Subject Name & Code:

MANUFACTURING PROCESSES-BE04000191

ASSIGNMENT-5: Milling Machines (CO-2,3,4)

Q1. Classify milling machines.

Classification of Milling Machines:

1. Based on Spindle Orientation:

- **Horizontal Milling Machine:** Spindle horizontal; arbor holds cutters.
- **Vertical Milling Machine:** Spindle vertical; end mills, face mills used.

2. Based on Purpose/Construction:

- **Column and Knee Type:**
  - Plain/Hand Milling Machine
  - Universal Milling Machine (table swivels)
  - Vertical Milling Machine
- **Fixed Bed Type:**
  - Simplex (one spindle)
  - Duplex (two spindles)
  - Triplex (three spindles)
- **Planer Type (Plano-Miller):** Large bed; multiple spindles on cross rail; for heavy work.
- **Special Purpose:**
  - Rotary Table Miller
  - Profiling/Duplicating Miller
  - Thread Miller
  - Gear Hobbing Machine
  - CNC Machining Centre

3. Based on Degree of Automation:

- Manual, Semi-Automatic, Automatic/CNC.

4. Based on Accuracy:

- Standard, Precision, High-Speed.

Q2. Draw a neat sketch of a plain milling cutter and label its various elements.

Plain Milling Cutter Elements:

Element	Description
Body	Main cylindrical part of cutter
Teeth	Cutting elements arranged around periphery
Cutting Edge	Intersection of face and land; does cutting
Face	Surface against which chip bears
Land	Narrow surface behind cutting edge
Flute/Gullet	Space between teeth for chip accommodation
Fillet	Radius at root of tooth for strength
Clearance/Relief Angle	Angle behind cutting edge to prevent rubbing
Rake Angle	Angle of tooth face (positive, zero, or negative)
Bore/Hole	Central hole for mounting on arbor
Keyway	Slot for driving key

Diagram:

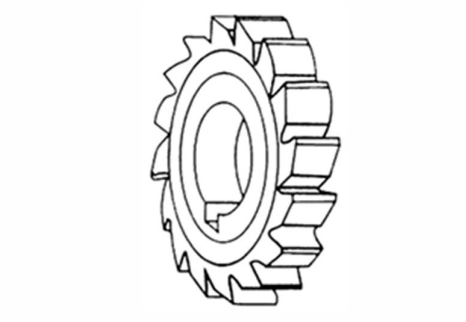


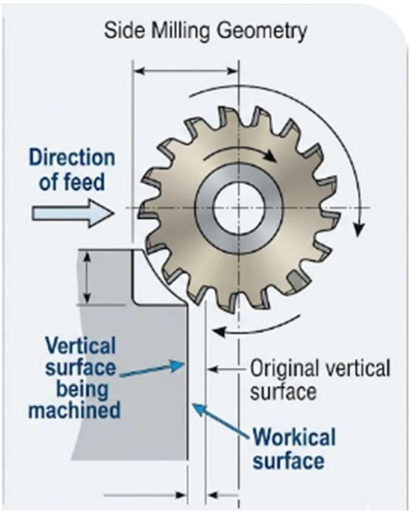
Fig.5.6 – Plain Milling Cutters

Q3. Explain side milling and angular milling operations with neat sketches.

1. Side Milling:

- **Definition:** Milling operation where cutting occurs on the **side face** of the cutter as well as the periphery.
- **Cutter Used:** Side milling cutter (teeth on periphery and one or both sides).
- **Application:** Producing vertical surfaces, slots, grooves, keyways.
- **Types:**
    - **Plain Side Milling:** Single side cutting.
    - **Straddle Milling:** Two side cutters mounted on same arbor to machine two parallel surfaces simultaneously.

Diagram:



2. Angular Milling:

- **Definition:** Milling operation producing **angular surfaces** (not at 90° to cutter axis).
- **Cutter Used:** Single angle cutter or double angle cutter.

- **Applications:**
  - Machining chamfers, bevels, dovetails.
  - Cutting flutes on reamers, milling cutters.
  - Producing V-grooves, serrations.
- **Types:**
  - **Single Angle Cutter:** Teeth on conical surface and one side.
  - **Double Angle Cutter:** V-shaped with teeth on both conical surfaces.

Diagram:

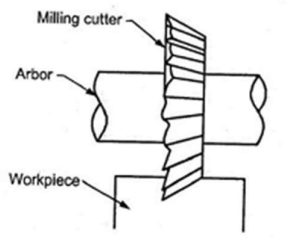


Fig.5.20 – Single angle milling cutters

Q4. Name the devices used for holding and driving various cutters on a milling machine.

A. Arbor-Based Holders (for Horizontal Milling):

1. **Standard Arbor:** Long shaft for mounting multiple cutters; supported by arbor support.
2. **Stub Arbor:** Short arbor for single cutter; no outer support.
3. **Shell End Mill Arbor:** Short arbor with pilot for mounting shell end mills.

B. Direct Spindle Mounting (for Vertical Milling):

1. **Collet Chuck:** Holds straight shank end mills.
2. **End Mill Adapter:** Morse taper or R8 adapter for end mills.
3. **Face Mill Arbor:** Short heavy arbor for face mills.

C. Special Holders:

1. **Fly Cutter Holder:** Holds single point tool for fly cutting.
2. **Boring Head:** Adjustable offset for boring operations.
3. **Drill Chuck:** For holding drills in vertical spindle.

D. Driving Devices:

1. **Arbor Collars/Spacers:** Position cutters on arbor.
2. **Draw Bar:** Pulls tool holder into spindle taper.
3. **Keys/Keyways:** Positive drive between arbor and cutter.

Q5. Draw a neat sketch of a knee and arbor type milling machine and label its parts.

Knee and Arbor Type (Horizontal) Milling Machine Parts:

Diagram:

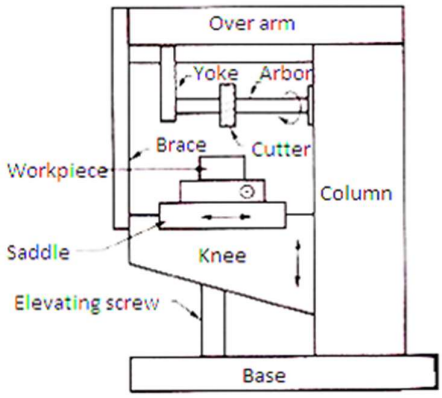


Fig.5.2 – Horizontal Milling Machine

Q6. State difference between up milling and down milling.

Parameter	Up Milling (Conventional)	Down Milling (Climb)
Direction	Cutter rotation **opposite** to feed direction	Cutter rotation **same** as feed direction
Chip Thickness	Starts **zero**, increases to maximum	Starts **maximum**, decreases to zero
Cutting Force	Tends to **lift** workpiece	Tends to **push** workpiece down
Tool Entry	Tool rubs before cutting; poor finish initially	Tool bites directly; better finish

Parameter	Up Milling (Conventional)	Down Milling (Climb)
Tool Life	Lower due to rubbing and heat	Higher; less rubbing
Surface Finish	Rougher	Smoother
Power Consumption	Higher	Lower (10-20% less)
Work Holding	Simpler clamping sufficient	Requires **backlash eliminator**
Machine Rigidity	Suitable for older/less rigid machines	Requires rigid machine and zero backlash
Application	Castings, forgings with scale/hard skin	Finishing cuts on rigid machines

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Q7. Explain simple indexing and compound indexing for a milling machine.

Indexing: Process of dividing workpiece periphery into equal or unequal divisions for machining (gear teeth, splines, flutes).

1. Simple Indexing:

- **Principle:** Workpiece rotation achieved through **worm and worm wheel** mechanism in dividing head.
- **Mechanism:** 40:1 ratio - 40 turns of index crank = 1 turn of spindle.
- **Formula:**
  n = 40 / Z
  Where: n = number of crank turns, Z = number of divisions required.
- **Example:** To cut 8 teeth gear: n = 40/8 = 5 turns. Crank rotated 5 complete turns between each tooth.
- **Procedure:**
  - Select indexing plate with hole circle divisible by required fraction.
  - Crank pin inserted in appropriate hole circle.
  - Sector arms set to count required holes.

2. Compound Indexing:

- **Definition:** Indexing method used when **simple indexing is not possible** (divisions not factors of 40).
- **Principle:** Index crank is moved through **two separate movements** on two different hole circles.
- **Procedure:**
    - Crank moved first amount on one hole circle.
    - Then indexing plate is **unlocked** and rotated together with crank by second amount on another hole circle.
- **Formula:**
  n = 40 / Z = (N1 / H1) ± (N2 / H2)
  Where: N1, N2 = number of holes moved; H1, H2 = hole circle numbers.
- **Example:** For 69 divisions (cannot be done by simple indexing as 69 is not factor of 40).
- **Applications:** Prime number divisions (51, 69, 87, etc.), differential indexing alternative.

Note: Compound indexing is more complex and prone to error; **differential indexing** is preferred in modern practice.
