

Advanced Manufacturing

⇒ Manufacturing is a science or technology through which the raw material is converted into finished product.

⇒ In manufacturing there are various steps these steps are known as manufacturing processes.

Traditional Machining or Conventional Machining

⇒ It requires the tool which is harder than the workpiece to be machined.

⇒ It removes certain portion or part of workpiece to change them into final product by penetrating the cutting tool upto certain depth in the workpiece.

⇒ There is relative motion between the tool and workpiece takes place.

⇒ Energy used is only mechanical energy.

⇒ Micro-chip formation takes place.

Note:- Now-a-days development of harder material in the world like ceramic, carbide, tungsten cannot be machined.

Limitation of traditional machining

- ⇒ Harder material is difficult to machine.
- ⇒ Very minute hole cannot be produced.
- ⇒ Tool must be harder than the workpiece.
- ⇒ Difficult to produce complex shape in harder material.

Non-traditional Machining :-

⇒ It is a process of manufacturing that removes the excess material from the workpiece to obtain the desired shape and structure by using various technique and energy like electrical energy, chemical energy, thermal energy or combination of these energy without interacting the cutting tool with the workpiece.

Characteristic :-

- ⇒ No physical contact between the tool and workpiece.
- ⇒ Tool need not to be harder than W/P.

- ⇒ take place
- ⇒ Different energy domain are used for Machining.
- ⇒ Any Material can be Machined irrespect of its hardness.
- ⇒ Any complicated shape can be produce.
- ⇒ Minute hole can be easily drilled.

⊕ Difference between conventional and unconventional machining

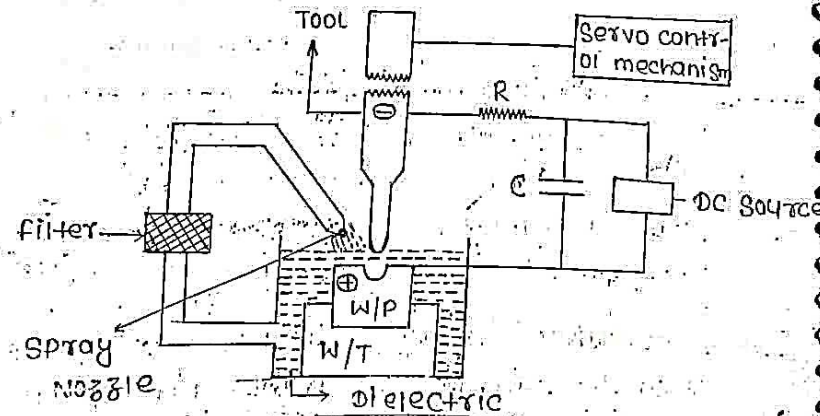
Conventional Machining	UNconventional
1.) Interaction between cutting tool and workpiece takes place.	1.) Interaction betw. cutting tool and workpiece not to place.
2.) only Mechanical energy is involved.	2.) various energy like electrical, thermal, mechanical, chemical are involved.
3.) Micro-chip formation takes place.	3.) Micro-chip format No chip formation takes place.
4.) Work hardening takes place.	4.) work hardness doe not takes place.
5.) tool must be harder than workpiece.	5.) tool need not be harder than W/P.

6) Complex structure use is difficult to produce. | 6) complex structure is very easy to produce.

★ Different type of machining operation.

- 1) EDM → It stands for electrode discharge Machining.
- 2) LBM → It stands for laser beam machining.
- 3) EBM → Electron beam machining.
- 4) USM → Ultrasonic Machining.
- 5) ECM → Electro chemical machining.
- 6) AJM → Abrasive jet machining.

1) Electrode discharge machining :-



Element of EDM :-

i) DC SUPPLY :-

⇒ It is used to connect the workpiece and the cutting tool and create a potential difference ranging between 50V - 450V between the tool and W.P.

ii) TOOL :-

⇒ It is generally made up of graphite, cast iron, silver, copper, tungsten i.e. those materials which have maximum no. of free electrons.

iii) Di-electric liquid :-

⇒ Its main function is to flush the metal material between the tool and workpiece. Generally kerosene is used as di-electric liquid as it prevents the formation of bubbles and eliminates the chance of cavitation.

iv) WORKPIECE :-

⇒ Workpiece is mounted on the worktable and is connected to the DC source and acts as anode.

→ The workpiece must be a conducting material.

v) NOZZLE :-

from the workpiece by facing the di-electric liquid stream with high velocity through erosion process.

vi) RC circuit :-

⇒ A Resistance capacitor is attached to the DC source in which the capacitor is in parallel combination with the DC source when the voltage in the capacitor reaches to the breakdown voltage, the di-electric liquid gets ionised and becomes ionised liquid.

vii) Servo control system :-

⇒ When spark is produced from the tool towards the workpiece then a propulsive effect is generated which forces the tool to move away from the workpiece. This increases the machining gap between the tool to move away from the W.P. This increases the machining gap b/w the tool and workpiece and the spark induced gets eliminated.

⇒ To continue the spark the tool must advance towards the workpiece to again establish the machining gap. This is done by a rack & pinion.

-pinion arrangement. this is known as servo control.

* Working :-

⇒ when the DC supply source is switched on first the capacitor charges and when the voltage across the capacitor is equal to breakdown voltage then dielectric liquid gets ionised and starts behaving like conducting liquid.

⇒ the electron is in abundance at the tool and deficient at the WIP therefore flow of electron from the tool to the WIP takes place in form of SPA. this sparks generates high temperature at the region where it is incident and melts the material which is further driven off by erosion process through the dielectric liquid and in this way machining takes place.

• Output characteristic of EDM :-

i) MRR :-

⇒ It is the volume of material removed per minute.

⇒ Material removal rate is directly proportional to voltage. As V increases I also increases and when I increases heat developed to melt the material increases which increases the material removal rate.

⇒ ex:- for a workpiece of steel when a voltage of 50V, material removal rate becomes $400 \text{ mm}^3/\text{min}$. and when voltage is equal to 400V material removal rate becomes $4800 \text{ mm}^3/\text{min}$.

ii) Accuracy :-

⇒ the tolerance value in EDM is $\pm 0.05 \text{ mm}$. However by controlling different variables tolerance value equals to $\pm 0.3 \text{ mm}$. these minimum tolerance value indicate the process is highly accurate.

iii) Heat affected zone :-

⇒ The workpiece material when melted is not completely expelled off, during this process as some melted material re-solidifies and forms a layer of

thickness 2-10 μm which is further removed by polishing.

⇒ Due to high temperature a layer of thickness 0.05mm - 0.2mm in temperate condition as because the topmost layer must be hard enough to resist the wear.

⊖ Desirable property of dielectric liquid used in EDM.

⇒ It must have low viscosity.

⇒ It doesn't contain any toxic particle.

⇒ It must be inflammable.

⇒ It does not have tendency to produce bubble as bubble formation may create cavitation.

⇒ It must be cheap and easily available.

⊖ Advantage of EDM :-

⇒ very fine holes can be drilled very easily.

⇒ there is no direct contact between the tool and workpiece therefore there is less chance of tool wear.

⇒ extremely very hard material can be machined very easily.

⇒ Since, in this process micro-chip formation takes place hence better surface finished is obtained.

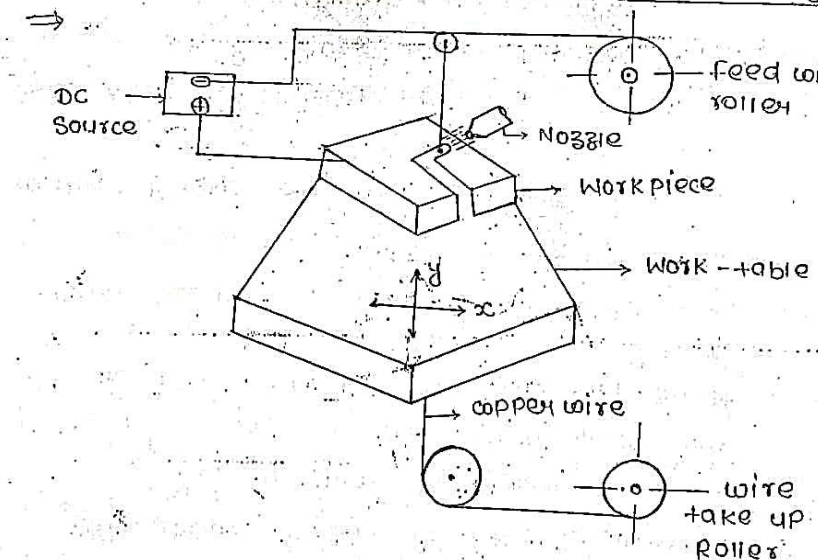
⊖ Disadvantage of EDM :-

⇒ It is only used for conducting workpiece.

⇒ Material removal rate is low.

⇒ Power consumption is very high. hence process is expensive in nature.

⊖ Wire-cut electrode discharge machining



ii) It removes the used wire by wire take up roller.

iii) It maintain proper amount of tension in the wire which is approximately 50-60% of its maximum tensile strength by proper positioning of the set of roller and pulley.

Principle :-

⇒ It works in same principle of EDM i.e. the heat energy generated by the spark through the wire is used to melt the material from the workpiece which is further flushed out by dielectric liquid.

Working :-

⇒ First a through hole is drilled through out the workpiece. a wire of 0.3 mm diameter works as a tool is feed through the hole. so that the machining gap of 0.5 mm is maintained.

⇒ When the DC source supply the voltage to create the potential differential upto 50 volt between wire and workpiece, electric spark is generated in the

Construction :-

1) DC Source :-

⇒ the workpiece is connected at positive terminal of DC source and tool i.e. copper wire is connected to the negative terminal of DC source.

⇒ DC source established a potential differential of 50 volt between the tool and workpiece.

2) Dielectric :-

⇒ the dielectric liquid used in this is water. A nozzle is employed to inject the dielectric liquid in the machining gap. the dielectric liquid flushes out the melted material from the workpiece.

3) CNC control System :-

⇒ Movement of table on which the workpiece is mounted is controlled by CNC control system. table has movement only in two perpendicular axes.

4) Wire drive system :-

liquid through the nozzle.

⇒ Since the wire is of very small in dia therefore the section of wire which produces the spark gets tilted and it is unable to produce the straight cut hence for straight cutting fresh wire is continuous feed through out the workpiece.

Output characteristic of wire-cut EDM

Discharge current :-

Material removal rate is directly proportional to the current developed i.e. on increasing the current material removal rate increases but since the wire is of very small diameter. Hence the value of current may increase upto 30 Ampere. Beyond this value wire cannot withstand.

Cutting rate / cutting speed :-

⇒ Wire speed 2.5 to 150 mm/sec.

→ Average machining rate is 10-15 mm²/min

Wire tension :-

⇒ In order to keep the wire straight proper tension in the wire must be maintained

⇒ to maintain the tension rollers and pulleys are used at proper distance such that the tensile strength in the wire is

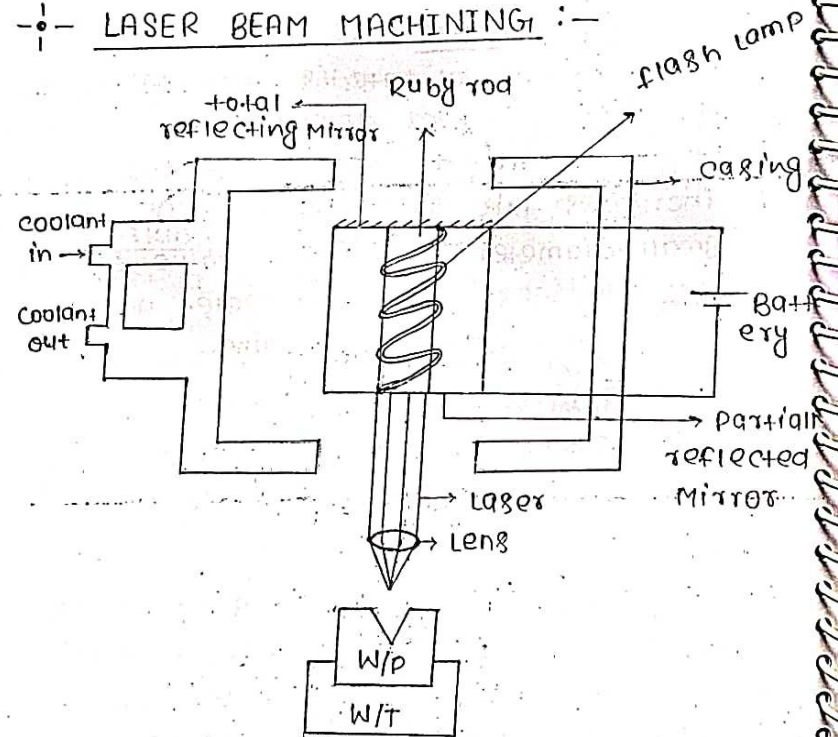
50-60 of its maximum tensile strength

4.) Di-electric flow :-

⇒ the Nozzle is used to spray the di-electric in the machining area the flow should be continuous.

⇒ the used di-electric can be again used only by filtration.

LASER BEAM MACHINING :-



Construction :-

i) Laser generation unit :-

⇒ In this unit ruby rod, flash lamp, power supply, mirror are used for production of laser.

⇒ the ruby rod contains Aluminium oxide with chromium. the end of ruby rod are attached with mirror. one is total reflecting while other is partially reflecting.

⇒ the flash lamp having Argon, Krypton, Xenon gas is wound around the ruby rod. the flash lamp is connected to electric power supply. the electric supply is so designed that it will produce 250-1000 watt energy.

ii) Cooling system :-

⇒ Ruby rod becomes less efficient at high temperature and it gives maximum efficiency when kept at a

⇒ Hence a cooling system is provided which liquid Nitrogen is used. Sometime air or water can also be used but it has less efficiency than Nitrogen.

Collimating lens :-

⇒ the laser beam is passed through a collimating lens whose tendency is to converge the laser beam at a particular point.

Work-Table :-

⇒ the work table is made up of Aluminium as because on Aluminium there is no hazardous (खतरनाक) effect.

Working :-

- ⇒ When the power supply is on the flash lamp emits flashes of light.
- ⇒ the ruby rod absorbs sufficient heat energy required to excite the chromium ion.
- ⇒ the chromium ion goes in excited state where it is unstable and remains for only 10^{-8} sec after this the excited ion releases its energy in form of photon with some wavelength.
- ⇒ But since the end of ruby rod is reflecting therefore after multiple number of reflection laser is produced.
- ⇒ the amplified beam of laser comes out from partially reflecting

Mirror and then passes through collimating lens.

- ⇒ the lens converges this laser beam to a particular point where machining is required.
 - ⇒ this melts the portion of a W/P where laser strikes and vaporises the W/P material thus machining is obtained.
- ## Controlling Parameters or output characteristics of laser beam machining :-
- i) Intensity of laser beam :-
 - ⇒ Intensity of laser beam decides whether the beam will produce cutting or welding.
 - ⇒ for machining operation the min. intensity required is 1.5×10^7 watt/cm², if intensity is less than 1.5×10^7 watt/cm² then welding will take place.
 - ii) flash lamp frequency :-
 - ⇒ flash lamp for good and efficient production of laser it should produce 12 flashes of light per min.
 - iii) focal distance :-
 - ⇒ the workpiece should be kept as close towards the lens. If the distance will be more than divergence will be more.

⊥ Difference between EDM and LBM.

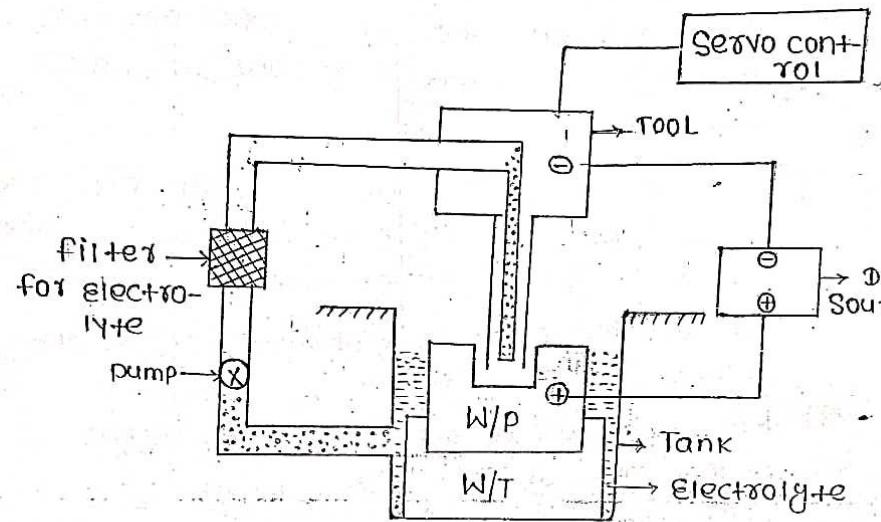
EDM	LBM
1) It works on the principle of spark erosion.	1) It works on the principle of laser.
2) It is used for conducting material.	2) It is used for conducting as well as non-conducting material.
3) Dielectric liquid is used.	3) Absence of di-elect.
4) EDM requires a tool which may be soft and have abundance of electron.	4) LASER is itself a tool.
5) Due to cavitation tool wear takes place.	5) No chance of tool wear as cavitation does not take place.
6) Heat affected zone are very high.	6) Heat affected zone are very low.

⊥ ELECTRO-CHEMICAL MACHINING :- (ECM)

Construction :-

⇒ workpiece is made anode by connect

fig :- Electro-chemical Machining



Material can be machined by this process

⊥ TOOL :-

⇒ A special design tool is used for ECM. It will form cathode. there must be passage inside the tool for the flow of electrolyte.

⇒ the tip of the tool is so design that its shape is replica of the shape

-|- DC Supply :-

⇒ the Power supply is of 3-4 V. the tool connected with negative terminal and work piece is connected with positive terminal.

-|- Electrolyte :-

⇒ Generally water soluble NaCl or water soluble NaNO_3 is used as electrolyte. Electrolyte dissolve workpiece material as precipitate it to facilitate the removal of workpiece material this process of diffusion of the workpiece in electrolyte is called Anodic dissolution.

-|- Servo control :-

⇒ Servo control is used to feed the tool towards the W/P.

⇒ During machining cavity forms where material is removed.

⇒ Due to which machining gap increases therefore servo control move the tool towards the workpiece to maintain a constant gap of 0.5 mm between the tool and workpiece.

-|- Fixture is used to fix the W/P in its position.

-|- Filter :-

⇒ It is used to filter the workpiece material dissolved in the electrolyte.

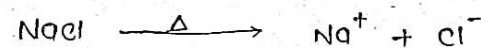
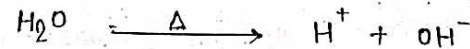
Principle :-

⇒ It works on Faraday law of electrolysis. It is the reverse process of electroplating because in electroplating material on the W/P is deposited. However in ECM material from the W/P is removed.

-|- Working :-

⇒ During ECM there will be electrochemical reaction takes place in which both electrical energy and chemical energy are involved.

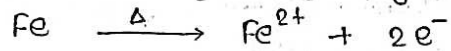
⇒ When the DC source is on a potential difference between the tool and W/P gets set up. due to which current start flowing. the aqueous NaCl gets split into ion.



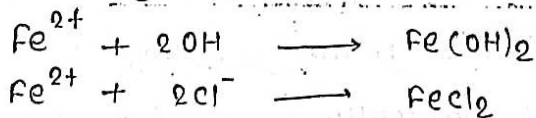
⇒ the H^+ ion move towards the tool and it combine with the electron release by the workpiece and liberated a hydrogen gas.

⇒ the other positive Na^+ ion react with Cl^- ion coming from the electrolyte coming from filter.

⇒ Act Anode due to high current Fe get ionised by releasing electron.



⇒ the Fe^{2+} ion combines with OH^- ion and Cl^- ion to form iron-hydroxide and iron chloride in form of scale which get dissolve in the electrolyte coming from the tool passage and thus material will removed from WIP and machining takes place.



EDM	ECM
i) dielectric liquid are used.	i) electrolyte are used.
ii) It works on spark erosion principle.	ii) It works on farada law of electrolysis.
iii) material is removed by melting.	iii) material is removed by diffusion through electrochemical reaction.
iv) only electrical energy is involved.	iv) both electrical & chemical energy are involved.
v) High voltage, low current (400V, 500A) is used.	v) low voltage high current (50V, 40000A) is used.
vi) low metal removal rate (1000 m ³ /min).	vi) High metal removal rate (15000 m ³ /min).

⚡- LBW (Laser beam welding) :-

⇒ LBW is basically a joining process between surface of two workpiece with the help of a laser beam.

⇒ If the intensity of laser beam is

less than $15 \times 10^7 \text{ watt/cm}^2$ then the
workpiece material between the two
surface get diffused into each other

→ the two surface becomes a unit that
is known as laser beam welding

L-14 → EBM
L-15 → OSM

UNIT - 4 CNC Milling Machine †

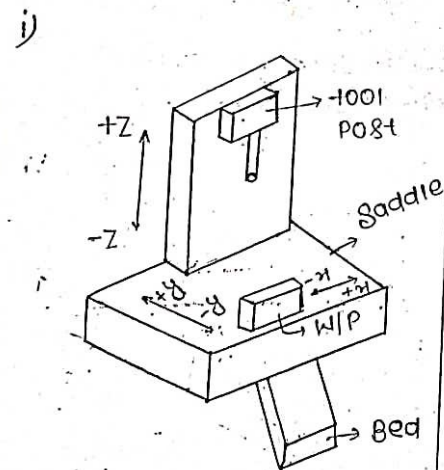
CNC Milling :-

↳ The word CNC means Computerised Numerical Control.

↳ therefore CNC milling machine are those milling machine in which various milling operation are obtained by computerised numerical control.

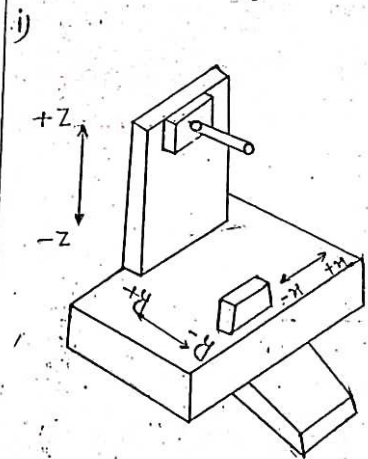
† Difference between vertical and horizontal milling machine center.

Vertical Milling Machine Center



ii) In this the axis of the spindle is vertical

Horizontal Milling Machine Center



ii) In this the axis of spindle is horizontal

3.) the tool post is mounted on the column with the help of a swivelling plate.	3.) Tool post is mounted directly on the column with the help of a swivelling plate.
4.) the tool post has to be swivelled at any desired angle therefore it must be small and light in weight.	4.) the tool post has to be swivelled along the column therefore it can be large and heavy in weight.
5.) Less number of tools can be held in the tool post.	5.) More number of tools can be held in the tool post.
6.) It contains a simple structure.	6.) It is rigid in structure.
7.) Material removal rate is low.	7.) Material removal rate is high.
8.) Mostly it is used in industry due to its versatile nature.	8.) It is not preferred to be used in industry as it is less versatile.

Axis identification :-

According to axis identification in CNC M/C three types of axes are defined.

- i) Linear axis
- ii) Rotational axis
- iii) Parallel axis

Linear axis :-

It is defined for the three principle axes in which the motion of either workpiece or milling cutter are linear.

It is of three types.

i) Z-axis :-

It is the axis of the spindle or axis of the tool.

If the tool moves downward i.e. towards the workpiece it will be negative Z.

If the tool moves upward i.e. away from workpiece it will be +Z in vertical milling machine center.

ii) X-axis :-

It is the axis along the longitudinal direction of the workpiece.

If the workpiece moves towards right it will be +X and if the workpiece moves towards left it will be -X.

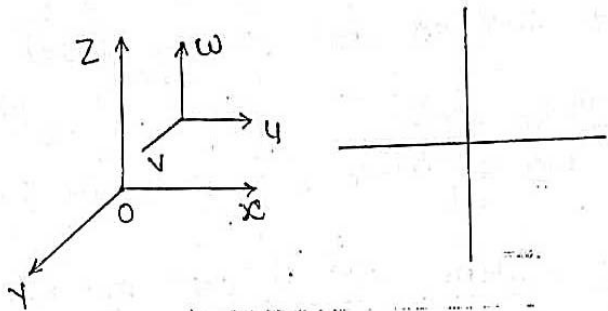
iii) Y-axis :-

It is the axis perpendicular to both X-axis and Z-axis. It is in lateral direction of workpiece.

If the workpiece moves towards the

Cutting tool it will be $+Y$ and away-cutting tool it will be $-Y$.

Parallel Axis :-



there are three parallel axis which are parallel to the principle axis,

i) U-axis :-

↳ those axis which are parallel to the X-axis are called u-axis.

ii) V-axis :-

↳ those axis which are parallel to the Y-axis are called v-axis.

iii) W-axis :-

↳ those axis which are parallel to the Z-axis are called w-axis.

Rotational axis :-

↳ there

then it will be positive and if the rotation is in anti-clockwise direction then it will be negative.

ii) B-axis :-

↳ It is the rotational axis about Y-axis.

iii) C-axis :-

↳ It is the rotational axis about Z-axis.

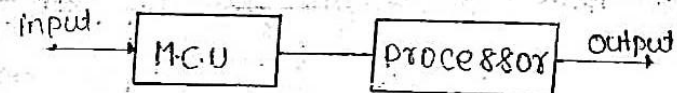
Control system used in CNC milling machine

↳ there are two type of control system used in CNC milling machine.

i) open loop control system.

ii) closed loop control system.

i) Open-loop Control System :-

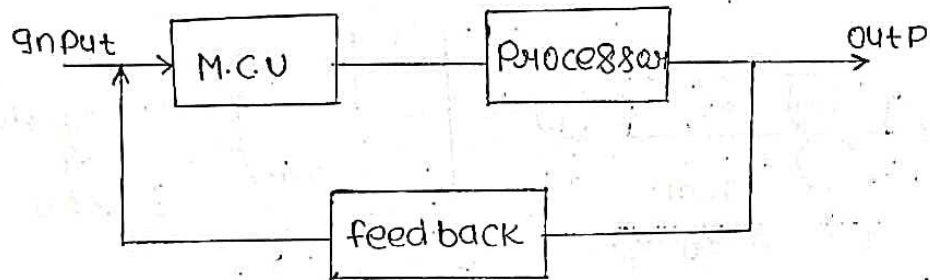


↳ In this system there is no feedback of output from given input.

↳ the accuracy of the machine depends fully on the response of processor.

has less working electronic component & it is less expensive.

ii) CLOSE LOOP CONTROL SYSTEM :-

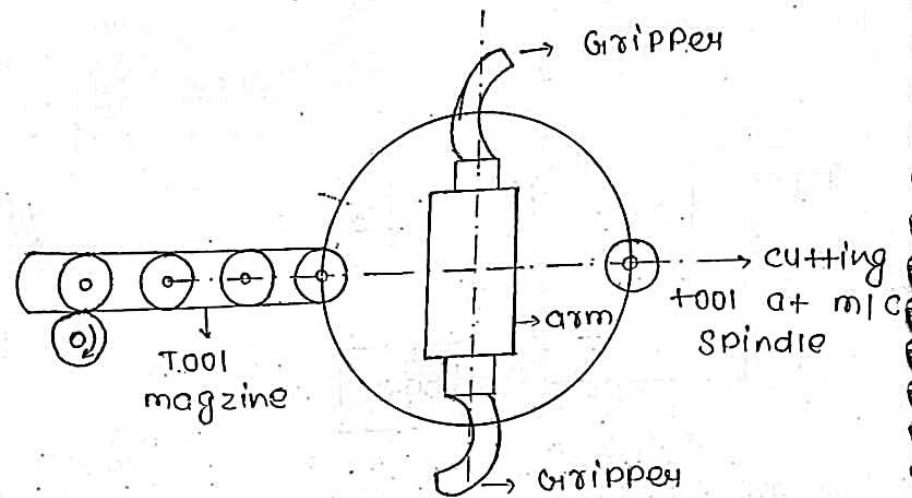


→ In this system there is feedback system which sense the deviation in the output from its accurate value and therefor by changing the input parameter desired output is produced.

→ the loop between input and output is closed.

→ Due to feedback system a large number of electronic component are present hence it is expensive.

Automatic tool exchanger :-



→ Automatic tool exchanger is used in machine to improve the rate of production and tool carrying capacity of the machine.

→ Automatic tool exchanger changes the tool very quickly, and reduces the non productive time and hence increase the productivity.

→ Generally it is use to improve the capacity of machine to work with large

of each block; we use symbol (;) at means end of block.

-|- System :-

→ It is basically sequence of programme it is the systematic arrangement of block of programme in sequential manner.

-|- Codes used in programming :-

→ there are two codes used in CNC mach

- i) G-codes (preparatory codes)
- ii) M-codes (miscellaneous codes)

i) G-Code :-

→ It is also known as preparatory code. It is starting function code and in this machine prepared itself to start machining operation.

-|- G00 :-

→ G00 का उपयोग CNC machine को अपनी full speed पर चलाने के लिए किया जात Tool को तुरंत अपने Home position से starting position पर लाने के लिए किया जाता है। G00 से हम cutting नहीं कर सकते हैं।

EX: [G00 X0.00 Z0.00 ;]

-|- G01 :-

→ इसका उपयोग linear direction में cut करने के लिए किया जाता है। अब हमको workpiece के उपर में linear direction में cut लगाना होता है। तो इसके साथ X, Z तथा feed भी use करते हैं।

EX:- [G01 X — Z — F — ;]

-|- G02 & G03 :-

→ इसका उपयोग job पर arc cutting करने के लिए किया जाता है।

G02 का उपयोग clockwise direction में cut करने के लिए किया जाता है। और

G03 का उपयोग anti-clockwise direction में cut करने के लिए किया जाता है।

इसमें X और Z के साथ R (radius) का प्रयोग किया जाता है।

EX:- [G02 X — Z — R — ;]

-|- G04 :-

→ G04 देने से tool अपने position पर dwelling करता है। इसका मतलब है इसके उपयोग से tool को हम एक ही जगह पर कुछ समय के लिए linear direction में move करने से रोक सकते हैं। इसका प्रयोग अधिकतम dwelling के समय देखा जाता है।

EX: - [G04, Z 5.00, X 2 Sec] X represent +

† G33 & G34 :-

→ G33 का उपयोग constant pitch thread cutting के लिए किया जाता है। इसमें pitch की value 1 ही होगी।

→ G34 का उपयोग variable pitch thread cutting के लिए किया जाता है।

† G40 (+tool nose radius compensation cancel)

→ इसका उपयोग हम पहिले programming में G41 or G42 को cancel करने के लिए किया जाता है।

† G41 (+tool nose radius compensation left)

→ इसके प्रयोग से +001 को इस प्रकार move करना है कि +001 के पीछे बैठे observer के respect में जो +001 के center or nose point के बीच में जो radial dir. होगा वो left की तरफ होगा।

† G42 (+tool nose radius compensation right)

→ इसके उपयोग से +001 को इस प्रकार से move करना है कि +001 के पीछे बैठे observer के respect में जो +001 के center or nose point के बीच

† G21 → All dimension are in mm.

† G90 → Absolute system

† G91 → Incremental system

† G92 → Co-ordinate system setting

† G94 → feed in mm/min

† G95 → feed in mm/revolution

† G96 → constant surface speed control
It is the working speed.

† G28 :-

→ इसके प्रयोग से +001 को space में कही से जी Home position पर लाने के लिए किया जाता है।

इसमें X को U से replace करते हैं and Z को W से replace करते हैं।

EX: - [G21 U 0.00 W 0.00 ;]

† M-CODE (Miscellaneous code)

* M03 → Clock-wise direction में spindle को rotate कराने के लिए इसका उपयोग किया जाता है।

आता है।

† M05 :-

→ Spindle को stop करने के लिए किया जा

† M08 :-

→ इसका प्रयोग coolant ON करने के लिए कि

आता है।

† M09 :-

→ इसका उपयोग coolant off करने के लिए

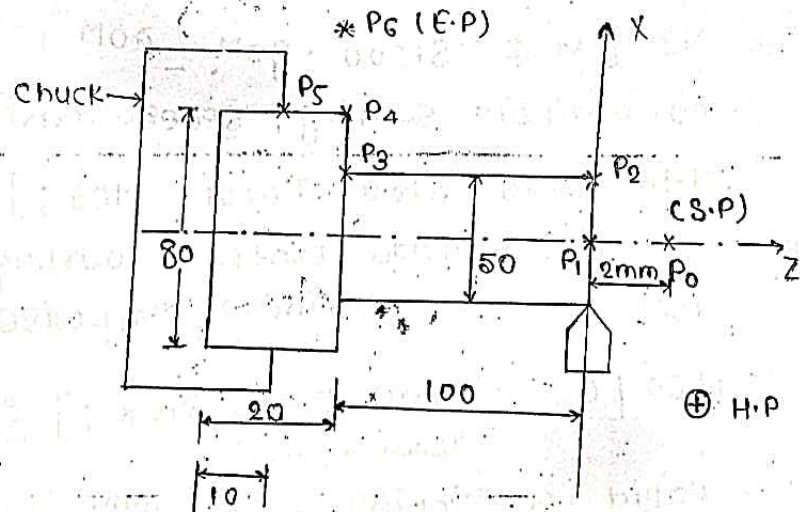
किया जाता है।

† M30 :-

→ End of programming & save the prog

ramme

Q. Write down the part programming for the plane turning operation performed to obtain the given workpiece.



Co-ordinate setting

	X	Z
P0	0.00	2.00
P1	0.00	0.00
P2	50.00	0.00
P3	50.00	-100.00
P4	80.00	-100.00
P5	80.00	-110.00
P6	85.00	-105.00

01234 — Programme Number

N10 [G18 U0.00 W0.00] :-

→ Return the tool to Home Position

N20 [G90 G21 G42 G45] :-

Absolute system, all dimension are in mm
T.N.R.C.R, feed in mm/revolution

N30 [G92 S1200] :-

co-ordinate setting, speed maximum

N40 [G96 S150 T0101 M03] :-

→ constant speed control, working speed
tool selected spindle clockwise rotation

N50 [G00 X0.00 Z2.00 M08] :-
(Common step)

→ Rapid positioning from Home position

to starting position Coolant ON.

N60 [G01 X0.00 Z0.00 F0.12 ;] :-

→ Move tool to P₁, F = 0.12

N70 [X50.00 Z0.00 ;] :-

→ Move to P₂

N80 [X50.00 Z -100.00 ;] :-

→ Move to P₃

N90 [X80.00 Z -100.00 ;] :-

→ Move to P₄

N100 [X80.00 Z -110.00 ;]

→ Move to P₅

N110 [X85.00 Z -105.00 ;]

→ Move to P₆

N120 [G00 G28 G40 U0.00 W0.00 ;]

Home position

N130 [M05 M09 ;]

N140 [M30 ;]

Machine-Tool Automation

⇒ Every industry has to improve quality of finished product. This objective has forced the industry to convert the manual operation into mechanical activity i.e. to replace the human by machine.

Mechanization :-

⇒ The term mechanization means that the operation are carried by machine instead being performed by human.

⇒ The movement of tool and workpiece are automatic but the operation like loading, unloading, clamping, checking the dimension of workpiece are done manually by the operator.

⇒ In mechanization there is no provision of feedback system hence it is open loop system.

Automation :-

⇒ The term automation means high degree of mechanization.

⇒ In this all the process of operation even material handling is also done automatically.

⇒ It means that operator is required only

for supervision and one operator can attend number of machine at a time.

⇒ thus, automation can be defined as the technology concerned with application of mechanical, electronic and computer based system to operate and control the machine.

⇒ Automation is a close loop system in which there is a provision of feedback.

Types of automation: -

- i) fixed automation
- ii) programmable automation
- iii) flexible automation
- iv) integrated automation

i) fixed automation: -

⇒ the machine are arranged as per sequence of operation to be performed.

⇒ It is inflexible and cannot accommodate or allow the variation in product.

⇒ the product design is also constant.

⇒ Product are produced on large scale with high production rate.

⇒ initial set-up cost is high.

ii) programmable automation: -

⇒ the sequence of operation depends on programme.

→ a new programme has to be written for new product.

→ It is used for low production where variation in product is required.

→ It is inflexible with manufacturing process but flexible to deal with variation and changes in product configuration.

Ex: - CNC Machine

iii) flexible automation: -

→ It is capable of performing various manufacturing processes and produces variety of product.

→ Since, it is flexible in both manufacturing process as well as product design therefore no loss in time during any change in product is encountered.

Ex: - A robotic arm that can be programmed for perform welding, forging, drilling painting etc.

iv) Integrated automation :-

↳ those automation in which the manufacturing process are integrated by production, planning, control i.e, sharing the information of workshop floor, quality control, market research with the manufacturing system.

→ It optimises the production industry (computerised integrated manufacturing) software is used for automation.

† Benefit of Automation :-

- ⇒ Increase in productivity.
- ⇒ Human fatigue is greatly minimised.
- ⇒ Good quality product is obtained.
- ⇒ Single operator can operate ^{more than one} many machines at a time.

† Single spindle automates :-

↳ those machine which have a single spindle and used for operating single component at a time are known as single spindle automates.

→ Based on single spindle automate automatic machine are classified in three ways.

i) Automatic cutting of machine :-

⇒ these machine are used for producing small

length shaft from a long bar.

⇒ they are used for cutting operation of a bar or rod to reduce ~~any~~ its length. the spindle carries the workpiece towards the cutting tool.

ii) Swiss type automatic machine :-

→ In this the tool post carrying the tool is fixed and the headstock carrying the workpiece is movable.

→ the headstock moves towards the turning tool to feed the workpiece.

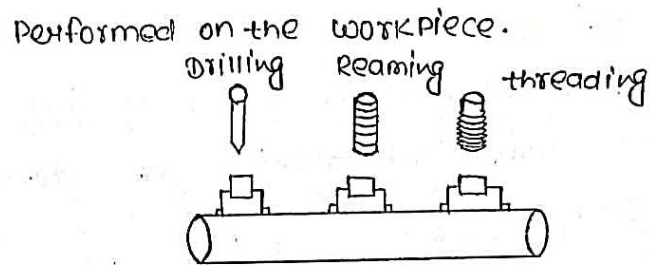
† Turret type automatic machine :-

⇒ In this the headstock carrying the workpiece is fixed at its position and the tool is move towards the workpiece.

⇒ It has a special design tool post in which multiple number of tool can be mounted.

† Transfer line :-

↳ transfer line is an automatic flow line to transfer the workpiece to different working station in a particular direction so that sequence of operation can be



→ It is a combination of material process unit and material handling unit.

→ Each machine in this are in series called machining station and performed operation simultaneously on the workpiece.

⊖ Requirement of a transfer line :-

⇒ correct starting up and finishing up time i.e. the time of operation at each work station must be synchronised.

⇒ Accurate transfer of workpiece at each working station.

⇒ the fixture carrying the workpiece must be rigidly clamped on the transfer line.

⊖ Advantage of transfer line :-

i) material handling is fast and automatic.

ii) faster machining there by reducing the cycle time and increasing the production rate.

iii) since material handling is automatic therefore greater accuracy is achieved.

iv) less number of operators are required.

⊖ Disadvantage :-

i) A very high initial investment is required.

ii) the failure of one machining station will temporarily stop production.

iii) the whole setup to be changed if component design changes.

iv) High maintenance is required.

⊖ type of transfer line :-

↳ transfer line are of three types.

i) Inline transfer line

ii) rotary transfer line

iii) drum transfer line

i) Inline transfer line :-

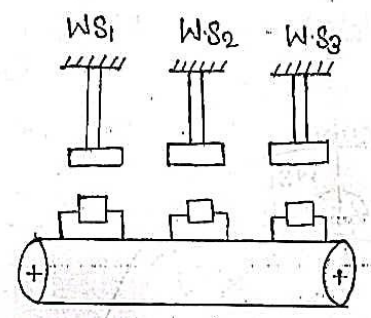
↳ In this type of transfer line the machining station attached on the transfer line are arranged in straight line.

→ but if the floor space is less the machining station can be arranged in various geometrical shape like- L, U, □, □ etc.

→ It is of two type :-

- i) Pallet type
- ii) Plain type

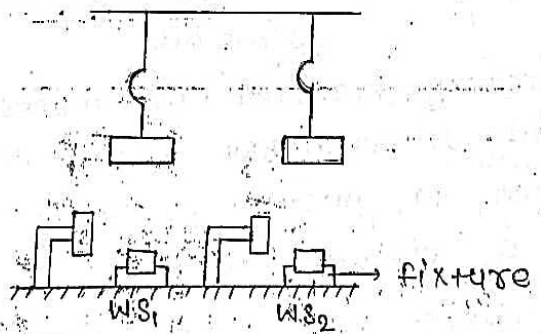
i) Pallet type :-



→ the workpiece is clamped in a holding fix called pallet.

→ In this type of transfer line the pallet carrying the workpiece moves from one machining station to another machining sta

ii) Plain type :-



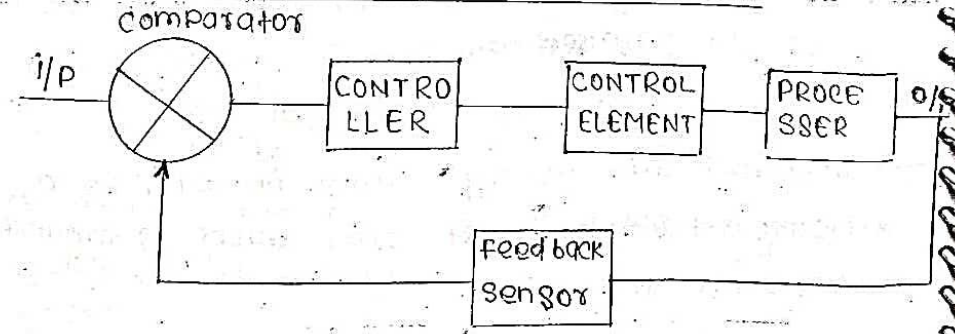
→ In this type of transfer line the w/p is moved itself through help of crane

- the workpiece are located radially on the front and rear side of drum.
- the workpiece are loaded and unloaded at the same working station.
- the station at the bottom of drum is known as idle station. In this machining station operation is not performed.
- It is used for heavy workpiece but it has a limitation that only two machining operation can be performed on the w/p.

Control System :-

→ control system is defined as an arrangement of electrical electronic and mechanical equipment in such a manner so that these combination will direct regulate and control any process or operation.

Block diagram of control system



Comparator :-

↳ It is also known as error detector. In comparator a value of desired product is initially set and this value is known as set point value.

→ After process the output value known a measured value is sensed by the sensor and transmitted to the comparator, where if the measured value differ from the set value then error is detected which is send through the signal to the controller.

Controller :-

↳ The controller examines and analyse the detected error then determine the act to be taken to make the measure value equal to set point value.

Control element :-

↳ It is known as brain of control system
→ It accept the signal given by controller which then transformed into part programming which is further send to the processor.

Processor :-

↳ It is used for implementing direct action given by the control element to perform desired operation.

Sensor :-

↳ The main function of sensor is to sense the output measured value and send the signal to the comparator.

Limit Switches :-

↳ Limit switches is an electro-mechanical devices which have contact actuator.

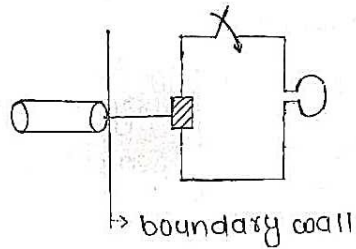
→ When an object comes in contact with actuator the limit switches operate and then either it will make or break the electric circuit.

→ A limit switches is configured so that its actuator is at boundary limit of the object.

→ So that when object reaches its boundary limit it makes contact with the contact actuator which will either open or close the circuit.

→ This change in state of circuit will detect

the object from going beyond its boundary level. Limit.



Proximity switches :-

Proximity switches allow the user to detect the presence of object without having establishment of physical contact.

Proximity switches open or closes the electric circuit ^{when} any object comes in the domain of proximity switches.

therefore proximity switches can be defined as the electronic switches which sense the presence of any object without touching it.

Difference between limit switches and proximity switches.

Limit switches	Proximity switches
i) they required physical contact between the object and switch actuator.	i) they detect the presence of object without physical contact.

Limit switches	Proximity switches
ii) they are completely slow in operation.	ii) they are fast in operation.
iii) Limit switches are less sensitive.	iii) they are highly sensitive.
iv) It is an electro-mechanical devices.	iv) It is an electronic sensor.
v) It respond when the object reaches its boundary or limit.	v) It respond when object comes in the domain of the switch.
vi) they contain mechanical parts hence wear may take place.	vi) they do not have any mechanical parts.
vii) they are less costly.	vii) they are more costly.

Types of proximity switches :-

i) Infrared proximity switches :-

they work by sending out beam of invisible infrared light.

A photo detector is installed with the proximity switches. when any object comes in front of these beam light gets reflected which is sensed by photo detector.

In this way presence of object is felt or sensed which open or close the circuit.

ii) Acoustic proximity switches :-

→ they are similar in principle of the infrared type proximity switches but they use ultrasonic sound wave instead of infrared light waves.

→ They use two transducers one emits the sound wave and other receives the sound wave.

→ When the emitted sound waves strike any object it gets reflected back which is sensed by second transducer hence presence of any object can be felt or sensed which open or close the circuit.

iii) Inductive proximity switches :-

→ these switches sense the object by the help of magnetic field lines.

In this a coil of wire is charged with electric current due to this magnetic field lines are generated around current carrying wire.

→ when any metallic object comes in the region of magnetic field line flux in the wire changes this variation in flux causes the open or close the circuit.

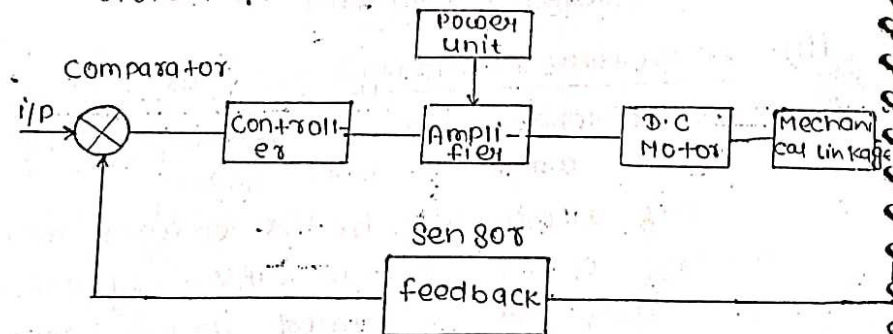
iv) Capacity proximity switches :-

→ In these switches two metal plates with a dielectric medium in between the metal plate is used known as capacitor.

→ when any object comes near the capacitor its dielectric strength varies which send signal to the proximity switches to open or close the circuit.

† Servo control system :-

element block-diagram of servo control system :-



→ It is a type of control system which is used for the process and control of a process of a servo motor.

→ A servo motor is an electromechanical device which produces large output mechanical energy by means of small input electrical energy.

→ It is a closed loop system because it uses feedback sensors.

† Objective of servo control system :-

→ Accurate and automatic control of motion without the need of human operator.

→ Control of high power output from low input.

→ Operation is very fast with less error.

† element of servo control system :-

i) Controller :-

→ Controller is a computer based system which receives signal from the comparator and it is so programmed to send the signal to the amplifier to activate the motor so that desired output is

produced.

ii) Servo-amplifier :-

→ The signal from controller is then passed into amplifier which amplifies the signal upto appropriate level as required for the operation of servo motor to produce desired output.

iii) Servo-motor :-

→ The motor is basically a dc motor which generates very high forces to provide high torque and high speed.

iv) Sensor :-

→ It is a feedback element which sends signal to the comparator where the output is desired or not.

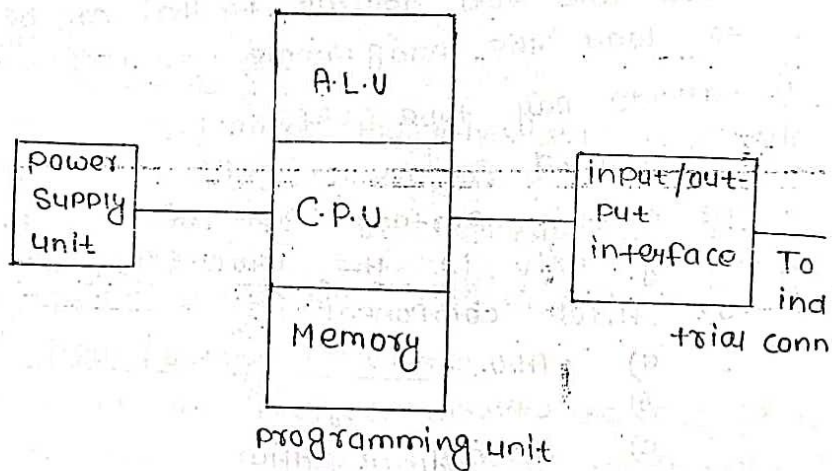
v) Mechanical linkage :-

→ It includes combination of mechanical parts to obtain different types of motion as required.

Programmable Logic Control :- (PLC)

→ It is a software and electronics based devices through which by varying the its parameter some logical decision are made to obtain the different desired output
Ex:- ATM Machine, petrol supply unit.

Element of P.L.C :-



Power supply unit :-

→ The power supply unit provide voltage is necessary to operate the circuit through out the PLC.
Some circuit of PLC required AC voltage and some will require low DC voltage

this requirement of voltage is fulfilled by power supply.

Programming unit :-

→ Programming unit is an external device that is connected to PLC.
→ It is used to enter the data and to edit the stored programme in the processor.

→ there are two devices that can be used to load the programme.

- i) Cathode ray tube (CRT)
- ii) keyboard

→ the most important part of the programming unit is the processor which has three component :-

- a) ALU
- b) CPU
- c) Memory

ALU (Arithmetical logic unit) :-

→ this unit perform mathematical calculation and make logic decision.

→ for desired output input also to be varied therefore ALU prepare logical decision according to varied input to

obtain output as required.

ii) C.P.U (Central Processing Unit) :-

- ↳ It stands for central processing unit
- ↳ It is the brain of PLC.
- ↳ It is a micro processor which work or process according to the logical decision made in the ALU and generate the required electrical signal towards output.

iii) Memory :-

- ↳ the programme and other data required in the PLC is stored in the memory. In PLC two type of memory are used RAM & ROM.

† Input/output interface :-

- ↳ It is an interface where the PLC is connected with industrial equipment.
- ↳ the output signal generated by the CP is received as an input signal by the industrial equipment hence it is known as input/output interface.

† Advantage :-

- ↳ It is hundred percent (100%) error free.

↳ It is very quick in response

↳ It is more reliable.

↳ It increases the productivity.

↳ If the output is to be varied then only by varying the input without varying the programme can be achieved.



Special Purpose Machine

General Purpose Machine :-

- ⇒ General purpose machine is a machine which enables us to perform the operation of different machine.
 - ⇒ A single general purpose machine enables us to avoid the use of some other machine, this results in large saving in investment.
 - ⇒ They can be used for production of large variety of product having different shape and sizes.
 - ⇒ They are slow in operation and therefore rate of production is low.
 - ⇒ GPM has less risk of obsolescence.
- Example :- Lathe machine.

Special Purpose Machine :-

- ⇒ Those machines which produce multiple number of product whose design i.e. whose shape and size are exactly same.

⇒ They produce many number of identical items.

⇒ They are used in mass production.

⇒ The cost of special purpose machine is very high, but it can be justified by its mass production.

⇒ Special purpose machines are defined for a particular product and if the product design changes the machine may not be of use.

Difference between General Purpose Machine and Special Purpose Machine.

GPM	SPM
⇒ It is flexible machine which perform operation to produce different product.	⇒ It is inflexible in nature as it produces only one kind of product.
⇒ Initial investment cost is low.	⇒ Initial investment cost is high.
⇒ They are slow in operation.	⇒ They are fast in operation.

on each workstation. this is known as indexing. hence the table is known as indexing rotary table.

ii) Multiple tool head :-

→ In SPM since different operation has to be performed on a particular workpiece continuously therefore multiple tool is required for different operation. and to operate these tool multiple tool head is required.

iii) Turret type tool post :-

→ Turret is a hexagonal shaped tool holder mounted on a saddle.

→ In this six type of tool are mounted on six faces of the turret.

→ Turret can be rotated about its vertical axis to change the tool during operation.

iv) Hydraulic slide table :-

→ It is a hydraulic oil operated table which is used to move the turret which carry the tool towards and away from workpiece and it also

give the table a rotary motion so that the necessary tool interact with workpiece.

v) Bar feed mechanism :-

→ When workpiece are to be machined a mechanism is required to transfer the workpiece from one machining station to another machining station so that the tool on the machining station can feed the workpiece.

vi) Bar stop mechanism :-

→ When machining operation is performed on the WIP to hold the workpiece at different machining station till the machining is achieved a bar stopped mechanism is required.

† Principle of SPM design :-

→ To design a SPM following principle are to be consider :-

i) Operation are combined :-

→ Various operation are to be performed on a particular workpiece therefore while designing of a SPM it should

be consider that the arrangement of different machining operation should orderly so that operation must be combined in a definite sequence.

ii) Automation :-

→ As far as possible manual operation should be eliminated i.e. make the operation automatic it will increase the production rate.

iii) faster cutting speed :-

→ to increase the production rate higher cutting speed are required for this hard tool made up of carbide, H.S.S, (High speed steel), diamond, CBN (Carboron Nitride) etc.

iv) Less handling of workplace and workpiece

→ Design of SPM should be such that it would be very small and compact so that it would occupy the less working space.

→ Design of SPM should be such that minimum handling of workpiece is done.

+ Number of tool work simultaneously :-

→ Design of SPM should be such that maximum number of tool work simultaneously and the motion of each tool must be synchronized.

+ Benefit of SPM :-

- i) increased in productivity (mass production)
- ii) Less time consuming.
- iii) Since it is high degree of automation therefore less requirement of staff and labour.
- iv) highly durable with less maintenance.
- v) error free production.

unit-05 Maintenance of Machine tool

1-1 Maintenance :-

- ⇒ the word maintenance signifies an art or science of maintaining any object, component or devices.
- ⇒ maintenance means a set of work of keeping something in proper condition. this means that it is an action taken to prevent any device or component from failing.
- ⇒ this maintenance can also be defined as a set of activities that are carried out to keep any equipment or devices in best operational condition to obtain maximum desired output.
- ⇒ the older concept of maintenance was to repair a machine or component only when the breakdown occurs but this leads into loss in production because if the breakdown occurs production will be stopped.
- ⇒ therefore now-a-days maintenance should be plan at regular interval to prevent the breakdown.

1-2 Objective of maintenance :-

- 1) → To minimize the number of breakdowns
- 1) → To keep the plant, any component or object in good working condition with high production rate.
- 1) → It prolong (वर्धना) the service life of machine tool, any equipment or device
- 1) → It minimize the hindrance (बाधा) or interruption (अवरोध) at work.
- 1) → to improve the quality of manufacture product upto desired level.
- 1) → It promotes constant supply of product in market thus prevent sudden increment in its demand and stabilize in price.

1-3 Cause of failure or cause of breakdown

- 1) → cause of failure or breakdown are as follows :-
- 1) ⇒ excessive friction between two machine part due to improper or insufficient lubrication.
- 1) ⇒ failure to replace that part, component or equipment which are in wear (शुरुआत)

of failing.

- ⇒ Neglecting the minor fault, for example - vibration and temperature over loading, working fuel and improper supply of voltage as per requirement.
- ⇒ Unskilled, untrained operator may leads to failure of machine and its equipment.
- ⇒ Poor foundation leads to failure of machine part as because the vibration produced in the machine can not be transmitted to the foundation and remains at the machine which leads to failure or breakdown of the machine and its equipment.

† Types of Maintenance :-

⇒ There are four types of maintenance done in manufacturing.

i) Preventive Maintenance

ii) Predictive Maintenance

iii) Corrective Maintenance

iv) Break-down Maintenance

i) Preventive Maintenance :-

- ⇒ It is based on principle of prevention is better than cure.
- ⇒ Instead of doing breakdown maintenance it is better to prevent or avoid the breakdown if it occurs.
- ⇒ It is basically just like routine checkup.
- ⇒ Maintenance is done on regular basis with fixed time-interval.

ii) Predictive Maintenance :-

- ⇒ During preventive maintenance there is a problem that the maintenance time schedule is fixed but there is a chance that fault may create on component, tool, machinery etc before schedule time which may result in failure of the plant and machinery.
- ⇒ Therefore we require a maintenance before the schedule time by predicting the fault in component part tool & machinery.
- ⇒ It has three steps :-

- i) Detection
- ii) Analysis
- iii) Correction

1) Detection :-

⇒ During this stage initialisation of fault is detected through unusual symptoms (unusual vibration, unusual sound, unusual heat etc).

ii) Analysis :-

⇒ this stage is for analysing the main cause of the fault and effectiveness of the fault. i.e, either it is major or minor in nature.

iii) Correction :-

⇒ During this stage after analysing the main root cause of the fault it is corrected in order to make it fault free.

3.1 Corrective Maintenance

the repair of component which are able to fail through detection by the help of different sensor, optical instrument and other measuring instrument mounted on every machine.

⇒ the unique feature of corrective maintenance is that after maintenance the component gets automatically tested through sensor, optical instrument and other measuring instrument mounted on every machine.

4) Breakdown Maintenance :-

⇒ as the name suggest in breakdown maintenance, maintenance is carried out after breakdown or failure of machine component.

⇒ the machine will not considered for maintenance until it gets completely fail.

Predictive

- 1) Predictive maintenance is carried out as the machine are in production mode or in running mode i.e when fault is detected.
- 2) It is a need based maintenance.
- 3) concerned is given to the actual performance with respect to optimum performance.
- 4) It is not repetitive w.r.t time.
- 5) Predictive maintenance is done on the basis of continuous inspection and monitoring.

preventive

- 1) preventive maintenance are carried out in a particular time schedule when the machine are completely shut off.
- 2) It is a time based maintenance.
- 3) there is no concern to the actual performance w.r.t optimum performance.
- 4) It is repetitive w.r.t time.
- 5) Preventive maintenance is done on the basis of manufacturing inspection.

-/- Difference between preventive and breakdown maintenance.

Preventive

- 1) It is generally done before failure.
for preventive maintenance the machine are shut down.
- 2) It is done at pre-schedule.
- 3) It is a time based maintenance.
- 4) Down time in maintenance is less.
- 6) It is independent of life of machine and equipment.

Breakdown mainte

- 1) It is generally done after failure.
- 2) In breakdown maintenance the machine are shut down.
- 3) It is done when a need occurs.
- 4) It is a need based maintenance.
- 5) Down time in maintenance is high.
- 6) It depends on life of machine and equipment as the machine gets older frequency of breakdown maintenance increases.

-/- Difference between corrective and breakdown maintenance.

corrective	breakdown maintenance
i) It involve the repair or replacement of machine component which are about to fail.	i) It involve repair or replacement of machine component which has failed.
ii) the fault can be recognized by the help of modern technique i.e through sensor and optical instrument.	ii) there is no any provision to recognize the fault before failure.
iii) After correcting the fault inspection and testing can be done automatically.	iii) After correcting the fault the machine or component has to be inspected manually.
iv) Testing equipment cost is required.	iv) testing equipment cost is not required.
v) down time is less because breakdown has not occurred.	Down time is more because breakdown has occurred.

Stages of preventive maintenance:-

⇒ there are ~~three~~ ^{four} stages used in preventive maintenance.

- i) INSPECTION :-
 - ⇒ It is the first stage of preventive maintenance. In this through inspection the fault in the machine component is recognized.
 - ⇒ In this no repair is done.
 - ⇒ In this, inspection of all mechanism at different speed is checked.
- ii) Small repair :-
 - ⇒ It is the second stage of preventive maintenance. It involve following operation:
 - Replace the used oil, coolant and cutting fluid and set new oil, coolant and cutting fluid upto required level.
 - Tightening of the nut and bolt.
 - Clean the oil filter and relative moving parts and then provide lubrication of them.
 - Adjust properly all the machine parts.
- iii) Medium repair :-
 - ⇒ It is the third stage of preventive maintenance.
 - After two small repair one medium repair

is done.

→ It involve following function:---

i) It removes, repair the damaging rotating moving parts such as - bearing, bushes, gears, belt, axle etc.

ii) It eliminates the leakage through the pipe, joint by proper insulation.

iv) Overhauling :-

⇒ It is the last stage of preventive maintenance. It is also known as de-assembly assembly stage because in this every component is de-assembled and is inspected to detect the fault.

→ Repair and replace the damage part.

→ After this assembly of component is done and the machine is tested in no load condition.

† Repair cycle :-

⇒ It is a cycle which represent the order or sequence of different stages used in preventive maintenance.

→ According to repair cycle after two small repair one medium repair is done & at two medium repair one overhauling is done.

$(I_1 S_1 I_2 S_2 I_3 M_1 I_4 S_3 I_5 S_4 I_6 M_2 I_7 C)$

Where, I = inspection

S = Small repair

M = Medium repair

C = Overhauling

⇒ The above sequence of preventive maintenance is known as half repair cycle and if this sequence is followed twice then it will represent one complete repair cycle.

† Repair complexity :-

⇒ If the machine has more number of mechanism and devices then it is called complex machine and its maintenance is very complicated.

⇒ The complexity of a machine plays a very important role in maintenance as because it forecast the maintenance type, maintenance cost, maintenance time &

equipment required.

⇒ The complexity of any machine is decided through a number known as repair complexity index. It is based on following factors :-

- i) Number of component in the machine.
- ii) Number of mechanism involved.
- iii) Number of labourer required.
- iv) Time in which to be spend.
- v) Money required during maintenance.

ex: - Lathe machine has repair complexity index of 5 while fan air compressor 8 therefore it indicate that the air compressor will required more time, money and labour in maintenance.

† Maintenance Manual :-

⇒ When the customer purchases any new product (machine part, vehicle, electrical & electronic component etc) the manufacturer provides a booklet called maintenance manual.

⇒ It provides information about part drawing assembly drawing technical information a maintenance schedule w.r.t time.

⇒ In the maintenance manual procedure of use and maintenance of each component indicated.

⇒ Maintenance manual is created on the basis of experiment, experience, observation made by the manufacturer of the product or component.

† Index of maintenance manual :-

⇒ It is collection of data containing all information about the product specification, services and its maintenance.

⇒ Index of maintenance manual is placed on the introductory page of the booklet.

† Contents of index :-

- i) Detail of part drawing / assembly drawing with bill of material.
- ii) Instruction of using machine component.
- iii) Table showing common fault (troubleshooting).
- iv) Important term (abbreviation)
- v) Maintenance schedule.

- vi) maintenance procedure.
- vii) Guarantee / warranty.
- viii) service center in country.

✦ Maintenance record :-

⇒ Maintenance department is engaged in various activity and thus it is necessary to prepare document of maintenance work in order to obtain the required information of maintenance history done on particular machine.

⇒ the unique feature of maintenance record is that this record help for analysing and detecting the fault which occur in the equipment.

⇒ the maintenance record is prepared by the maintenance operator which gives two information :-

- i) which component on which time it is under maintenance.
- ii) It indicate the nature of maintenance i.e. whether it is preventive, predictive, corrective and breakdown.

✦ House-keeping :-

⇒ House-keeping is a process of creating a place where everything is placed in proper condition at its right place.

✦ Benefit of house-keeping :-

⇒ Good house-keeping at work-place benefit both employer and employee.

⇒ It eliminates the clutter (waste material such as broken part, scrap of workpiece, used nut & bolt, nails, lubricating oil or grease sprayed on the floor) which is a common cause of accident such as slip, fall, fire etc.

⇒ Reduces the chance of harmful material entering into the body.

Ex:- dust particle, poisonous vapour.

⇒ Improve productivity (right tool & mate both any job will be easy to find).

⇒ Help company or any organization to improve its image which will impress employee & customer.

⇒ Help company to keep its inventory to a minimum (good house-keeping make it easy to keep accurate count of the product in the organization).

- helps any industry to make use of its space
- + Indication & Symptom of poor house-keeping
- ⇒ Leakage in any fuel carrying container
- ⇒ dust & dirt particle sprayed on the floor
- ⇒ items that are in excess and no longer in use.
- ⇒ over flowing of waste-bin.
- ⇒ tool and equipment left on any machine or in working area instead of being return to its proper place.
- ⇒ poor light an improper arrangement of window & ventilation.

- + Total productive maintenance :-
- ⇒ total productive maintenance is a preventive maintenance plus continuing effort to modified and refine the machine component during production to increase productive
- It is first adopted by Japan.
- Total productive maintenance is defined as production management approach which induces responsibility of maintenance on the worker and operator.
- It is operator oriented maintenance process.

- It is also known as zero maintenance or defect process.
- It involve encouragement of operator an giving them proper education and training of basic maintenance.
- + Benefit of total productive maintenance:
- ⇒ It improves the overall equipment effectiveness and overall efficiency.
- ⇒ It helps the operator in determining the exact location where the maintenance a what type of maintenance is required.
- ⇒ Since the operator is involve in maintain which will improve his job scope.
- ⇒ Productivity maximised and defect minimi