Lathe, Milling Machine, Computer Numerical Control (CNC) and Robots

Lathe - Principle of working of a center lathe. Parts of a lathe. Operations on lathe - Turning, Facing, Knurling, Thread Cutting, Drilling, Taper turning by Tailstock offset method and Compound slide swiveling method, Specification of Lathe.
Milling Machine - Principle of milling, types of milling machines. Working of horizontal and vertical milling machines. Milling processes - plane milling, end milling, slot milling, angular milling, form milling, straddle milling, and gang milling. ***(Layout sketches of the above machines need not be dealt. Sketches need to be used only for explaining the operations performed on the machines)***
Introduction to Advanced Manufacturing Systems
Computer Numerical Control (CNC): Introduction, components of CNC, open loop and closed loop systems, advantages of CNC, CNC Machining centers and Turning centers.
Robots: Robot anatomy, joints and links, common robot configurations. Applications of Robots in material handling, processing and assembly and inspection.

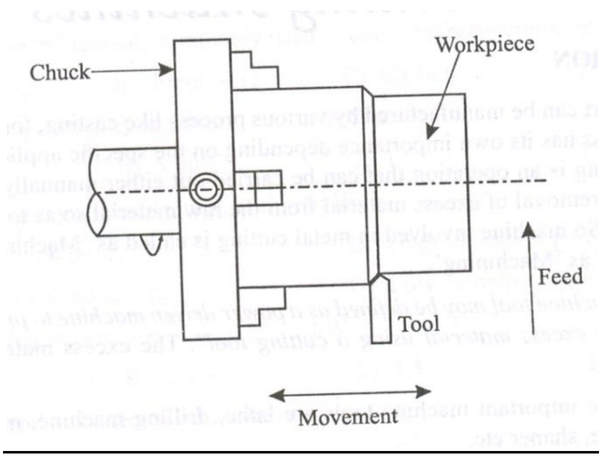
INTRODUCTION –

A product or part can be manufactured by various processes like casting, forging, machining etc. Machining is an operation that can be carried out manually or by machine, which involves *removal of excess material from the raw material* so as to get the required shape and size. So any machine involved in metal cutting is known as a 'Machine tools' and the process is called 'Machining'.

"A machine tool may be defined as a power driven machine to produce a product by removing the excess material using a cutting tool". The excess material removed is called as chips. Some of the important machine tools are lathe, drilling machine, milling machine, grinding machine, shaper etc.

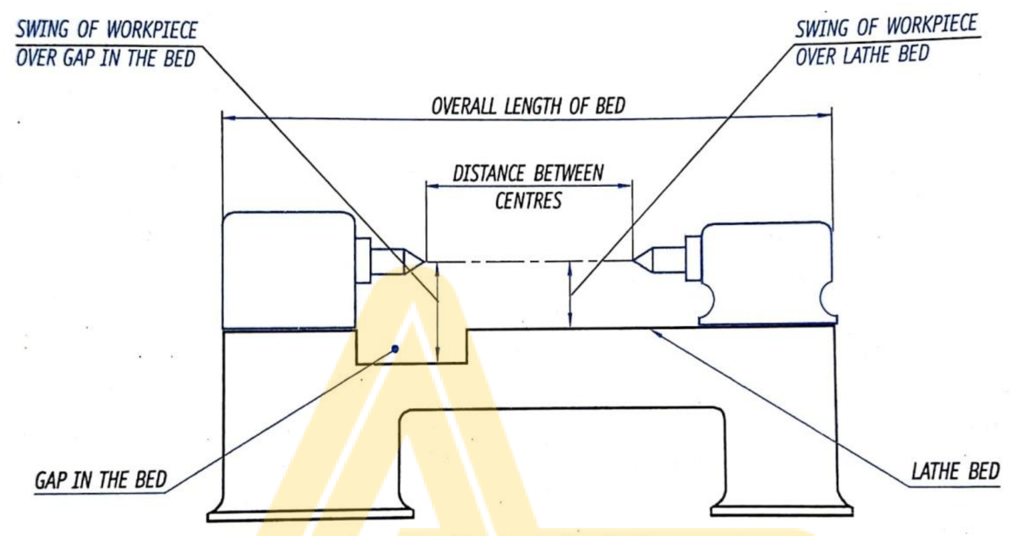
Lathe :-A Lathe is a machine tool employed generally to produce circular object. It is said to the mother of all machine tools, generally used to perform on other machine tool like grinding shaping milling can be performed

Principle of working



A lathe, basically a turning machine works on the principle that a cutting tool can remove material in the form of chips from the rotating work pieces to produce circular objects. This is accomplished in a lathe which holds the work pieces rigidly and rotates them at high speeds while a cutting tool is moved against it.

Lathe Specification



Specifications of a Lathe

The size of a lathe is specified by the following as shown in Fig

1. Maximum diameter of the work piece that can be revolved over the lathe bed. Instead of this sometimes, the height of the centres above the lathe bed is also specified. One of these specifications is given by the manufacturers; however both of them are loosely called as "Swing of the lathe".

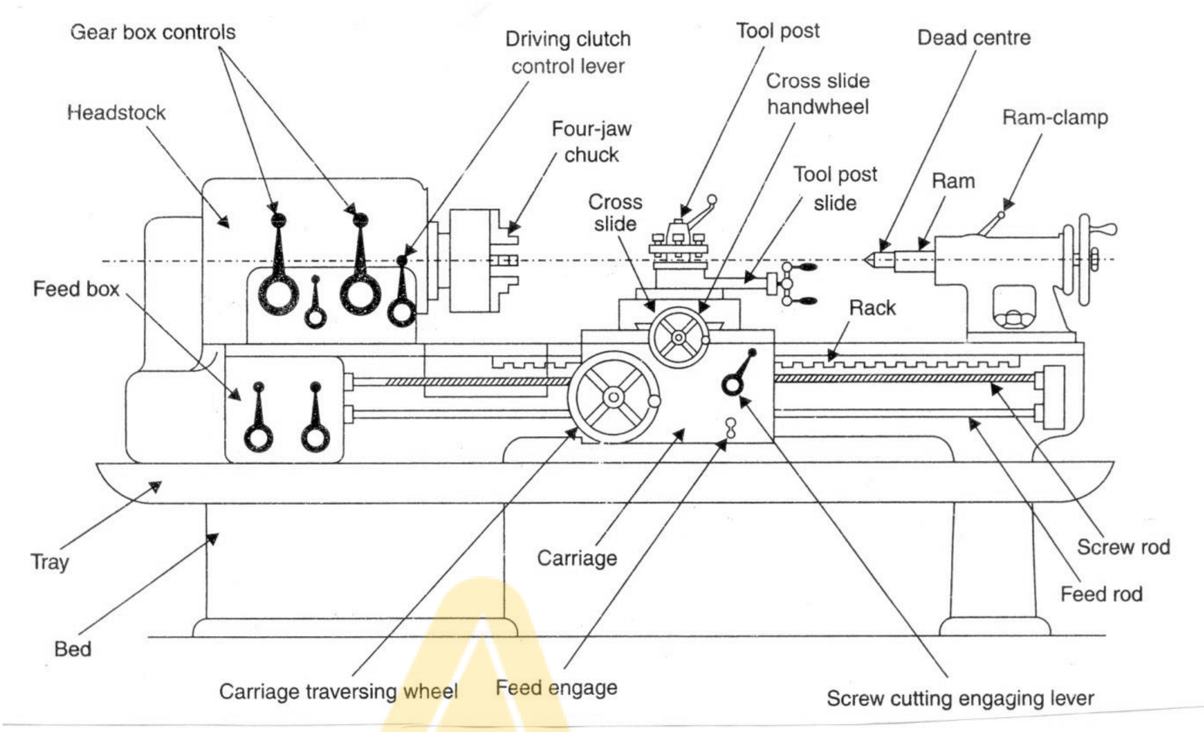
2. The Maximum diameter and the width of the workpiece that can swing when the lathe has a gap bed.

3. The maximum length of the workpiece that can be mounted between the centres.

4. Overall length of the bed. It is the total length of the lathe itself.

Major parts of a Lathe

1. Bed
2. Head stock
3. Tail stock
4. Carriage assembly
5. Feed rod
6. Lead screw



1. Bed – the bed is the foundation of the lathe and supports all other parts. The head stock and tail stock are mounted on the inner guide ways, while the carriage assembly is mounted on the outer guide ways of the bed.

2. Head stock – it is located on the left side over the bed. It comprises of the main drive for different speeds. The main spindle called the live centre projects out it holds the work piece and rotates the work piece at various speeds.

3. Tail stock – it is a movable part mounted on the right side of the lathe bed. It carries the dead center in it. The main functions are –1.*To support the free end of the work piece 2.To hold tools like drill bit, reamers, taps etc.*

4. Carriage assembly – it guides over the outer guide ways of the lathe bed. This assembly holds the cutting tool and controls the cutting process. It consists of saddle, cross slide, compound rest, tool post and apron

(a) Saddle – It is a H – shaped casting sliding over the guide ways and supports the cross slide, compound rest and the tool post.

(b) Cross slide – it is mounted on the saddle. This enables the cutting tool to move perpendicular to the lathe axis (lateral feed), so as to give the required depth to the work piece.

(c) Compound rest – it is mounted on the cross slide and supports the tool post. It has a circular base which can be swiveled to any angle in the horizontal plane. It is used in taper turning operation.

(d) Tool post – it is mounted on the compound rest and holds the cutting tool firmly during cutting process.

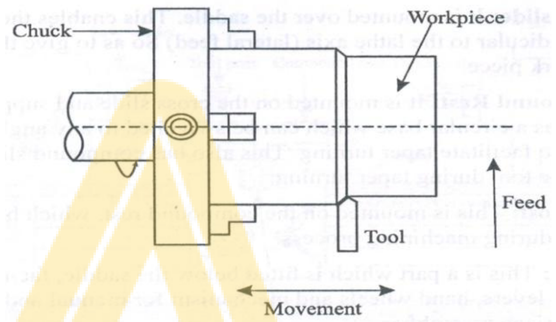
(e) Apron – this is the area below the saddle, which houses the levers, hand wheels, mechanism for moment of the carriage assembly.

5. Feed rod – it is a long rod in front of the lathe bed and gives longitudinal movement for the carriage for all its operations expect thread cutting.

6. Lead screw – it is a long screw with square threads on it mounted front of the lathe bed. It gives the automatic feed to the carriage during the thread cutting operation.

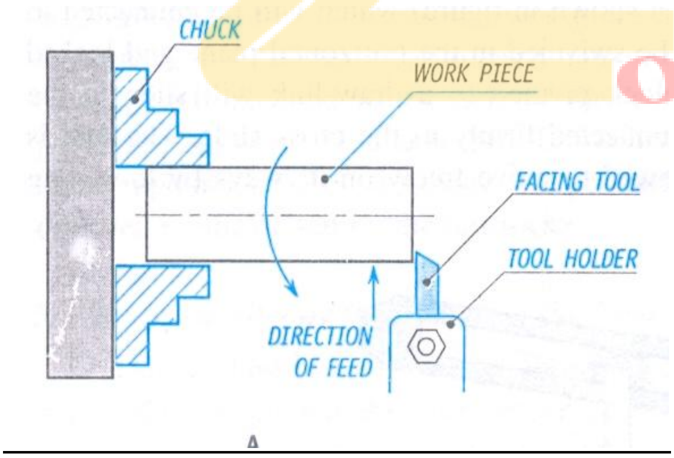
Operation on Lathe

1.Plain Turning (Turning)



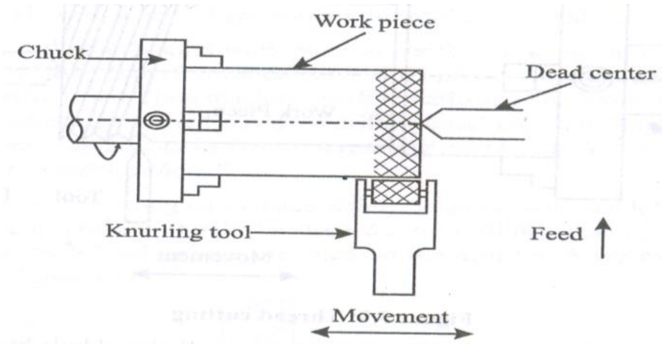
The work piece is supported between the two centers which permit the rotation of the work piece. The cutting tool is fed perpendicular to the axis of the work piece to a given depth of cut, and is then moved parallel to the axis of the work piece. "*This method of machining operation in which the work piece is reduced to a cylindrical section of required diameter is called 'turning'*".

2. Facing



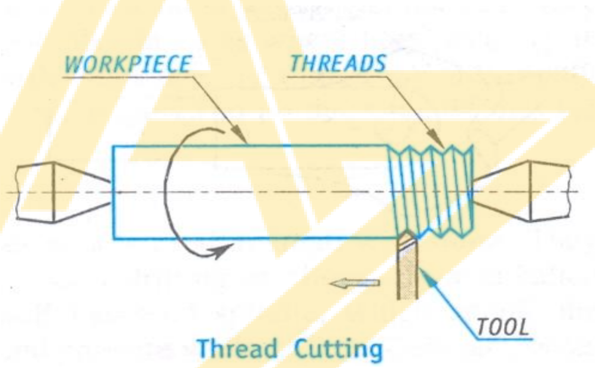
This operation on lathe is used to produce either flat surface or shoulders at the end of the work piece and used to reduce the Length of the work piece. The work piece is held rigidly in the chuck. The cutting tool is fed perpendicular to the axis of the lathe from the outer edge of the work piece towards the center.

3. Knurling



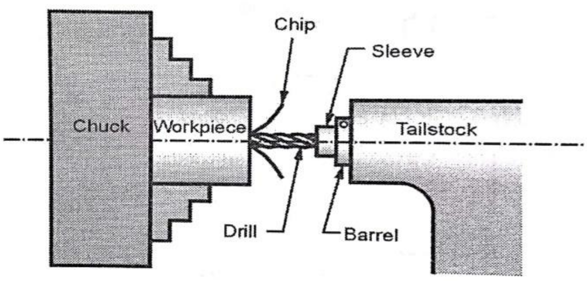
It is an operation used to emboss serrated surface on work piece using a knurling tool. It is used to produce straight, angled or diamond pattern on the work piece mainly for gripping purpose. The knurling tool is set in the tool post such that upper and lower rollers of the knurl head touches the surface of the work piece. The spindle speed is kept 60 to 80 rpm. The feed of the knurl tool is 0.38 to 0.76 mm/rev.

4. Thread cutting



A thread is a helical ridge formed on a cylindrical rod. This operation generates V-threads or square threads on the work piece. The work piece is held between centers and rotated. By maintaining an appropriate gear ratio between the spindle (work piece) and the lead screw (tool movement), screw thread of required pitch can be cut. The tool moves parallel to the lathe axis.

5. Drilling



Setup for drilling on a lathe

For drilling, the work piece is held in a suitable device such as face plate, chuck and the drill is held in the sleeve or barrel of the tailstock. Refer Fig. Dead centre is removed and drill chuck or sleeve is inserted in its place. Then, the drill is fed by rotating the hand wheel of the tailstock. First a shorter length is drilled, by using smaller and shorter drill, followed by producing the required diameter by using the correct drill size. The already drilled hole acts as a guide for the latter drill

6. Taper Turning

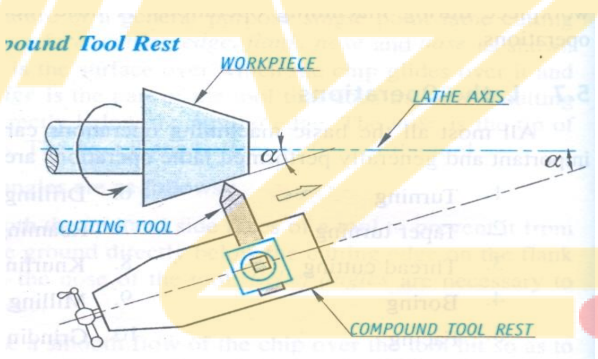
It is an operation done on the lathe to produce conical surface on the work piece. It can done by two methods –

(a) Swiveling the Compound rest

(b) Offsetting the Tailstock

(a) Swiveling the Compound rest

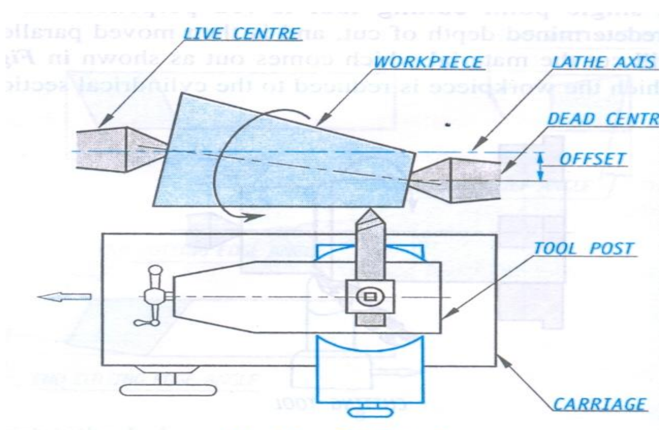
In this operation the work piece is mounted coaxial with the axis of the lathe centers. The cutting tool is mounted on the compound rest and swiveled to the required taper angle and locked. The carriage is also locked in that position. The feed is given to the compound rest which produces a taper on the work piece. This is limited for shorter taper lengths.



Swiveling Compound Tool Rest
Fig. 5.6

(b) Offsetting the Tailstock – *This is also known as "set over tailstock" method.*

In this method, the tailstock of the lathe is offset to the axis of the lathe bed. When the work piece is mounted between the centers, it will be inclined to the lathe bed. The cutting tool is moved parallel to the lathe bed to cut the taper. This method is suitable for long work pieces having less taper.



Offsetting Tail Stock

MILLING

Milling is a metal removal process in which the work piece is fed into a revolving cutting tool, thereby removing excess material. The cutting tool is known as milling cutter which is a multipoint cutting tool. Milling Machine – It is a power operated machine tool in which the work piece mounted on the table is fed against the milling cutter to get the required shape.

PRINCIPLE OF MILLING –

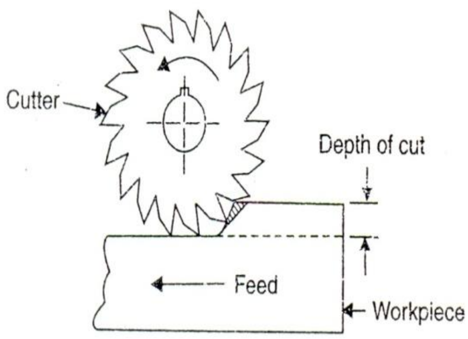
In milling, the work piece is rigidly held on table and is slowly fed into the uniformly rotating cutter to get the required shape.

The work piece can be fed in either direction of the rotating cutter.

(a) *Up milling (conventional)*

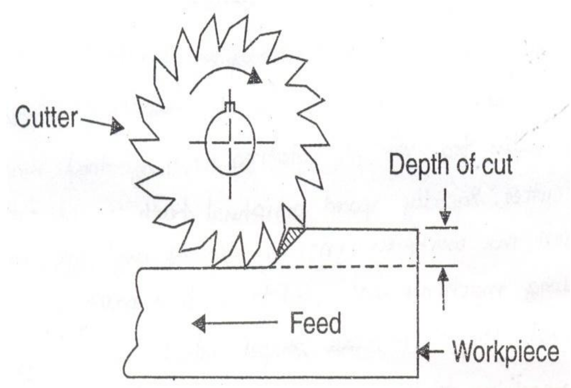
(b) *Down milling (climb)*

a).Up Milling (Conventional)



The work piece is fed opposite to the direction of the rotating cutter. Chips are progressively thicker. Since the cutting forces are directed upwards it tends to lift the work piece. Gives poor surface finish. Used for hard materials.

(b) Down Milling (Climb)



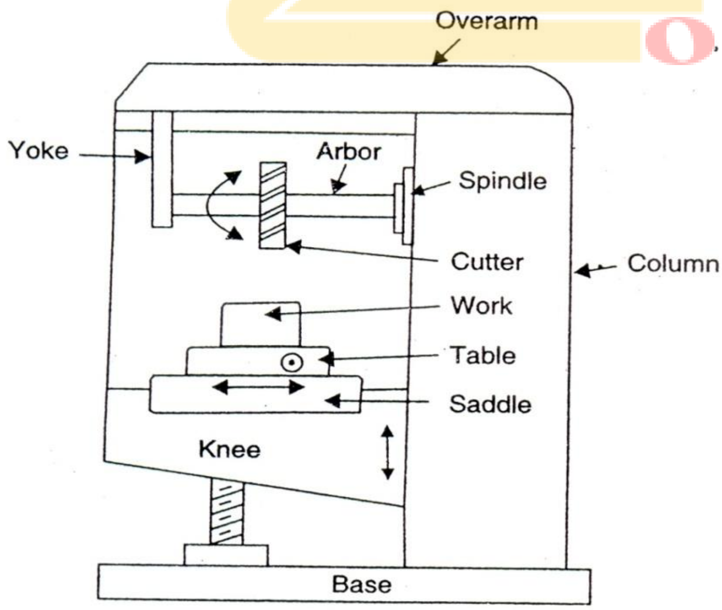
The work piece in the direction of the rotating cutter. Chips are progressively thinner. Cutting forces are directed downwards, which keep the work piece pressed to the table. Gives good surface finish. Used for soft materials and finishing operations.

Classification of Milting Machine

The milling machines are broadly classified into:

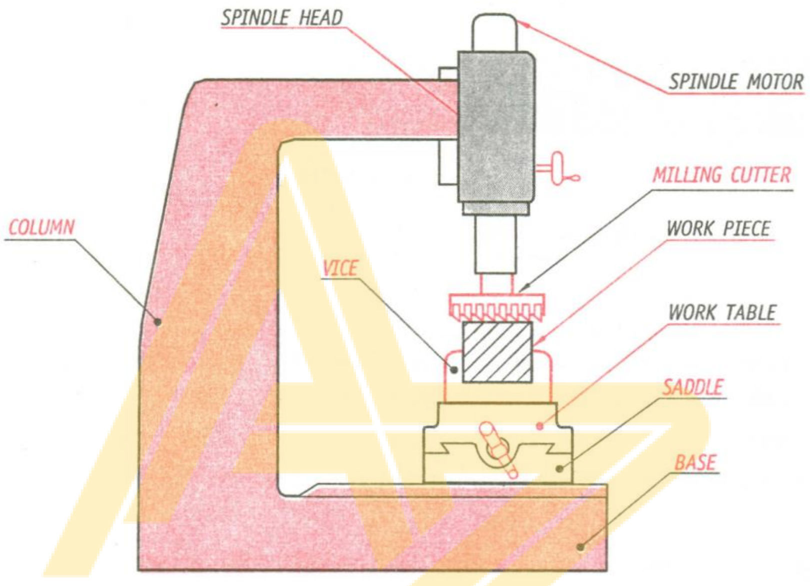
1. Plain or Horizontal Type of Milling Machine
2. Vertical Milling Machine
3. Universal Milling Machine
4. Planer Type Milling Machine
5. Profile Cutting Milling Machine

1.<u>Horizontal Milling Machine</u> (Column and knee type)



The horizontal milling machine shown in Fig. has its cutter axis horizontal. The work piece is held in a vice mounted on the machine table which is fitted over a saddle. The feed is given by moving the table against the horizontal axis of the revolving cutter. The cross feed handle enables the entire table to move across the knee. The knee can be raised or lowered by the knee elevating handle. This type of milling machine is commonly employed for milling operations which can be performed by feeding the workpiece in a straight line, either vertically or horizontally. Few examples of milling operations carried on this type of machine are: keyways, grooves, gear teeth, spline shafts, etc.

2. Vertical Milling Machine:



Vertical Milling Machine

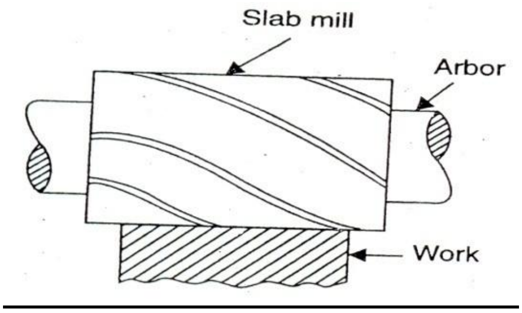
In a vertical milling machine shown in Fig, the spindle is mounted with its axis vertical perpendicular to the work table. The column and the base are formed into an integral casting. The spindle head is fitted vertically in the guideways provided in the projecting end of the column. The spindle can be moved up and down over the guideways. A saddle is mounted over the guideways provided on top of the base. The saddle can be moved in the transverse direction. The work table will be mounted over the saddle and can be moved longitudinally. In-this machine, unlike the horizontal milling machine, the workpiece can be moved only in the horizontal plane both longitudinally and in the transverse direction, but not vertically.

Milling Process

1. Plain Milling or slab Milling

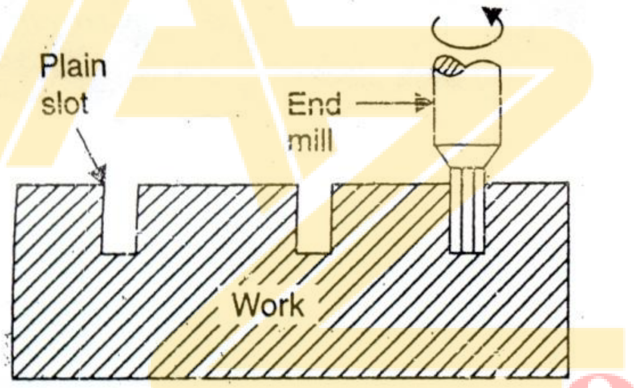
Plain Milling or slab milling is a process used to mill flat surfaces of workpieces in such a way that the milling cutter axis is parallel to the surface that is being milled. The figure below

illustrates plain milling operation carried out on a horizontal milling machine with the milling cutter mounted on the standard milling arbor.
In plain milling, the surface of the workpiece is parallel to the fable surface as shown in Fig



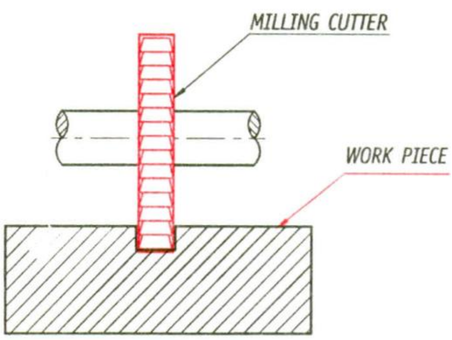
2. End Milling

End Milling is a process of milling that is used to mill slots, pockets and keyways in such a way that the axis of the milling cutter is perpendicular to the surface of the workpiece.
A typical end milling operation is as shown in Fig. End Milling operation. The advantage of the End Milling Operation is that we can achieve depth of cut of nearly half the diameter of the mill.

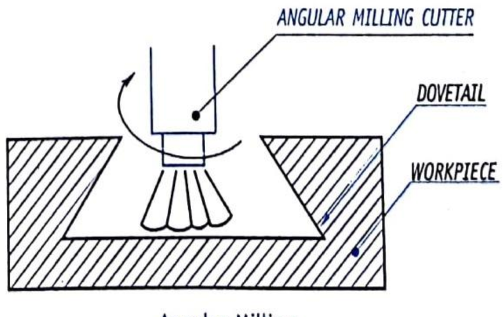


3. Slot Milling

Slot Milling Slot Milling is the process of milling slots using a different type of cutter called "Slot drill" which has the capacity to cut into solid material. Slot drill is used majorly in cases where it takes a lot of time to pre-drill a hole for an end mill and there is not enough room for the end mill to plunge using a helical motion.



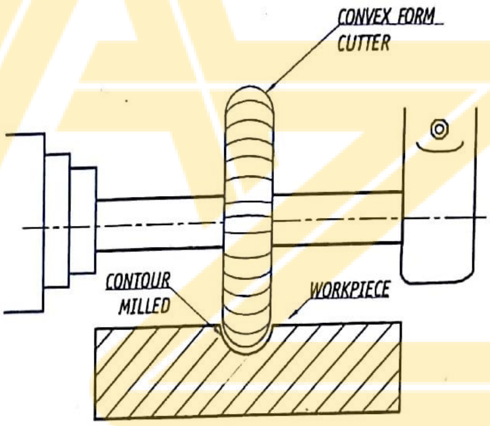
4. Angular Milling



Angular Milling

Angular Milling is the milling operation used to mill flat surfaces that are neither parallel nor perpendicular to the milling cutter axis.
Angular surfaces like dovetail grooves, chamfers and serrations are done through this operation. The most popular is milling of dovetails as shown in the Fig

5.Form Milling

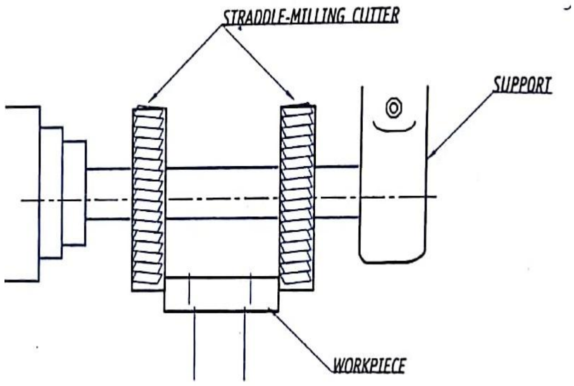


Form Milling

Form Milling is a milling process used to machine special forms / contours consisting of curves and /or straight lines by using a special "form mill cutter" which is shaped exactly to the contour that is to be form-milled.

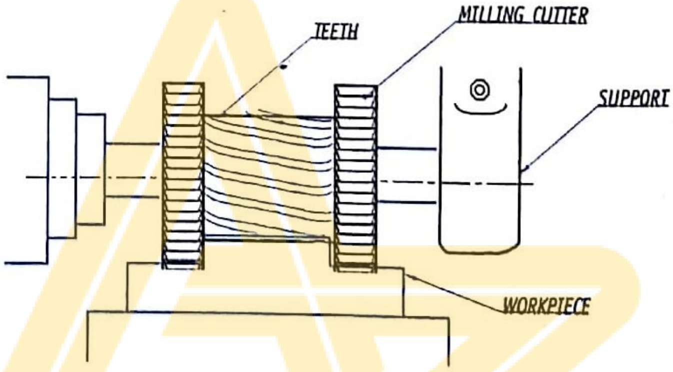
6.Straddle Milling

Straddle Milling is a milling operation that is used to machine two or more parallel vertical surfaces at a single time by mounting two side milling cutters on the same standard milling arbor separated by a calculated spacing



Straddle Milling

7.Gang Milling



Gang Milling

Gang milling is a process of milling which is similar to the Straddle Milling, but the machining is done with several types of milling cutters according to the shape of the desired work surface. But, in straddle milling (which can be called as a special type of gang milling operation) only side and face milling cutters are used.

INTRODUCTION TO ADVANCED MANUFACTURING SYSTEM

COMPUTER NUMERICAL CONTROL (CNC)

Introduction

Definition: *Computer Numerical Control or CNC is an advanced form of the NC system where the machine control unit is a dedicated microcomputer instead of a hard-wired controller, as in conventional NC.*

Computer Numerical Control has evolved during the rapid improvements of the computer technology. The advent of Microprocessors from the 1970s have helped in quick advancements in the Computer Technology and is in turn adapted in modern CNC

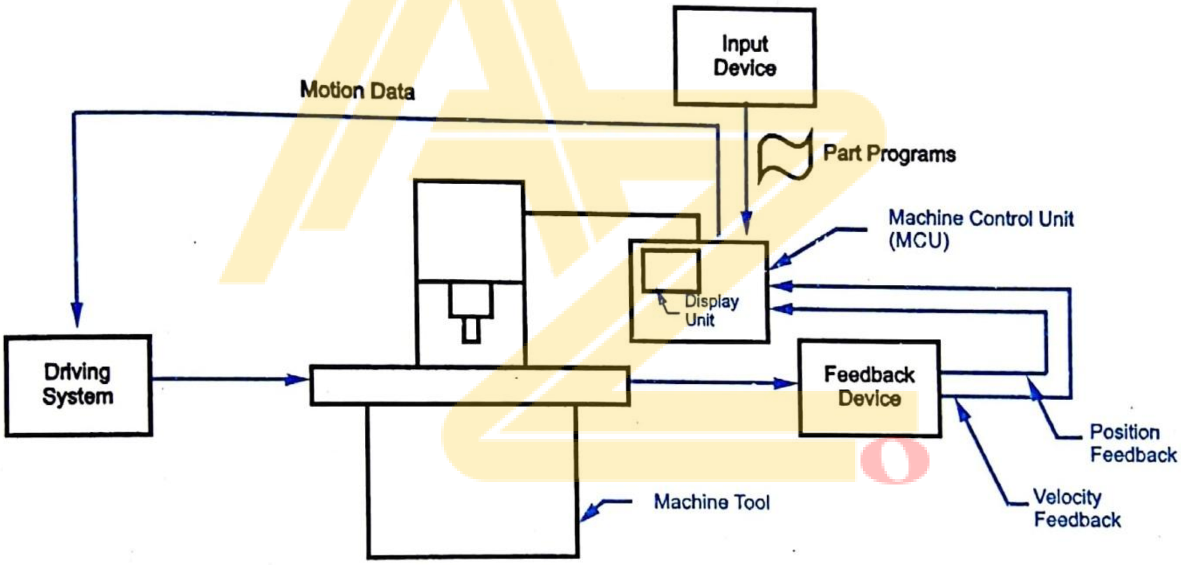
Technology. Today's CNC Controller has latest features like high speeds of operation, large memories, bus architectures, improved servos, etc.

CNC Technology has powered the Machine Tool industry today. It is used in majority of machine tools like machining centers, turning centers, grinders, lathes, drilling machines, etc.

COMPONENT OF A CNC SYSTEM

A CNC System consists of the following elements:

I. Input Device
2. MCU or Machine Control Unit
3. Machine Tool
4, Driving System
5. Feedback devices
6. Display Unit



Elements of a CNC system

1. INPUT DEVICE: The part program is entered into the CNC Control or the MCU through the input device. There is various input devices used on a CNC Machine such as

a. USB (Universal Serial Bus) Flash drive: Here the USB flash drives transfer data to the control. USB is very common nowadays and its use is increased in modern computers.
b. Serial Communication: A serial communication port connects a computer system and a CNC Machine tool through an interface called RS-232. Most machines have RS-232 port and an RS-232 cable connects the computer and the CNC Machine to transfer data from the computer to the CNC Machine.

c. Ethernet Communication: The Ethernet communication is a more reliable and efficient means of transferring part programs from Computer to the CNC Control.

d. Conversational Programming: This is another way to input part programs to the controller through a keyboard. Built-in intelligent software inside the controller enables the operator to enter step by step data.

2. MCU OR MACHINE CONTROL UNIT: The Machine Control Unit or the MCU is the heart of the CNC System. It consists of the following components:

a. Central Processing Unit: The CPU is the brain of the MCU and it comprises of

i. **a control section** that retrieves data from the memory and generates signals which in turn activates all MCU components.

ii. **An ALU (Arithmetic Logic Unit)** that performs integer arithmetic operations like addition, subtraction, multiplication, counting, etc and logical operations

iii. **Immediate Access** Store or Immediate Access Memory: This holds the data and programs temporarily that is required at that instant by the control section.

b. CNC Memory: The memory of the CNC is divided into

i. Main Memory which consists of Read Only Memory (ROM) and Random Access Memory (RAM). The ROM stores the Operating System Software and machine interface programs. The RAM stores the Part programs.

ii. Secondary Memory such as Hard disks which is used to store large programs and which can be used by the main memory when required.

c. Input/output Interface: The Input/output interface or the I/O interface establishes communication between the machine operator, the components of the CNC system and other connected computers. The Operator control panel is the interface through which the machine operator communicates with the CNC system. A keyboard and a display screen are also included in the panel.

d. Machine tool controls: A Machine Tool consists of various axes such as X, Y, Z, A, B, C and a spindle which rotates at the designed RPM. The position and velocity control of each of the axis and the rotational speed control are accomplished by certain hardware components in the MCU. The MCU generates control signals that are transformed into a form suitable for the specific position control systems that is required to drive the various axes of the machine.

e. Sequence controls for auxiliary functions: Apart from the general functions like spindle speed, feed rate, etc, certain auxiliary functions like cool emergency stop, tool changing function, etc are carried out under par control program controls.

3. MACHINE TOOL: This can be any type of machine tool such as a Machining center, a turning center, a lathe, milling machine, etc. The essential parts of the machine tool include the machine table, machine slide, the driving lead screw, ball screw, rigid and heavy machine Structure, and automatic tool changing system, spindle and spindle drive system, chip removal System etc. The machine table is controlled in the X and Y axes, while the spindle runs along the Z axis. In other machine tools, there are additional axes such as A, B or C that allows rotary motions around the X, Y and Z axes.

4 DRIVING SYSTEM: A drive system essentially is made up of amplifier circuits, drive motors, and ball lead-screws. The control signals (position and speed) of each axis are fed by the Machine Control Unit (MCU) to the amplifier circuits. Then, the control signals are augmented to actuate drive motors which in turn rotate the ball lead-screws to position the machine table. The commonly used types of electrical motors include DC Servo Motor, AC Servo Motor, Stepping Motor and Linear Motor.

5. FEEDBACK DEVICES: For the accurate operation of a CNC Machine, the positional values and speed of the axes needs to be continuously updated. This is done by the feedback devices.

6. DISPLAY UNIT: The display unit is the device that ensures interaction between the machine operator and the machine. Display unit displays the current status of operation such as the spindle RPM, the running part program, the feed rate, position of the machine slide, etc.

CLOSED LOOP CONTROL SYSTEM (FEEDBACK CONTROL SYSTEM):

In this control system, the output variable is compared to an input parameter and the difference between the output variable (which is the actual condition) and input parameter (which is the input condition) is sensed and fed back to drive the output according to input requirements.

The basic elements of a feedback control system shown in Fig. above are:

a. Input parameter: This is the set point which defines what must be the output value.

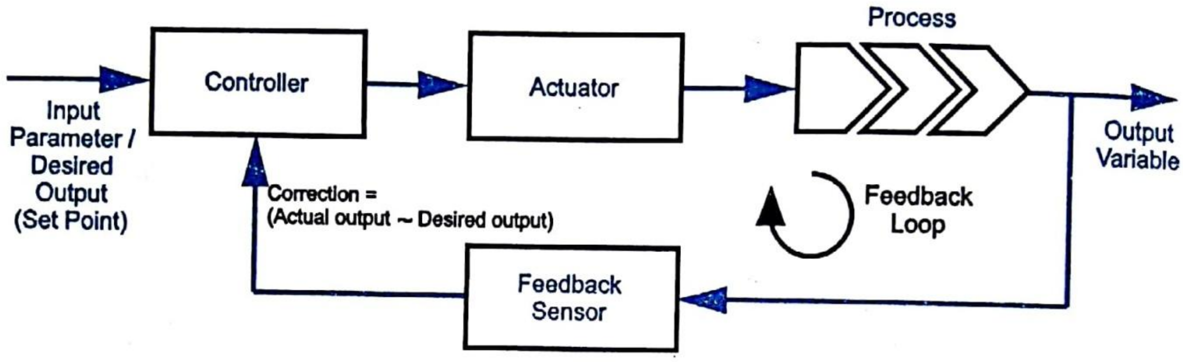
b. Process: Process is the operation that is being controlled.

c. Output variable: The output variable is the actual value of the parameter.

d. Feedback Sensors: Sensors measure the output variable and feeds it back to the control system. Thus, a feedback loop is created between input and output.

e. Controller: The function of the controller is to compare the actual output with the desired input, compute the difference and make suitable process adjustments that reduce the difference between output and input.

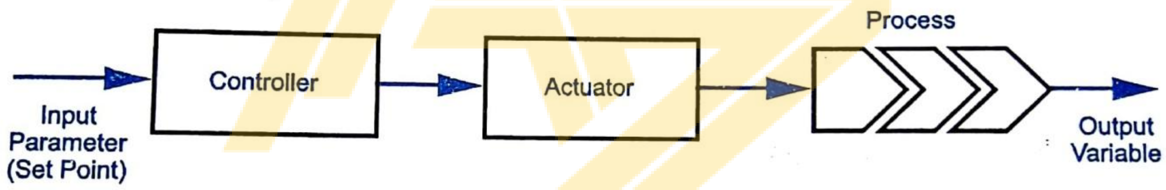
f. Actuators: The adjustments made in the process are actuated by hardware devices called Actuators that uses hardware devices like motor or valve to physically control the actions.



A feedback control system

OPEN LOOP CONTROL SYSTEM:

In this control system, there is no comparison of the output variable to the input parameter since feedback element is missing here. The Open loop control system is given below in terms of a simple block diagram



An open loop control system .

The open loop control system is chosen when the actions performed by the control system are simple, the reliability of the actuator is very high and the reaction forces counteracting the actuator are so negligible that they do not have any effect on the actuator.

CNC Machining Centers and Turning Centers

Several of our application examples of single station manufacturing cells consisted of CNC machining centers. The machining center, developed in the late 1950s before the advent of CNC, is a machine tool capable of performing multiple machining operations on a work part in one setup under NC program control. Today's machining centers are CNC. Typical cutting operations performed on a machining center use a rotating cutting tool, such as milling, drilling, reaming, and tapping.

Machining centers are classified as vertical, horizontal, or universal. The designation refers to the orientation of the machine spindle. A vertical machining center has its spindle on a vertical axis relative to the worktable, and a horizontal machining center has its spindle on a horizontal axis.

Numerical control machining centers are usually designed with features to reduce non-productive time. These features include the following:

• **Automatic tool-changer.** A variety of machining operations means that a variety of cutting tools is required. The tools are contained in a tool storage unit that is integrated with the machine tool. When a cutter needs to be changed, the tool drum rotates to the proper position, and an automatic tool changer (ATC), operating under part program control, exchanges the tool in the spindle for the tool in the tool storage unit. Capacities of the tool storage unit commonly range from 16 to 80 cutting tools.

• **Automatic work part positioned.** Many horizontal and universal machining centers have the capability to orient the work part relative to the spindle. This is accomplished by means of a rotary table on which the work part is fixture. The table can be oriented at any angle about a vertical axis to permit the cutting tool to access almost the entire surface of the part in a single setup.

• **Automatic pallet changer.** Machining centers are often equipped with two or more separate pallets that can be presented to the cutting tool using an automatic pallet changer while machining is being performed with one pallet in position at the machine; the other pallet is in a safe location away from the spindle. In this safe location, the operator can unload the finished part from the prior cycle and then fixture the raw work part for the next cycle.

. A modern NC turning center is capable of performing various turning and related operations, contour turning, and automatic tool indexing, all under computer control. In addition, the most sophisticated turning centers can accomplish

(1) Work part gaging (checking key dimensions after machining),

(2) Tool monitoring (sensing when the tools are worn),

(3) Automatic tool changing when tools become worn, and

(4) Automatic workpart changing at the completion of the work cycle.

Another development in NC machine tool technology is the mill-turn center, which has the general configuration of a turning center, but also the capability to position a cylindrical work part at a specified angle so that a rotating cutter can machine features into the outside surface of the part.

Advantages of CNC machines

1. The accuracy and repeatability obtained is high.
2. Complex shaped contours can be machined.
3. Can be easily programmed to handle variety of product styles.
4. High volume of production compared to conventional machines
5. Even lesser skilled or trained people can operate CNC Machines unlike the Conventional ones where highly skilled people are required.
6. CNC Machines can be used uninterruptedly without turning them off provided regular maintenance is done.
7. Prototypes can be produced faster and thus results in reduced lead times.
8. Avoids errors that were otherwise committed by humans operating conventional machines.
9. Since CNC machines can be programmed, one person may well take care of a number of CNC Machines. This reduces the employees and hence costs are reduced.
10. Using CNC Machines results in a safer work environment since the operator is not exposed to the machine area during machining.
11. CNC Machines can be upgraded to newer technologies by replacing the existing CNC Control with an advanced one.
12. Many CNC Machines can be linked together to a main 'computer. Programs from the main computer can be downloaded to any connected CNC Machine. This leads us to another type of NC concept called as the Direct Numerical Control (DNC).

Disadvantages of CNC machines

1. A thorough programming knowledge is required by the operators or programmers. This again requires skilled programmer and hence the cost of labour can be high.

2. Cost of a CNC Machine is high compared to the Conventional Machine Tools.

3. The spares of CNC Machines are relatively costlier than Conventional Machines.

4. CNC Machines require air conditioned environment and/or a chiller unit. Thus extra costs are involved.

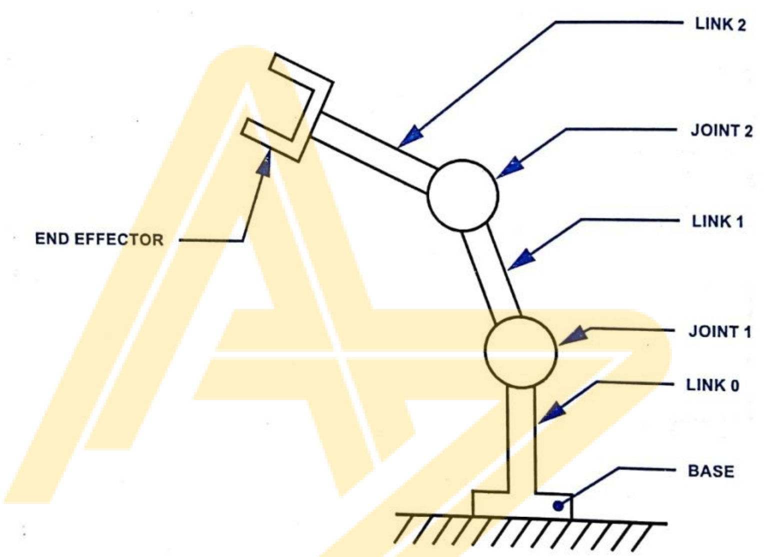
ROBOTS

Robot definition: *"A Robot is a reprogrammable, multifunctional manipulator designed to move material, parts, tools or specialized devices through variable programmed motions of performance of a variety of tasks".*

A robot that is used to perform tasks in industries is called as an "industrial robot". An industrial robot can perform wide range of industrial tasks like loading, unloading, welding, painting, inspection, assembly, material transfer, etc.

Robotics definition: Robotics can be defined "as a field of technology that deals with the conception, design, construction, operation and application of robots". Robots possess anthropomorphic characteristics (meaning human-like characteristics) such as mechanical arm (resembling human arm) to perform variety of tasks, capability to respond to sensory inputs, communication, interaction and taking decisions.

Robot anatomy



Simple Robot Construction

1. Manipulator: manipulator is an arm-like mechanism which is designed to manipulate or move materials, parts or tools without direct human contact.

2. Joint: A joint is the one that integrates two or more links to provide controlled relative movement between input link and the output link.

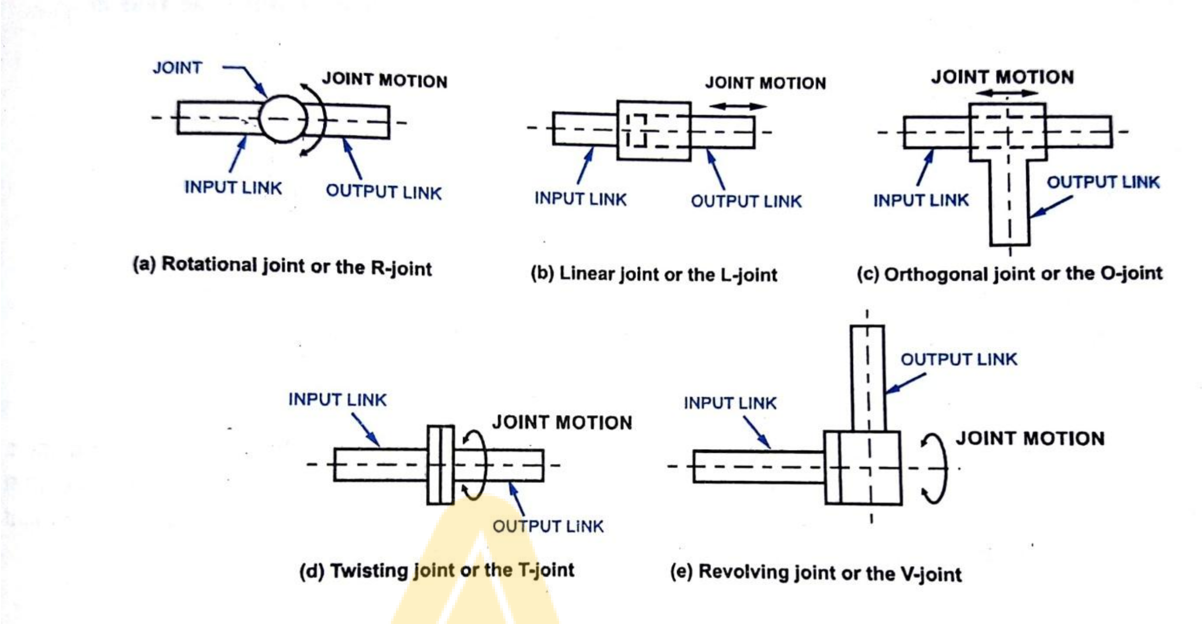
3. Link: The link is a rigid member that connects the joints. Link can be an input link and an output link. The movement of the input link causes various motions of the output link.

4. Degrees of freedom (d.o.f): The degrees of freedom describe a robot's freedom of motion in the three-dimensional space.

5. End effectors: End effectors or end-of-arm tool is the device at the end of the robotic arm which is shaped like a hand or as a special tool depending upon the application.

6. Base: The support for the robot arm is called as the base.

Joints and Links



Types of Robot joints

There are various types of joints that are used in the construction of a robot. These joints are called the robot joints. There are majorly five types of robot joints:

1. Rotational joint or the R-joint: This type of joint allows rotary relative motion where the axis of the rotation is perpendicular to the axes of the input link and the output link. This is shown in Fig (a)

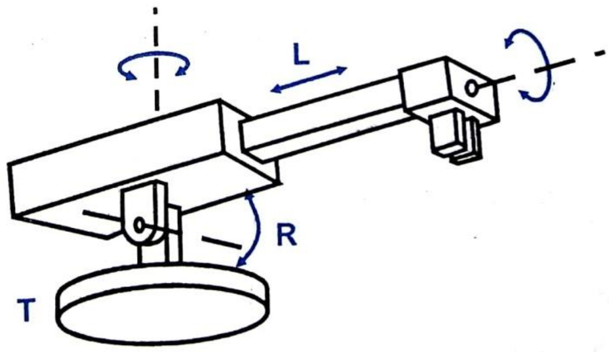
2. Linear joint or the L-Joint: This type of joint allows a translational sliding motion between the input and the output links with the axes of the links parallel as shown in the Fig (b). **3. Orthogonal joint or the 0-joint:** This type of joint allows a translational sliding motion between the input link and the output link with the axis of the output link perpendicular to the input link as shown in Fig. 5(c).

4. Twisting joint or the T-joint: This type of joint allows rotary motion where the axis of rotation is parallel to the axes of the input and output links as shown in the Fig (d).

5. Revolving joint or the 17-joint: In this type of joint, the input link axis is parallel to the rotational axis of the joint whereas the output link axis is perpendicular to the rotational axis of the joint as shown in the Fig (e).

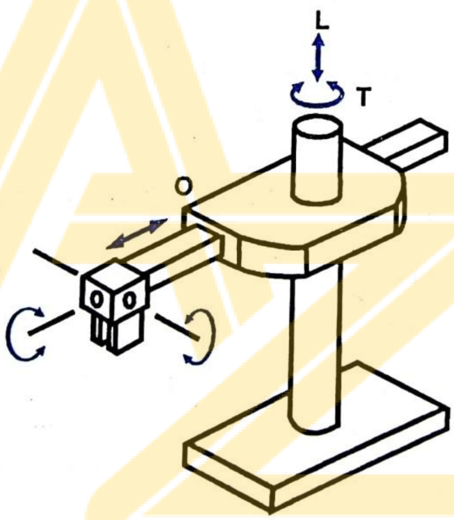
Robot Configuration

1. Polar Configuration (Spherical Configuration): The Polar configuration robots also called as the spherical configuration robots consists a sliding arm (L-joint) that is actuated relative to the body and a rotational base along with a pivot, which can rotate about a horizontal axis (R joint) and the vertical axis (T Join This is shown in the Fig



Polar Configuration Robot

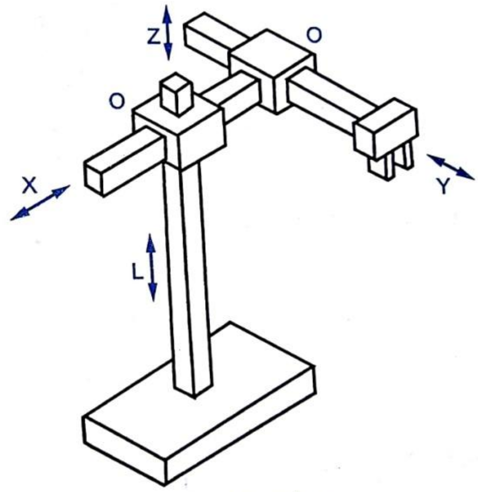
2. Cylindrical Configuration: Robots of the cylindrical configuration consists of a slide in the horizontal position and a column in the vertical position. The arm assembly moves up or down relative to the column using as L-joint. The column is rotated about its axis using the T-joint. The radial movement of the arm is achieved using the o-joint as shown in the Fig



Cylindrical Configuration Robot

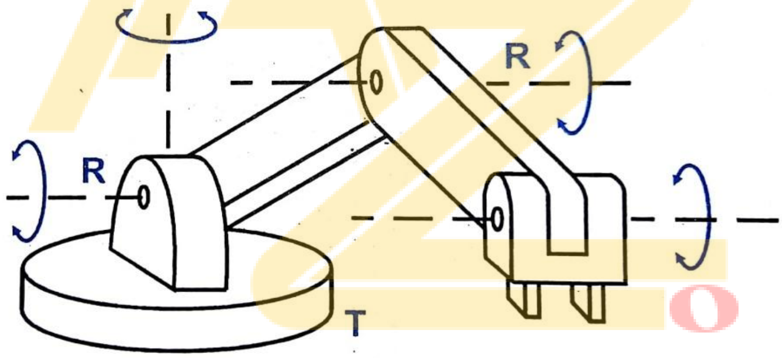
3. Cartesian Co-ordinate Robot

It is also called as a rectilinear robot or a XYZ Robot. It consists of Three Sliding joints along the X, Y and Z direction in three dimensional spaces. There are two orthogonal Joints. Since movement can stop and start and start simultaneously along X, Y and Z axes the motion of the tool tip is smoother



Cartesian Co-ordinate Robot

4. Jointed-arm Configuration Robot: This type of Configuration resembles the human arm where the column swivels about a base (the column and the base forms a T-joint), the column top connects to the shoulder through a shoulder joint (which is the R-joint) and the shoulder connecting to the elbow through an elbow joint (which is also an R-joint). Thus, this configuration has the capability to be controlled at any adjustments in the work space. This is shown in Fig



Jointed arm Configuration Robot

Application of Robots

I. Material / Part Handling applications

Most of the applications of the Robot falls under this category. Here the Robots are used to

a. Transfer materials from one location to another location. Typical applications are as given below:

i).Pick-and-place application: The most common and simplest application here is the pick-and-place application where objects are picked from one location and placed to another location.

ii. Palletizing application: Another application that is slightly complex is the "Palletizing application" where the robot stacks products or carton boxes onto a pallet at various positions on the pallet to the required height

iii. Depalletizing application: Here the robot picks parts from an orderly stacked pallet to another location.

iv. Stacking application: Here, the robots are used to stack parts one upon another. After each placement, the vertical position is re-calculated and the new stacking height is determined.

v. insertion operation: Here, the robots are used to insert parts into the compartments or spaces provided in a carton.

b. Machine loading/unloading: In the machine loading/unloading application, a robot is used to move the work parts to or/and from the production machine.

Following are the industrial applications of robots used for machine loading/unloading:

1. Die casting: Here the robot is used to safely unload the parts from a die-casting machine with the safety gates closed.

2. Forging: Forging is one of the toughest environments considering the extreme heat, pollution and noise. The use of a robot immensely helps to face the environment of forging. Here the robot loads the red hot billet on to the die of the forging hammer, holds it during the blows and unloads to a safe place away from the hammer.

3. Plastic injection moulding: Here a robot unloads parts from the injection moulding machine, cuts the runner and drops runner to scrap area.

4. Sheet metal press operation (Press working): Here a robot loads a blank into the press, and then after the press stamping operation is performed the robot unloads the scrap and throws it into the scrap area. The stamped parts from the blank falls in the container placed at the back of the machine.

5. Machining operations: Here the robot loads the raw blanks on to the machine tool and unloads the finished parts.

6. Heat treating: Here the robot loads/unloads parts to/from a furnace.

II Processing operations Robots are used to carry out the processing operations such as spray painting, spot welding, etc by using a tool at its end-effectors. The tools can be a spray painting gun for spray painting operation, a spot welding gun for spot welding operation, etc. In processing operations, the robot manipulates a tool to perform a process on the work part.

Following are few processes that use industrial robots:

a. Spot Welding: The end effectors of the robot here is the spot welding gun that applies the approximate pressure and current to the sheet parts to be welded. The spot welding robots have enough number of axes of motion to approach points in the work envelope at any angle. This was difficult to realize in a manned environment in the absence of robots. Spot welding is used largely in the automobile industry to weld automobile bodies such as car panels.

b. Arc Welding: The welding here is continuous unlike spot welding. When arc welding is manually carried out, the conditions are difficult for the operators since they require Personal Protective Equipment like welding shield with special glass to avoid UV rays are under the danger of operating at high temperatures involving high amount of heat and moreover they must be accurate in following the welding path. These problems are now overcome with the use of arc welding robots.

C.Spray Coating: Spray coating is a process where parts are coated by a spray gun spraying the fluid on to the surface of the part. The fluid passes through the nozzle of the spray gun and is dispersed at high velocity to the surface to be coated. Common examples are powder coating and spray painting.

III. Assembly and Inspection a. Assembly: The combination of two or more parts to form a new object is called as an assembly. The parts that join to form a new entity are securely held together either by fastening or joining processes. Assembly automation using robots will ensure higher productivity, consistency in quality and cost savings when compared to manual assembly. Robots have saved the assembly workers from the tedious, dull and repetitive jobs which were quite labour-intensive.

Inspection: Inspection is a means to separate poor quality products from the good ones to ensure the required quality. Inspection, when manually carried out is a labour-intensive job that is also time consuming and costly. More inspection means increased manufacturing lead time and increased product cost without adding any real value to the products. So, the use of robots for inspection activities are slowly on the rise in industries. Following are some of the inspection task cases performed by robots:

i. The robot arm manipulates an inspection probe that moves relative to the product to be inspected. The end-effectors here are the inspection probe. Here care must be taken to present the part at the inspection workstation at the right position and the right orientation so that the part is inspected accurately.

ii. Robots can inspect whether the part is present on an assembly or not. Inspection systems for instance look at an engine to find out if it is completely assembled or not.

iii. The robot picks part at the cell entry point, loads to the inspection machine and after inspection unloads the part and then places to the cell exit point. Few cases may also involve robot taking additional responsibility of segregating parts based on inspection result.

iv. Robots are used to detect flaws by comparing the good part with the bad part. This requires the end users to define what a good part is and what a bad part is.

Advantages of Industrial Robots

1. Robots can be substituted for humans to work in hazardous work environments.
2. Robots can produce greater quantity in a short span of time with consistency and accuracy that cannot be matched by humans.
3. Robots can work at constant speeds without any break which is not possible by humans.
4. Robots are capable of lifting heavy loads without getting tired or injured.
5. Robots can work in tight spaces where human reach is not possible.
6. Robots can be re-programmed with changed tooling to take up a different task after the end of a batch or a production run. In such cases, robots are better than fixed automation.
7. Accidents at the workplace is avoided since robots perform the risky jobs which were otherwise done by humans.
8. Since Robots are controlled by computers, they can be integrated to other computer systems to realize Computer Integrated Manufacturing (CIM)
9. The usage of robots produces lesser or no defective parts and hence saves time of rework and money to the organization.

Disadvantages of Industrial Robots

1. Organizations have to make huge investments to introduce robots at their workplaces.
2. Since parts of a robot are made very precisely, their replacement is very difficult and to maintain, it costs huge amount of money.
3. To program and setup the robotic systems and robots, and to avoid unnecessary future problems and mishaps, it requires highly skilled technical engineers and programmers which again is a significant cost for the organization.
4. Unless the level of the artificial intelligence is highly sophisticated, robots may not be able to respond properly during times of emergency, during times of accidents or when an unexpected variance occurs.