CHAPTER:-1

Q. Circuit voltage in EDM ?(S-2016)

Ans: The electric current is varied from 0.5 to 400 A at 40-300 volt dc. The voltage which is flow in the circuit to produce spark is known as circuit voltage.

Q. Spark gap : (S-2012)

Ans: The gap between cathode and anode at which spark occur and material remove is known as spark gap.

Q. Gases used in PAM ?(S-2015,S-2016)

Ans: Hydrogen (H_2) & Nitrogen (N_2) is used in plasma

Q. Explain with neat sketch the working principle, advantages and applications of electro-discharge machining.(S-2016)

Ans: Electro –discharge machining (EDM)

EDM is a non – conventional machining process in which the maching action is caused by the formation of an electric spark between an electrode shaped to the required contour and the workpiece. The conventional EDM machine cuts metals by electrical discharge or "spark erosion" between the metal to be cut (–ve charge) and an electrode (+ve charge). This cutting takes place in a non – conductive fluid known as a dielectric.

Description of process:-

→ The mechanical and the electrical set – up for EDM method is shown.

→ Power for generating the spark is fed from an A.C. source to rectifier. The D.C., output is then fed to the spark generating circuit.

→ the tool and work are submerged in a fluid having poor electrical conductivity (dielectric fluid)

→ The function of the servo – mechanism is to maintain a very small gap approximately 0.025 to 0.075 mm between the tool and the work.

→ The spark is a transient electric discharge across the gap between work and tool.

→ When the potential discharge (voltage) across the gap becomes sufficiently, large, the dielectric fluid becomes ionized and breaks down to produce an electrically conductive spark channel and the condensers discharge current across the channel in the form of a spark.

→ When the voltage drops to about 12 volts, the spark discharge extinguishes and the dielectric fluid once again becomes de ionized. The condensers start to recharge and the process repeats itself.

→ the spark occurs in an interval of 10 to 30 microseconds and with a current density of 15 -500 Amp/mm^2. Thus thousands of spark-discharge occur per second across the gap between tool and work, which result in a local temperature of approximately 12000^oC. Frequency of the sparks may range from 500 to 5×10^5 sparks per second.

→ At each discharge, heat transfer from high temperature spark (plasma) to both tool and work melts. Partially vaporizes and partially ionizes the metal in a thin surface layer. The resulting work surface is composed of extremely small craters. The time interval between the sparks is so short that the heat is unable to conduct into the tool and work.

Advantages of EDM(S-2016)

i. Metals of any hardness, toughness or brittleness could be machined by this process provided they are conductor of electricity.

ii. Dies of harder materials like alloy steels tungsten carbide etc. for moulding forging, extrusion and press tools could be reproduced.

iii. Dies can be machined even in the hardened state.

iv. Any complicated shape that can be made on the tool can be reproduced on a work piece.

v. Very fine holes can be drilled accurately since the cutting forces are tool small.

vi. The accuracy of work produced can be as high as 0.005 mm in finishing operations.

vii. More suitable for producing surfaces that are to be used for wear resistance because the surface produced has micro craters (appear as shot blasted surface) which can contain lubricants effectively.

viii. The machining time especially for harder work materials is much less than conventional machining process.

Limitations of EDM:

i. the power requirement is very high compared to conventional process (of the order to 120 J/mm^2).

ii. Some of the materials may become brittle at room temperature and there is some chance of surface cracking

iii. Sometimes a layer of 0.01 to 0.1 mm containing 4 % carbon may get deposited on steel work pieces.

iv. The metal removal rate is comparatively low (approximately 75 mm^3/sec)

v. It is difficult to reproduce sharp corners.

vi. In some cases the microstructure of the work piece surface gets distorted necessitating subsequent etching.

Q. Explain with a neat sketch the working principle of Electro beam machining. State four applications.(2016-w)

Ans: Electron Beam machining: This process utilizes the high kinetic energy of electrons which melts and vaporizes the material to give it proper shape and size. The surface of a metal can emit electrons when sufficiently heated the free electrons move under the influence of electric or magnetic fields and are accelerated greatly. When these narrow stream strikes the work piece by impact, the kinetic energy of the electrons is converted to powerful heat energy which is quite sufficient to melt and vaporize any material. The figure shown all the elements of an electron beam machining equipment. The set-up is placed in a chamber which is evacuated to a pressure of about 1×10^{-5} mm of mercury. The work to be machined is placed over the work table. The filament of the heated is heated to a temperature of approximately 2000°C. It emits a cloud of electrons. The electrons ar attracted to the anode. The electron beam emitter is so designed to help the electrons to move through the anode's small aperture.

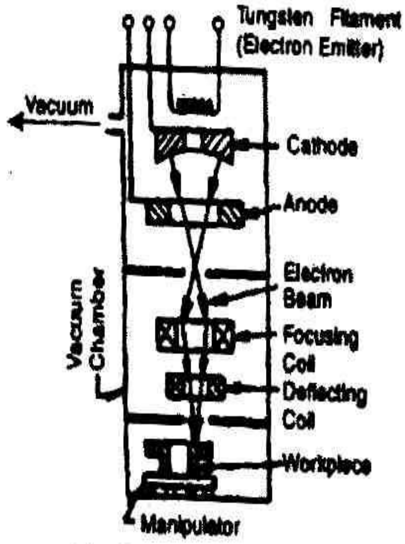


Fig. Electron Beam Machining

In this process the kinetic energy of the emitted electrons is utilized for machining purposes, so to impart high kinetic energy a very high voltage difference (of the order of 10^6 to 10^8) is maintained between the cathode and the anode. The velocity of the electron goes to the order of 1.6×10^5 km/sec. The stream of electrons moving with such tremendous speed passes through a small hole of the anode then through a tungsten diaphragm, then through the electromagnetic coils. It is now focused with the help of electromagnetic focusing lens on to the work piece. The electron beam deflection electromagnetic foil is kept on deflecting the beam by about 10 mm on the workpiece. However the table carrying the work piece has feeding device which enables the movement of the work piece. The electrons on impingement over the work piece heat it up and raises its temperature to a value as high as 5000^{o}C. Due to this the material melts and vaporizes locally.

Applications:

i. Used for drilling synthetic jewels in the watch industry.
ii. For making fine gas orifices in space nuclear reactors and turbine blades for supersonic aero-engine it is used.
iii. Wire drawing dies, light ray orifices could also be produced by this.
iv. Fine copper wires (0.003 mm) can be welded to transistors.
v. Suitable for welding small pieces of highly reactive and refractory metals.

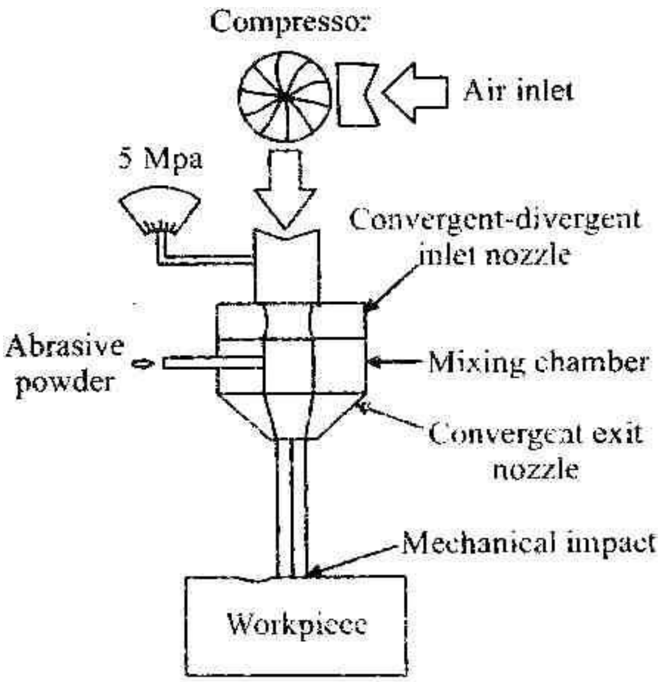
Q. Classify different Non-conventional machining process.2016(S)

Ans:
1. Abrasive jet machining process (AJM)
2. PAM (plasma Arc machining process)
3. EDM (Electric discharge machining process)
4. ECM (Electron chemical machining process)
5. LMB (Laser beam machining process)
6. USM (Ultrasonic machining process).

Q. Describe with neat sketch about Abrasive Jet Machining.(W-2014, S-2016)

Ans: The fundamental principle of abrasive jet machining involves the use of a high-speed stream of abrasive particles carried by a high pressure gas or air on the work surface through a nozzle. The metal removal occurs due torsion caused by the abrasive particles impacting the work surface at high speed. With repeated impacts, small bits of material get loosened and a fresh surface is exposed to the jet.

Fig. show a schematic diagram of working of the process. The filtered gas, supplied under a pressure of 2 to 8 kgf/cm^2 to the mixing chamber containing the abrasive powder and vibrating at 50 Hz. Entrains the abrasive particles and is then passed into a connecting hose. This abrasive and gas mixture emerge from a small nozzle mounted on a fixture at high velocity ranging from 150 to 300 m/min. the abrasive powder feed rate is controlled by the amplitude of vibration of the mixing chamber. A pressure regulator controls the gas flow and pressure. To control the size and shape of the cut either the work piece or the nozzle is moved by cams, pantographs or other suitable mechanisms. The carrier gas should be cheap, non-toxic and easily available. Air and nitrogen are two of the most widely used gas in AJM.

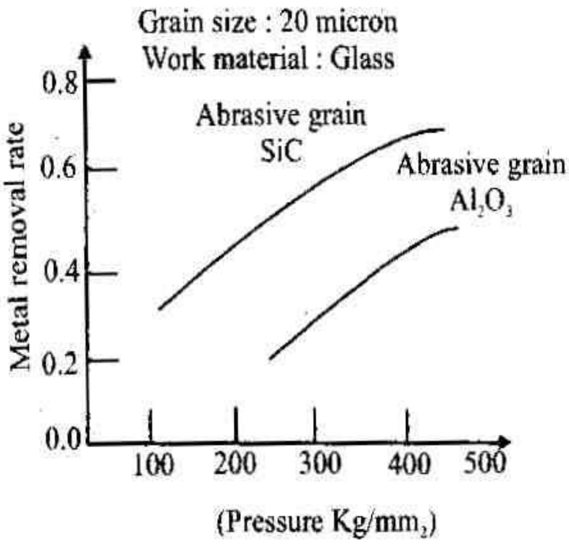


The abrasives generally employed are aluminum oxide., silicon carbide, glass powder or specially prepared sodium bicarbonate. The average particle sizes vary from 10 to 50 microns. Larger sizes are used for rapid removal rate while smaller sizes are used for good surface finish and precision work. In addition to the above abrasives dolomite (calcium magnesium carbonate) of

200 grit size is found suitable for light beads of diameter 0.30 to 0.60 mm are light polishing and deburring.

Sine nozzles are subjected to a great degree of abrasion wear, they are made of hard materials such as tungsten carbide or synthetic sapphire (ceramic) to reduce the wear rate. Nozzles made of tungsten carbide have an average life of 10 to 20 hours while nozzles of sapphire last for about 300 hour of operation when used with 27μ abrasive power. The gases used are nitrogen carbon dioxide or clean air.

The metal removal rate depends upon the diameter of nozzle, composition of abrasive gas mixture, jet pressure, hardness of abrasive particles and that of work material, particle size, velocity of jet and distance of work piece from the jet. A typical material removal rate for abrasive jet machining is 16 mm/min in cutting glass. Fig. shows the effect of abrasive jet pressure and grain size of the material removal rate.

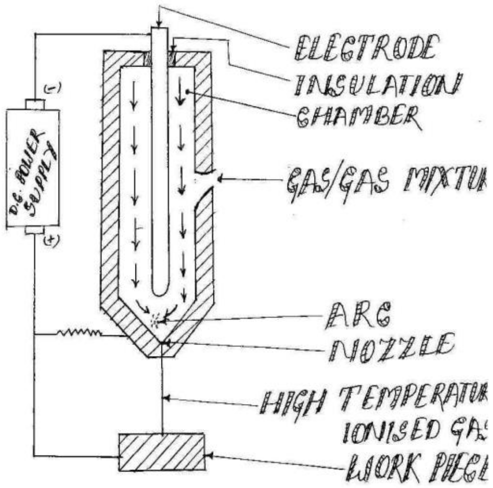


Effect of jet pressure for AJM

Accuracy : With close control of the various parameters a dimensional tolerance of ± 0.05 mm can be obtained. On normal production work in accuracy of ±0.1 mm is easily held.

Application: The process finds application in cutting slots, thin sections, contouring, drilling for producing shallow crevices, deburring and for producing intricate shapes I hard and brittle materials. It is often used for cleaning and polishing of plastics, nylon and Teflon components, frosting of the interior surface of the glass tubes, etching of markings on glass cylinders.

Q. Plasma ARC Machining (PAM)(S-2016)



When a gas is heated above 5500°C it is partially ionized and exists in form of mixtures of positively charged ions, neutral atoms and free electrons this mixture is known as plasma.

Plasma are cutting torque carries as tungsten electrode.

Working Principle:

In plasma are machining a plasma arc cutting torque uses a tungsten electrode which is fitted in a chamber. This electrode is connected to the negative terminal of D.C. power supply and is known as a cathode on the other hand there is a nozzle which is fitted bottom of the chamber and is connected to the positive terminal of D.C. power supply and is known as anode. There is a passage of one side of torque through which gas is passed into the chamber.

There is a also provision for water circulation on one side of torque to keep both electrode and nozzle water cooled.

When a strong electrode are struck between electrode (cathode) and nozzle (anode) and at the same time a gas is fed into the chamber gas molecules are ionize and large amount of heat is generated, due to collision of gas molecules with high velocity of electron arc. This hot ionize gas known as plasma is directed to impinge on the work piece which metals it material and blows it away.

Advantages of plasma Arc:

→ It is faster process

→ It an be used to cut any metal.

→ Due to this machining process a large amount of heat is generated for use.

Dis Advantages of Plasma Arc

→ Initial cost of equipments is high.

→ Safety precautions are needed for operator.

Application:

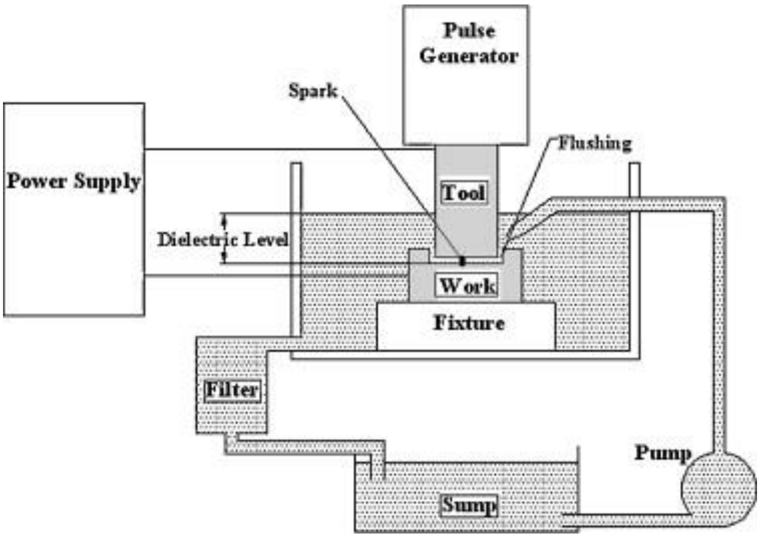
→ It is used for cutting stainless steel and non-ferrous metals, Aluminium alloys and their profile cutting.

→ It is used in nuclear power plant and chemical industry.

Q. Describe working principle of ECM & its function with neat sketch (W-2014)

Electrochemical machining (**ECM**) is a method of removing metal by an electrochemical process. It is normally used for mass production and is used for working extremely hard materials or materials that are difficult to machine using conventional methods. Its use is limited to electrically conductive materials. ECM can cut small or odd-shaped angles, intricate contours or cavities in hard and exotic metals, such as titanium aluminides, Inconel, Waspaloy, and high nickel, cobalt, and rhenium alloys. Both external and internal geometries can be machined.

ECM is often characterized as "reverse electroplating", in that it removes material instead of adding it. It is similar in concept to electrical discharge machining (EDM) in that a high current is passed between an electrode and the part, through an electrolytic material removal process having a negatively charged electrode (cathode), a conductive fluid (electrolyte), and a conductive work piece (anode); however, in ECM there is no tool wear. The ECM cutting tool is guided along the desired path close to the work but without touching the piece. Unlike EDM, however, no sparks are created. High metal removal rates are possible with ECM, with no thermal or mechanical stresses being transferred to the part, and mirror surface finishes can be achieved.



Advantages of ECM:

1. Complex, concave curvature components can be produced easily by using convex and concave tools.
2. Tool wear is zero, same tool can be used for producing infinite number of components.
3. No direct contact between tool and work material so there are no forces and residual stresses.
4. The surface finish produced is excellent.
5. Less amount of heat is generated.

Disadvantages

The saline (or acidic) electrolyte poses the risk of corrosion to tool, work piece and equipment

Only electrically conductive materials can be machined. High Specific Energy consumption.

Currents involved

The needed current is proportional to the desired rate of material removal, and the removal rate in mm/minute is proportional to the amps per square mm.

Typical currents range from 0.1 amp per square mm to 5 amps per square mm. Thus, for a small plunge cut of a 1 by 1 mm tool with a slow cut, only 0.1 amps would be needed.

However, for a higher feed rate over a larger area, more current would be used, just like any machining process—removing more material faster takes more power.

Thus, if a current density of 4 amps per square millimetre was desired over a 100×100 mm area, it would take 40,000 amps (and lots of coolant/electrolyte).

Applications:

Some of the very basic applications of ECM include:

- Die-sinking operations

- Drilling jet engine turbine blades
- Multiple hole drilling
- Machining steam turbine blades within close limits

Q. What is LASER ?(W-2014)

A device that generates an intense beam of coherent monochromatic light (or other electromagnetic radiation) by stimulated emission of photons from excited atoms or molecules. Lasers are used in drilling and cutting, alignment and guidance, and in surgery; the optical properties are exploited in holography, reading barcodes, and in recording and playing compact discs.

CHAPTER:-2

Q. What is Automation ?(W-2014)

Ans: Automation may be defined as :

i. It is a system in which many or all of the processes in the production, movement and inspection of parts and materials are automatically performed or controlled by self-operating devices.

ii. It is technology connected with performing a process by means of programmed commands combined with automatic feedback control to ensure proper execution of the instructions.

iii. It is the process of following a predetermined sequence of operations with little or no human labour, using specialized equipment and devices that perform and control manufacturing process.

Q. What are the different types of Automation ?(S-2015)

Ans: The various types of automation are :

i. Fixed automation (Hard automation)

ii. Programmable automation

iii. Flexible automation (soft automation)

i. Fixed Automation:-

→ It is characterized by having the sequence of operations necessary to manufacture or assemble a product fixed by the equipment configuration. As such, there is typical equipment which is inflexible to product changes.

→ The production lies are designed to produces a standardized product, such as engine blocks, valves, gears, spindles.

→ It is typically associated with high production rates.

→ This type of automation makes sense only when product designs are stable and product life cycles are long.

→ The machines employed in fixed automation applications are usually built on the "building block" or "modular" principle they are generally called "transfer machines" are consists of two major components (i) power led production units, (ii) Transfer mechanisms.

Advantages :

i. Unit cost is low

ii. Very initial efficiency

Disadvantages :

i. Inflexibility

ii. High initial investment

Programmable Automation:

→ The work "Programmable" means that one set of task can be easily switch up over to another set by changing the computerized instruction.

→ Programmable automation uses information technology and numerical engineering to provide co-ordination, machine control and communication through computers in the most effective way.

→ Equipment is highly reprogrammable to accommodate high product variety but has low production rates relative to fixed automation.

→ Parts are typically loaded into programmable automated production system in bathes. Each batch consists of a different part, and the machines comprising the systems to manufacture the part are reprogrammed for each batch. Change-over from one bath to the next also requires a change in physical set-up of the machine tools, that is their fixing and tooling. Such change-over results in a loss of production time.

Example:- Numerically controlled machine tools and industrial robots.

→ the principal programmable automation technologies are :

1. Computer Aided Design (CAD):

    i. Computer aided design and drafting (CADD).

    ii. Computer Aided Engineering (CAE)

2. Computer Aided manufacturing (CAM)

i. Computer numerically controlled machine tools (CNC).
ii. Robots
iii. Flexible manufacturing system (FMS)
iv. Automated Material Handling System (AMH)
V. Automated storage and retrieval system (AS/RS)

3. Computer Integrated Manufacturing (CIM)
   i. Management Information System (CIM)
   ii. Computer Aided Planning (CAP) and
   iii. Computer Aided Process Planning (CAPP)

Advantages : For large bathes the unit cost is low.

Disadvantages: Long set-up time is required for a new product.

Flexible Automation:-

→ The birth of flexible automation has been positive with the advent of micro-electronics, micro-computers and programmable controller.

→ It has the capability of producing a variety of parts with minimal change over time from one part to the next. The ability to change part programs and to hange the physical set-up of the production system with little or no loss of production time is the primary difference between flexible automation and programmable automation.

Advantages:

i. Parts with complex shapes can be produced
ii. Customized products.

Disadvantages:

i. High initial investment.
ii. Unit cost is relatively high.

Q. State the need of Automation.(W-2014)

Ans: Need of Automation :

i. To improve product quality
ii. To enhance labour productivity.
iii. To reduce labour cost
iv. To improve work safety
v. To accomplish process that can’t be done manually

vi. To reduce manufacturing load time.

vii. To avoid high cost of not automating.

viii. To economies on floor space in manufacturing plant by arranging the machines, material movement and related equipment more efficiently.

ix. To accomplish process that cannot be done manually.

x. To reduce eliminate routine manual electrical tasks.

CHAPTER – 3

Q. Write down the component of DNC system.(S-2015)

Ans: Components of DNC system: Direct numerical control can be defined as a manufacturing system in which a number of machines are controlled by a computer through direct connection and in real time. The tape reader is omitted in DNC, thus relieving the system of its least reliable component. Instead of using the tape reader, the part program is transmitted to the machine tool directly from the computer memory. In principle, one large compute can be used to control more than 100 separate machines. The DNC computer is designed to provide instructions to each machine tool on demand. When the machine needs control commands, they are communicated to it immediately. DNC also involves data collection and processing from the machine tool back to the computer.

Components of a DNC system :-

Figure illustrates the configuration of the basic DNC system. A direct numerical control system consists of four basic components.

1. Central Computer
2. Bulk memory, which stores the NC part programs.
3. Tele-communication lines
4. Machine tools

The computer cells the part program instructions from bulk storage and sends them to the individual machines as the need arises. It also receives data back from the machines. This two-way information flow occurs in real time, which means that each machine's requests for instructions must be satisfied almost instantaneously. Similarly, the computer must always be ready to receive information from the machines and to respond accordingly. The remarkable feature of the DNC system is that the computer is servicing a large number of separate machine tools, all in real time.

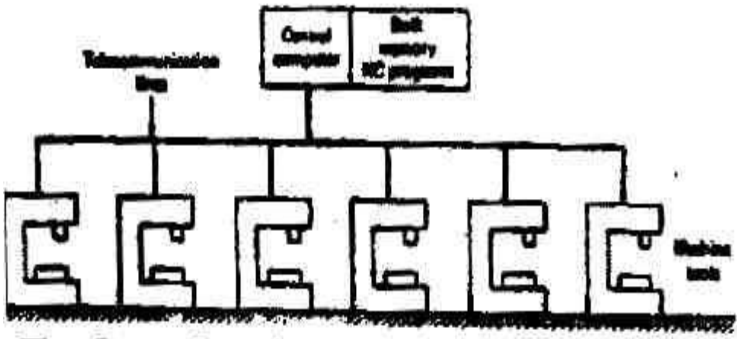


Fig. General configuration of direct numerical control (DNC) system

Depending on the number of machines and the computational requirements that are imposed on the computer, it is sometimes necessary to make use of satellite computers, as shown in figure. These satellites are mini-computers, and they serve to take some of the burden off the central computer. Each satellite controls several machines . Groups of part program instructions are received from the central computer and stored in buffers. They are then dispensed to the individual machines as required. Feedback data from the machines are also stored in the satellite's buffer before being collected at the central computer.

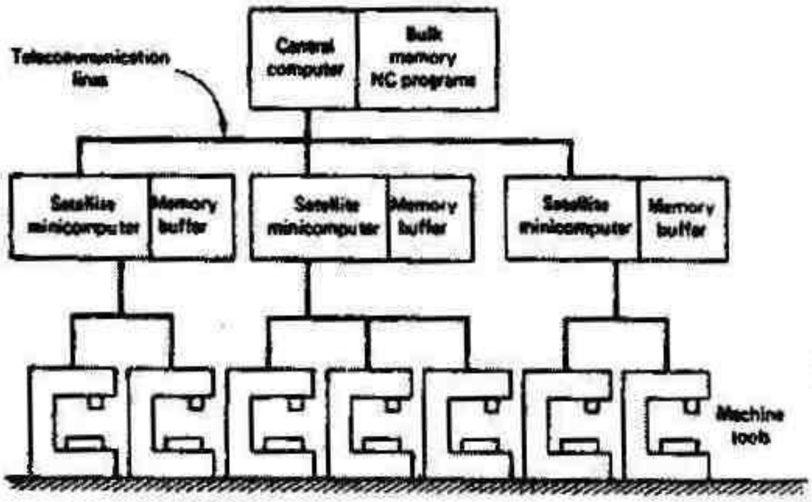


Fig. 2 : DNC with satellite minicomputers

Q. Economy of NC Systems ?(S-2015)

Ans: Some prominent advantages and disadvantages doing NC machines are the following:

ADVANTAGES:

1. Increased productivity. Due to reduced set-up and lead times.
2. Reduced Scrap. Due to elimination of human errors and high accuracy of NC system.
3. Increased rate of production. Due to heavy reduction in non-machining times and optimization of machining conditions.
4. Reduced non-productive time. Due to the use of lesser set-ups, lesser setting time, lesser work handling time, facility of automatic tool hanging on some machines, etc.
5. Reduced lead time for manufacturing. Due to the requirements of fewer set-ups and less set-up time.
6. Lesser requirement of jigs and fixtures. Due to the fact that work and tool positioning is done by NC type, only simple and cheaper varieties of fixtures may be needed in NC machining.
7. Reduced tooling cost. Due to the requirement of simpler and less costly fixtures, the cost incurred on the design and fabrication of fixtures is substantially reduced.
8. Reduced inspection requirement. Due to the production of parts of uniform quality.
9. Higher accuracy. The degree of accuracy of parts produced through NC machining is so high and quality so uniform that there is no difficulty in interchangeable use of these parts.
10. Better quality control. Due to higher accuracy of NC systems, the quality of products is effectively controlled.
11. Ease of complex machining. NC facilitates performing of complex machining operations easily, accurately and at much faster rate.

12. Greater flexibility in manufacturing. Due to easy adaptability of NC to changes in part design, changes in production schedule, etc., according to requirements.
13. Reduced inventory. The firm can do with a smaller inventory due to reduced lead times and requirements of fewer set-ups.
14. Greater utilization of manpower. Since the operator is not required to attend to a running NC machine constantly, he can be utilized to perform. Some other functions during that period.
15. Reduction of human error. Due to the replacement of all the operator's functions of conventional machining by tape in NC machining, the chances of human errors are reduced to a minimum.
16. Enhanced safety of operator. The operator's involvement in NC operations is minimum because the console, which operates different NC systems, is located at a distance from the machining area, the operator gets to chance to be exposed to this area.
17. Better safety of machine tool. There is practically no chance of any damage to the machine tool due to human error since there is almost no requirement of operator's involvement during the operation.
18. Better utilization of machine tool. Due to lesser requirement of set-up time and no requirement for operator adjustments and manipulations more time is available for machining, leading to a greater use of machine and, thus, an increased rate of production.
19. Reduced space re requirements. Lesser storing space is required in NC machining, because a few jigs and fixtures are needed. Also, when a NC machining centre is used, it eliminates the requirement of many conventional machine tools, which results in a reduced space requirement for a NC machine tool.
20. Accurate predications. The product cost and rate of production can be accurately predicted because of the programmed machining, which does not allow any deviation of the actual production time from the programmed time.

21. No need of skilled operator. Since all the manual skills required in conventional machining are transferred are transferred to the machine in NC, the essential requirement of a skilled operator can be easily done away with.

DISADVANTAGES:

1. Heavy investment. Which should be justified by full utilization of NC machines, otherwise the invested amount will be blocked.
2. Costly and complicated maintenance. Because a well trained maintenance task force is needed.

Q. Define work zero.(S-2015)

Ans: It can be set at any point inside the machine's electronic grid system usually it needs to be defined for each new set-up.

Q. Differentiate between machine centre and machining centre.2012-s

Ans: Machine centre refers to conventional machines whereas machining centre refers to NC machines.

A numerically controlled machine tool which is capable of carrying out a range of machining functions normally performed by a number of different types of conventional machine tools is formed as a machining centre. Through machining centres .

Operations such as milling, drilling boring remaining etc are performed automatically in accordance with instructions expressed numerically. The advantage of the machining centre is that it can accomplish, in a single set-up, the machining operations which would need overall individual machine set-ups on a succession of conventional machines. The machine centre has the capacity to hange tools automatically under the tape command.

Q. Explain the advantages and disadvantages of NC machine tool over conventional machine.2014-s

Ans: **Advantage** of NC system over conventional systems.

1. Accuracy of the components is high
2. Production rate is high.
3. Overall cost of tools is less.

4. Lead time is less.
5. Machine can be set to optimum speeds or feeds i.e. productivity is more.
6. Operator error is substantially reduced.
7. A less skilled operator can perform the job.
8. Reliability of NC machine is excellent.
9. Change in design can be early incorporated
10. Cost accounting and production control becomes very precise.
11. Elimination of operator errors.
12. Change in operator activity.
13. Lower labour cost.
14. Small batches.
15. Longer tool life.
16. Elimination of special jigs and fixtures.

Reduced inspection, less scrap, Accurate costing and scheduling

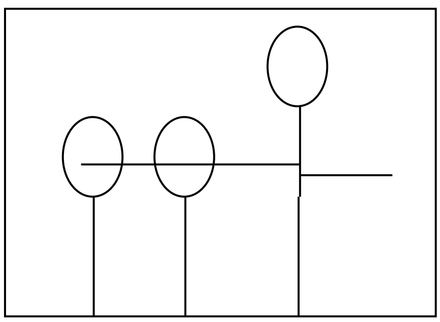
Disadvantages:

1. Higher investment cost.

Q. Define Tool positioning system(S-2016)

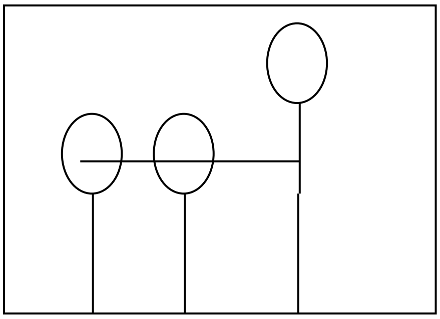
Ans: In NC programming the following two types of positioning systems or modes of programming are used:

Absolute system:-



In this system, the positions are indicated from a fixed zero point or reference point or origin Her all the tool positions i.e. the center of the hole circus, are marked with references to a fixed zero point. In this case the reference or zero point is left hand bottom corner of the work piece and all the distances are given from this point.

A drawback of this system is that if an error creeps in a dimension, it continuous to be saint that particular dimension.



In this system the tool positions or locations are indicated with reference to a previously known location.

Here all the dimensions are given i.e. the locations of all the tool positions are marked with reference to a previously known location.

An inherent draw back of this system is that if an error creeps into the dimensions of any will carry this error.

Motion Control System:-

They are also known as position control systems. It means a system of movement through which there will be a relative motion between the tool and work piece to enable proper positioning of tool and machining of w/l

There are basic three systems of 10 control these motions. 10 point system (PTP system)+

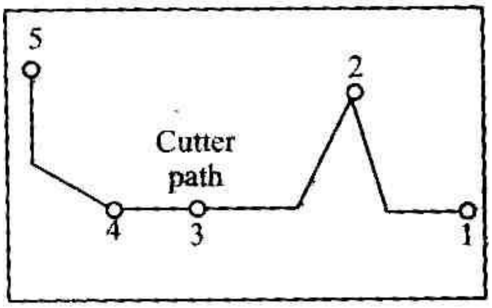
Q. Explain with a neat sketch point to point types of NC co-ordinate system.(S-2015)

Ans: Point-To-Point NC Co-Ordinate System:

Point to point (PTP) co-ordinate system is one where accurate positional control is required only to place the machine slides infixed position and the machine tool slide is required to reach a particular fixed co-ordinate point in the shortest possible time. The machining operations are performed at specific points and there is no machining while the machine table/slides move from one point to the next. No machining takes place until the machine slides have reached the programmed co-ordinate point and slide movement ceases.

Since there is no machining when the machine slides move from one point to other point, all the slide movements are made in rapid traverse to save time. Also the path of movement is not important but care must be taken to ensure that the cutting tool should not hit the work piece while moving from one position to the next. The movement along different axis may be sequential or simultaneous and each axis is controlled independently. The simultaneous movement along the axis results in reduced cycle time.

PTP control follows a some what irregular straight line path.

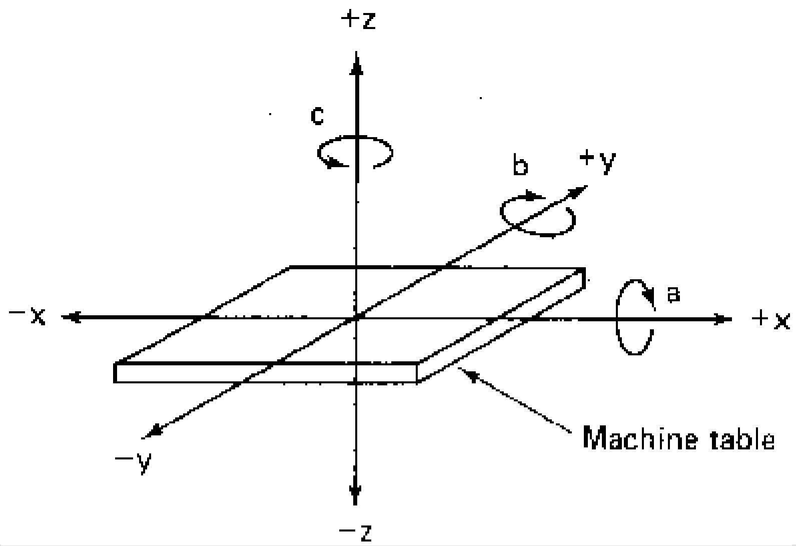


The PTP systems are simplest machine tool control systems. Most suitable for drilling, boring, tapping, punch presses, jig boring machines etc.

Q. Describe Coordinate system of NC Machine (W-2014)

The Coordinate system and Machine Motions

In order for the part programmer to plan the sequence of position and movements of the cutting tool relative to the work piece, it is necessary to establish a standard axis system by which relative position can be specified. Using an NC drill press as an example, the drill spindle is fixed in vertical position and the table is moved and controlled relative to the spindle. However to make things easier for the programmer we adopt the viewpoint that the work piece is stationary while the drill is moved relative to it. According, the coordinate system of axes is established with respect to the machine table. Two axis are defined as shown in figure.



Two axes x and y are defined in the plane of the table . The z axis is defined in the plane perpendicular to the table and the movement in the z direction is controlled by the vertical motion of the spindle. The positive and negative directions of motion of the cutting tools are relative to the table along these axes. NC drill presses are classified as other two axis or the three axis machines, depending on whether or not they have the capability to control the z-axis.
A numerical control machine and similar machine tools use the axis system similar to the drill system. However in addition to the three linear axes, these machines may possess the capacity to control one or more rotational axes. These axes are used to specify the angle about the x, y and z axes respectively. T o distinguish positive from negative angular motions the right hand rules can be used. Using the right hand with thumb pointing in the direction of positive linear axis direction the fingers of the hand are curled to point the positive rotational direction. For turning operations two axes are required to command the movement of the tool relative to the rotational work piece The arrangement is illustrated in figure.

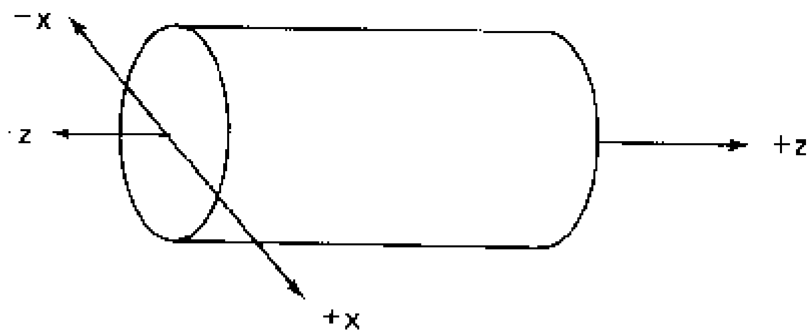


FIGURE 7.4 The *x*- and *z*-axes in NC turning.

Other features of the Location system
The purpose of the coordinate system is to provide a means of locating the tool in

relation to the work piece. Depending on the NC machine the part programmer may have several different options available for specifying this location.

FIXED ZERO VERSUS FLOATING POINT ZERO

The programmer must determine the position of the tool relative to the origin (zero point) of the coordinate system. NC machines have either of two methods for specifying the zero point. The first possibility is for the machines to have fixed zero. In this case the origin is always located at the same position is for the machine table. Usually that position is the southwest corner of the table and all the tool locations will be defined by positive x and y coordinates.
The second and more common feature on modern NC machines allows the machine operator to set the zero point at any position on the machine table. This feature is called floating point zero. The part programmer is the one who decides where the zero point should be located. The decision is based on part programming convenience. For example the work part may be symmetrical and the zero point should be established at the centre of symmetry.

ABSOLUTE VERSUS INCREMENTAL POSITIONING

Another option sometimes available to the part programmer is to use either an absolute system of tool positioning or an incremental system. Absolute positioning means that the tool locations are always defined in relation to the zero point. If a hole is to drilled at the spot that is 8 inches above the X-axis and 6inches to the right of the y-axis the coordinate location of the hole would be specified as x=+6.000 and y=+8.000. By contrast incremental positioning means that the next tool locations must be defined with reference to the previous tool location.

Q. Explain the adaptive control in advanced manufacturing process. (S-2015)

Ans: Adaptive control (A.C.) is basically a feedback system in which the operating parameters automatically adapt themselves to the actual conditions of the process.

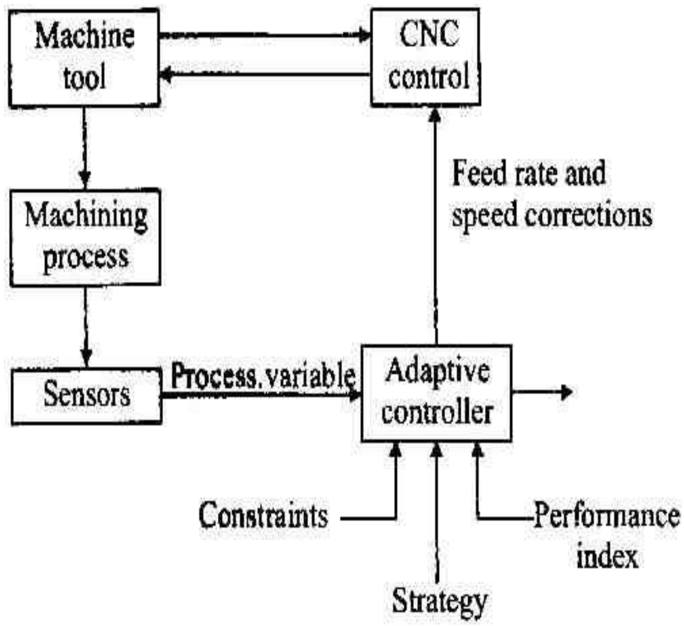
The numerical control guides the sequence of tool positions or path of the tool during machining.

Adaptive control determines – proper speeds, feed, depth of cut during machining for any variations in the work material hardness, width or depth of cut, etc.

Adaptive control has the capacity to respond to and compensate for these variation during the process. NC does not have this capability.

The adaptive control is to achieve improvement in production rate, or reduction in machining cost, by calculating and setting of the optimal operating parameters during machining itself. This calculation is based upon measurements of process variable in real time and is followed by a subsequent on-line adjustment of the operating parameters subject to machining constraints in order to optimize the performance of the overall system.

In CNC system the cutting speed and feed rates are prescribed by the part-programmer on the basis of work and tool and other factors. These values remain constant brought machining. If there is adaptive control then only the system will adapt the new value itself. Otherwise the operator can put the new values through the console, (note that the system does not adapt itself).



Situations where AC is Beneficial:

i) When in process gauging takes significant portion of the machining time.

ii) There are significant sources of variability in the work quality. For example, if the hardness varies along the length and depth of the work, no single value of speed or feed is optimum.

iii) The cost of operating the machine tool is high mainly due to high cost of the machine tool. In this case it is desirable to operate the machine at the optimum cutting condition. If the setting by manual gauging the down time is very high, then adaptive control is most suited.

iv) For jobs of steel, titanium and high strength alloys, this system is desirable. The wear rate is high, the cutting fores also high, for these materials, so constant monitoring of speeds, feeds, depth of cut are warranted for their adjustments to get desired surface finish.

Q. Differentiate between conventional and Nontraditional Machining process.(S-2016)

Ans: Non conventional machining:

1. In this process the tool and w/p are not joining to each other
2. Ex. PAM, LBM, USM
3. Less Labor required.

Conventional machining:

1. In this process the tool and w/p are directly connected to each other
2. Exam. Lathe machining
   Shaping
   Milling
3. More labor required.

Q. Define N.C. & CNC machine (W-2014)

Ans:

N.C-Numerical control system means control by number

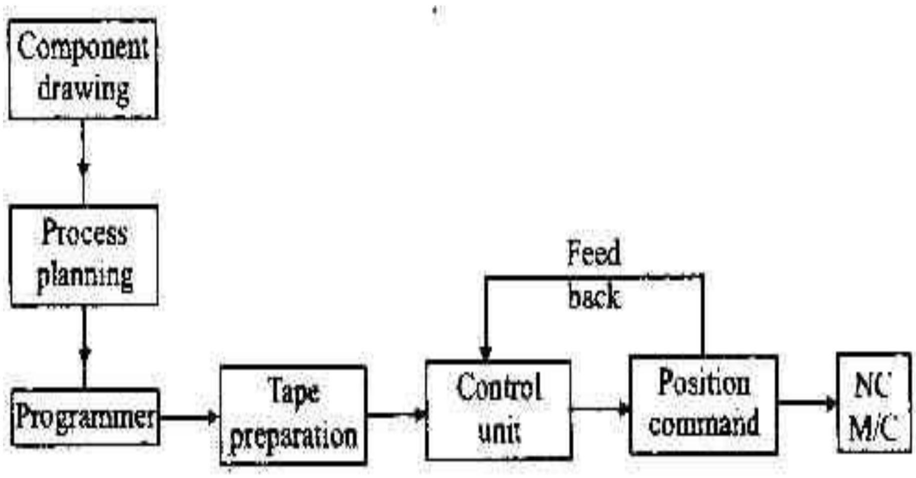
These number are arranged in the form of block and strip, which carry specific instruction

CNC Machine: Computer Numerical Control (CNC) is the improved from of machine tool that the numerically control (NC) machine. In CNC, a dedicated micro-computer is used to perform all the basic NC functions.

Q. Explain with the block diagram the NC system . (S-2015,2016)

Ans: Block Diagram of NC System:

Numerical control is a technique of automatically operating a productive facility, based on a code of letters, numbers and special characters. The complete set of coded instructions, responsible for executing an operation or a set of operations is called a part program. This program is translated into electrical signals to drive various motors to operate the machine to carry out the required operations. The schematic block diagram of a traditional NC machine is shown below.



The main elements of a NC machine tool are :

→ Machine control unit (MCU) also known as N.C. console or director.

→ Drive units or actuator.

→ Position feedback package.

→ Magnetic box

→ Manual control

The hardware also includes the associated circuits.

NC machine tool = MCU + Machine tool

MCU = Machine control unit.

= Date processing unit (DPU) + control loop unit (CLU)

The functional elements involved in MCU are

i. Data Input : The instructions for manufacturing the component are written in a coded language (Paper tape is the most commonly used device) are read by a
tape reader

ii. Data processing: the instructions undergo electronic processing resulting information in the form of electrical signals (pulsed commands)

i. Data Output : The control unit sends command signals to the drive units of machine tool and also to the electrical control cabinet called “Magnetic Box”. Command signals sent to the drive units of the machine tool, control the lengths of travel and the feed rates, while the command signals sent to the magnetic box control, other functions such as : Spindle motor starting and stopping, selecting spindle speeds, actuation of tool change, coolant supply etc.

It is clear from the above that MCU basically consists of two elements : Data processing unit (DPU) and control loops units (CLU).

The DPU processes the data (in coded form) read from the tape or any other source and passes the information regarding the various controls to CLU> NC is used to provide the following controls:

→ all cutting speed.

→ complete path and feed rates of a cutter in relation to the workpiece or fixture

→ all auxiliary functions such as turning cutting fluids off and on.

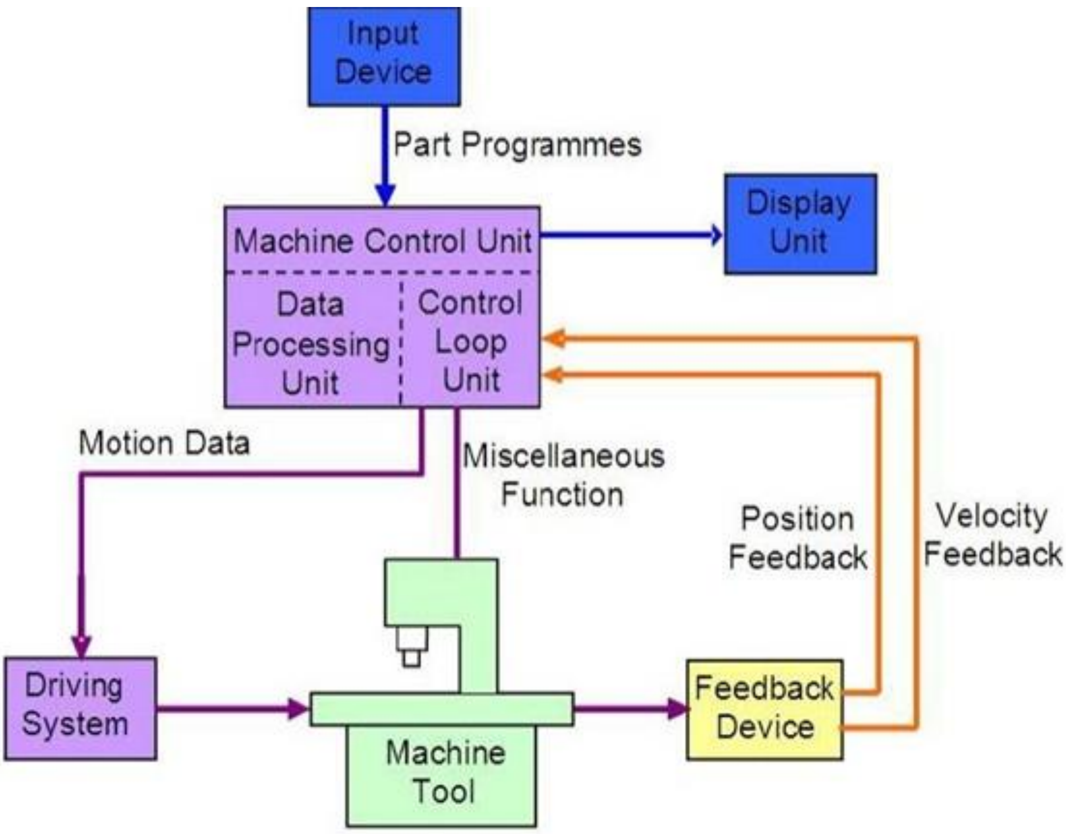
The CLU operates the drive mechanisms of the machine tool, receives feedback signals regarding the actual position and velocity of each of the axes and signals the completion of the operation. The DPU reads and processes the data sequentially.

Feedback transducer checks the required length of travel have been obtained or not by sending the information of the actual position achieved to the control unit. If there is any difference between the input command signal and the actual positioned achieved, the drive unit is actuated by suitable amplifier from the error signal.

Manual control or operator control helps the operator control helps the operator to perform some functions manually such as :

Motor start-stop, coolant supply control, axes movements, speed and feed change etc.

Q. Define elements of CNC system with diagram ?(W-2014)



Q. Explain the following with respect to NC systems.(2014-s)

Ans: i. Machine Zero

It is the point where the X, Y, Z axis of the machine tool intersect. It is also called as zero point or datum point or home position or machine reference point or home position or machine reference point. It is the origin of a machine co-ordinate system. In a NC system, machine zero is located at the positive end of each axis travel range. Figure shown the machining volume and various planes. The machine zero is located at the end of positive ranges of X, Y and Z-axes. Machine control unit (MCU) understands the dimensions provided with respect to the machine reference point. But the programmer is providing the dimensions on the drawings based on the local co-ordinate system i.e., part co-ordinate system. Machine zero point can be set to three methods.

→ By operator.

→ Manually by a programmed absolute zero shift.

→ By work co-ordinates to suit the holding fixture or the part to be machined.

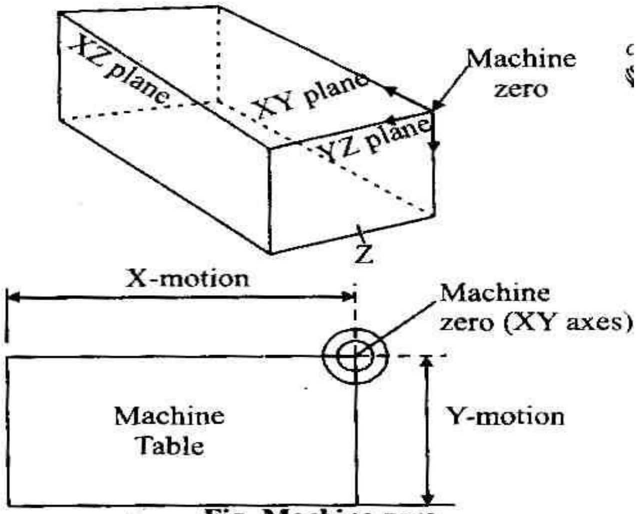


Fig. Machine zero

ii. **Work Zero**

It can be set at any point inside the machine's electronic grid system. Usually it needs to be defined for each new set-up.

iii. **Tool zero and tool offset.**

It is also called home position of the tool. It is the point from where the tool start for its motion while executing a program and return back at the end of the cycle. This can be any point within the workspace of th tool which is sufficiently away from the part.

Tool Off-set:

A numerical value stored in the NC system that repositions the tool. It is used to adjust for variations in tool geometry, part size, tool wear etc. Each tool requires its own off-set, which it measured from the tip of the tool to the gauge line.

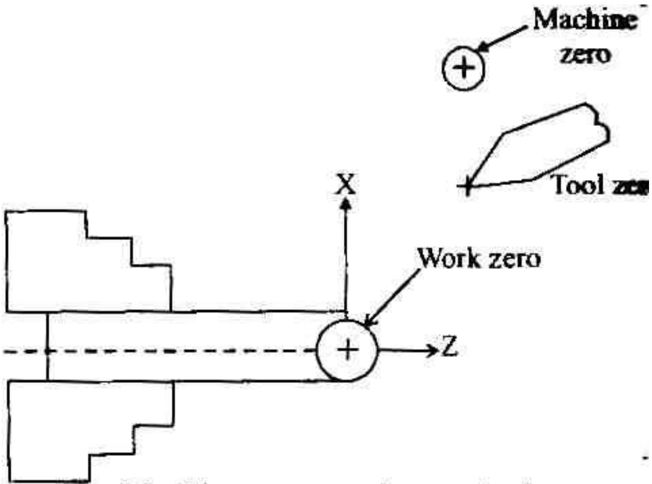


Fig. Machine zero, work zero, tool zero

Q. What is DNC ?2014-s

Ans: Direct Numerical Control (DNC) is a manufacturer system in which a large number of machines at controlled by a computer through direct connection. All the machines are linked to a main frame computer which sends information to individual machines and when required. The part programmes for all the components which are to be manufactured on the machines in DNC system, are stored in the memo of the computer. When a machine needs control commands, they are communicated by the computer immediately.

Q. Define CAM and CAD.(W-2014)

Ans: **CAM:** Computer-aided manufacturing (CAM) can be defined as the use of computer systems to plan manage and control the operations of a manufacturing plant through either direct or indirect computer interface with the plant's production resources.

CAD: Computer Aided Design (CAD) can be defined as the use of computer system, to assist in the creation, modification, analysis, or optimization of a design. The computer systems consist of the hardware and software to perform the specialized design functions required by the particular user firm. The CAD hardware typically includes the computer, one or more graphics display terminals, key-boards and other peripheral equipment. The CAD software consists of the computer programs to implement computer graphics o the system plus application programs to facilitate the engineering functions of the user company. Examples of these application programs include stress-strain analysis of components dynamic response of mechanisms, heat transfer calculations and numerical control part programming.

Q. State the benefits of CAD and CAM.(S-2015)

Ans: **Benefits of CAD ad CAM**

→ Improved accuracy of design and product manufacturing.

→ Improved quality assurance.

→ Standardized produce design and manufacturing

→ Reduced requirements of skilled personnel.

→ Improved engineering productivity and more customer satisfaction.

→ Design and modifications in product easily made.

→ Provides better and accurate functional analysis to reduce prototype testings.

→ Errors are minimized in part programming.

→ Saves materials and machining time by optimization algorithms.

→ Assistance in inspection of complicated parts.

→ Better engineering drawings and greater legibility.

→ Reduced lead time and in process inventory.

→ Cost saving in tool design and other capital investments.

→ Provides increased capacity due to reductions in set up times.

→ Reduced material handling costs.

→ High equipment utilization and reduced waste.

→ Flexible production schedule.

→ Increased capacity.

→ Complex design of product and frequent design changes can be incorporated.

→ Avoidance of sub-contracting to meet schedules.

→ Improved productivity in tool design.

→ Provides the potential for using more existing parts and tooling.

→ To create a data base of manufacturing.

→ Better communication interfaces and greater understanding among engineers, designers drafters, management and different project groups.

Q. Write short notes on the following:

(i) CNC(2014) (ii) CIM(S-2015)

Ans: i. CNC: Computer Numerical Control (CNC) is the improved from of machine tool that the numerically control (NC) machine. In CNC, a dedicated micro-computer is used to perform all the basic NC functions. The complete part programme to produce a component is input and stored in the computer memory and the information for each operation is fed to the machine tools i.e., motors etc. The part programmes can be stored in the memory of the computer and used in future. The conventional NC machine tools are not much in use these days and these are replaced by CNC machine tools due to many new control features available on these machines. The machines are basically found their applications in automated and mass production units. Some of the important features available in CNC machine tools are :

→ Because the computer can be readily and easily reprogrammed, therefore, the system is very flexible. The machine can manufacture a part followed by other parts of different designs.

→ The part programme once entered into the computer memory can be used again and again and can be edited and optimized at the machine tool itself which make it more versatile.

→ Program to manufacture a component can be easily called. This saves time and eliminates error due to tape reading.

→ Greater accuracy and ease of operation.

→ CNC control unit allows compensation for any changes in the dimensions of the cutting tool.

→ The CNC machines have the facility for proving the part programme without actual running it on the machine tool.

→ With th CNC control systems, it is possible to obtain information on machine utilization which is useful to the management. The control system can provide the information such as umber of components produced, time per component, time for setting up a job, time for which a particular tool has been in use, time for which machine has not been working and fault diagnosis etc.

→ Elimination of operator errors and activity.

→ Reduced lead time and lower labour cost.

→ Longer tool life and elimination of special jigs and fixtures.

→ Less scrap and reduced inspection.

→ Higher investment and maintenance cost.

→ Useful for complex design jobs with large number of operations to perform.

→ Requires highly skilled operator.

ii. **CIM:**

Computer-integrated manufacturing (CIM) is the manufacturing approach of using computers to control the entire production process. This integration allows individual processes to exchange information with each other and initiate actions. Through the integration of computers, manufacturing can be faster and less error prone, although the main advantage is the ability to create automated manufacturing processes.

→ CIM is the complete integration of CAD, CAM, CNC, DNC (Direct numerical control), FMS (|Flexible manufacturing system), automated inspection methods, computer process control, industrial robotics etc.

→ CIM represents the union of hardware, software, database management and communications to plan and control production activities from planning and design to manufacturing and distribution.

→ CIMs are being used for high volume, highly standardized production where mass production technology has traditionally been employed. However CIMs allow for much smaller and economically viable batch production capabilities.

→ It can be said that CIMs are designed to fill the gap between high production transfer lines and low production NC machines.

Advantages of CIM:

→ Better quality of product and reduced waste.

→ Shorter design cycles.

→ Better utilization of machines and equipments.

→ Better management control.

→ Reduced labour cost and greater productivity.

→ Reduced manufacturing lead time.

→ Labour in-process inventory and flexible production scheduling.

Q. What is Adaptive Control System ?(S-2015)

Ans: For a machining operation, the term adaptive control denotes a control system, that measures certain output process variables and uses these to control speed and or feed. Some of the process variables that have been used in adaptive control machining systems include spindle deflection or force, torque cutting temperature, vibration amplitude and horse power. In other words, nearly all the metal cutting variables that can be measured have been tried in experimental adaptive control systems. The motivation for developing and adaptive machining system lies in trying to operate the process more efficiently

Q. Describe the types of Co-ordinate system used in CNC.2015

Ans: Two types of co-ordinate systems are used to define and control the position of the tool in relation to the work piece. Each system has its own applications and the two co-ordination systems may used independently or may be mixed within a CNC part programme according to the machining requirements of the component. The co-ordination systems used are :

(i) Absolute co-ordination system.

(ii) Incremental co-ordination system.

In addition, the dimensions can be given in metric system and inch (FPS) system.

Absolute co-ordination system: In the absolute co-ordination system the co-ordinates of a point are always referred with reference to the same datum. The datum position in the X-axis , Y-axis and Z-axis are defined by the user/programmer before starting the operation on the machine. A major advantage of using absolute system is that it is very easy to heck and correct a programme written using this method. If a mistake made in the value of any dimension in a particular block, it will affect that dimension only and once the error is corrected there will be no further problems.

Incremental co-ordination system: In the incremental system the co-ordinates of any point are calculated with reference to the previous point i.e., the point at which the cutting tool is positioned is taken ad datum point for calculating the co-ordinates of the next point to which movement is to be made. It is difficult to check a part programme written in incremental dimension mode.

Q. Explain the function of M and G code.(S-2015)

Ans: Part programme is an important component of the CNC system. The shape of the manufactured components will depend on how correctly the programme has been prepared. Part programme is s a set of instruction which instructs the machine tool about the processing steps to be performed for the manufacture of component. Part programming is the procedure to which the sequence of processing steps and other related data, to be performed on the CNC machine planned and documented. The part programme is the transferred to one of the input mediums, which is used to instruct the CNC machine.

M and G code are important part programming code used in CNC programming.

Function of 'M' Code:

The miscellaneous function code is used specify certain miscellaneous or auxiliary function which do not related to the dimensional movement of the machine. The functions may be spindle stage spindle stop, coolant ON/OFF etc. An example of M code is M02 which indicates end of programme. The miscellaneous function are given in table below.

Miscellaneous Functions (M-Code)

Code	**Function**
M02	Programme stop
M03	Spindle start (clock-wise)
M04	Spindle start (counter clock-wise)
M05	Spindle Stop
M06	Tool change
M08	Coolant on
M09	Coolant off
M30	Programme stop and tape rewind.

Function of 'G' Code(S-2016)

G-Code prepares the control unit to execute the instructions that are to follow. The function is represented by two digits preceded by G. The preparatory function enables the controller to interpret the data which follows and it precedes the co-ordinates words. For example G01 is used to prepare the controller for linear interpolation. Some of the preparatory functions are given in table below.

Preparatory Function (G-Code)

Code	Function
G00	Rapid traverse
G01	Linear interpolation
G02	Circular interpolation (Clock-wise)
G03	Circular interpolation (Counter clock-wise)
G04	Dwell
G05	Hold/delay
G17	XY plane designation
G18	ZX plane designation
G19	YZ plane designation
G33	Thread cutting
G40	Cutter compensation cancel
G41	Cutter compensation left
G42	Cutter compensation right
G63	Thread cutting cycle
G70	Dimensioning in inch units.
G71	Dimensioning in metric units
G80	Canned cycle cance
G81-G89	Canned cycles
G90	Absolute dimensioning
G91	Incremental dimensioning
G92	Zero preset
G94	Feed rate mm/min
G95	Feed rate mm/rev.

Q. Explain the various reference point used in NC system ?(2015-s)

Ans: Various point used in NC system:

In an NC co-ordinate system, the tool position is always indicated in terms of its co-ordinates with reference to the origin in zero point of the system. A part programmer can use any one of the following two methods for this purpose.

(i) Fixed zero method

(ii) Floating zero method

Fixed zero method:

In this method, the zero point is always situated a fixed location on the machine table. Normally, this location is left hand lower corner of the table of the machine and the X and Y co-ordinates of all the tool positions are mentioned with respect to this fixed position of the zero point.

Floating Zero method:

In this method, the part programmer decides the location of zero point anywhere according to convenience and the machine operator is duly informed about the same. In the beginning of the operation, the operator is required to do a little setting manually. What he actually does is that he brings the tool to a specific point, called target point on the work-piece. This is a point of which the co-ordinates have already been decided and fixed with reference to the zero point. All subsequent movements and locations of the tool are then controlled by the machine tool with reference to this target point as zero point.

In NC programming, the following two types of positioning systems or modes of programming are used :

(a) Absolute System:

In this system, the positions are indicated from a fixed zero point or reference point. In this case, the zero or reference point is the left hand bottom corner of the work-piece and all the distances are given from this point.

(b) Incremental System :

In this system, the tool positions or locations are indicated with reference to a previously known location.

Q. Applications of N.C:-2016-s

Ans: i. It is used when machining of a part is likely to be subjected to the frequent changes in design.

ii. It is used where complex machining operations are involved.

iii. It is used when several operation have to be performed in machining a parts.

iv. It is also used when the part carries complex geometry.

v. It is used in metal removal record rate is required to be high.

vi. If finds application where the dimensional accuracy of the part is high.

Q. N.C. part programming:2016-s

Ans: Programming involves a set of instruction the required for machining. This will required a planning these sets of instruction. A part programme does this manually be preparing a planning sheet all details regarding sequence of operations, tool speed feed etc are mentioned clearly and the required specification are also given important. But this method is labour same and time consuming so the instructions required for machining is fed in terms of machine language to MCU of controller by automatic means known as NC. Part programming. This method has many advantages. It doesn't required production drawing for manufacture a part like manual part programming. Secondly it eliminates the involvement feeding of date into computer is done automatically. So it is a faster process and given more accurate results then part programming method.

The following types of formats are used to represent the sets of instruction. They are fixed squinty format. T_{AB} sequential format, word address format and compatible format.

In fixed sequential format, the sequence of instruction are fixed and a code. TAB is used to separate each word from other. In word address format instructions are represented by words using an alphabet as prefix. Formats are used to represents specific instructions suitably coded and stored in tape. Compatible formats are similar to word address format. By using this format the tape reader can easily read the tape.

G Code:

G00 → Point positioning

G01 → linear interpolation

G02 → Clockwise circulation interpolation

G03 → Counter wise circulation interpolation

G04 → D. Well

G05 → Hold

G06 → Interpolation

G17 → XY plane section

G19 → ZX plane section

CHAPTER:4

Q. Explain the different sensors used in Robot.(S-2015)

Ans: Sensor used in Robot: for certain robot applications, the type of work station control using interlocks is not adequate. The robot must take on more human like senses and capabilities in order to perform the task in a satisfactory way. These senses and capabilities include vision and hand-eye coordination, touch and hearing. Accordingly, we will divide the types of sensors used in robotics into the three categories.

i. Vision sensors

ii. Tactile and proximity sensors

iii. Voice sensors.

(i) Vision Sensors: This is one of the areas that is receiving a lot of attention in robotics research. Computerized visions systems will be an important technology in future automated factories. Robot vision is made possible by means of a video camera, a sufficient light source and a computer programmed to process image data. The camera is mounted either on the robot or in a fixed position above the robot so that its field of vision includes the robot's work volume. The computer software enables the vision syste4m to sense the presence of an object and its position and orientation, vision capability world enable the robot to carry out the following kinds of operations.

Retrieve parts which are randomly oriented on a conveyor.

Recognize particular parts which are intermixed with other object.

Perform visual inspection tasks.

Perform assembly operations which require alignment.

All of these operations have been accomplished in research laboratories. It is merely a matter of time and economies before vision sensors become a common feature in robot applications.

(ii) Tactile and proximity sensors:

Tactile sensors provide the robot with the capability to respond to contat forces between itself and other objects within its work volume. Tactile sensors can be divided into two types:

(a) Touch sensors

(b) Stress sensors (also called force sensors)

Touch sensors are used simply to indicate whether contact has been made with objet. A simple micro switch can serve the purpose of a touch sensor. Stress sensors are used to measure the magnitude of the contact force. Strain gauge devices are typically employed in force measuring sensors.

Potential uses of robots with tactile sensing capabilities would be in assembly and inspection operations. In assembly, the robot could perform delicate part alignment and joining operations. In inspection, touch sensing would be useful in gauging operations and dimensional measuring activities. Proximity sensors are used to sense when one object is close to another object. On a robot, the proximity sensor would be located on or near the end effector. This sensing capability can be engineered by means of optical-proximity devices, eddy-current proximity detectors, magnetic field sensors or other devices.

In robotics, proximity sensors might be used to indicate the presence or absence of a work part of other object. They could also be helpful in preventing injury to the robot's human co-workers in the factory.

(iii) Voice sensors:-

Another area of robotics research is voice sensing of voice programming. Voice programming can defined as the oral communication of commands to the robot or other machine.

Q. Define a Robot.(S-2016)

Ans: A robot is a programmable, multi-functional manipulator designed to move material parts, tools, or special devices through variable programmable motions for the performance of a variety of tasks.

Q. State the objective of using an industrial robot.(S-2016)

Ans: Objectives of using Industrial Robots:

The use of Industrial Robots is increasing day-by-day with a view to achieve the following main objectives:

1. To increase productivity.
2. To raise the quality level of products.
3. To minimize the labor requirement.
4. To reduce production time
5. To take advantage of fatigue-free continuous deployment of robots, because the human beings are always bound to experience fatigue when put to continuous working.
6. To improve existing manufacturing processes.
7. To enable the life of production machines.
8. To make the viability and applicability of new high-speed production processes and their related machinery possible.
9. To increase the safety level of the labor force by replacing them by robots for performing monotonous, tedious and hazardous jobs and thereby creating better working conditions for workers.
10. Thus, to minimize the loss of man-hours on account of accidents and diseases.

With these factors in view, continuous research all over the world is going on to ultimately produce such robots which could sense by touching, seeing , tasting and hearing, just like human beings and could, therefore, take decisions themselves.

Q. Make a neat sketch of a robot and show its main parts on it. (S-2015,S-2016)

Ans: Main components of a Robot:

A robot carries a large number of components, of which the main components are the following:

1. Base. Which may be fixed or mobile.
2. Manipulator Arm. With a number of degrees of freedom of movement.
3. Gripper or end effector. For holding a piece or a tool, depending upon the application of the robot.
4. Drives. Also known as actuators, they move the manipulator arm and end effector to the required position in space.
5. Controller. It delivers commands to the actuators with the help of hardware and software support.
6. Sensors. They perform dual functions:

   (i) To act as feedback devices to direct further actions of the manipulator arm and the endeffector (gripper), and (ii) To interact with the robot's working environment.

Q. What is the use of sensors ?(S-2015)

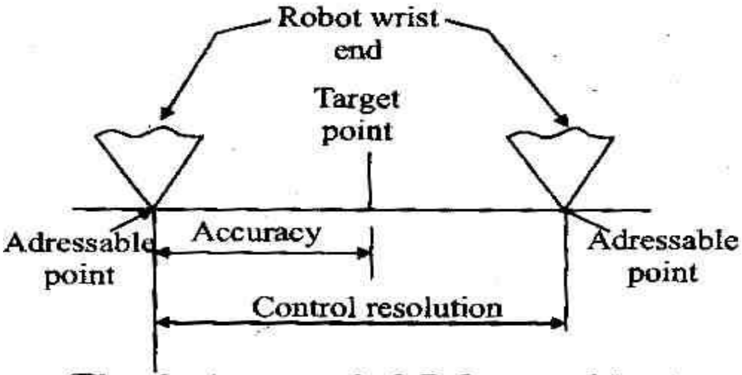
Ans: **Use of Sensors**: A sensor is a transducer used to make a measurement of a physical variable. The basic function of an electric sensor is to measure some feature of the world, such as light, sound or pressure and convert that measurement into an electrical signal, usually a voltage or current.

The most common and minimal use of sensors is to provide information about the status of links and joints of the manipulator and about the working environment of the robot. In addition, sensors may be deployed to provide data for inspection and quality control, safety monitoring and to detect and resolve interlocks in the work cell.

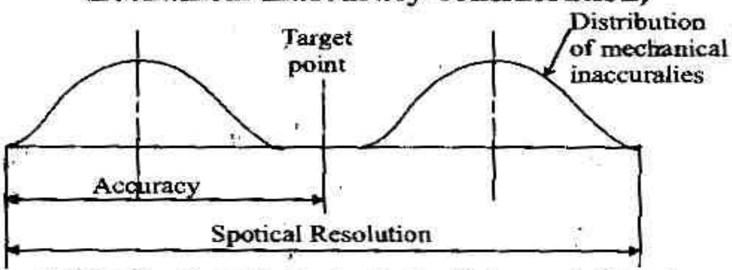
Q. Explain the accuracy and repeatability of Robot.(S-2015)

Ans: Accuracy :

It refers to a robot's ability position its wrist end at a desired target point with the work volume, and it is defined in terms of spatial resolution. At first accuracy depends on robot technology and how closely the control increment can be defined for each of the joint motions, excluding for the moment the mechanical inaccuracy which include the robot manufacture quality. Initially we define accuracy as one half of the control resolution, considering the worst case where the target point is directly between two control points (fig.1). A more realistic considerations include mechanical inaccuracies with a statistical distribution (fig.2) in that case accuracy is defined as one-half of the spatial resolution.



(Fig : 1 - Accuracy in 2-D frame, without mechanical inaccuracy consideration)



(Fig : 2 - Accuracy and spatial resolution in which mechanical inaccuracies are represented by a statistical distribution

The term accuracy in robotics is often confused with the terms resolution and repeatability. The final accuracy of a robotic system depends on its mechanical inaccuracies, the computer control algorithms and the system resolution.

$$\text{Robot accuracy} = \frac{(\text{BRU} + \text{Mechanical accuracy})}{2}$$

$$\text{BRU} = \text{Basic Resolution Unit}$$

Repeatability:

It is a statistical term, associated with accuracy, it describes how a point is repeated. If a robot joint is instructed to move by the same angle from a certain point a number of times, all with equal environmental conditions, it will be found that the resultant motions lead to differing displacement fig. Although a target is always missed by large margin, if the same error is repeated, then we say that the repeatability is high and accuracy is poor. Repeatability does not describe the error with respect to absolute co-ordinate. For example, ±0.2 mm indicates that any point might be as much as 0.2 mm beyond or short of the centre of the repeatability pattern.

Most of robots have a numerical value for the repeatability rather than the accuracy. The reason is that the accuracy depends upon the particular load that the gripper carries. A heavier weight causes larger deflections of the robot links and larger load on the joints which degrade the accuracy, while the repeatability value, however is almost independent of the gripper load.

Q. State the type of robot configuration. With a neat sketch, explain the working of a Cartesian co-ordination robot.(W-2014,S-2015,S-2016)

Ans: Type of Robot configuration: The majority of commercially available robots can be grouped into the following types configurations.

→ Cartesian co-ordinate or rectangular configuration

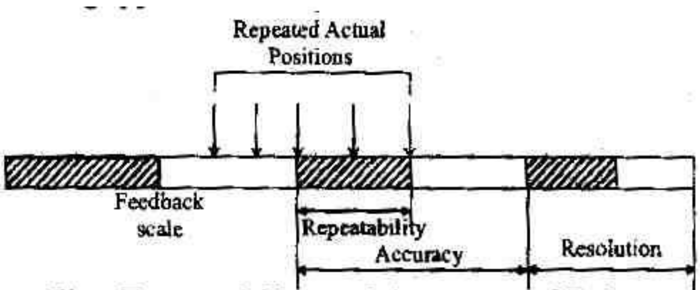


Fig : Repeatability and Accuracy of Robot

→ Cylindrical configuration

→ Polar or spherical configuration

→ Jointed arm or articulated or revolute configuration.

→ Spine configuration

→ Pendulum configuration.

Working of a Cartesian Co-ordination Robot:

The Cartesian or rectangular configuration robot provides for three linear axes of movement at right angle (sometimes termed as orthogonal) to eah other. In this, the simplest of configurations, the links of the manipulator are constrained to move in a linear manner. Axis of a robotic deice that behave in this way are referred to as "Prismatic".

The movement of this type of robot is similar to those of a milling machine, providing movement in X, Y, Z axes. It may also be termed as rectangular configuration since its working range sweeps out a three-dimensional rectangular volume. The Cartesian devices may be of two types :

→ Cantilevrd Cartesian

→ Gantry style Cartesian

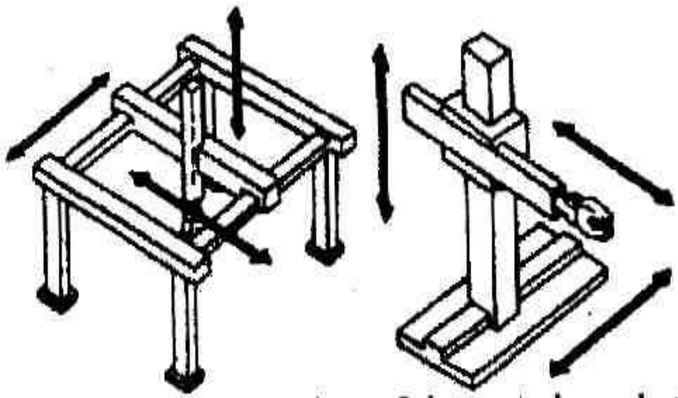


Fig. Two implementations of the cartesian robot configuration.

Particular advantages of this configuration includes :

→ Easily controlled/programmed movements

→ Highly accuracy

→ accuracy, speed and payload capacity constant over entire working range

→ Control system simplicity

→ Familiar X, Y, Z co-ordinates easily understood

→ Inherently stiff structure.

→ Large area coverage

→ Structural simplicity, offering good reliability

→ Large payload capacity

→ Easy to expand modular fashion.

This robot configuration finds application in those areas where linear movements and high accuracy are demanded for example, manipulation of components through apertures (i.e. furnace doors, machine openings and similar confined spaces), or pick and place applications where the work plane is essentially flat.

Q. Discuss the gripper as an end effector.(S-2015)

Ans: Gripper as an end Effector : The end effector is the special purpose tooling which enables the robot to perform a particular job. Various types of end effectors are designed for the same robot to make it more flexible and versatile.

End effectors are categorized into two major types

Grippers and Tools

Grippers: These are used to hold either work pieces (in pick and place operations, machine loading or unloading, or assembly work) or tools.

Grippers used in robot applications are :

i. Mechanical grippers- Here friction or the physical configuration of the gripper retains the object.

ii. Suction or vacuum cups – Used for holding flat objects.

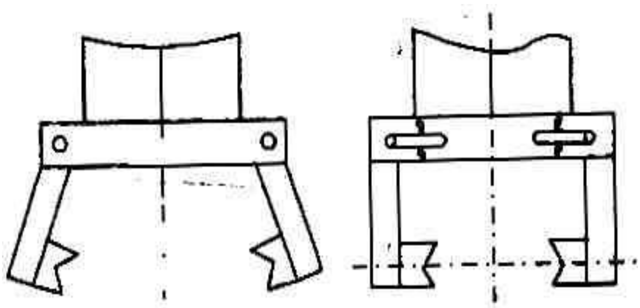
iii. Magnetized gripper – Used for ferrous object.

iv. Hookes – Used to lift parts of conveyors

v. Scoops or ladles – Used for fluids, powders pellets etc.

vi. Adhesive or electro-static grippers.

Figure shown are some sample gripper designs.



(a) Pivot-action gripper

(b) Slide action gripper

Q. Write down the various configuration of Robot ?(S-2015)

Ans: Configuration of Robot: The majority of commercially available robots can be grouped into four basic configurations:

i. Cartesian co-ordinate configuration.

ii. Cylindrical configuration.

iii. Spherical configuration

iv. Jointed-arm configuration (Revolute).

i. Cartesian co-ordinate configuration:

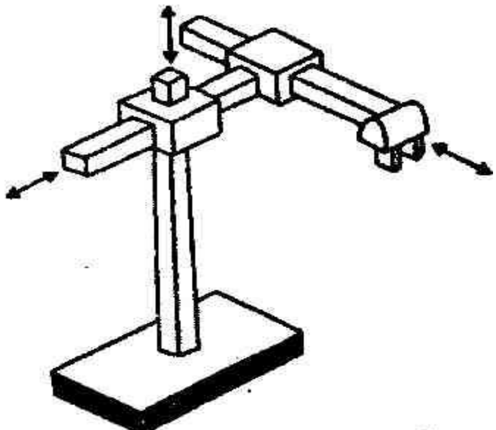


Fig. Cartesian configuration

→ The Cartesian or rectilinear robot also termed as gantry robot, has three mutually perpendicular axes which define as rectangular work volume.

→ In this, the simplest of configurations, the links of the manipulator are constrained to move in a bilinear manner. Axes of a robotic device that behave in this way are referred to as "prismatic".

→ The Cartesian devices may be of two types

a. Cantilevered Cartesian:

→ Such devices tend to have a limited extension from the support frame are less rigid, but have a less restricted workspace than other robots.

→ They have good repeatability and accuracy (even better than SCARA types) and the easier to program because of the "more natural" co-ordinate system/

b. Gantry-style Cartesian:

→ Such robots are used when extremely heavy loads must be precisely moved.

→ They are often mounted on the ceiling.

→ They are generally more rigid but may provide less access to the work-space.

iii. Cylindrical configuration:

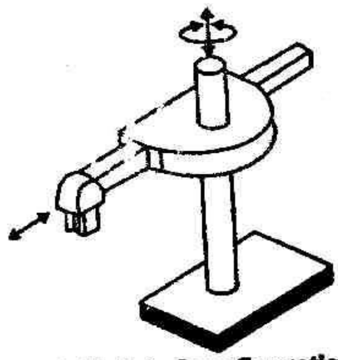


Fig. Cylindrical configuration.

→Cylindrical configured robots use a vertical column with the robot arm attached to a side which can move up and down the column. Simultaneously, the arm can move radically with respect to the column.

→ Usually, a full 360° rotation in θ is not permitted due to restriction imposed by hydraulic electrical, or pneumatic connections or lines Also, there is minimum, as well as maximum extension (i.e., R) due to mechanical requirements. Consequently, the overall volume or work envelope is a portion of a cylinder.

iii. Spherical (polar) configuration:

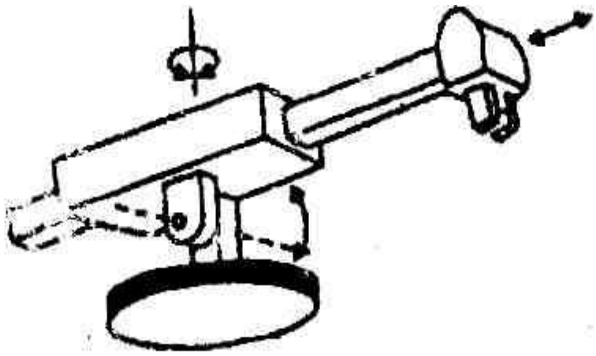


Fig. Spherical configuration

→ The configuration has a telescope arm which pivots about a horizontal axis and also rotates about a vertical axis.

→ Owing to mechanical and/or actuator connection limitations, the work envelope of such a robot is a portion of sphere.

→ Figure below shows the working volume of spherical co-ordinate robot.

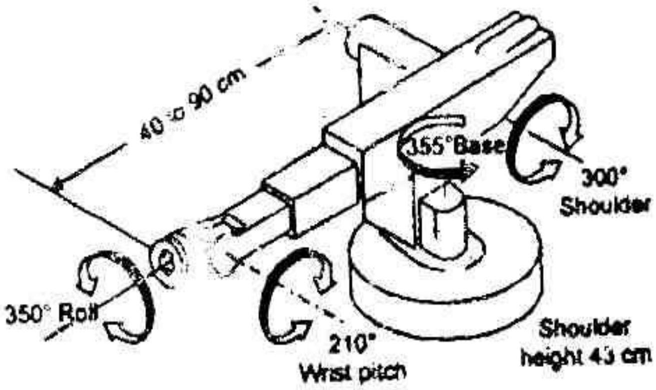


Fig. Range of motion of spherical coordinate robot

(iv) Jointed-arm configuration (Revolute) :

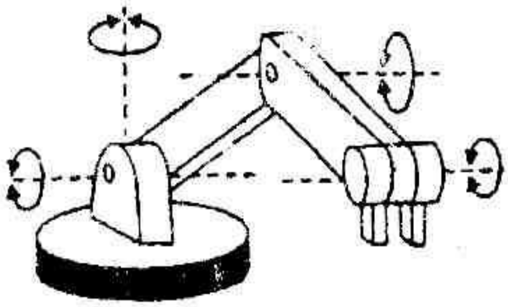


Fig. Jointed-arm configuration

→ The joined arm robot most resembles as human arm and consists of a series of links connected by rotary joints which when referenced from base are referred to as the shoulder, arm and wrist joints.

→ There are actually three different types of jointed arm robots.

a. Pure spherical

b. Parallelogram spherical.

c. Cylindrical

→ A sub-class of the jointed cylindrical manipulator is the selective compliance. Assembly Robot Arm (SCARA) type of robot (See figure); its shoulder and elbow rotational axes are vertical.

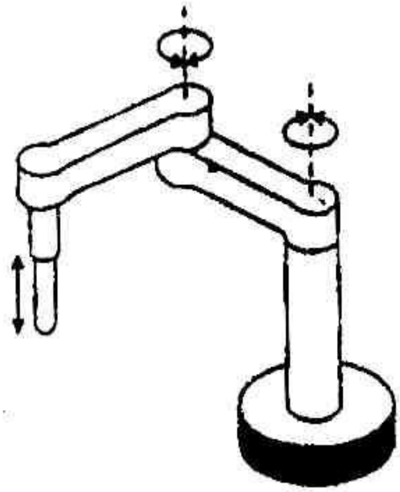


Fig. SCARA body-and-arm assembly configuration.

→ Typical, these devices are relatively inexpensive and are used in applications that require rapid and smooth motions.

Q. Explain Robot anatomy.(repeat S-2015.0216)

Ans. Anatomy of a Robot:

The anatomy of an industrial robot deals with the assembling of other components of robot such as wrist, arm and body.

Many similarities exist between a robotic system and a human manipulator system. Both systems have advantages and disadvantages. In order to understand the robotic system, it is helpful to compare it to the human system, as illustrated in figure below.

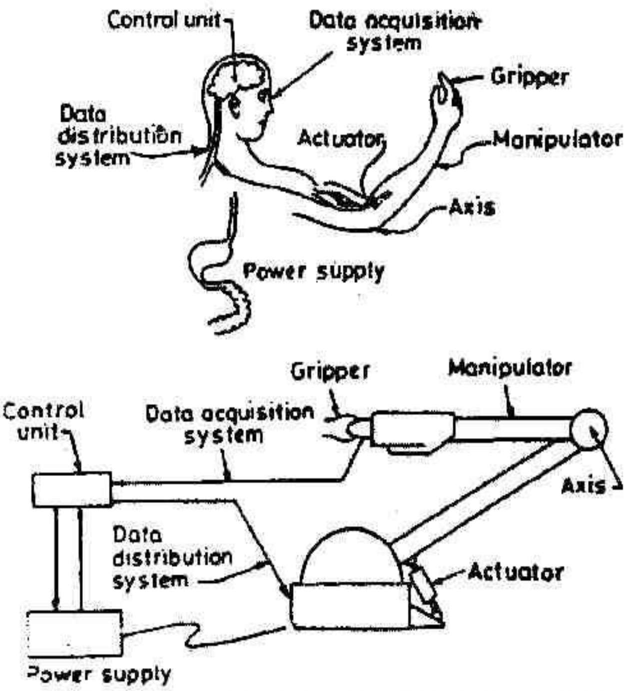


Fig. Human and Robotic Manipulator systems

i. **Manipulator:** Robot arms must move tools through various motions so that they may perform the operations that are required of them. Because the tools may be heavy, some sort of rigid structure must provide support while the tools are being manipulated. This support is supplied by the manipulator, which is the mechanical skeleton that serves as a rigid structural framework to support the arm.

ii. **Axes (Joints of Degrees of Freedom).** While the manipulator provides the support needed, there must be flexible joints in the system to follow for movement in different directions. The axes are flexible joints in the system to allow for movement in different directions. The axes are flexible pivots in the mechanical skeleton that allow the bending of the structure at that point. Like the joints in the body, the manner in which the joint can be flexed is determined by the type of axis it is. Most axes resemble the human elbow and can only flex in an angular manner. Low tech robots generally have three axes, medium-tech have three to five, and high tech have five to ten.

iii. **Actuators.** Just as the human body requires muscles, the robot arm requires actuators to move the manipulator. The actuators are devices that exert force to drive the manipulator into a predetermined position or series of positions and hold the joints rigidly once the position is reached. There are two types of actuators angular and linear. Angular actuators rotate their loads, linear actuators extend and retract their loads. The classification of actuators is related to the type of power they use. Electrical actuators use electrical power, hydraulic actuators use hydraulic power and pneumatic actuators use pneumatic power.

iv. **Grippers ad other end effectors.** The gripper is similar to the human hand. Just the hand graps the tools to perform the work, the gripper secures the robot's work piece while the operation is being performed. The shape of the gripper is determined by the task it has to perform. Two-pronged or general grippers are used to pick up cylindrical and cubic objects, three-pronged grippers are used on spherical objects and specialized grippers can be designed for unique tasks. Some grippers are equipped with a sense of touch so that they can determine when an object has been grasped. In addition to grippers, other end effectors may be used on robots. These include tools designed to weld, paint, or perform machining operations such as milling and grinding.

v. **Control Unit.** The control unit is much like the human brain which coordinates the muscles of the body. It keeps track of time, the position of the joints, and the movements of the manipulator. It does this in accordance with a list of instructions. The instructions are stored in a part of the control unit called the memory. The control unit can be either mechanical (cam logic), pneumatic (pneumatic logic), or electrical (micro-computer).

Unlike the human brain, the control unit is incapable of the creative thinking required for adaptive behavior. All movements must be stored in its list of instructions; it cannot cope with environmental conditions that are not provided for in the programme. Consequently, while a robot manipulator can be programme to draw a picture, it does not have the capacity to create an original drawing.

vi. **Power supplies.** Just as the human digestive system converts food into usable energy the robot power supply provides the actuators and the control unit with the energy that they need to function. The energy must be in a form that the robot system can use. For example, if the actuators are hydraulic and the work place only has electrical energy into hydraulic energy. This is usually done by driving a hydraulic pump with an electrical motor.

vii. **Data Distribution System:** In the human body , the motor neurons receive messages from the brain and pass those messages on to the muscles. In the same way, the data distribution system receives messages from the control unit and passes them on to the actuators. This process takes place through the output port or interface. These interfaces are needed because the control unit usually runs on very low currents and voltages. The actuators require currents and voltages that would no destroy the control unit.

Viii. **Data Acquisition Systems.** Sensory neurons in the human body receive messages from the environment and pass those messages to the brain. Human sensory neurons respond to touch stimuli, such as contact with objects or changes in temperature. After receiving these messages, the brain can make judgments about the environment. In a similar fashion, the robotic data acquisition system receives messages from the environment and passes those messages to the control unit. For instance, if a human being has walked into reach of the robot manipulator, then the robot must be able to sense his presence and cease functioning so as not to hurt the individual.

Q. Discuss various types of end effectors.(S-2015)

Ans: The end effector is the special propose tooling which enables the robot to perform a particular job. Various types of end-efforts are designed for the same robot to make it more flexible and versatile.

End effectors are categorized into two major types:

(i) Grippers and

(ii) Tools

Grippers:

Grippers are used to hole either work parts (in pick and place operations, machine loading, or assembly work) or tools.

These are further classified as :

i. Mechanical grippers – Here friction or the physical configuration of the gripper retains the object.

ii. Suction or vacuum cups – Used for flat objects.

iii. Magnetized gripper – These devices are used for ferrous objects.

iv. Hooks – Used to lift parts off conveyors

v. Scoops or ladles – Used for fluid, powders, pellets etc.

vi. Adhesive or electrostatic grippers.

Figure shows sample gripper designs.

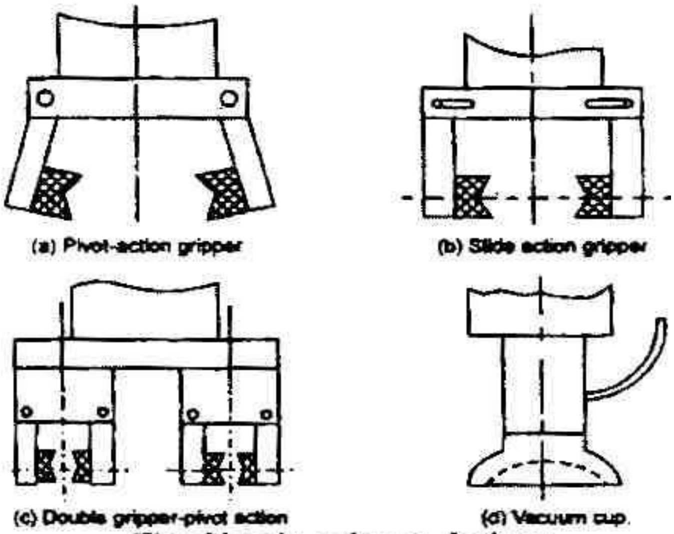


Fig. Simple gripper designs

The grippers may also be classified as follows:

i. Part handling grippers:

These grippers are used to grasp and hold objects that are required to be transported from one point to another or placed for some assembly operations.

The part handling applications include :

a. Machine loading and unloading
b. Picking parts from a conveyor and moving parts etc.

ii. Tool handling grippers:

These grippers are used to hold tools like welding gun or spray painting gun to perform a specific task.

The robot hand may hold a de burring tool.

iii. Specialized grippers

These grippers may be specialized devices like Remote Centre Compliance (RCC) to insert an external mating component into an internal member, viz. inserting a plug into hole.

CHAPTER:5

Q. What is flexible manufacturing system?(S-2015,S-2016)

Ans: **Flexible Manufacturing system (FMS)**: Flexible manufacturing system (FMS) may be defined as a set of machines in which parts are automatically transported under computer control from one machine to another for processing.

Flexibility refers to the ability to respond effectively to hanging circumstances. A flexible system is one which is able to respond to change.

AFMS should be capable of coping with both external changes (i.e. changes in the type, mix, processing requirements and quality of job allocated to the system, changes in the training and skill of operators assigned to the system), as well internal changes or disturbances (i.e., machine and material handling system breakdowns, variability in processing time, operator absences, quality problems etc.).

Q. Explain different component of FMS.(S-2015,S-2016)

Ans: Components of FMS:-

The various components of flexible manufacturing system (FMS) are :

i. Machine tools

ii. Control system

iii. Handling system

iv. Planning system

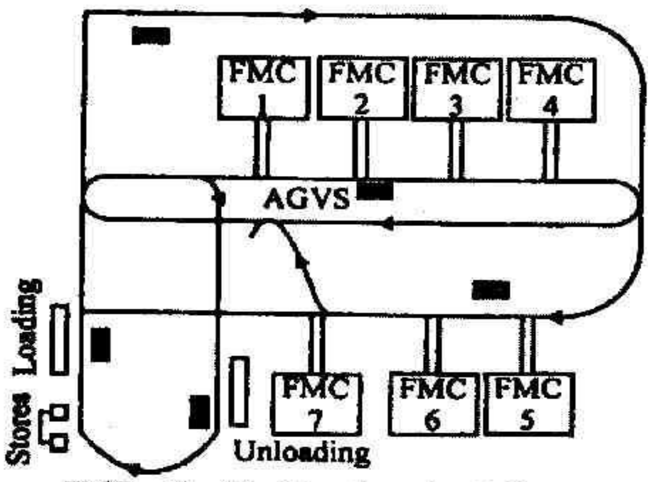
v. CAD/CAM

All these components have to be properly co-ordinate to make a functional system.

→ A FMS uses the various kinds of CNC machines, machining tools depending on the requirements.

→ The control system guides the operations on the various machines to produce the required parts. It also regulates the flow of work-pieces and monitors their location within the system through the material handling system.

→ The handling system could either be a separate unit (like industrial robot) or a part changer which is an integral part of the machine itself. In the latter case, cost is low as same control system and programming procedures are used for both machine and part handling. It utilizes less complicated pattern of movements. The industrial robot is best used for serving several machines in a so called production cell.



FMC – Flexible Manufacturing Cell
AGVS – Automated Guided Vehicles
Fig : Flexible Manufacturing System (FMS)

→ In principle, it is possible to build a fully automated factory where all tasks such as processing material handling tool changing inspection etc. are accomplished without any assistance from operators. This however, has not yet been achieved and the human operators still play critical roles.

→ FMSs are versatile because they can produce a variety of parts and are adaptable since the system can be quickly modified to produce a completely different set of parts.

→ A FMS consists of several CNC machines which are served by computer controlled material handling devices and tool changing capabilities. It can be easily reconfigured to produce a variety of parts because of the computer control and tool changing capability.

CHAPTER: 6

Q. Part programme for lathe machine.2016

Ans: The part program is a sequence of instructions, which describe the work which has to be done on a part, in the form required by a computer under the control of a numerical control computer programme. It is a task of preparing a programme sheet from a drawing sheet. All data is fed into the numerical control system using a standardized format. Programming is where all the machining data are translated into a language which can be understood by the control system of the lathe machine. The machining data is as follows :

i. Machining sequence classification of process, tool start up point, cutting depth, tool path etc.
ii. Cutting conditions, spindle speed, feed rate, coolant etc.
iii. Selection of cutting tools etc.

While preparing apart program in a lathe machine the following steps are needed to perform.

→ Determine the start up procedure, which includes the extraction of dimensional data from part drawings and data regarding surface quality requirements on the machined components.

→ Select the tool and determine the tool offset.

→ Set up the zero position of the work-piece.

→ Select the speed and rotation of the spindle

→ Set up the tool motions according the profile required.

→ Return the cutting tool to the reference point after completion of work.

→ End the program by stopping the spindle and coolant.

The part programming for lathe machine contains the list of co-ordinate values along the X, Y and Z directions of the entire tool path to finish the component. The program should also contain information such as feed and speed. Each of the necessary instructions for a particular operation given in the part program is known as a NC word. A group of such NC words constitutes a complete NC instruction, known as block. The commonly used blocks are N, G, F, S, T and M. Generally the methods used for lathe machine part programming depending upon the techniques are-

a) Manual part programming

b) Computer aided part programming.

The figure shown below the interactive graphic system used in computer aided part programming used in CNC lathe machine