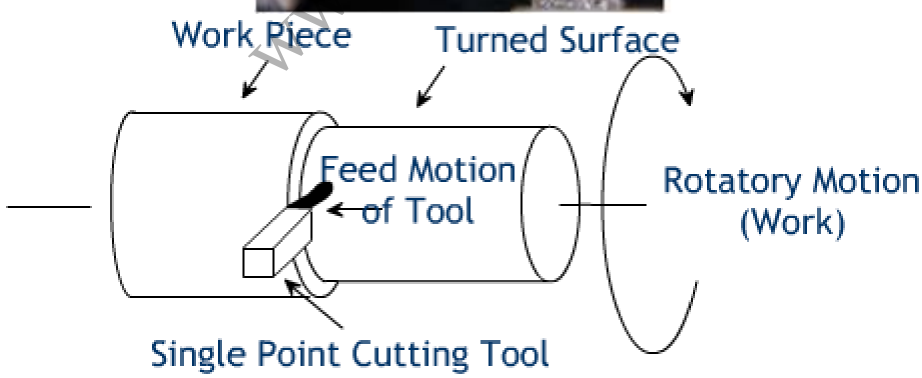
Module -3

Machine Tools and Automation

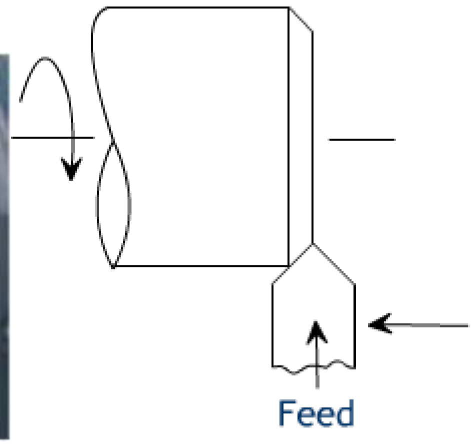
Machine Tools Operations:

Turning:

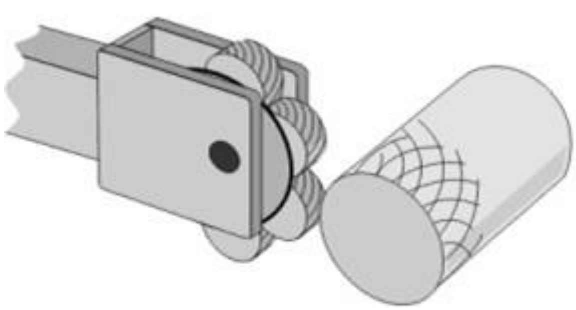
Turning is the removal of metal from the outer diameter of a rotating cylindrical work piece. Turning is used to reduce the diameter of the work piece, usually to a specified dimension, and to produce a smooth finish on the metal. Often the work piece will be turned so that adjacent sections have different diameters.

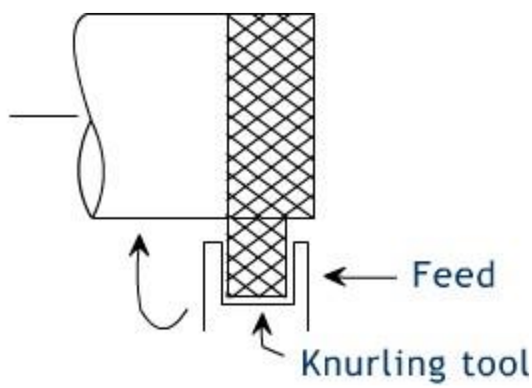


Facing: Facing is the process of removing metal from the end of a work piece to produce a flat surface. It is some time called squaring. The facing tool used is of round edge, if the tool is pointed then the work piece will not have good finishing. The work piece rotates about its axis and the facing tool is fed perpendicular to the axis of lathe. Most often, the work piece is cylindrical, but using a 4-jaw chuck you can face rectangular or odd-shaped work to form cubes and other non-cylindrical shapes.

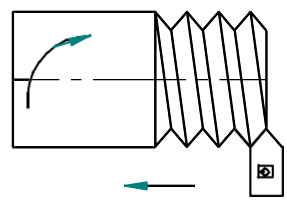


Knurling: It is the process of embossing a required shaped pattern on the surface of the work piece. This diagram shows the knurling tool pressed against a piece of circular work piece. The lathe is set so that the chuck revolves at a low speed. The knurling tool is then pressed against the rotating work piece and pressure is slowly increased until the tool produces a pattern on the work piece.

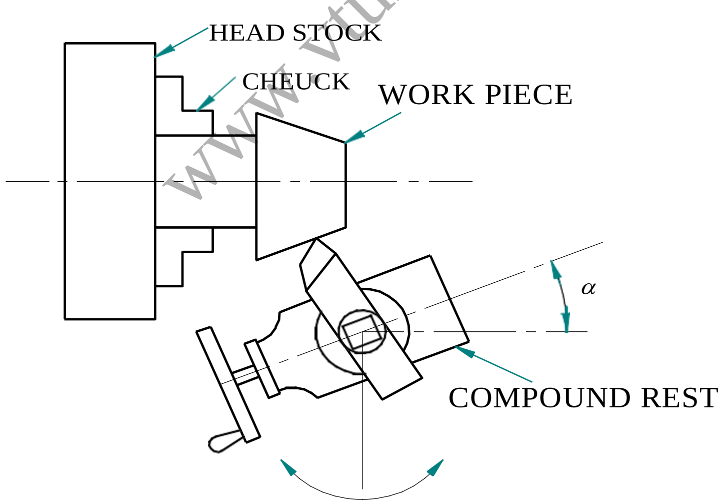




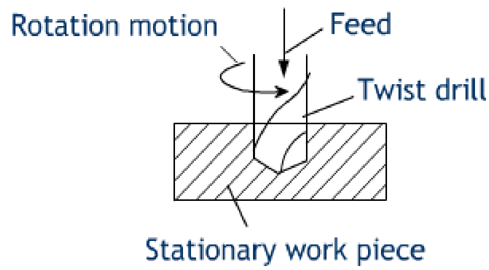
Thread cutting: A thread is a uniform helical groove cut on or in a cylinder or cone. The tool is ground to the shape of the thread and is moved longitudinally with uniform motion. The required pitch can be obtained by maintaining the appropriate gear ratio between the spindle and the lead screw which enables the tool to move longitudinally at appropriate speed.



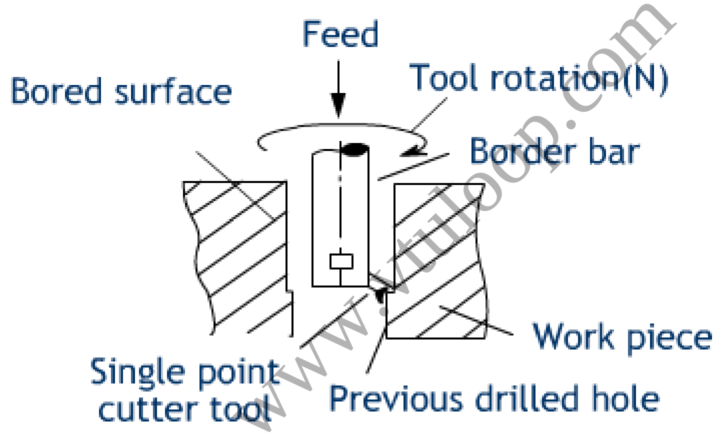
Taper Turning by swivelling the compound rest: In this method of taper the half taper angle is calculated. The compound rest has rotating base graduated in degrees, which can be rotated to any angle (according to the taper angle). In this method the tool is advanced by rotating the compound rest and hand wheel so that the tool moves according to set taper angle. This method produces taper length larger than form tool method.



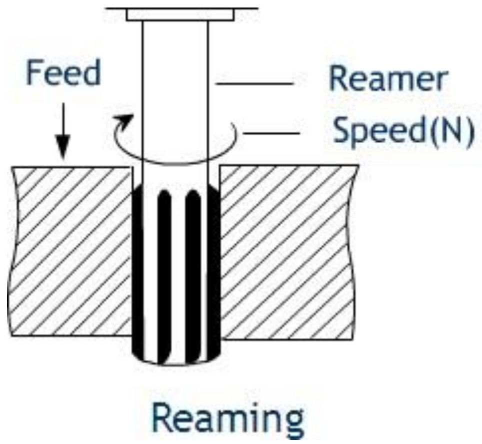
Drilling: The drilling is one of the simplest methods of producing a hole. Before drilling a hole, the center point of the hole has to be marked on the work piece. The center point of the hole is marked by just drawing two cross lines or by using instruments. The mark is indented using a center punch. The hole to be drilled may be a through hole or a blind hole. Through hole can be drilled on any machine, but to drill a blind hole we need a sophisticated machine.



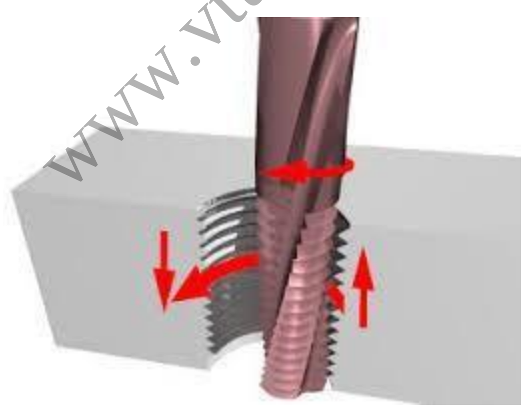
Boring: It is an operation employed to enlarge a hole by means of an adjustable cutting tool with only one cutting edge. This is necessary where suitable sized drill is not available or where the hole diameter is so large that it cannot be ordinarily drilled. It is used to finish a hole accurately and to bring it to the required size. In precision machines the accuracy is as high as 0.00125mm; the process is slower compared to reaming and requires several passes of tool.



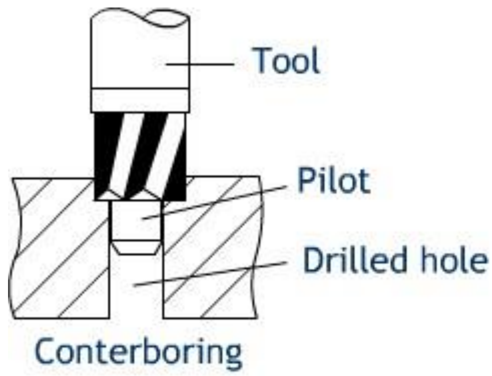
Reaming: Reaming is a sizing and finishing operation performed on a previously drilled hole. The tool used for reaming operation is known as reamer, which has multiple cutting edges. The spindle speed is half compared to drilling operation. Reamers cannot produce hole, but follow the path already defined by the drilling. The metal removed in this process is small, range is about 0.35 mm.



Tapping: Is an operation of cutting internal threads by means of a cutting tool called a ***tap***. A slightly smaller diameter hole is drilled before tapping and a tap is fitted in the tapping attachment which in turn is mounted in the drilling machine spindle.

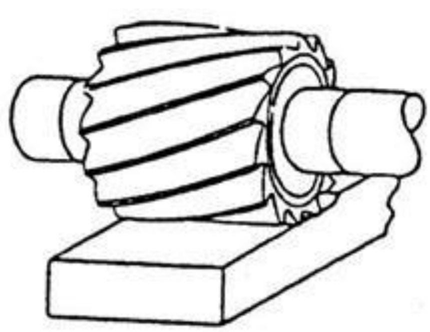


Counter Boring: Is an operation of enlarging the end of a hole cylindrically. The enlarged hole forms a square shoulder with the original hole. The tool is guided by a pilot which extends beyond the end of the cutting edges. The pilot fits into the small diameter hole having running clearance and maintains the alignment of the tool. Counter boring is done to accommodate the heads of bolts, studs, pins etc. Counter boring can give accuracy of about 0.050mm.

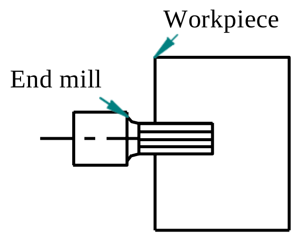


Counter Sinking: Is an operation of making a cone-shaped enlargement of the end of a hole to provide a recess for a flat head screw or countersunk rivet fitted into the hole. The tool used for countersinking is called a countersink. Standard countersinks have 60^0, 82^0 or 90^0 included angle and the cutting edges of the tool are formed at the conical surface.

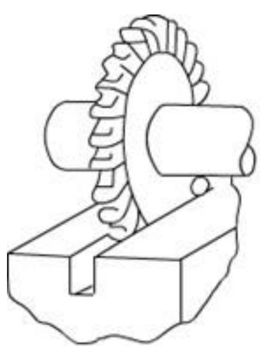
Plane milling: The plain milling is the operation of production of a plain flat horizontal surface parallel to the axis of rotation of a plain milling cutter. The operation is also called slab milling.

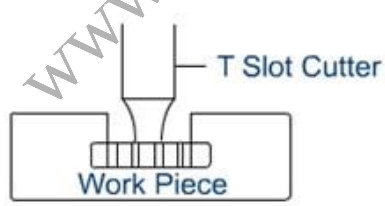


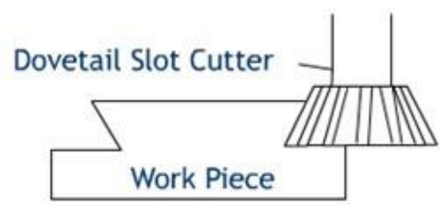
End milling: The end milling is the operation of production of a flat surface which may be vertical, horizontal or at an angle in reference to the table surface. Use to produce slots, grooves or key ways.



Slot milling: The process of producing keyways grooves and slots of varying shapes and sizes is known as slotting. The side milling cutter is mounted on to the arbor of a horizontal milling machine when slotting had to be done on Horizontal milling machine. T–Slots and dovetail slots are carried out on a veridical milling machine.







Robotics and Automation:

Introduction

An industrial robot is a general purpose, programmable machine possessing certain anthropomorphic characteristics. The most obvious anthropomorphic characteristic of an industrial robot is its mechanical arm, which is used to perform various industrial tasks. Other human like characteristics are the robot's capabilities to respond to sensory inputs, communicate with other machines, and make decisions. These capabilities permit robots to perform a variety of useful tasks.

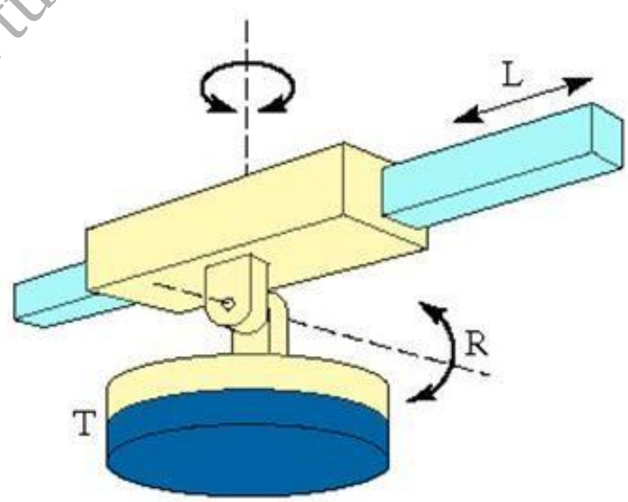
Some of the qualities that make industrial robots commercially and technologically important are listed

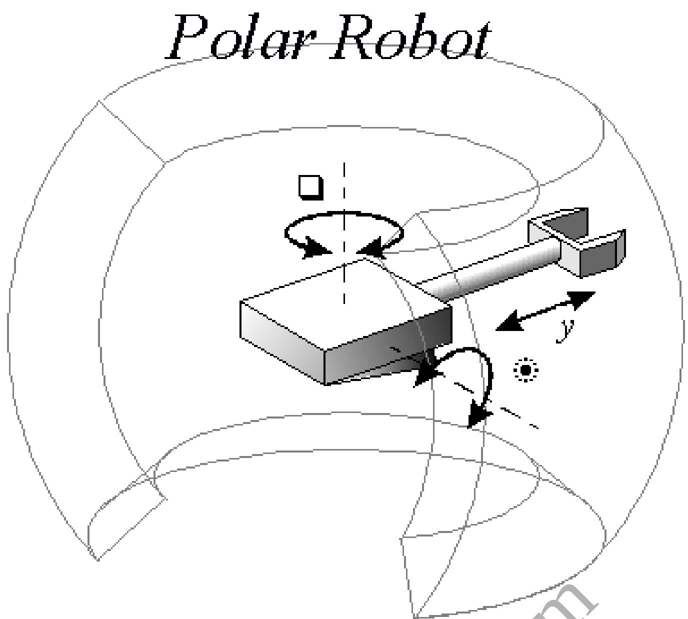
- Hazardous work environments
- Repetitive work cycle
- Consistency and accuracy
- Difficult handling task for humans
- Multi shift operations
- Reprogrammable, flexible
- Interfaced to other computer systems

Classification based on robots configuration

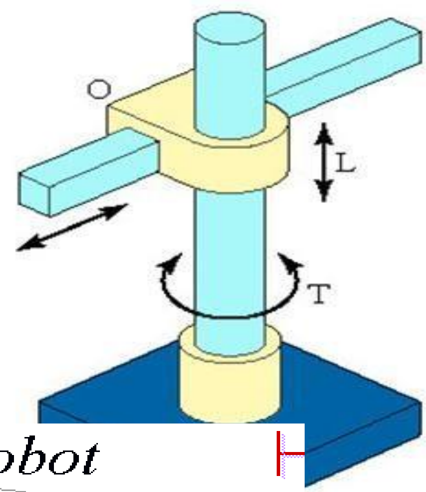
- Polar Coordinate
- cylindrical Coordinate
- Cartesian Coordinate

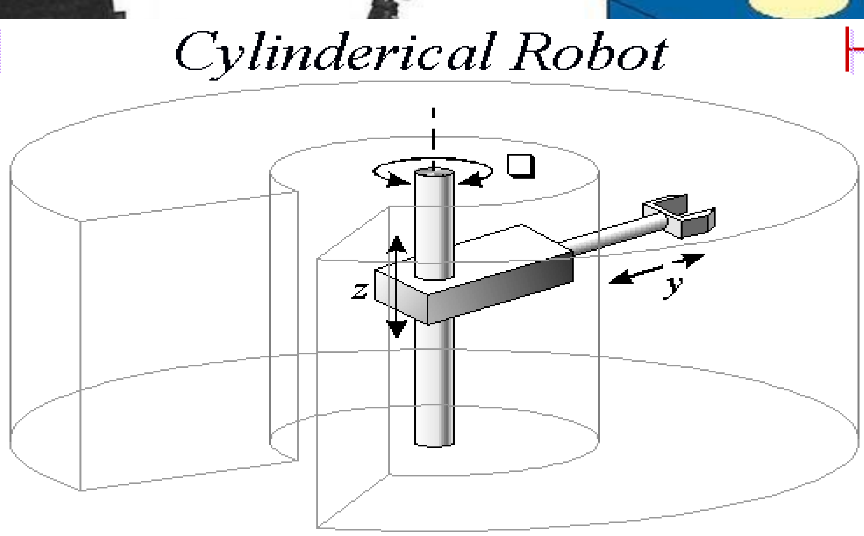
Polar Coordinate: This configuration Consists of a sliding arm (L joint) actuated relative to the body, which can rotate about both a vertical axis (T joint) and horizontal axis (R joint)

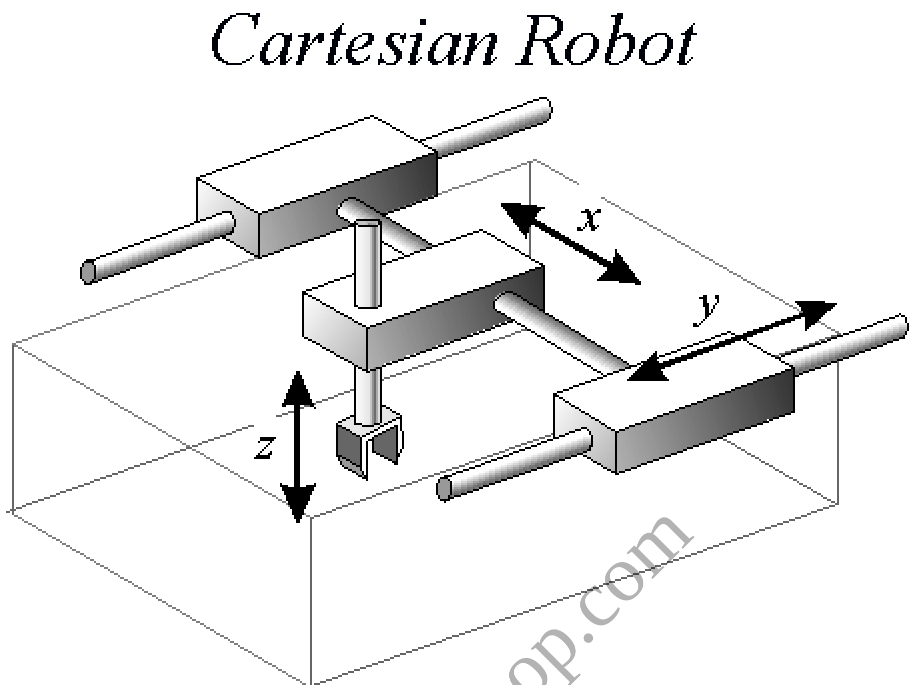




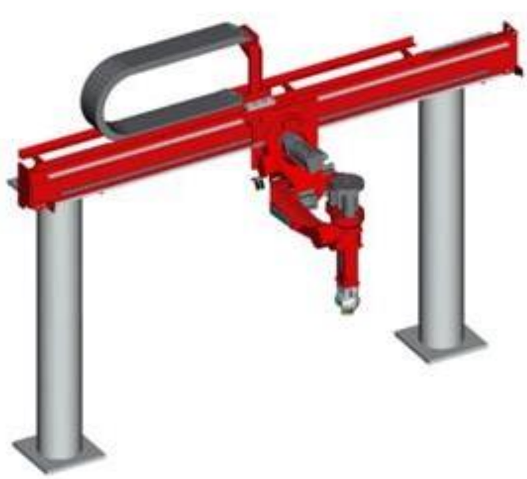
Cylindrical Coordinate: This configuration Consists of a vertical column, relative to which an arm assembly is moved up or down. The arm can be moved in or out relative to the axis of the column

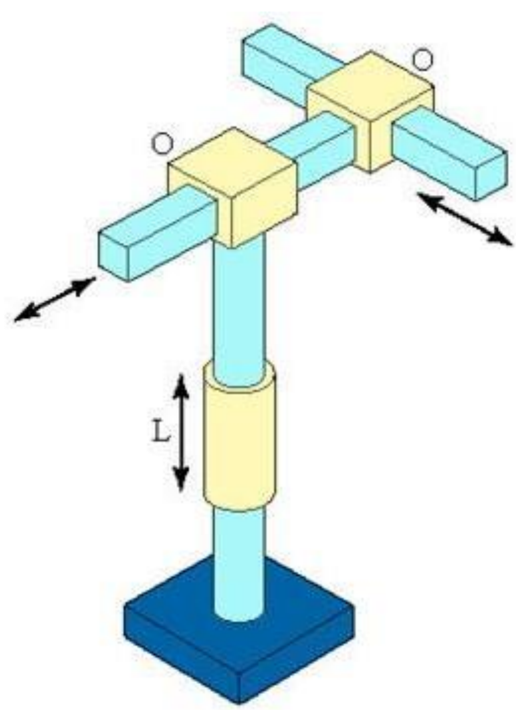






Cartesian coordinate: Other names for this configuration include rectilinear robot and x-y-z robot. It is composed of three sliding joints, two of which are orthogonal.





Automation:

Automated manufacturing is a manufacturing method that relies on the use of computerized control systems to run equipment in a facility where products are produced. Human operators are not needed on the assembly line or manufacturing floor because the system is able to handle both the mechanical work and the scheduling of manufacturing tasks. The development of fully automated manufacturing systems dates to the later half of the 20th century, and this manufacturing technique is used in facilities of varying scale all over the world.

Automation of production systems can be classified into three basic types:

1. Fixed automation (Hard Automation)

2. Programmable automation (Soft Automation)

3. Flexible automation.

1. Fixed automation (Hard automation): Fixed automation refers to the use of special purpose equipment to automate a fixed sequence of processing or assembly operations. Each of the operation in the sequence is usually simple, involving perhaps a plain linear or rotational motion or an uncomplicated combination of two. It is relatively difficult to accomodate changes in the product design. This is called hard automation.

Advantages:

1. Low unit cost

2. Automated material handling

3. High production rate.

Disadvantages:

1. High initial Investment

2. Relatively inflexible in accommodating product changes.

2. Programmable automation: In programmable automation, the production equipment is designed with the capability to change the sequence of operations to accomodate different product configurations. The operation sequence is controlled by a program, which is a set of instructions coded. So that they can be read and interpreted by the system. New programs can be prepared and entered into the equipment to produce new products.

Advantages:

1. Flexible to deal with design variations.

2. Suitable for batch production.

Disadvantages:

1. High investment in general purpose equipment

2. Lower production rate than fixed automation.

Example: Numerical controlled machine tools, industrial robots and programmable logic controller.

3. **Fixed Automation:** (Soft automation): Flexible automation is an extension of programmable automation. A flexible automation system is capable of producing a variety of parts with virtually no time lost for changeovers from one part style to the next. There is no lost production time while reprogramming the system and altering the physical set up.

Advantages:

1. Continuous production of variable mixtures of product.

2. Flexible to deal with product design variation.

Disadvantages:

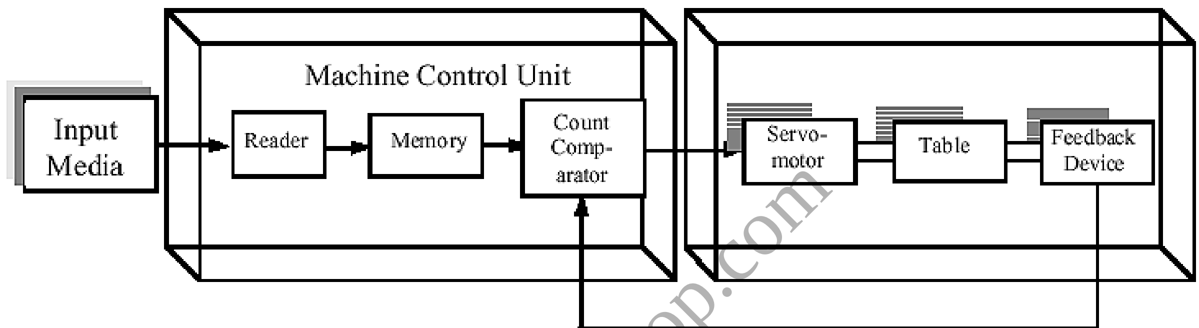
1. Medium production rate

2. High investment.

3. High ‘unit cost relative to fixed automation.

Numerical control (NC):

Numerical Control refers to the method of controlling the manufacturing operation by means of directly inserted coded numerical instructions into the machine tool. It is important to realize that NC is not a machining method; rather, it is a concept of machine control. Although the most popular applications of NC are in machining, NC can be applied to many other operations, including welding, sheet metalworking, riveting, etc.



The major advantages of NC over conventional methods of machine control are as follows:

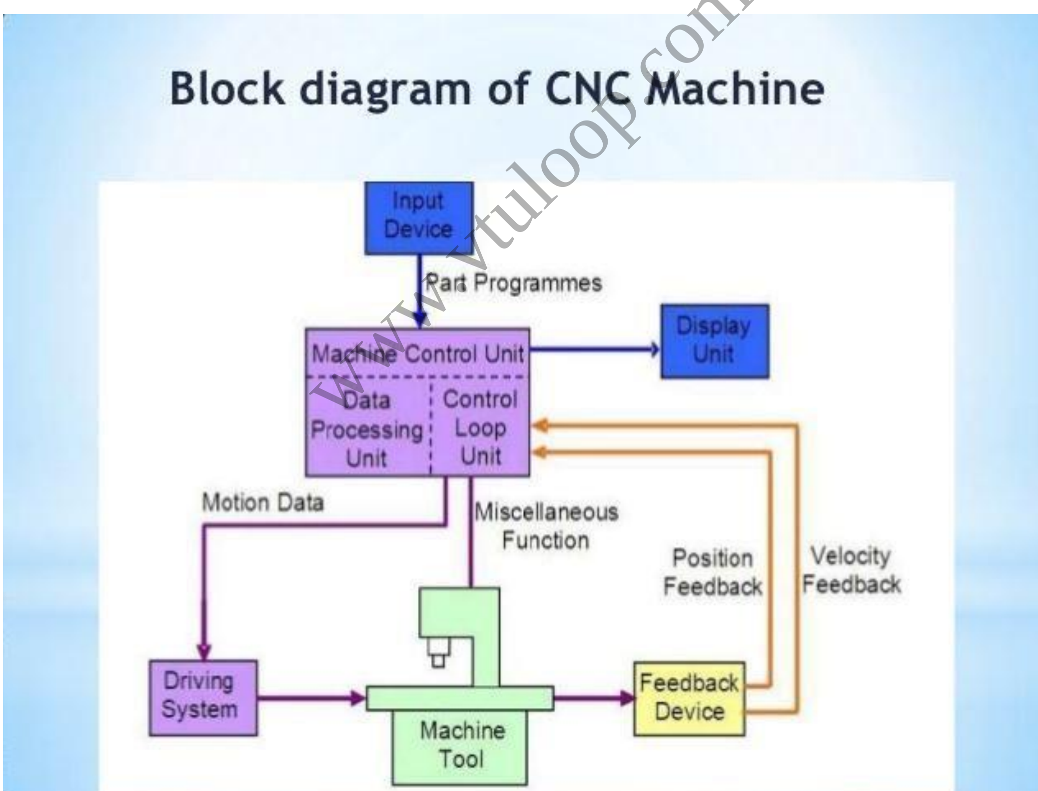
- Higher precision: NC machine tool are capable of machining at very close tolerances, in some operations as small as 0.005 mm;
- Low operator qualification: the role of the operation of a NC machine is simply to upload the work piece and to download the finished part. In some cases, industrial robots are employed for material handling, thus eliminating the human operator.
- Multi-operational machining: some NC machine tools, for example machine centers, are capable of accomplishing a very high number of machining operations thus reducing significantly the number of machine tools in the workshops. Very low operator qualification: the role of the operation of a NC
- Higher productivity: NC machine tools reduce drastically the non machining time. Adjusting the machine tool for a different product is as easy as changing the computer program and tool turret with the new set of cutting tools required for the particular part.
- Better quality: NC systems are capable of maintaining constant working conditions for all parts in a batch thus ensuring less spread of quality characteristics;

The major disadvantages of NC

- Relatively high initial cost of equipment
- Need for part programming
- Special maintenance is required
- More costly breakdown

Computer Numerical Control (CNC):

CNC is a self-contained NC system for a single machine tool that uses a dedicated computer controlled by stored instruction in the memory to implement some or all of the basic NC functions. It is flexible and relatively low-cost.



The major advantages of CNC

- Increased productivity
- High accuracy and repeatability
- Reduced production costs
- Reduced indirect operation costs

- Facilitation of complex machining operations
- Greater flexibility
- Improved production planning and control
- Lower operator skill requirement
- Facilitation of flexible automation

The major disadvantages of CNC

- High initial investment
- High maintenance
- For low production it is costlier process

ROBOTICS

Robots are devices that are programmed to move parts, or to do work with a tool. Robotics is a multidisciplinary engineering field dedicated to the development of autonomous devices, including manipulators and mobile vehicles.

The Origins of Robots

Year 1250

Bishop Albertus Magnus holds banquet at which guests were served by metal attendants. Upon seeing this, Saint Thomas Aquinas smashed the attendants to bits and called the bishop a sorcerer.

Year 1640

Descartes builds a female automaton which he calls “Ma fille Francine.” She accompanied Descartes on a voyage and was thrown overboard by the captain, who thought she was the work of Satan.

Year 1738

Jacques de Vaucanson builds a mechanical duck quack, bathe, drink water, eat grain, digest it and void it. Whereabouts of the duck are unknown today.

Year 1805

Doll, made by Maillardet, that wrote in either French or English and could draw landscapes

Year 1923

Karel Capek coins the term *robot* in his play *Rossum's Universal Robots (R.U.R). Robot* comes from the Czech word *robota* , which means "servitude, forced labor."

Year 1940

Sparko, the Westinghouse dog, was developed which used both mechanical and electrical components.

Year 1950's to 1960's

Computer technology advances and control machinery is developed. Questions Arise: Is the computer an immobile robot? Industrial Robots created. Robotic Industries Association states that an "industrial robot is a re-programmable, multifunctional manipulator designed to move materials, parts, tools, or specialized devices through variable programmed motions to perform a variety of tasks"

Year 1956

Researchers aim to combine "perceptual and problem-solving capabilities," using computers, cameras, and touch sensors. The idea is to study the types of intelligent actions these robots are capable of. A new discipline is born: A.I.

Year 1960

Shakey is made at Stanford Research Institute International. It contained a television camera, range finder, on-board logic, bump sensors, camera control unit, and an antenna for a radio link. Shakey was controlled by a computer in a different room.

The first industrial robot: UNIMATE Year 1954

The first programmable robot is designed by George Devol, who coins the term Universal Automation. He later shortens this to Unimation, which becomes the name of the first robot company (1962).

Year 1978

The Puma (Programmable Universal Machine for Assembly) robot is developed by Unimation with a General Motors design support

Year 1980s

The robot industry enters a phase of rapid growth. Many institutions introduce programs and courses in robotics. Robotics courses are spread across mechanical engineering, electrical engineering, and computer science departments.

Year 1995-present

Emerging applications in small robotics and mobile robots drive a second growth of start-up companies and research

2003

NASA's Mars Exploration Rovers will launch toward Mars in search of answers about the history of water on Mars

Robot Physical Configuration

Industrial robots come in a variety of shapes and sizes. They are capable of various arm manipulations and they possess different motion systems.

Classification based on Physical configurations

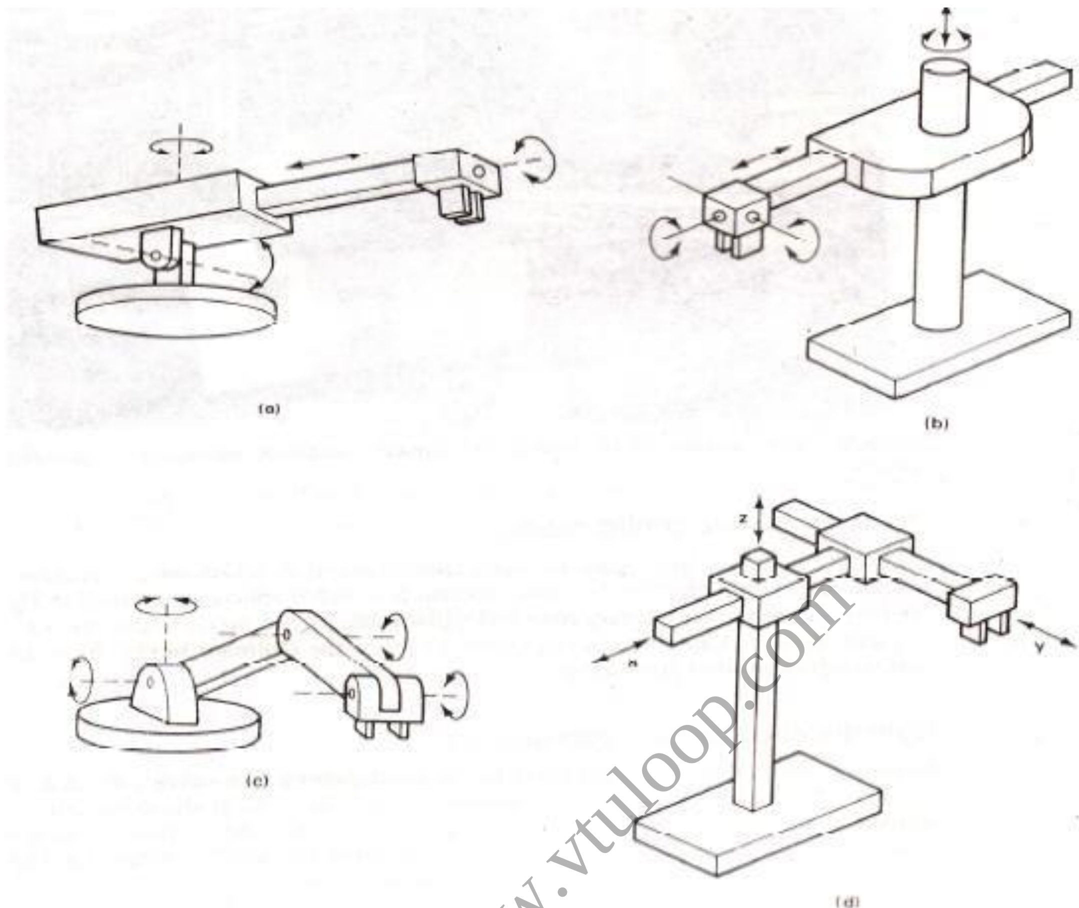
Four basic configurations are identified with most of the commercially available industrial robots

1. Cartesian configuration: A robot which is constructed around this configuration consists of three orthogonal slides, as shown in fig. the three slides are parallel to the x, y, and z axes of the Cartesian coordinate system. By appropriate movements of these slides, the robot is capable of moving its arm at any point within its three dimensional rectangularly spaced work space.

2. Cylindrical configuration: in this configuration, the robot body is a vertical column that swivels about a vertical axis. The arm consists of several orthogonal slides which allow the arm to be moved up or down and in and out with respect to the body. This is illustrated schematically in figure.

3. Polar configuration: this configuration also goes by the name “spherical coordinate” because the workspace within which it can move its arm is a partial sphere as shown in figure. The robot has a rotary base and a pivot that can be used to raise and lower a telescoping arm.

4. Jointed-arm configuration: is combination of cylindrical and articulated configurations. This is similar in appearance to the human arm, as shown in fig. the arm consists of several straight members connected by joints which are analogous to the human shoulder, elbow, and wrist. The robot arm is mounted to a base which can be rotated to provide the robot with the capacity to work within a quasi-spherical space.



Basic Robot Motions

Whatever the configuration, the purpose of the robot is to perform a useful task. To accomplish the task, an end effector, or hand, is attached to the end of the robots arm. It is the end effector which adapts the general purpose robot to a particular task. To do the task, the robot arm must be capable of moving the end effectors through a sequence of motions and positions.

There are six basic motions or degrees of freedom, which provide the robot with the capability to move the end effectors through the required sequences of motions. These six degree of freedom are intended to emulate the versatility of movement possessed by the human arm. Not all robots are equipped with the ability to move in all sex degrees. The six basic motions consist of three arm and body motions and three wrist motions.

Arm and body motions

1. Vertical traverse: Up and down motion of the arm, caused by pivoting the entire arm about a horizontal axis or moving the arm along a vertical slide.

2. Radial traverse: extension and retraction of the arm (in and out movement)

3. Rotational traverse: rotation about the vertical axis (right or left swivel of the robot arm)

Wrist Motion

• Wrist swivel: Rotation of the wrist

• Wrist bend: Up or down movement of the wrist, this also involves rotation movement.

• Wrist yaw: Right or left swivel of the wrist.