* **Machining:** Machining is a process in which a material is cut to a desired shape and size by a controlled material removal process.

* **Machine Tool:** When machines perform the metal cutting operation by cutting tools mounted on it, they are called machine Tools.

* Common machine Tools are
  (i) Lathe
  ii) Milling machine tool
  iii) Drilling machine tool
  iv) Grinding machine tool etc,

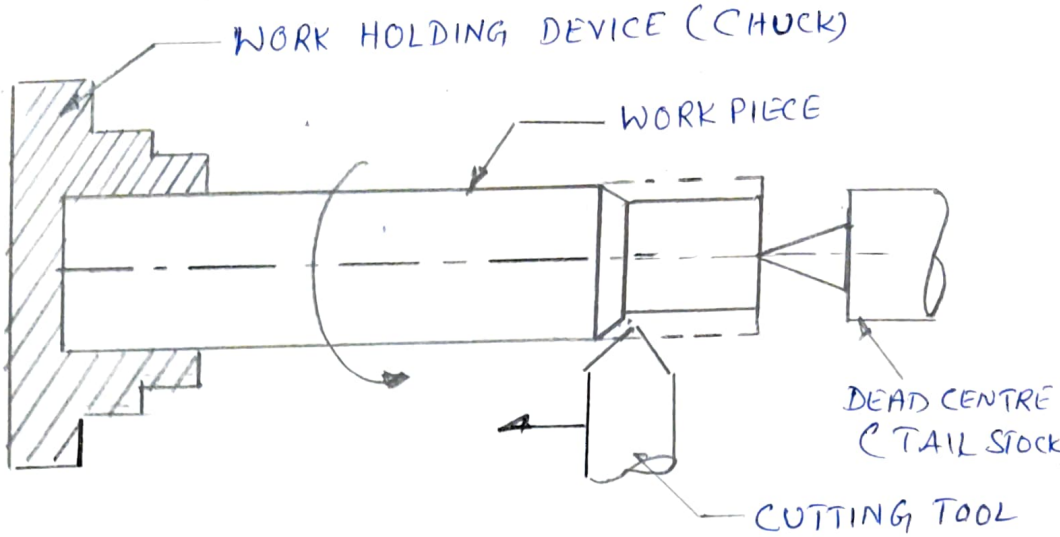
Lathe:

* Lathe is the basic and oldest machine tool used in industries.

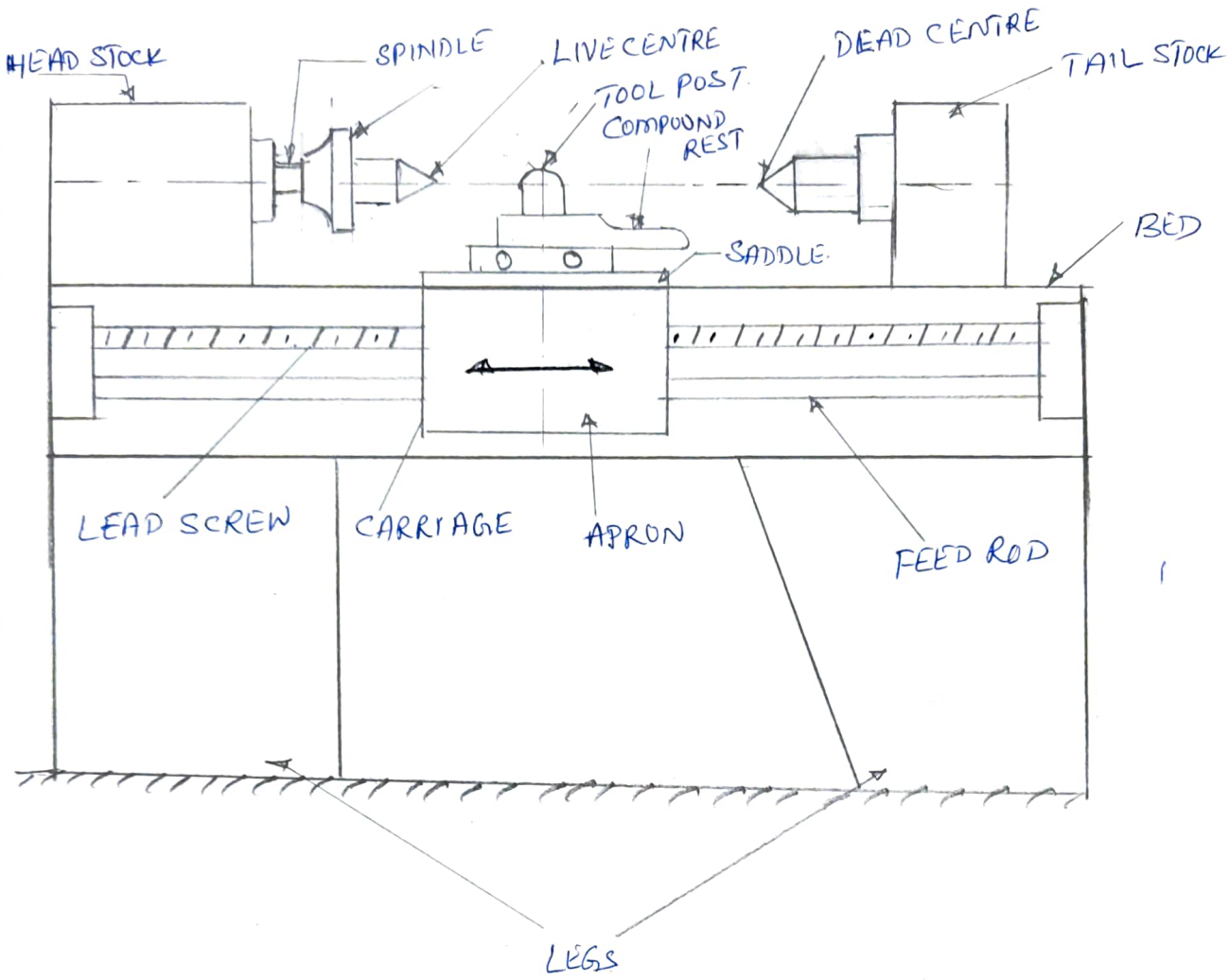
* Earlier lathes were driven by steam engine, therefore, they are called as Engine lathe. It is also called as Centre lathe, because the workpiece is held between two centres, ie, live centre and dead centre.

* Lathe machines are commonly used to produce cylindrical objects.

WORKING PRINCIPLE OF LATHE:



* WORK PIECE is held between two centres and rotat (between Chuck and Tail Stock) at high Speed
* A Cutting tool is held against the rotating workpiece and moves parallel to the axis of the work piece, thereby removes excess ~~metal~~ material in the form of chips.
* The material of the tool should be harder and stronger than the material of the work piece.



PARTS OF LATHE MACHINE TOOL

(1) Head Stock: (Live Centre)

* It is mounted on the left side of the lathe bed.
* It serves as a housing for the spindle, driving system.
* It is provided with live centre or chuck to support one end of the workpiece.

(2) Tail stock (Dead Centre):

* Tail stock is mounted on the Right side of the lathe providing support to the other end of the workpiece
* It holds the tool for performing operations like drilling, reaming and tapping etc.

(3) Carriage: Cutting tool is supported, moved and controlled with the help of carriage. The carriage consists of

(i) Saddle: It supports the cross slide, compound rest and tool post

(ii) Cross slide: It is mounted on saddle. It is made to move perpendicular to the saddle movement

(iii) Compound rest: It is mounted on cross slide and supports tool post

(iv) Tool post: It is mounted on a compound rest and used to hold the cutting tool firmly

(v) Apron: It houses the gears, levers, hand wheels and clutches to operate the carriage by hand or by automatic power feed.

(vi) Feed rod: It is a long shaft which gives automatic feed to the carriage for various operations, except thread cutting

(vii) Lead Screw: It is a square thread long shaft. It is used in thread cutting operations

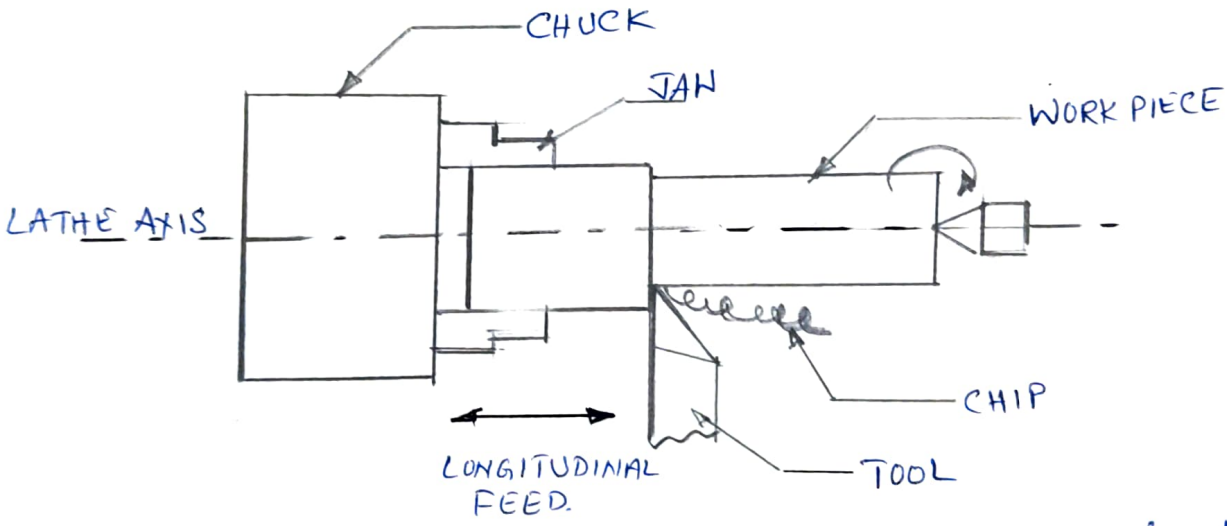
(viii) Bed: It is a rigid structure which forms foundation for all other parts.

(ix) Legs: These are supports, which carries entire load of the machine.

Lathe operations:

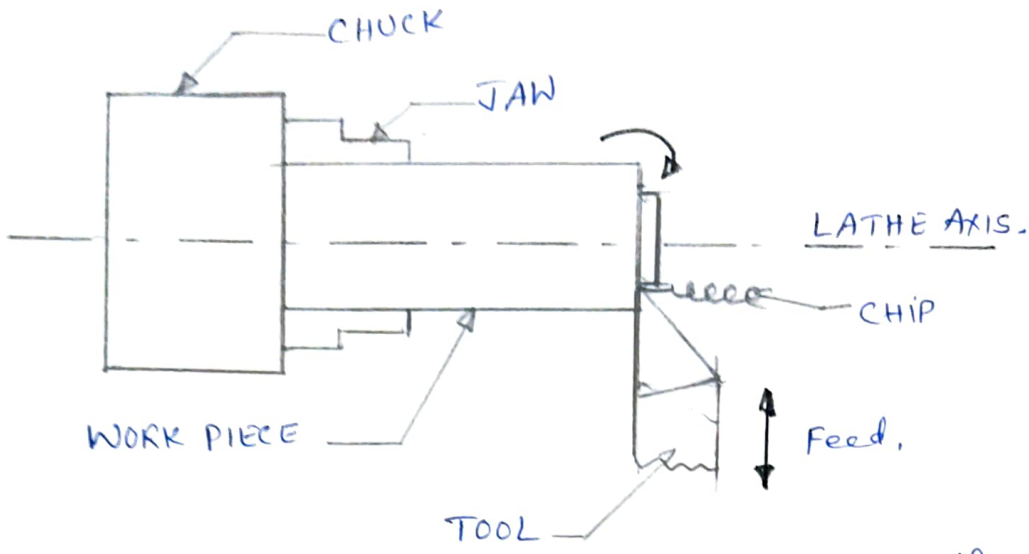
(1) Turning
(2) Facing
(3) Knurling (knurling)
(4) Thread cutting
(5) Taper Turning
(6) Drilling
(7) Boring

(1) Turning Operation:



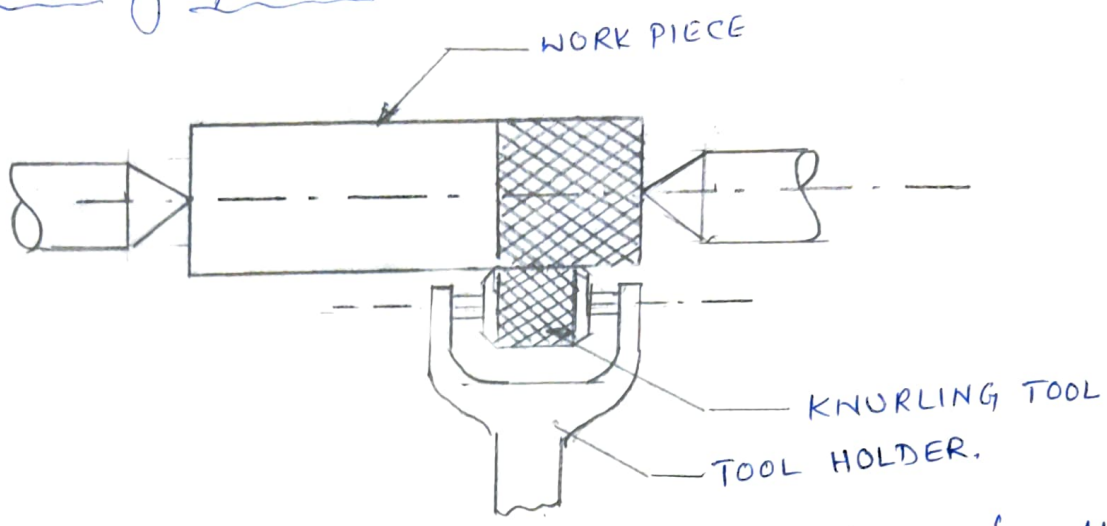
* It is a machining process producing cylindrical surface on the workpiece.
* One end of the workpiece is held rigidly in a chuck, while the other end is supported by Tail Stock.
* The cutting tool fed against the revolving Workpiece in a direction parallel to the lathe axis.
* In this operation diameter of the workpiece is reduced.

(2) Facing Operation:



* It is used to produce flat surface at the end of face of the workpiece
* One end of work piece is rigidly held in the chuck and other end is free
* The Tool is feed perpendicular to the lathe axis to produce flat surface.
* Facing is also used to ~~produce the~~ reduce the length of the workpiece

3. Knurling Operation:



(*) It is the operation to produce diamond pattern on the workpiece.

(*) The workpiece is made to revolve at slow speed and the knurling tool is pressed against the workpiece

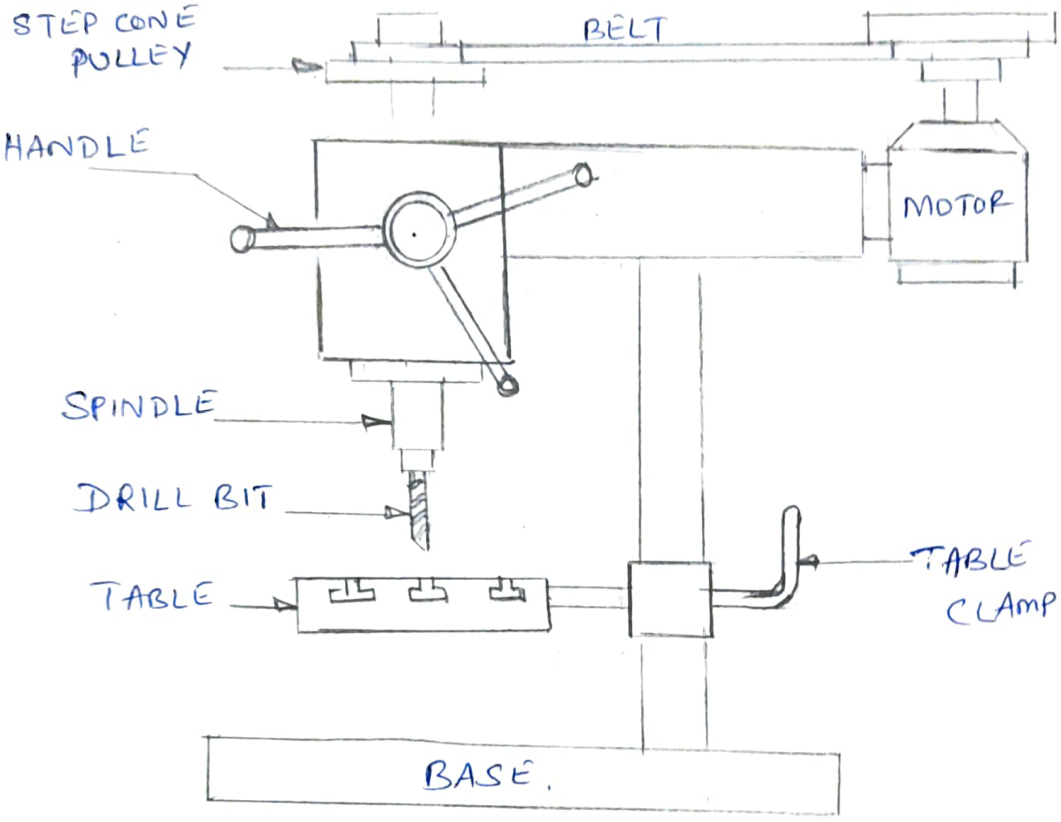
(*) Depending on the knurling tool selected, different patterns can be obtained on the workpiece

Lathe Specifications:

1. The maximum length of the workpiece that can be mounted between centres
2. Swing over the bed [Max. diameter of the workpiece that can be revolved over the lathe bed)
3. Overall length of the bed
4. Distance between the centres.
5. Swing of workpiece over gap in the Bed.

DRILLING MACHINE:

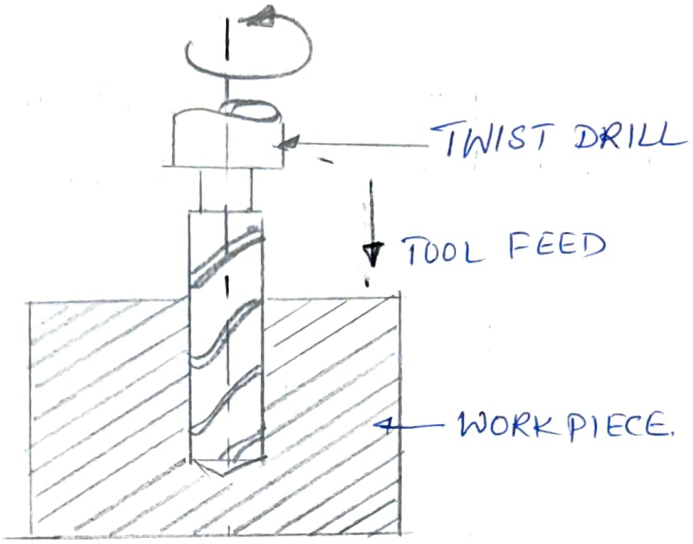
* Drilling is a machining process of producing a cylindrical hole in a solid workpiece by means of a revolving tool called drill bit.



BENCH DRILLING MACHINE

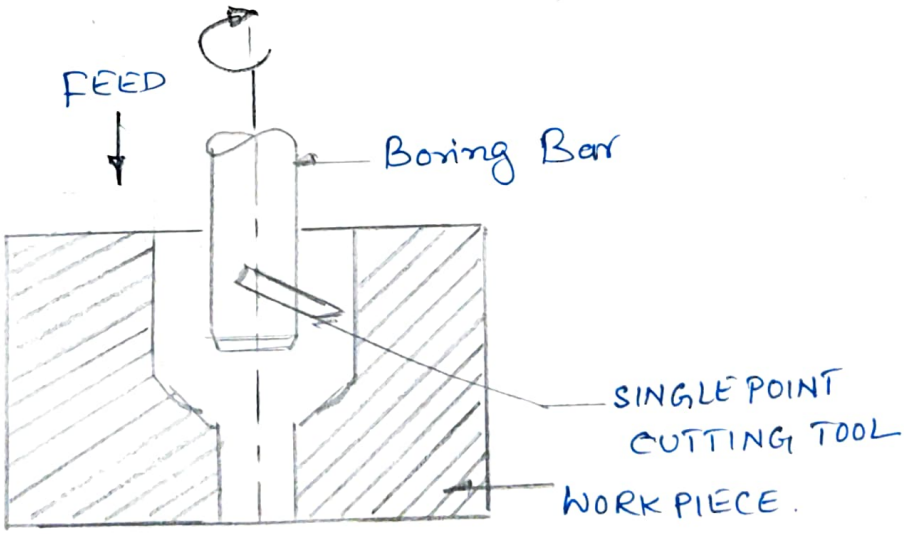
DRILLING OPERATIONS:

(1) Drilling:



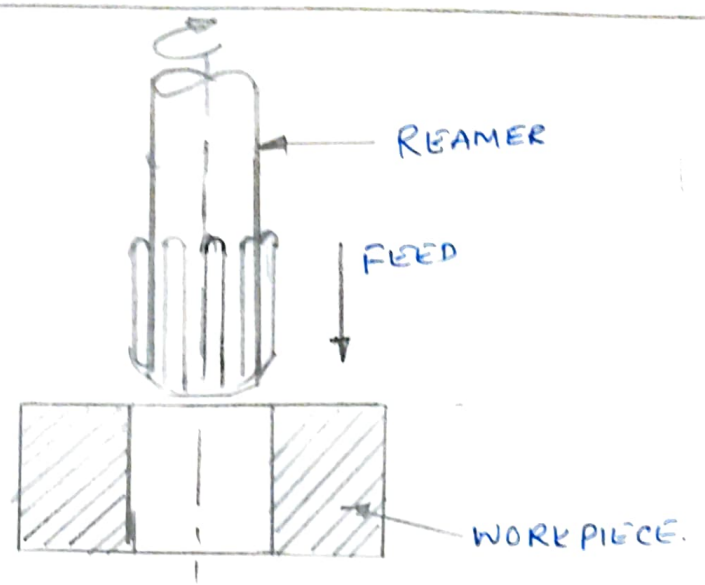
* Drilling is a machining process of producing a cylindrical hole in a solid workpiece by means of a revolving tool called drill bit.

(2) Boring:



* Boring is a machining process for enlarging a previously drilled hole.
* To enlarge the hole an adjustable cutting tool having only one cutting edge is used.
* This operation is commonly used when suitable size of the drill is not available.

(3) Reaming:



* Reaming is a machining process carried for finishing a previously drilled hole.
* It brings already drilled hole to a exact size and to improve the surface finish of the hole.

Difference between Drilling, Boring and Reaming

Drilling	Boring	Reaming
1) Used to produce a solid hole in a workpiece	(1) Used to enlarge an existing hole	(1) Used to carry out finishing and exact size of hole
2) Cutting tool is called twist drill	(2) Cutting tool is called boring bar	(2) Cutting tool is called Reamer
(3) Single point cutting tool is used	(3) Single point cutting tool is used	(3) Multi point cutting tool is used
(4) Material removal rate is higher	(4) Material removal rate is between drilling and Reaming	(4) Material removal rate is lower
(5) Drilling can increase the length of the hole not the diameter unless drill bit is changed	(5) Boring can increase the diameter of hole not the length of the hole	(5) Neither diameter or length of the hole can be increased.

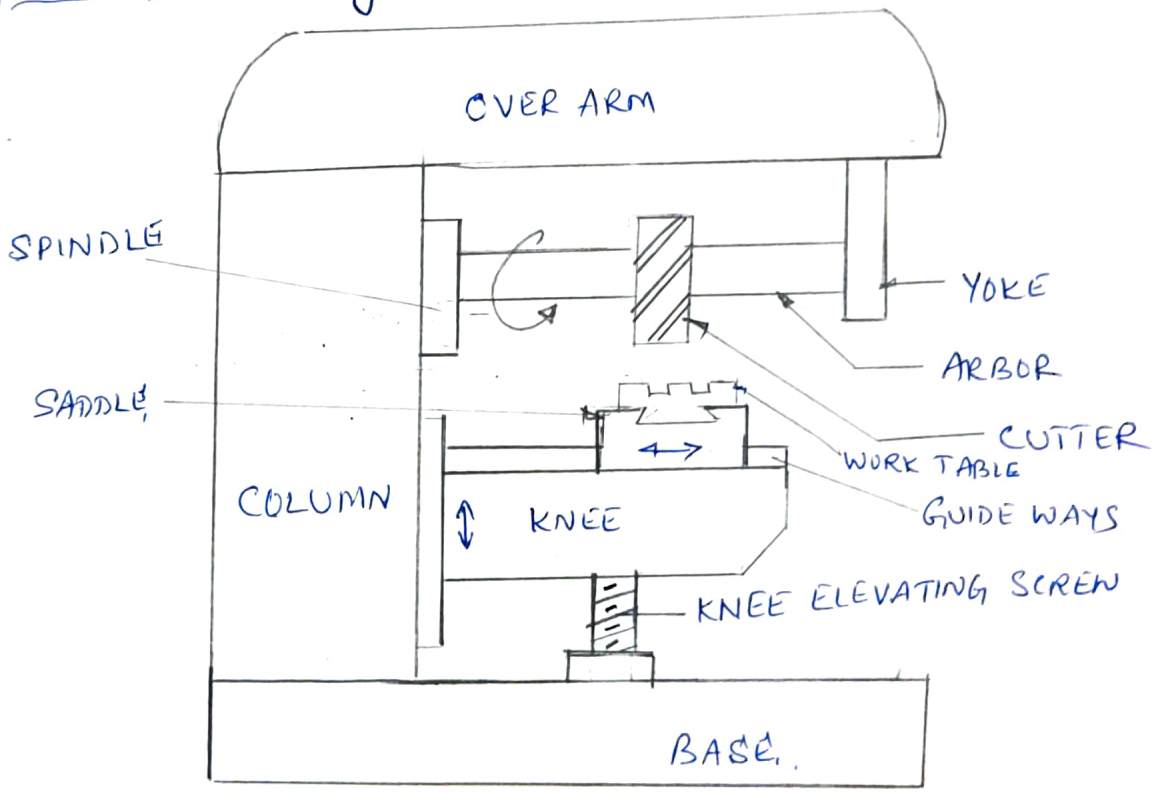
Milling Machine:

Milling: Milling is a process of shaping workpiece by feeding the workpiece against a multipoint Rotating Cutter.

Types of Milling machine:

1. Horizontal Milling machine
2. Vertical milling machine.

Horizontal milling machine



(1) **Base:** It is a Strong and a hollow part upon which all the parts are mounted.

(2) **Column:** It is a vertical hollow casting and is usually combined with the base to form a single casting.

(3) Spindle:
* It is a hollow shaft supported by the column and bearings to absorb both radial and thrust loads.
* It obtains power from the motor and transmits it to the arbor.

(4) Over arm:
* Mounted on the vertical column, supports yoke.

(5) Knee:
* It is a casting that slides up and down on the vertical guideways.
* Knee supports saddle

(6) Saddle:
* It is mounted on the knee, provided with guideways

(7) Work table:
* It rests on the saddle.
* It is provided with T-slots, in order to mount vice or other work holding devices
* The work table may be manually controlled or power fed.

Computer Numerical Control

[CNC]

"CNC may be defined as an NC system in which a dedicated stored computer program is used to perform some or all of the basic NC functions in accordance with control programs stored in read write memory of the computer"

(or)

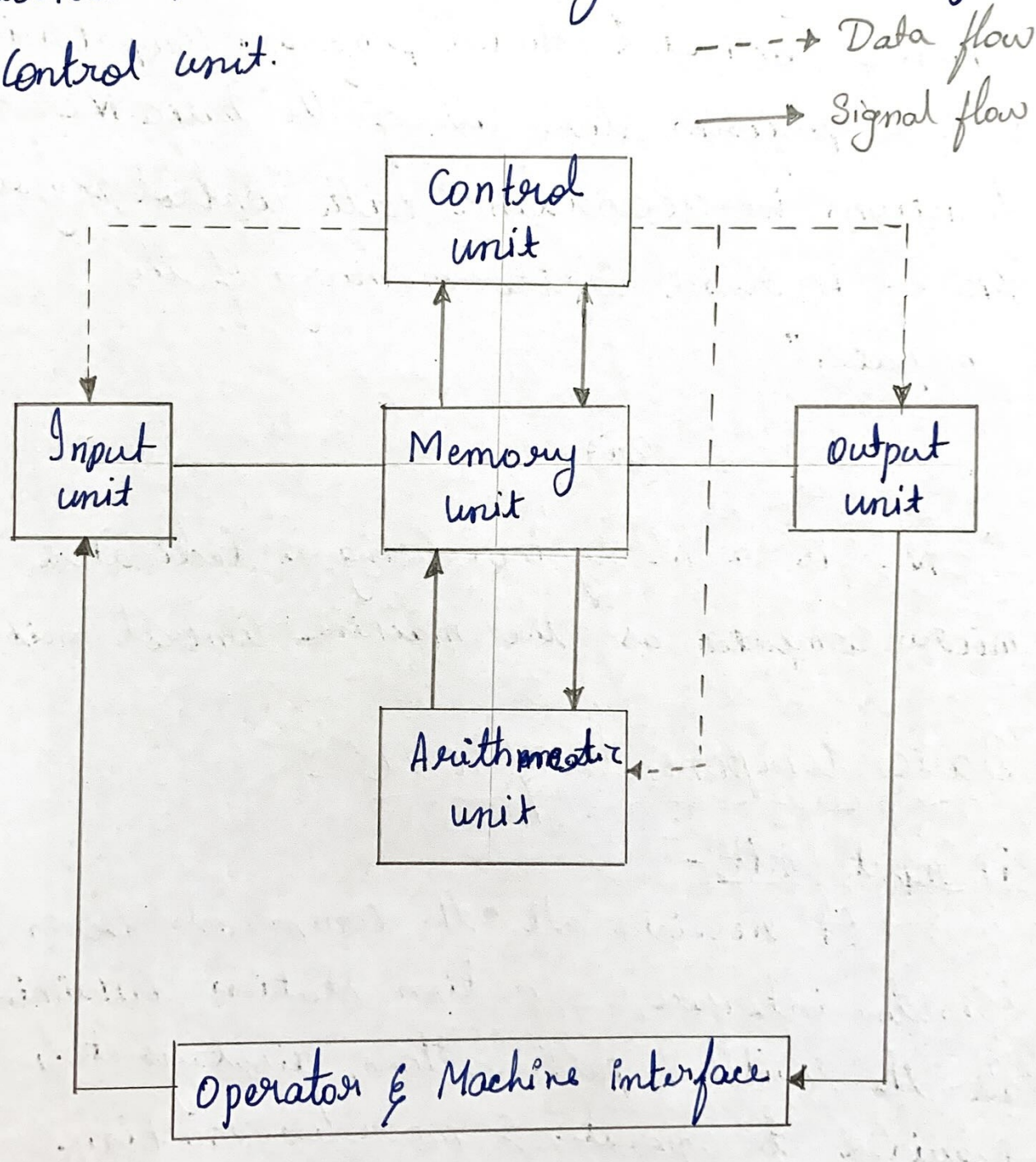
"CNC is a NC system using a dedicated micro computer as the machine control unit"

Basic components of CNC :-

(i) Input unit :-

It receives all the commands from operator interface [operation station containing all the switches, push buttons, displays etc., required to operate & monitor machine activities) & feed back or status of machine

in the form of A.C, DC & analog signals. All the input signals are made compatible to be understood by control unit. Software is input by means of paper tapes or magnetic devices stored in memory unit needed by control unit.



(ii) Control unit :-

It receives instructions from the memory unit & interprets & manipulated by this unit will help the hardware logic & Computer programs. Control unit then Sends proper instructions to other unit for the execution of instructions.

(iii) Memory unit :-

It acts as a storage devices for storing instructions, data received from the input & results on ~~air~~ arithmetic operations. It also supplies the information to the output unit. The amount of memory required based on the size of the programs & spaces required to manipulate data. Programs are stored in RAM & ROM

(iv) Arithmetic unit :-

This unit performs all arithmetic calculations & makes decisions. The results are stored in memory unit

(v) Output unit :-

This unit receives data from memory unit & the signals are converted so that

signals are made compatible with output devices. Digital signals are first converted to analog form to control axis drive servomotors. Output signals are used to turn on & off device, display information, position axis etc.,

(vi) Operator Interface :-

It consists of

(a) punched tape, most commonly used input system for NC

(b) Magnetic devices, having the ability to store large amount of data on a small amount of surface are also used to feed input to memory unit

(c) Computer to carry computation to correct for various machine conditions such as tool wear or errors inherent in the machine tool itself like lead screws. errors.

(vii) Machine interface :-

It consists of all devices used to monitor & control machine tool like extreme travel, limit travel switches, control valves, servo mechanism etc.,

Types of Control System

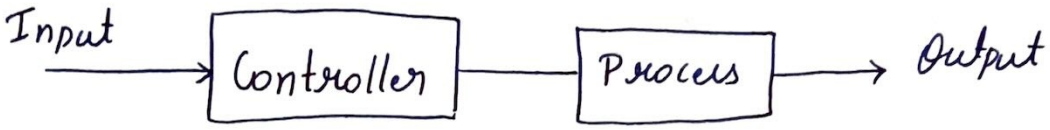
Control system is a device or a system that gives commands to manage the behavior of other devices or system. The commands can be set or programmed & the output is determined by the input.

There are two types of control system

(i) Open loop control system
(ii) Closed loop control system

(i) Open loop Control system.

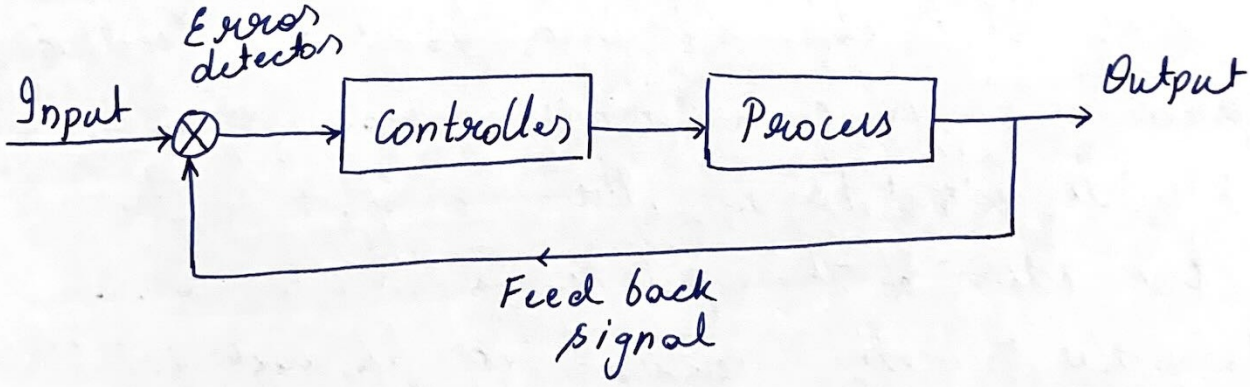
It is also refferred to as non-feedback system, is a type of continuous control system in which the output has no influence or effect on the control action of the input signal. In other words, the output is neither measured nor fed back for comparison with the input. Therefore, an open-loop system is expected to follow its input commands or set point regardless of the final results. Also, an open loop system has no knowledge of the output condition & the output error cannot be corrected.



Open loop control system

(ii) Closed loop control system

The system in which the output has an effect on the input quantity in such a manner that the input quantity will adjust itself based on the output generated is called closed loop control system. Open loop system can be converted into closed loop system by providing a feedback. This feedback automatically makes the suitable changes in the output due to external disturbance. In this way this system is called automatic control system



CNC Machining Center

Conversion of manually controlled conventional milling machine (Vertical or horizontal) to made semi automatic or fully automatic is the agenda behind development of machining Centers. Initially conversion of Vertical milling machine started with two automatic movements viz X & Y movement for the table & Z movement for the up & down movement of the spindle. Now with the instructions of the programmes machine table can move horizontally in two directions & specifying the depth of cut by up & down movement of the spindle

Later vertical spindle head is replaced with indexable tool turret to accommodate more number of tool on the machine & automatically use tools as per requirements which are needed during the machining process.

The modified machine is with limited number of tools, hence turret was replaced by large tool magazine which accommodate still more number of ~~tools~~ tools ~~magazine~~ by which any

any desired machining operations can be achieved. To facilitate machining of both vertical & horizontal surfaces, horizontal machining center was developed with more than 32 tool accommodating facility on tool magazine. Later automatic pallet changer was introduced to change the machined work piece with raw work piece to carryout farter machining operations. Later machine is made flexible such that vertical machine can be made horizontal & vice versa so that any configuration can be machined

CNC Turning Center :-

Computerization of Lathe machine was started with incorporation of two servo motors to the system i.e. one for saddle & other for cross slide having indexable tool turret. All there upgradation was done on straight bed configuration later it was changed to slant bed configuration.

Later development of multi functional machine to perform different operations like milling, drilling, keyway cutting etc., by the addition of one more ~~axis~~ axes to the machine

Later introduction of second turret is with additional axes to the existing machine to perform simultaneous machining with reduced cycle time. A drum type tool magazine was incorporated for easy changing of tools for different operations. Sensors were fitted on to the main spindle to detect ~~the~~ unwanted vibrations during the machining process by which tool performance can be monitored High spindle speed of 8000 rpm & 1 to 2 sec for tool changing will facilitate high productivity & speedy manufacturing. Coolant circulation system helps in breaking the long continuous chips into smaller segments & flushing of chips produced during the machining process.

Advantages of CNC System

1) Increased productivity
2) Reduced man power
3) Higher flexibility
4) Reduced material wastage
5) Reduced productivity time
6) Faster manufacturing
7) High accuracy

8) Precise manufacturing
9) Consistent quality
10) Automatic material handling
11) Advanced materials machining
12) Shorter cycle time.

Disadvantages of CNC System

1) High machine cost
2) Maintenance cost is high
3) Skilled operator required for machining process
4) High tooling cost
5) High level of cleanliness is required

3D Printing : 3D Printing or Additive manufacturing can be defined as the layer by layer fabrication of three dimensional physical models directly from a computer aided design (CAD) data

3D Printing steps [Additive Manufacturing Process]

↳ Conceptualization
↳ CAD
↳ Conversion to STL
↳ Transfer to additive manufacturing.
↳ STL file manipulation
↳ Machine setup
↳ Build file preperation
↳ Build removal & clean up
↳ Post processing.

Conceptualization : The process of developing a thought about the function and appearance of the product. This may be in the form of textual descriptions, sketches, 3-dimensional computer models. Conceptualization is done through making 3d ~~cad~~ CAD model.

CAD : After conceptualizing object to be built, ~~modelling~~ modelling is done using a computer-aided design software packages. Solid modeling packages like solid works, catia and unigraphics are used to represent 3d objects.

Conversion to STL : The STL [standard triangulation language] format of a 3D cad model captures all surfaces of the 3D model by means of sticking triangles of various sizes on its surfaces. The geometry information is stored in STL files.

Transfer to additive manufacturing: Once a correct STL file is available, proper orientation of the 3d model with respect to the build platform is decided.

STL file manipulation: Once the CAD model is imported to STL file format, some errors will occur. These errors can include missing triangles, inverted or double triangles etc. These errors are corrected or modified in this stage.

Machine setup: Machine setup is further divided into machine hardware set up and process control. Machine hardware set up includes cleaning of the build chamber, loading of powder material - etc. The Process control includes allowing the manufacturing system to accept and process the build files, preparing the machine for finished part extraction, unloading of material - etc.

Support generation: The primary function of the "support" structure is to extract heat from the model & to.

Build file preparation: In this step slicer program is used to divide the models into layers in the build direction, based on the desired layer thickness. Once the slice information is generated, it is transferred into the interface program that runs on additive manufacturing systems.

Build removal: This stage involves the removal of the generated model/build. The build time of the powder bed process mainly depends on the height of the build.

Post-processing This step is carried out to clean the build, change the surface, material properties of the built part.

Techniques of 3D printing / Additive manufacturing

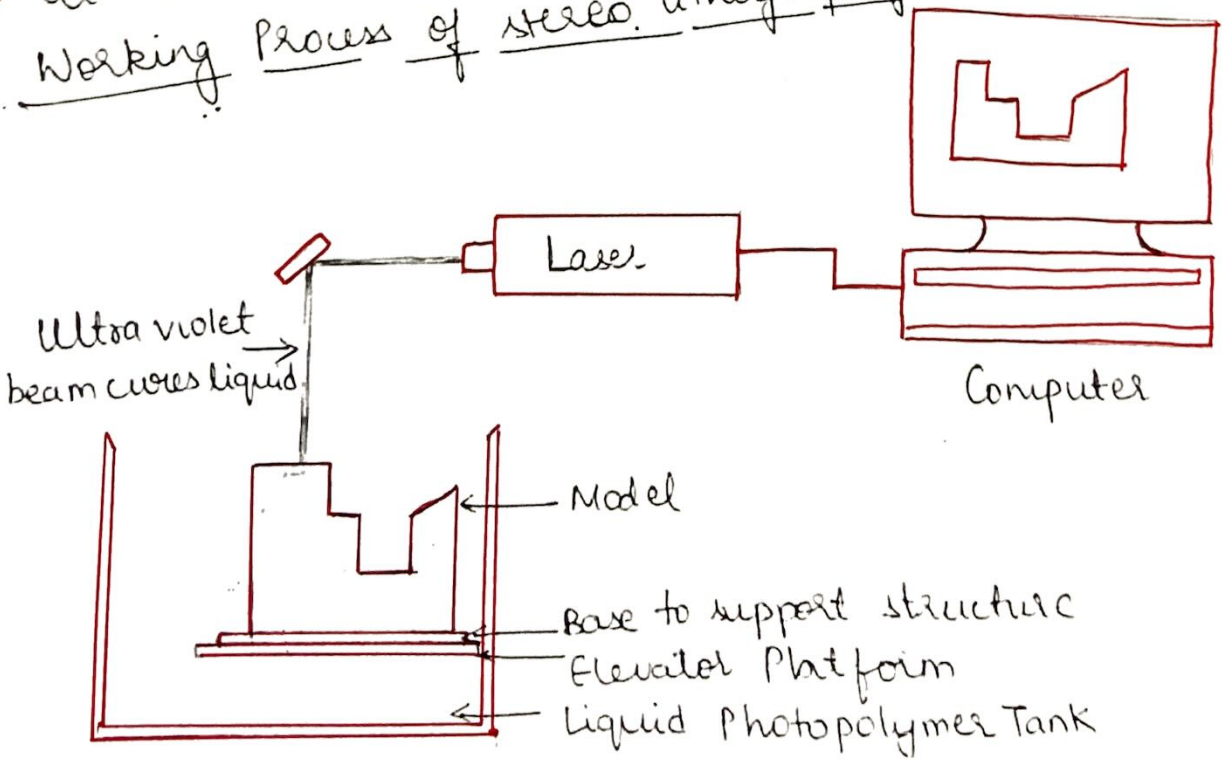
↳ Liquid polymer system
↳ Discrete particle system
↳ Molten material system
↳ Solid sheet system.

Stereo lithography (SL) is the first process ever developed in rapid prototyping field with the meaning of 3D printing

Principle of stereo lithography.

The parts are built from a photo-curable liquid resin that cures when exposed to a laser beam. which scans across the surface of the resin. The building is done layer by layer, each layer being scanned by the optical scanning system and controlled by an elevation mechanism which lowers at the completion of each layer.

Working Process of stereo lithography:



Stereolithography has four main parts, a tank that can be filled with liquid plastic (photopolymer), a perforated platform that is lowered into the tank, an ultraviolet (UV) laser and a computer controlling the platform and the laser

Initially a thin layer of photopolymer is exposed above the perforated platform. The UV laser hits the perforated platform, "painting" the pattern of the object being printed. The UV-curable liquid hardens instantly when the UV laser touches it, forming the first layer of 3D-printed object.

Once the initial layer of the object is hardened, the platform is lowered, exposing a new surface layer of liquid polymer. The laser again traces a cross section of the object being printed, which instantly bonds to the hardened section beneath it. The process is repeated again & again until the entire object has been formed and is fully submerged in the tank. The platform is then raised to expose a three-dimensional object. Later it is rinsed with a liquid solvent to free it of excess resin, the object is baked in ultraviolet oven to further cure the plastic

Advantages of 3D printing

↳ Flexible design.
↳ Increased productivity
↳ Cost effective
↳ Waste reduction
↳ Customised products can be prepared.
↳ Reduced errors

Disadvantages:

↳ Initial cost of the printer is high.
↳ Post processing of the model is required in certain cases.
↳ Special skill required for 3D modelling.
↳ Manufacturing Job losses.

Applications of 3D printing Technology:

↳ Aerospace & Aviation: Many 3D printed aircraft components are manufactured and tested succesfully & even used in industry. Ex fuel nozzle of aircraft
↳ Automobile industry: Many automotive components are manufactured using 3D printing technology.
↳ Medical: Building of personalised prothetics, 3D printed dental fixtures and hearing aids are being designed and customised as per the needs of the users.
↳ Jewellery: 3D printing has made it easier to rapidly prototype jewellery designs that accurately fits the customers and also made it easier to build customized jewellery.

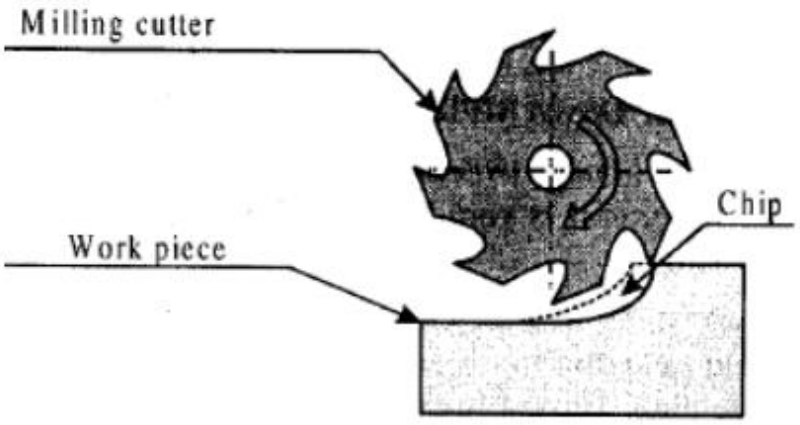
MILLING MACHINES.

Milling is a machining process in which the metal cutting takes place with the help of a rotating multi-point cutter called milling cutter. Here the job is held stationary and fed against a rotating tool.

The cutter has multiple cutting edges and it rotates at high speed. The machining takes place at a much faster rate and generally a good surface finish is obtained.

The machine tools employed for various milling operations are called milling machines.
Milling machines are quite versatile and can do several operations like making flat surfaces, grooving, thread and gear cutting.

Working Principle of Milling Machine:

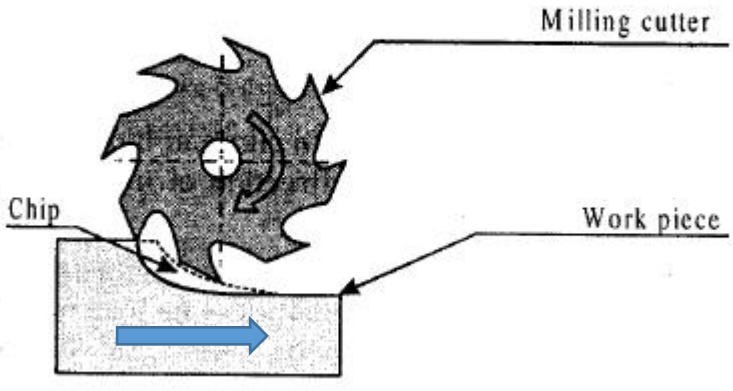


- The milling cutter is attached to a horizontal rotating shaft known as arbor.
- The work piece which clamped on the table is fed in the direction opposite to the milling cutter(up milling) or in the same direction of the milling cutter (down milling)
- The metal is removed by advancing the workpiece during each revolution of the rotating cutter in the form of chips.
- The milling operation is extensively used in machining flat surfaces contoured surfaces external & internal threads, helical surfaces of various cross sections.

Depending upon relative feed direction of worktable and rotation of cutter two different methods of milling is possible

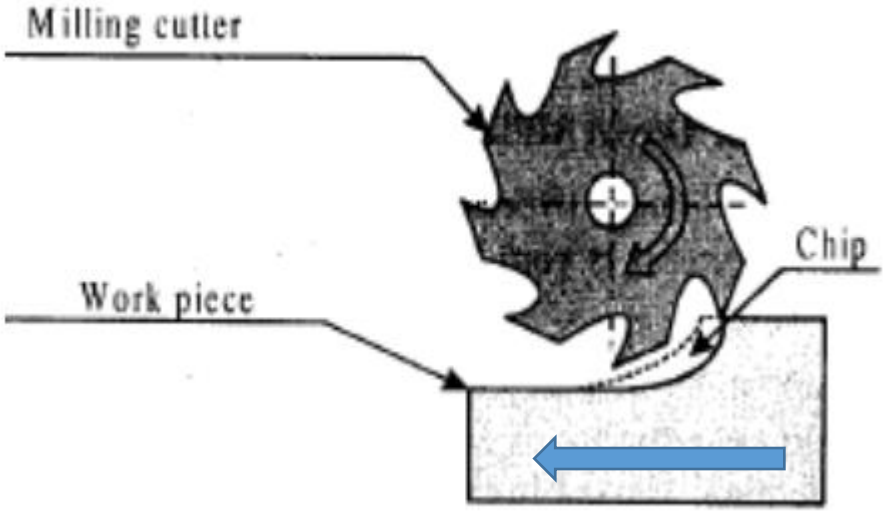
1. **Up milling** or Conventional milling
2. **Down milling** or Climb milling

1. **Up milling** or Conventional milling



The milling cutter is attached to a horizontal rotating shaft known as arbor. The work piece which clamped on the table is fed in the opposite direction of the milling cutter. The metal is removed by advancing the workpiece during each revolution of the rotating cutter in the form of chips. In up-milling, the chip thickness varies from a minimum at the tooth entrance to a maximum at the tooth exit. The forces produced by the cutting tool tend lift the work piece up from the table. Hence conventional milling process requires heavy work holding devices. Up milling leads to poor surface finish, due to vibrations developed by cutting forces of the cutter.

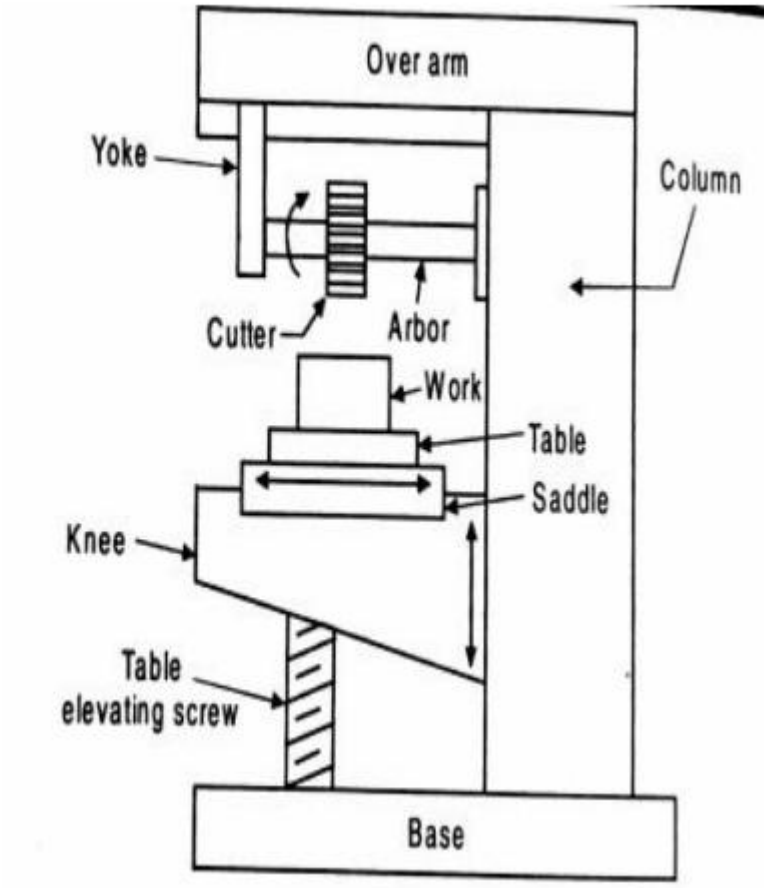
3. **Down milling** or Climb milling



In down milling, the metal is removed by the rotating cutter fed in the direction of movement of the workpiece In down milling, the chip thickness varies from a maximum near the tooth entrance to a minimum near the tooth exit. Thus the cutting tooth is subjected to a maximum load from the very beginning. The cutting forces in down milling tend to act downwards, forcing the workpiece into the fixture or the vice.

Hence the down milling process doesn't require heavier work holding devices This type of milling produces higher surface finish compared to up milling.

Column and Knee-Type (Horizontal) Milling Machine:



It is a general-purpose milling machine. The worktable is mounted on a knee which slides in the guide ways of the column. It can be adjusted to a desired height. Figure above shows the block diagram of a column and knee-type milling machine with horizontal arbor. Following are its principal parts:

• **Column with base:** It is the main structural body of the milling machine to support other parts.

• **Arbor:** It holds and provides rotary motion to the cutter.

• **Ram**: It is also known as over arm. It supports the arbor and can be adjusted to accommodate different arbor lengths.

• **Machine table:** The job and its holding devices are mounted on the machine table. It can move longitudinally to provide the feed motions to the job.

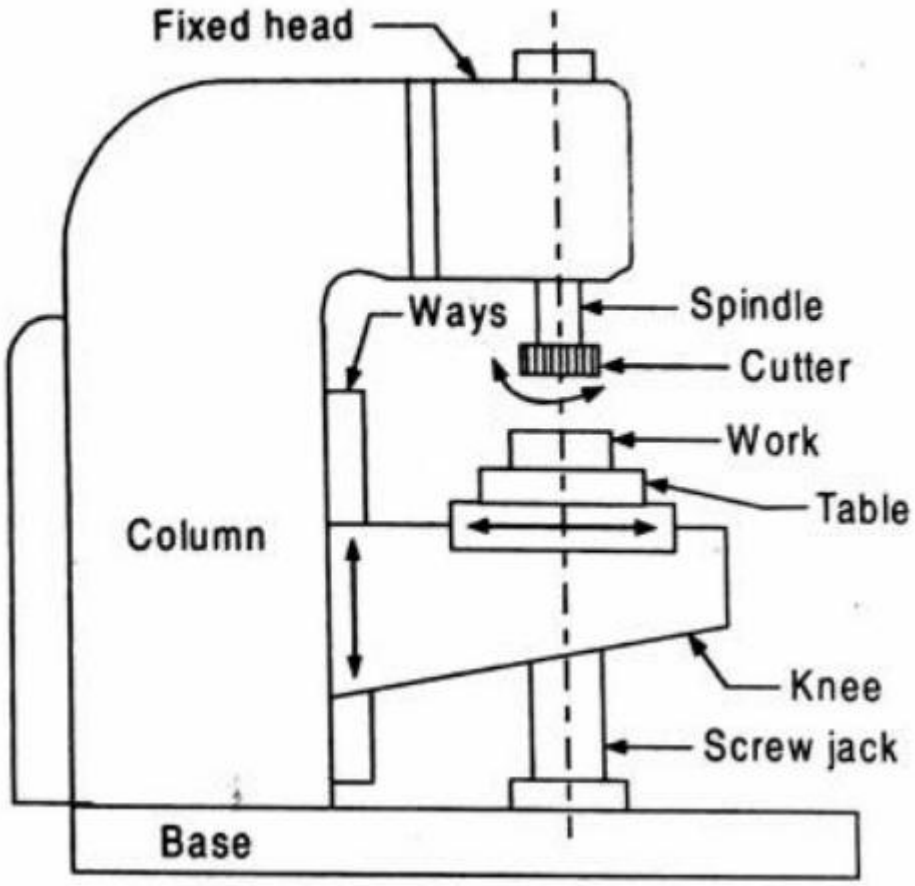
• **Power drive with gear boxes:** It provides power and motions to the tool and work.

• **Bed:** It moves vertically upward and downward and accommodates the various drive mechanisms.

Working : Work piece is mounted directly on table using machine vice. Cutter of required shape and size are mounted over the arbor which is driven by spindle.

Feed in all 3 axes can be given by using knee elevating handle, cross slide handle, table movement handle.

Vertical Milling Machine



In vertical milling machine, the axis of the spindle is perpendicular to the work table.The work piece can be moved both in vertical and horizontal plane.The spindle head can be moved up and down over the guide ways. The saddle is mounted on a knee which can be moved up and down over the guide ways provided on the column face. The worktable mounted on the saddle can be moved longitudinally over the guide ways provided on the top of the saddle. The machine is used to machine grooves, slots and flat surfaces.

Base and column – base is the foundation for the machine and column is the vertical part houses motor, transmission system.

Spindle head – mounted on front face of the column at the top. It has a vertical spindle run by motor to which milling tool is fitted to end.

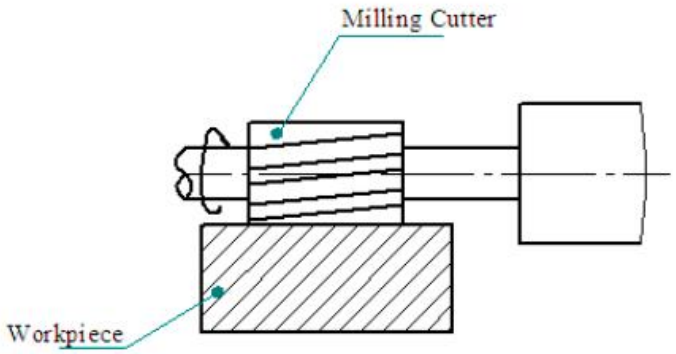
Working : Work piece is mounted on table and cutter is mounted on vertical spindle. Feed is given by movement of knee, saddle and table and also vertical movement of tool

Milling Operations Various milling operations can be performed on a milling machine to produce flat, vertical, inclined surfaces, grooves, slots, keyways, gear teeth etc. Some of the most commonly operations are, plain or slab milling, angular milling, face milling, form milling, slot milling, and straddle milling.

Plain milling:

Slab milling or plain milling is a method of producing flat surfaces parallel to the cutter axis as shown in the figure. The cutter used in this operation is called plain milling cutter or slab milling cutter. It has straight or helical teeth cut on the periphery of a cylindrical surface. This operation is performed on a horizontal milling machine.

Plain Milling



2. **Slot milling:**

3. It is process to produce desired slots, grooves and key ways using suitable cutters. Figure illustrates groove milling operation using a side milling cutter, which has teeth on its periphery and also on one or both of its sides. Similarly open slots and closed slots can be cut by using plain milling cutters and end milling cutters respectively. T-slots and dove tail slots are cut by using special cutters.

Slot Milling