Advanced Manufacturing Processes

Time: 3 Hrs.] Prelim Question Paper Solution **[Marks : 100**

Q.1(a) Attempt any THREE of the following: [12]

Q.1(a) (i) Write any four advantages of non-traditional machining over conventional machining. [4]

(A) **(i) Applicable to all materials**
These methods are not affected by hardness, toughness and brittleness of work materials.

(ii) Intricate shape machining
It can produce complex-intricate shape on any workpiece material.

(iii) Extreme hard material machining
Hard to machine materials like tungsten, uranium, tantalum can be machined.

(iv) No mechanical contact
Material is removed without mechanical contact with the workpiece and tool.

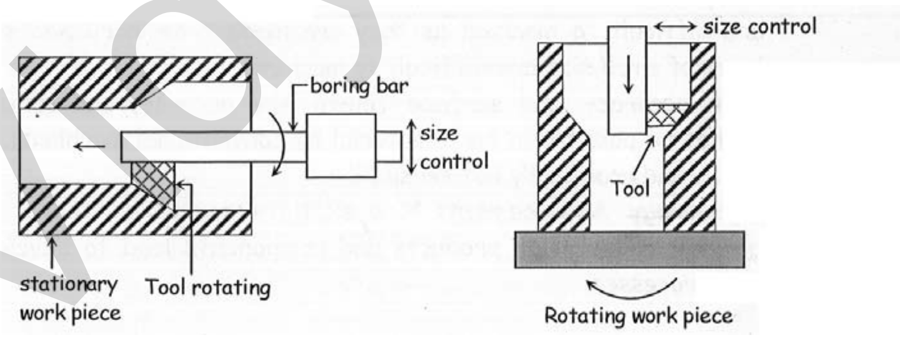
Q.1(a) (ii) Differentiate between absolute and incremental mode. [4]

(A)

	Point	Absolute co-ordinate system	Incremental co-ordinate system
1)	Reference	The co-ordinates will be measured with respect to fixed origin.	The co-ordinates of any point will be calculated with reference to previous point.
2)	Origin	It is always fixed and never changed	It is always changes and preceding point is taken as reference
3)	Changes of error	Minimum chances of error	As reference changes every time error may occurs.
4)	'G' code	G go is used in a program	G–91 is used in a program

Q.1(a) (iii) Draw the sketch of the boring head. State the conditions under which it is used. [4]

(A)



Simple sketch of boaring heads is as shown in figure.
Conditions for use of boaring Heads :
i) It use in specified axis vertical or horizontal.
ii) Ground arrangement of machine is very important. It must be proper direction and level.
iii) Boaring is takes place according to tool displacement so that control of size must be properly control.

Q.1(a) (iv) Compare both EDM and wirecut EDM for its applications. **[4]**
(A)

	Point	EDM	Wire cut EDM
1.	Electrode	Shape is mirror image of work piece	Thin wire
2.	Life of electrode	Used for large period	Only once use
3.	Blind hole machining	Blind hole can make	Blind hole cannot make
4.	Dielectric	Kerosene oil	Deonised water
5.	Applications	EDM – Drilling EDM – Curve hole, drilling EDM – Milling	– Productions of prototype – Small series ports – Sintering dies – Plastic modeling dies

Q.1(b) Attempt any ONE of the following: **[6]**

Q.1(b) (i) With a neat labeled sketch, describe Laser Beam Machining process w.r.t. its principle, applications and limitations. **[6]**

(A) Principle of laser machining :

- It works on the principle of conversion of electrical energy of flash lamp into heat energy to emit the laser beam by pumping the energy.
- Laser beam is then focused by a lens to give high energy in the concentrated form and helps to melt and vaporize the material of workpiece.
- As laser interacts with the material, the energy of photon is absorbed by the work material leading to rapid rise in local temperature and results in melting and vaporization of the work material.

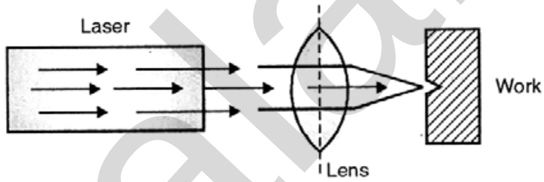
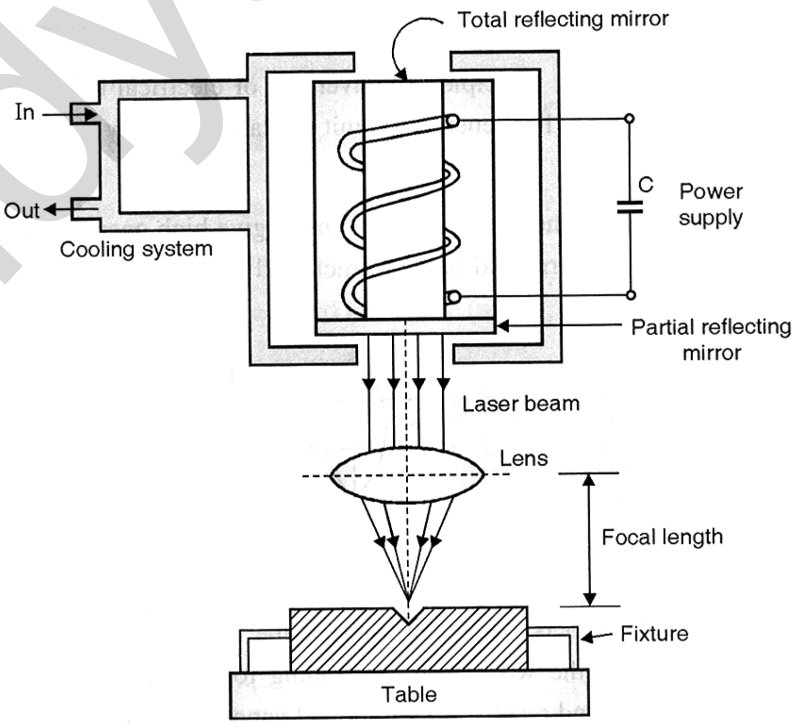


Fig. 1

Working :



- Laser beam machining utilizes the narrow beam of intense monochromatic light which melts and vaporize the material of the workpiece.
- The setup for this process is shown in the figure 2. It mainly consists of:
  (i) Laser generation unit.
  (ii) Cooling arrangement.
  (iii) Collimating lens.
  (iv) Workpiece table

Application of Laser Beam Machining :
(i) Laser welding :
- It is useful for joining sheet metal or stock pieces of about 2.5 mm thick or less.

(ii) Laser drilling :
- It has ability to make small and very small holes of shallow depth.

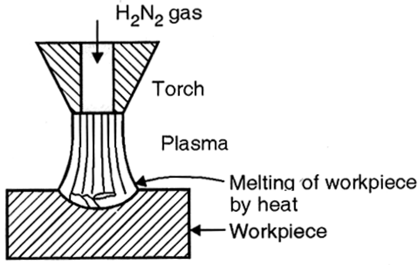
(iii) Laser cutting :
- It used in cutting metals, plastics, ceramics, textile, cloths and even glass. It also used for cutting complex shapes.

Limitations of Laser Beam Machining :
(i) It has very low material removal rate.
(ii) It is not suitable for machining highly conductive and reflective materials like copper, aluminium, and its alloys.
(iii) Flash lamp has limited life.
(iv) Machined holes may have taper from entry to exit.
(v) High initial cost and maintenance cost.
(vi) Overall efficiency is about 10–15%
(vii) Output energy of laser is difficult to control precisely.

Q.1(b) (ii) Explain Adaptive Controls. [6]
(A) Adaptive Controls
- It is an improvement over NC and CNC systems. In NC/CNC machines part programmer has to select cutting speed, feed and other process variables. However there may be likely variations during the process cannot ensure optimum performance.
- It indicates a control system that measures one or more process variables such as cutting force, temperature, horse power, etc. and manipulates feed and speed in order to compensate for undesirable changes in the process variables.
- Adaptive control uses information about a machining process to improve the efficiency of that process while it is taking place.
- It determines the proper feeds, speeds during machining as a function of variations in such factors as work material hardness, depth of cut, etc. as per actual cutting conditions.
- Adaptive control has the capability to respond to and compensate variations during the process.

Q.2 Attempt any FOUR of the following : [16]
Q.2(a) With a neat sketch, describe the principle of PAM. [4]
(A)
- It is the electro-thermal machining process in which ionized gas in the form of flame is used for machining.
- When a flowing gas is heated to a sufficiently high temperature of 16500°C to become partially ionized, it is known as "plasma". It is a mixture of free electrons, positively charged ions and neutral atoms.
- The heat from the plasma in the form of high velocity jet of high temperature is used for metal removal.
- This process is suitable for machining hard to cut metals such as super alloys, particularly cutting off or rough slitting operations.

Principle of PAM



- In this process, the material of the workpiece melts similar to gas flame cutting operation. The melting occurs due to:
  (i) Convective heat transfer from high temperature plasma
  (ii) Direct electron bombardment of an electric arc
- The ionized stream of gas is impinged on the workpiece surface to cause it melt and erode.

Q.2(b) Explain Axis identification in CNC Milling Machine. **[4]**

(A)
- After understanding the constructional details of machining centre, it is important to learn axis identification for machining centres.
- During machining of component, it is necessary to move the spindle, slides in a different direction to obtain desired shape of the workpiece.
- Part programming requires determination of co-ordinates for given product as per drawing and it is essential to identify the machine axes to determine the co-ordinates as per the standardized system.
- The basis of axis identification is the three dimensional Cartesian co-ordinate system and it consists of:
  (1) Linear axes: The movements are in a straight line by the machine slides and represented as X, Y, Z axes.
  (2) Rotary axes: The movements are rotary about axes for the spindle and designated by A, B and C axes.

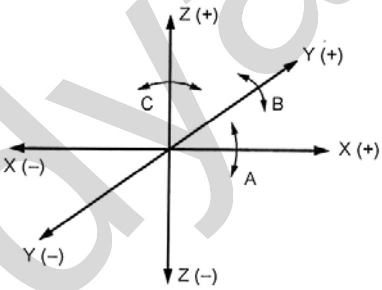


Fig. 1

(1) Linear axes

(a) Horizontal machining centre

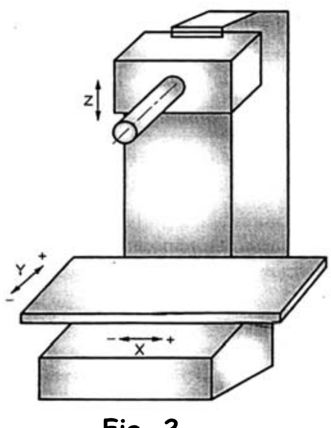


Fig. 2

In this machining centre:

(i) Z axis:

- It is spindle axis which represents main spindle axis of machining centre.
- It is horizontal as spindle is located horizontally.
- Positive 'Z' movement (+Z) increases the distance between workpiece and tool. While (−Z) negative Z movement is used to specify depth of cutting.

(ii) X axis:

- It is always horizontal and parallel to the work holding surface whenever possible.
- It indicates longitudinal movement of the work table.
- When Z axis is horizontal, positive X axis motion is to the right when looking from the spindle towards the workpiece.

(iii) Y axis:

- Y axis movement is perpendicular to both X and Z axes. +Y is the direction as per right hand co-ordinate system with +X and +Z.
- It represents the transverse or cross travel of the work table and it completes 3 dimensional co-ordinate system.

(b) Vertical machining centre

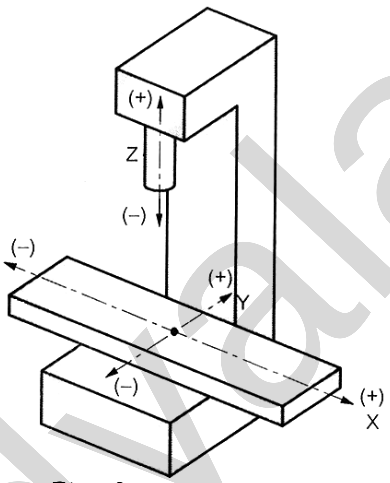


Fig. 3

In this type of machining centre:

(i) Z axis:

- It is represented by the axis of main spindle of the machining centre.
- On vertical machining centre, Z axis is vertical and positive movement of Z axis moves the cutter in the upward direction while negative movement of Z axis moves the cutter in the downward direction toward the workpiece.
- It is important for depth of cut during machining.

(ii) X axis:

- It is always horizontal and represents work holding surface.
- When Z axis is vertical, positive X axis movement is identified as being to the right when looking from the spindle towards column.
- It indicates longitudinal movement of the work stable.

(iii) Y axis:

- It is perpendicular to the X and Z axes. It indicates cross travel of the work table.

(c) Turning centre (Lathe machine)

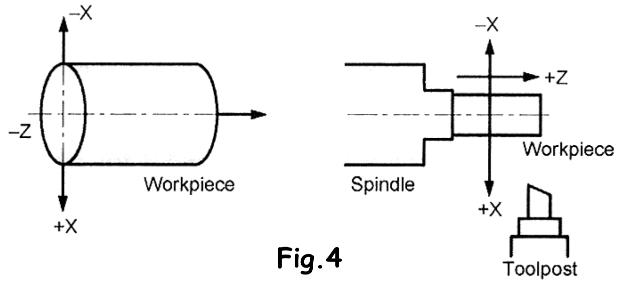


Fig.4

In turning centre i.e. lathe machine only two axes are:
(i) Z axis: The axis of rotation of the workpiece is specified by Z axis.
(ii) X axis: The radiac location of the cutting tool is represented by X axis.

(2) Rotary Axes
(i) A axis: It is rotary motion about X axis and clockwise rotation is designated as positive movement and counter clockwise rotation as negative movement.
(ii) B axis: It is rotary motion about Y axis and clockwise rotation is designated as positive movement and counter clockwise rotation as negative movement.
(iii) C axis: It is rotary motion about Z axis and clockwise rotation is designated as positive movement and counter clockwise rotation as negative movement.

Q.2(c) Describe how a grinding wheel is specified with an example. **[4]**

(A)
- The Indian standard marking system for grinding wheels (IS:551–1954) has been prepared with a view to establish uniform system for designation of grinding wheels.
- It consists of six symbols representing following properties of grinding wheel :
  (i) Manufacture's symbol
  (ii) Type of abrasive
  (iii) Grain size
  (iv) Grade
  (v) Structure
  (vi) Type of bond
  (vii) Manufactures symbol (optional) for reference

Example
51 A 36 L 5 V 40
51 → Manufacturers symbol indicating type of abrasive
(prefix) (optional)
A → Abrasive (Aluminium oxide)
36 → Grain size (Medium)
L → Grade (Medium)
5 → Structure (Dense)
V → Bond (Vitrified)
40 → Manufacture symbol (Suffix) optional

Q.2(d) Two gears are to be manufactured with 25 and 35 teeth. Using simple indexing method, calculate number of turns for indexing. Consider standard sharp & brown plates. **[4]**

(A) No. of gear tooths = 25 = N
∴ No. of divisions = 25

∴ Index crank movement = $\frac{40}{N}$

OR

No. of turns = $\frac{40}{25} = \frac{8}{5}$

Q.2(e) Explain Preventive Maintenance. [4]

(A) Preventive Maintenance

- It is the planned maintenance of machine tools at regular intervals in order to prevent or minimize breakdown.
- The primary goal of preventive maintenance is to prevent the failure of equipment before it actually occurs.
- After preventive maintenance repairs, the equipment's health is restored back nearly to the equipment's original condition.
- Preventive maintenance covers vast area like routine inspection, minor repairs, lubrication, cleaning, replacement of consumables like belts, gaskets etc. and overhauling and reconditioning.
- In addition, workers can record equipment deterioration so they know to replace or repair worn parts before they cause system failure.
- Maintenance work should be carried out by properly trained workers, to ensure rapid work at minimum cost.
- Preventive maintenance is actually an investment to protect and prevent emergency and major breakdown from occurring.
- The frequency of preventive maintenance is planned earlier and it is carried out at fixed time interval.
- The interval is decided mainly keeping in view, the complexity of the machine tool and the amount of its usage.
- The actual duration of preventive maintenance schedule is derived from manufacturer's recommendations, by past experience of similar machines or by monitoring the conditions.
- The preventive maintenance schedule should be decided correctly otherwise preventive maintenance may lead to preventing production rather than to preventing breakdowns.
- A tailor made programme for preventive maintenance is not practicable and the frequency should be improved over time.

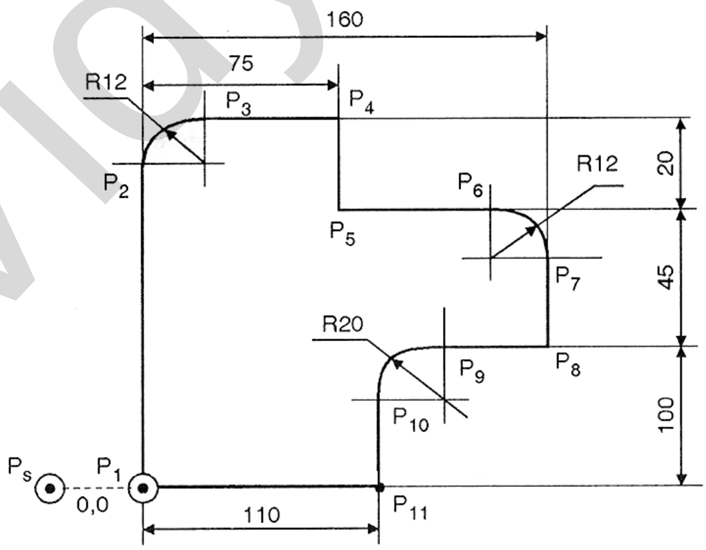
Q.3 Attempt any TWO of the following : [16]

Q.3(a) Describe the standard vertical boring mill with neat sketch. [8]

(A)
- Prepare a part programme for the given job as shown in figure 1. Use following machine data:

  Speed = 800 rpm   Feed = 10 mm/min.

  Depth of cut = 3 mm   Thickness of job = 3 mm



Assume

(1) Start point P_s away from workpiece

(2) Tool path $P_s \rightarrow P_1 \rightarrow P_2 \rightarrow P_3 \rightarrow P_4 \rightarrow P_5 \rightarrow P_6 \rightarrow P_7 \rightarrow P_8 \rightarrow P_9 \rightarrow P_{10} \rightarrow P_{11} \rightarrow P_1 \rightarrow P_s$

(3) Absolute mode (G90)

Co-ordinates as per G90

Point	X	Y
P_s	–5	–3
P_1	–3	–3
P_2	–3	153
P_3	12	168
P_4	78	168
P_5	78	148
P_6	148	148
P_7	163	133
P_8	163	97
P_9	133	97
P_{10}	113	80
P_{11}	113	–3

Calculation of I, J values for arc points

(a) Arc 1(P_2 to P_3) Clockwise (G01)
P centre (12, 153)
P start (0, 153)

I = X centre – X start
= 12 – 0 = 12
J = Y centre – Y start
= 153 – 153 = 0

(b) Arc 2(P_6 to P_7) Clockwise (G02)
P centre (148, 133)
P start (148, 145)

I = X centre – X start
= 148 – 148 = 0
J = Y centre – Y start
= 133 – 145 = –12

(c) Arc 3(P_9 to P_{10}) Counter clockwise (G03)
P centre (130, 80)
P start (130, 100)

I = X centre – X start
= 130 – 130 = 0
J = Y centre – Y start
= 80 – 100 = –20

All other points are joined by straight line hence linear interpolation is to be used (G01).

Part program

Block	Explanation
012C Profmill02	Program Name
N10 G28 U00 V00 W00 EOB	Return to reference point
N20 G90 G21 G94 G40 EOB	Absolute mode, unit mm, feed mm/min
N30 M03 S800 M08 EOB	Spindle start, spindle speed, coolant on
N40 G00 X – 5 X – 3 EOB	Rapid travel of tool to the point P_s
N50 G00 Z5 EOB	Rapid travel of tool above workpiece by 5 mm
N60 G01 X – 3 Y – 3 EOB	Rapid travel of tool to the point P_1
N70 G01 Z – 3 EOB	Depth of cut 3 mm
N80 G01 X – 3 Y153 EOB	Machining from $P_1 \rightarrow P_2$
N90 G02 X12 Y168 I12 J0 F20 EOB	Machining from $P_2 \rightarrow P_3$ arc

N100 G01 X78 Y168 EOB	Machining from $P_3 \rightarrow P_4$
N110 G01 X78 Y148 EOB	Machining from $P_4 \rightarrow P_5$
N120 G01 X148 Y148 EOB	Machining from $P_5 \rightarrow P_6$
N130 G01 X163 Y133 I0 J – 12 EOB	Machining from $P_6 \rightarrow P_7$ arc
N140 G01 X163 Y97 EOB	Machining from $P_7 \rightarrow P_8$
N150 G01 X133 Y97 EOB	Machining from $P_8 \rightarrow P_9$
N160 G28 X113 Y80 I0 J−20 EOB	Machining from $P_9 \rightarrow P_{10}$ arc
N170 G01 X113 Y−3 EOB	Machining from $P_{10} \rightarrow P_{11}$
N180 G01 X−3 Y−3 EOB	Machining from $P_{11} \rightarrow P_1$
N190 G00 X – 5 X – 3 EOB	Rapid travel from $P_1 \rightarrow P_s$
N200 G00 Z5 M05 EOB	Spindle upward and stop movement
N210 G28 U00 V00 W00	Return to reference point
N220 M09 M30 EOB	Coolant off, end of program

Q.3(b) Following are the machining requirements. Select appropriate non-traditional machining method for each with justification **[8]**
(i) Deep drilling
(ii) Machining of injection moulding mould
(iii) Profile cutting of turbine blade
(iv) Die block used in press tools

(A) Deep drilling :
For deep drilling EDM (electro discharge machining)
For deep drilling EDM is used because in this process erosion of metals takes place by an interrupted electric spark discharge. This discharge are repeated thousands time / sec in selected area of workpiece. So that deep hole obtained.

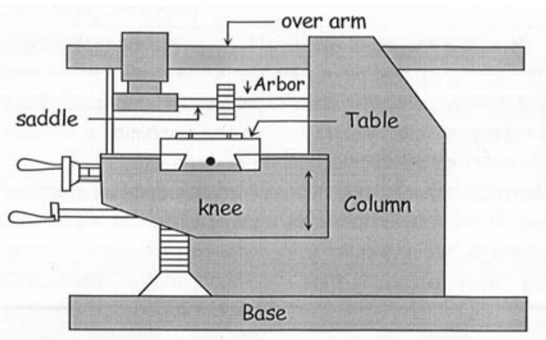
Maching of injection moulding mould :
For this process WJM method can be used. Because in this process high velocity, high press jet is used which produce note for injection system.

Profile cutting of turbine blade :
For profile cutting of turbine blades wire cut EDM is used. Because for profile cutting accuracy is required which achieved by this process because in this process guide rollers are provided.

Die blocks used in press tools :
For this process EDM process used. Because in this process we use manufacture of tools having complicated profiles and other components with special machining objective. So that we can produce die–blocks also.

Q.3(c) Describe construction and working of column and knee type milling machine with neat sketch. **[8]**

(A)

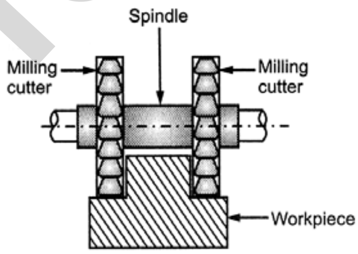
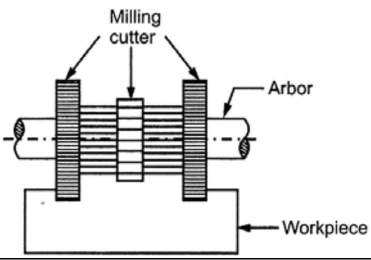


- This milling machine has two main structural elements.
  (1) A column (main frame) (2) A knee shaped projection table
- Column contains the spindle and their drive mechanism and knee moves vertically on the column.

Six principle parts of this mechanisms are :
1) Base : The base on which the machine structure built.
2) Column : It contains the spindle and its driving mechanism.
3) Overam : It is mounted on column, it supports the other end of the arbor.
4) Knee : It is structural member attached to the column and which moves verticals.
5) Saddle : It is mounted on the knee and which moves horizontally.
6) Table : It is mounted on saddle which moves at right angles to the saddle. Work is clamped on the table.

Working :
Table of the machine has movement in three directions.
(A) longitudinal
(B) transverse
(C) vertical
Knee and column type milling machines are used for small and medium sized work in tool rooms and protype shops.
This machines are made with both horizontal and vertical spindles
They have manual or power control for all movements.
The primary cutting motion is obtained by the milling cutter mounted on horizontal arbor with rotary motion and feed motion of worktable motion.

Q.4(a) Attempt the THREE of the following: [12]
Q.4(a) (i) Differentiate between straddle milling and gang milling. [4]
(A)

	Straddle Milling	Gang Milling
1.	It is milling operation of flat vertical surfaces on both sides of w/p by using two side milling cutters mounted on same arbor.	It is the modification of straddle milling with more number of cutters in the machining.
2.	The distance between two cutters is correctly adjusted by using suitable spacing collers.	Distance and diameters of cutters may be same or different arc to applications.
3.	Required more machining time	This operation save much machining time and repetitive work.
4.		
5.	It is commonly used to produce square and hexagonal surfaces.	It is used to produce complex shape.

Q.4(a) (ii) State different types of milling cutters mentioning the names of operations for which they are used. [4]

(A) (i) Plain milling cutter (ii) Side milling cutter
(iii) Angles milling cutter (iv) Form milling cutter
(v) End milling cutter (vi) Metal slitting saw
(vii) Special application cutter

Name of operations :

(a) Plain milling cutter (Helical type) : Profile milling work, smooth cutting action for brass and soft steel

(b) Side milling cutter (plain type) : straddle milling operations

(c) Angle milling cutter (single angle) : Milling of dovetails, notches on rachet wheel etc.

(d) Form milling cutter (Concave type) : To produce concave shape.

(e) End mill cutter (Tapper shank) : Longer cutting life and better surface finishing, slot key ways.

(f) Metal slitting saw (plain type) : Ordinary slotting.

Q.4(a) (iii) Explain centreless type grinding machine. **[4]**

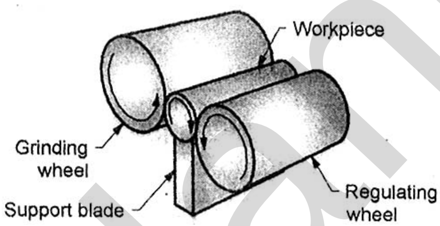
(A) Centreless type grinding machine :

It means without using centres for holding workpiece.

Definition

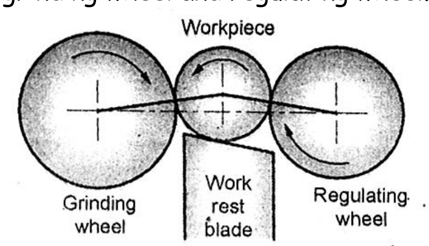
When the workpiece is not supported by centres but between grinding wheel and regulating wheel by a workrest blade, it is called as centreless grinding.

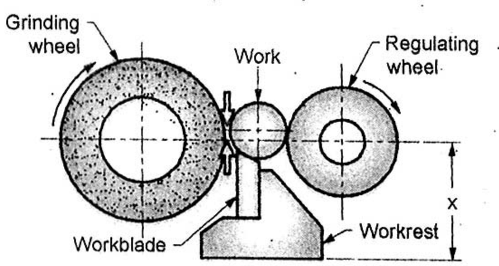
Principle



Principle of centreless grinding

- Centreless grinding eliminates the need for centre holes, drivers and other fixtures required to hold the workpiece.
- The workpiece is held or supported on a work rest blade between grinding wheel and regulating wheel.
- Both wheels are rotated in same direction. The rotation of the grinding wheel forces the workpiece on to the work rest blade and against the regulating wheel.
- The regulating wheel controls the speed of the work and longitudinal feed movement.
- The work rest is adjusted so that the workpiece centre is kept slightly above centerline joining the.centres of grinding wheel and regulating wheel.





Q.4(a) (iv) Write short notes on Repair Complexity. **[4]**

(A) Repair Complexity

- It indicates the complexity of a machine tool. (i.e. it tells about how complex a machine is to repair.)
- Repair complexity cannot be measured by any absolute means, but can be decided from relative figures of similar machines.
- It is a relative index to give a comparative idea of the complexity of a machine.
- It takes into account the mechanical gearings, hydraulics and pneumatic unit, guide surfaces and other transmission units incorporated in the machine.
- Repair complexity is indicated by figures.
- Repair complexity plays a very important part in the machine tool maintenance.
- It helps in deciding the duration between the individual repair and in turn the repair cycle.
- Also, the cost of repair, manpower required, spares required etc. depends upon the complexity of the machine tool.
- For example,
  (i) Repair complexity for a centre lathe of small size is 5.
  (ii) Repair complexity for a medium duty milling machine is between 11 to 15.
- The Repair complexity for a machine changes with the change in specification.
- Its value increases with increase in capacity of the machine.

Need of Repair Complexity

The repair complexity concept is used to determine the following:

(i) Number of maintenance personnel required.
(ii) Quantity of spare parts required.
(iii) List of the material required for the maintenance work.
(iv) Estimate the annual repair cost of the machine tool.
(v) Number of times the breakdown may occur.

Importance of Repair Complexity

(i) Tells about requirement of material for maintenance.
(ii) Tells about requirement of time for maintenance.
(iii) Tells to buy components required for maintenance.
(iv) Tells about material, labour and overall cost.

Q.4(b) Attempt any ONE of the following: **[6]**

Q.4(b) (i) List different types of gear finishing methods. Describe any one in detail. **[6]**

(A) Methods of Gear finishing :

(i) Gear shaving.
(ii) Gear grinding.
(iii) Gear burnishing.
(iv) Gear lapping.
(v) Gear honing.
(vi) Roll finishing.

Gear Shaving :

- It is a finishing operation that removes small amount of metal from the flank of the gear tooth.

- **Gear shaving process helps to**

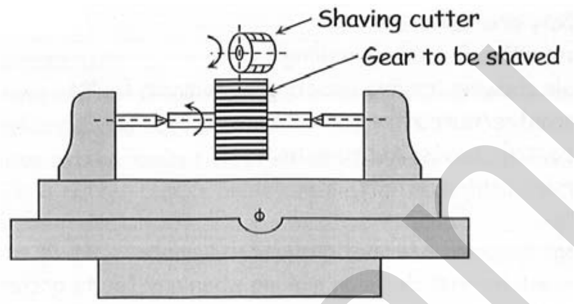
(i) Correct small errors in tooth spacing.
(ii) Helix angle.
(iii) Tooth profile error and concentricity.

Gear shaving improves :
(i) Finish on tooth surface
(ii) Eliminate tooth end load concentration
(iii) Reduce gear noise
(iv) Increases load carrying capacity

Operation :
There are two basic methods.
(1) Rack shaving (2) Rotary shaving

Rack shaving :
- In this method a rack type shaving tool is reciprocated under the gear and in feed is given at the end of each stroke.
- This process is suitable for gears of 150 mm maximum diameters.

Rotary shaving :



- In this method gear shaving cutter is used which has grooves cut across the flanks in the planes at right angles to the axis of the cutter.
- These grooves on the cutter from the cutting edges. They removes only a small amounts of metal between 0.03 and 0.08 mm, it means they merely shave the teeths of gear hence it is known as gear shaving machine.

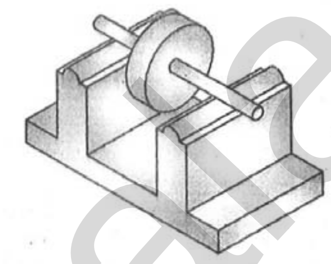
Q.4(b) (ii) Explain Balancing of Grinding Wheel. **[6]**
(A) Balancing of Grinding Wheels
Introduction
- When a new grinding wheel is used, it should be first checked for proper balance. Most manufactures balance their wheels before selling them.
- A wheel is said to be unbalanced when some portion of it is heavier, whereas the other is lighter. An unbalanced wheel will greatly affect the surface finish and accuracy of the work.

Effect of Unbalanced Wheel
(1) At high rotational speeds, slight unbalance will produce vibrations that will cause waviness in the work surface.
(2) Unbalance may cause the wheel to break, with the chances of damage to the machine and serious injury to the operator.
(3) Excessive imbalance creates vibration which will damage the spindle bearings.
Wheels should be tested for balance occasionally and balanced if necessary.

Methods of Balancing of Wheel
(1) Static balancing
- In this method grinding wheel is taken off from the grinding machine and balanced with the help of balancing stand and arbor.
- Wheel is balanced by using counterweights around the wheel flange at desired location.

(2) Dynamic balancing
- In this method there is no need to remove grinding wheel from the machine and it can be balance while wheel is running on the machine.
- New grinding machine has faciliting of automatic balance of grinding wheel.

Procedure to Balance a Grinding Wheel
(1) Mount the wheel and adapter on the surface grinder and true the wheel with diamond dresser.
(2) Remove the steel assembly and mount a special tapered balancing arbor in the hole of the adapter.
(3) Place the wheel and arbor on a balancing stand that has been levelled.
(4) Allow the wheel to rotate until it stops and identify the heavy side and mark it with chalk.
(5) Rotate the wheel and stop it at three positions (90°, 180°, 270°) i.e. counter turn, half turn, three quarter turn to check the balance.
(6) Loosen the set screws in the wheel counter balances, in the grooved recess of the flange and move the counter balances opposite the chalk mark.
(7) Check the Wheel in the four positions mentioned in steps 4 and 5.
(8) Move the counter balances around the groove and check for balance again.
(9) Continue to move the balances away from the heavy side until the wheel remains stationary at any position.
(10)Tighten the counter balance in place.



Q.5 Attempt any FOUR of the following: [16]
Q.5(a) Write short notes on Repair Cycle Analysis. [4]
(A)
- Preventive maintenance involves carrying out inspection, repair and complete overhaul of the machine.
- The inspection and repair activities are carried out on the machine tool in a particular sequence.
- This sequence is determined forehand in the early life of the machine.
- Thus the cycle of I, R (small or medium repair) and C (complete overhaul) is repeated till three or four overhauling.
- The cycle of inspection, small repair and medium repair between two complete overhauls is called as repair cycle.
- OR The cycle from machine commissioning to first complete overhaul is called as repair cycle.
- For example,
  (i) $I_1 - S_1 - I_2 - S_2 - I_3 - M_1 - I_4 - S_3 - I_5 - S_4 - I_6 - M_2 - I_7 - S_5 - I_8 - S_6 - I_9 - C$ is a repair cycle for a particular grinding machine. After every inspections, small repair is carried out. However, after every three inspections, medium repair is carried out and after two medium repairs, complete overhauling is carried out.

  (ii) $C - I_1 - I_2 - I_3 - S_1 - I_4 - I_5 - I_6 - M_1 - I_7 - I_8 - I_9 - S_2 - I_{10} - I_{11} - I_{12} - C$ is a repair cycle for an elevator which consists of one medium repair, two small repairs and twelve inspections between two overhauls.

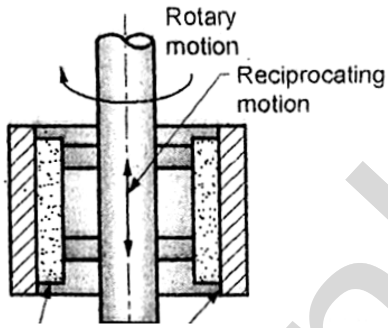
Need of Repair Cycle Analysis

The need of repair cycle analysis in maintenance of machine tools is :

(1) To carrying out inspection, repair and complete overhaul of the machine.
(2) To know when the inspection or repair turn comes.
(3) To determine Number of maintenance personnel required.
(4) To determine Quantity of spare parts required.
(5) To determine List of the material required for the maintenance work.
(6) To estimate the annual repair cost of the machine tool.
(7) To determine Number of times the breakdown may occur.

Q.5(b) With a neat sketch, describe working principle of honing process. State its two applications. [4]

(A) Honing Process :



Principle

- Honing is a wet cutting process which removes metal from the workpiece by means of revolving tool that also reciprocate up and down usually inside the workpiece.
- Honing is usually adopted for internal cylindrical surfaces but by using special machines it can be used for honing of external surfaces.

Applications

(1) Internal honing

Engine cylinders, gun barrels, long tabular parts.

(2) External surfaces

Gear teeth, valve seating, races of roller and ball bearings, piston rods, piston pins, spindles, shafts.

Q.5(c) Compare gear shaping and gear hobbing process with respect to accuracy, rate of production, quality and types of gears produced (At least one each) [4]

(A)

Points		Gear Shaping	Gear Hobbing
1.	Accuracy	Gear Shaping process is less accurate than Gear hobbing. Due to reciprocating motion used.	More accurate process due to rotating motion of cutter
2.	Rate of production	Rate of production law.	Rapid rate of production.
3.	Quality	Quality of gear is good in shaping process.	Quality of gear is better in gear hobbing process
4.	Types of gears	All type of gears without warm and warm gear.	Symmentrical shape gears, conventional gears

Q.5(d) Define following cutting parameters of milling operation. [4]

(i) Cutting speed **(ii) Feed**
(iii) Depth of cut **(iv) Machine time calculation**

(A) **(i) Cutting Speed**

The cutting speed of milling cutter is its peripheral linear speed resulting from rotation. It is expressed in m/min. The cutting speed is calculated as,

$$\text{Cutting speed (v)} = \frac{\pi \times d \times N}{1000} \text{ m/min}$$

Where,

v = Cutting speed in m/min
d = Diameter of cutter in mm
N = Speed of cutter in RPM

(ii) Feed

The feed in milling machine is defined as 'the rate with which the work piece advances under the cutter'. The feed can be defined in following ways,

(a) Feed per tooth
It is defined as 'the distance the work advances in a time between engagements by the two successive teeth'. It is expressed in mm/tooth of cutter.

(b) Feed per cutter revolution
It is 'the distance the work advances in the time when the cutter turns through one complete revolution'. It is expressed in mm/revolution of cutter.

(c) Feed per minute
It is defined as 'the distance the work advances in one minute'. It is expressed in mm/min.

(iii) Depth of Cut

It is the thickness of material removed in one pass of the work under the cutter. It is a perpendicular distance measured between the original and final surface of the work piece, measured in mm.

(iv) Machining Time Calculation **[W-14]**

The time required for machining on milling machine is calculated as,

$$\text{Machining time (T)} = \frac{L}{F \times Z \times N} \text{ min}$$

Where,

L = Length of milling slot in metre
T = Machining Time in min
F = Feed per tooth in mm
Z = Number of teeth on milling cutter
N = Speed of cutter in RPM

Q.5(e) State and explain working principle of 'PLANOMILLER' with block diagram. **[4]**

(A) **Planomiller**

- As the construction of this machine is similar to a double housing planer, it is called as planomiller.
- A planomiller is shown in the figure 1 and its construction is explained below.

Construction

(i) Bed: A fixed bed is considered as the base of the machine.
(ii) Table: A table is mounted on the bed. The table has longitudinal movement only.
(iii) Column: Two vertical columns, one on each side of the bed are mounted on the bed.
(iv) Cross–rail: A cross rail is fitted on the column. It may be lowered or raised to suit the height of the workpiece.
(v) Milling Head: Two vertical milling head are fitted on the cross-rail which can move towards each other. two horizontal milling head are mounted on the column which can move vertical over it.
(vi) Milling cutter: Each milling head carries on cutter.

Working:
The workpiece can be machined in four different ways according to requirements.
(i) By moving the table and cutter rotate in its position.
(ii) By keeping the table stationary and feeding the cutters by moving the milling heads.
(iii) By moving the table and the milling heads simultaneously.
(iv) By heaping the table stationary, moving the cross-rail downwards and the side cutter up and down.

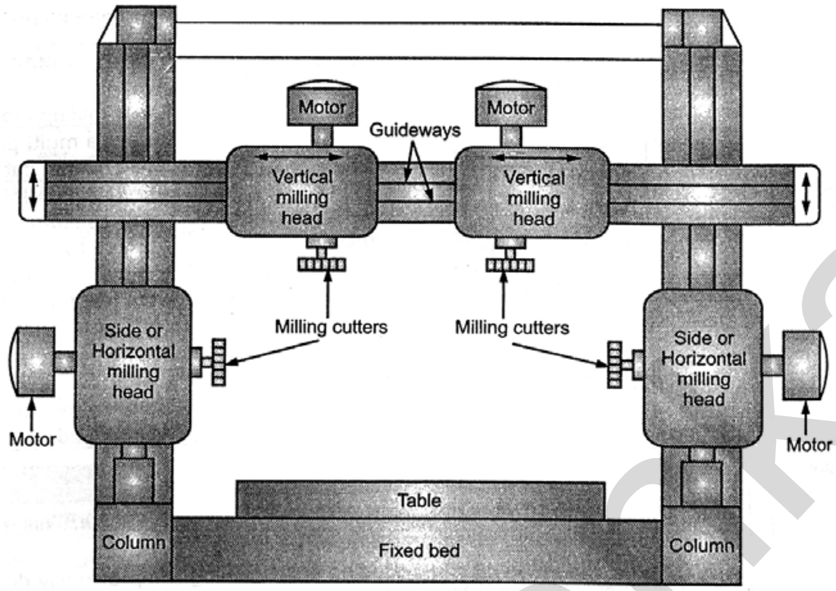


Fig. 1 : Planer type Milling Machine (Block diagram)

Q.6 Attempt any FOUR of the following: [16]
Q.6(a) Explain selection criteria of grinding wheel. [4]
(A) Selection Criteria of Grinding Wheel
As per Indian Standard (ISI1249 – 1958) the following factors may be considered for wheel selection.

(a) Constant factors
(i) Material to be ground
(ii) Amount of stock removal and finish required
(iii) Area of contact
(iv) Type of grinding machine

(b) Variable factors
(i) Wheel speed
(ii) Work speed
(iii) Machine condition
(iv) Personal factor

(c) Other factors
(i) Severity of grinding operation
(ii) Type of bond to be used
(iii) Grain size, grade, structure
(iv) Wet/Dry grinding

Material to be ground
- For soft materials use coarser grit wheel and for hard material use finer grits.
- For H.S.S. tools use aluminium oxide or Borazon wheel.
- For steel and alloy steel use aluminium oxide wheel.

- For cast iron, brass, aluminium use silicon carbide wheel.
- For carbide tools use silicon carbide or diamond wheels.

Amount of stock removal and finish required
- Coarser grit wheels for rapid stock removal where finish is not important.
- Fine grits used for high finishes. Excellent finish can be obtained through 60 to 80 grit.
- Resinoid, rubber or shellac bonded wheels are used for highest finishes.

Area of contact
Small contact area use finer and harder wheels while larger contact area such as internal grinding use coarser, softer grades grinding wheels.

Type of grinding machine
Heavy rigidity machines takes softer wheels and light machines in poor condition requires harder wheels.

Wheel speed
- The maximum safer RPM is marked on each wheel. It influences the selection of grade and the bond.
- Vitrified bond is suitable upto speed of 2000 m/min.

Work speed
A high work speed means more material ground in a given time and greater wear of the wheel, hence higher the work speed, harder must be the bond of wheel.

Condition of the machine
Spindle loose in bearing, shaky foundations may lead to use of harder wheels than machines with proper operating condition.

Personal factor
- A skilled worker can work with softer wheels compare to unskilled for better and more economical production.
- Piece work grinding requires harder wheels than daily routine work.

Severity of grinding operations
Deep cuts, high feed rates, etc. requires tough grinding wheel.

Wet / Dry grinding
- Wet grinding, permits use of harder wheel gives longer life.
- Soluble-oils, sulphurised oils, synthetic compounds are used to cool and clean the work and the grinding wheel.

Q.6(b) State advantages and limitations of broaching process. **[4]**

(A) Advantages :

(1) It is suitable for mass production as the rate of production is very high.
(2) No special skill are required in this operation.
(3) High accuracy and good surface finishing can be achieved by this operation.
(4) In single pass roughing and finishing cut are possible.
(5) Internal and external surface can be machined.
(6) Variety of shapes can be reproduce.

Disadvantages :

(1) High tooling cost because broach is special multi–tooth cutter. The broach is usually suitable for one type of job.
(2) Large workpieces are difficult to mounts on the fixture and cannot broached.

(3) The initial cost of the broach is very high as compared to other cutting tool.
(4) Not suitable for small quantity and variety of sizes components due to high tooling cost.
(5) Very light and delicate jobs cannot be broached easily. They may be broken distorted due to high cutting process.

Q.6(c) Explain Maintenance Practices for **[4]**
(i) Bearing (ii) Coupling

(A) (i) Bearing

- Bearing may fail before its expected life, if its proper care and maintenance is not taken. Many bearings require periodic maintenance to prevent premature failure, although some such as fluid or magnetic bearings may require little maintenance.
- Most bearings in high cycle operations need periodic lubrication and cleaning and may require adjustments to minimize the effects of wear.
- Bearing life is often much better when the bearing is kept clean and well lubricated.
- The following care is required to increase the life of bearing.
  - Keep the bearings dirt-free, moisture free, and lubricated.
  - Water will rust the bearings and dirt will destroy the smoothness of the super finish on your bearing races, increasing friction.
  - Clean the bearings when they become dirty or noisy with the most environmentally friendly cleaner.
  - Do not add oil to dirty bearings. It will not clean the bearing, but merely flush the existing dirt further into the bearing.
  - Clean the bearings before re-lubricating them.
  - Additional supply of grease should be given to the newly procured bearings before they are started running, or to the bearings that have stopped running for more than 2 months before they are re-started for running.
  - The discharged grease should be removed timely.

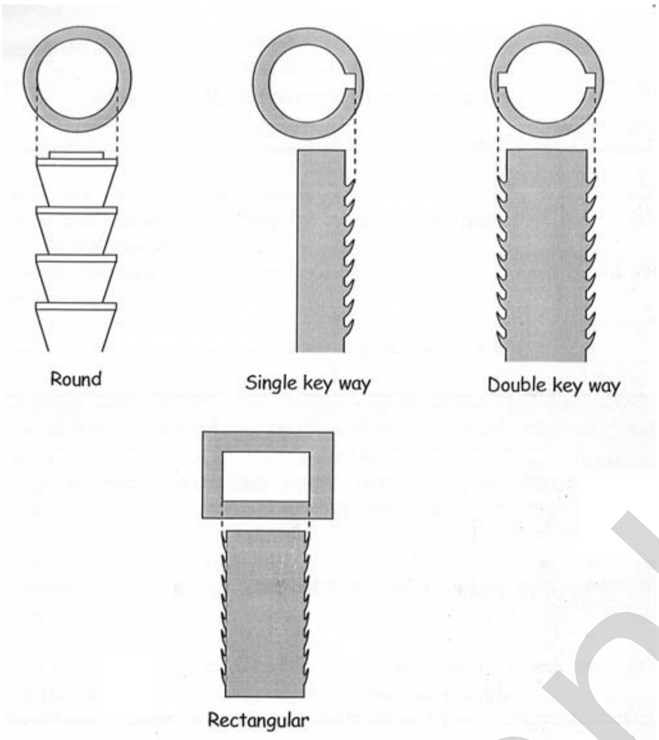
(ii) Coupling

- Gasket should be placed in the female coupling to make the connection water tight. Gasket should be checked every time a connection is made and should be replaced if there is an indication of wear cut etc.
- To facilitate making and breaking connections, couplings are furnished with rocker lugs. Rocker lugs are located on all male and female couplings with the exception of couplings found on booster hose.
- All couplings are attached to the hose jacket by an expansion ring. This expansion ring is pressed outward, securing the hose jacket to the coupling.
- The lug portion, the locks and the race way of the coupling should be lubricated.
- Do not lubricate the gasket or seals. Replace the gasket periodically.
- Following practice should be followed for bearing:
  - Coupling maintenance is generally a simple matter, requiring a regularly scheduled inspection of each coupling.
  - It consists of performing visual inspections, checking for signs of wear or fatigue, and cleaning couplings regularly.
  - Checking and changing lubricant regularly if the coupling is lubricated.
  - This maintenance is required annually for most couplings and more frequently for couplings in adverse environments or in demanding operating conditions.
  - Documenting the maintenance performed on each coupling, along with the date.

Q.6(d) Sketch any four profiles which can be produced by broaching process. **[4]**

(A) Some example of internal broaching are given below :

Broaches and products shape :



Q.6(e) State the significance of – G01, G04, M06, M03 in part programming. **[4]**

(A)
G01 → Linear interpolation
G04 → Dwell
M06 → Tool change
M03 → Spindle start (clockwise)

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