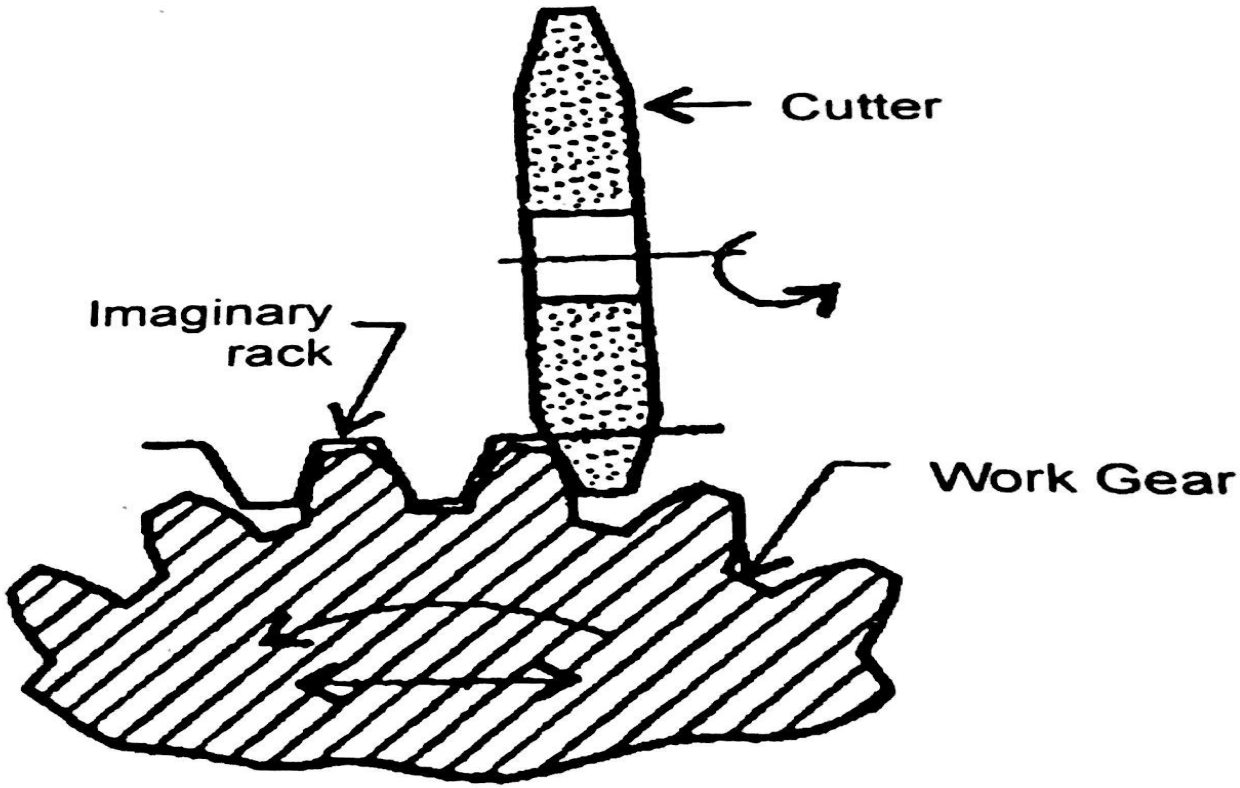
Gear grinding

- Formed wheel grinding

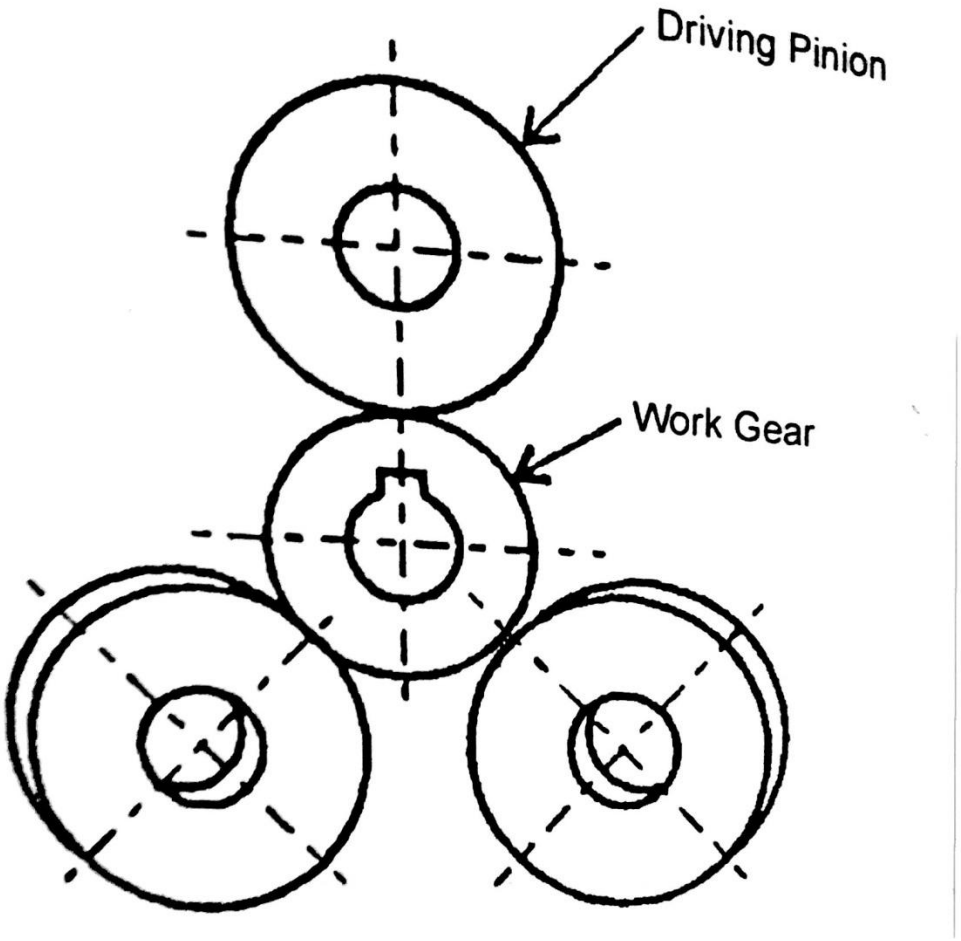




- Generation gear grinding



Gear lapping



WHAT IS LAPPING ?

- **Lapping** is a machining operation, in which two surfaces are rubbed together with an abrasive between them, by hand movement or by way of a machine.
- This can take two forms. The first type of lapping (traditionally called grinding), typically involves rubbing a brittle material such as glass against a surface such as iron or glass itself (also known as the "lap" or grinding tool) with an abrasive such as aluminum oxide, jeweller's rouge, optician's rouge, emery, silicon carbide, diamond, etc., in between them. This produces microscopic conchoidal fractures as the abrasive rolls about between the two surfaces and removes material from both.

Gear lapping

- Imparting very fine finish to gear teeth
- Improves the wear properties of gear teeth
- Free lapping : introducing abrasive slurry (Pr.) while the gears are engaged
- Fixed lapping : the lapping cutter is bonded with abrasive material like SiC
- The abrasives remove small amount of metal as the gears rotate
- Also takes care of surface imperfections.
- video