LECTURE NOTES
ADVANCED MANUFACTURING & CAD CAM

(TH-4)

(6^{th} semester MECHANICAL ENGINEERING)

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CH-01 >> Nonconvectional M/C Process <<

→ Two types of Maching process.

① Convectional

② Non convectional

→ convectional → Workpiece touches the tool.

→ Drilling, Maching, Grinding, lathe etc.

→ Low surface finish, larger man power moretime consumption, low tool life.

→ Nonconvectional → W/P is not touch the tool

→ for ex: electro chemical M/C Process

Electro discharge

Plasma arc

Leaser beam

abrasive jet

electron beam.

→ Low surface finish.

Lesser power required.

Aparantely using time requires.

Long tool life.

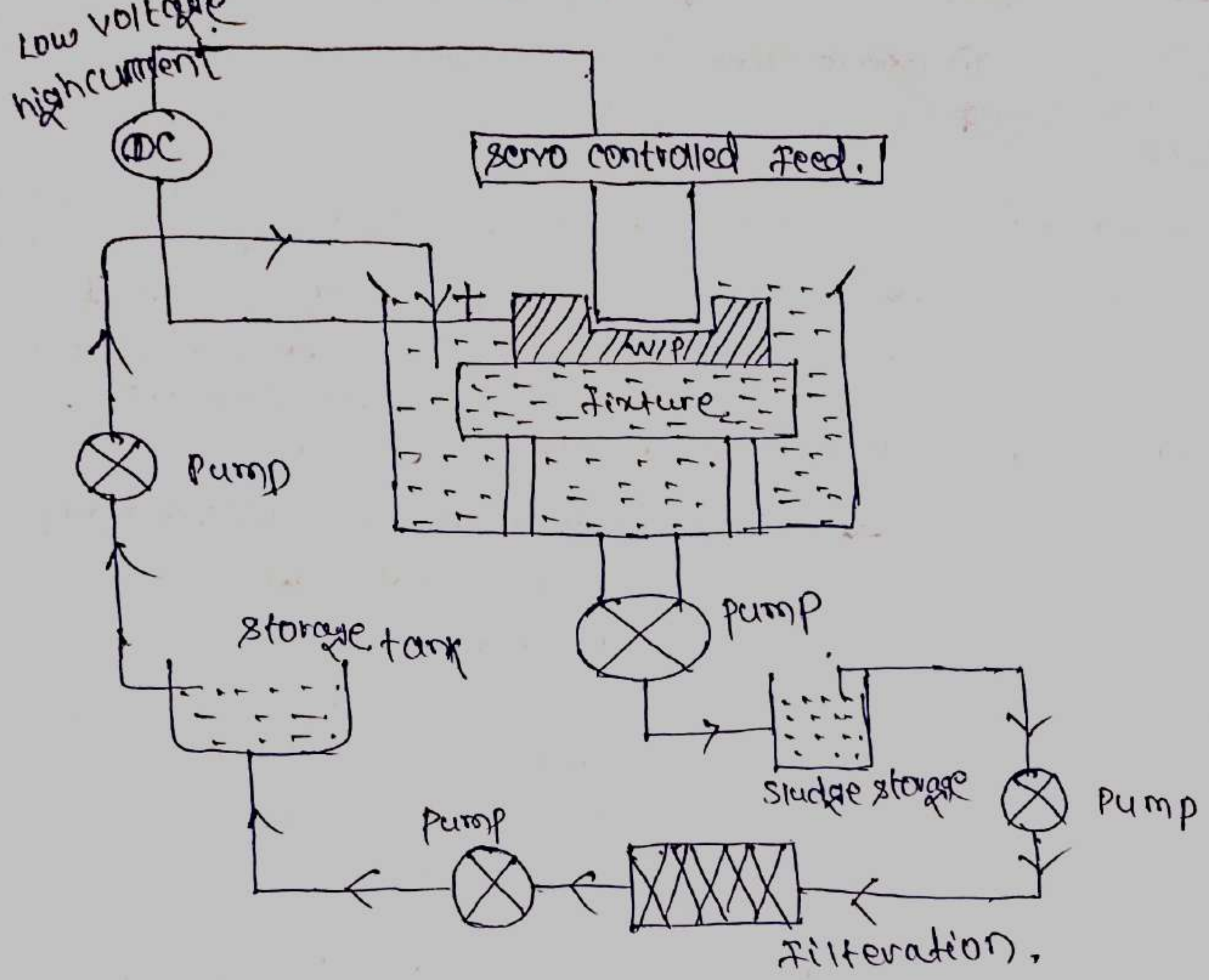
Non convectional :-

→ Those energy source which are renewable & ecological safe that is called nonconvectional machining process.

→ It is a special type of Machining process in which there is no direct contact bet^n the tool & the workpiece.

→ In non-convectional m/c process It is a form of energy is used to remove unwanted material from a given w/p.

→ Electro chemical Machining Process :-



*> Working Process :-

→ First the workpiece is assembled in the fixture tool & tool is brought close to the workpiece. The tool & w/p is immersed in a suitable electrolyte.

→ After that, potential difference is applied across the workpiece (anode) & tool (cathod). The removal of material is starts. The material is removed as in the same manner as we have discussed above in the working principle.

→ Tool feed system advances to the tool towards the workpiece & always keeps a required graph in bet^n them. The material from the workpiece is comes out as possible ions & combine with the lines present in the electrolyte & precipitates as as sludge.

, Hydroxen gas is libarated at cathode during the machining process.

→ Since the dissocitation of the material from the workpiece takes place at atomic level, so it gives excellent surface finish.

→ The sludge from the tank is taken out & separated from the electrolyte. The electrolyte after filtration again trasported to the tank of the ECM process.

→ **Application :-**

→ The ECM process is used for die sinking operation, profiling & contouring, drilling, grinding, trepanning & Micro machining.

→ It is used for machining steam turbine blades within closed limits.

→ **Advantages :-**

→ Negligible tool wear.

→ Complex & concave curvature parts can be produced easily by the use of convex & concave tools.

→ No forces & residual stress are produced, because there is no direct contact bet^n tool & w/P.

→ Excellent surface finish is produced.

→ Less heat is generated.

Disadvantages :-

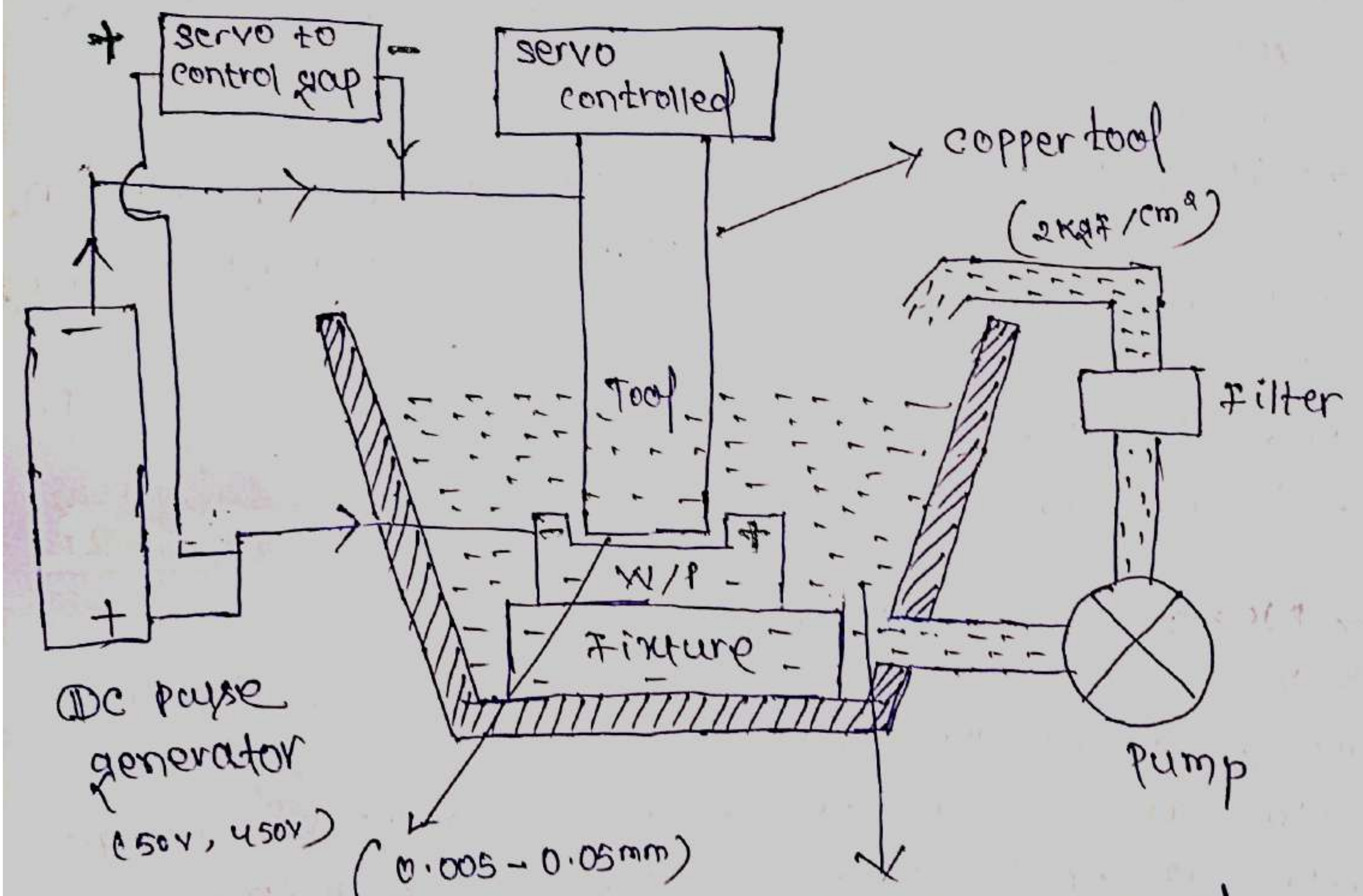
→ The risk of corrosion for tool, workpiece & equipment increases in the case of saline & acidic electrolyte.

→ Electrochemical machining is capable of machining electrically conductive materials only.

→ High power consumption.

→ High initial investment cost.

② Electro discharge Machining process :(EDM) :-



1kgf = 9.8 N

2kgf = 19.6 N/cm².

→ **Equipment** :- The various equipment used in electro discharge machining are

① Dielectric reservoir, Pump & circulating system :-

→ Pump is used to circulate the dielectric medium betⁿ the two electrodes. Kerosene or deionized water is used as dielectric medium.

② Power generator & control unit :-

→ Generator is used to apply potential difference. The voltage used in this machining process is not constant but it is applied in pulse form.

③ Working tank with work holding device :-

→ It has working tank with a work holding device. The workpiece is hold in the work holding devices. The tank contains dielectric medium.

④ Tool holder :- It is used to hold the tool.

⑤ Servosystem :- A servosystem is used to control the tool. it maintains the necessary gap betⁿ the electrodes.

Working of EDM :-

1 → First the tool & w/p is clamped to the m/c. After that with the help of servo mechanism a small gap is maintain in betⁿ the tool & workpiece.

2 → The tool & w/p is immersed in dielectric medium.

3 → A potential difference is applied across the electrode. An electric spark is generated in betⁿ the tool & w/p. The spark generates a heat about 10000 degree celsius & due to this heat the material from the w/p starts to vaporize & melts.

4 → The spark generates in electrical discharge machining

is not contineous. As the voltage breaks, the dielectric fluid flushes away the molten materials leaving behind a crater.

→ This process keep continue & machined the w/p.

*) Advantages :-

→ Less time required as compared to convectional machining.
→ Metals having high melting point temp. can be easily machined.
→ Excellent surface finish can be obtained.
→ Complex shapes & corners can be machined.
→ Burrface machining surface.

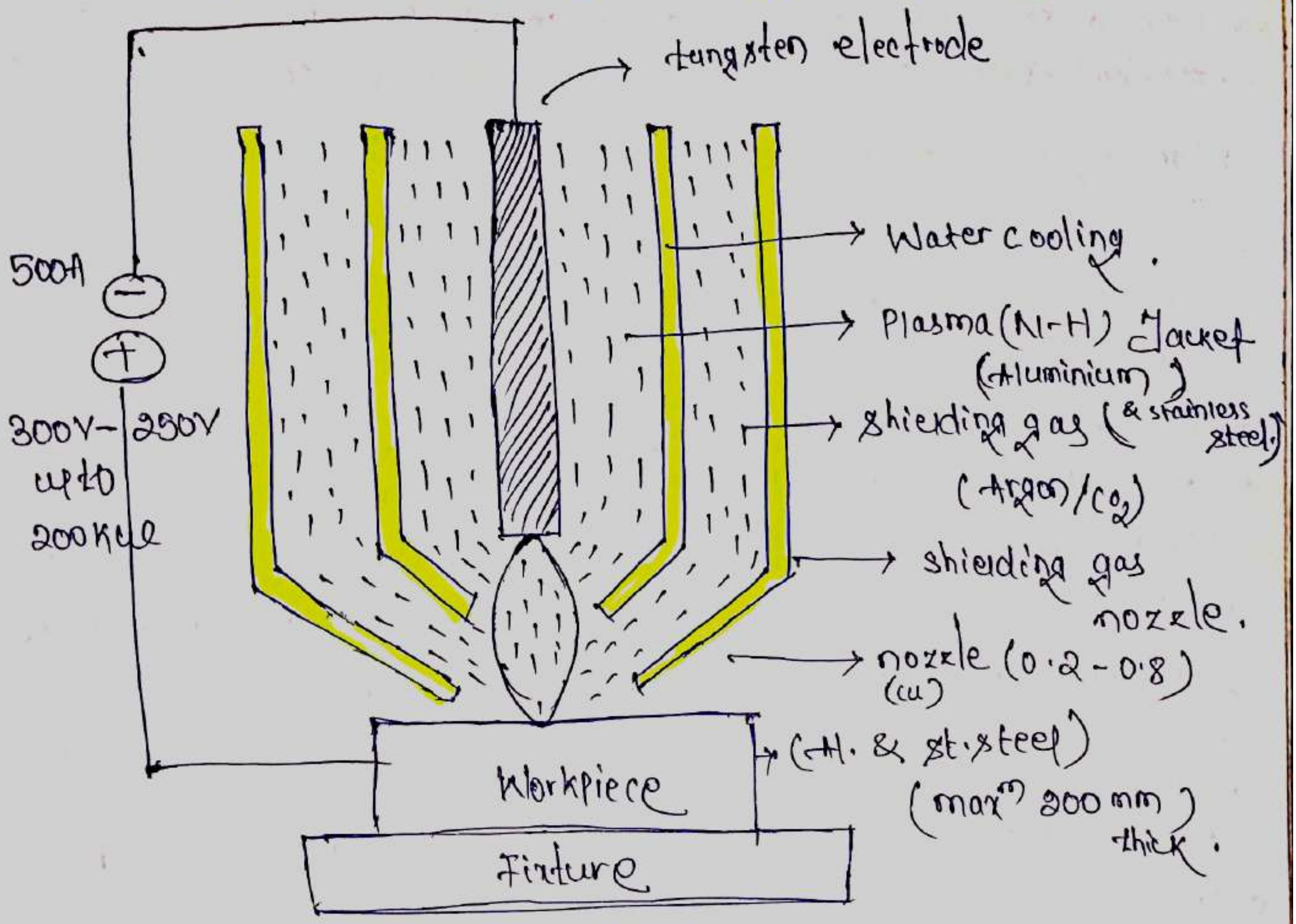
*) Disadvantages :-

→ Only electrical conductive materials can be machined.
→ High voltage required.
→ High initial cost.
→ High maintanance.
→ More time required for machining.
→ Thin materials can't be machine.

*) Appl^n / uses :-

→ It is mostly used by mold making & dies industries.
→ It is used for coinage die making.
→ It also used in aerospace Industries.
→ It use to creat small holes in variety of application.

* PLASMA ARC Machining Process ÷ (PAM)



→ **Equipments required ÷**

1. Dc electric Supply.
2. Tungsten electrodes.
3. Nozzle.
4. Plasma & Shielding gas.
5. W/P & Fixture.

→ **What is plasma ÷**

→ When a gas or air heated at high temps, the number of collisions betn atoms increases.

→ When you heat the gas above 5500°C, it partially ionises into +ve ions, negative ions & neutral ions.

→ When you further heat the gas above 11000°C then, it completely ionises.
→ Such a completely ionised gas is called plasma.
→ Plasma states lies in betⁿ temp 11000°C to 28000°C.

Working of PAM :-

→ It consist of a plasma gun.
→ Plasma gun has an electrode made up of tungsten situated in the chamber.
→ Here this tungsten electrode is connected to the -ve terminal of DC power supply thus the tungsten acts as cathod.
→ While the +ve terminal of DC power supply is connected to the nozzle, thus the nozzle of the plasma gun acts as anode.
→ As we give the power supply to the system, an electric arc develops betⁿ the cathodic tungsten electrode & an anodic nozzle.
→ As the gas comes in contact with the plasma, there is a collision betⁿ the atoms of gas & electrons of an electric arc & as a result, we get an ionized gas, that means we get the plasma state that we wanted for PAM.
→ Now this plasma is targeted towards the workpiece with a high velocity & the machining process starts.
→ In the whole process, high temp condⁿs are required, as a hot gasses come out of nozzle there are chances of over heating.
→ In order to prevent this over heating, a water Jacket is used.

Advantages :-

→ In PAM hard as well as brittle metals can be easily machined.
→ It can be applied to almost all types of Metals.

→ We get a better dimensional accuracy.
→ It is a simple process to carry out & a very efficient process.
→ It takes a big part in automobile repair of Jet engine blades.

Disadvantages :-

→ Its initial cost is very high.
→ It is uneconomical for bigger cavities to be machined.
→ Inert gas consumption is high.
→ This process can affect human eyes so a proper goggles or helmet must be worn by an operator.
→ Take proper precaution for whole process.

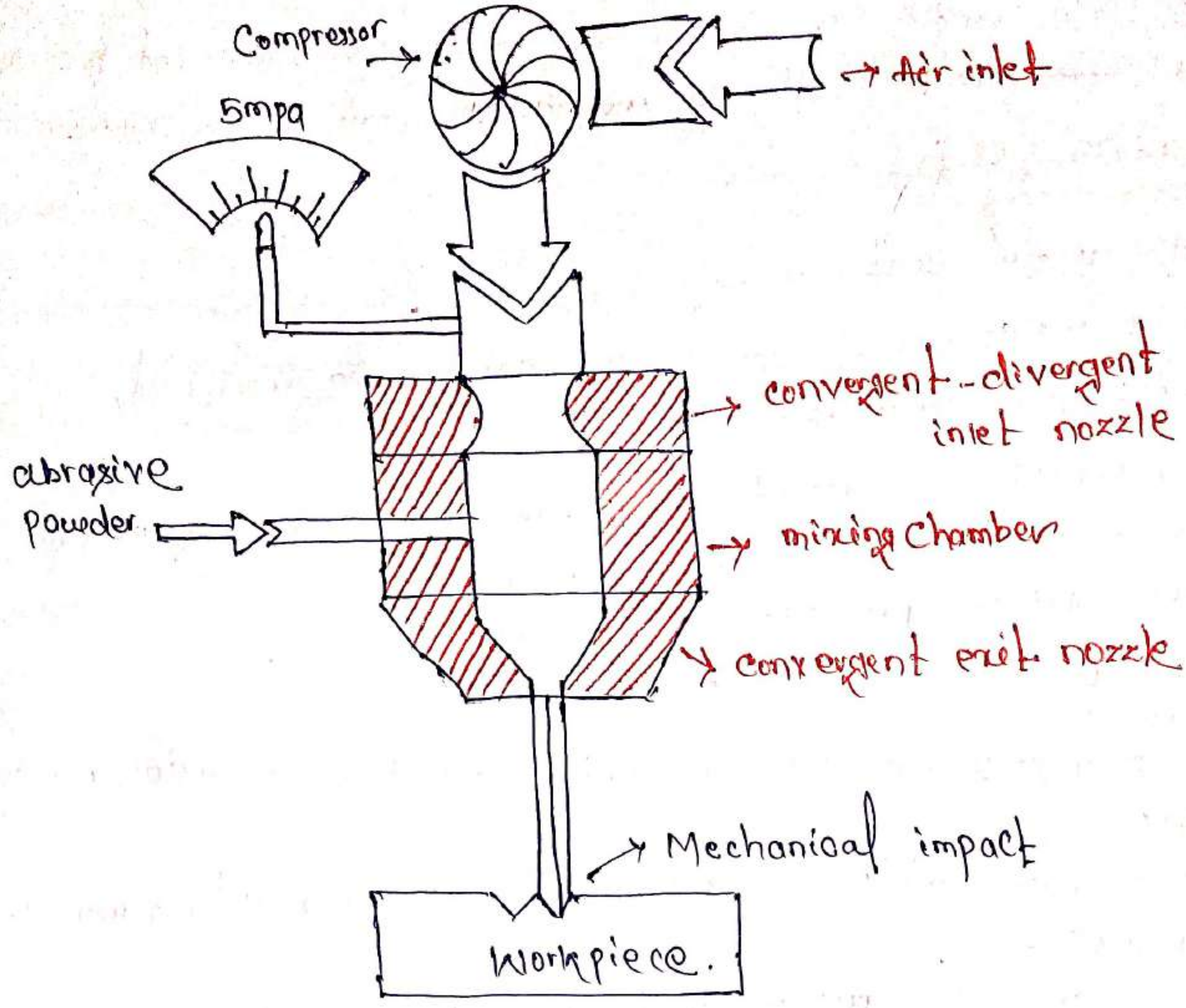
Application :-

→ It is mostly used for cryogenic, high temp corrosion resistance alloys.
→ It is also used in case of titanium plate upto 8 mm thickness.
→ It is used in nuclear submarine pipe system & for welding steel rocket motor case.

*) Abrasive Jet Machining Process :- (AJM)

→ Equipments are used in AJM are as follows.

① Gas propulsion system
② Abrasive feeder.
③ Abrasive
④ Cutting nozzle.
⑤ Machining chamber
⑥ Compressor
⑦ Air inlet.



***) Working principle :-**

→ The basic consept of AJM is abrasive erosion or metal cutting by high velocity abrasive particle. Its working process can be easily summarized into following point.

① 1st gas or air compressed into gas compressor. There the density & pressure of gas increases.

② Now this compressed gas send to filtration unit, where dust & othere suspended particle removed from it.

③ This clean gas sends to drier, which absorb moisture from it. It is used to avoid water or oil contamination of abrasive power.

④ Now this clean & dry gas sends to mixing chamber where abrasive feeder feed abrasive particle in it. The abrasive particle is about 50 micro meter grit size.

(5) The high pressuring abrasive carried gas send to nozzle where its pressure energy converted into kinetic energy. The velocity of abrasive particle leaving the nozzle is about 200m/s.

(6) The standoff distance bet^n workpiece & nozzle is about 2 mm.

(7) Now these high velocity abrasive particles impinge on the w/p. These high velocity abrasive particles remove the material by micro cutting action as well as brittle fracture of the work material.

Advantages :-

- High surface finish.
- It can machine heat sensitive material.
- It is free from vibration.
- Initialization cost is low.
- Thin section can be machined easily.

Disadvantages :-

- Low metal remove rate.
- Abrasive particle can embedded into w/p mostly in soft metals.
- Nozzle life is limited so it needs frequently replacement.
- Abrasive particle can't be reuse in this process.
- It can't use for m/c soft & ductile material.

Application / uses :-

- It is used in drilling & cutting of hardened metals.
- It is used for machining brittle & heat sensitive material like glasses, quartz, sapphire, mica, ceramic etc.
- It is used for manufacturing electronics devices.

*) Leaser Beam Machining process :-

*) **Main parts** :- The various main parts used in the LBM are

1) **A pump medium** :- A pump medium is needed that contains a large number of atoms. The atoms of the media are used to produce leasers.

2) **Flash lamp** :- It is used to provide the necessary energy to the atoms to excite their electrons.

3) **Power supply** :- A high voltage power source is used to produce light in the flash tube.

4) **capacitor** :- It is used to operate the leaser beam machine at pulse mode.

5) **Reflecting Miror** :- There are two types of miror is used. First one is 100% reflecting & other is partially reflecting.

→ 100% reflecting miror is kept at one end & partially reflecting Miror is at another end.

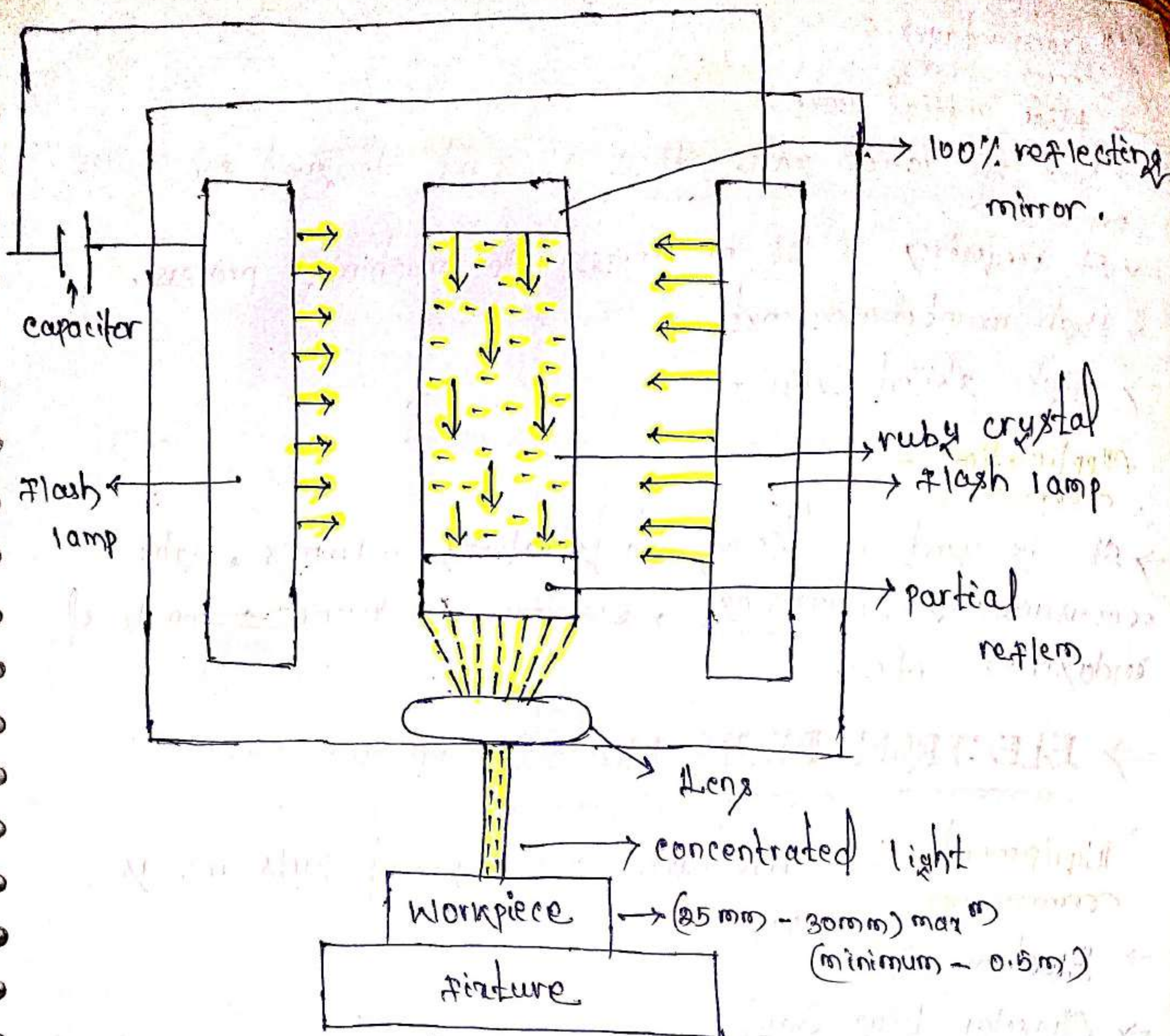
→ The leaser beam comes out wher partially reflecting miror is kept.

→ Working of Leaser Beam Machining :-

→ A very high energy leaser beam is produced by the laser m/c. This leaser beam produced is focoused on the workpiece to be machined.

When the leaser beam strikes the surface of the workpiece, the thermal energy of the leaser beam is transferred to the surface of the workpiece. This heats, melts, vaporizes & finally removes the material from the workpiece.

→ In this way leaser be machining works.



Laser (Light amplification by stimulated emission of radiation)

Advantages :- It can be focused to a very small diameter.

→ low maintenance cost.

→ It produces a very high amount of energy, about 100 mkJ per square mm of area.

→ It is capable of producing very accurately placed holes.

→ There is no physical contact betn the tool & w/p.

→ Very high precision work.

Disadvantages :-

→ High initial cost.
→ Low production rate since it is not designed for mass production.
→ It requires a lot of energy for machining process.
→ High maintenance cost.
→ High skilled trainer.

Application :-

→ It is used in heavy manufacturing industries, light manufacturing industries, electronic industries, medical industries etc.

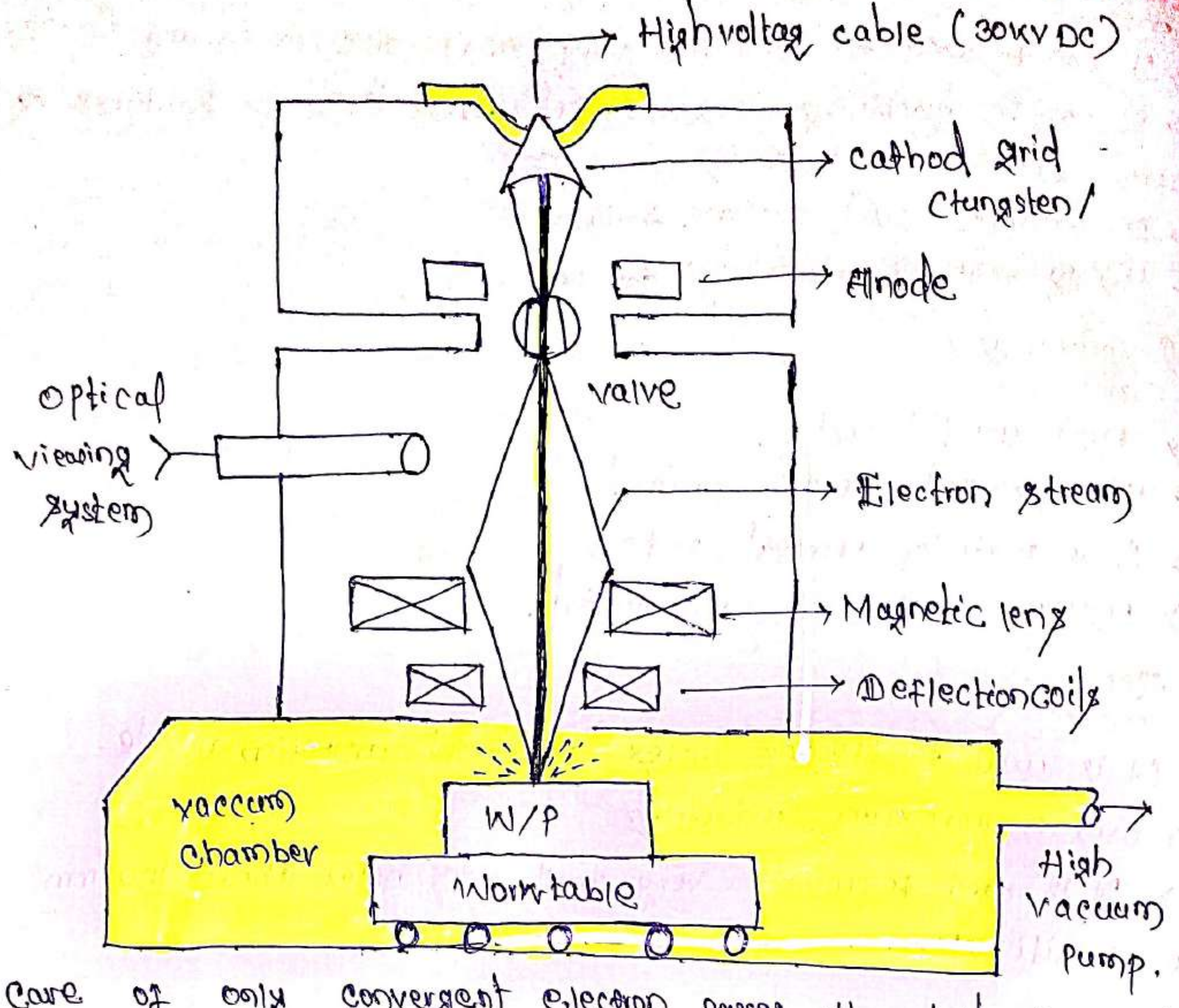
⇒ ELECTRON BEAM Machining process :-

Equipments :- There are some important parts are as follows

→ Electron Gun.
→ Annular Bias Grid.
→ Magnetic Lenses.
→ Electromagnetic lens & deflection coil.
→ W/P & work holding device.

→ **WORKING :-** The EBM works same as laser beam machining. Its working can be summarize into following points.

① 1st electron gun produces high velocity electron particles. These electron particles move towards anode which is placed after cathod table.
② Now this high intense electron beam passes through magnetic lenses. There are a series of lenses which take



care of only convergent electron passes through it. It absorb all divergent electron & low energy electron. It provide a high quality electron beam.

③ The electron beam now passes through electromagnetic lens & deflecting coil. It focus the electron beam at a spot.

④ The high intense electron beam impinges on the w/p where kinetic energy of electrons convert into thermal energy.

⑤ The material is removed from contact surface by melting & vaporization due to this high heat generated by conversion kinetic energy of ~~electrons~~ convert into thermal energy. This whole process take place in a vaccum chamber otherwise these electron collide with air particle bet^n path & loses its kinetic energy.

Advantages :-

→ It can be used for produce very small size hole in any shape.
→ It can be machining any material irrespective its hardness & other mechanical properties.
→ It provide good surface finish.
→ Highly reacting material can be easily.

Disadvantages :-

→ High capital cost.
→ High skilled operator required.
→ Low material removal rate.
→ Regular maintenance is required.

Application :-

→ It is used to produce holes in diesel injection nozzle.
→ used in aerospace industries
→ It is used to provide very small size holes about 100 mm to 2 milimeter.

>> AUTOMATION <<

CH-02

- **Defination :-** It is a technology which is used to complete some process by minimizing the human effort.

→ It is the combination of automatic + Machine.

→ In this process machinary are used which are operated through programms to do some useful work.

→ For example :- Watch, metrorail, face unlock, voic to talk etc.

- **Industrial Automation :-**

→ Industrial automation is the use of control system such as computer or robots, TLC, TLSI, scada etc for handling different process & machinary in an industry to replace a human being.

- **Advantages :-** It reduces human envolvement & effort.

→ Increases production rate.

→ Increase accuracy.

→ less time consumption.

→ avoid human error.

→ Reducess accident.

- **Disadvantages :-** High machining setup rate.

→ High maintenance cost.

→ Increases unemployement.

→ Pollution is highly created.

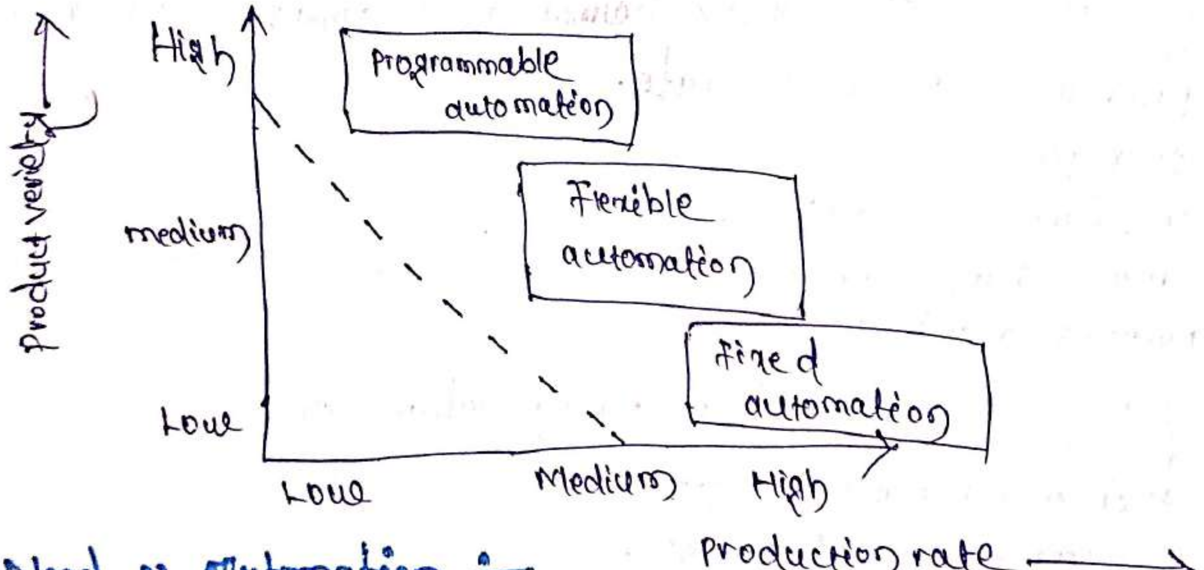
→ High energy consumption

→ High skilled operator.

- **Types of Automation :-**

1. Fixed Automation
2. Programmable Automation.
3. Flexible automation.

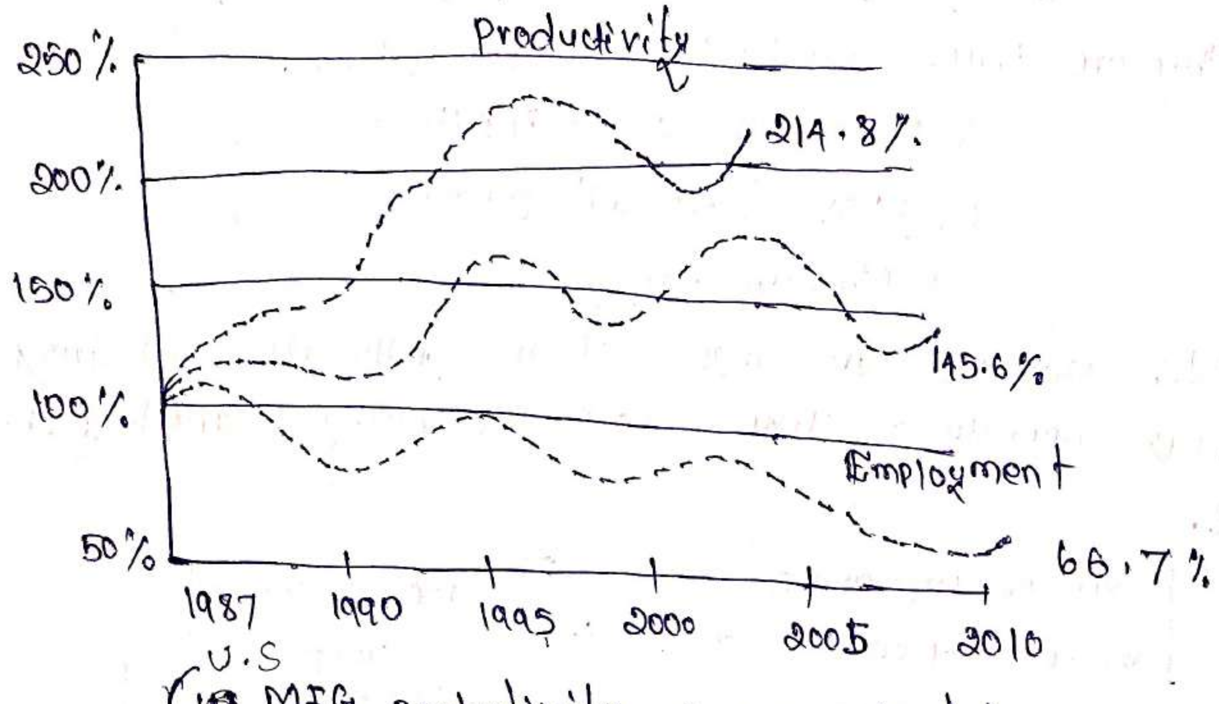
Fixed Automation	Programmable Automation	Flexible automation
1 - Limited / Fixed variety of product can be produced.	1 - Large veriety of production can be produced.	1 - Medium veriety of products.
2 - High production rate.	2 - Low to medium production rate.	2 - Medium production rate.
3 - High quality & precission products can be produced.	3 - High precision & qualitative product cost.	3 - Medium to high production.
4 - Attractive production cost.	4 - High / effective product cost.	4 - Effective production rate
		5 - Ex:- FMS



- **Need of Automation :-**

1) To reduce human effort.
2) To improve production rate.
3) To improve product veriety.
4) To reduce human error.
5) To increase the production hour.
6) To ~~increase~~ reduce the labour cost.

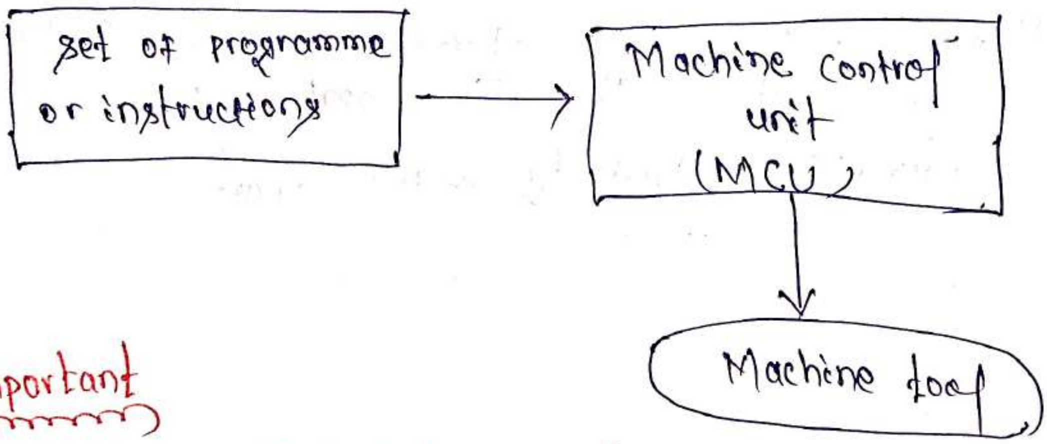
→ To minize the Labour shortage.
→ To reduce routine manual & lorical cast.
→ To improve worker safety.
→ To improve product quality.
→ To reduce manufacturing lead time.
→ To accomplex process that can't be done manually.
→ To avoid the high cost of not automating.



(U.S MFG productivity & O/P chart)

<< Numerical Control >>

- It is a form of programmable automation in which the process is Control by numbers, letters & symbols.
- In NC M/C the numbers from a programme of instructions design for a particular Job.
- When Job change the programme of instructions is also change.
- There are three important of NC system.
  1. programme of instructions.
  2. M/C control unit (MCU)
  3. Machine tool.
- NC Machines are also used in automatic industries for various operations like Milling, drilling, grinding, honning etc.

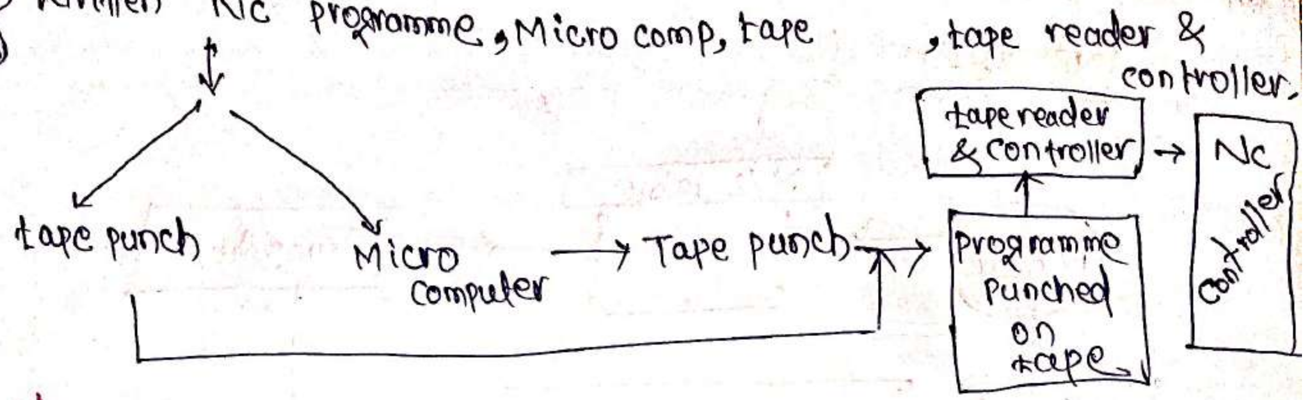


Important

① set of programme or instructions :-

- A typical desktop programme gives the instructions to the computers to perform certain functions. The programme of instructions of the NC M/C is the step by step set of instructions that tels the m/c what to do.
- The set of instructions contains the following parts or elements,

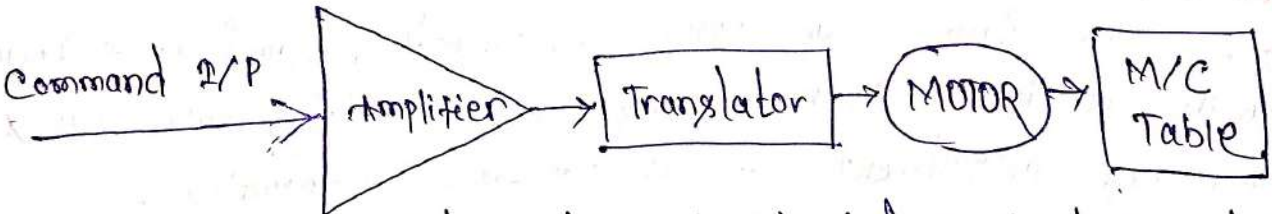
① Part drawing.
② Written NC programme, Micro comp, tape, tape reader & controller.
③



Position & M/C control in NC Machine :-

→ A group of devices, electrical, hydraulic or numetic are used to control the position & motion of the m/c tool. The most common types of control systems are open loop system & closed loop system.

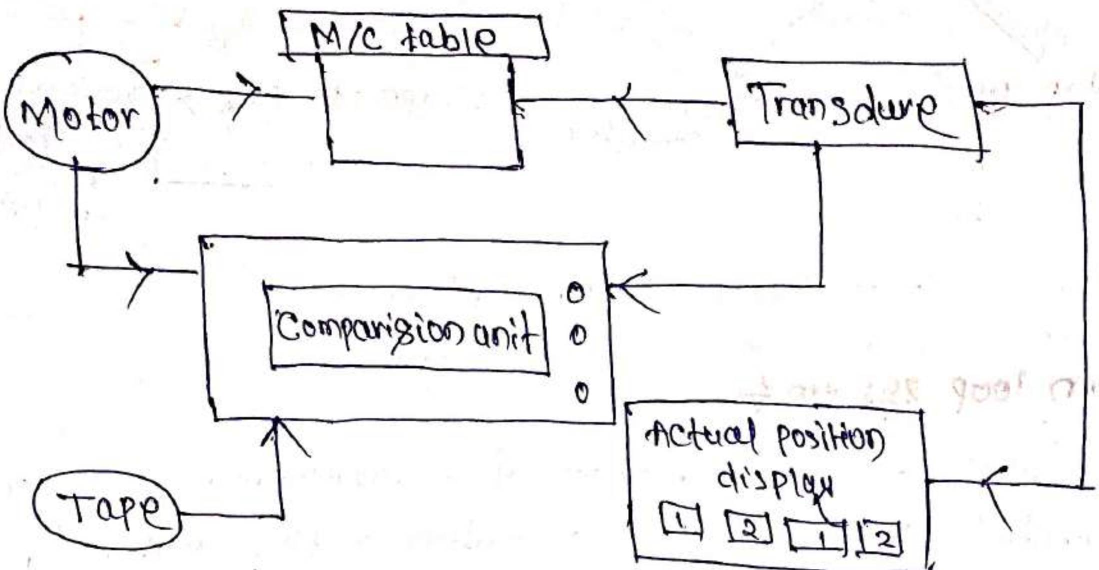
Open loop system :- It is a control system that has no means of comparing the O/P with the I/P for control purpose. such that there is no feed back system.



→ The information stored in tape is decoded by the tape reader
→ Tapereader stored the information till the M/C is ready to receive it. Tape reader converts the information into electrical pulses or signals which are sent to control unit.
→ The control unit in term energises the driving control unit which actuates DC Motors to perform the desired function.
→ Driving Motors mainly stepper motors are used in open loop system.

→ A presicion lead screw coupled with the Motor rotates causing the M/C table to slide.

Closed loop system :-



→ In close loop system along with the components of open loop system a feed back unit is added into the electrical Circuit.

→ A large veriety of feedback centers are available for comparing the actual table moment with the desired table movement.

→ In case there is an error the corrective signal is fedback to the driving Motor (Mainly DC servometer) which makes necessary adjustment to companisate the deviation.

→ In closed loop NC system the accuracy is very high such that the m/c table can slide with an accuracy of 0.0025 mm.

→ special Motors called servo motors are utilized in closed loop system.

→ The Motor types include AC, DC & Hydraulic servos.

→ Hydraulic servo motors are mainly used for large NC Machines as their most power-ful.

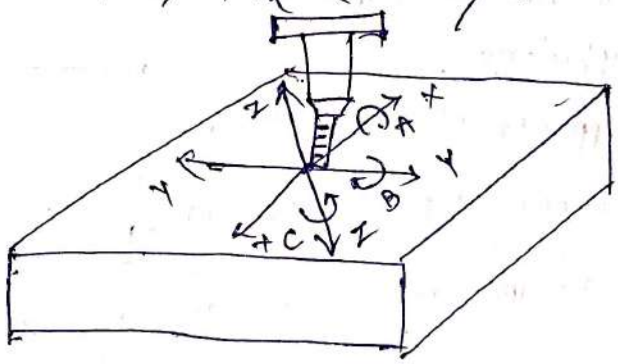
→ The speed of AC or DC Motor is variable & depends upon the current passing through it.

→ Comparing the both control systems close loop control systems are more preffer.

N/C Axis Of Motion :-

→ The location of a N/C tool at any pt of time is controlled by cartecian co-ordinate system. The system is composed of 5 directional lines mutually intersecting 90° with each other.

→ The 5 axes are known as X, Y & Z axis.



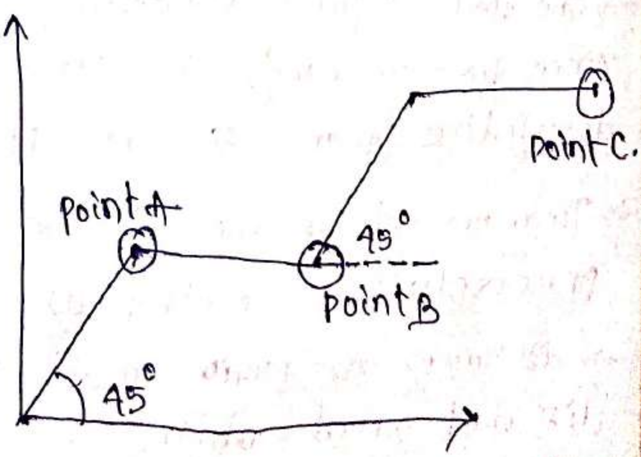
→ There are 5 types of Motion control of tools used in NC system:

① point to point.
② straight cut.
③ contouring.

1/ Point to point (PTP)

→ point to point system is also known as positioning System.

→ It is used for operations that requir first movement to a point followed by a manufacturing operation at that point.



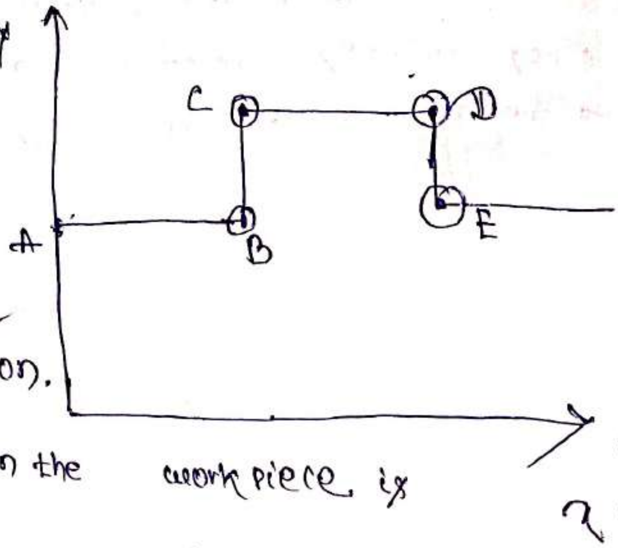
→ NC Drill M/C is an example of PTP system.

→ In these machines after the drilling M/C is perform the tool is moved to the next location for the operation till the operations are completed.

→ The PtP NC M/Cs are the simplest & least expensive & are commonly used in drilling, boring, hole punching etc.

→ In this method the tool moves in x & y axes simultaneously.

2/ Straight cut :-



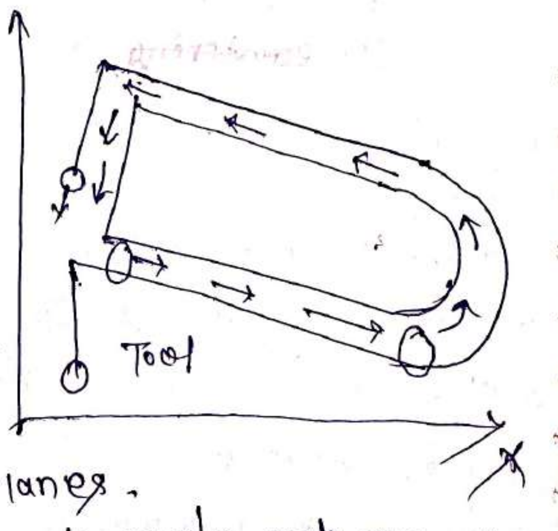
→ In straight cut motion control system the tool moves parallel to one of the major axis at a desire rate suitable for machining.

→ It is quite appropriate for milling workpieces of rectangular configuration.

→ In this process no angular cuts on the workpiece is possible.

→ Any NC M/C tool capable of straigh cut movements can perform point to pt operation also.

3/ contouring system :-



→ It is also known as contineous path system.

→ The tool follows the desired shape since the commands as far more destrictive than for the PtP system.

→ The movement of the tool is precisely is control as in all planes.

→ All axes of motion might more simultaneously each one at a different speed while the speed may be changed even with in the path betn two given points.

→ Contouring NC M/Cs have a complex circuitry / design which can feed & read information of the tool that are normally programmed with the help of computers. This system is commonly used in milling Machines.

→ Tool Positioning Mode :-

*) Absolute System :-

→ An absolute system is one in which all moving commands are referred to want refference point which is in origin & It is called zero point.

→ All position command are given as absolute distance from that zero point.

→ The zero point may be defind as the point outside the w/p or at the corner of the w/p.

→ If a fixture is used it could be a point on the fixture or on the M/C table.

→ It is estimated that considerably more than 90% of point to point NC Machines use absolute programming.

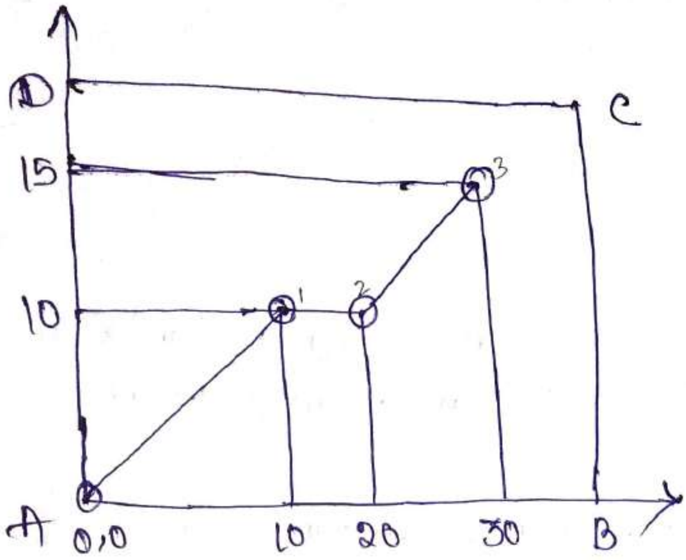
*) Incremental System :-

→ An incremental system is one in which the refference point to the next instruction is the end point of the preciding operation.

→ Each Dimensional data is apply to the system as a distance increment majored from the Preciding point at which the axis of motion was present.

→ Incremental controls are generally low cost to bill but they are not often used from controlling point to point M/C tools.

→ one Major draue back of incremental system is that if one incremental movement is in error, all over subsiquent movements become error.



	absolute		Incremental	
*	x mm	y mm	x mm	y mm
1	10	10	10	10
2	20	10	10	0
3	30	15	10	5

NC Part Programming :-

1) Manual part programming.
2) computer assisted programming.
3) Manual data input (MDI).

1- Manual part programming :-

→ In manual part programming the data required for machining a part is written in a standard format on a special manuscript.

→ The manuscript is a planning chart or a list of instructions which describes the operations to be done.

→ It is generally used for path to be produce on a point to point machining.

→ Tool part calculations are very simple in this method. When the complete programme is typed all the instructions in the form of cores are checked for accuracy.

→ Here a set of instructions is called N/C block. A block is a complete line of information to the N/C M/C which consist of the block number, some codes (G-code, m code, T-code etc) & finally at the end it is marked at the end of the block.

→ For ex :- N0030 · G90 G00 X-3.2 · Y-4.2 · S1000 ;

Sequence number (N-code) :-

*) It identifies the block.

*) It increases sequencially through the programme.

Properties Codes (G-code) :-

→ It informs the controller what type of motion or action is to be carried out.

→ The mode of moment is indicated by the numerical valve following the G-address.

→ In General a G-code is typed at the beginning of the block after N-code, so that It can set the control for a perticular mode of action.

→ G-code is of two types.

(a) Modal.

(b) Non modal.

→ For modal type G-code specification will remain in effect for all subsequent block unless replaced by another modal G-code.

→ For non-modal type G-code specification will only affect the block in which it contains.

→ For example :-

G02 :- That the next motion will be circular interpulation in clock wise direction. G02 is modal type.

Feed rate (F-code) :-

→ It indicates the rate at which the spindle moves along a programming axis. In English system the feed rate is Inch / min.

→ The feed rate is expressed in Inch/min in metric system. It is mm / min. The feed rate is a modal code & it remains in effect in subsequent block unless a new 'F' code is replaced on the old one.

Spindle speed (S-code) :-

It is specified the spindle speed (rotation per min) at which the spindle speed. A numerical valve upto 4 digited is enter the following address 'S'.

→ For ex :- S1500 denoates that the spindle speed is set that 150 RPM.

→ The S code is also a model code.

Tool number :- (T-code)

→ It indicates which tool is to be usual during the operation.

Miscellaneous code (M-code) :-

→ It executes various Numerical control (NC M/C) function that are not related to dimensional or axis movement.

→ The are classified into 2 catagories

① The first catagory consist of those which execute with the start of motion described in a block.

② The second catagory consist of those which execute with the completion of motion described in the block.

Machine zero :-

→ Each CNC M/C has a built in location that is called M/C zero. This pt is typically located at the farthest +ve direction along the x, y & z axis.

→ It can't be changed by anyone after it leaves the original manufacturer.

Work zero :- Work '0' is normally set at the front face & centre of the Job. Here it is shown two axis m/c x-axis (transverse) & z-axis (longitudinal) & the both axis should be made be '0'.

Tool offset :- The word offset reffers to the allowance made by the CNC m/c for the diameter & length of the tool to cut the Job.

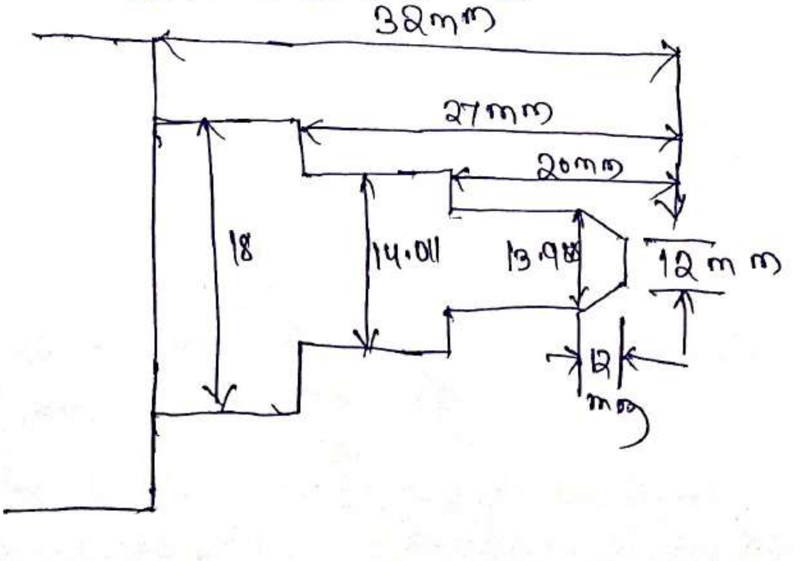
→ Tool offsets are the set of values that move the centre pt of the cutter to the correct position to cutting a w/p to using a specific tool.

Tool zero :-

→ The zero point set by the tool above the w/p is known as tool zero.

→ It is variable for different w/p.

*) Simple part programme for lathe :-



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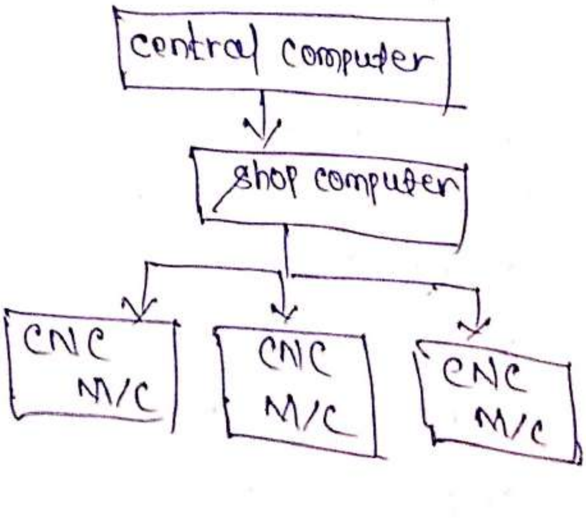
O 0005
T0000
G28 U0 W0
T0303
G92 M04 S850
G96 S100
G00 Z2.0
G00 X25.5
M07
G71 U0.5 R0.5
G71 P10 Q20 U0.1 F0.3
N10 G01 X12.0
G01 X13.988 Z-2.0
G01 Z-20.0
G01 X14.011
G01 Z-27.0
G01 X18.0
N20 G01 Z-32.0
G00 Z2.0
G00 X25.5
G97 T0000 M09
G28 U0 W0
N1 T0303
G92 M04 S850
}
G70 P10 Q20 F0.1
G00 Z2.0
G00 X25.5
G97 T0000 M09
G28 U0 W0
M05
M30
%
```

:- CNC :-	:- DNC :-
→ CNC M/C is control one machine.	→ DNC computer control more than 1 M/C using local networking.
→ CNC computer is an integrated part of the machine.	→ DNC computer is located at a distance from the m/c.
→ CNC computers are having less processing power.	→ DNC computers are having high processing power than CNC. (micro processer are used).
→ CNC softwere control only one machine.	→ DNC softwere considers management of information through to a group of M/C.
→ veriety of products can be produced in a definite time.	→ unique products can be produced in the diffne time.
→ Less production rate as compared to DNC.	→ High production rate as compared to CNC.



→ It is the capability of the system to modify its own operation to achieve the best possible more operation.
→ A general defination of adaptive control emplize that an adaptive control must be capable of performing the

following function. for ex:- feed back control system, feed forward control system etc.

CHAPTER-4 ROBOT TECHNOLOGY

*) Robot is an any automatically operated machine that is used to replace the human effort.

*) A robot is an artificial agence that act like human beings.

*) Robots are usually machines control by a computer programme or electronic circuits. They may be directly control by humans. Most robots do a specific Job & they don't always look like human.

→ Robotics :- It is the engineering dealing with the design, construction & operation of robots.

→ Industrial Robots :-

→ An industrial robot is a robot system is used for manufacturing. Industrial robots are automated, programmable & capable of movement mor than 3-axis.

→ Typical application of robots in industry include

→ welding
→ painting
→ Assembly / dis assembly.
→ Plick & place for printed circuit board, packing & levelling.
→ Inspection & quality control.

→ All these process are dawn with high speed & precission

→ They can also assist in material handling.

Field of Application of Robots :-

(1) Space Industries Robotics :-

→ The research area space robotics deals with the development of intelligent robots for extraterestrial explorations focusing on

(i) Re configurable systems for planetary exploations.

(ii) AI Best methods for autonomus navigation & mission planning in unknown terrain.

(iii) Image evaluation & object recognization.

(iv) AI best support systems for scientific experiments.

(2) Under water Robotics :-

→ This area deals with the development & realization of AI method in under water systems.

→ The main point of research are

(i) Development of systems for user support in remot control under water vehicles, employing virtual imertion methods.

(ii) under water applications particularly with state of the art sencer technology such as visual.

(iii) Image evaluation & object recognisation with module & inteligent under water cameras.

(iv) Design & Control of autonomos under water vehicles.

(v) Electric mobility.

(vi) Production & consumer

(v) Agricultral robotics.

③ Electric Mobility :-

→ In the field of electric mobility we are testing concepts for electric vehicles, battery charge technologies & the collection vehicle data.

→ We are creating models for intelligent, environmently sound & integrated urban mobility.

→ Our research focuses around :-

(A) Development & demonstration of innovative vehicle concepts.

(B) Design of new approaches to mobility & traffic control, application support, technology integration.

(C) Data collection by fleet tests with technologically different electric vehicles.

(D) Coordinating of the regional project office of the model region electric mobility Bremen / oldenburg.

④ Logistics, production & consumer (LPC)

→ In this area, robots are developed to act autonomously & or support humans in intralogistic, Industrial & consumer Scenarios.

→ Our research focuses around the new robotics for the industrie 4.0 & beyond :-

(A) Intelligent human-robot collaboration using hybrid teams for production environments.

(B) Development of cognitively enhanced robot capabilities for flexible manufacturing

(C) Modular, novel & safe robots for human-robot collaboration.

(D) Autonomous mobile manipulation for intralogistics & manufacturing scenarios

(E) Innovative robotics solutions for inspections.

(5) Search & Rescue (SAR) & Security Robotics :

→ In this area robots will be developed to support rescue & security personnel. Main points of our research are :

(A) Development of highly mobile platforms for indoor & outdoor applications.

(B) Development of autonomous systems that are able to identify potential victims (SAR) or intruders (security).

(C) Embedding for robot systems into existing rescue & security infrastructures.

(D) Autonomous navigation & mission planning.

6) Assistance & Rehabilitation Systems :

→ This field deals with robotic systems that can support humans in complex, exhausting or often repeated tasks.

→ Application areas are both help during activities of everyday life & medical rehabilitation.

→ support can either take place using systems the human is wearing like.

→ exoskeletons or orthoses, or by service robots performing the task.

core topics include :

→ concept development, design & construction

→ Intelligent hardware - system architectures.

→ software architectures.

→ embedded biosignal analysis, ex: using information from :

- Muscle (EMG)
- eye (eyetracking, EOG)
- or from brain activity (EEG)
- Fusion of different sensors.

→ direct online signal processing (hard & software)

→ Robust learning systems capable to adapt.
⇒ Joint communication layers for better human - m/c interaction.
→ Automonously acting system.
→ Assist - as - needed.

(7) Agricultral Robotics :-

→ We develop robots for agricculture applications & transfer methods & algorithms from robotics to convectional agricultral machines.

→ Our objective to increase the performance of m/cs & processes & to reduce resource consumption at the same time.

→ Our research is fococused on technology applications used in the cultivation of land. Primary research topics are :-

(A) Methods for autonomous planning & navigation of outdoor machinery

(B) Methods for environment recognition in agricultral machinary control

(C) Methods of infield logistics to optimize cooperation & resource consumption betn multiple agricultural machines.

(D) Interoperability at the level of communication, processes & knowledge processing.

Robot Configuration :

→ The Various types of movements, co-ordinate systems & degree of freedoms maintain during the design of a robot is known as configuration.

TYPES : Cartesian configuration
Polar configuration
Cylindrical configuration
Joined arm configuration
SCARA [Selective compliance assembled robot arm]
Delta [VLSI / PLC]
6 - Axis.

Imp

Cartesian configuration :

→ In this configuration there are 3 orthogonal directions x, y & z.

→ x coordinate axis may represents left & right motion
→ y coordinate axis may represents forward & backward func.
→ z coordinat axis represents up & down function.
→ For ex : over head crain movement

Adv :

→ Work involve can be increased by travelling along x axis.
→ Linear movement & simple control.
→ High degree of accuracy & repetability due to their structure.
→ Can carry heavier loads.

Disadv :-

→ Movement is limited to only one dirⁿ at a time

application :-

→ pick & place
→ assembly & sub assembly
→ Necluar material Handling
→ Welding

Cylindrical configuration :-

→ It uses a vertical column & a slide that can be mooved up or down along the column.
→ The robot arm is attached to the slide so that it can be moved radially with respect to the column.
→ It contains two linear motions & one rotational motion.
→ Angular motion along vertical axis or trasnlaction motion along z axis, radial in or out translation.

Adv :- Results in large work volume than a rectangular manipulator.
→ Vertical structure conserves floor space.
→ Capable of carrying large pay loads.

Dis adv :-

→ Repetability & accuracy are lower in the dirⁿ of rotary motion.

→ It requires more complicated control system.

Applⁿ :- Assembly, coating applⁿ, diecasting, Foundary & Forging applⁿ, M/C loading & unloading applⁿ.

Polar configuration :-

→ It uses a arm that can be raised or lower about a horizontal pivot.

→ The pivot is mounted on a rotating base.

→ The various Joints provide the robot withe capability to move its arm with in a sperical space & hence it is also caled as spherical coordinat robot.

→ It has one linear & two rotary motions.

→ The ~~ultimat~~ unimate 2000 series is an ex of spherical robot.

Adv. :-

→ Larger work enrolve that the cylindrical configuration

→ vertical structure conserves less space

Dis adv :- Repetability & accuracy are also lower in rotary motion.

→ It requires more sofisticated control system.

Application :-

→ Die casting

→ Foreging

→ glass handling

→ Injection moulding etc.

÷ ROBORT ANATOMY ÷

Introduction ÷ An industrial robort is a general purpose, programmable m/c. It possesses some atmospheric characterstics, i.e human like characteristics that resemble the human physical structure. The robots also respond to sensory signals in a manner that is similar to humans. Anthropomorphic characterstics such as mechanical arms are used for various industry tasks. Sensory preceptive devices such as sensors allow to the robots to communicate & interact with other machines & to take simple decisions. The general commercial & technological adv. of robots are listed below.

→ Robots are good substitutes to the human being in hazardous or uncomfortable work environments.

→ A Robot performs its work cycle with a consistency & repetability which is difficult for human beings to attain over a long period of contineous working.

→ Robots can be programmed. When the production run of the current task is completed, a robot can be reprogrammed & equipped with the necessary tooling to perform an altogether different task.

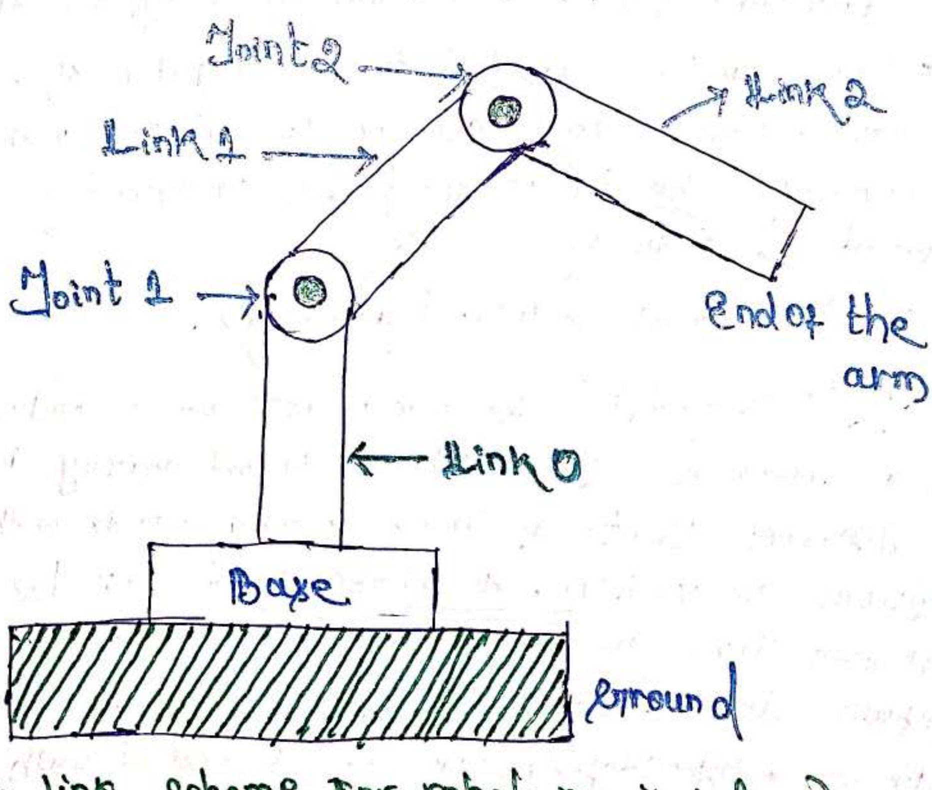
→ Robots can be connected to the computer system & other robotics systems. Now a days ecobots can controlled with wire less control technologies. This has enhanced the Productivity & efficiency of automation Industry.

** Robot anatomy & related attributes.

• **Joints & Links ÷** The manipulator of an industrial robot consist of a series of Joints & links. Robort anatomy deals with the study of different Joints & links & other aspects of the manipulator's physical construction. A robotic Joint provides relative motion betn two links of the robot. Each Joint or axis, Provides a certain degree-of-freedom (dof) of motion. In most the cases only one degree-of-freedom is associated with each Joint.

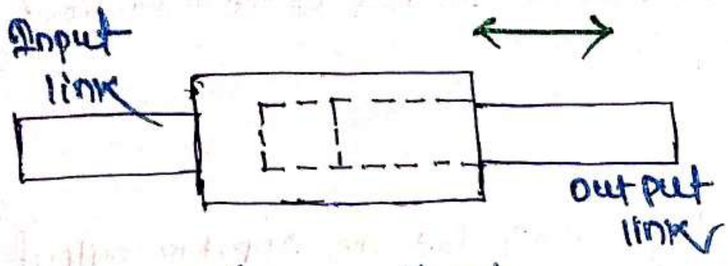
→ Therefore the robots complexity can be classified according to the total no of degrees-of-freedom they posses.

Each Joint is connected to two links, i/p link & o/p link. Joint provides controlled relative movement bet^n the I/P link & output link. A robotic link is the rigid component of the robot manipulator. Most of the robots are mounted upon a stationary base, such as the floor. From this base, a Joint-link numbering scheme may be recognized as shown the below fig. The robotic base & its connection to the first Joint are termed as link-0. The first Joint in the sequence is Joint-1. Link-0 is the input link for Joint-1, while the o/p link from Joint-1 is link-1 which leads to Joint-2. Thus link-1 is, simontaneously, the o/p link for Joint-1 & the input link for Joint-2. This Joink-link-numbering scheme is further followed for all Joints & link in the robotic system.

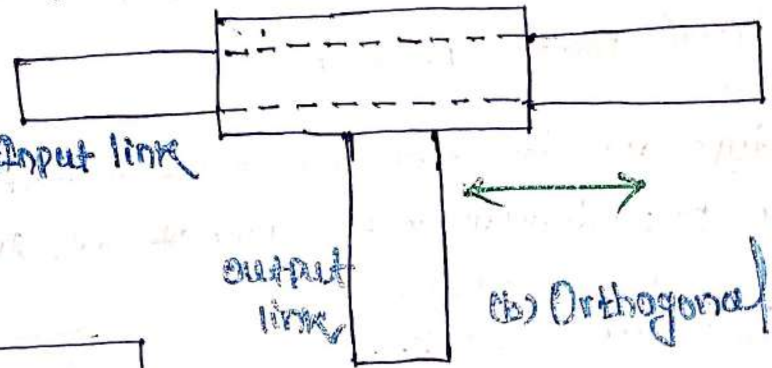


(Joint-link scheme for robot manipulator)

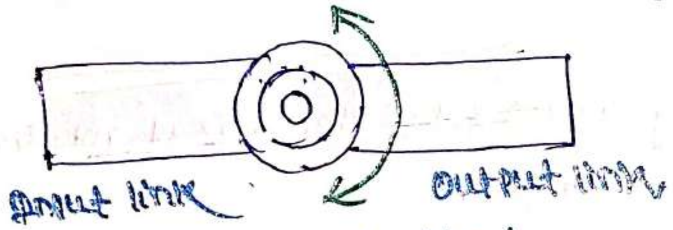
*) Nearly all industrial robots have mechanical Joints that can be classified into following five types as shown in below fig.



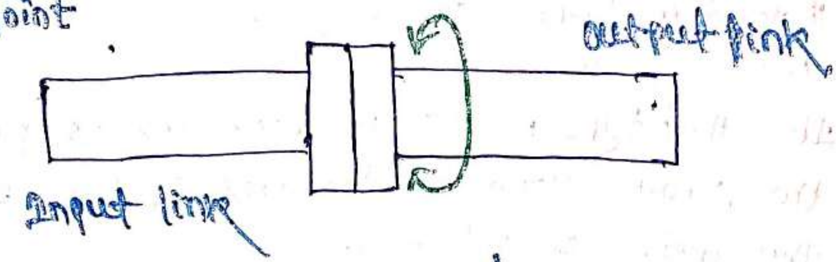
(a) Linear Joint



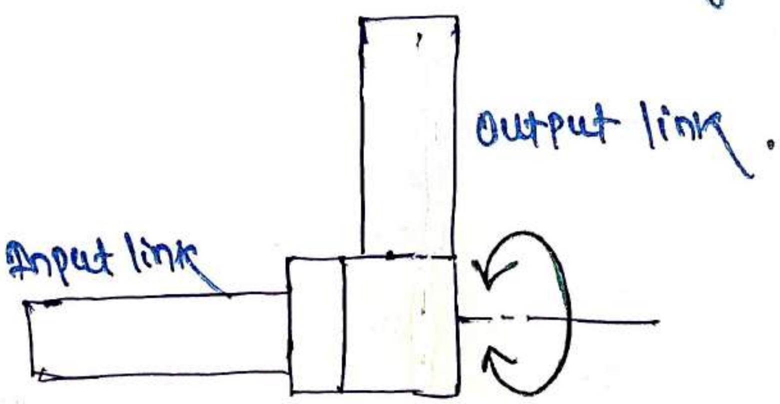
(b) Orthogonal Joint



(c) Rotational Joint



(d) Twisting Joint



(e) Revolving Joint

(a) Linear Joint (L-Joint)

→ This relative movement bet" the input link & the output link is a translational sliding motion, which the axes of the two links being parallel.

(b) Orthogonal Joint (U-Joint)

This is also a translation sliding motion but the input or output links are perpendicular to each other during the move.

(c) Rotational Joint (R-Joint)

→ This type provides rotational relative motion, with the axis of rotation perpendicular to the axes of the input & output links.

(d) Twisting Joint (T-Joint)

→ This Joint also involves rotary motion, but the axis of rotation is parallel to the axis of the two links.

(e) Revolving Joint (Type V-Joint)

→ In this type, axis of input link is parallel to the axis of rotation of the Joint. However the axis of the output link is perpendicular to the axis of rotation.

÷ FLEXIBLE MANUFACTURIRNG SYSTEM ÷

→ In fms the term flexibility means that the machine is above to process a veriety component without having to adjust machine setup or tool changing.

→ Flexible manufacturing system is characterised by the following main components ÷

① Two or more work stations with computer controled machine tool.
For example ÷ CNC Machine.

② An automated material handling system for moving the work in process.

③ Advanced mechanism for transferring work in process between the m/c tool & material handling system.

④ storage by an automated storage & retrival system of work in process & tooling.

⑤ Central computer control of the entire process.

→ Flexible Manufacturing is a highly automated group technology (GT) machine cell consisting of a group of processing work stations, Interconnected by an automated material handling & storage system & controlled by a distributal computer.

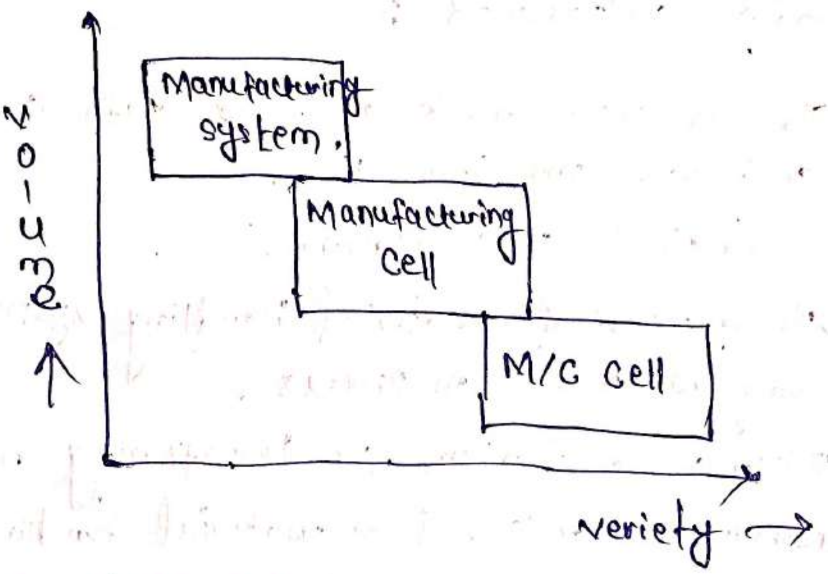
Classification of Flexible manufacturing :

→ It can be classified as according to the number of m/c in the system.

① Single m/c cell.

② Flexible manufacturing cell.

③ Flexible manufacturing System.



Single M/C Cell (SMC) :

→ A single m/c cell consist of one SMC machining centre combined with a parts stoarge system on attended operation.

→ Completed parts are periodically unloaded on the storage unit & new, raw materials are loaded into it.

Flexible manufacturing cell (FMC) :

→ It consist of 2 or 3 processing stations mainly CNC machining centers & material handling, storage system.

→ The part handling system is connected to the loading & unloading station.

Flexible manufacturing system (FMS) :-

→ A FMS has 4 or more processing work stations connected mechanically by the storage & material handling system & loading or unloading system.

NEED OF FMS :-

→ External changes such as change in product design & production system.

→ optimising the manufacturing cycle time.

→ Reduced production cost.

→ Overcoming internal changes like breakdown etc.

→ To reduce inventry cost, direct labour cost etc.

→ To increase m/c utilization.

CAM, CAD/CAM, AND CIM

We have briefly defined the terms CAM, CAD/CAM, and CIM in our introduction. Let us explain and differentiate these terms more thoroughly here. The term *computer integrated manufaclUrlng* (CIM) is sometimes used interchangeably with CAM and CAD/CAM.

Although the terms are closely related.our assertion is that CIM possesses a broader meaning than does either CA M or CAD/CAM

Computer Aided Manufacturing

Computer-aided manufacturing (CAM) is defined as the effective use of computer technology in manufacturing planning and control. CAM is most closely associated with functions in manufacturing engineering, such as process planning and numerical control (NC) part programming. With reference to our model of production in Section 13.2, the applications of CAM can be divided into two broad categories:(1) manufacturing planning and (2) manufacturing control. We cover these two categories in Chapters 25 and 26, but Jet us provide a brief discussion of them here 10 complete our definition of CAM.

Manufacturing Planning. CAM applications for manufacturing planning are those in which the computer is used indirectly to support the production function, but there is no direct connection between the computer and the process. The computer is used "offline" to provide information for the effective planning and management of production activities. The following list surveys the important applications of CAM in this category:

Computer-aided process planning (CAPP). Process planning is concerned with the preparation of route sheets that list the sequence of operations and work centers required 10 produce the product and its components. CAPP systems are available today to prepare these route sheets. We discuss CAPP in the following chapter.

Computer-assisted NC part programming. The subject of part programming for NC was discussed in Chapter 6 (Section 6.5). For complex part geometries, computer assisted part programming represents a much more efficient method of generating the control Instructions for the machine tool than manual part programming is.

Computerized machinability data systems. One of the problems in operating a metal cutting machine tool is determining the speeds and feeds that should be used to machine a given work part. Computer programs have been written to recommend the appropriate cutting conditions to use for different materials. The calculations are based on data that have been obtained either in the factory or laboratory that relate tool life to cutting conditions. These machinability data systems are described in.

Development of work standards. The time study department has the responsibility for setting time standards on direct labor jobs performed in the factory. Establishing standards hv direct time study can be a tedious and time-consuming task. There are several commercially available computer packages for setting work standards. These computer programs 'use standard time data that have been developed for basic work elements that comprise any manual task. By summing the limes for the individual element, required to perform a new Job, the program calculates the standard lime for the job. These packages are discussed in

Cost estimating, The task of estimating the cost of a new product has been simplified in most industries by computerizing several of the key steps required to prepare the estimate. The computer is programmed to apply the appropriate labor and overhead rates to the sequence of planned operations for the components of new products. the program then sums the individual component costs from the engineering bill of materials to determine the overall product cost.

Production and inventory planning. The computer has found widespread use in many of the functions in production and inventory planning. These functions include: maintenance of inventory records, automatic reordering of stock items when inventory is depicted. production scheduling, maintaining current priorities for the different production orders, material requirements planning, and capacity planning. We discuss these activities in Chapter 26.

Computer-aided line balancing. Finding the best allocation of work elements among stations on an assembly line is a large and difficult problem if the line is of significant size. Computer programs have been developed to assist in the solution of this problem (Section 17.5.4).

Manufacturing Control. The second category of CAM application is concerned with developing computer systems to implement the manufacturing control function. Manufacturing control is concerned with managing and controlling the physical operations in the factory. These management and control areas include:

Process monitoring and control. Process monitoring and control is concerned with observing and regulating the production equipment and manufacturing processes in the plant. We have previously discussed process control in Chapter 4. The applications of computer process control arc pervasive today in automated production systems. They include transfer lines. assembly systems. NC, robotic>. material handling. and flexible manufacturing systems. All of these topics have been covered III earlier chapters.

Quality control: Qua1ity control includes a variety of approaches to ensure the highest possible quality levels III the manufactured product. Quality control systems were covered in the chapters of Pan IV.

Shop floor control. Shop floor control refers to production management techniques for collecting data from factory operations and using the data to help control production and inventory in the factory. We discuss shop floor control and computerized factory data collection systems in Chapter 26.

Inventory control. Inventory control is concerned with maintaining the most appropriate levels of inventory in the face of two opposing objectives: minimizing the investment and storage costs of holding inventory and maximizing service to customers. Inventory control is discussed in Chapter 26.

Just-in-time production systems. The term just-in-time refers to a production system that is organized to deliver exactly the right number of each component to downstream workstations in the manufacturing sequence just at the lime when that component ts needed. The term applies not only to production operations but 10 supplier delivery operations as well. Just-in-time systems are discussed in Chapter 26.

CAD/CAM

CAD/CAM is concerned with the engineering functions in both design and manufacturing. Product design, engineering analysis, and documentation of the design (e.g.. drafting) represent engineering activities in design. Process planning, NC part programming, and other activities associated with CAM represent engineering activities in manufacturing.

The CAD/CAM systems developed during the 1970s and early 1980s were designed primarily to address these types of engineering problems. In addition, CAM has evolved to include many other functions in manufacturing, such as material requirements planning, production scheduling, computer production monitoring, and computer process control.

It should also be noted that CAD/CAM denotes an integration of design and manufacturing activities by means of computer systems. The method of manufacturing a product is a direct function of its design. With conventional procedures practiced for so many years in industry, engineering drawings were prepared by design draftsmen and later used by manufacturing engineers to develop the process plan. The activities involved in designing the product were separated from the activities associated with process planning. Essentially a two-step procedure was employed. This was time-consuming and involved duplication of effort by design and manufacturing personnel. Using CAD/CAM technology, it is possible to establish a direct link between product design and manufacturing engineering. ln effect, CAD/CAM is one of the enabling technologies for concurrent engineering (Section 25.3). It is the goal of CAD/CAM not only to automate certain phases of design

and certain phases of manufacturing, but also to automate the transition from design to manufacturing. In the ideal CAD/CAM system, it is possible to take the design specification of the product as it resides in the CAD data base and convert it into a process plan for making the product, this conversion. being done automatically by the CAD/CAM system. A large portion of the processing might be accomplished on a numerically controlled machine tool As part of the process plan, the NC part program is generated automatically by CAD/CAM, The CAD/CAM system downloads the NC program directly to the machine tool by means of a telecommunications network. Hence, under this arrangement, product design, NC programming, and physical production are all implemented by computer.

Computer Integrated Manufacturing

Computer integrated manufacturing includes all of the engineering functions of CAD/CAM, but it also includes the firm's business functions that are related to manufacturing. The ideal CIM system applies computer and communications technology to all of the operational functions and information processing functions in manufacturing from order receipt, through design and production, to product shipment. The scope of OM, compared with the more limited scope of CAD/CAM, is depicted in Figure 24.7.

The CIM concept is that all of the firm's operations related to production are incorporated in an integrated computer system to assist. augment. and automate the operations. The computer system b pervasive throughout the firm, touching all activities that support manufacturing. In this integrated computer system, the output of one activity serves as the input to the next activity, through the chain of events that starts with the sales order and culminates with shipment of the product. The components of the integrated computer system are illustrated in Figure 24.8. Customer orders are initially entered by the company's sales force or directly by the customer into a computerized order entry system. The orders contain the specifications describing the product. The specifications serve as the input to the product design department. New products are designed on a CAD system. The components that comprise the product are designed, the bill of materials is compiled, and assembly drawings are prepared. The output of the design department serves as the input to manufacturing engineering, where process planning. tool design, and similar activities are accomplished to prepare for production. Many of these manufacturing engineering activities are supported by the (1M system. Process planning is performed using CAPP. Tool and fixture

ADVANCED MANUFACTURING AND CAD/CAM

(Code : MET-603)

Full Marks : 70

Time : 3 hours

Answer any five questions

Figures in the right-hand margin indicate marks

1. (*a*) What is LASER ? 2

   (*b*) Explain the function of dielectric fluid in EDM. Name the common dielectric fluids used in EDM. 5

   (*c*) Explain the need for non-traditional-machining processes. 7

2. (*a*) List the common abrasive powders used in AJM. (Abrasive Jet Machining). 2

   (*b*) Write down the area of applications and limitation of AJM Process. 5

(Turn Over)

(c) Briefly describe the principle of EBM with neat sketch. 7

3. (a) Define CAD, CAM and CIM. 2

(b) What is an AGVS ? What are its functions ? 5

(c) Discuss of different types automation. Illustrate with the help of a diagram to show the relationship of different types of automation system. 7

4. (a) Define flexible manufacturing system. 2

(b) What are the advantages and disadvantages of FMS ? Describe. 5

(c) Differentiate between NC, CNC and DNC systems. 7

5. (a) What are the tool positioning modes in NC programming ? 2

(b) Give the benefits of a CAD system. 5

(c) If you are to drill 3 holes (*A*, *B* and *C*) of equal diameter in a plate, show the difference

of part dimensioning in absolute and incremental systems. The centre of holes are; *a*(3, 5) *B*(15, 20), *c*(20, 20). 7

6. (a) Define Robot. 2

(b) Sketch and discuss the various Robot grippers. 5

(c) Describe the main components of Robot with neat sketch. 7

7. (a) Define G-code and M-code. 2

(b) Classify the different Non-conventional Machining Processes. 5

(c) Identify different components of FMS. Describe them in brief. 7

Advanced Manufacturing (set -2)

*) Ans all the questions. [2x10]

① What is Non - convectional M/c process & give example.
② What is automation.
③ What is NC axis of Motion.
④ What is M code & G code.
⑤ What is room zero & tool zero.
⑥ List the common abrasive powders used in AJM.
⑦ Difference betn CNC & DNC.
⑧ What is cartesian configuration.
⑨ What is Robort anatomy.
⑩ In Robort anatomy what are the types of Joint,

*) ANS Any Five [5x6]

① Describe the leaser beam machining process.
② Write down the need of automation.
③ What is Incremental system explain it.
④ Difference betn CNC & DNC.
⑤ Define Robort configuration & its types.
⑥ classify Flexible manufacturing system.
⑦ Describe Adv, Dis adv ~~of~~ & uses of AJM.
⑧ Give the benifits of CAD system.

* Ans Any 3

① What are the field of applⁿ of Robots. [10 x 3]

② Describe position & M/C control in NC M/C with neat sketch.

③ Describe PAM process with neat sketch.

④ Describe the main components of robot with sketch.