GUJARAT TECHNOLOGICAL UNIVERSITY

BE-4 SEMESTER – OLD PAPER – S22 TO W25 – QUESTION BANK SOLUTION

Subject Name & Code:
Manufacturing Processes (3141908)

⚙ UNIT 5: Milling Machines

Q.1 – Categorize milling machines according to applications and construction. (3 marks)
Appeared in: S25(3), S22(3), W25(3), W23(3)
Ans:
According to construction:

- Column & knee type (plain, universal)
- Bed type (fixed table)
- Planer type (heavy duty)
- Special type (duplicating, gear milling)

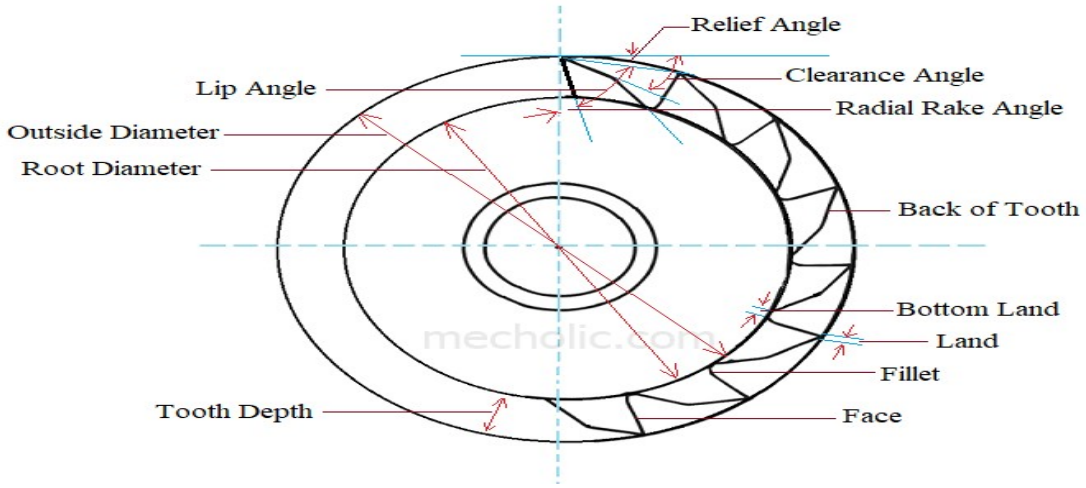
According to applications:

- Horizontal milling (slotting, gear cutting)
- Vertical milling (die sinking, contouring)
- Universal milling (helical grooves)

Q.2– Describe milling cutters with drawing. (4 marks)
Appeared in: S25(4), S22(4), W25(4)
Ans:
Types:

1. **Plain milling cutters**
   a. Light duty cutters
   b. Heavy-duty cutters
   c. Helical cutters
2. **Side milling cutters**
   a. Plain cutters
   b. staggered teeth cutters
   c. Half cutters
   d. Interlocking cutters
3. **Metal slitting cutters**
   a. Plain cutters
   b. staggered teeth cutters
4. **End milling cutters**
   a. Taper shank cutters
   b. Straight shank cutters
   c. Shell cutters
5. **T-slot milling cutters**
6. **Woodruff key slot milling cutters**
7. **Fly cutters**

Plain Milling Cutter:[DG]



Form relieved cutter (e.g., gear cutter) – special profile. Label each.
Material: HSS or carbide tipped.

Q.3 – Explain any five milling operations with neat sketch. (7 marks)
Appeared in: S25(7), S22(7), W25(7), W22(4) → Highest: 7 marks
Ans:
1. Plain milling (slab milling) – cutting flat surface parallel to cutter axis.
2. Face milling – cutting flat surface perpendicular to cutter axis.
3. End milling – producing slots, pockets with end mill.
4. Gang milling – multiple cutters on same arbor for complex profile.
5. Form milling – producing irregular profiles (e.g., gear teeth).
[DG]

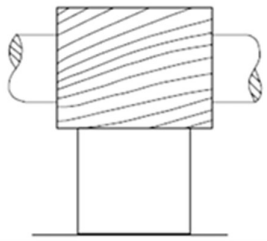


Fig.5.32 – Plain or slab milling

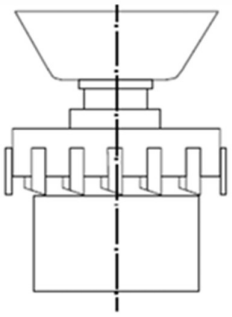


Fig.5.33 – Face milling

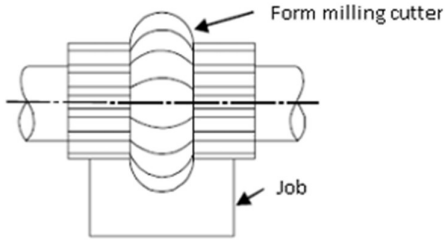


Fig.5.35 – Form milling

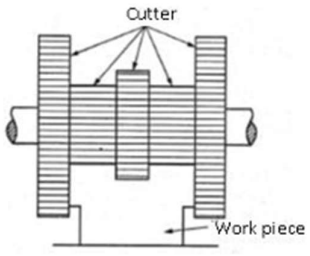


Fig.5.37 – Gang milling

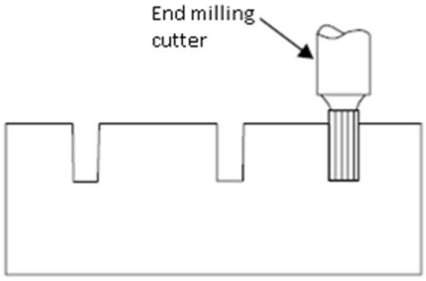


Fig.5.43 – End milling

Real-world: Gang milling produces multi-step shafts in one pass; face milling used for engine block decks.
Advantage: High metal removal rate.
Limitation: Vibration with overhanging arbors.

Q.4 – Differentiate between up milling and down milling. (4 marks)
Appeared in: S25(4), S23(3), S22(3), W24(4), W23(3) → Highest: 4 marks
Ans:

Parameter	Up milling (conventional)	Down milling (climb)
Chip thickness	Zero → max	Max → zero
Cutting force direction	Upward (lifts workpiece)	Downward (presses down)
Surface finish	Poor (tearing action)	Good
Power consumption	Higher	Lower
Use	For hard materials, roughing	For finishing, light cuts
Requirement	No backlash eliminator	Must have anti-backlash

Q.5 – Explain single indexing and compound indexing in milling machine. (7 marks)
Appeared in: S25(7), W24(7)
Ans:
Indexing (dividing head): Rotating workpiece by precise angles to cut gear teeth, splines, etc.
Single indexing:
- Using index plate with concentric circles of holes.
- Crank turned by N = 40 / Z (where Z = number of divisions, 40 = worm ratio).
- Example: Z = 8 → N = 40/8 = 5 full turns.

Compound indexing:
- Uses two index plates simultaneously to achieve divisions not possible with single.
- Formula: (40 / Z) = (N1 / A) ± (N2 / B) where A, B are hole circles.
- Useful for prime numbers like Z = 127.

[DG PROMPT]
Title: Indexing head – single & compound
Description: Draw dividing head (worm & worm wheel). Index plate with multiple rings. Crank with spring pin. For compound: show two plates mounted coaxially. Label: Worm (40 teeth), Work spindle, Index plate, Crank, Sector arms.
Real-world application: Cutting 127 teeth for metric threads on imperial leadscrew.

Q.6 – List alignment tests required for milling machine. (3 marks)
Appeared in: W25(3), W24(3)
Ans:
1. Parallelism of table movement to spindle axis
2. Perpendicularity of column to table
3. Runout of spindle taper
4. Squareness of vertical head to table (for vertical mill)
5. Flatness of table surface

Q.7 – Write advantages and limitations of broaching. (3 marks)

Appeared in: S25(3), S23(3), W23(3)
Ans:
Advantages:
- Very high production rate (0.5–5 sec per part)
- Excellent surface finish (Ra 0.4 µm)
- High accuracy (IT6–IT7)
- Both internal & external shapes possible

Limitations:
- High tool cost (broach)
- Not suitable for blind holes
- Dedicated machine required
- Workpiece must pass through broach (through hole)

Q.8 – Explain gang milling and form milling operations. (3 marks)
Appeared in: S23(3)
Ans:
Gang milling: Multiple cutters mounted on same arbor to mill several surfaces simultaneously. Example: milling steps on a connecting rod.
Form milling: Using a shaped cutter (form relieved) to produce concave/convex contours, gear teeth, or any irregular profile. Example: milling gear teeth with involute cutter.

Q.9 – What is indexing? Describe direct indexing with example. (7 marks)
Appeared in: S23(7), W25(4), W23(4) → Highest: 7 marks
Ans:
Indexing: Rotating workpiece by predetermined angular increments using dividing head.
Direct indexing:
- Index plate has 24 slots.
- Plunger engages slots directly (without worm).
- Simple indexing: divisions = factors of 24.
- Example: 6 divisions → 24/6 = 4 slots between indexes.

► The indexing ratio is calculated by:

$$\text{Required ratio} = \frac{N}{n}$$

Where, N=Number of slots on the periphery of the index plate,

n=Number of divisions required to be machined

Example: Cutting a hexagon (6 sides) – advance 4 slots per face.
Advantages: Fast, no calculations.
Limitation: Only divisions that divide 24.

Q.10 – Explain alignment test of milling machine with sketch. (4 marks)
Appeared in: S22(4), W23(4)
Ans:

Tests for machine tool

- The surface produced after machining is achieved by both work and tool movement.
- Hence the accuracy of the finished product depends on the accuracy of the machine tool and its alignment with the parts of the machine tool.
- Various tests are performed on the machine tool to check its installation, flatness, perpendicularity of the various axes, the parallelism of the various surfaces of machine tool and some practical tests.
- The instruments used for these alignment tests are dial gauges, test mandrels, straight edges, spirit levels, frame levels, etc.

1. Table surface parallels to arbor rising towards overarm.
2. Table surface parallels to longitudinal movement.
3. Transverse movement parallel with the spindle axis.
4. T-slot parallel with longitudinal table movement.
5. Cutter spindle axial slip and eccentricity of external diameter.

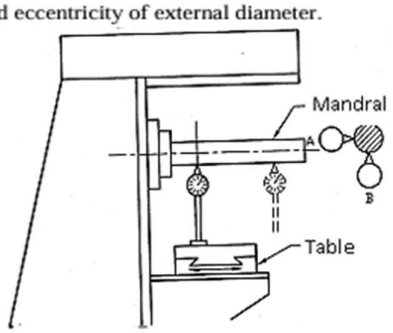


Fig.5.51 – Transverse movement parallel to the spindle axis

Q.11 – Describe knee and column vertical milling machine with neat sketch. (7 marks)
Appeared in: W25(7), W24(7), W22(7)
Ans:
Construction:

- **Base** – supports entire machine
- **Column** – hollow casting with guideways
- **Knee** – vertical sliding member on column (moves up/down)
- **Saddle** – moves horizontally on knee (cross traverse)
- **Table** – moves longitudinally on saddle
- **Vertical head** – contains spindle (adjustable angle)

[DG]

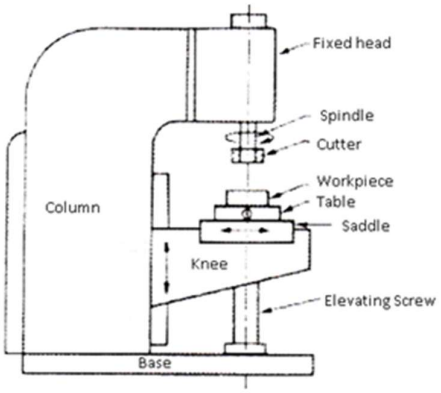


Fig.5.3 – Vertical Milling machine

Working: Work clamped on table. Vertical spindle rotates cutter. Movements: X,Y,Z manual

or power feed.
Real-world application: Engraving, pocket milling, die making.
Advantage: Rigid for heavy cuts.
Limitation: Limited height for tall workpieces.

Q.12 – Compare between plain and universal milling machine. (4 marks)
Appeared in: S24(4)
Ans:

Feature	Plain milling machine	Universal milling machine
Table swivel	No	Can swivel up to ±45°
Helical milling	No	Yes (by swivelling)
Applications	Horizontal slots, flat surfaces	Helical grooves, gear cutting
Dividing head	Optional	Essential accessory
Cost	Lower	Higher

Q.13 – Discuss how cutting force changes with variation of speed and angle of milling cutter. (4 marks)
Appeared in: S24(4)
Ans:

- **Effect of cutting speed:** Increasing speed decreases cutting force initially (due to reduced friction), but beyond optimal speed, force increases (due to higher strain rate).
- **Effect of rake angle:** Positive rake reduces cutting force; negative rake increases force.
- **Effect of helix angle:** Higher helix angle reduces impact force (smoother entry).
- **Effect of radial rake angle:** Negative radial rake increases force, used for hard materials.

Example: For steel, increasing speed from 50 to 150 m/min reduces tangential force by ~30%.

Q.14 – Explain helical milling operation and its limitations. (3 marks)
Appeared in: S22(3)
Ans:
Helical milling: Producing helical grooves (e.g., drill flutes, threads) by synchronising table feed with dividing head rotation.
Limitations:

- Requires universal milling machine with swivel table.
- Complex setup (change gears for lead).
- Slower than dedicated hobbing for gears.

Real-world application: Milling spiral bevel gear teeth.

Q.15 – Discuss indexing mechanism of milling machine. (3 marks)
Appeared in: W22(3)

Ans:

Indexing mechanism (dividing head):

- Worm (40 teeth) & worm wheel (40:1 ratio).
- Index plate with hole circles (e.g., 15, 16, 17... holes).
- Crank with spring pin engages holes.
- Sector arms adjust to count holes.

Formula: Crank turns = 40 / Z.

Example: For 15 teeth: 40/15 = 2 + 10/15 → 2 full turns + 10 holes on 15-hole circle.
