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# PRESENTATION

## Metal Cutting and Forming : (18ME45A)

**By**


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# Metal Cutting and Forming

**Syllabus of MCF covers basically - 2 Manufacturing Processes**

**- Metal Cutting - Metal Forming**

**Module -1, Module - 2 and Module - 3 : Metal Cutting.**

**Module - 4 and Module – 5 : Metal Forming.**

# Metal Cutting

**Metal cutting :** It is also called as **Machining process,** where extra metal (material) is removed From the workpiece in the **forms of chips** to get the required size and shape product.

**Eg:** Lathe operations, Milling operations, Drilling operations, Shaper, Planer and Slotting Operations, Grinding operations etc.

**Requirements :**

- Machine tools like Lathe, Drilling machine etc.
- Sharp and Hard cutting tools.
- Energy/Force to cut the metal (material)

# Metal Forming

**Metal forming :** It is also called as **Metal shaping process,** where the given volume of workpiece (Raw material) is **plastically deformed** to get the required size and shape product.

**Eg.** Forging, Rolling, Extrusion, Drawing and Sheet metal forming etc.

**Requirements:**

- Machine Tools like Forging machine, Rolling machine etc,.
- Hard Dies (Tools) of required shape and size and
- Energy/Force required to deform the metal plastically to get the required size and shape product.

# Syllabus of Metal Cutting and Forming (MCF)

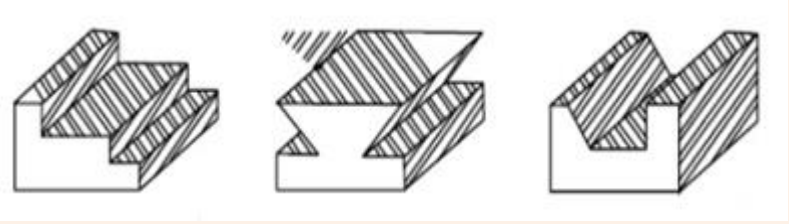
## Module-2

- **Milling:** Various Milling operation, classification of milling machines, Vertical & Horizontal milling, up milling & down milling. Indexing: need of indexing, simple, compound & differential indexing.
- **Drilling:** Difference between drilling, boring & reaming, types of drilling machines. Boring operations & boring machines.
- **Shaping, Planning and Slotting machines**-machining operations and operating parameters.
- **Grinding:** Grinding operation, classification of grinding processes: cylindrical, surface & center-less grinding.

# Milling

**Milling :** Milling is a metal cutting operation in which the excess material from the work piece is removed by a rotating multipoint cutting tool called milling cutter.

- **Milling Machine :** It is a machine tool that removes excess material from the work piece using rotating multipoint cutting tool called milling cutter.
- When the rotating milling cutter touches the work piece the excess material is removed from the work piece in the form of chips to get a required shape and size product.
- Milling machines are used to obtain flat surfaces, contoured surfaces, external and internal teeth on gear blanks and also helical surfaces.



**Milling Operations:** Any metal cutting operations performed in milling machine are called **Milling operations.**

**Various types of Milling operations are:**

1. Plain/Flat surface milling.
2. Face milling.
3. Side milling.
4. Straddle milling.
5. Angular milling.
6. Gang milling.
7. Form milling.
8. Profile milling.
9. End milling.
10. Slot milling.
11. Gear cutting.
12. Special milling operations : Saw milling, Helical milling, Cam milling, Thread milling etc.

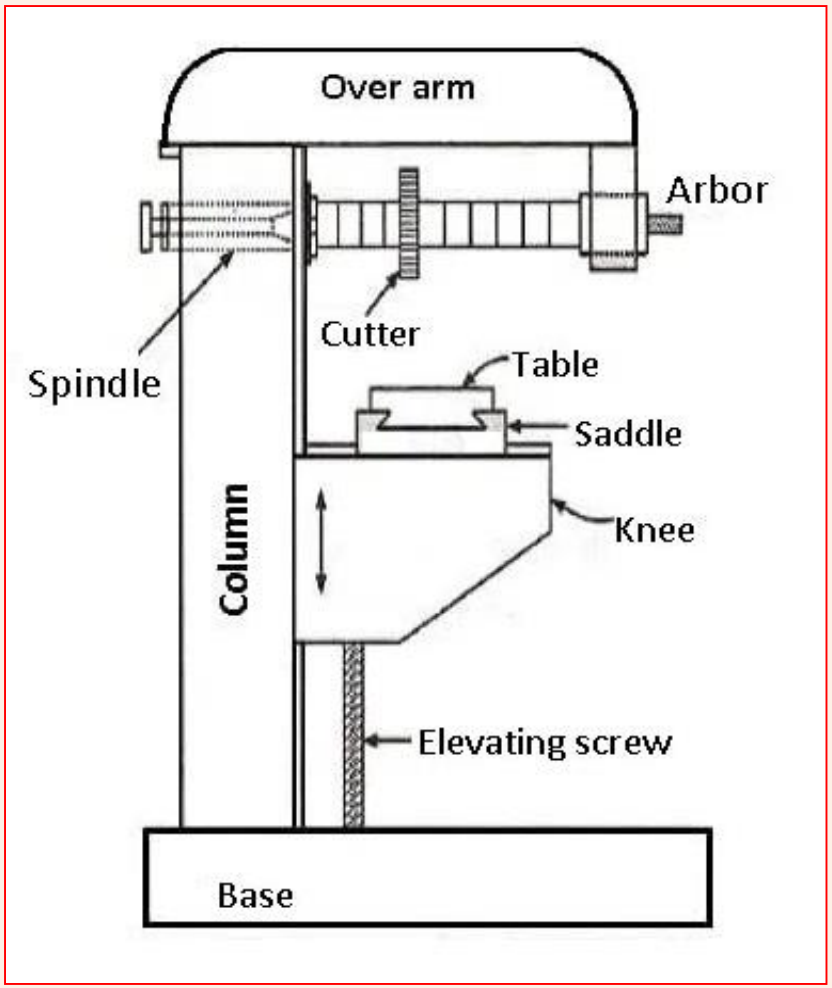
## Classification of Milling machines:

**Milling machines may be classified in various forms .**

**Based on constructional features, Spindle position, Bed type etc.**

1. **Column and Knee type Milling Machine.**
   - **Plain or Horizontal Milling machine.**
   - **Vertical Milling Machine.**
   - **Universal Milling Machine.**
2. **Fixed bed type Milling Machines.**
   - **Simplex milling machine, Duplex milling machine, Triplex milling machine.**
3. **Planer type milling machine.**
4. **Special type milling machine.**
   - **Rotary table milling machine.** - **Drum milling machine.**
   - **Pantograph milling machine.** - **Profile tracer milling machine. Etc.**

# Horizontal Milling machine (Column and Knee type)



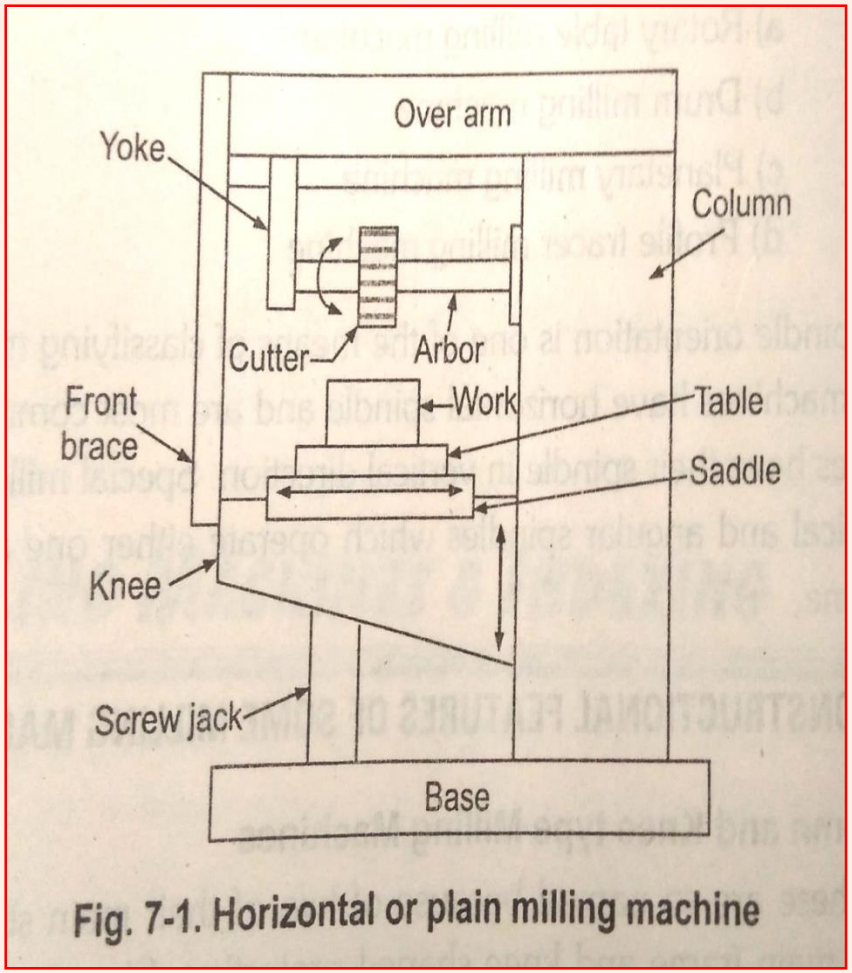
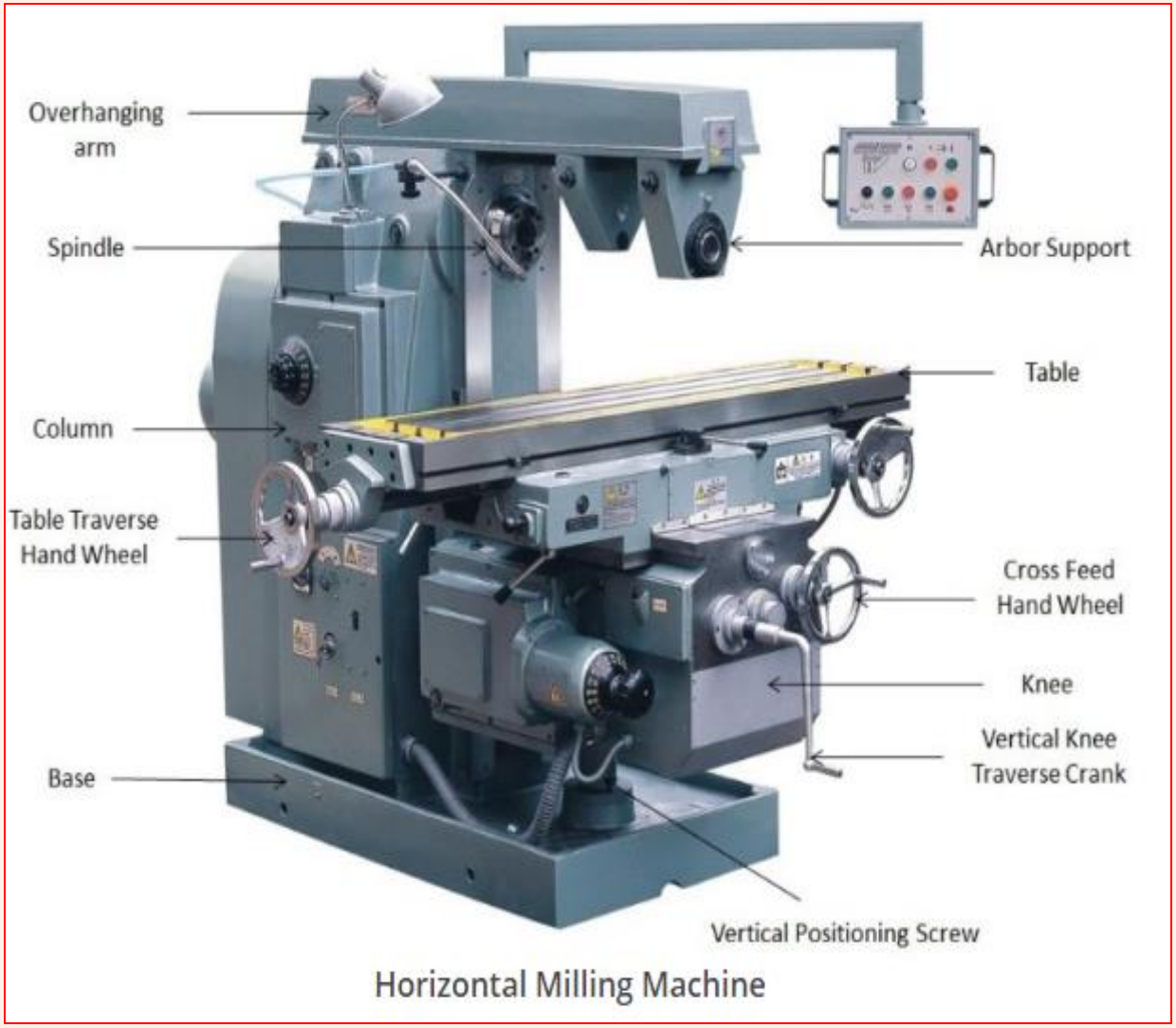



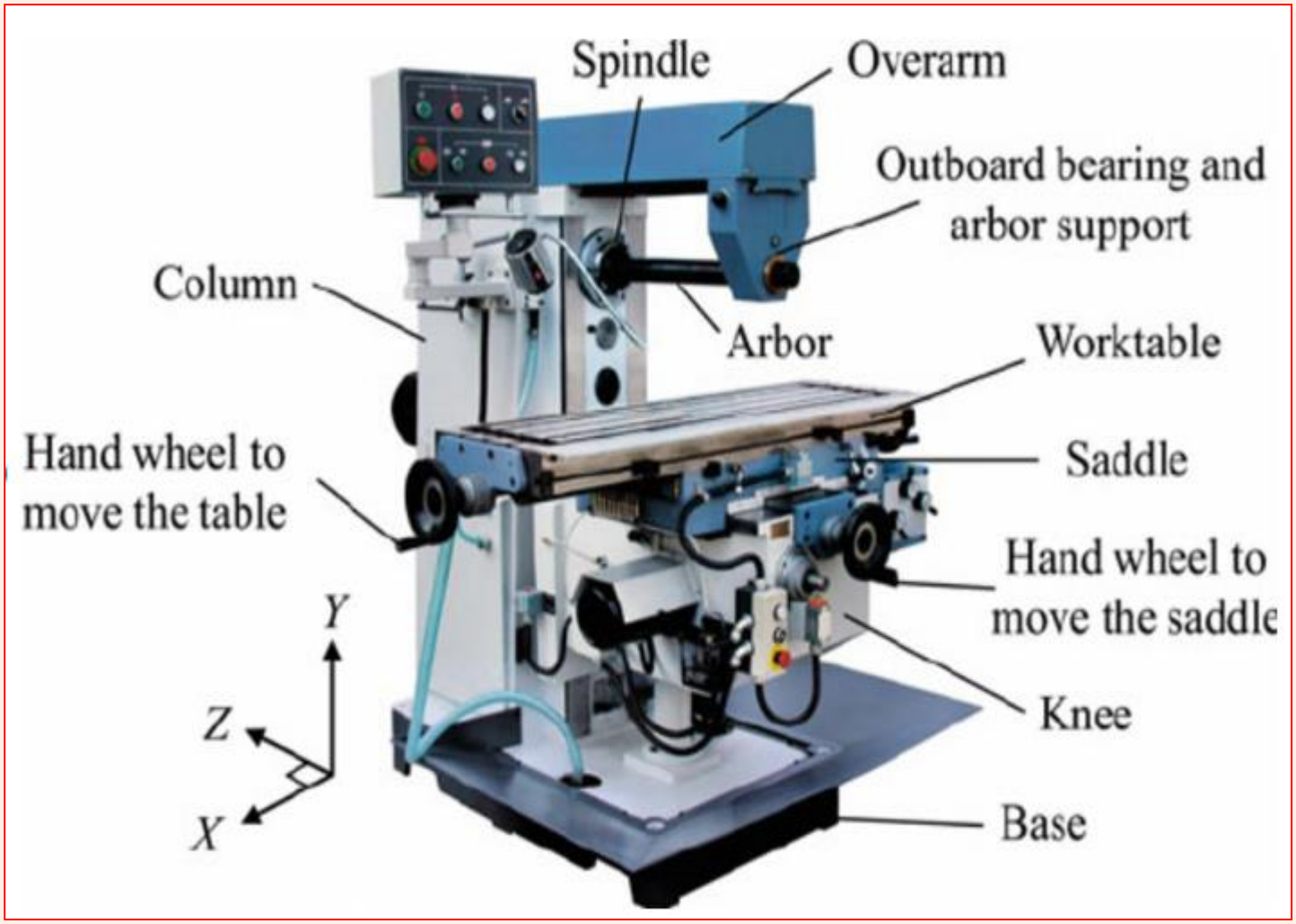

Fig. 7-1. Horizontal or plain milling machine

# Horizontal Milling Machine

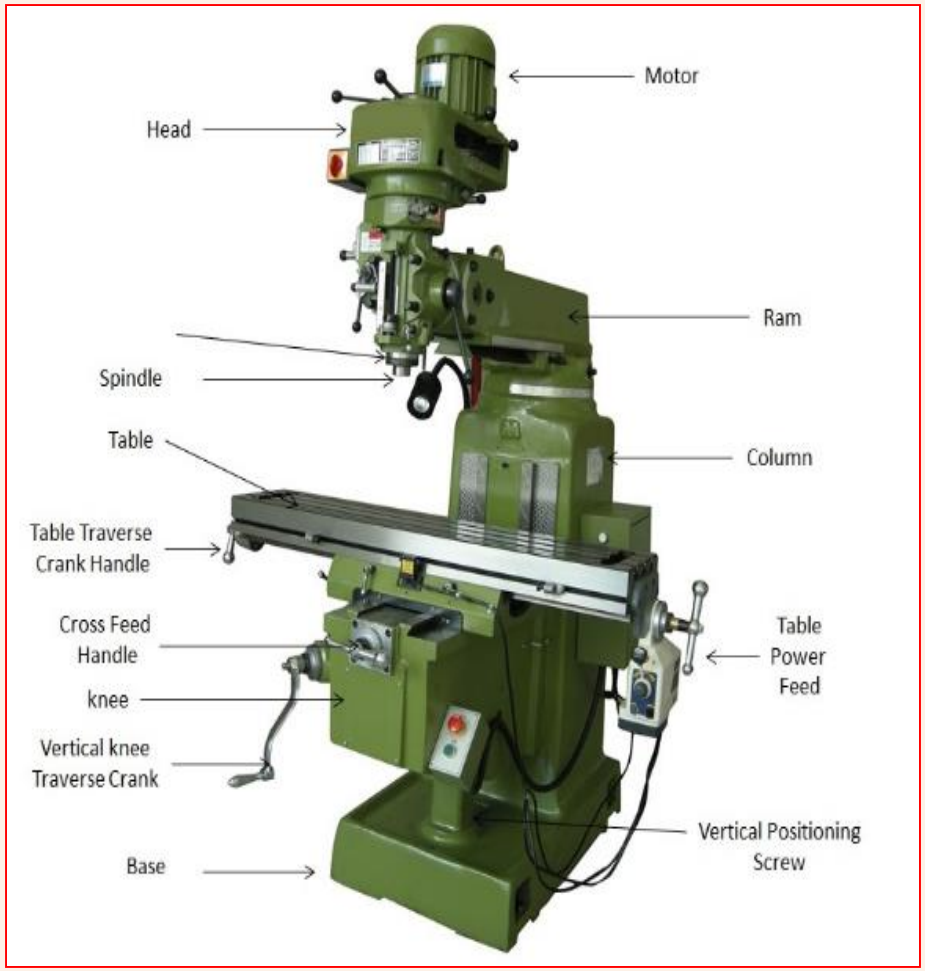



Horizontal Milling Machine

# Horizontal Milling Machine



# Vertical Milling Machine



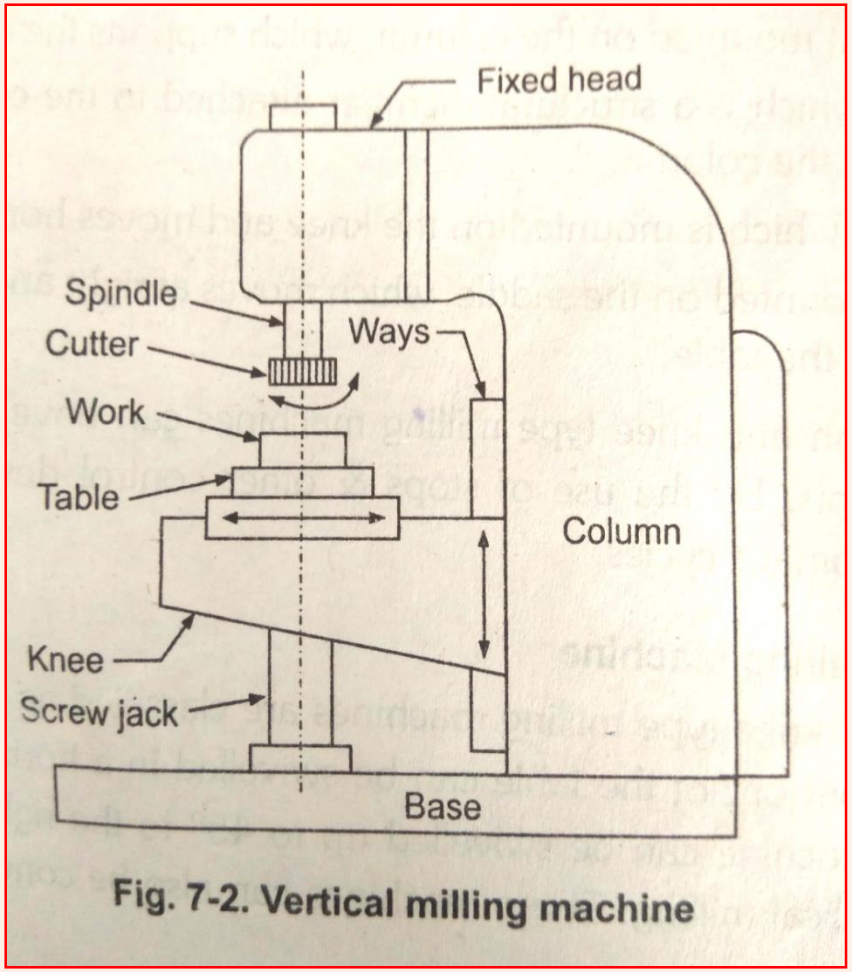
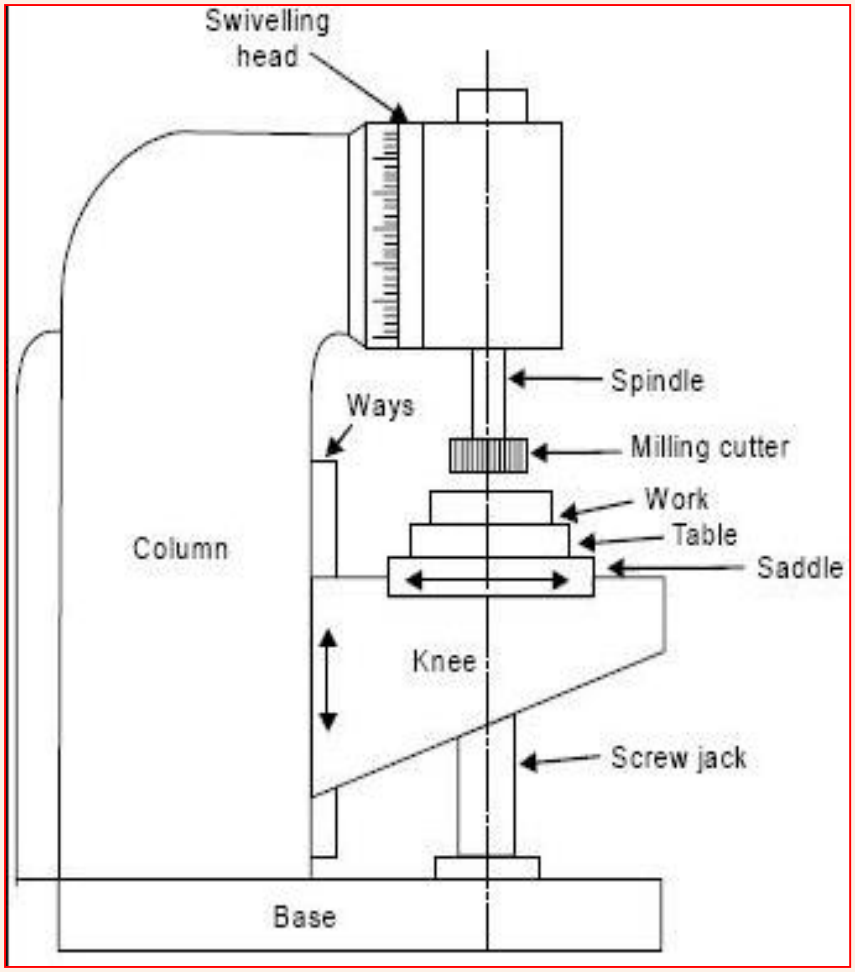



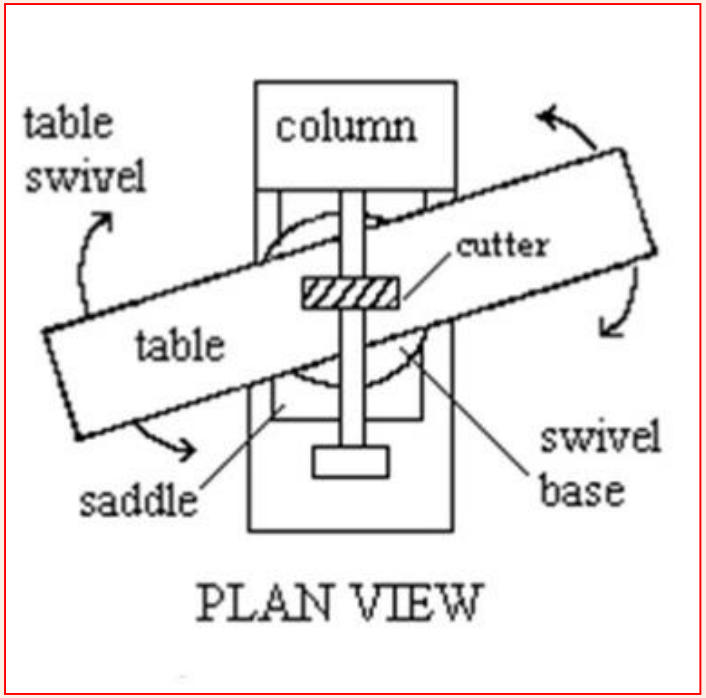

Fig. 7-2. Vertical milling machine

# Vertical Milling machine (Column and Knee type)

# Universal Milling machine (Column and Knee type)




**Horizontal UMM, Table is swiveled**




**In Universal milling machine (Vertical), spindle head can be swiveled 45* to either side to the centre line and thus fed at an angle to the spindle.**

# Fixed Bed type Milling machine

The table is mounted directly on the guideways of a fixed bed. The table movement is restricted to reciprocating at a right angle to the spindle axis with no provisions for cross or vertical adjustment.

It is classified as simplex, duplex, triplex based on a machine provided with the single, double and triple spindle heads respectively.

Simplex – single spindle head.

Duplex – two-spindle head.

Triplex – three spindle head.

# Planer type Milling Machine

It is a massive machine used for heavy-duty lengthy work pieces having spindle heads adjustable in the vertical and transverse direction.

It relates to a planer and like a planing machine. This machine has a cross rail capable of being raised or lowered carrying the cutters. It has their heads, and the saddles, all supported by rigid uprights.

# Rotary table Milling Machine

Here the table is circular in nature and rotates about a vertical axis. Here cutters are set at different heights. Which results in one cutter roughing the workpiece and other one cutter finishing them.

The advantage of this machine is that continuous loading and unloading of workpieces can be done by the operator, while work is in progress.

# pantograph mechanism

# Pantograph Milling Machine

A pantograph machine can duplicate a job by using a pantograph mechanism. It allows the size of the workpiece reproduced to be smaller than, equal to or greater than the size of a template. Also used for the different model for special purposes.

A pantograph is a mechanism that is generally constructed of four bars or links which are connected in the form of a parallelogram.

Pantograph machines are available in two dimensional and three-dimensional models. The two-dimensional pantograph is used for engraving letters or other designs. Whereas three-dimensional models are employed for copying any shape and contour of the workpiece.

## Milling Methods / Processes:

**Milling Methods / Processes can be classified as follows:**

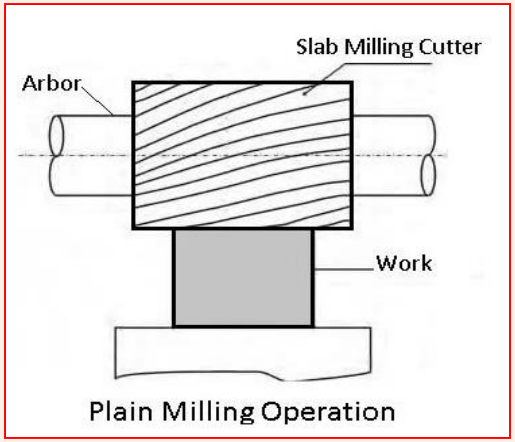
1. **Peripheral milling**
   - **Up-Milling (Conventional Milling)**
   - **Down-Milling (Climb Milling)**
2. **Face Milling.**
3. **End Milling.**

## Peripheral Milling

It is the machining operation performed by a plain milling cutter to produce a machined surface parallel to the axis of rotation of the cutter.

Peripheral milling is classified under 2 types:

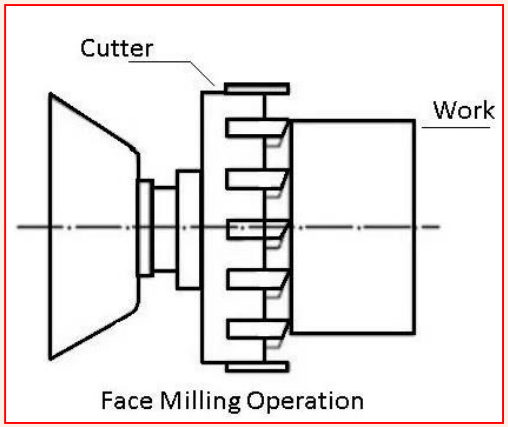
1. Up milling  2. Down milling



Plain Milling Operation

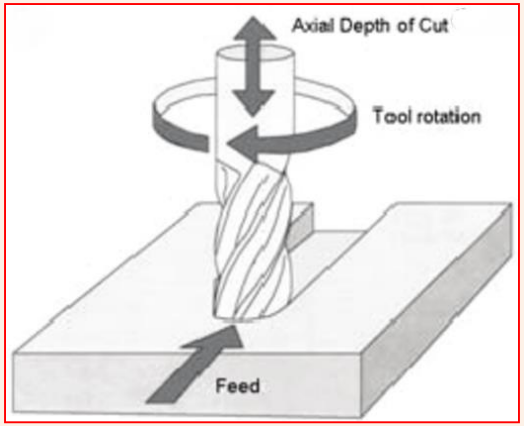
## Face Milling

It is the operation performed by a milling cutter to produce a flat-machined surface perpendicular to the axis of rotation of the cutter.



Face Milling Operation

The peripheral cutting edges of the cutter do the actual cutting, whereas the face cutting edges finish up the work surface by removing a very small amount of the metal.

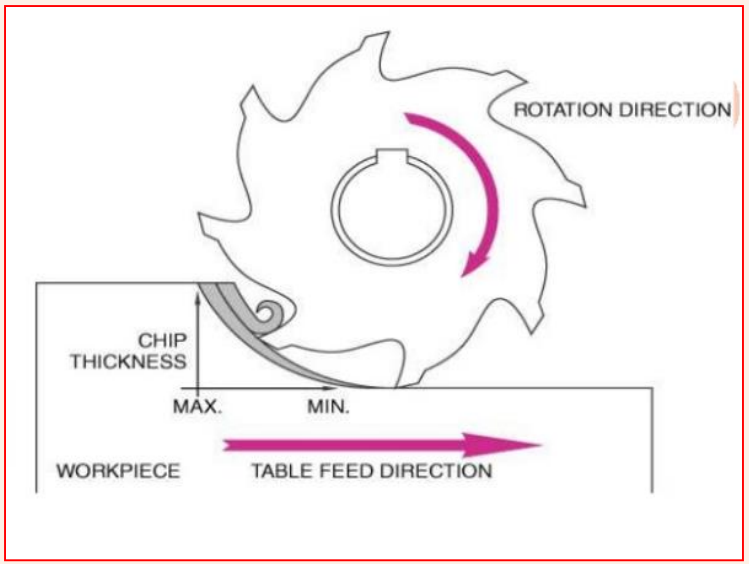



## End Milling

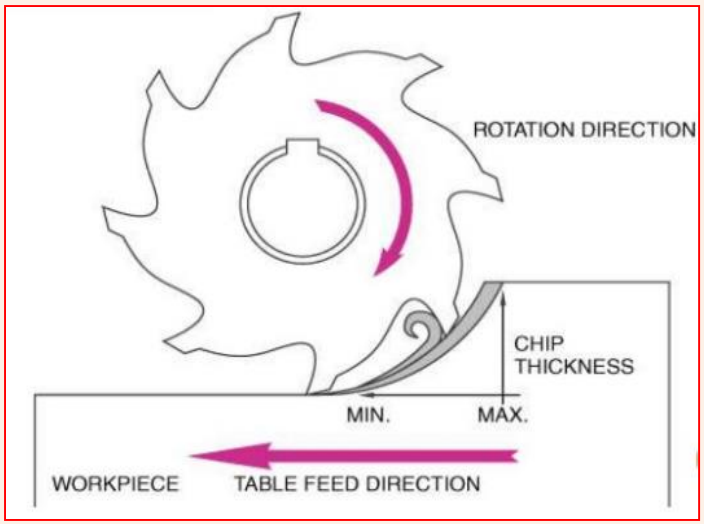
End milling is the combination of peripheral and face milling.

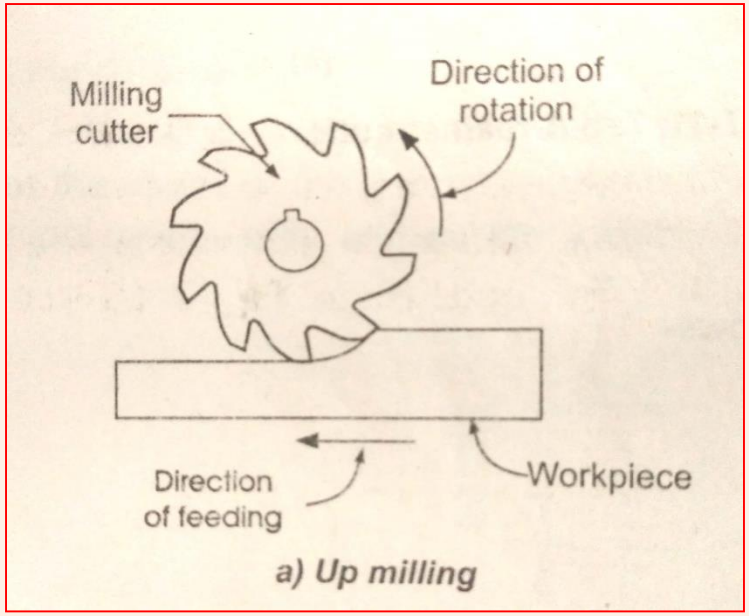
# Peripheral Milling - Up Milling & Down Milling

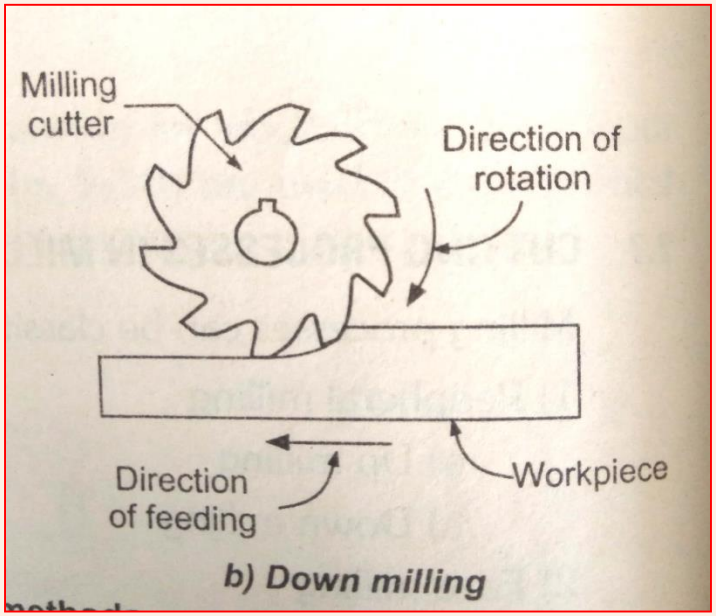
## Up Milling (Conventional Milling)




## Down Milling (Climb Milling)



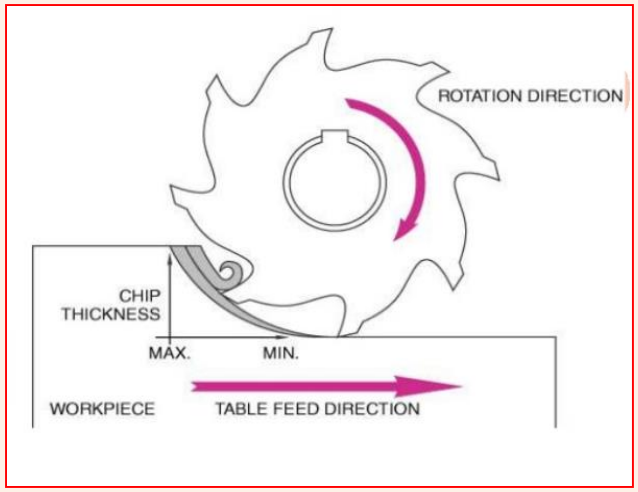



## Up Milling (Conventional Milling)

1.Up-milling or conventional milling

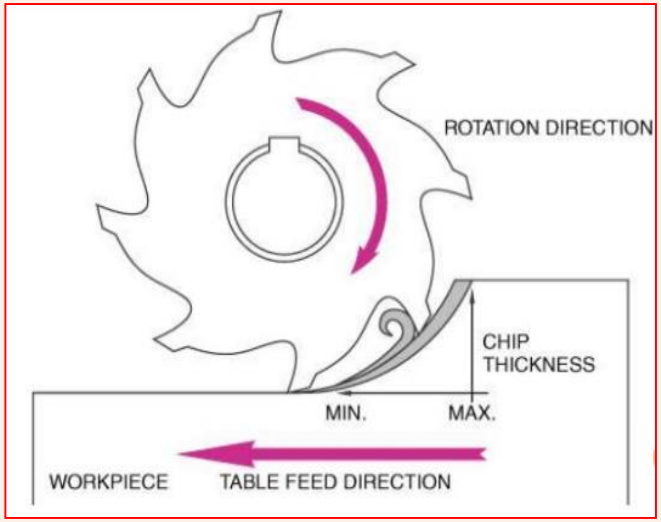
- Metal is removed by cutter rotating against the direction of travel of the workpiece.
- Needs stronger holding of the job.
- Chip thickness is minimum at the start of cut and maximum at the end of the cut.
- Disadvantage- tendency to lift work from the fixtures and poor surface finish.




## Down Milling (Climb Milling)

2.down-milling or climb milling

- Metal is removed by cutter rotating in the same direction of travel of the workpiece.
- teeth cut downward instead of upwards.
- Chip thickness is maximum at the start of cut and minimum at the end of cut.
- Less friction involved
- Better surface finish.
- Less power consumption.






- Advantage: Does not tend to lift the workpiece from the fixtures.

# Difference between Up Milling & Down Milling

| Sr No. | Up Milling | Down Milling |
|---|---|---|
| 1 | There is a tendency to lift the work piece so extra clamping force is required | Forces are enough on job to press to press down. So no need of extra clamping forces |
| 2 | Cutter rotates against direction in which the work being fed | Cutter rotates in similar direction in which the work being fed |
| 3 | Cutting force varies from Zero to max. | Cutting force varies from max to zero |
| 4 | Chip thickness varies from minimum to maximum | Chip thickness varies from max to minimum |
| 5 | Higher surface finishing can be obtained | Obtains lower surface finish |
| 6 | Use of cutting fluid is difficult | Use of cutting fluid is easy |
| 7 | Job and tool movement is opposite direction | Job and tool movement in same direction |

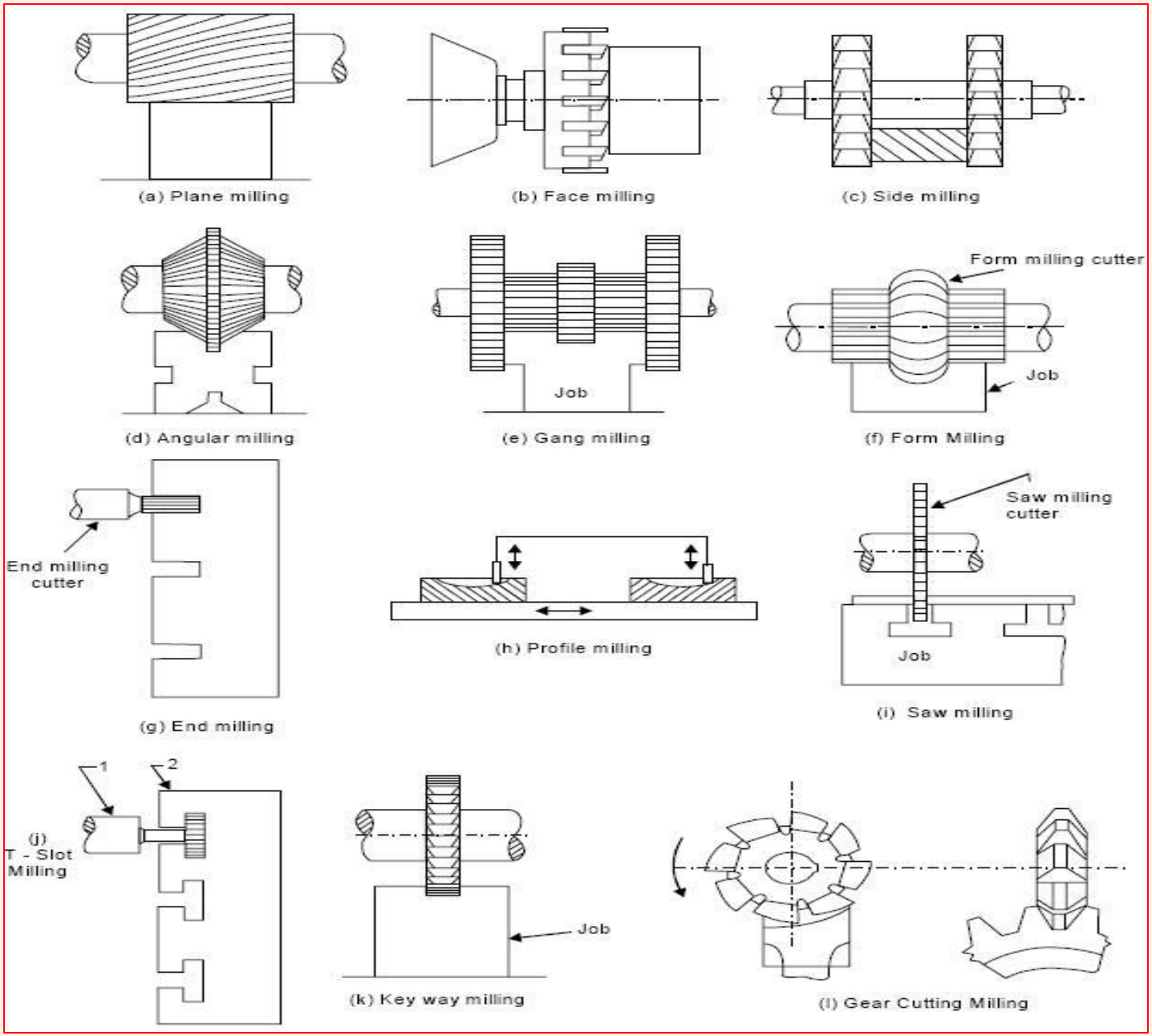
# Milling Operations

**Milling Operations:** Any metal cutting operations performed in milling machine are called **Milling operations.**

**Various types of Milling operations are:**

1. Plain/Flat surface /Slab milling.
2. Face milling.
3. Side milling.
4. Straddle milling.
5. Angular milling.
6. Gang milling.
7. Form milling.
8. Profile milling.
9. End milling.
10. Slot / Key way milling.
11. Gear cutting.
12. Special milling operations : Saw milling, Helical milling, Cam milling, Thread milling etc.

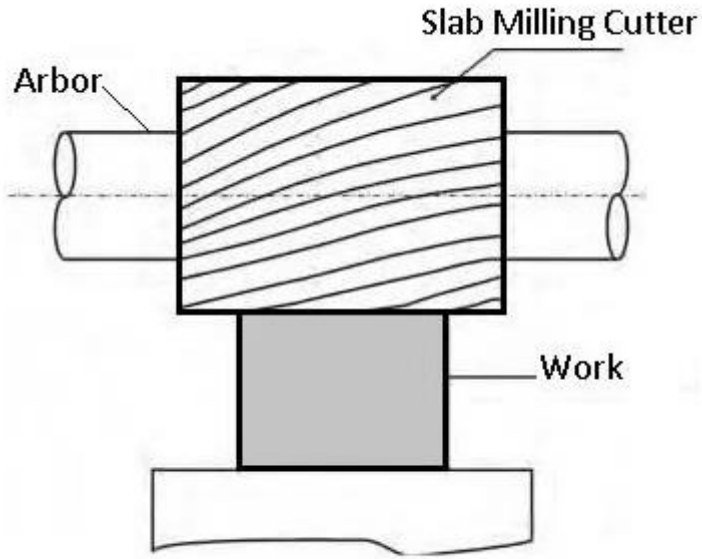
# Various Milling Operations



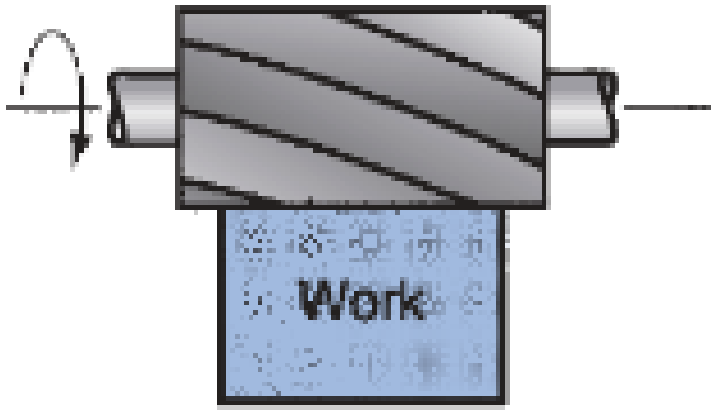
## 1. Plain/Flat surface /Slab milling.

**Tool - Plain/slab Milling cutter**

- The plain milling is the most common type of milling machine operations.
- Plain milling is performed to produce a plain, flat, horizontal surface parallel to the axis of rotation of a plain milling cutter.
- The operation is also known as slab milling.
- To perform the operation, the work and the cutter are secured properly on the machine.
- The depth of cut is set by rotating the vertical feed screw of the table. And the machine is started after selecting the right speed and feed.



Plain Milling Operation

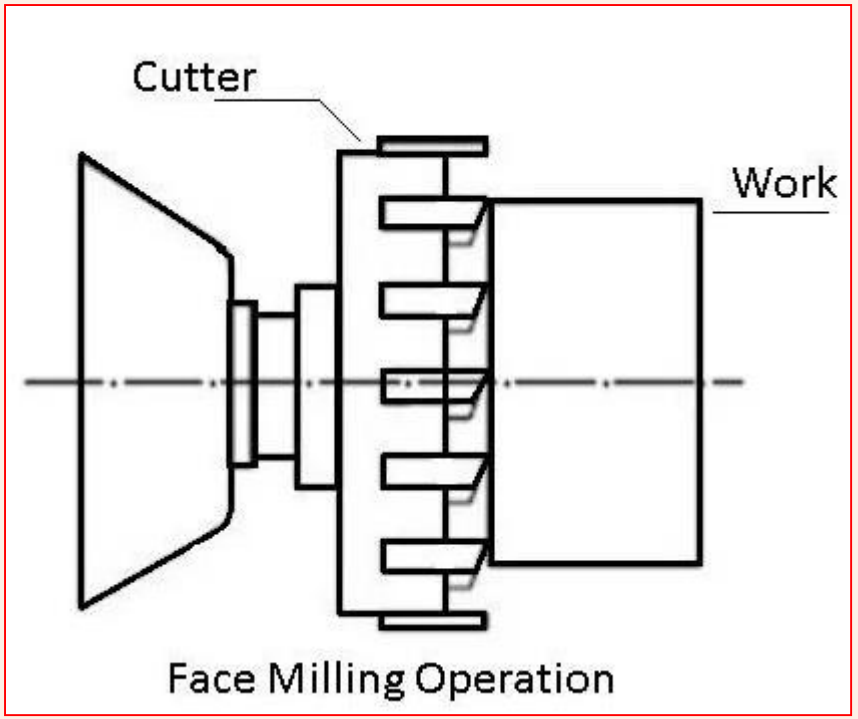


(a)

## 2. Face Milling

- The face milling is the simplest milling machine operations.
- This operation is performed by a face milling cutter rotated about an axis perpendicular to the work surface.
- The operation is carried in plain milling, and the cutter is mounted on a stub arbor to design a flat surface.
- The depth of cut is adjusted by rotating the cross feed screw of the table.

**Tool – Face Cutter**

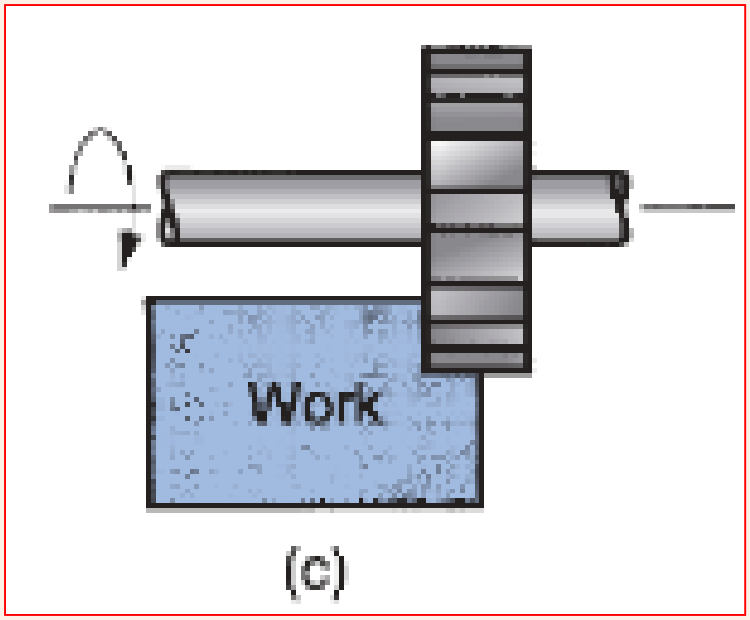


Face Milling Operation

## 3. Side Milling

**Tool – Side milling Cutter**

- **The side milling is the operation of producing a flat vertical surface on the side of a workpiece by using a side milling cutter.**
- **The depth of cut is set by rotating the vertical feed screw of the table.**



# Straddle Milling

**Tool – Side milling Cutter**

- The straddle milling is the operation of producing a flat vertical surface on both sides of a work-piece by using two side milling cutters mounted on the same arbor.
- Distance between the two cutters is adjusted by using suitable spacing collars.
- The straddle milling is commonly used to design a square or hexagonal surfaces.

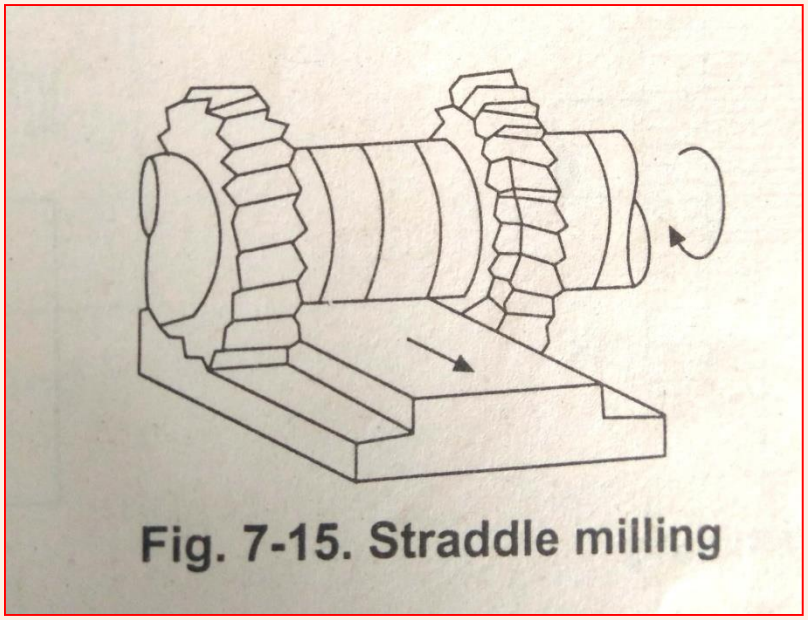
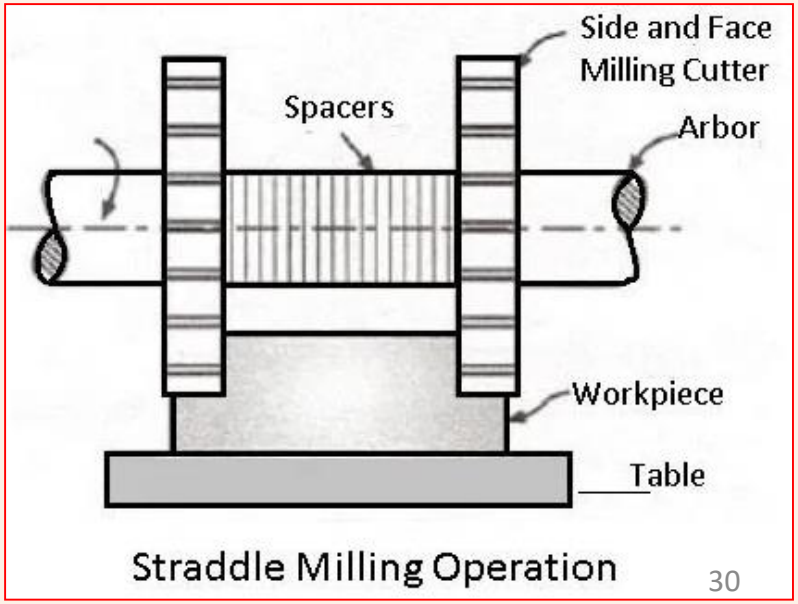


Fig. 7-15. Straddle milling




Straddle Milling Operation

# Angular Milling

**Tool – Angular millingCutter**

- The angular milling is the operation of producing an angular surface on a work-piece other than at right angles of the axis of the milling machine spindle.
- The angular groove may be single or double angle and may be of varying included angle according to the type and contour of the angular cutter used.
- One simple example of angular milling is the production of V-blocks.

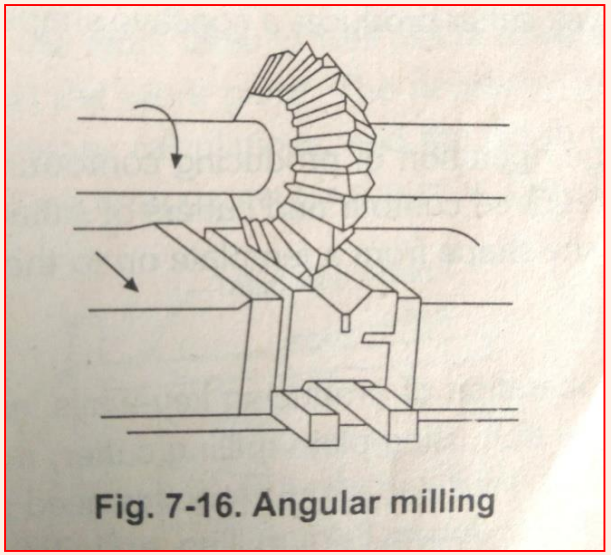
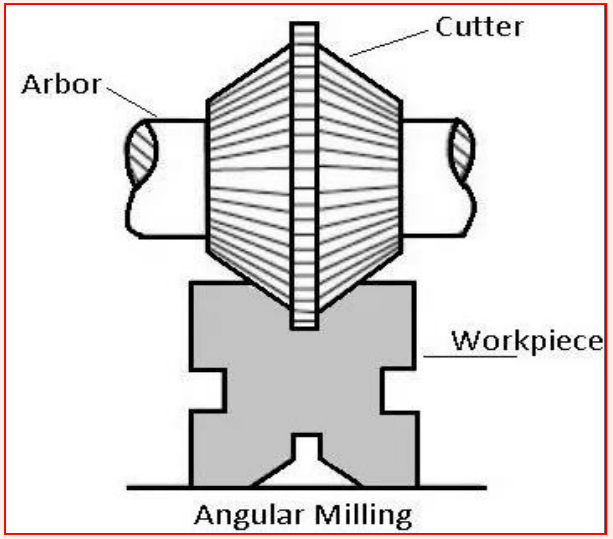


Fig. 7-16. Angular milling



# Gang Milling

- The gang milling is the operation of machining several surfaces of a work-piece simultaneously by feeding the table against a number of cutters having the same or different diameters mounted on the arbor of the machine.
- The method saves much of machining time and is widely used in repetitive work.
- Cutting speed of a gang of cutters is calculated from the cutter of the largest diameter.

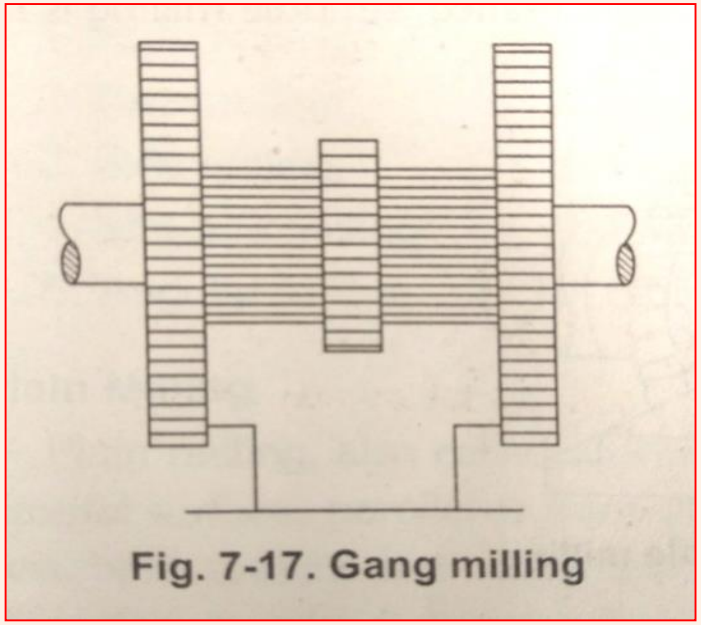
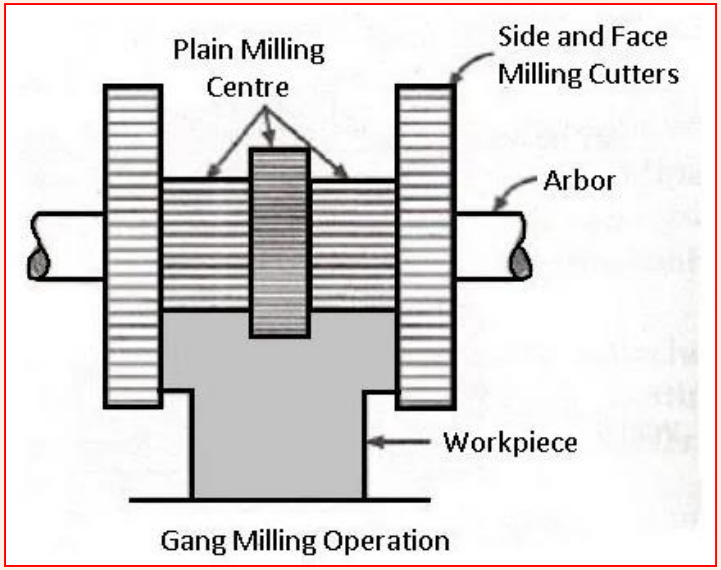


Fig. 7-17. Gang milling

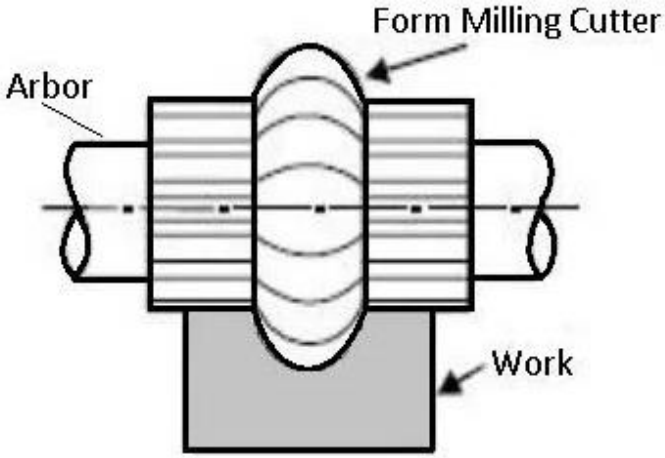



Gang Milling Operation

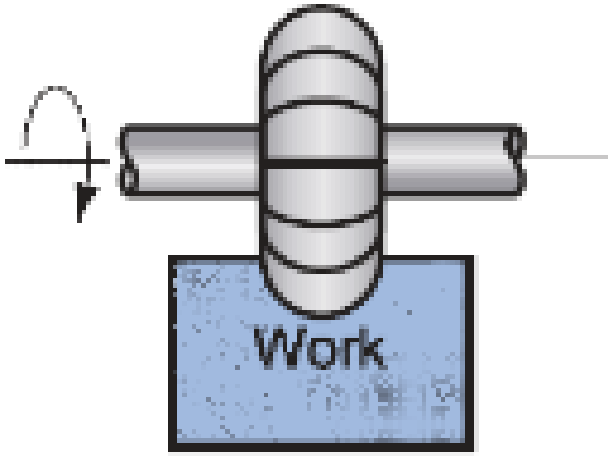
# Form Milling

- The form milling is the operation of producing the irregular contour by using form cutters.
- The irregular shape may be convex, concave, or of any other shape. After machining, the formed surface is inspected by a template gauge.
- Cutting rate for form milling is 20% to 30% less than that of the plain milling.

**Tool – Form milling Cutter**



Form Milling Operation

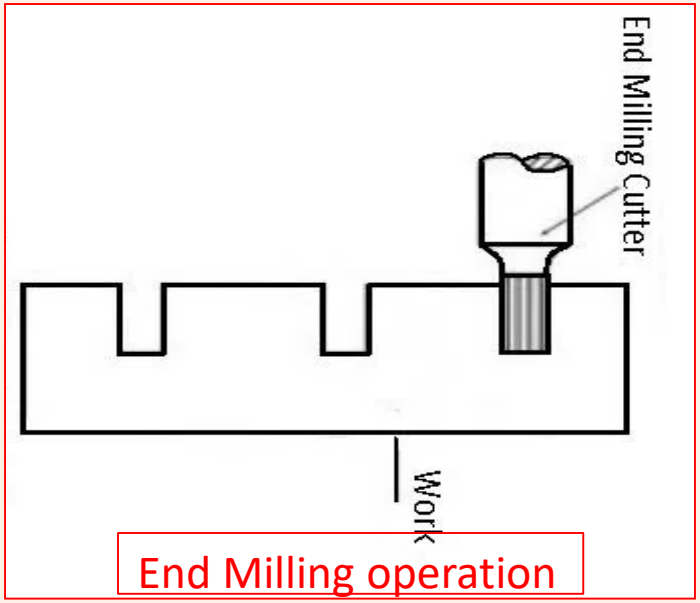


(e)

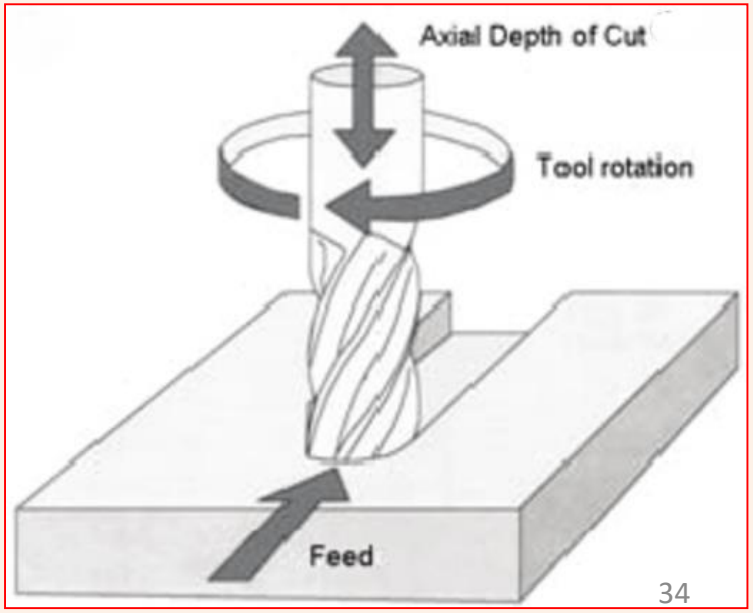
# End Milling

- The end milling is the operation of producing a flat surface which may be vertical, horizontal or at an angle in reference to the table surface.
- The cutter used is an end mill. The end milling cutters are also used for the production of slots, grooves or keyways.
- A vertical milling machine is more suitable for end milling operation.

**Tool – End milling Cutter (End Mill)**

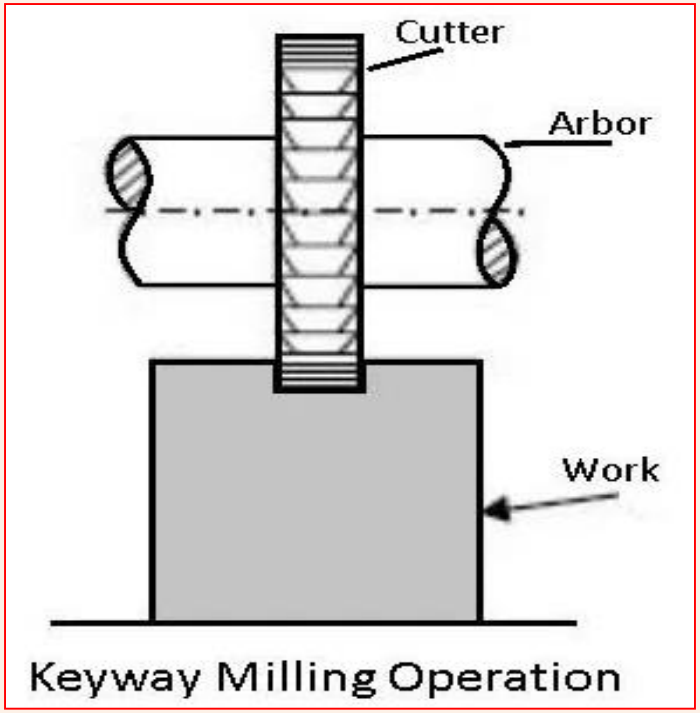



End Milling operation

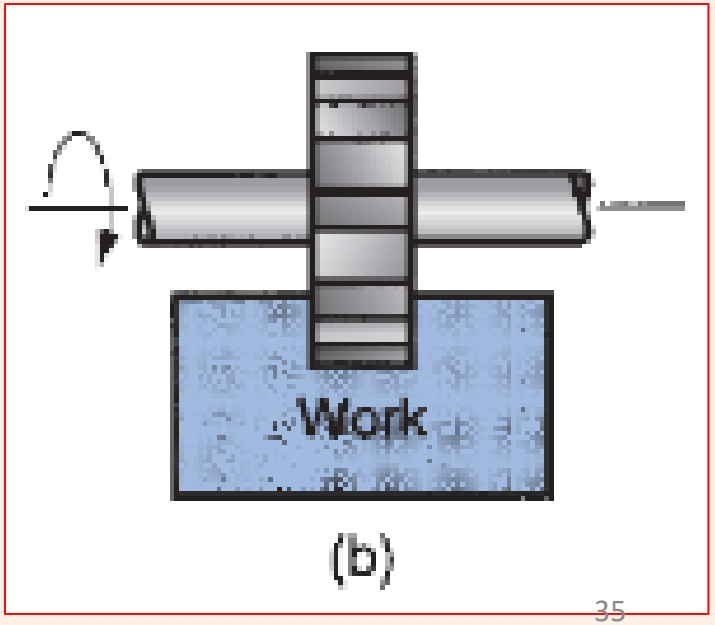


# Keyway/Grooves/Slot Milling

- The operation of producing of keyways, grooves and slots of varying shapes and sizes can be performed in a milling machine.
- It is done by using a plain milling cutter, a metal slitting saw, an end mill or by a side milling cutter.
- The open slots can be cut by a plain milling cutter, a metal slitting saw, or by a side milling cutter. The closed slots are produced by using end mills.



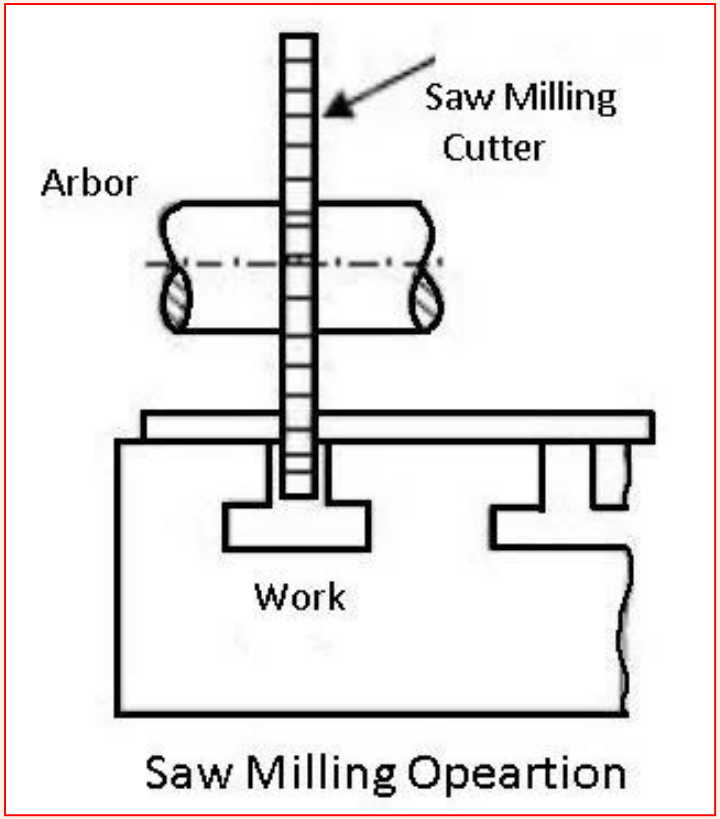
Keyway Milling Operation



# Saw Milling

**Tool – Saw milling Cutter**

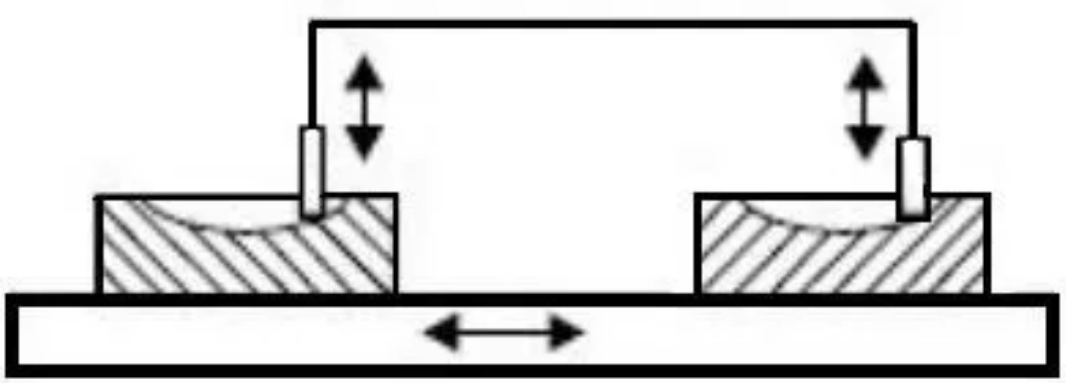
- **Saw-milling is the operation of producing narrow slots or grooves on a work-piece by using a saw-milling cutter.**
- **The saw-milling also performed for complete parting-off operation.**
- **The cutter and the workpiece are set in a manner so that the cutter is directly placed over one of the T-slots of the table.**



Saw Milling Opeartion

# Profile Milling

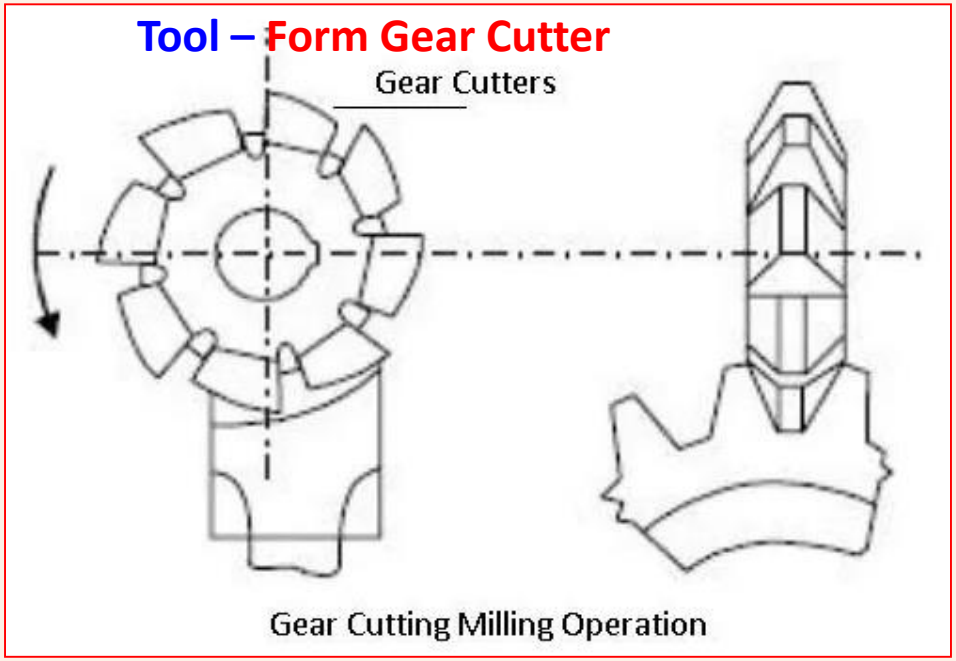
- The profile milling is the operation of reproduction an outline of a template or complex shape of a master dies on a work-piece.
- Different cutters are used for profile milling.
- An end mill is one of the widely used milling cutters in profile milling work.



Profile Milling Operation

# Gear cutting Milling

- The gear cutting operation is performed in a milling machine by using a form-relieved cutter (Gear cutter). The cutter may be a cylindrical type or end mill type.
- The cutter profile fits exactly with the tooth space of the gear.
- Equally spaced gear teeth are cut on a gear blank by holding the work on a universal diving head and then indexing it.



# T-Slot Milling

- A dovetail slot or T-slot is manufactured by using special types of cutters designed to give the required shape on the work-piece.
- The second slot is cut at right angles to the first slot by feeding the work past the cutter.
- A woodruff key is designed by using a woodruff key slot cutter.
- Standard keyways are cut on the shaft by using side milling cutters or end mills.
- The cutter is set exactly at the centre line of the work-piece and then the cut is taken.

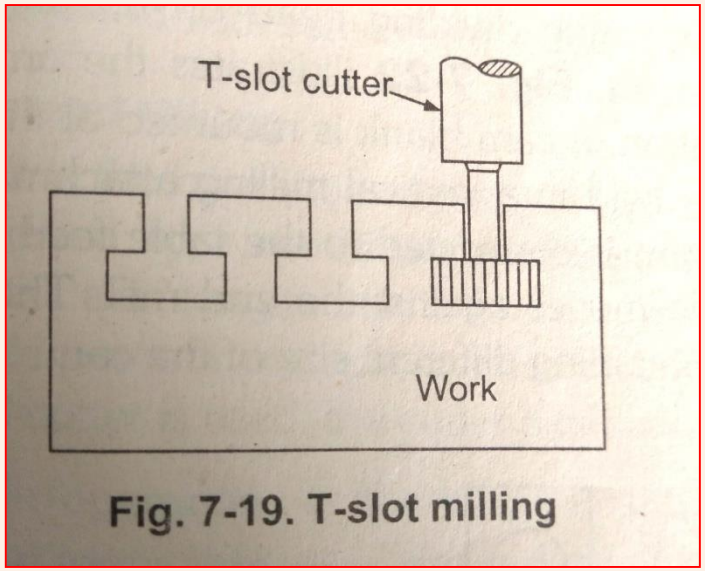
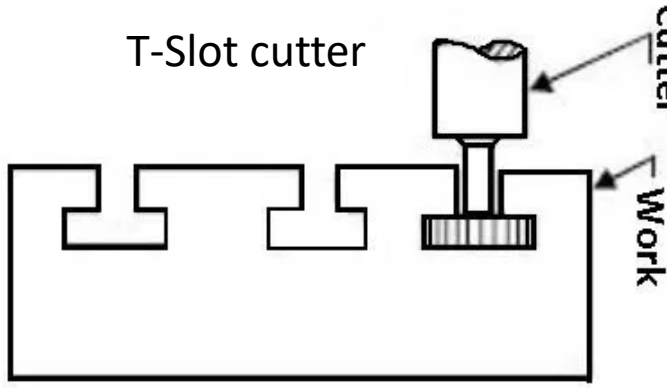


Fig. 7-19. T-slot milling



T-Slot Milling operation

# Different types of Milling cutters (Multi-point cutting tools)

Slab Mill Cutter


Involute Gear Cutter

Face Mill Cutter

Slide and Face Cutter

# Different types of Milling cutters (Multi-point cutting tools)

Dovetail Cutter


Wood Ruff Cutter

End Mill Cutter

# Different types of Milling cutters (Multi-point cutting tools)

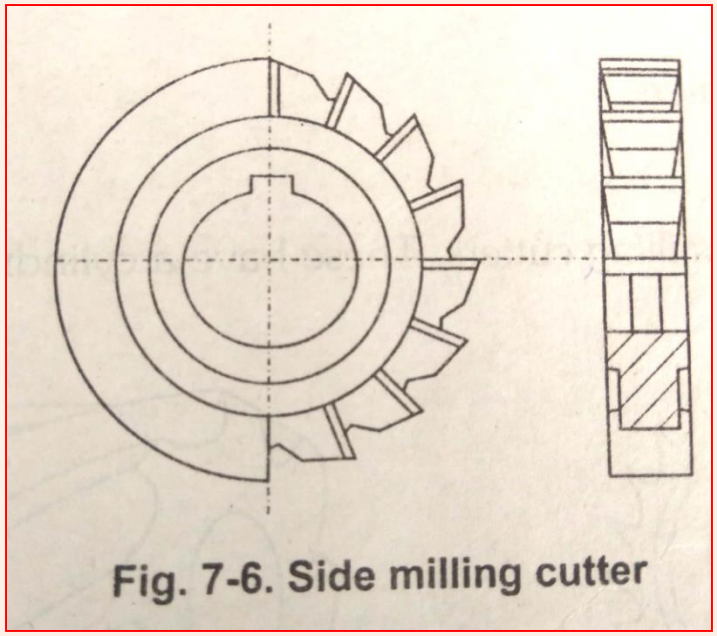
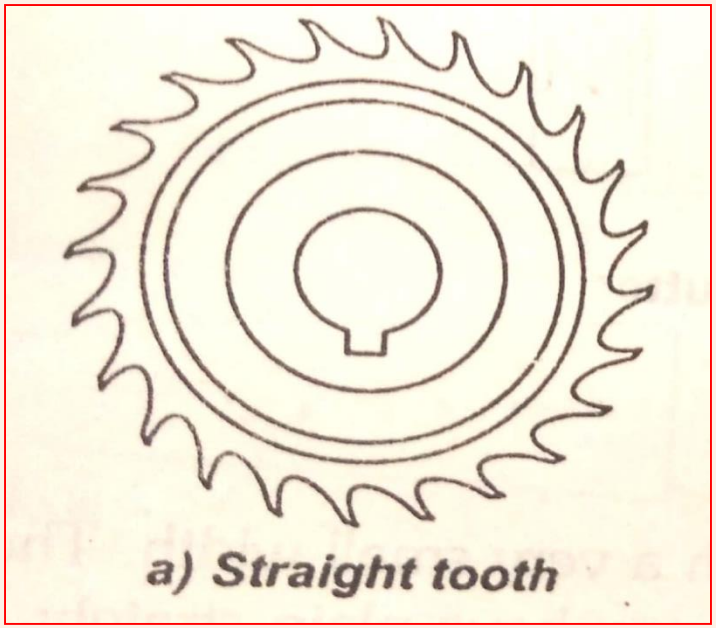


Fig. 7-6. Side milling cutter



a) Straight tooth

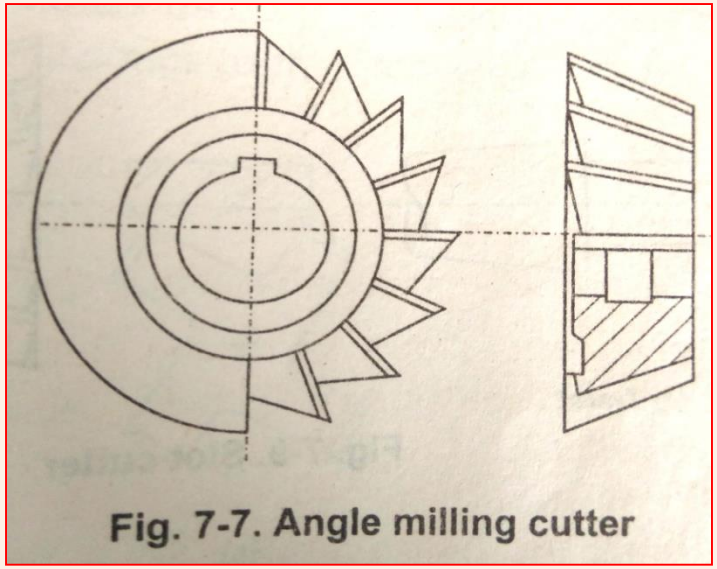
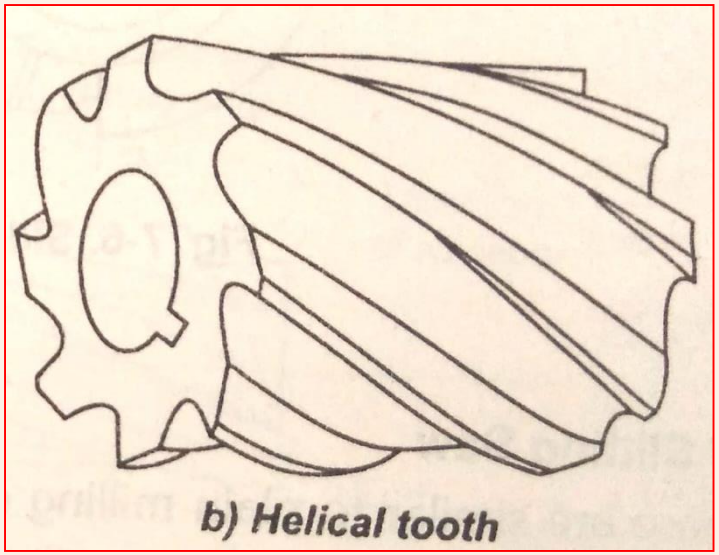


Fig. 7-7. Angle milling cutter



b) Helical tooth

# Different types of Milling cutters (Multi-point cutting tools)

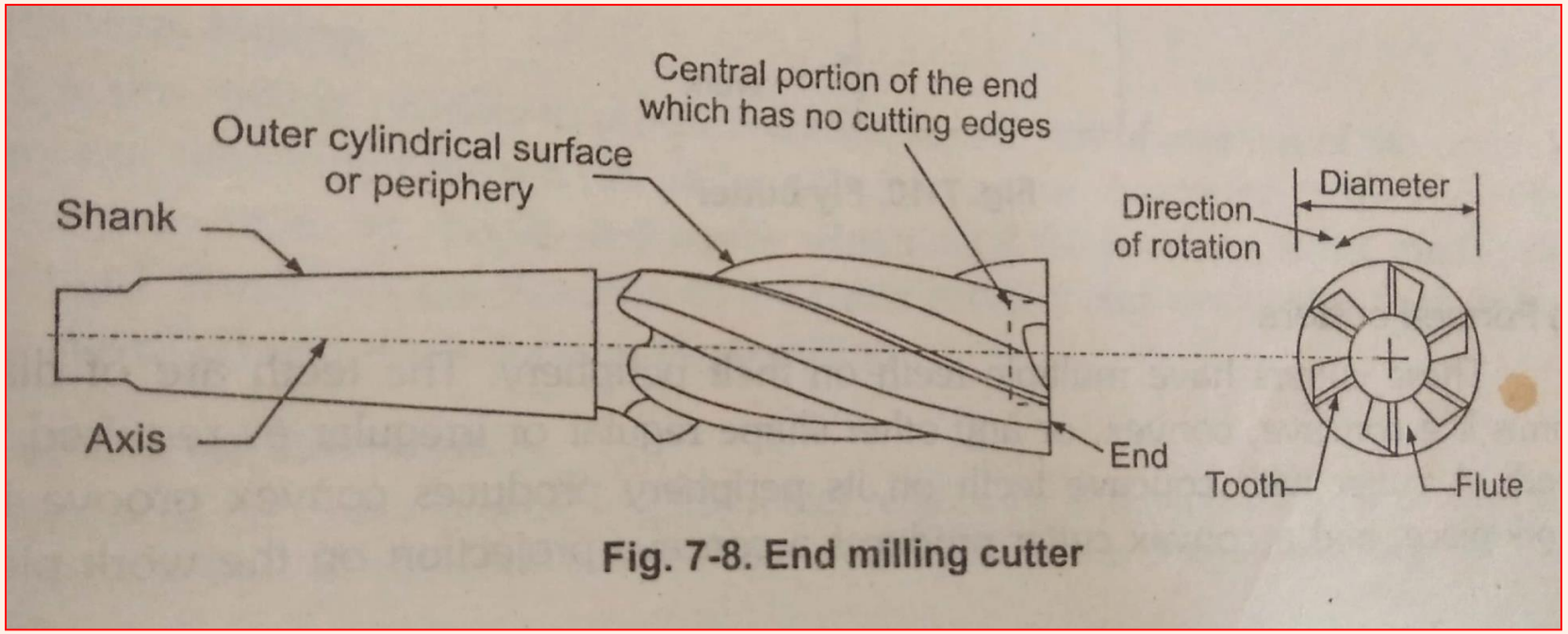
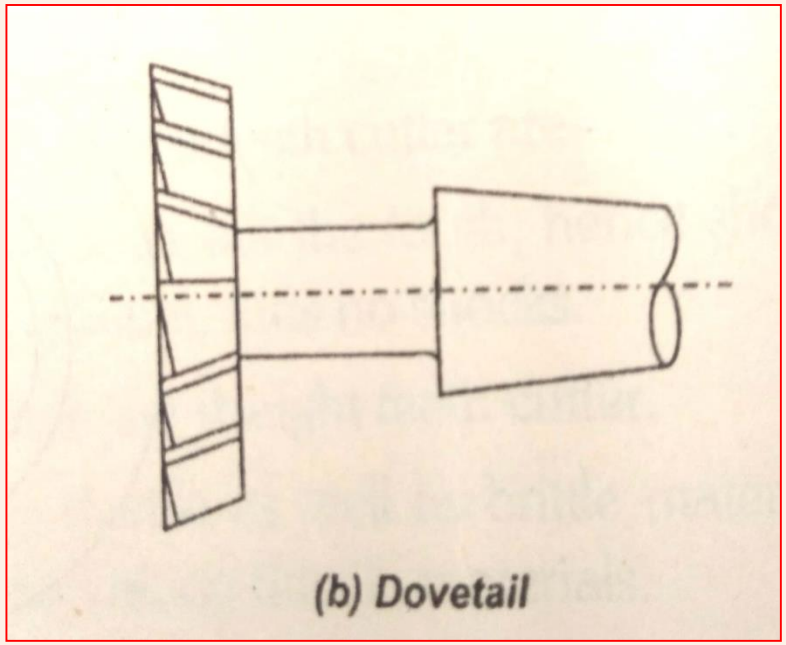
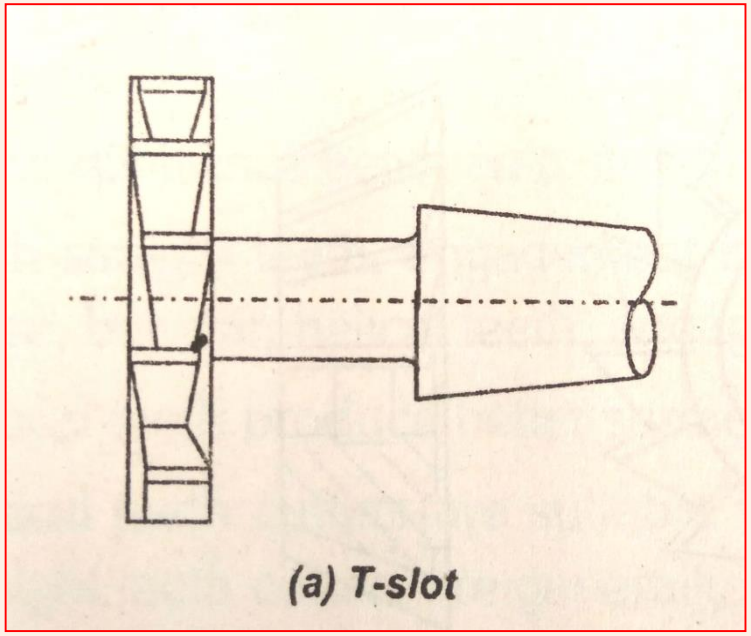



Fig. 7-8. End milling cutter



(b) Dovetail



(a) T-slot

# END