Machine Tool's

Unit - I

→ A machine tool is a power driven machine for making articles of a given shape, size and accuracy by removing metal from workpiece in the form of chips.

Functions of Machine Tool's

→ Hold the job

→ Hold the cutting tools

→ move one or both of these (rotary motion or Reciprocating motion)

→ provide a feeding motion for one of these.

Classification of machine tools

1) **Basic Machine Tools :-**

→ Basic machine Tools are used for performing a great variety of machining operations on a wide range of workpiece.

→ General purpose machine tools include : plain turning lathe, Turret lathe, Milling Machines, drilling Machines, Grinding machines

2) **Single Purpose Machine Tools :-**

→ These Machine Tools are designed to perform a single definite machining operation

Example :- Broaching, Thread cutting, Gear shaping and hobbing machines for machining pistons, crank shafts, cam shafts and for turning the cam countours on cam shafts Etc.

3) Limitted purpose machine Tools :-

→ These machine Tool's are capable of a narrow range of operations on a wide variety of workpiece.

Ex :- Automatic cutting off machines.

4) Production machine Tools :-

→ These are mainly used in batch and mass production and feature high power and rigidity.

These machine Tools include : multi-tool lathes, single and multi spindle automatics, semi-automatic lathes, plunge-cut cylindrical grinder, centerless, plane-type milling machines threadrolling machines for tap production.

5) specialized machine tools :-

→ These are used for machining articles similar in shape but size is different.

6) special machine tools :-

→ These machine Tools are designed and manufactured individually and are intended for performing a certain definite operation in machining a certain definite workpiece.

→ machines for sharpening round threading dies, for Grinding relief surfaces at the chamber of round threading dies

According to accuracy the machine Tools

→ Normal accuracy
→ Higher accuracy
→ precision
→ High precision
→ super high precision.

According to weight

→ Light weight (upto 1 tonnes)

→ medium weight (upto 10 tonnes)

→ Heavy-weight (over 10 tonnes)

According to the type of Processing operations they perform the tools all machines canbe divided into nine Groups.

1) Lathe
2) Drilling and Boring machines.
3) planers, shapers, slottors and Broaching machines
4) milling Machines
5) Grinding and micro-finishing machines
6) Gear and Thread cutting Machines
7) combination machine Tools
8) Cutting-off machines
9) miscellaneous machine Tools

Unit - I

Metal cutting.

- metal working
  - chip forming process (metal cutting process)
    - Continuous contact cutting
      - Single edge cutting (Turning, shaping, Boring)
      - Double Edge cutting (Drilling)
    - Intermittent cutting
      - Sizeable swarf (milling, hobbing)
      - Ground chip (honing, Grinding)
  - chipless forming process (metal forming)
    - Continuous (Rolling, spinning)
    - Intermittent (forging, stamping)

→ metal working industry workpiece of most different shapes and dimensions and Different materials are worked.

→ working processes fall into two groups.

1) Non- cutting shaping process
2) cutting shaping process

Non- Cutting shaping Process :-

→ In this process no chip formation takes place and the metal is shaped under the action of heat, pressure or both.

Ex:- Forging, pressing, drawing, spinning, rolling, Extrusion.

Cutting shaping process

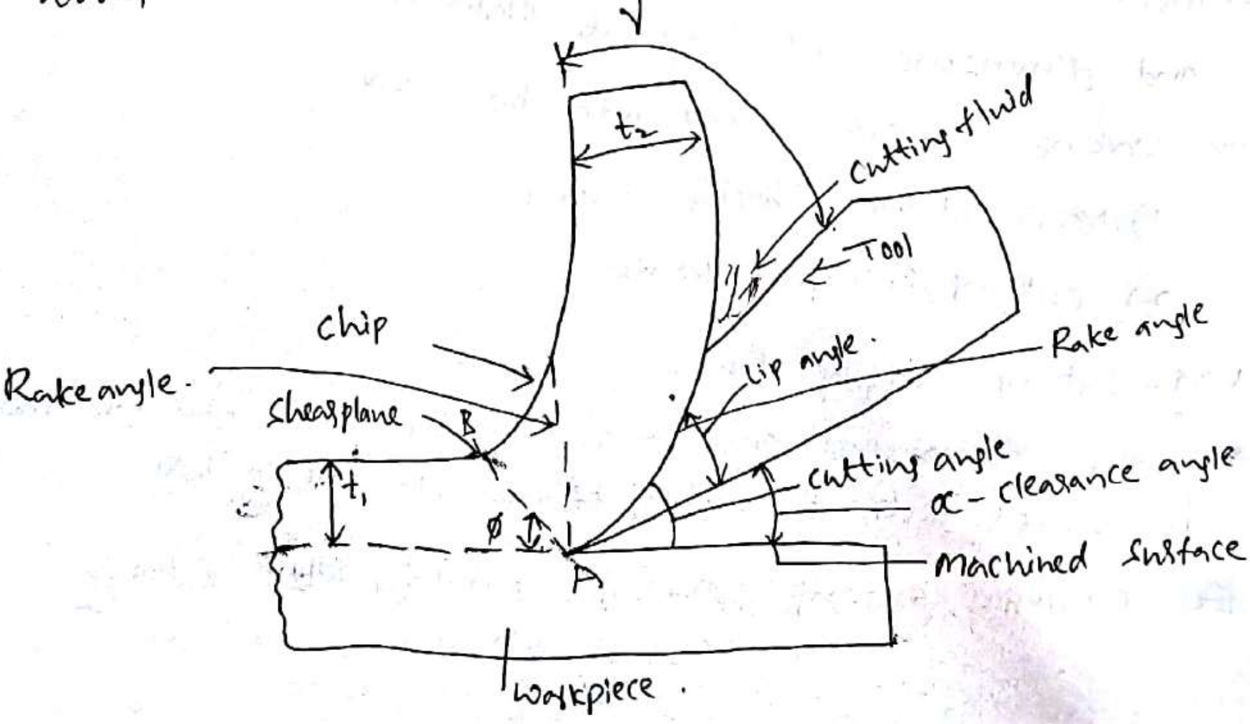
— By which finish surface of desired shape and dimensions is obtained by separating alayer from the parent workpiece in the form of chips.

Ex:- Turning, drilling, milling.

→ Desired shape and size by removing the unwanted material from the parent metal in the form of chips through machining.

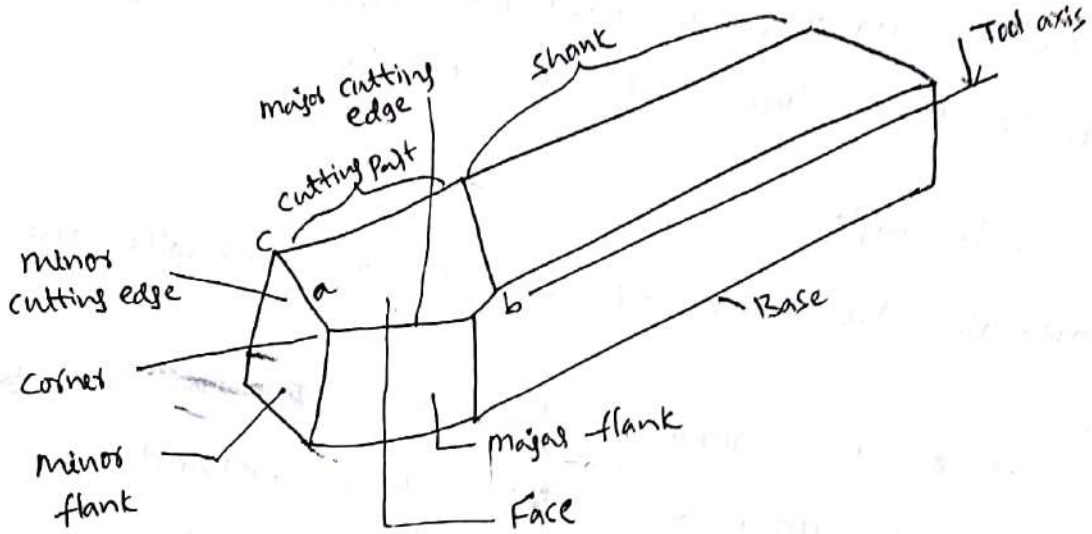
1) Quick metal removal
2) High class surface finish.
3) Economy in tool cost
4) Less power consumption
5) Economy in the cost of replacement and sharpening of tools.
6) Minimum idle time of machine tools.

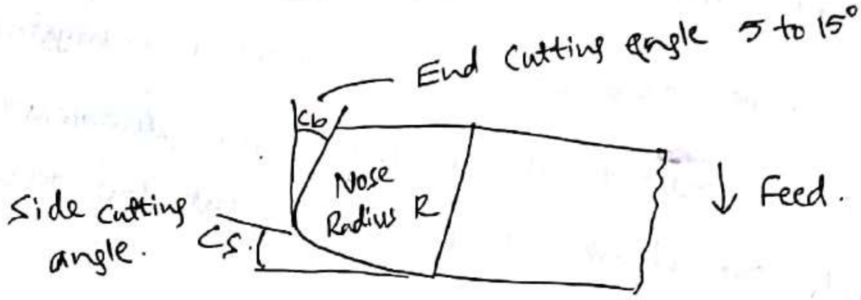
Basic Elements of all machining operations are workpiece, Tool, chip.

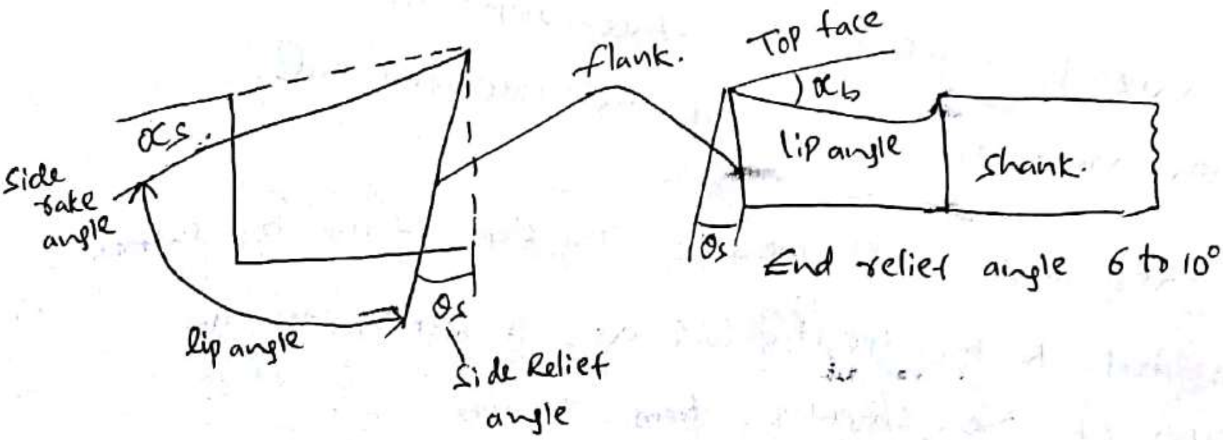


Tool nomenclature

* Cutting tool nomenclature comprises the various parts of a tool and various tool angles
* The comple nomenclature of single point cutting tool.







Face :- It is the surface over which the chip flows below the cutting edge.

Flank :- It is the surface

Nose :- nose is the junction of the side and end cutting edge

Side Cutting Edge angle :-

* It is formed by the intersection of the flank and the side flank
  It does the main work in cutting
* End or auxiliary cutting edge :- It is the Intersection of face and flank.

Tool angles :- In a simple point tool, there are various angles each of them has a definite purpose.

Back rake angle :-

* It measure the downward slope of the rear alon the longitudinal axis
* Its purpose is to guide the direction of chip flow the size of the angle depends upon the material to be machined
* Back rake angle may be positive, neutral or negative
* The angle is positive if the face slopes downwards from the tip towards the shank it is used to cut low tensile strength and non- ferrous materials.
* The angle is negative if the face slopes for high tensile strength materials, heavy feed and interrupted cuts.
* side rake angle :- It measures the slope of the top surface of the tool to the longitudinal axis. It also guides the direction of the chipway from the job

Tool Geometry :-

* Maximum use from a tool before it needs regrinding is one of the objectives of tool technology

* Tool life is defined as the length of the time, a tool will operate before its failure occurs.

* They are many factors that contribute to cutting too efficiency

1) The shape of the cutting edge that removes the excess metal

2) correct selection of the type of cutting tool for the material to be machined

3) The correct choice of cutting speed and feed

4) Proper setting of cutting tool relative to work

5) Correct choice and proper application of coolants.

Optimum Tool Geometry

1) workpiece material

2) machine variable

a) cutting speed   b) Feed   c) Depth of cut.

3) material of the tool point

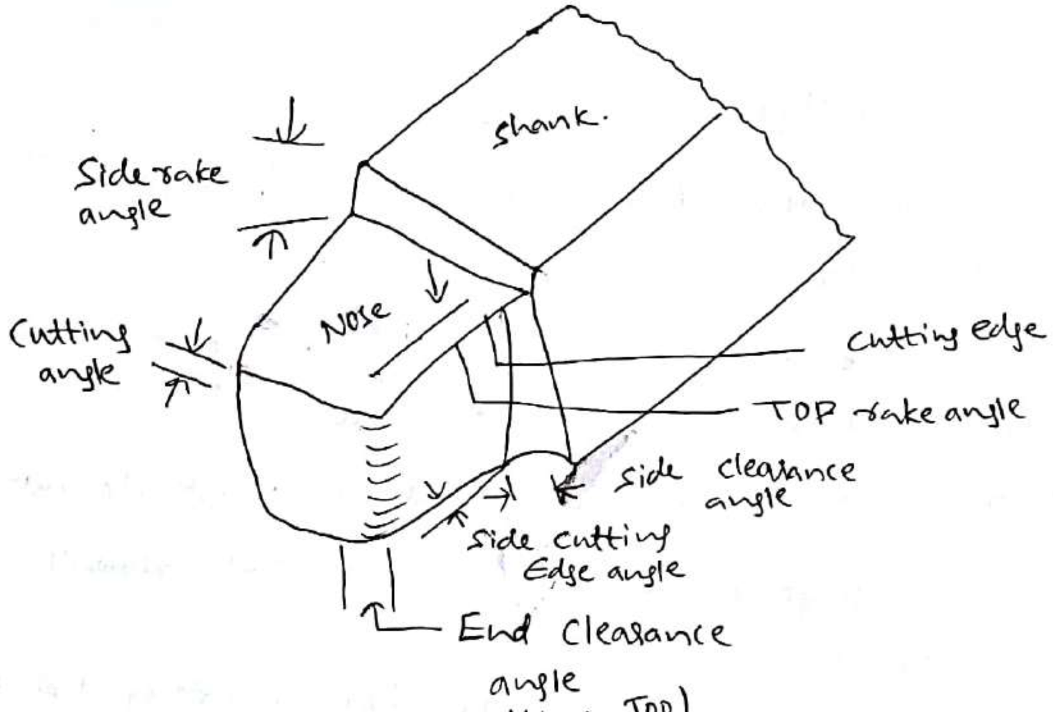
4) Type of cutting

$$\text{cutting speed } (V) = \frac{\pi d N}{1000} \text{ m/min}$$

$$\text{Depth of cut } (t) = \frac{d_1 - d_2}{2} \text{ (or) } \frac{D-d}{2}$$

d_1 = dia of the work surface before machining

d_2 = dia of the machined surface.



— Single point Cutting Tool

* A single point cutting tool consists of a sharpened cutting part called it's point and shank. The point of the tool is bounded by the face.
* The side flank or major flank, minor flank and the base
* The side cutting edge, is formed by the intersection of the face and side flank.
* The End cutting edge is formed by the intersection of the face and the end flank.
* Chips are cut from the w/p by the side cutting edge.
* The point 'P' where the end and side cutting edges meet is called the "nose" of the tool.

Various tool elements and angles.

1) Back Rake angle (BRA) γ_b
2) Side Rake angle (SRA) γ_s
3) End cutting edge angle (ECEA) ϕ_e
4) Side cutting edge angle (SCEA) ϕ_s
5) Side relief angle (SRA) α_s
6) End relief angle (ERA) α_e.

γ – rake angle

ϕ – Shear angle

α – clearance angle (or) Relief angle

t_1 – Uncut chip thickness

t_2 – chip thickness after cut.

→ The Cutting action of list in two dimensional (or) orthogonal cutting.

→ Cutting action, a relative motion b/w tool and the workpiece.

→ workpiece Provides the Parent metal from which the unwanted metal is removed by the Cutting action of the tool to obtain the predetermined shape and size of the component.

→ chemical composition and the physical Properties of the metal Of the W/P have a significant effect on the machine operation.

Rake angle :- It is the angle b/w face of the tool called as Rake angle and normal to the machining direction.

→ This angle specifies the case with which a metal in cut.

* Higher rake angle, better is the cutter and less cutting forcess

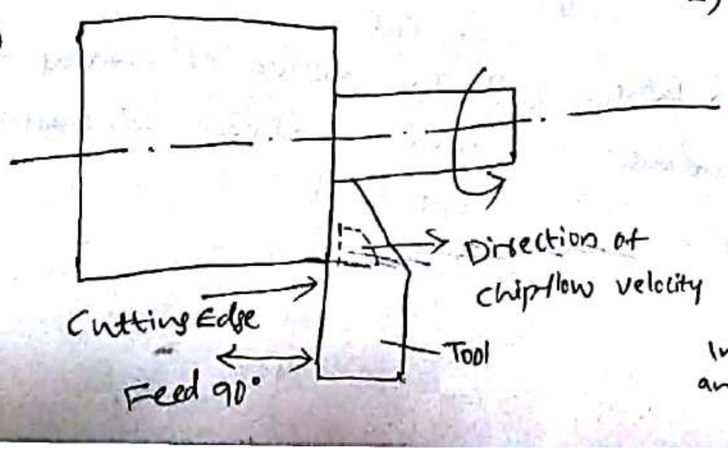
* It is Possible to have rake angle at zero or negative. as show in fig.

<u>Process of metal cutting</u>

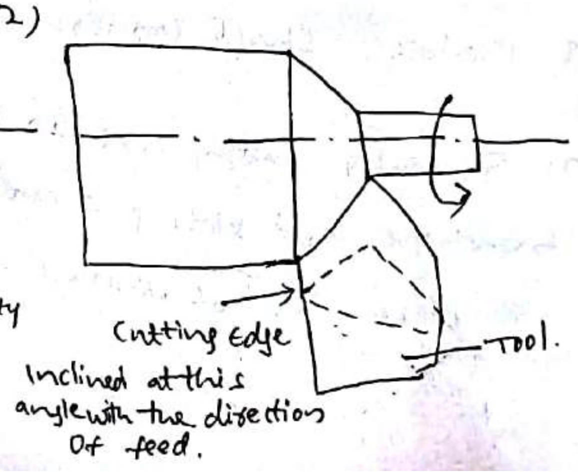
1) orthogonal Cutting (Two Dimensional)

2) Oblique Cutting (Three Dimensional).

1)



2)



Orthogonal cutting	Oblique cutting.
1) The cutting Edge of the tool remains normal to the direction of tool feed.	1) The cutting Edge of the tool is inclined at an angle to the direction of tool feed.
2) The direction of chip flow velocity is normal to the cutting Edge of the Tool	2) The direction of chip flow velocity is an angle with the normal to the cutting edge of the tool.
3) The cutting edge clears the width of the workpiece on either ends.	3) The cutting Edge may or may not clear the width of the W/P.
4) only Two components of cutting forces act on the tool. these two components are perpendicular to each other	4) Three mutually perpendicular components to cutting forces act at the cutting edge of the tool.
5) The chip coils in a tight flat spiral	5) Chip flows side ways in a long curl
6) The force which shears the metal acts on a smaller area so the tool life is less	6) Tool life is more because the cutting force acts on larger area.
7) Cutting edge is larger than width of cut	7) cutting edge is smaller than the width of cut.
8) Produces sharp corners	8) Produces a chamfer at the end of cut
9) Generally Parting off in lathe broaching and sloting operations are done in this method	9) This method of cutting is used in almost all maching operations.

Scanned by CamScanner

Nature of Relative motion for various cutting operation.

Operation	motion of Job	motion of cutting tool.
1) Shaping	— Intermittent translation	- Translation.
2) planing	- Translatory	- Intermittent translation
3) Milling	- Translatory	- Rotation
4) Turning	- Rotary	- Forward Translation
5) Boring	- Forward Translation	- Rotation
6) Drilling	- Fixed	- Rotation as well as translatory feed
7) Hobbing	- Rotation	- Rotation and translation

Classification of machine cutting tools

* Depending upon the number of cutting edges. the cutting tools.
  1) single point cutting Tool
  2) Multipoint cutting tool

1) Single Point cutting Tool :-

* This type of Tool has a effective cutting edge and removes excess materials from the w/p along the cutting edge.
* single point cutting tool is 4 types.
  1) Ground Type
  2) Forged Type
  3) Tipped Type
  4) Bit Type.

1) Ground Type :-

The cutting edge is formed by grinding the end of a piece of tool steel stock

2) Forged Type :-

The cutting edge is formed by rough forging the end of a piece of tool steel stock.

3) Tipped Type :-

The cutting tool the cutting edge is in the form of a small tip made of high grade material which is welded to a shunk made up of lower grade material.

4) Bit type :-

A high grade material of a square, rectangular or some other shape is held mechanically in a tool holder.

* Single Point tool's are commonly used in lathes, shapers, planes, boring, machines and slottors.

multipoint cutting Tool :-

* They have more than one cutting Edge
* milling cutters, drills, broaches, grinding wheel are multipoint cutting tools.

Three types according to the motion :-

1) Linear motion :- Lathe, boring, broaching, planing, shaping too etc

2) Rotary motion tools :- milling cutter, Grinding wheels etc.

3) Linear and Rotary Tool :- Drills, honing tool, boring heads.

Chip formation

* The Type of chip produced during metal cutting depends upon the machining conditions. and material being cut.
* The variable which influence the type of chip produced are as follow.
  1) properties of material cut especially ductility.
  2) Depth of cut
  3) Effective rake angle of tool
  4) Cutting speed
  5) Type and quantity of cutting fluid

Types of chip :-

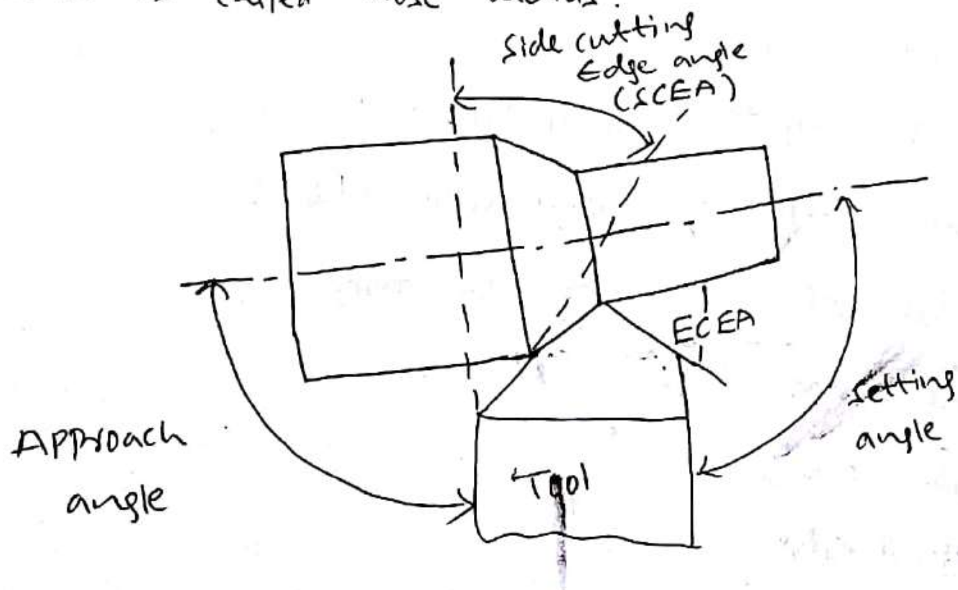
* Chips formed during metal cutting three types of chips
  1) Dis continuous chips
  2) continuous chips (or) ribbon type chips
  3) Continuous chip with bultup edge (BUE)
* Loadze classified chips into diff. types
  a) Irregular shaped chips
  b) continuous chips
  c) No-built up edge
  d) with BUE
  e) Elements of chips
  f) joined chips or partially continuous chips.

Side relief angle :-
It is the angle made by the flank of the tool and a plane perpendicular to the base just under the side cutting edge. This angle permits the tool to be fed side ways into the job, so that it can cut without rubbing.

End Relief angle :- It is the secondary relief angle b/w a plane perpendicular to the base and the end flank.

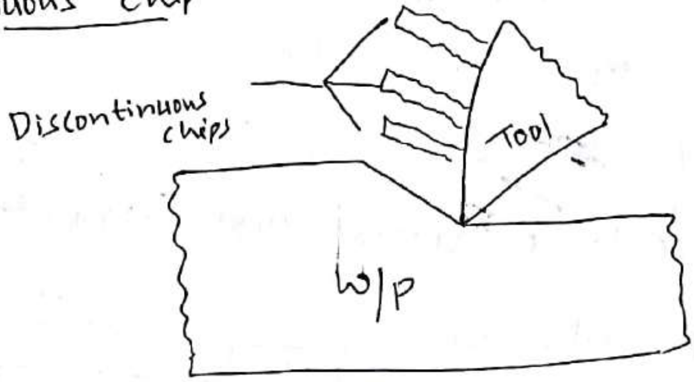
Side cutting edge flank :-
It is the angle between the side cutting edge and the longitudinal axis of the tool.

Nose radius :-
It is the curve formed by joining the side cutting edges. The angle so formed is called nose angle and the radius of the curve is called nose radius.



— SCEA and ECEA

1) Discontinuous chip

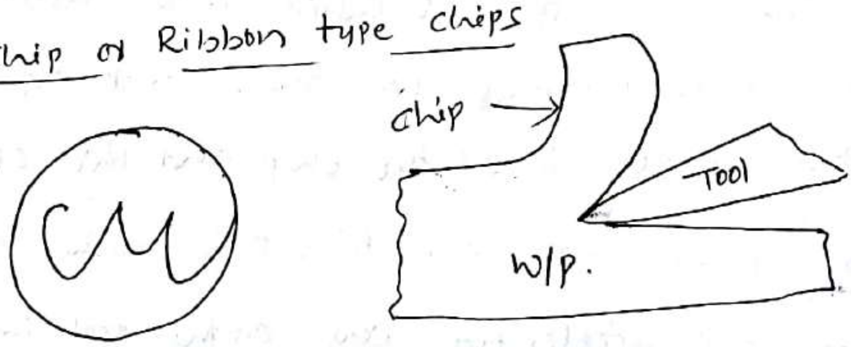


* Brittle materials such as grey cast Iron, lack of the ductility necessary for appreciable plastic chip formation

* Consequently the compressed material ahead of tool fails in a brittle manner along the shear zone producing small fragments this chips are called discontinuous chips.

* Lower cutting speed and insufficient rake angle cause the formation of such chips

2) Continuous chip or Ribbon type chips



* A continuous chip is obtained when cutting ductile material such as low carbon steel, aluminium and copper

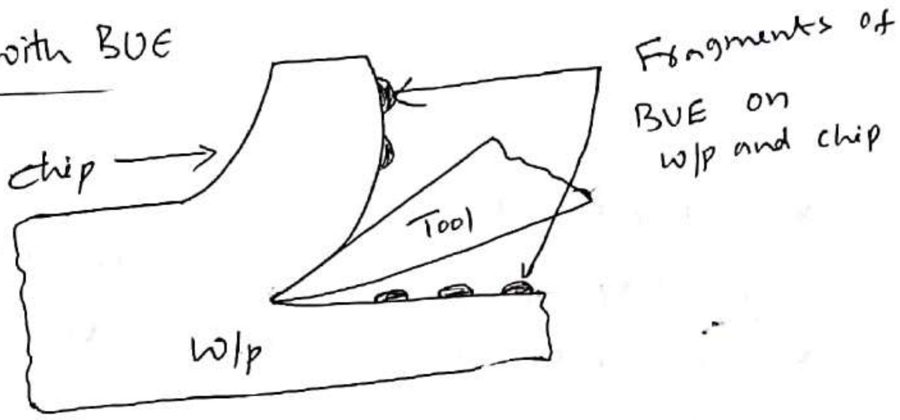
* This chip is severly deformed and either comes off in the form of a long string or curl into a tight Rol.

* Some very soft and ductile material with a low strength tend to tear away from the Parent metal of the w/p rather then shear clearly

* This results in a rough surface that has to be cleaned up by a very keen cutting edge.

* Favours their formation are fine feed, sharp cutting edge, higher cutting speeds and larger rake angles.

<u>Continuous chips with BUE</u>



* During cutting, the temp and pressure is quite high it causes the chip material to weld itself to the tool face near the nose. This is called 'BUE' This accumulated build up of chip material will then break way, Part adhering to the underside of the chip and part of the w/p

* This process gives rise to a poor finished on the machined surface and accelerated wear on the tool face

* High friction at tool face, course feed, low rake angle and ineffective use of cutting fluid produce such chips.

a) 18-4-1 high speed steel :-

* It has 18% tungsten 4% Chromium and 1% Vanadium. It has about 0.75% C. It is an all purpose tool steel.
* Most of the cutting tools are made of thies steel.
* lathe, shaper tools, planer, drill bits, milling cutter etc.

b) molybdenum H.S.S

* This steel has 6% molybdenum, 5% tungsten, 4% chromium and 2% vanadium. It has high toughness and cutting ability

c) Cobalt H.S.S :

* It has 12% cobalt, 20% tungsten, 4% Chromium, and 20% Vanadium.
* It is also known as super high speed
* This steel is used for heavy duty rough cutting tool, like planer tools, lathe tools and milling cutter

Cast alloys (stellites)

* It is a non-ferrous cast alloy
* It has cobalt, chromium and Tungsten (CO-45% Cr-35%, Tn-15% Carbon -2%) Hardness is retained upto 100°C cutting speed is 2 time higher than high speed steel.
* stellites are used for cutting rubber and plastics.

Cemented Carbides :-

* cemented carbides are made by powder metallurgy method these withstand temp. upto 1000°C
* These are two types → straight tungsten carbides → Alloyed tungsten carbides.
* straight tungsten carbides Consists of tungsten Carbide 85 to 95% and cobalt 5 to 15%
* Alloyed Tungsten carbides have additions of Titanium and niobium etc.
* cemented Carbides used in the form of Small chips

Cutting Tool materials

* The materials used for tools must be harder than the metal to be cut and must posses wear resistance, hot hardness, high thermal conductivity low co-efficient of friction machinability
* The following tool materials are most commonly used for lathe Tools.
  1) High Carbon steel
  2) High speed steel
  3) Cast alloys
  4) Cemented Carbides
  5) Ceramics
  6) Diamond.

1) High Carbon steel :-

* This material was used for making tools
* The carbon content in this type of material is low and various from 0.8 to 1.5 percent
* The Carbon steel tools are easy to manufacture and this cutting edges can be sharpened easily
* They loose their hardness rapidly at temp. greater than 200°C
* They are particularly used in the manufacture of hard tools, like taps, files, hacksaw blades, wood working tools, knife etc.

2) High speed steel (H.S.S)

* This tool steel cuts the metal effectively even at high speeds.
* It has superior hot hardness and wear resistance.
* The cutting speeds can be 2 to 3 times higher that Carbon steels This tools steel maintenance its hardness even upto 900°C
* Carbon content is upto 0.8% the main alloying in high speed steel are tungsten, molybdenum, cobalt, chromium and Vanadium
* These high speed steels are used to make drills, turning tools, broaches, taps, dies and milling cutters.

Coated Carbides :-

* Coating of aluminium and zirconium oxides deposited on the tool surface at high temp. retard the diffusion wear of the tool.

Ceramics :-

* Tool material consists of aluminium oxide
* Aluminium oxide powder is pressed in moulds at high pressures and sintered at 2200°C
* Ceramic tools are made is tips and clamped on the metal shanks of tools
* ceramics tools have high hot hardness and high compressive strength but they are brittle
* They can't be used for operations where there is vibration and heavy chip removed.
* They can withstand temp upto 1200°c cutting speed is 40times of high speed steel
* NO coolant is needed but the tool must be very strongly supported

Diamond :-

* It is the hardest cutting material
* cutting speed is 50times higher than high speed steel
* It can resist temp upto 1250°c Diamond conducts heat quickly
* It has Low co-efficient of friction
* Diamond tipped tools are used for machining very hard materials like abrasive wheels, glass, plastic and ceramics
* max. depth of cut is only 0.125 mm.

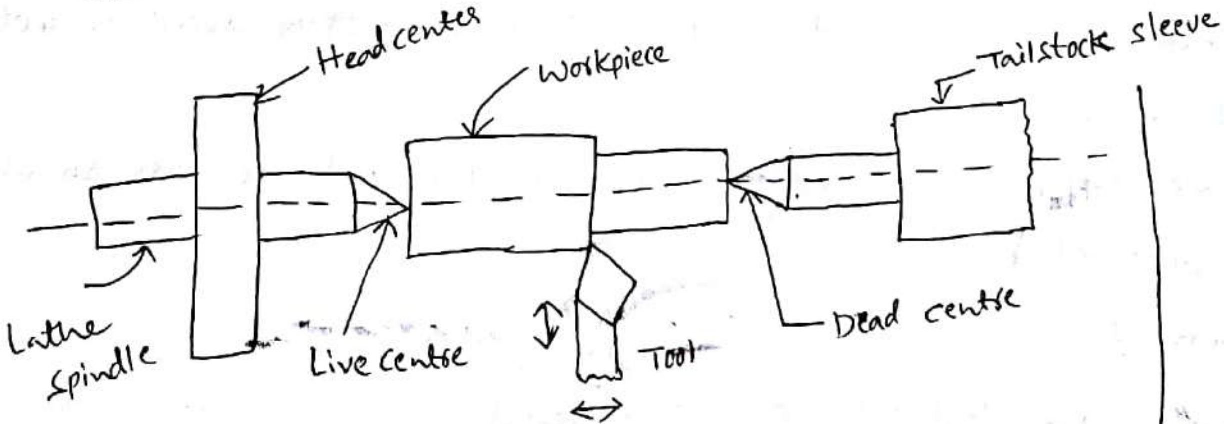
Lathe Machine

Working Principle of Lathe Machine

Working Principle

* The lathe is a machine tool which holds the workpiece between two rigid and strong supports called centers or in a chuck or face plate which revolves. The cutting tool is rigidly held and supported in a tool post which is fed against the revolving work. The normal cutting operations are performed with the cutting tool fed either parallel or at right angles to the axis of the work.

* The cutting Tool may also be fed at an angle relative to the axis of work for machining tapers and angles.



Construction :-

The main parts of the lathe are the bed, headstock, quick changing gear box, carriage and tailstock

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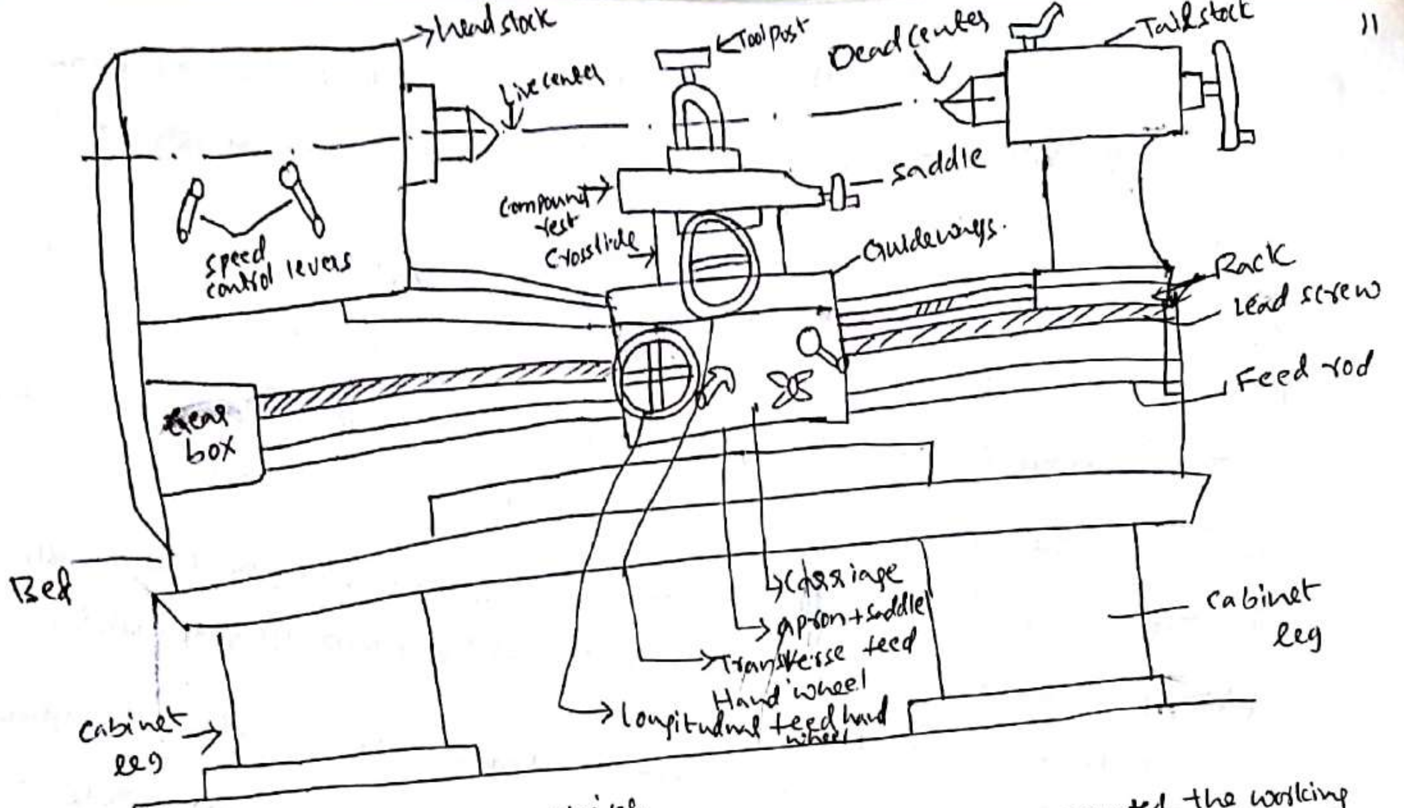


— Lathe Machine

<u>Bed</u> :- The bed is a heavy, rugged casting in which are mounted the working parts of the lathe. It carries the headstock and tail stock for supporting the workpiece and provides a base for the movement of carriage assembly which carries the tool.

<u>Legs</u> :- The Legs carry the entire load of machine and are firmly secured to floor by foundation bolts.

<u>Headstock</u> :- The headstock is clamped on the left hand side of the bed and it serves as housing for the driving pulleys, back gears, headstock spindle, live centre and the feed reverse gear. The headstock spindle is a hollow cylindrical shaft that provides a drive from the motor to work holding devices.

<u>Gear box</u> :- The quick change gear box is placed below the headstock and contains a number of different sized gears

<u>Carriage</u> :- The carriage is located between the headstock and tailstock and serves the purpose of supporting, guiding and feeding the tool against the job during operation

The main parts of the carriage are

a) The Saddle :- is an H-shaped casting mounted on the top of the lathe ways. It provides support to cross-slide, compound rest and tool post.

b) The Cross slide :- is mounted on the top of saddle, and it provides a mounted or automatic cross movement for the cutting tool.

c) The Compound rest :- is fitted on the top of cross slide and is used to support the tool post and the cutting tool

d) The Tool post :- is mounted on the compound rest, and it rigidly clamps the cutting tool or tool holder at the proper height relative to the work centre line

e) The apron :- is fastened to the saddle and it houses the gears clutches and levers required to move the carriage or cross slide. The engagement of split nut lever and the automatic feed lever at the same time is prevented she carraige along the lathe bed.

Tail stock :- The Tail stock is a movable casting located opposite the head stock on the ways of the bed. The tail stock can slide along the bed to accommodate different lengths of workpiece between the centers.

* A tail stock clamp is provided to lock the tailstock at any desired position. The tailstock spindle has an internal taper to hold the dead center and the tapered shank tools such as reamers and drills.

Lathe Operations

* The Engine lathe is an accurate and versatile machine on which many operations can be performed. These operations are

1) Plain Turning

2) Facing

3) Parting

4) Drilling

5) Reaming

6) Boring

7) Knurling

8) Grooving

9) Threading

10) Forming

11) Chamfering

12) Filling and polishing

13) Taper Turning.

Types of lathe

1) Engine lathe (or) Centre lathe

a) Belt drive

b) Individual motor drive

c) Gear head lathe

2) Speed lathe

a) wood working lathe

b) Centering

c) polishing lathe

d) metal spinning

3) Bench lathe

4) Tool room lathe

5) Capston and Turret lathe (semi-automatic lathe)

6) Automatic lathe

7) Special purpose lathe

a) Wheel lathe b) Gap bed lathe c) T-lathe d) Duplicating lathe

e) missile lathe.

8) copying lathe

Classification of single Point lathe tools

1) According to the direction of feed

a) Right hand tool   b) left hand tool

2) According to the method of manufacturing the tool.

a) Solid tool   b) Brazed tool   c) Inserted or Bit tool

3) According to the method of using the tool

Turning Tool — Rough Turning tool
Finish Turning tool.

* Chamfering tool

* External thread cutting tool

* Internal thread cutting tool

Facing tool

Forming tool

Grooving tool

Boring tool

Counter boring tool

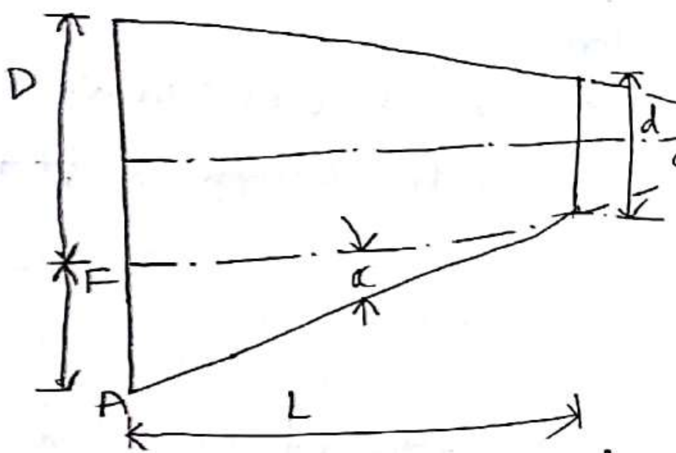
Under cutting tool

Parting off tool

Round nose tool.

Taper turning

* A large Variety of components used In Engg. Practice is found to have conical shapes or if that having a gradual reduction in width or thickness along their length such components are known as tapered.
* For Conical Pieces the difference between the diameters of their ends is known as taper and for flat pieces the different between the widths or thickness of their end is known as taper.
* Parts may have external or internal taper according to the requirement



* D is the diameter of the large end and 'd' of the small end of the tapered piece.

L represents the total length of the tapered piece.

* Total taper of the job is $D-d$
* Taper length of the job i.e, $\text{Taper} = \dfrac{D-d}{L}$

Tapers and taper turning:

A Taper may be defined as a uniform increase or decrease in the diameter of a Piece of work measured along its length

Inch tapers:- are expressed in taper per tooth (tpt) or taper per inch (tpi)

$$tpf = \frac{(D-d)\times 12}{T.L}$$

metric tapers are expressed as a ratio of 1mm per unit of length.

* A Taper provide a rapid and accurate method of aligning machine parts and an easy method of holding tools such as twist drills, lathe centers, holding tools such as twist drills lathe centres, reamers.

Classifies tapers used on machines and tools as

1) self - holding tapers
2) self - releasing tapers (or) step tapers

* self holding tapers are those that remain in position due to the wedging action of the taper
* steep self relasing tapers such as those used on milling machine arbors and accessories are held in the machine by and row bolt and are driven by keys.

Taper turning methods.

Taper may be turned by any one of the followed method.

1) By a broad nose form tool
2) By setting over the tail stock centre
3) By swiveling the compound rest
4) By Taper turning attachment
5) By combining longitudinal and cross feed in a special lathe.

Lathe attachments

* These are a number of attachments used on lathe to increase efficiency and production.

The commonly used attachments are.

a) stops b) Grinding attachment

c) milling attachment d) Taper turning attachement

e) Copying attachment f) Relieving attachment.

Stops : These are used on the carriage and the cross slide to position them accurately. These are used for repeated accuracy. These are used for repeated works. These stops save set up time and given more accurate works.

Grinding attachment :-

A special grinding attachment is mounted on the cross-slide of the lathe. Both the grinding wheel and job are rotated during grinding. For grinding external surface. the w/p is revolved b/w centers. for internal grinding.

The w/p is revolved in a chuck or plate. longitudinal feed is given by the carriage. Depth of cut is given by the cross slide.

milling attachment :

milling operation can be done on the lathe using a milling attachment

It is done by 2 methods

1) The milling cutter is held in a chuck and rotated. The work is supported on the cross slide by a special attachement.

* The depth of cut is given by vertical adjustment of work given by the attachment. This method is used for cutting keyways or grooves.

2) The work is supported b/w centers and does not rotate. the milling attachment is mounted on the carriage. The cutter is driven by a separate motor

* The feeding is given by the carriage. The cutter can be moved vertically in the attachment.

Taper turning attachment :-

* This is used for producing tapers on cylinders, various attachments like copying attachment, relieving attachment, etc. can be used on a lathe.

Capstan and Turret lathes

In any ordinary centre lathe, generally cylindrical components are produced we have to change the tool every time when a new operation is to be done. When a large number of identical components are to be produced an ordinary lathe is not suitable.

* The changing and setting of tools will take more time
* The rate of production will be very low, also the cost of production will be high
* The rate of production can be increased by reducing the time spent in changing and setting the tool. This is done by a single setting of tools. more than one tool (multiple tools) can be applied at a time.
* capstan and turret lathes have these facilities. These lathes are called semi - automatic lathes.
* these operations like loading, feeding of bar stock, bringing the different tools to correct position are done manually.

Types of capstan and turret lathes

* The operations are done automatically but the loading and unloading operations are done manually.

1) Turret or saddle type lathe
2) Capstan or ram type lathe.

these two construction and working principle of the lathes are same.

Turret lathe is meant for large and heavy jobs

capstan lathe is meant for light and small jobs

Main parts of Capstan and turret lathe (or) Semi automatic lathes

Depending on the position of the turret lathes are classified into 2 types

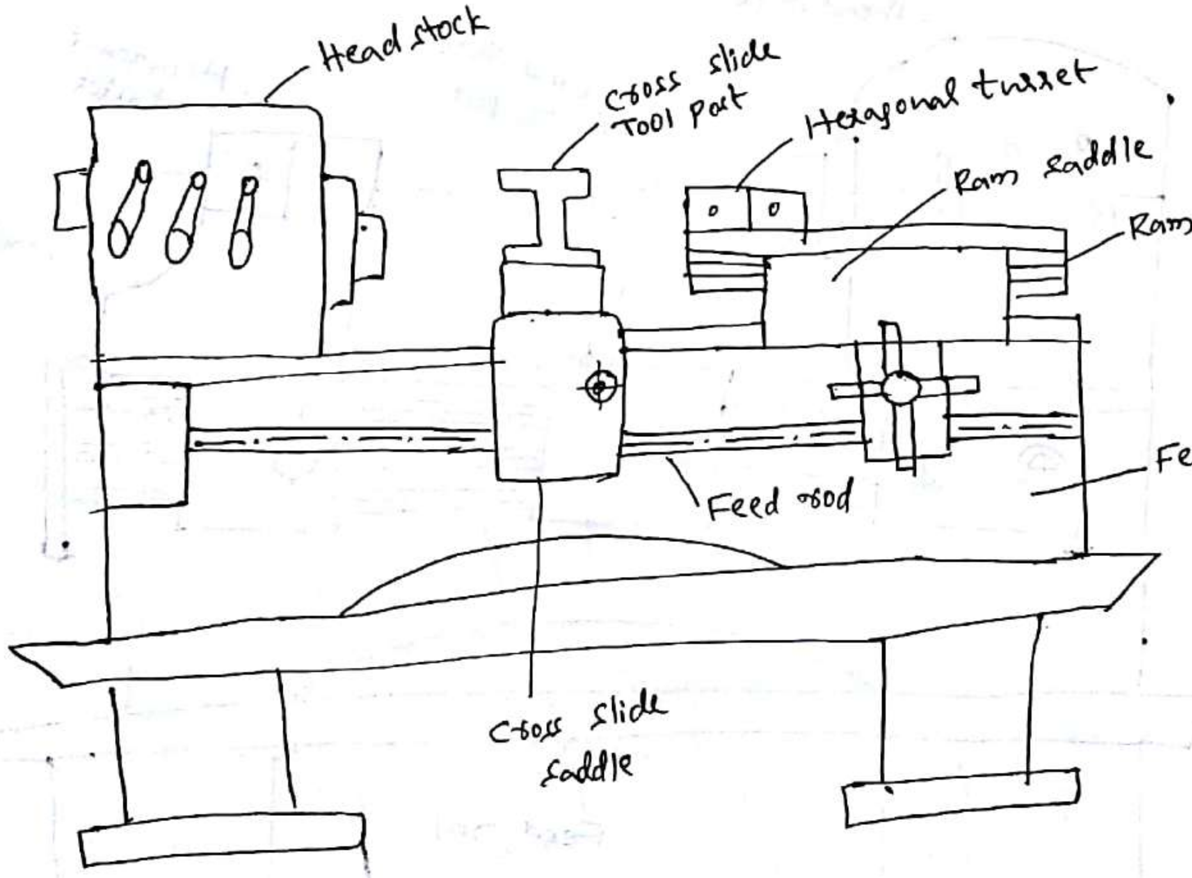
1) Horizontal turret lathe
2) vertical turret lathe.

The commonly used horizontal turret lathe are further classified as

i) The ram type turret lathe or capstan lathe
ii) The saddle type turret lathe or combination turrets.

Main parts of capstan and turret lathes

1) Bed
2) Head stock
3) Turret heand and saddle
4) cross slide.



—Capstan lathe

Bed: The bed forms the base of the machine. It is made of cast iron. It is rigid enough to absorb vibrations and with stand cutting forces. the bed has machined guideways on its top. at one end of the bed, head stock is mounted. at the other end. a saddle moves over the bed. The Tailstock in an ordinary lathe is replaced by a saddle in turret and capstan lathe

Cross slide is mounted on the bed b/w head stock and saddle.

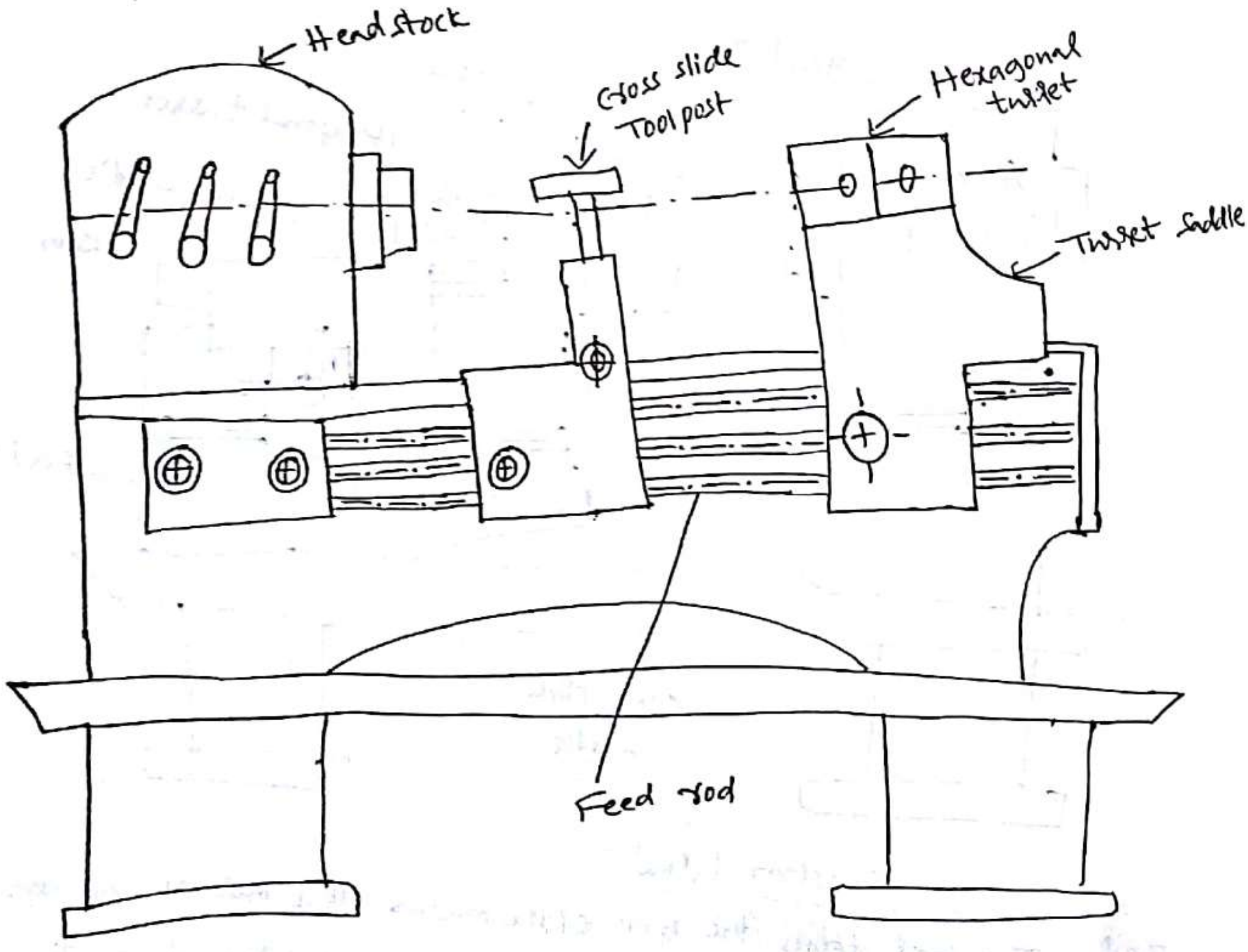
Head stock :-

The head stock is similar to that at an ordinary centre lathe But here it is larger and heavier in construction. a more powerful motor is provided.

The spindle speed ranges from 30 to 2000 rpm

The different types of head stock generally used as.

1. Step-cone pulley head stock
2. Electric motor driven head stock.
3. All geared head stock
4. Pre-optive or pre-selective head stock.



— Turret lathe

Automats

Machines capable of handling the work piece as well as performing the metal cutting operations automatically are known as automatic machines.

Various methods used for achieving automation in machine tools.

1) The feeding arrangements, like feed hoppers and strip feed rolls

2) Incorporation of cams and mechanical movements.

3) Special purpose machines designed specifically for these operations.
i.e, gear shaper, gear hobber, broaching machines.

4) Transfer machine system.

Classification of Automats

1) According to the type of work materials used
   a) Bar stock machine
   b) chucking machine
2) According to the number of spindles
   a) single spindle machine
   b) multi spindle machine
3) According to the position of spindles
   a) Horizontal spindle type
   b) vertical spindle type
4) According to the use
   a) General purpose machine
   b) single purpose machine.
5) According to the feed control.
   a) single cam shaft rotating at constant speeds
   b) single cam shaft with two speeds
   c) Two cam shafts.

Bar stock machine :-

→ Hense collects are used for holding the work.

→ The work material in the form of bar (or) Pipe stock.
Components like screws, nuts, studs, bushes, rings, etc.

Chucking machine :-

→ These machines are used for producing components in the shape of separate blanks.

→ The blanks may be forgings and casting.

Single spindle machine :-

→ These machines, machine one component at a time as they have only one spindle. Automatic cutting off machines and Swiss type machine belong to this type.

Multi spindle machine

These machine have 2 to 8 spindles, But 4 & 6 spindle machines are commonly used. operations are performed simultaneously in all the spindles. Hence the rate of production is very high.

These are two types

1) Parallel action type
2) progressive action type.

Horizontal spindle type :-

These machines, have their spindles in a horizontal direction
These are used for machining long jobs of small diameter.

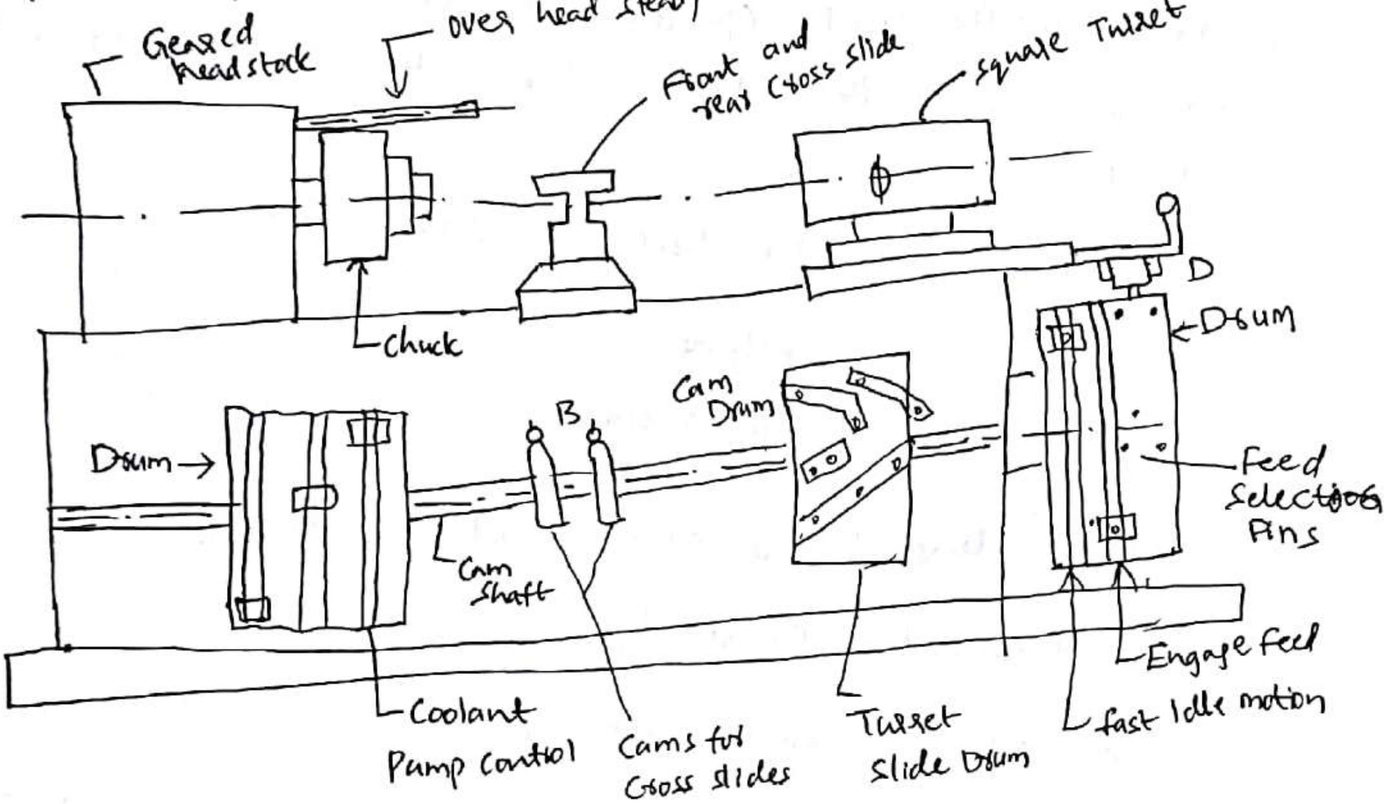
Vertical spindle type :-

→ These machines have their spindles in a vertical direction.

→ They occupy less floor area.

Single spindle automatic lathe

These machines, machine one component at a time as they have only one spindle.



* The lathe has a generated head stock
* The spindle of the head stock has one slao speed.
* At the end of the bed, a square turret is provided.
* Two cross slides are situated b/w head stock and the turret.
* One cross slide is at the front and the other at the rear slide.
* The cross slides have independent movements.

The following types of single spindle automatic lathe are mostly used

1) Automatic cutting off machine
2) Automatic screw cutting machine
3) Swiss type automatic screw machine.

Multi spindle automats

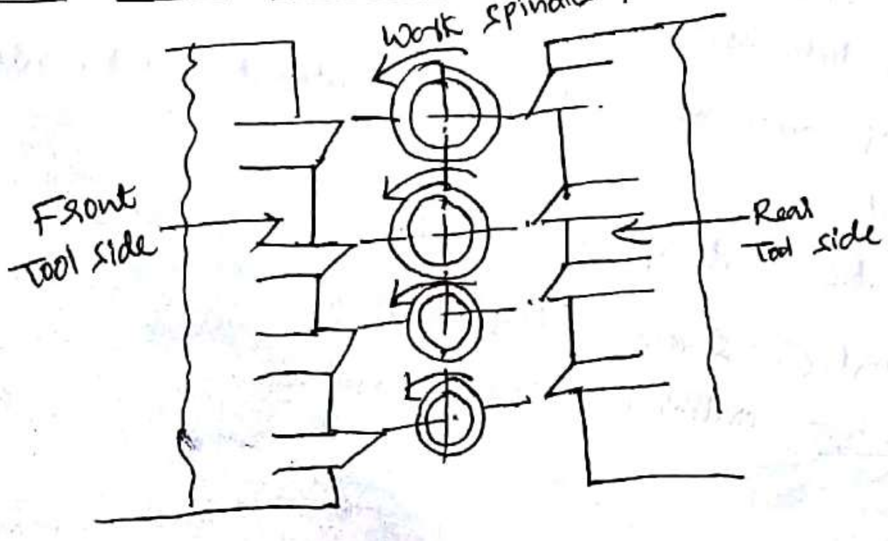
* These machines are the improved type of single spindle automats They have 2 to 8 spindles. But 4 and 6 spindles are generally used. Operation are carried out simultaneously in all the spindle. Hence the rate of production is very high.

1) According to the type of workpiece used
   a) Bar type machine
   b) chucking type machine

2) According to the arrangements of spindle
   a) Horizontal spindle type
   b) verticle spindle type.

3) According to the principle of operation.
   a) parallel action type
   b) Progressive action type

Parallel Action multi-spindle



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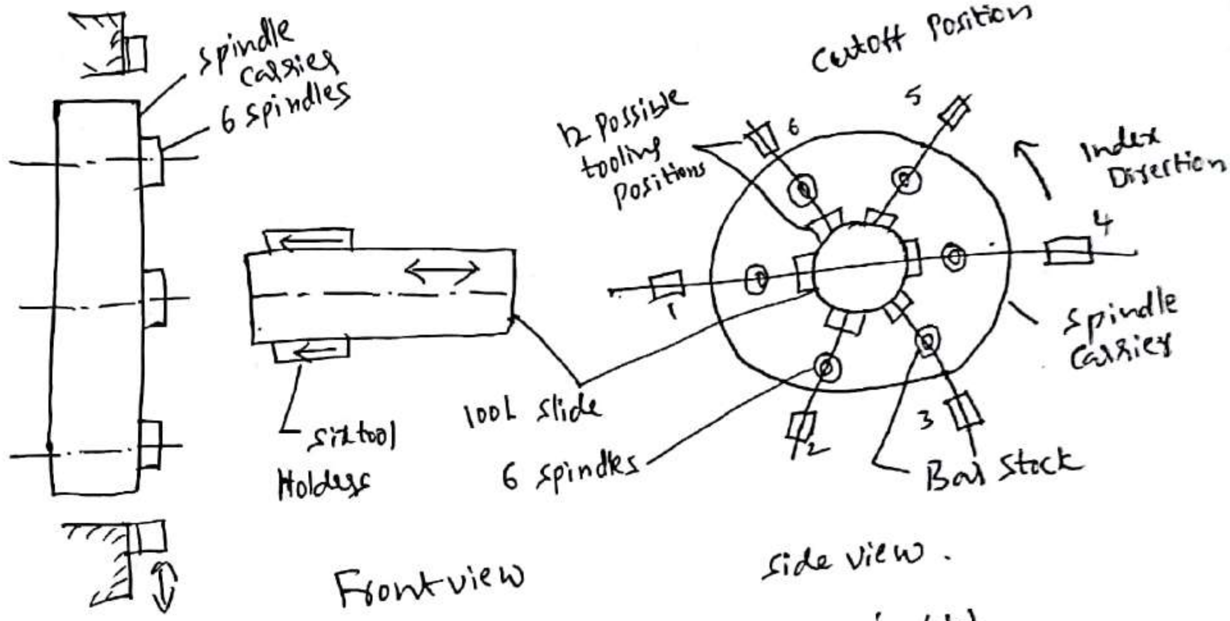
Progressive Action Multi-spindle Machine



→ The multispindle machine rate of production is high

→ machining accuracy is low.

→ Indexing of spindle take place through 90° to 60°.

Tool layout :

* Standard tools should be highly used for small batches of work
* special tools must be used for large quantities of work, which minimizes machining time and ~~retain~~ cutting qualities for large period.
* overlap working operations, whenever required.
* Provide a finish cut with a single tool.
* Use centre drill before drilling small diameter holes. This results in better drill axis location and smooth drilling.
* Holes should be extended in diameter and finished by boring tool.
* Contour surface is to be obtained in two cuts ~~rather~~ than in single cut.

Unit - II

Drilling :-

* It is the Process of making Cylindrical holes in a workpiece, by means of rotating cutting tool called drill
* It is used for making holes, whereas boring and reaming is used for enlarging and finishing respectively.
* The drill used for drilling is a multipoint cutting tool having one or more flutes for the passage of chips and cutting fluid.
* The cutting tool is fed along its axis of rotation. The w/p is held stationary, during the process.

Types of Drilling machine

Drilling machines are made in many different types and sizes, each designed to handle a class of work or specific job to the best advantage.

1. Hand drilling machine
2. Portable drilling machine
3. sensitive drilling machine
   a) Bench mounting
   b) Floor mounting.
4. Upright drilling machine
   a) Round column section
   b) Box column section
5. Radial drilling machine
   a) plain radial drilling machine
   b) semi universal radial drilling machine
   c) Universal radial drilling Machine
6. Gang drilling Machine or straight line type
7. multiple drilling machine

8. Deep – hole drilling machine

i) vertical type

ii) Horizontal type

9. Turret drilling Press

10. N.C. drilling machine

11. Automatic drilling machine.

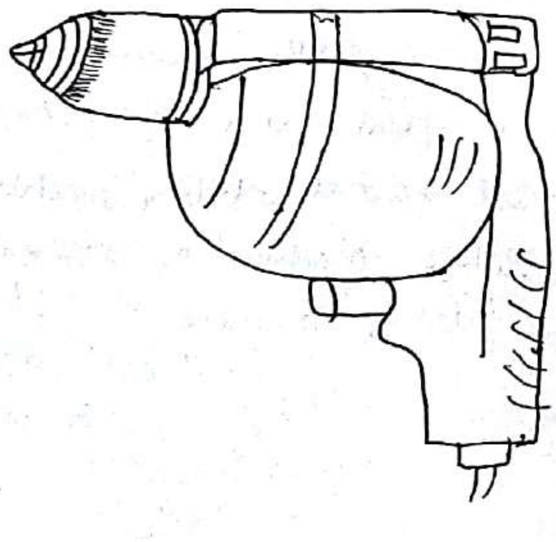
12. Micro or miniature drilling machine.

1) <u>Hand drill</u>

Hand drill is used for drilling small holes. the handle of the hand drill is held in the left hand while the right hand turns the crank which in turn causes the drill to rotate.

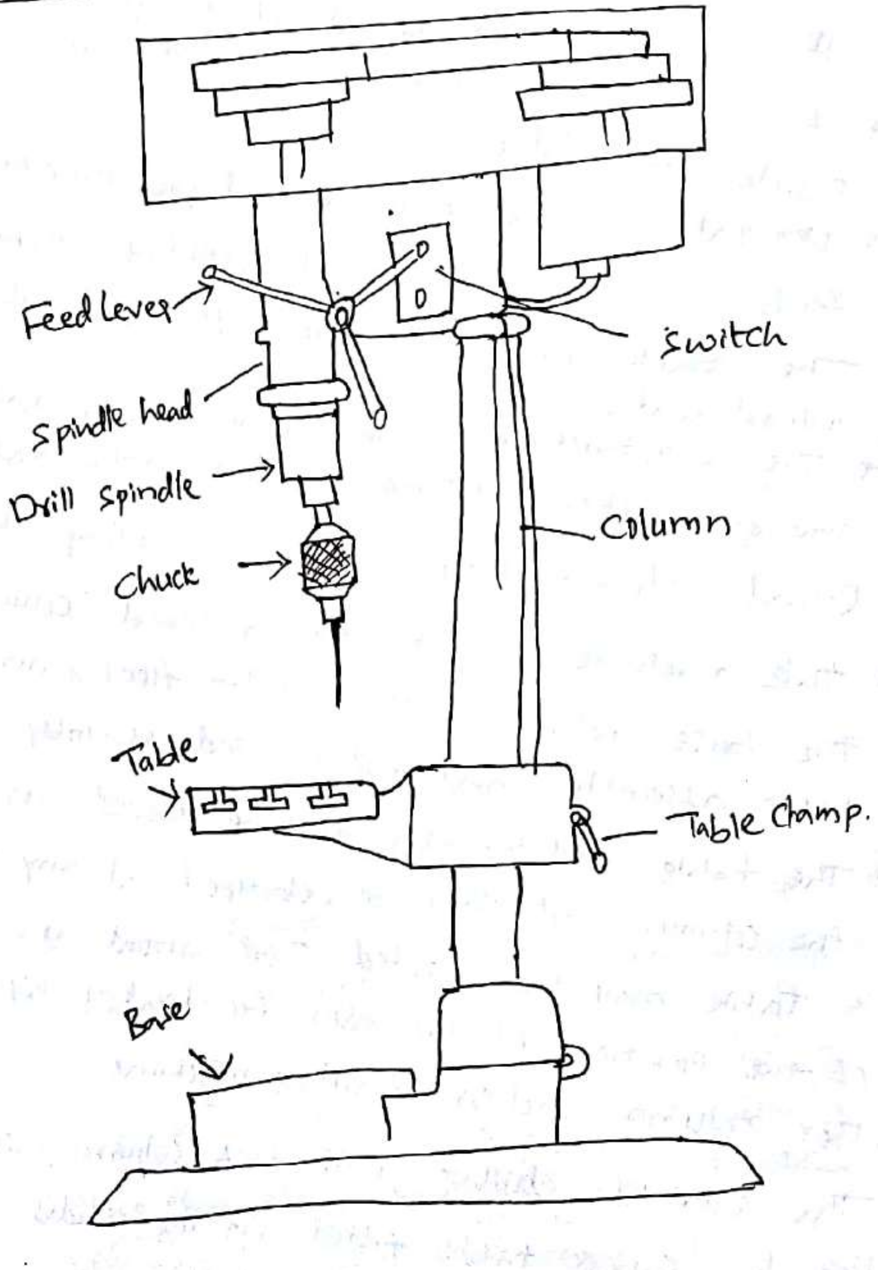
— Hand drill.

2) <u>Portable Drilling machine</u>



* This is small and compact. It is used for drilling holes in any position. These machines are used for drilling holes upto 18mm diameter.
* Some of the portable machines are operated by hand power, but most of the machines are driven by individual motor. Both A.C and D.C. power used.
* Some of the portable machines are driven by pneumatic power.

Sensitive drilling machine



* Hand feed permits the operator to feel or sense the progress of the drill into the work. So that if the drill becomes worn out or jams on any account, the pressure on the drill may be released immediately to prevent it from breaking.

* As the operator sense the cutting action, it any instant is called sensitive drilling machine
* This machines are capable of rotating drills of diameter from 1.5 to 15.5mm.
* Super sensitive drilling machines are designed to drill holes as small as 0.35mm in dia. The machine is rotated at a high speed of 20,000 rpm or above.

Upright Drilling machine (Single spindle)

* It is also known as standard, vertical or pillar drilling machine and has back gearing arrangement
* It is used for heavier work similar to a lathe.
* Upright drilling machine a large number of spindle speeds and feeds may be available for drilling different types of work. The table of the machine also have different types of adjustments.
* The construction is similar to a sensitive drilling machin for having a vertical column mounted on the base.

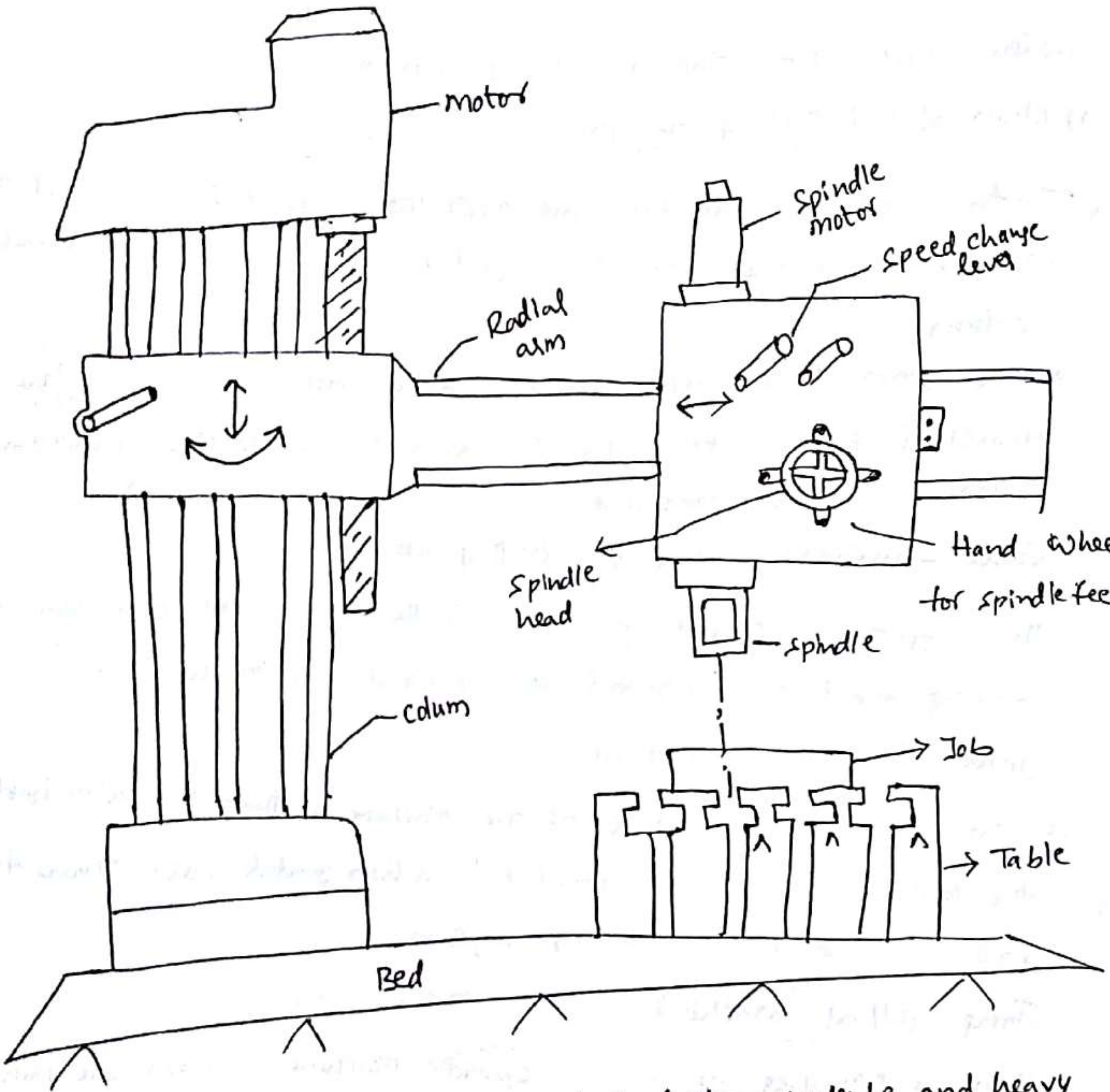
Round column section (or) Pillar Drilling machine

* This machine consists of a round column that rises from the base which rests on the floor, an arm and a round table assembly, and a drill head assembly.
* The table and the arm may be moved in an arc upto 180° around the column and may be clamped at any position
* Table may be rotated 360° about its own centre independent of the position of the arm for locating w/p under the spindle.

Box column section Drilling machine

* The upright drilling with box column section has the square has the square table fitted on the slides at the front face of the machine column.
* These special features permits the machine to work with heavier w/p and holes more than 50mm in dia. can be drilled by it.

Radial drilling machine :-



* The radial drilling machine is used for drilling moderate and heavy workpiece. It consists of a single spindle which handles a large and heavy work
* A radial drilling machine esentially consists of a base, column, radial arm, motor for elevating the arm, elevating screw, guideways, motor for driving the drill spindle, drill head and table.
* The arm may be swung around to any position over the workbed The drill head containing mechanism for rotating and feeding the drill is mounted on a radial arm and can be moved horizontally on the guide-ways and clamped at any desire position.

* The maximum size of holes that the machine can drill is not more than 50 mm

Various Types of radial drilling machines

1) Plain Radial Drilling machine

* In this machine provision are made for horizontal, vertical and circular movement of the arm in horizontal plane about the vertical colum

* The plain type only three movements are catered for, the semi universal type caters for 4-movements. while the universal system has five movements.

Semi - universal radial drilling machine

The fourth movement provided is that the drill head can be swung about or horizontal axis perpendicular to the arm.

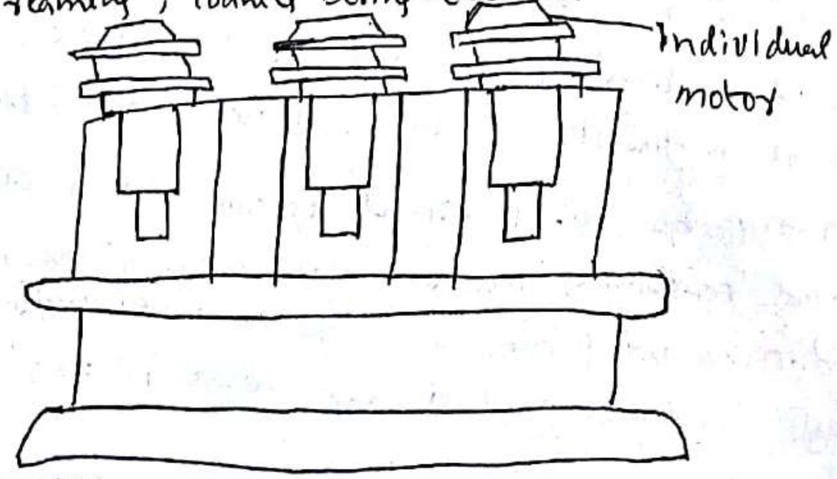
Universal drilling machine

* The additional feature of the machine is that the arm holding the drill head may be rotated in a horizontal area. Thus the w/p may be worked at any angle.

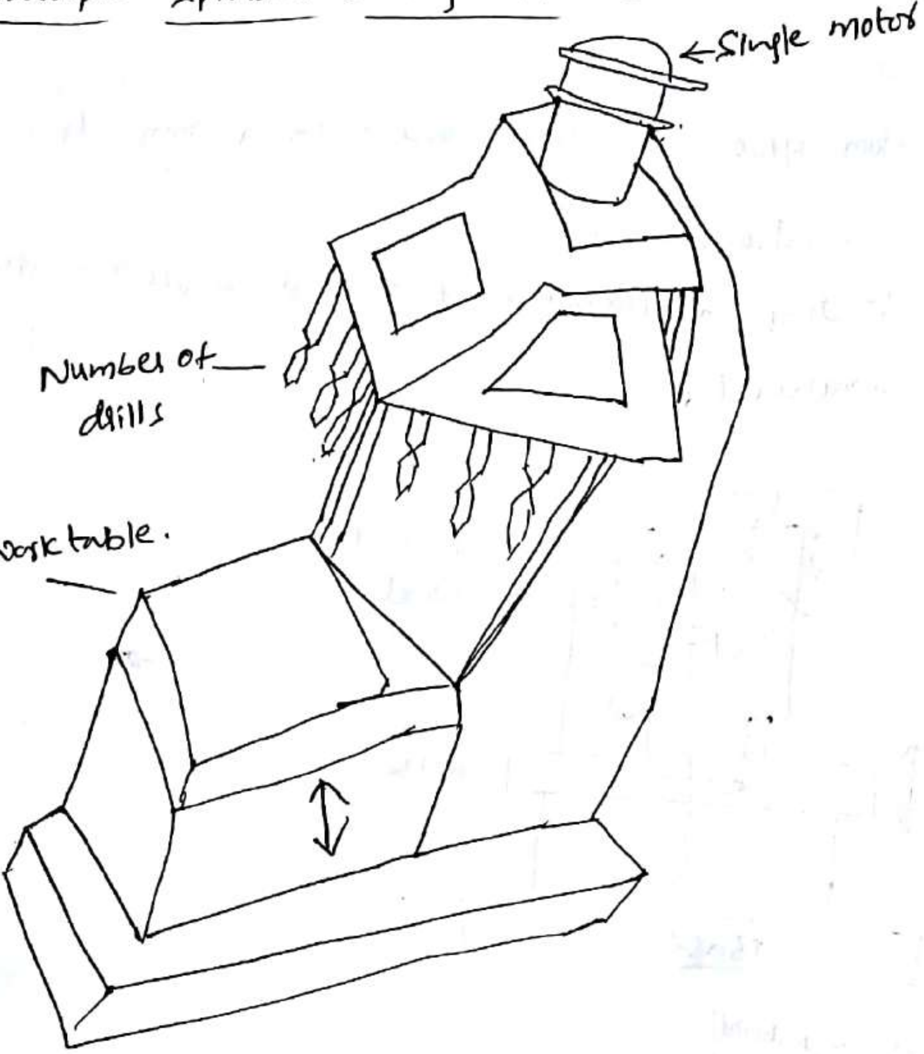
Gang drilling machine :-

When a Number of single spindle machine column are placed side by side in a common work table the machine is known as gang drilling machine.

* This machine is used for a workpiece having several operations such as drilling, reaming, counter boring etc. for drilling holes of several different size.



Multiple spindle drilling machine



→ this machine has multiple spindle on a single head. It is a verticle type. the function of multi spindle drilling machine is to drill a number of holes in a piece of work simultaneously and to reproduce the same pattern of holes in a number of identical pieces in a mass production.

* Drill jigs are sometimes used to guide accurately into the work.

Deep hole drilling machine

* very long holes of relatively ~~...~~ smaller diameter are required to be drilled these machines are used. such as in rifle barrels and long spindles
* The machines can be obtained both in (i) vertical (ii) Horizontal type, according to the requirement. In these machines is provided a head stock and a carriage.
* The work is mounted b/w these two and the carriage carries the drill. on the headstock side, the work is supported on a spindle which is also rotates.

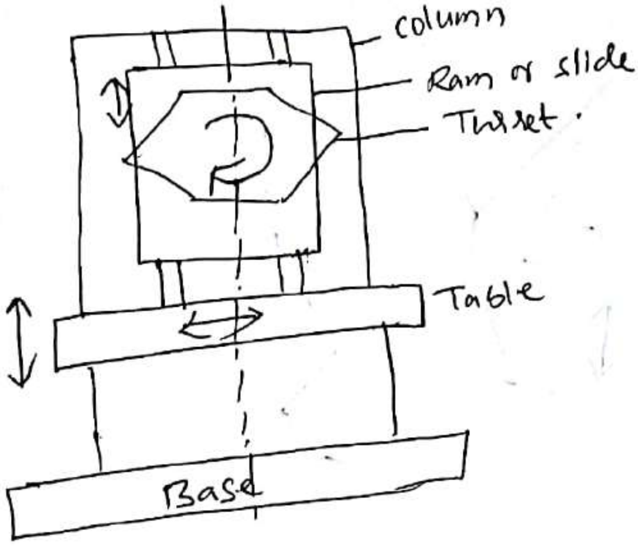
* A sectional (enlagged) view of the cutting area.

Turret drilling Press

Overcomes the floor space restriction caused by a gang drill Press

Numerical control is also available.

This (Fixtures) enables loading and unloading of one Part while the other Part is being machined.



NC (Numerically (controlled) drilling Machine :-

* This is the latest type of drilling machine. In this machine, the table is positioned with the help of numerical controls so as to locate the work accarately under the drill.

Programmed tape is used.

Specification of Drilling Machine

* It is depends on the type of machine
* small portable drilling machine is specific by the max. diameter of drill that can be hold, where as the sensitive and upright drilling machine are specified by largest dia. of w/p that can be centered under spindle

* A sectional (enlarged) view of the cutting area.

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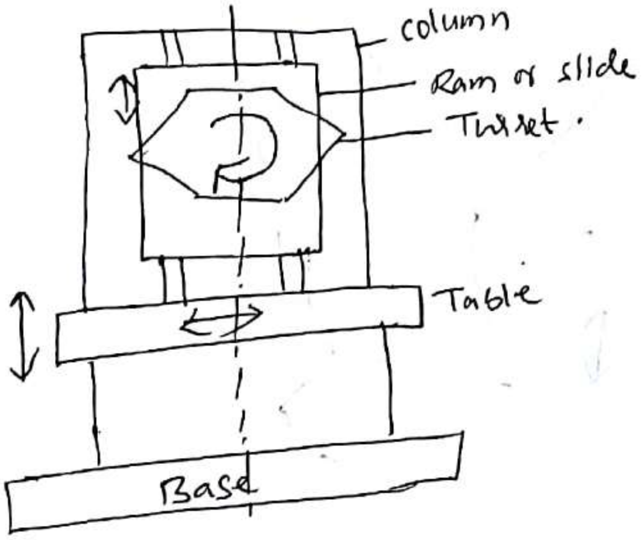

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Drilling operations

* with the use of various cutting tools, a variety of operations can be performed on drilling.

1) Drilling
2) Reaming
3) Boring
4) Counter boring
5) spot facing
6) Lapping
7) Tapping
8) Counter sinking
9) Trepanning.

Drilling :- Drilling is the process of producing a cylindrical hole, by means of a rotating tool called drill.

Reaming :- It is an accurate method of sizing and finishing a drilled hole. The speed of the spindle is taken as half of the speed in drilling and then feed is given.

→ It is provided with multiple cutting edges.

Boaring :- It is the process of enlarging a drilled hole. It also finishes a hole, machines the internal surface of a hole and corrects the location of the hole by means of a single point tool.

→ This operation Perform on drilling machine.

Counter boring :- It is the process of enlarging the end of a hole cylindrically. The tool used for this purpose is called counter bore.

→ Counter bore is a piloted, cutting tool having two or more cutting teeth, flutes which may be straight or helical for inlet of cutting fluids and for flow of chips.

Spot facing :-

It is an operation of squaring and smoothening the surface around a hole for providing the seat of a nut.

Lapping :- It is an operation of sizing and finishing a hardened small hole by removing a small amount of material the tool used for this operation is called lap.

Tapping :- It is an operation of production internal threads. The tool used for this operation is called tap and is similar to a bolt with threads on it.

Counter sinking :-

It is an operation of producing a cone shape enlargement of the end of a hole. The tool used for this process is called counter sink.

Trepanning :-

It is an operation of producing an annular groove with a solid cylindrical core in the centre. The tool or cutter consists of one or more cutting edges along the circumference and is operated at higher speeds.

Specifications of Drilling machine

→ A drilling machine is specified based on the type of machine and the workpiece. The various specifications are

* Maximum diameter of ~~workpiece~~ the drill bit to be held for portable drilling machine.

* Maximum diameter of workpiece that can be drilled for sensitive and upright drilling machine.
* Length of arm and column diameter for radial drilling machine
* Drilling area, size of hole and number of holes for multiple spindle drilling machine

In british system, there are 3 different range of sizes used for specification ie,

Number sized Drill

The standard set of number sized drill consists of 60 drills. Numbering 1 to 60. In this drill series, higher the number, smaller is the drill size and vice versa.

Ex:- diameter of NO-1 drill measures 0.228" and of NO-60 measures 0.04.

Letter sized Drill

The standard set of this series of drills are designated by letters from A to Z, in which Z represents the largest size and A represents the smallest.

Fractional sized Drills

In this series, the drill starts from $\left(\frac{1}{64}\right)''$ upto 5" in diameter and drill $\left(1\frac{3}{4}\right)''$ the size is uniform in steps of $\left(\frac{1}{64}\right)''$ and beyond this, it varies.

* Maximum diameter of workpiece that can be drilled for sensitive and upright drilling machine.
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Boring

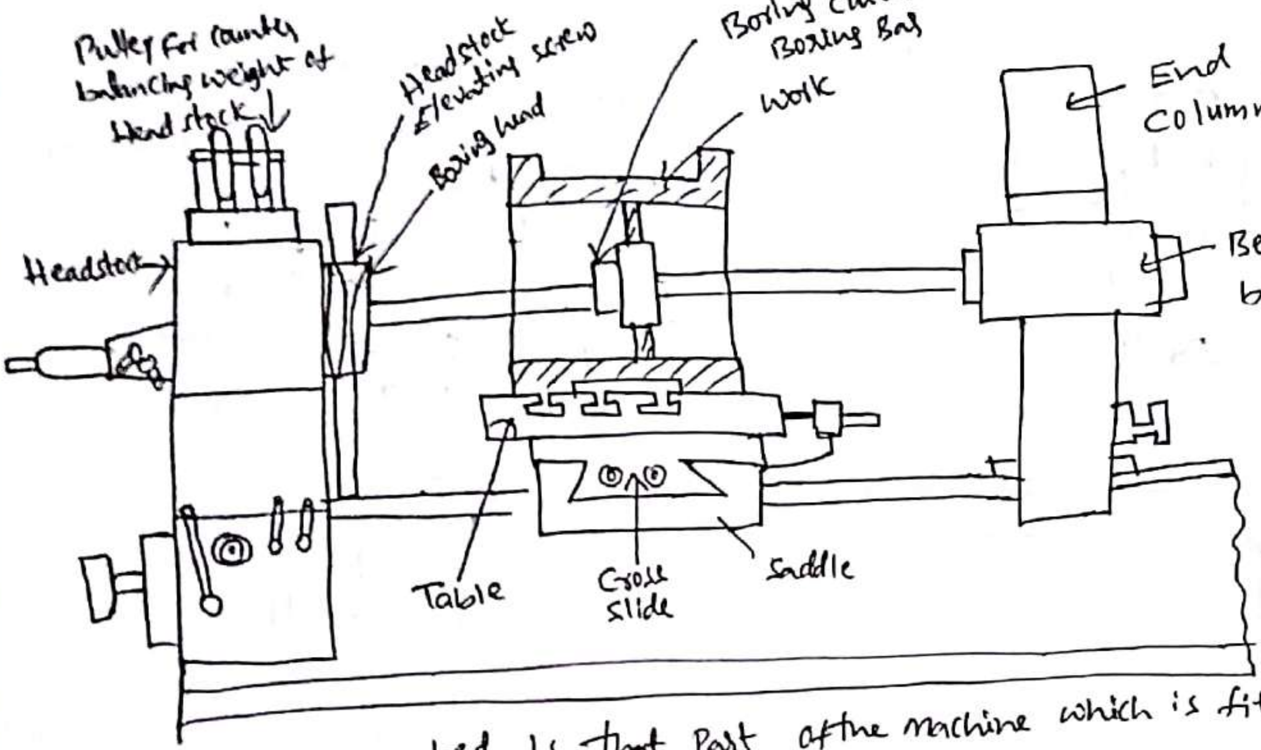
It is the process of enlarging an existing hole, which may be drilled, punched or produced in casting or forging. It gives required size and better finish to the hole and also corrects the hole location.

As compared to reaming, boring gives high accuracy of about ±0.0125 mm.

Types of Boring Machines

1) Horizontal boring machine [HBM]
   a) Table type HBM
   b) Floor type HBM
   c) planer type HBM
   d) multiple head type HBD
2) Vertical boring machines
   a) vertical turret lathe
   b) standard vertical boring mill
3) Fine / precision boring machine
   a) Horizontal type
   b) vertical type
4) Jig boring machines
   a) vertical milling machine type
   b) planer type jig boring machine.

Horizontal Boring Machine (HBM)



Bed :- The bed is that part of the machine which is fitted on the floor of the shop and has a box like casting.
The bed supports the columns, tables and other parts of the machine.

Head stock supporting column :- the column provides supports to the head stock and guides it up and down the guide ways provided on the face of the column.

End supporting column :- The end supporting column situated at the other end of the bed houses the bearing block for supporting a long boring bar.

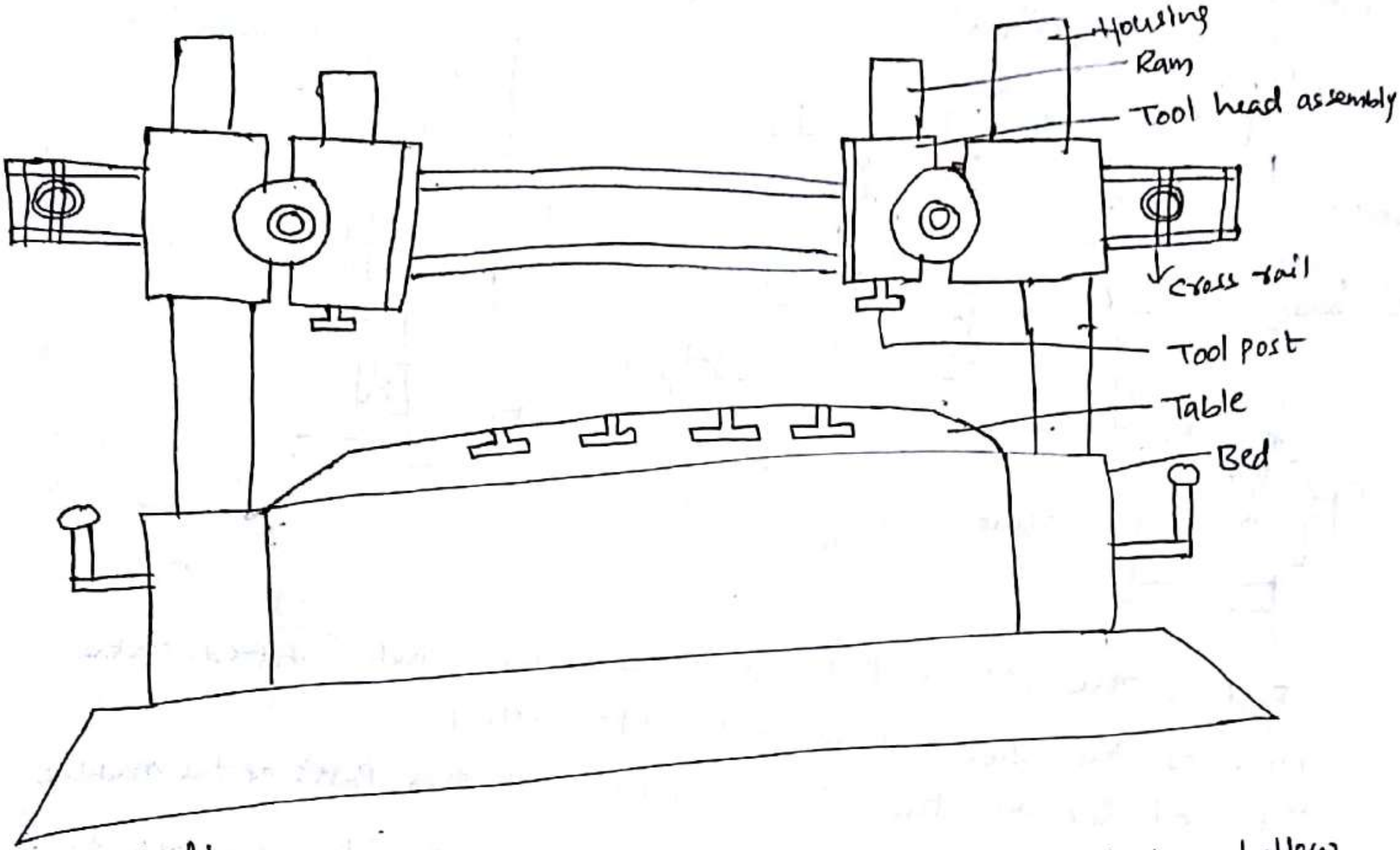
~~Housing :- Two vertical members known~~

Column Base :- It supports the Column and houses the various gear and drive mechanism's

Saddle :- The movement of the table at right angles to the spindle is provided with saddle. It supports and guides table.

Headstock :- The Headstock guides and feed the cutting tool. The machine spindles are also housed in it. ~~Depe~~
The fast moving spindle is used for light operations
The slow moving spindle is used for heavy operations.

Vertical boring machine (VBM)



Bed:-

It is the bottom most part of the machine, which is a hollow circular casting attached to the floor. The table is attached to the top of the bed. Spindle and pinion are housed in the bed for rotating the table

Table:- The workpiece is clamped on the horizontal surface of the table, by means of T-slots or chuck jaws. In small machines. bevel gear is provided underside of table, which meshes with driving pinon.

Housing:-

Two vertical members known as housings are mounted along the two sides of the bed, to ensure the rigidity of the machine. The front of housing is provided with guideways on which cross-rail slides

Crossrail:- The horizontal element mounted on the two front faces of the housing, Rotation of screws makes the crossrail to move up and down for work of various heights.

Tool Head assembly

It consists of saddle, ram and tool post. the saddle slides on the cross rail, to produce flat horizontal surface by the tool. the movement of arm takes place in the saddle at any angle of perpendicular to table, to produce tapes and cylindrical surfaces.

Specifications of Boring Machines

Specifications of a horizontal boring machine

1) Type of Machine
2) Maximum travel of the spindle
3) maximum travel of table in longitudinal and cross direction, If it is a table type machine
4) spindle speeds and feeds
5) max. allowable weight of workpiece.
6) power of electric motor.
7) Height of columns
8) size of table or floor plate, as the case may be.
9) Cross weight of the machine.
10) Floor space required

Specifications of a vertical boring machine

Distance from spindle axis to spindle head = 270 mm

Distance from spindle axis to column ways = 340 mm

Distance from spindle axis to table minimum = 30 mm

Distance from spinde face to table maximum = 580 mm.

max. vertical travel of spindle head = 550 mm

No. of interchangeable spindles = 3

Diameter of inter changeble spindle = 62, 78, 120 mm

Working surface of table = 1000 X 500 mm

Max. table travel – longitudinal = 800 mm

cross = 50 mm.

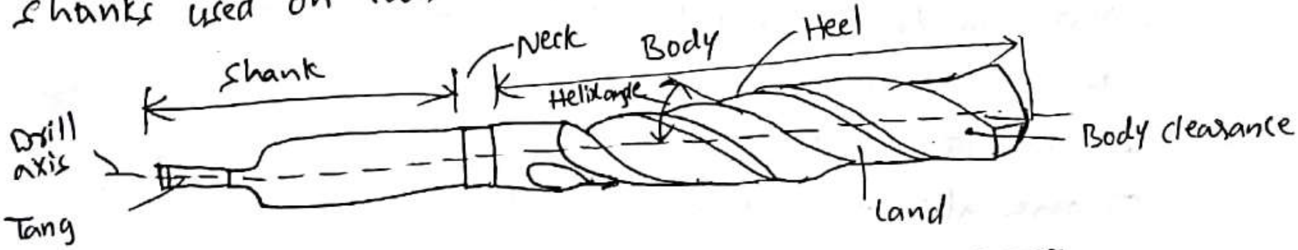
No. of spindle speeds = 6.

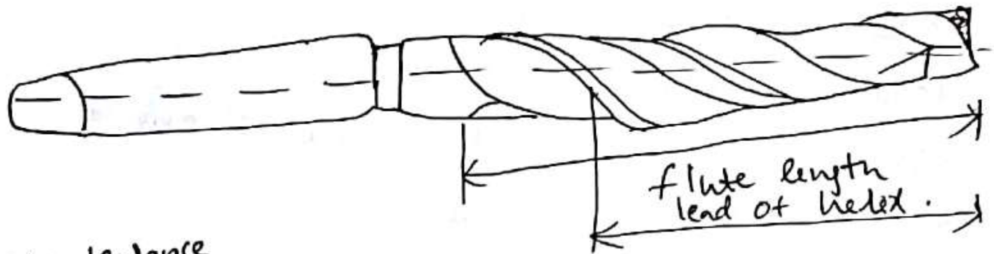
Twist drill

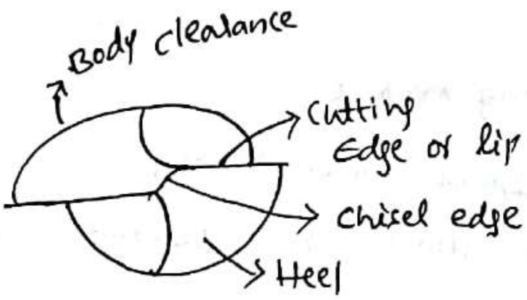
→ The most common type of drill in used today is the twist drill. It was originally manufactured by twisting a flat piece of tool steel longitudinally for several revolution, then grinding the diameter and the point.

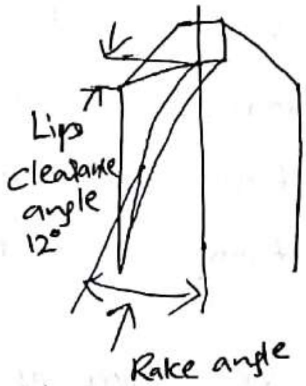
→ Twist drill is an end cutting tool. shank, length of the flute and overall length of the drill. Small drill say upto 12.7 mm dia.

→ most is commonly used for the tapered shank, other types of shanks used on twist drill an bit shank and rachet shank.

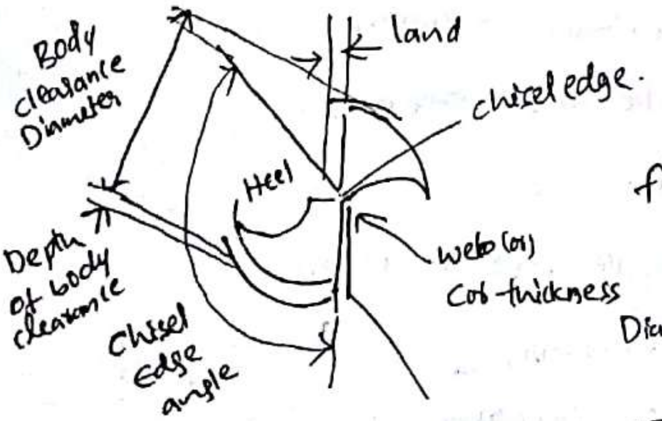


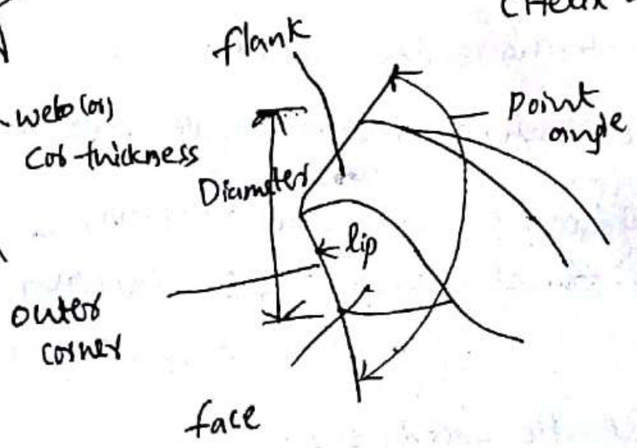






(Helix angle at periphery) 30°





Shank :- The shank is the part of drill, which is held in machine spindle and driven by it

Tang :- It is the flattened end of a shank, intended to fit into a slot in the drill holder

Neck :- It is the reduced Portion b/w body and shank

Body :- It is the fluted portion of a drill

Flutes :- Helical grooves formed in the body of drill are called as flutes.

Web :- The central portion of the body, which separates the flutes and run through entire length of drill

Cutting lip or Edge :-

The edge formed by intersection of flank and face, and correspond to the cutting edge of a single point tool.

Land :-

The cylindrical ground surfaces on the leading edges of a drill flutes.

Body clearance :-

The diameter over the surface of the body, which is situated behind the land

Margin :-

Narrow surface along the groove which keeps the drill aligned is called as margin

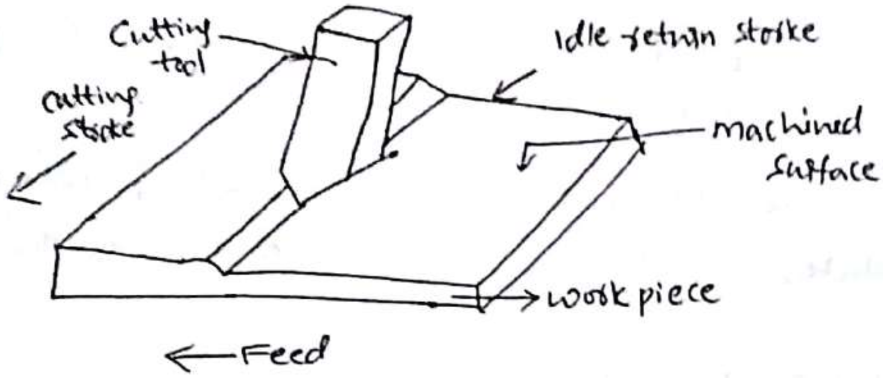
Heel :-

The Edges formed by the intersection of flute surface and body clearance is known as heel.

Shaper :-

Shaper is a machine, used to produce flat surfaces, which can be horizontal, vertical or inclined. The advantage of this machine is flexibility in quick adjustment and easy work holding devices. It uses a single point cutting tool.

Working Principle of shaping machine



* A single point cutting tool is used, which reciprocates over the workpiece that is held stationary in a vice, clamped on the machine table
* The cutting tool is held, in the tool head mounted on the ram

The reciprocating action of the ram in the forward stroke (cutting stroke) cuts the material from the workpiece and there is no cutting of material in the backward stroke (idle stroke)

Thus, duration of the return stroke is less than the forward stroke.

Classification of shapers

1. According to the length of stroke
   a) 30cm shaper
   b) 45cm shaper
   c) 60 cm shaper
2) According to the Position of ram
   a) Horizontal shaper
   b) vertical shaper
   c) Travelling head shaper

3) According to the table design
   a) standard or plain shaper
   b) universal shaper
4) According to the types of driving mechanism
   a) mechanical shapers
      (i) Crank type
      (ii) Geared type
5) According to the type of cutting stroke
   a) push cut type
   b) Draw cut type.

Types of shaper

30 cm shaper :- These type of shapers are older models with fixed length of stroke. The designation 30 represents the length of stroke in centimeters. later the shapers are designed with variable length of stroke. 45 cm and 60 cm shapers are defined in similar manner

Horizontal shaper :- In this type, the ram holding the total reciprocates in a horizontal axis. This is mainly used to produce flat surfaces.

Vertical shaper :- In a vertical shaper, the ram holding the total reciprocates in a vertical axis. In appearance and operation it resembles a slotting machine. vertical shaper and slotter are frequently used interchangeably but the marked difference is, the ram of a vertical movement, can also be adjusted from it's vertical position to about 10° on either side, but the ram of a slotter always moves in vertical direction

Standard shaper or plain :- The standard shaper, the table has only two movements, vertical and horizontal to give the feed. The table may or may not be supported at the outer end. Some machines have a provision for the table to swivel around a horizontal axis parallel to the ram.

Universal Shaper :- This is also a horizontal shaper, but it's table can be swing about a horizontal axis parallel to the ram ways. The top of the table can be tilted about another horizontal axis, which is normal to the former axis. It is called a universal shaper. since the job can be tilted in any direction through the required angle with the help of swivel vice.

Mechanical shaper

a) Crank type mechanical shaper :-

This is the most common type of shaper in which crank and slotted link mechanism is used to give a reciprocating motion of the ram.

b) Geared type :- The reciprocating motion of the ram is given by means of a rack and pinion. the rack teeth that are cut directly below the ram mesh with a spur gear.

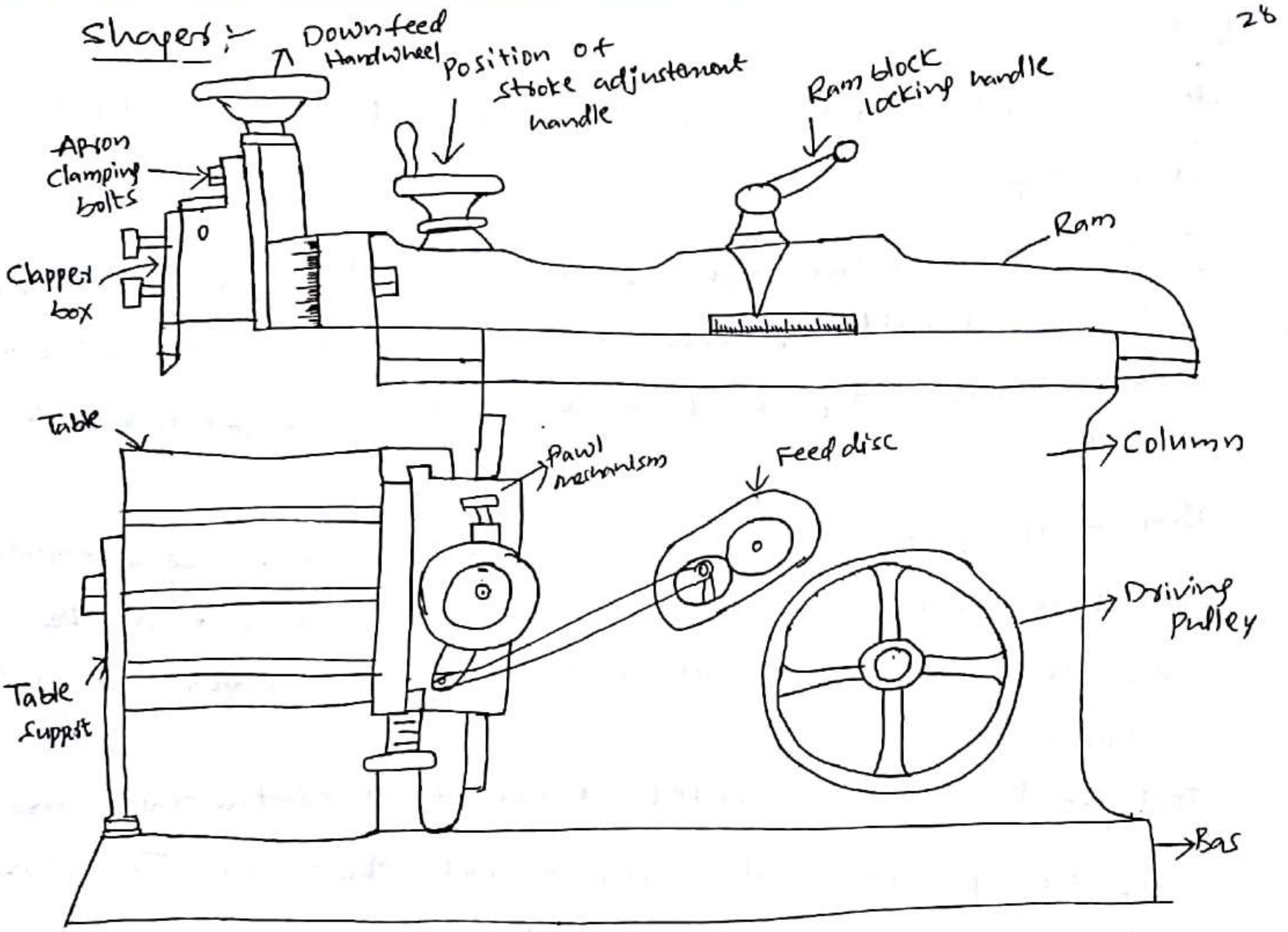
Hydraulic shaper

The reciprocating movement of the ram is obtained by hydraulic power oil under high pressure is pumped into the operating cylinder fitted with a piston. The end of the piston rod is connected to the ram. The high pressure oil acts on one side of piston causing piston to reciprocate and the motion is transmitted to the ram.

Push cut type :- This is the most general type of shaper used in practise. The metal is removed in forward stroke of the ram.

Draw cut type :- In This type metal is removed in the backward stroke of the ram. The tool is set in reverse direction to that of a standard shaper. vibrations in these machines are eliminated.

Shaper :-



— shaper

Base :- It consists of a heavy robust cast iron structure, which supports all the other parts of the machine.

Column :- It is a box type structure. It is made of cast iron. It is mounted on the base. It houses the ram driving mechanisms. It has two guide ways on the top. The ram reciprocates on this guide ways. The front face also has two machined guide ways. a cross rail moves vertically along these guide ways.

Cross rail :- It is a heavy cast iron construction, mounted on vertical guideways column. ~~the~~ it has guide ways on it, over which saddle is mounted. It houses two mechanisms i.e., one for sliding the table up and down and the other is cross traverse of the table.

Saddle :-

It is mounted on the cross rail. It holds the table firmly on its top.

Table :- It is a box type cast iron block. It slides along the cross-rail. It holds the work. It has T-slots on the top and sides for clamping the work. The front of the table is clamped to a table support.

Ram :- It is the reciprocating part of the shaper, semi-circular in shape and carries the tool head in front of it. It gets its drive from the quick return mechanism, which is inside the column.

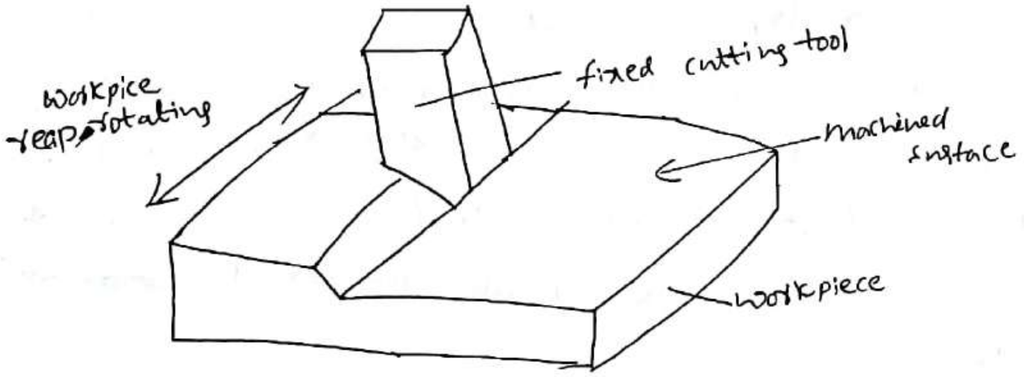
Tool head :- It is mounted at the front of the ram and consists of tool slide, tool post and clapper box. Tool head holds the tool firmly, which slides up or down and can be swivelled at any angle

Planer :-

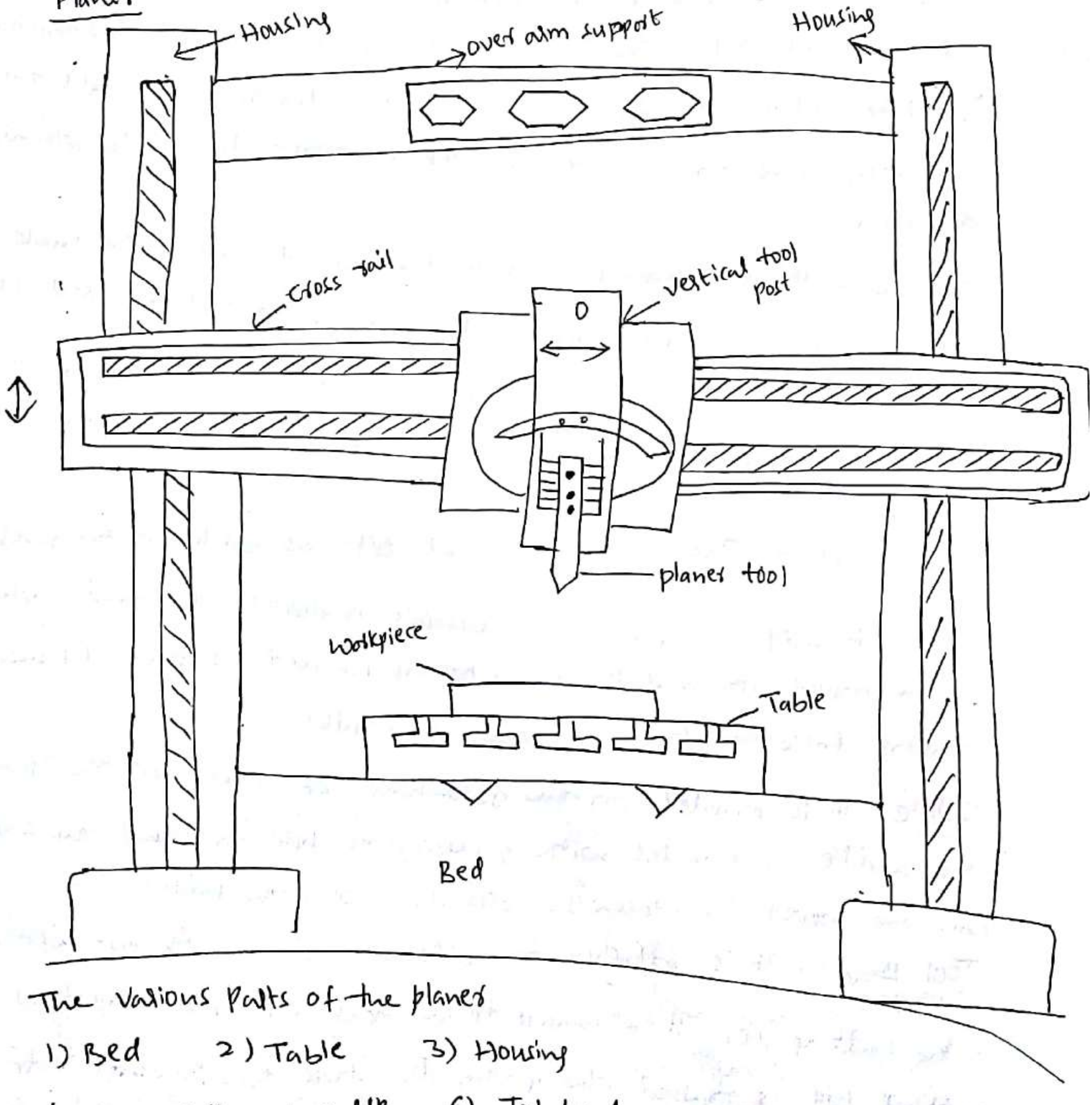
A variety of machines are used for producing flat surfaces.
A planer is a large machine tool used for machining flat surfaces by means of single point cutting tools.

Principle :-

It is almost a reverse case to that of a shaper. The work is rigidly held on the work table or platen of the machine. The tool is held vertically in the tool head mounted on the cross rail. The work table, together with the job is made to reciprocate past the vertically held tool. The indexed feed, after each cut, is given to the tool during the idle stroke of the table.



Planer



The various parts of the planer

1) Bed 2) Table 3) Housing

4) Cross rail 5) Saddle 6) Tool head

7) Controls.

Bed :- It is a very large and heavy cast iron structure, that acts as foundation of the mathine. It also made in two halves. which are properly machined and then fasterd together, to form a single length of bed. The length of bed is usually twice that of the table. at the top of the bed, guide ways are provided, to support and guide the table.

Table :- It is a large rectangular thick cast iron, plate, that moves over bed on guide ways. The upper surface of the table has T-slots, to facilitate clamping of Workpices. It's main function is to hold the w/p and reciprocate on guideways, to impart motion to job for plaining operation.

Housing :- It is a vertical casting, that extends, across the table and bed. It acts as a support for operating mechanism and tool head. its accurately machined parts provides precession to surface, for an accurate movement of Cross-rails. It is also called as Column (or) Uprights.

Cross-rail :- The mechanism that acts as guide for transverse travel of saddle is known as Cross-rail It supports tool heads, which Can be moved up and down. by means of feed screws. for accurate working, table and Cross-rail must be Parallel

Saddle :- It is mounted on the guideways of Cross-rail. The front of the saddle is provided with guideways to hold tool head the saddle can be moved in Crosswise direction over the table

Tool Head :- It is attached to saddle and Contains tool post, which holds the Cutting tool. It is hinged to the head in such away that the cutting tool is raised during the idle stroke. this prevents cutting of material in idle stroke. A planer may be fitted with two or more tool heads, to Perform more than one operation.

Controls :-

Different controls for starting, operating and stopping the various mechanisms, speed and feed regulations, usually provided within a quick approach of the operator of the machine.

Specifications

Planers are made in different size and they are specified by the following main dimensions.

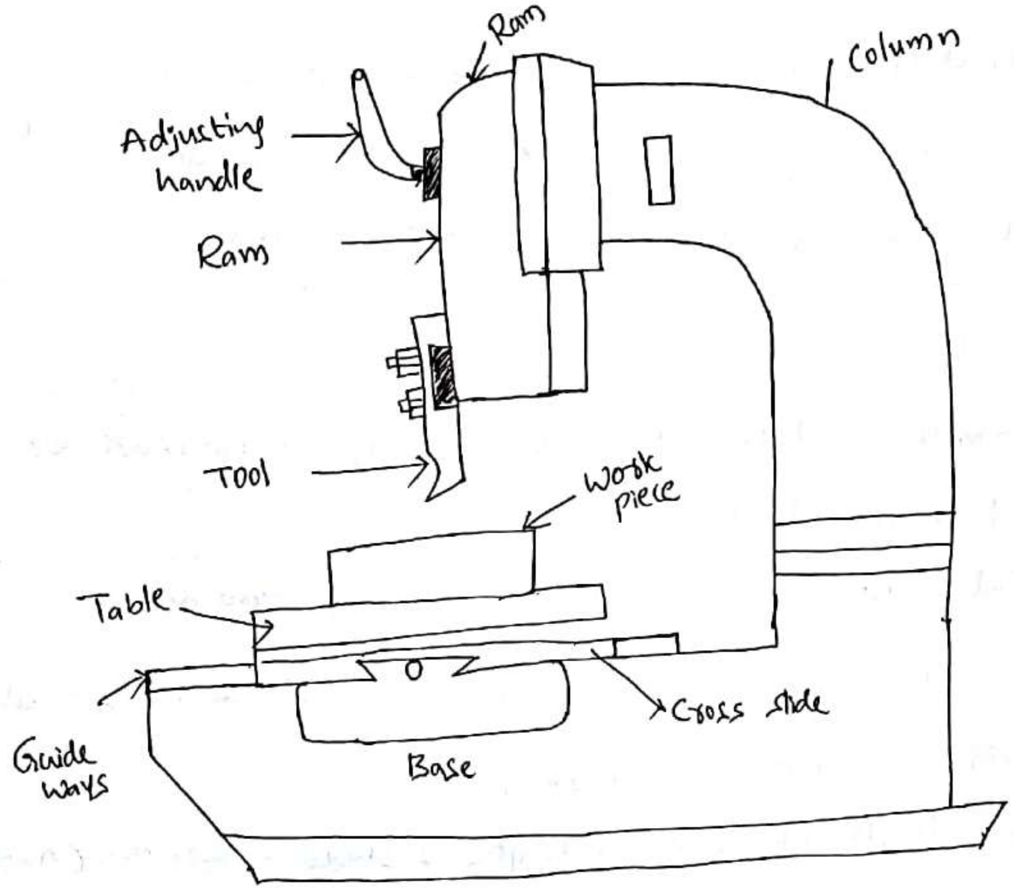
1. Horizontal distance b/w the two vertical housings
2. vertical distance b/w the table top and the cross rail in its upper most position - 762mm
3. maximum length of table or length of stroke - 1220mm (According to requirements)

Types of Planers

1) Standard or double housing planer
2) open side planer
3) Edge or plate planer
4) pit planer
5) Divided table planer
6) plano - guillotine shearing machine
7) planer miller.

Slotter :-

slotter is a reciprocating type machine tool. In this machine the ram reciprocates vertically. The tool held in the ram cuts during downward stroke only.



— Slotting Machine

The Main Parts of slotting Machine are

1) Base
2) Table
3) Column
4) Ram.
5) Cross slide
6) saddle.

Base :- It is a heavy cast iron construction. It supports the column and the saddle. It has horizontal guideways on its top. These guideways are perpendicular to the column.

Column :- It is cast integral with base. It houses driving mechanism of ram and feeding mechanism. The top vertical front face has guide ways. The ram slides vertically in it.

Saddle :- It moves on the guide ways provided on the base. It moves either towards or away from the column. It is for longitudinal feed. The top face of saddle has guide ways. These guideways are perpendicular to the guide ways on the base.

A Cross slider moves on the guideways. It moves parallel to the face 31
of the Column. It is for Cross feed.

Cross slide:— It is mounted upon the guideways of the saddle and may be moved Parallel to the face of the Column. The movement of the slide may be controlled either by hand or power to supply cross feed.

Rotary table:—

The rotary table is a circular table. It is mounted on the top of the cross slide. It can be rotated about a vertical axis. It has T-slots on the top. It is for holding the work. The table bottom is graduated in degrees.

Ram and Tool head:—

Ram is a reciprocating member. It slides vertically on the guideways of the Column. It has tool head at its bottom end. The ram has a slot at the back surface. It is for changing the Position of ram. The tool is set in the tool holder.

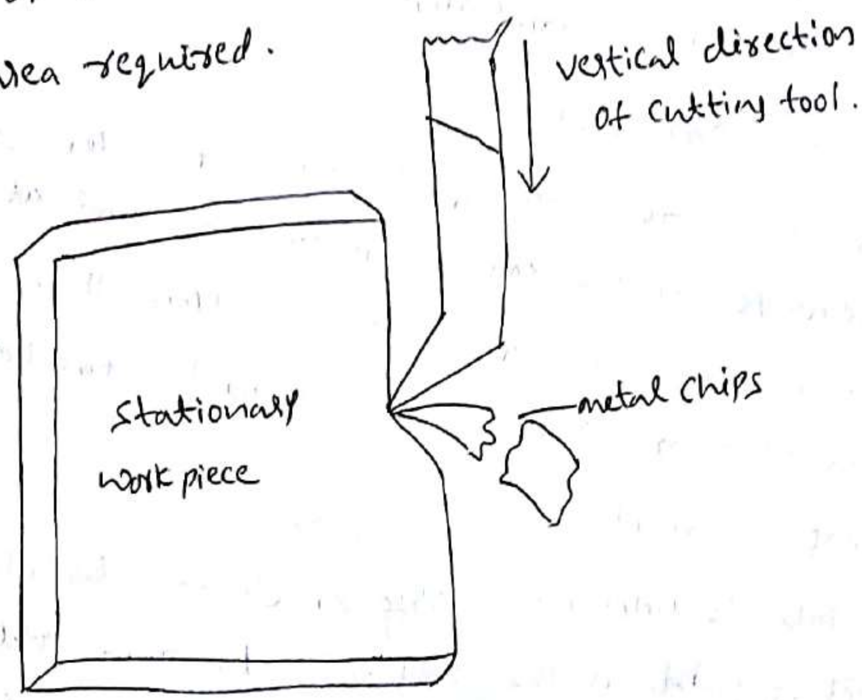
Working Principle

The Job is held in a vise or clamped directly on the table The tool is held in the tool post. The ram holding the tool reciprocates vertically. The ram gets power from the driving mechanism.

The return stroke is idle. The feed and depth of cut are given by moving the table. The depth of cut is given by longitudinal movement of the table. The feed is given by the cross movement or rotary movement of the table.

Specification of slotter

1. Maximum stroke length
2. Diameter of rotary table
3. maximum travel of saddle and cross slide
4. type of drive used
5. power rating of motor
6. Net weight of machine
7. Number of amount of feeds
8. Floor area required.



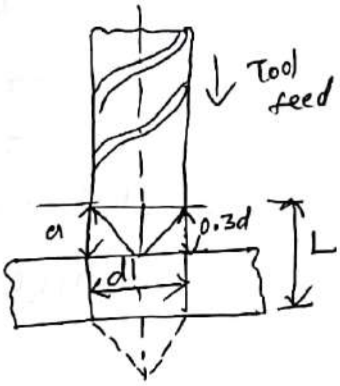
1) At what speed a 15mm diameter drill with run, to drill a hole through a brass plate 20mm thick, in order to cut the material at a surface speed of 60 mpm. also calculate the feed used/rev.

Sol:- Given that,

Drill diameter, $D = 15mm$

plate thickness, $l = 20mm$

Cutting speed, $S = 60\ m/min$.



i) speed $N = \frac{S}{\pi \times D} = \frac{60}{\pi \times 0.015}$

$\therefore N = 1273\ r.pm$

ii) Feed $= \frac{L}{N}$

The distance axially moved, $L = l + a$

$\therefore L = l + 0.3d$.

$= \frac{20 + (0.3 \times 15)}{1273}$

$\therefore$ Feed $= 0.02mm$ per.rev.

2) A hole of 50mm diameter and 75mm depth is to be drilled in a mild steel component. The cutting speed can be taken as 65 m/min and the feed rate as 0.25 mm/rev. Calculate the machining time and material removal rate.

Sol:- given that.

$D = 50mm$

Depth $l = 75mm$

cutting speed $S = 65\ m/min$

feed rate, $f = 0.25\ mm/rev$.

Spindle speed.

$N = \frac{1000S}{\pi D} = \frac{1000(65)}{\pi \times 50}$

$N = 413.803\ rpm$

Break through distance,

$$A = \frac{D}{2\tan\alpha} \quad [\because \alpha = 59°]$$

$$= \frac{50}{2\tan 59} = 15.02\,mm$$

Total length of drill travel, $L = 75 + 15 + 3$

$L = 93\,mm$.

time for drilling the hole,

$$T = \frac{L}{f \times N} = \frac{93}{0.25 \times 413.803} = 0.898\ min$$

$$T = 53.88\ sec.$$

$$T \simeq 54\ sec.$$

metal removal rate,

$$MRR = \frac{\pi D^2 f N}{4}$$

$$= \frac{\pi (50)^2 \times 0.25 \times 413.803}{4}$$

$$= 203125.073\ mm^3/min$$

$$\therefore \underline{MRR} = 203.125\ cm^3/min$$

3) A 10mm drilled hole in a casting of 10mm thickness is to be brought in alignment by boring. Calculate the time taken in boring operation, assuming cutting speed 30m/min and feed 0.13 mm/rev.

Sol: Given that.

drilled hole diameter $D = 10mm$

Thickness, $t = 10mm$

cutting speed, $S = 30m/min$

Feed, $f = 0.13mm/rev$.

$\therefore$ Spindle speed

$$N = \frac{S \times 1000}{\pi D} = \frac{30 \times 1000}{\pi \times 10} = 954.929\ rpm.$$

$\therefore$ machining time $T = \frac{t}{N \times f}$

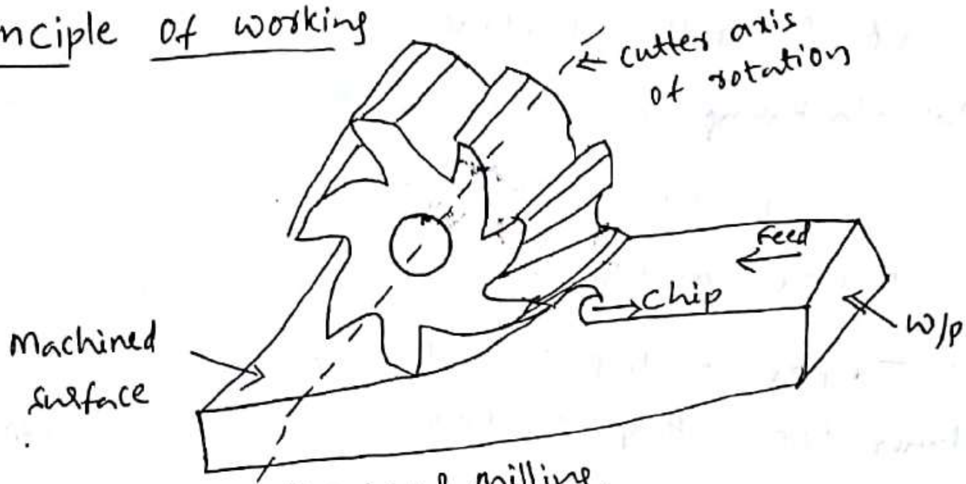
$$\therefore \underline{T} = \frac{10}{954.929 \times 0.13}\ min = \frac{10 \times 60}{954.929 \times 0.13}\ sec = 4.83\ sec$$

Unit - III

Milling machine:

Milling is the process of removing metal by feeding the work against a rotating multipoint cutter. In milling operation the rate of metal removal is rapid as the cutter rotates at a high speed and has many cutting edges.

Principle of working



Peripheral milling.

— milling operation

→ The working principle, employed in the metal removing operation on a milling machine, is that the work is rigidly clamped on the table of the machine, or held between centres and revolving multiteeth cutter mounted either on a spindle or an arbor

→ The cutter revolves at a fairly high speed and the work fed slowly past the cutter.

→ The work can be fed in a vertical, longitudinal or cross direction. as the work advances, the cutter teeth remove the metal from the work surface to produce the desired shape.

Classification of Milling Machines

1. Column and Knee type milling machine
   a) hand milling machine
   b) plain milling machine
   c) universal milling machine
   d) Omniversal milling machine
   e) vertical milling machine.
2. Manufacturing or Fixed bed type
   a) Simplex milling machine
   b) Duplex milling machine
   c) Triplex milling machine.
3. planer type milling machine
   a) single column machine
   b) Double housing plano millers.
4. machining centres
   a) Numerical control type
   b) computer Numerical Control type
5. special type milling machines.
   a) Rotary table milling machine
   b) Drum milling machine
   c) planetary milling machine
   d) Pantograph, profilling, tracer control milling machine
   e) Gear milling or gear hobbing machine
   f) Cam milling machine
   g) Thread milling machine
   h) Spar milling machine.

Column and knee type milling machine.

The Column and knee type is the most commonly found in shops. It derives its name from the fact that the work-table is supported on a knee like casting, which can slide in a vertical direction along a vertical column. Based on the spindle position and table movements.

It is classified as follows

a) Hand milling machine

b) Horizontal or plain milling machine

c) Universal milling machine

d) Omuniversal milling machine

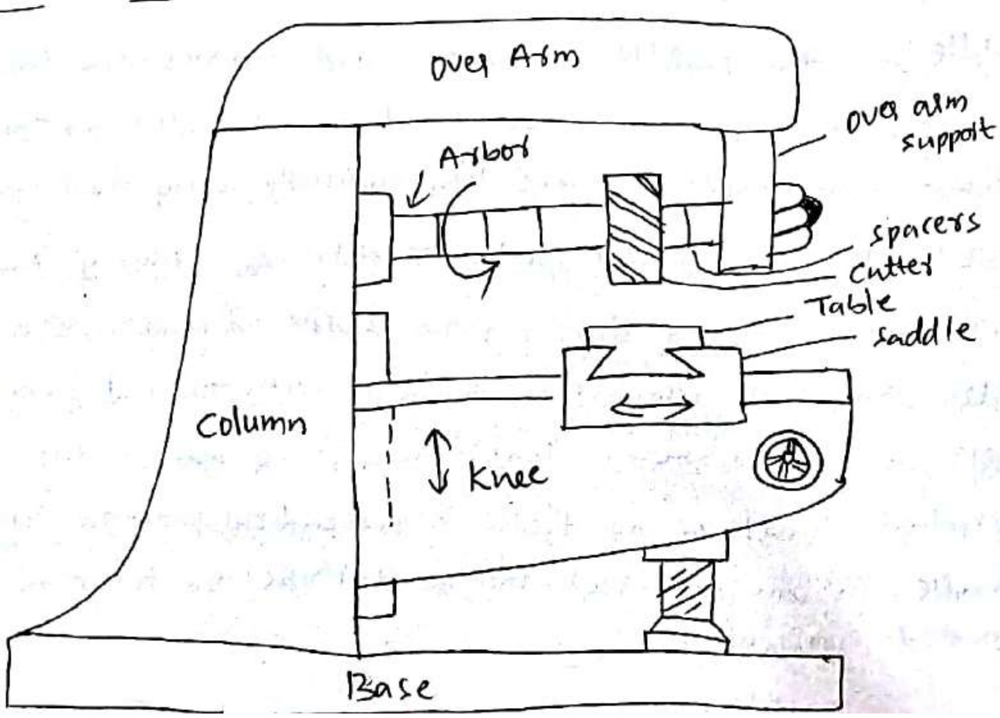
e) Vertical milling machine.

Hand milling machine :-

→ It is the simplest of all the milling machines and smallest in size. All the operations expept the rotation of arbor, are performed by hand. The tables carrying the work over it is moved by hand to feed the work.

This machine is specially useful in producing small components like hexagonal or square heads on bolts, cutting slots on screw heads, cutting key ways etc.

Horizontal or plain milling machine



The plain milling machine the spindle of the machine is horizontal
The principal parts of horizontal milling machine are:-

1) Base
2) column
3) Knee
4) saddle
5) Table
6) over-arm
7) spindle
8) Arbor
9) spindle drive and table feed mechanism's

Base :- It is the foundations of the machine. All other parts are mounted on it. It carries the column at its one end. It also serves as a reservoir for the cutting fluid.

column :- It is the main supporting frame. the motor and the others driving mechanisms are housed on it. It supports and guides the knee in its vertical travel. the top of the column is holding an over arm that extends outwards at the front of the machine.

Knee :- The Knee has a horizontal guide ways perpendicular to the front face of the column. the knee Projects from the column and moves up and down on the vertical guide ways of the column face.

Saddle :- The saddle supports and carries the table. the top of the saddle has horizontal guideways Parallel to the face of the column. the table travels longitudinally along these guideways.

Table :- It is provided with T-slots for clamping the work the table rests on the ways on the saddle. a lead screw is provided under the table when it is engaged with the nut provided in the saddle the table moves longitudinally bey hand or power. the longitudnal travel of the table is perpendicular to the axis of the spindle. In an universal milling machine the table may also be swivelled horizontally.

Over arm :-

the over arm is mounted on the top of the column. It serves as a bearing support for the other end of the arbor. more than one bearing support may also be provided for the arbor.

Spindle :-

The front end of the spindle, called nose projects from the ~~do~~ column face. it is provided with a tapered hole for inserting either arbor or shank type milling cutter. the milling cutters are connected either directly to the spindle nose or mounted on the arbor. The spindle obtains its power from the motor through belts and gears and transmits it to the arbor or cutter.

Arbor :-

Arbor is an accurately machined shaft cutters are mounted on the arbor which is rigidly supported by the over-arm spindle and end braces. It is tapered at one end to fit the spindle nose and has two slots to fit the nose keys for locating and driving it

Spindle drive and table feed mechanism

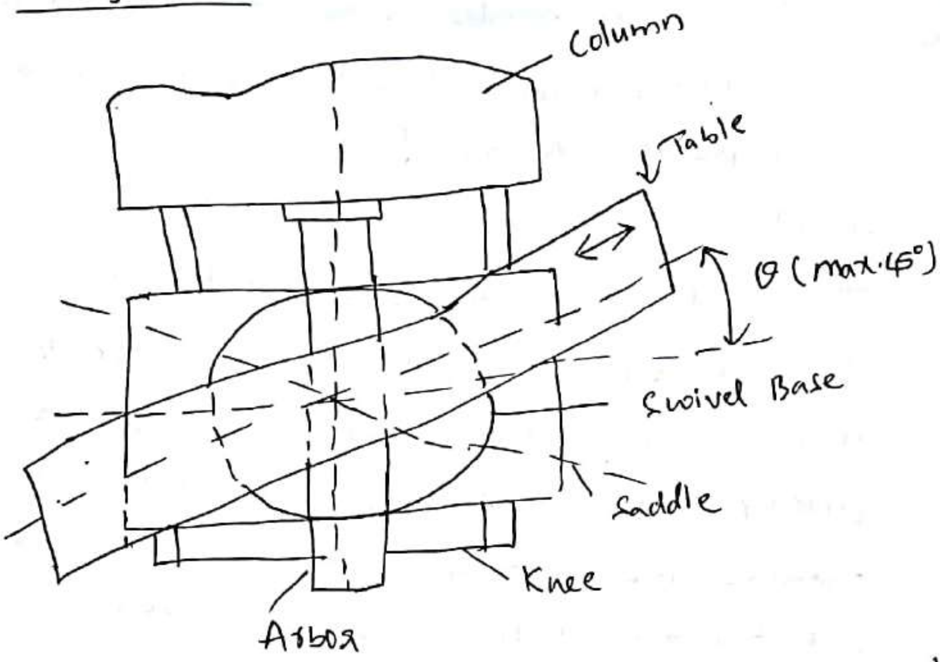
The spindle receives power from the combination of belts, gears and clutch assembly. multiple speeds of spindle may be obtained by changing the gear ratio. the feeding mechanism mechanism is housed by the knee.

The vertical movement of knee longitudinal movement of table and cross feed movement of saddle can be obtained by hand power.

Salient features

→ The milling machine yields high production of different varities of jobs. facing operations of all kinds, slotting key way cutting, grooving making of hexagonal and other heads of bolts machining concave and convex surface, indexing operations of cutting spurs, helical gear's

Universal Milling Machine



→ The universal milling machine is similar in all respects to the horizontal plain milling machine except for additional swivelling movement for table

→ Table is mounted on a swivel base.

→ The swivel base has got degree graduations. the table can be swivelled about a vertical axis. It can be swivelled upto a maximum of 45° on either side of the normal position.

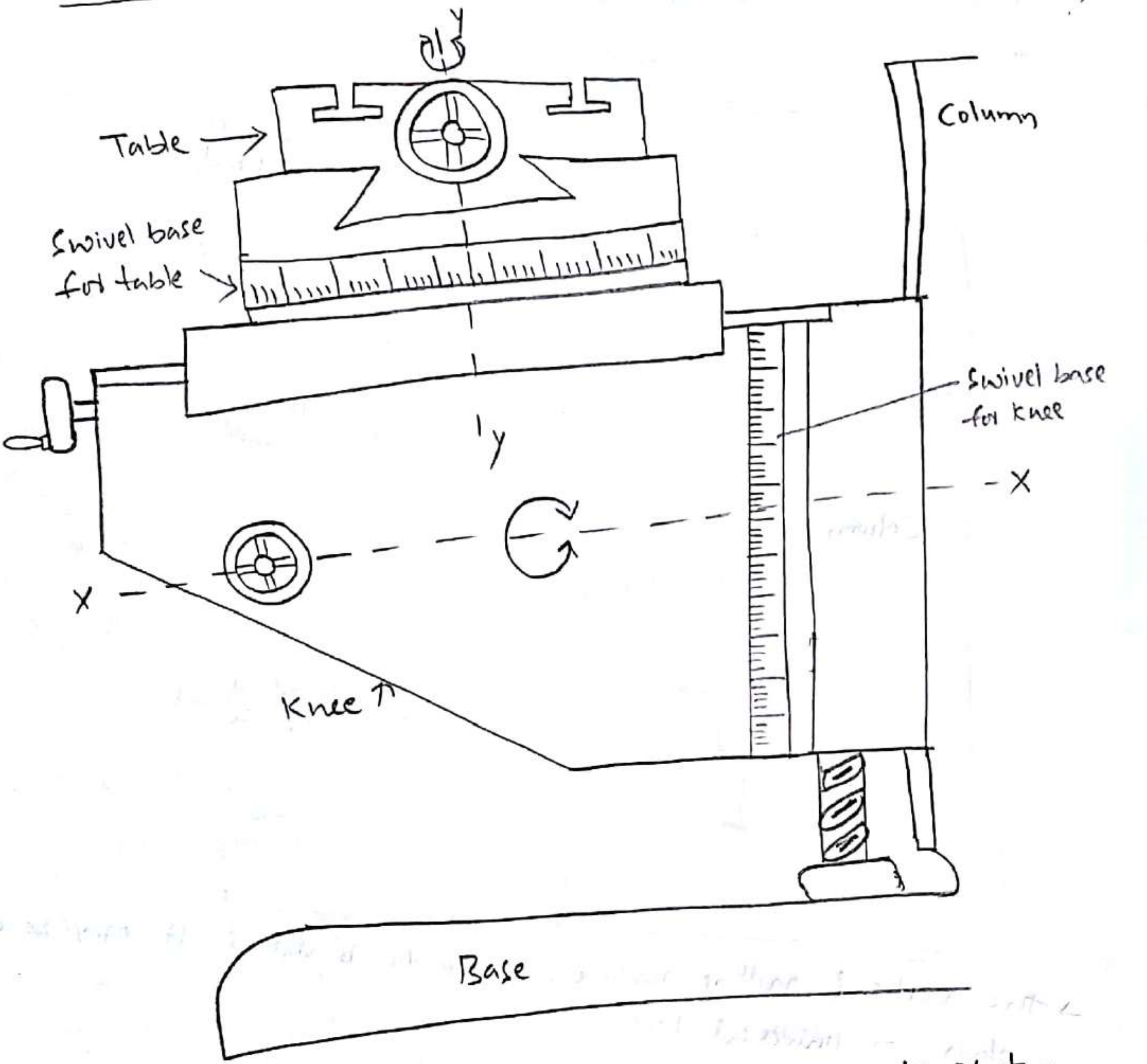
→ The universal milling machine table has the following movements.

1. Vertical movement – through the knee
2. Cross wise movement – through the saddle
3. Longitudinal movement of the table
4. Angular movement of the table – by swivelling the table on the swivel base.

→ By swivelling the table, the work can be fed at an angle to spindle axis. This is used in helical milling operations.

→ Using these attachmants the machine can produce spur gear, helical gear, bevel gear, twist drill and reamers.

Omuniversal Milling machine

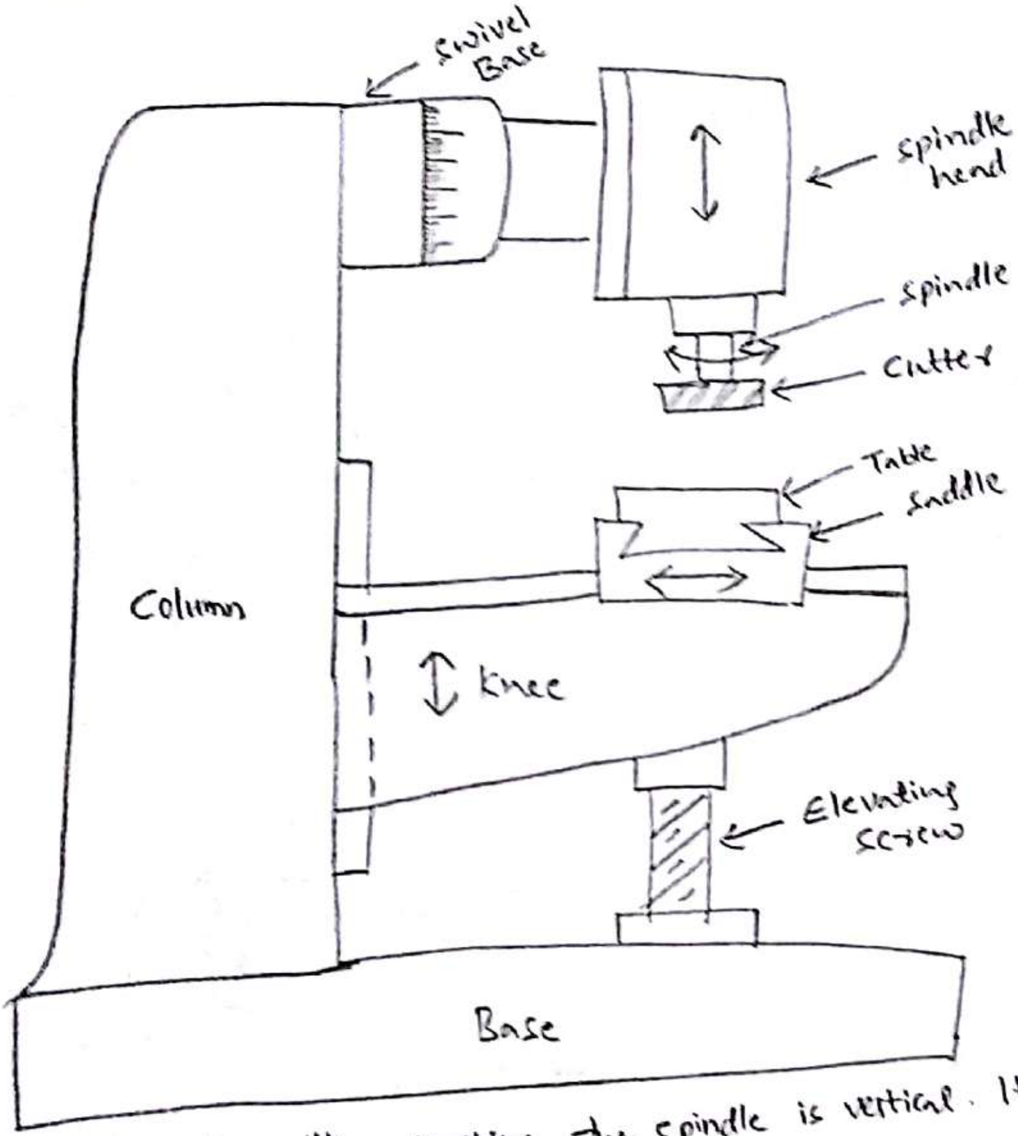


→ The table of this machine has all the four movements of the universal milling machine. It has one more adjustment for the table. The table can also be swivelled about a horizontal axis XX' parallel to the spindle.

→ In this machine the knee has a swivelling arrangement. Using additional swivelling movement, we can machine tapered spiral grooves in reamers bevel gears etc.

→ ~~[illegible]~~ Omuniversal milling machine is a tool room machine.

Vertical milling machine



→ The vertical milling machine, the spindle is vertical. It may be of plain or universal type.

→ 1. Base
2. Column
3. Knee
4. Saddle
5. Table
6. Spindle drive and feeding mechanisms
7. Spindle head.

Spindle ~~head~~:-

The spindle of the machine is located vertically in the swivelling or fixed head and receives driving power from electric motor through belts, gears and clutches.

~~Horizontal~~

Working principle

→ The material is removed, as the w/p is fed against the rotating milling cutter. The cutter rotates at high speeds and removes excess metal, at a very fast rate

→ milling cutter rotates only in one direction and w/p fixed on the table is fed vertically, to get required depth of cut.

→ Each cutting edge of the tool removes metal in the form of chips.

→ For machine grooves, slots and flat surfaces., gears, keyways

Horizontal milling machine :-

→ It is provided with horizontal spindle, parallel to the w/p.

→ This machine comprises a vertical column incorporated with an over arm to support arbor carrying a cutting tool.

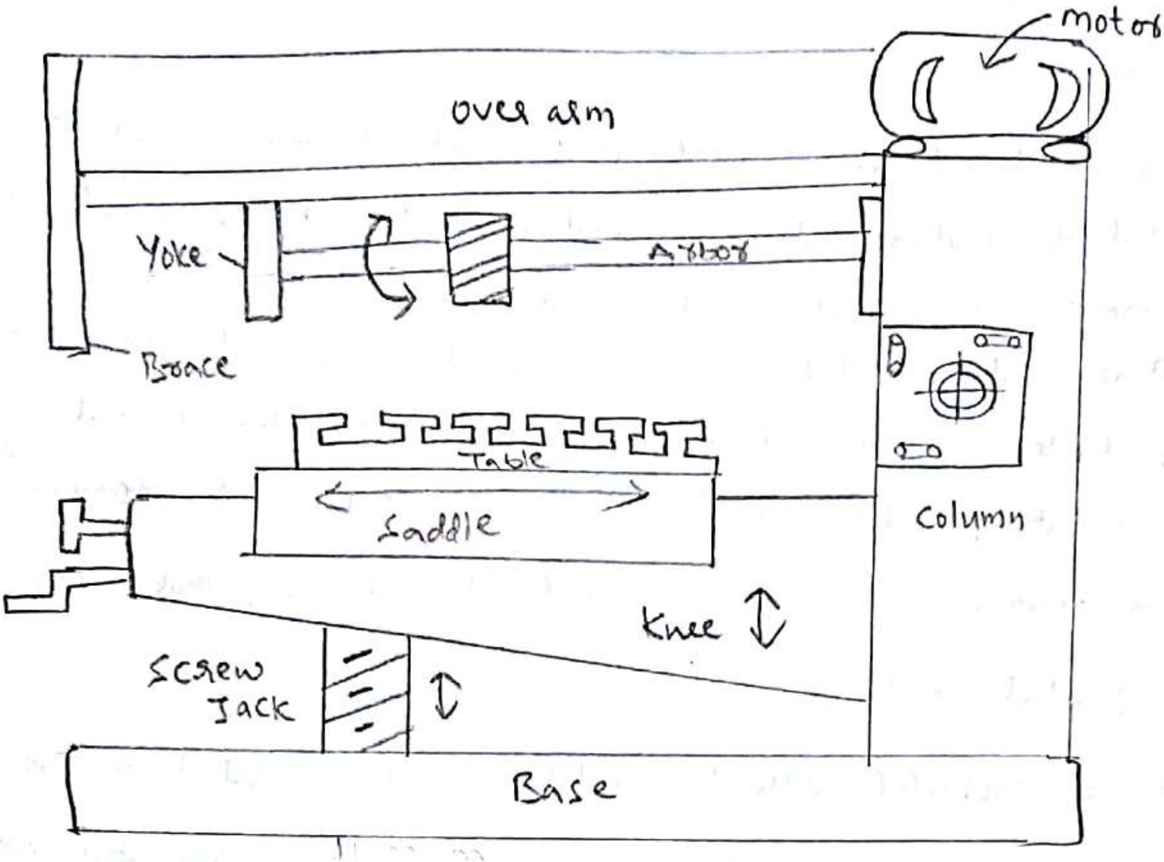
→ The table mounted on the knee can be moved in three linear directions
i.e, longitudinal, cross and vertical.

→ It can't be swivelled

→ This type of machine is employed for manufacturing operations

main parts

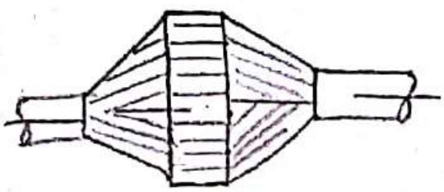
1) Base
2) Column
3) Saddle
4) Knee
5) work table
6) over arm
7) spindle
8) Ram
9) Tool head.



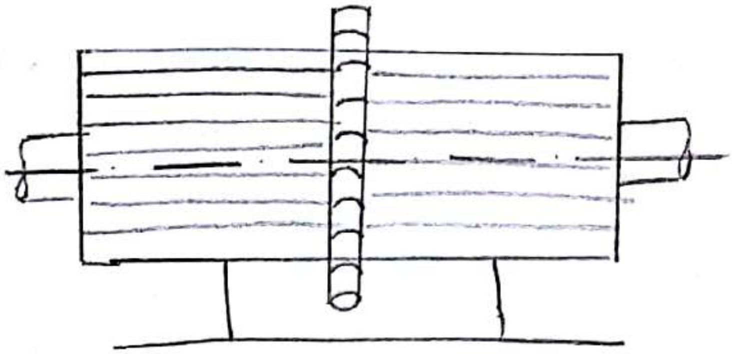
Horizontal Boring machine.

→ milling Operations

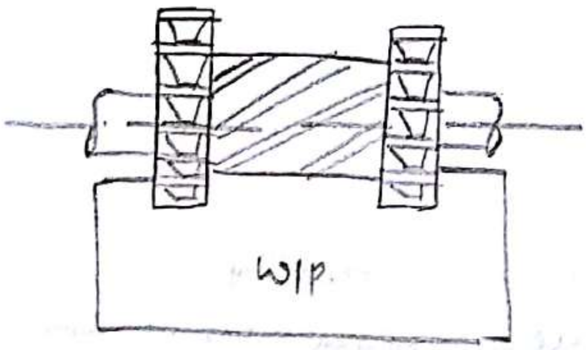
1) Angular milling → Angular surface on the w/p can be obtained.
2) Form milling → irregular, concave, convex and diff. shaped w/p can be mached.
3) Gang milling → machining a no. of flat horizontal & vertical surfaces on a w/p. simultaneously.
4) plain or slab milling → machining flat surfaces.
5) straddle milling. → two parallel vertical surfaces of a job are cut simultaneously by a pair of side milling cutters.



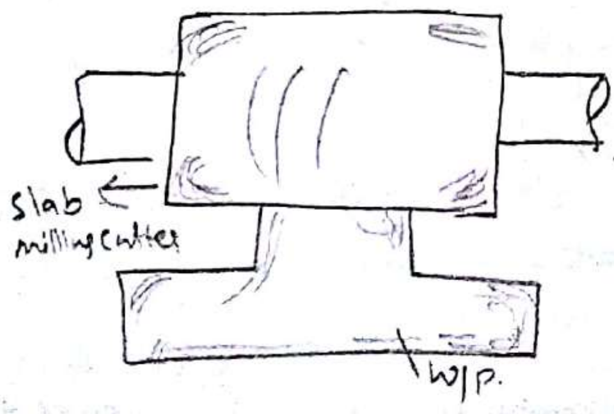
Angular milling.



Form milling.



Gang milling.



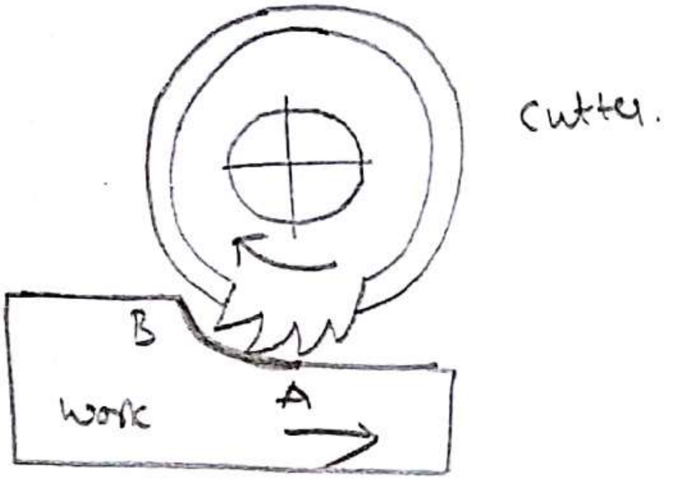
Slab milling

Scanned by CamScanner

Up milling :-

→ In this ~~machine~~ method known as conventional milling machine

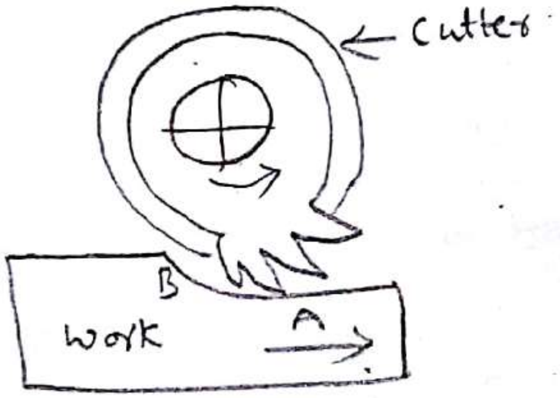
→ In this method of milling, the cutter rotates in a direction opposite to that, in which the work is fed.



Down milling

→ In this ~~machine~~ method known as climb milling.

→ The direction of rotation of the cutter is same, in which the work is fed.



→ on comparing the two methods, it can be observed that shape of the chip (shaded area b/w points A & B) removed by the cutter in both cases is the same, but an imp. difference is that in conventional milling, as the cut proceeds, the chip thickness increases gradually.

→ climb milling the chip thickness decreases gradually.

→ The selection of the above two methods depends on nature of work.

Ex:– conventional milling is used for machining castings, and forgings and climb milling is useful for finishing operations and small work.

Tool Geometry of milling cutters.

→ The geometry of milling cutters includes four angles such as radial rake angle, axial rake angle, radial relief angle, axial relief angle.

→ these angles are considered for three types of milling cutters like face mills, end mills, side and slot mills.

→ when angles of milling cutter are compared with the angles of single point tool, axial rake angle of milling cutter is similar to back rake angle of single point tool. whereas radial rake angle of milling cutter is similar to side rake angle of single point tool.

Radial Rake angle

The angle measured b/w the side face and the radial plane passing through the cutter axis is referred as radial rake angle

→ It can be positive or negative.

→ Due to positive rake angle, the cutting edge becomes weak or may break also. Negative rake angle makes the cutting edge more stronger..

→ The radial rake angle depends on the type of material being used for w/p and tool.

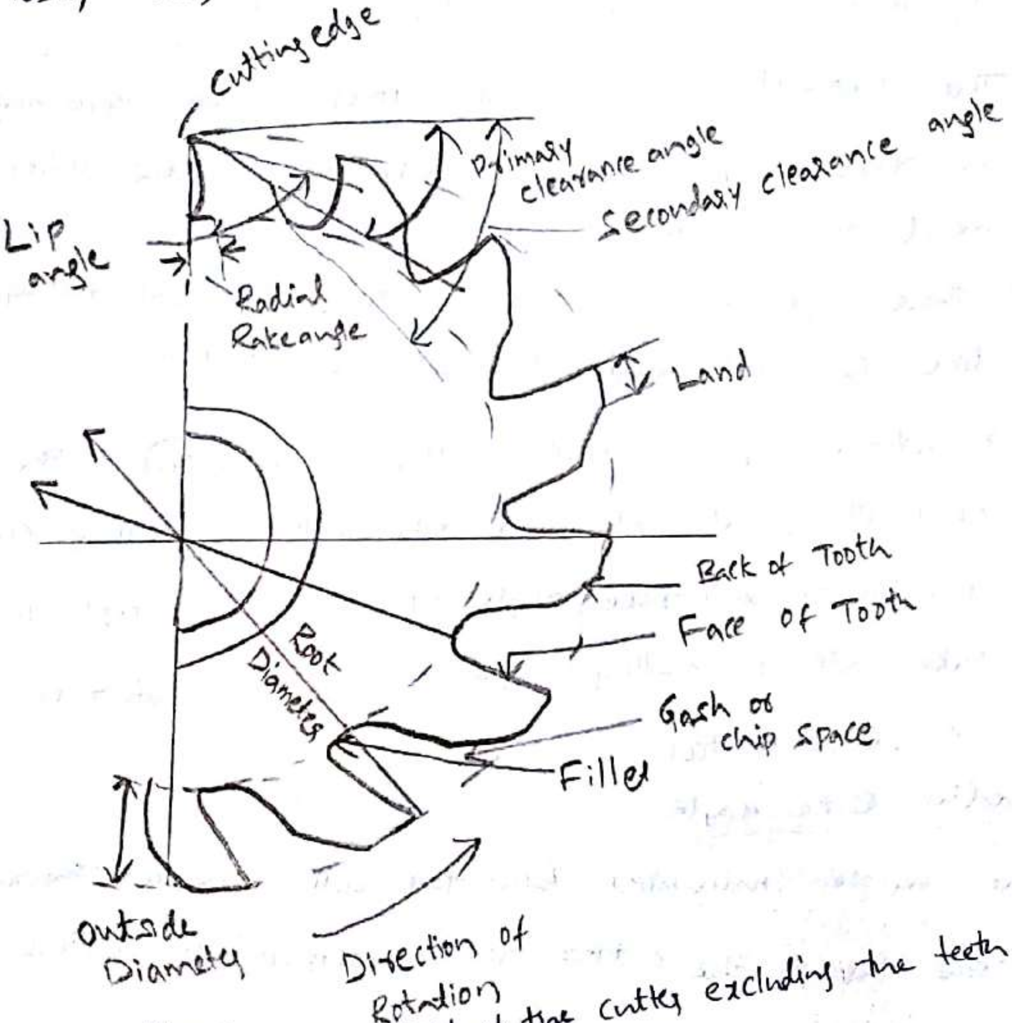
Axial Rake Angle

→ It is the cutting edge inclination with respect to cutter axis. It also gives the direction of chip flow. It can be positive or negative

→ Positive axial rake angle removes the chips away from the cut, when rake nose of cutter contacts with the w/p. while

→ negative axial rake angle traverse the chips along the direction of w/p. It also makes the cutting edge more stronger.

→ mostly negative axial rake angle is applied in carbide cutter.



Body of Cutter :- The Part of the cutter excluding the teeth portion is called body.

Land :- The Part of the back of tooth adjacent to the cutting edge the edge formed by the intersection of the face and the land.

Face :- It is the front Portion of tooth

Fillet :- The curved surface of the bottom of the gash.

Milling Cutters

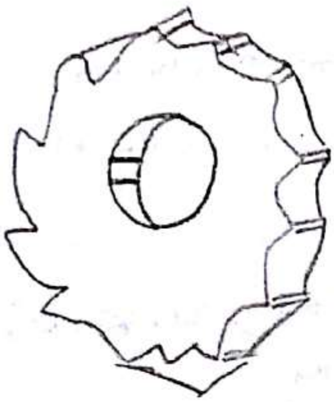
→ Milling cutters are use the rotating tools, having many cutting edges. They are classified depending on the shape, type of work, the method of mounting.

1. Plain milling cutters
Plain milling cutters or cylindrical cutter have teeths on the circumferential surface only. They are used to produce flat surfaces. the teeths of the cutter may Parallel to the axis of milling cutter. the be straight or helical depending on the size.

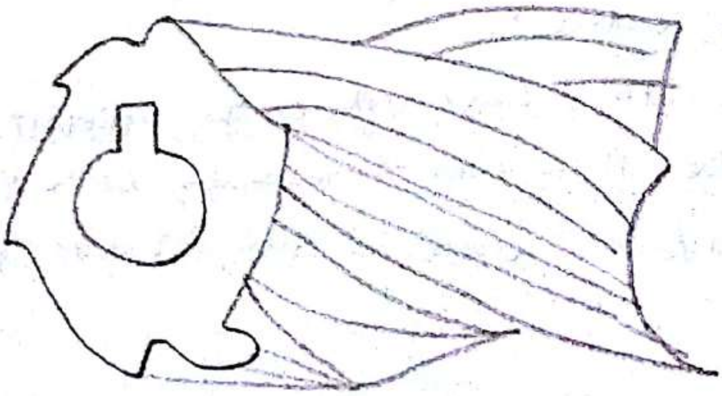
a) Light duty plain milling cutter.
(helix angle of about 25°)

b) Heavy duty plain milling cutter
(helix angle ranging from 25° to 45°)

c) Helical plain milling cutter.
(helix angle ranging from 45° to 60°)



Light duty cutter



Helical cutter

2) Side milling cutter

It is similar to plain milling cutter and have teeth on its periphery and on both side faces. They are used for removing metal from the sides of a work and is available from 50 to 200 mm in diameter and 5 to 32 mm width of the cutting edge.

a) plain side milling
b) Half side milling
c) staggered teeth side milling.

3) Metal slitting saw

→ It is similar to plain milling cutter in appearance, but have very small width

→ They are generally used for parting off operations and to make thin deep slots.

a) plain metal slitting saw.
b) staggered teeth metal slitting saw

4) Angle milling cutter

→ These cutters are used for machining angle other than 90°. The cutting edge is formed on the periphery of the conical surface.

a) Single angle milling cutter → 30°, 45°, 60°, 65°, 70°, 75°, 80° & 85°
b) Double angle milling cutter.

5) End milling cutter :—

These milling cutters have teeth on the periphery as well as on the end face. It is used for machining both vertical & Horizontal surface. used in slots, key ways, grooves etc.

a) Shank type
b) shell type.

6. Form milling cutters

They have different profiles on the cutting edge, in order to generate required contours on the work.

a) Convex milling cutter.

It has outward curved teeths on the circumference, to form the contour of a semi-circle.

b) Concave milling cutter :-

It has inward curved teeths on the circumference to form the contour of a semi-circle. It produce convex surfaces and rounded corners.

c) Gear Cutters :-

It has the profile similar to that required in the space b/w the two involute gear teeth. The profile of the cutter tooth should be shaped differently.

Calculation of Number of teeth on milling Cutter.

Fluted & relieved cutter,

$$Z = 2.75\sqrt{D} - 5.8$$

where,

Z = no of teeth

D = Diameter of cutter in mm

For fairly coarse teeth over 66 mm diameter.

$$Z = \frac{D}{12} + 8$$

For inserted blade face milling cutter :

$$\therefore \text{Number of Blades} = \frac{\text{Circumference of Cutter}}{\text{Required blade space in}}$$

Indexing :-

1) plain indexing

→ more than one index plate is used, which have different number of holes and hence, range of indexing is increased.

→ The index plate is fixed in position, by lockpin and then spindle is rotated by handle, which is keyed to worm shaft to obtain 'N' no. of divisions on the Job, the number of turns through which index crank must be rotated is

$$T = \frac{40}{N}.$$

For 10 divisions on the work, the crank will make

$$\frac{40}{10} = 4 \text{ turns}.$$

2) Compound indexing

→ This indexing involves two separate indexing movements and is done in two stages.

→ 1) Rotating crank through certain angle in one direction, keeping index plate fixed.

2) Turning indexing plate and crank both in same or reverse direction, thus adding or subtracting movement from obtained movement in first stage.

→ For example, a 27 teeth gear is to be cut i.e., 27 divisions are to be made, then the rotation required for one tooth spacing is $\frac{40}{27}$ which may be given as

$$\frac{2}{3} + \frac{22}{27} \text{ or } \frac{12}{18} + \frac{22}{27}$$

→ worm will be rotated by 12 holes of 18 holes circle, with the help of crank and then index plate is rotated by 22 holes of 27 hole circle.

Differential Indexing

→ The index plate is unlocked and connected to a train of gears which obtain their motion from the worm gear spindle. as the handle is turned, the index plate also turns. but at a different rate and in opposite direction.

→ Differential indexing enables to rotate the work by any fraction of revolution with the index plates.

→ Let 'N' be the no. of devisions to be indexed and 'n' be the number greater or lesser than N. Then, the relation to determine the change of gears, when placed b/w the spindle and the worm shaft is given by

$$\frac{\text{Driver}}{\text{Driven}} = \frac{40}{n} \times (n-N) \text{ and Crank movement}, T = \frac{40}{n}.$$

→ if $n > N$ the index plate will rotate in the direction of the crank

→ $n < N$ the plate will rotate in opposite direction to crank.

Grinding :-

→ Grinding is an abrasive machining process that uses a grinding wheel as the cutting tool.

→ A wide variety of machines are used for grinding

Hand - cranked knife - sharpening stones (grindstones)

Handheld power tools such as angle grinders and die grinders

Surface grinding machines

1) Disc surface grinders

2) Reciprocating type vertical spindle surface grinding machines

3) Rotary " " " " "

1) Disc surface grinders

→ These are used to finish flat surfaces and remove stock rapidly, by grinding with the sides of disc wheels

→ These grinders are employed for production of ordinary tolerances at high rates of production.

→ The grinding wheel is relatively large in size.

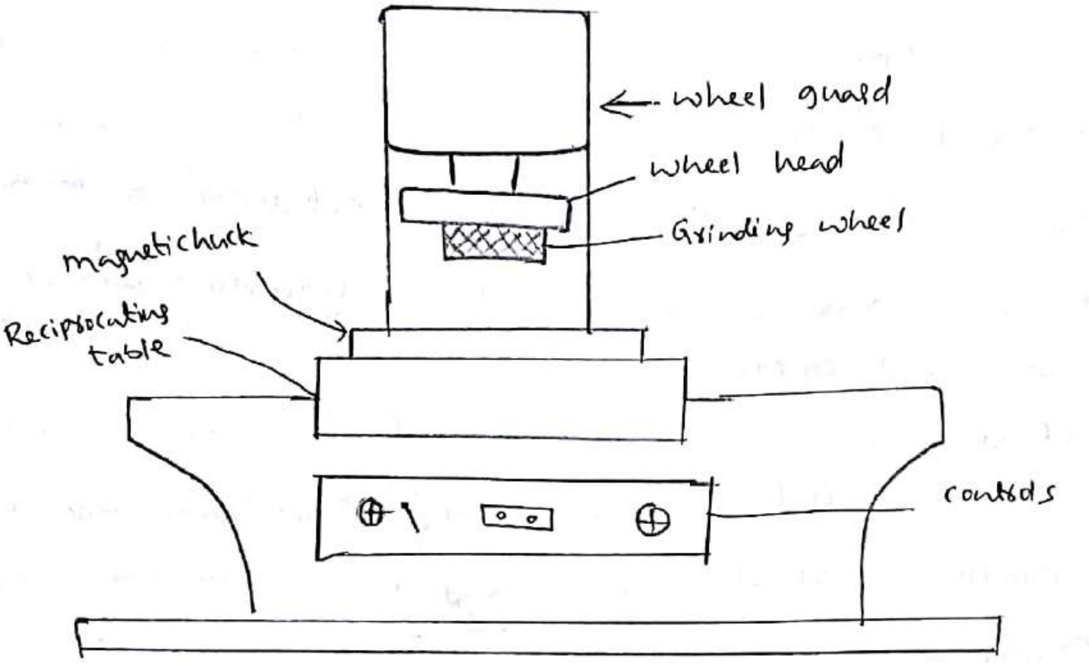
2) Reciprocating type vertical spindle surface Grinding machines

→ It consists of a vertical spindle, on which grinding wheel is mounted and the table along with the w/p. reciprocates under the wheel

→ The traverse of this table is provided by a hydraulic system. The wheel covers a major portion of the width of the job.

→ The feeding of the wheel vertically is done manually or by power. it produces plane surfaces, similar to vertical milling machines.

→ Speed range up to 30 m/min.

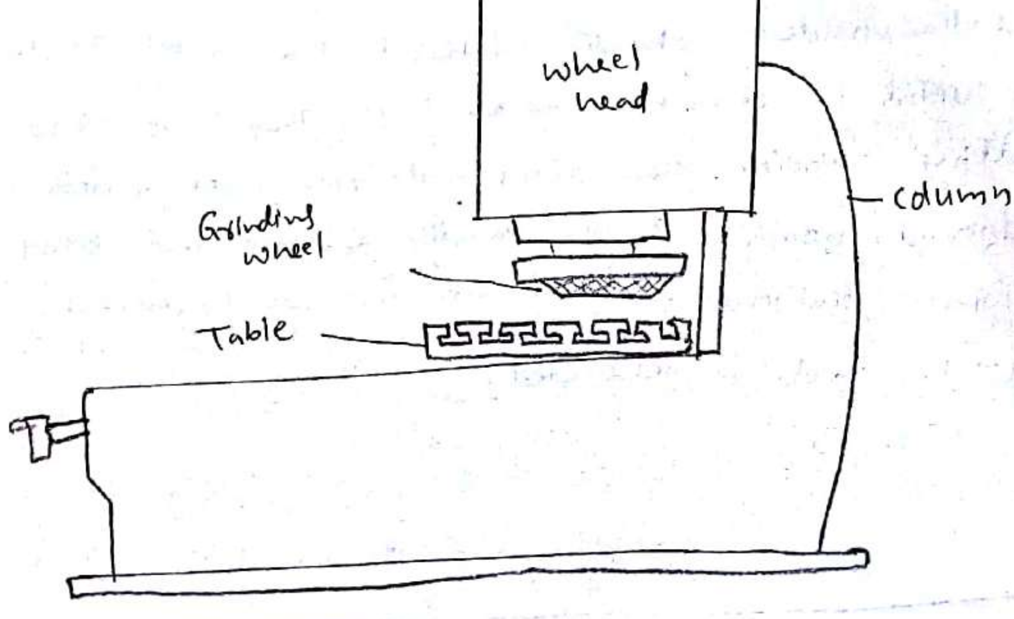


— Reciprolating Type vertical spindle surface grinding machine

3) Rotary Type vertical spindle surface grinding machines

→ It consists of a grinding wheel mostly in the shape of cut mounted on a vertical spindle. The spindle rotates in a fixed position fed only along its axis. The w/p is held on a rotating magnetic chuck, which rotates in a direction opposite to that of the wheel. The moment of the table is mainly for positioning the Work under the grinding wheel.

→ It is mainly use for heavy duty operations.



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Abrasives

→ two main types

→ 1) Natural Abrasives.

These are directly obtained in nature or in mines. The natural abrasives are sand stone, corundum, diamond, garnet and emery.

Sand stone :-

It is also called a solid quartz. these stones are used for producing grinding stones and it lacks uniform bond

Emery :-

It is a natural aluminium oxide, which contains 50-60% crystalline alumina (Al_2O_3) and remaining is iron oxide and other impurities. Emery, because of variations in natural bond, is not suitable for grinding work.

Corundum :-

→ It contains 75-90% crystalline alumina and the remaining is iron oxide. It has greater hardness and better abrasive action than sand stone.

Diamond :-

→ It is the hardest abrasive material. the wheels made of diamond are useful is cemented-carbide tools. They have very rapid cutting ability. slow wear and free cutting action. Natural diamond grains do not readily fracture and break down.

→ when diamonds are used as abrasive material, very little heat is generated.

Garnet :-

→ Garnets are used in the form of coated abrasive. Coated abrasive is a cloth or paper, on which abrasive grains are cemented. These are used for machine grinding in the form of disc or belt.

2) Artificial Abrasives

These are also called a synthetic abrasives and are manufactured. These are harder and have greater toughness than other natural abrasives, except diamond. The quality and composition of abrasive particles is easily controlled.

1) Silicon carbide (SiC)
2) Boron carbide (B_4C)
3) Aluminium oxide (Al_2O_3)
4) Cubic Boron Nitride.

1) The important contents of silicon carbide are silica, sand and coke. To this saw dust is added to make porous mixture and then it is put in an electric furnace. They formed resultant mass is crystalline in nature and is crushed and graded to particle size.

→ They are two type. 1) green silicon carbide (97%) 2) Blue silicon carbide (95%)

→ It has high hardness and sharpness and is brittle as compared Aluminium oxide.

2) Boron carbide (B_4C) :- It is produced from boric acid and coke at very high temp. in an electric furnace. This is harder than silicon carbide. It is used in stick form to dress grinding wheels, for carrying out lapping operations on very hard materials such as hardened steel.

3) Aluminium oxide (Al_2O_3)

→ It is the most used grinding abrasive. It is prepared by refining bauxite mixed with coke and iron burning. The resultant mixture is crushed and screened into grit size.

→ The wheel made from this abrasive may be black, pink, grey, or white.

→ They are used for grinding materials like carbon steels, wrought iron, malleable iron, tough bronze and alloy steels.

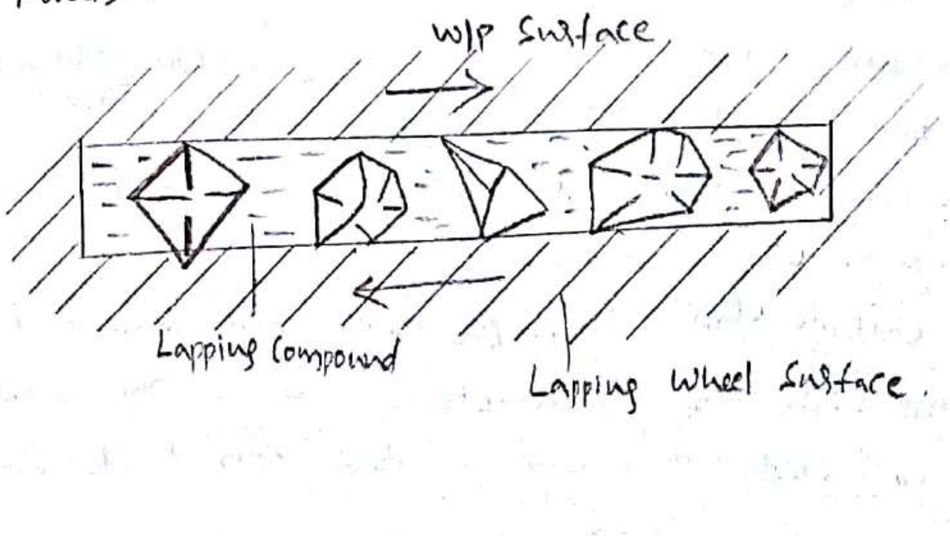
4) Cubic Boron Nitride

→ It is the second hardest abrasive. It has a tight network of interlocking and alternating nitrogen and boron atoms.

→ It is used for grinding high speed steel. hard and tough tool steels

Lapping :-

Lapping is a process of chipping away material with loose abrasive grains. Extremely high accuracy of form and dimensions, as well as very good surface quality, can be obtained with this process.



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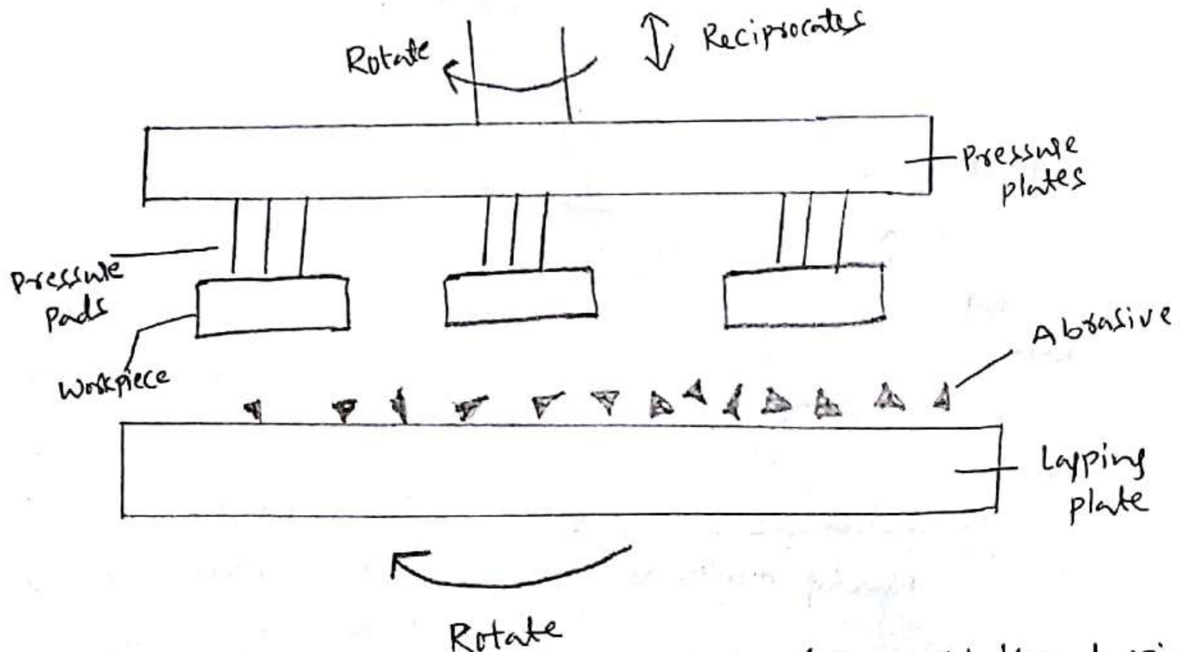
→ The abrasive substance, consisting of silicon carbide, refined corundum, boron carbide or diamond, in grain sizes b/w 18 and 150 μm, is mixed with a liquid (oil, kerosine, etc) and the mixture is known as lapping compound or lapping paste. This lapping compound. Chips away material when it is introduced b/w the surfaces of the lapping wheel and the w/p & the two are moved against each other with the application of light pressure.

→ Laping is a machining operation, in which two surfaces are rubbed together with an abrasive b/w them, by hand movement or by way of a machine.

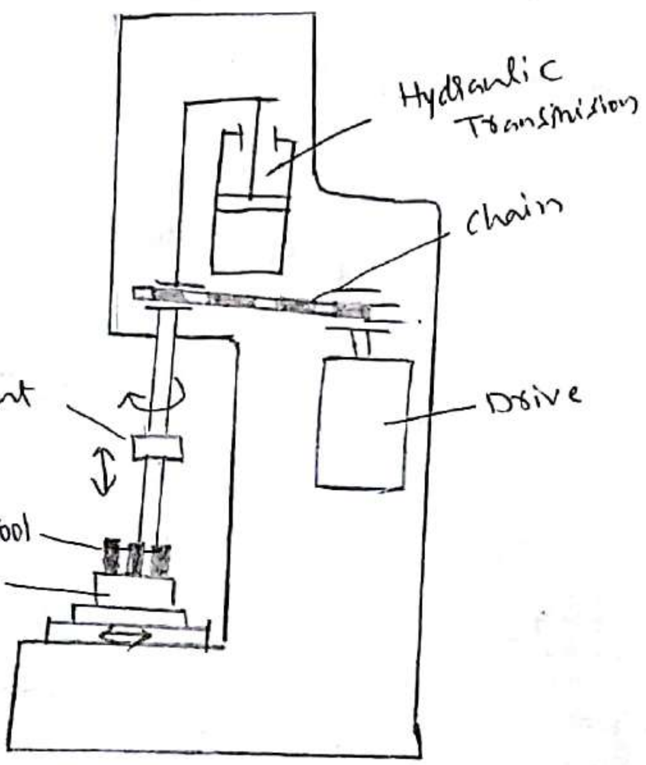


→ In single-wheel lapping, the w/p is placed on a rotating lapping wheel and moved back and forth manually in the radial direction, with the application of gentle pressure.

Honing

→ Honing is a process of machining with bonded abrasive grains. It serves to improve the shape, size, accuracy and surface quality of the w/p.

→ One distinguishes b/w long-stroke honing and short-stroke honing (superfinishing), in terms of the movement cycles, Both processes can be used for internal surfaces (holes) as well as for outer surfaces (shafts).



Honing machine.

→ Finishing in cylinder holes, bore holes.

→ Cutting fluid is coolant or lubricant is used. (oil + kerosine).

Grinding machines

1. Rough Grinder.

2. Precision grinder.

1. Rough grinder

1. Floor stand grinder

2. Bench / Pedastal Grinder

3. Portable and flexible shaft grinder

4. Swing Frame grinder.

5. Abrasive belt grinder

2. Precision Grinder :- Finish parts to a very accurate dimensions

are mainly classified into 3 types

1. Cylindrical Grinding

a) plain cylindrical grinder

b) universal cylindrical grinder.

c) centerless grinder.

2. Internal Grinders

a) Chucking internal grinders

i) plain internal grinders

ii) universal Internal grinders

b) planetory internal grinders

c) centerless internal grinders.

3. Surface grinders

According to the table movement.

a) Reciprocating table type.

i) Horizontal spindle type

ii) Vertical spindle type

b) Rotating table type

i) Horizontal spindle type

ii) vertical spindle type.

4. Tool and cutter grinders.

i) universal grinders

ii) special grinders.

5. special grinding machine.

a) Roll grinders

b) Cam shaft grinders

c) Disc grinders.

d) Crank shaft grinders.

e) piston grinders.

f) Thread grinders

g) Tool post grinders.

h) Gear teeth grinders.

Broaching

→ Broaching is a Machining process that uses a toothed tool, called a broach, to remove material.

→ They are two main types of broaching
1) Linear 2) Rotary.

→ In linear broaching, which is the more common process, the broach is run linearly against a surface of w/p to effect the cut. Linear broaches are used in a broaching machine.

→ Rotary broaching, the broach is rotated and pressed into the w/p to cut an axisymmetric shape. a rotary broach is used in a lathe. or screw mach.

1) Pull Broaching machine :–

→ The work is held stationary and the tool is pulled through or across the work. Depending on the requirement, this may be pulled up or pulled down.

→ In a vertical pull-up machines, there are 8 tools operating simultaneously. thereby increasing the productivity.

2) Push Broaching machine

→ The work is held stationary and the tool is pushed through or across the work. It may be horizontal or vertical machine.

→ During the operation the w/p is loaded on the work table. for surface broaching, the broach is pushed through the work

→ The w/p is then removed and the broach is then returned to the starting position.

→ uses for sizing holes. and cutting keyways.

3) Surface Broaching machine

→ These machines are generally used for machining flat surfaces, where the work and tool moves across each other.

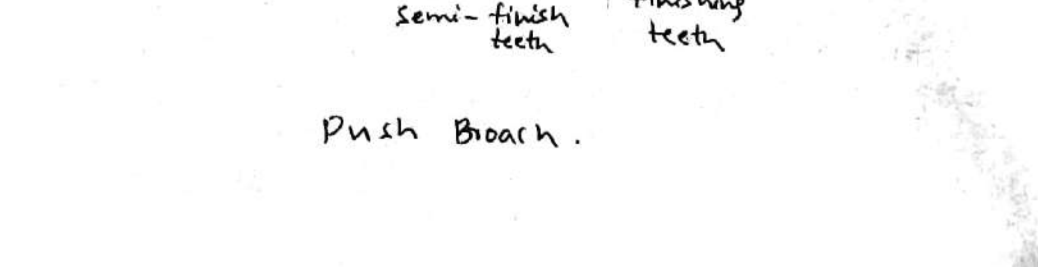
→ They are usually vertical in type and are hydraulically operated. The fixtures required in this machine should be rigid and quick acting. For surface broaching, the w/p. should be rigidly mounted and supported.

→ used for large quantities of work.

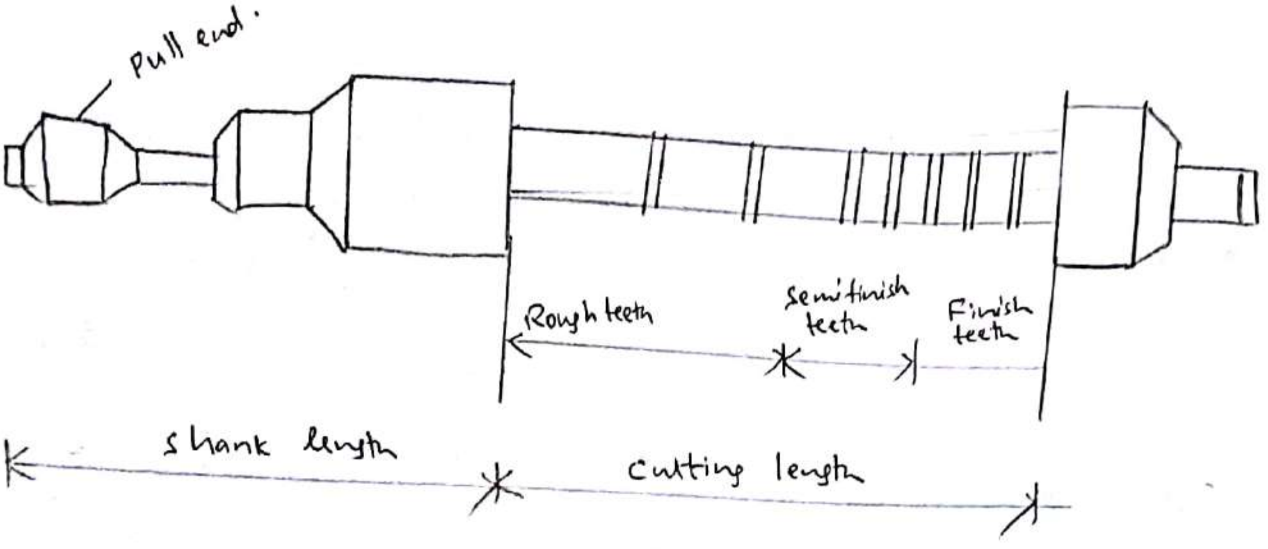
4) Continuous Broaching machine :-

→ The tool is held stationary and the w/p is moved continuously against it. The path of movement of the work may be horizontal or circular during operation, the w/p is machined as it passes the broach and the chips produced are carried away by a chip conveyor.

→ Used for broaching parts which are similar.



Push Broach.

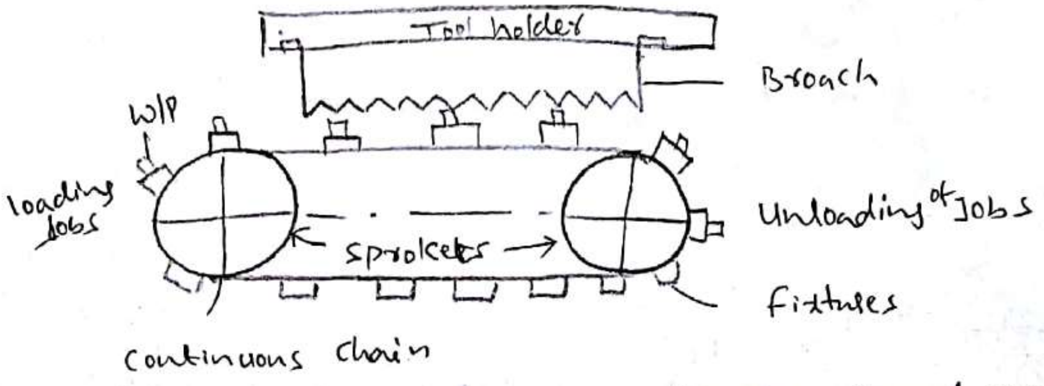


Pull Broach

→ Continuous Broaching machine

1) Horizontal continuous broaching machine
2) Rotary table horizontal continuous machine
3) Rotary table vertical continuous machine.

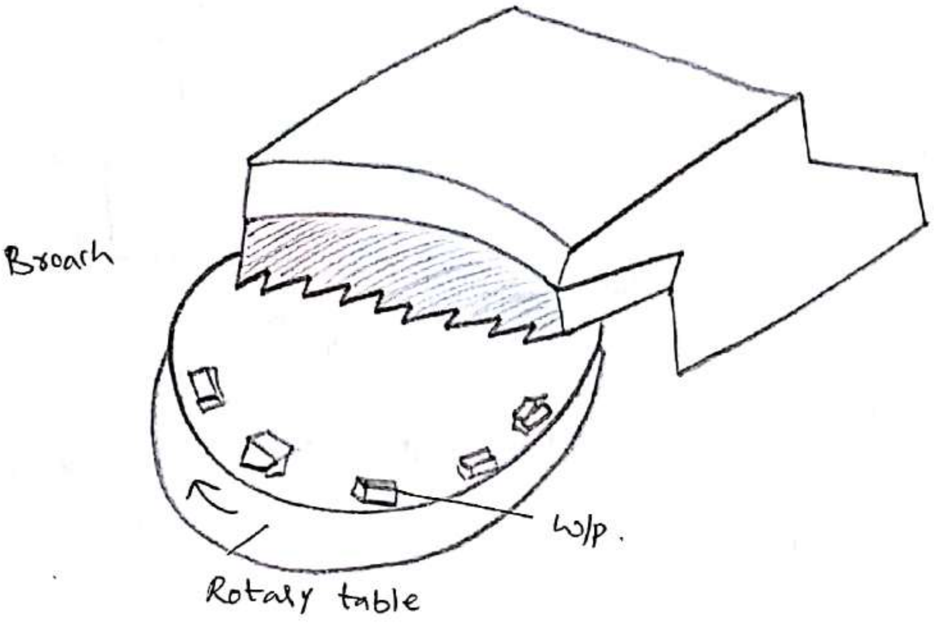
1) Horizontal continuous broaching machine



→ W/P are placed on fixtures, which are carried away by continuous chain, which is mounted on two rotating sprockets

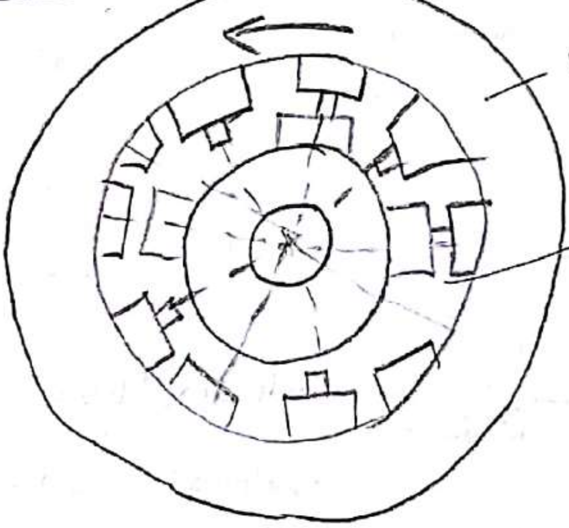
→ W/P are loaded from one side of the machine and are unloading from the other side of the machine. the Projection of teeth is opposite to the direction of the W/P.

· 2) Rotary Table Horizontal Continuous machine



→ the w/p are fixed on the rotary table, by means of a magnetic holder. the rotary table rotates about vertical axis, and w/p are broached by the broach

3) vertical Rotary Table Continuous Machine



→ This broaching machine consists of a rotary table and vertical column. The broach is fitted horizontally in the vertical column, above the rotary table. The w/p are clamped on fixtures. these type of broaching machines are generally used for slotting and facing of parts.

UNIT-IV Engineering metrology

E.M → It is the scientific study of measurements.

Fits :- Degree of Tightness or Looseness Between Two Mating Parts is known as a Fit of the Part.

→ The nature of fit is charecterised by the presence and size of Clearance and Interference.

Types of fits According to Indian standards the fits are classified into 3 Groups.

1. Clearance fit :- In this type of Fit, The size limit for mating parts are so selected. the Clearance between them always occurs. It may be noted that in a clearance Fit, The Tolerance zone of the Hole is Entirely above Tolerance zone of shaft.

→ Always has a gap b/w two mating Parts.

→ shaft size is small, compared to ~~to~~ Hole size

→ Generally in this type of fit, the lower limit size of the hole is greater or at least equal to the upper limit size of the Shaft.

2. Transition fit :-

→ It is a fit where both clearance and interference may occur in the Coupling

→ Here tolerance zones of the hole and shaft are partly or completely interface.

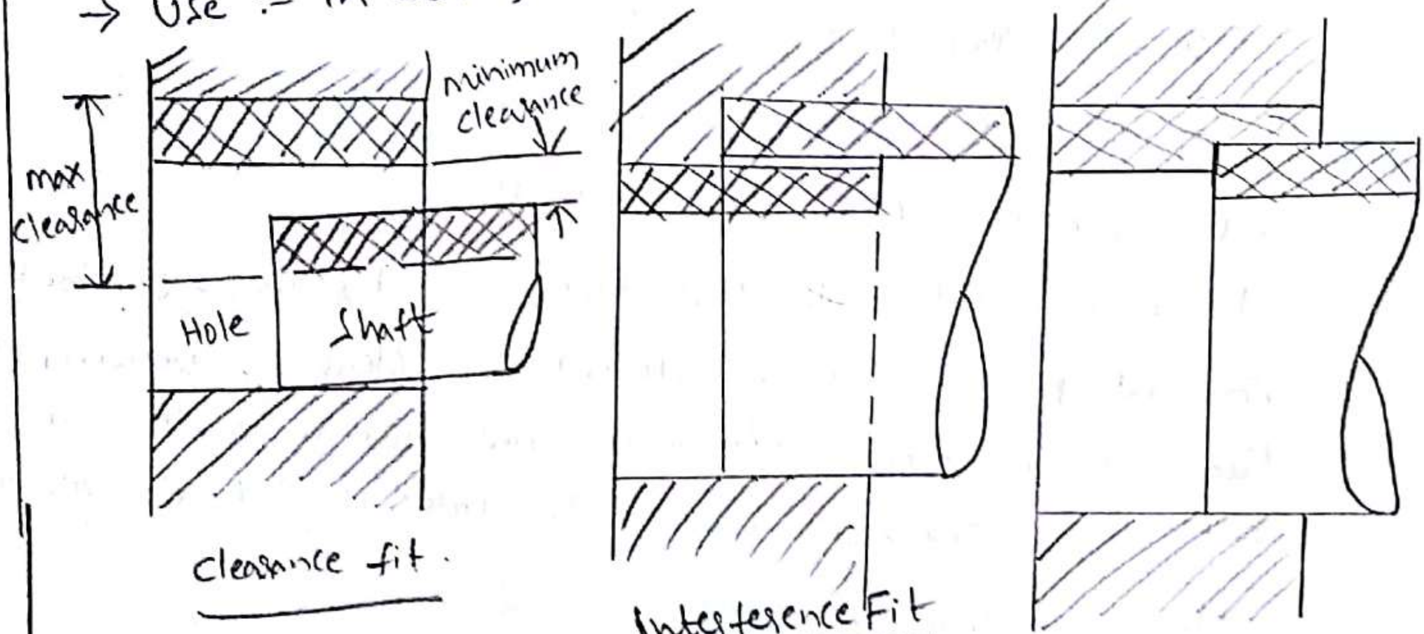
→ Uses : Pulleys and bushing, Flushed bolts etc.

3) Interference Fit :-

It always overlap & are used mainly for Press fits where the two parts are pushed together, and require no other fasteners.

→ The Upper limit size of the hole is smaller or at least equal to the lower limit size of the shaft.

→ Use :- In bearing bushings, flanges etc.



Clearance fit.

Interference Fit

Transition FIT

Limits of Sizes

There are Two Extreme possible sizes for a dimension of the Part. The Largest permissible size for a dimension is called Upper or High or maximum limit, whereas the Smallest size is known as lower or minimum limit.

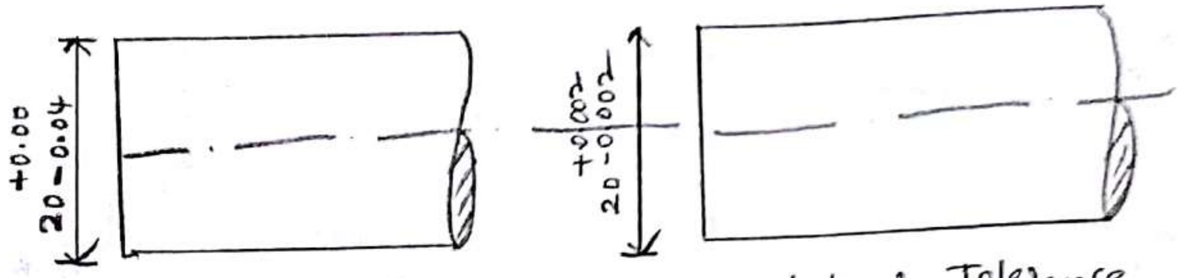
Allowance :-

→ It is the difference B/w the basic dimensions of the mating Parts. the allowance may be Positive or negative when the shaft size is less than the Hole size. then the allowance is positive; when shaft size is greater than Hole size the Allowance is Negative.

Tolerance

It is the diference B/w the upper limit and lower Limit of (Tolerance) Dimension.

In other words it is the maximum permissible Variation in dimension. the Tolerance may be Unilateral or Bi lateral.



a) Unilateral Tolerance

b) Bilateral Tolerance

→ When All tolerance is allowed on one side of Naminal size e.g. $20^{+0.00}_{-0.04}$, Then it is Unilateral

→ when Toletrance is allowed on Both sides of Naminal size e.g $20^{+0.02}_{-0.02}$, Then it is said to be Bilateral Tolerance system.

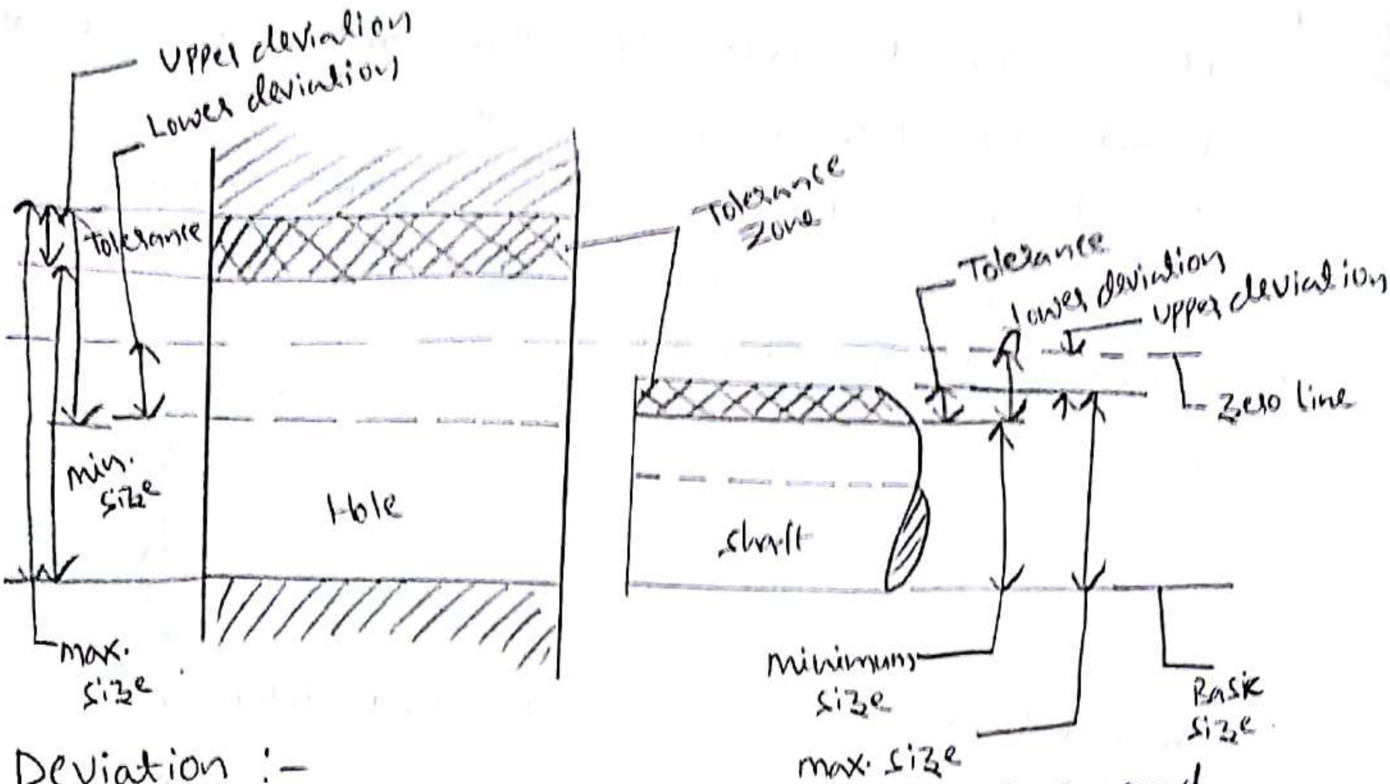
→ Unilateral Tolerance either positive or negative but not both

→ Bi-lateral tolerance in both posite and negative directions from the nominal dimension.

→ Tolerance is always positive.

→ Holes are capital letters

→ shafts are small letters



Deviation :-

It is the Algebraic Difference b/w a size and Corresponding Base size.

→ Deviation may be positive, Negative or zero.

Upper deviation :-

→ It is the Algebraic B/w the max. limit of the size and its corresponding Basic size

→ This is designated as 'Es' for Hole.
'es' for a shaft.

Lower Deviation :-

→ It is algebraic Diff. B/w minimum Limit of size and it's corresponding Basic size.

– This is designated as 'EI' for a hole and
'ei' for a shaft.

Actual Deviation :-

→ It is the Algebraic Diff. b/w the actual size and it's corresponding basic size.

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System of Fits

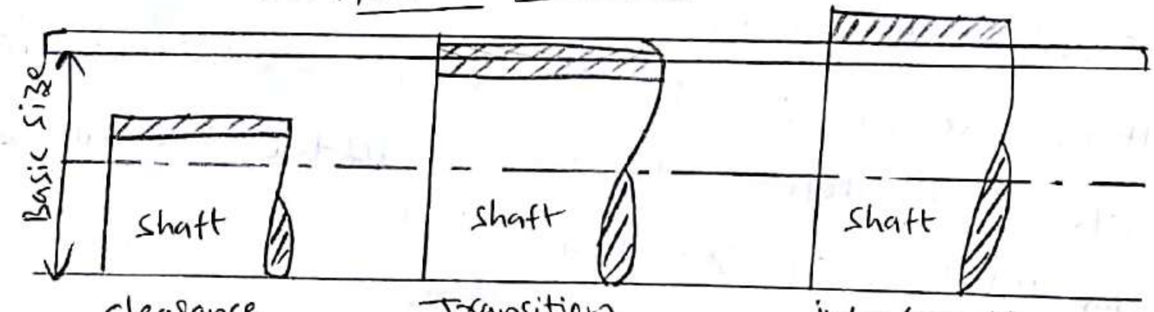
Hole Basis system

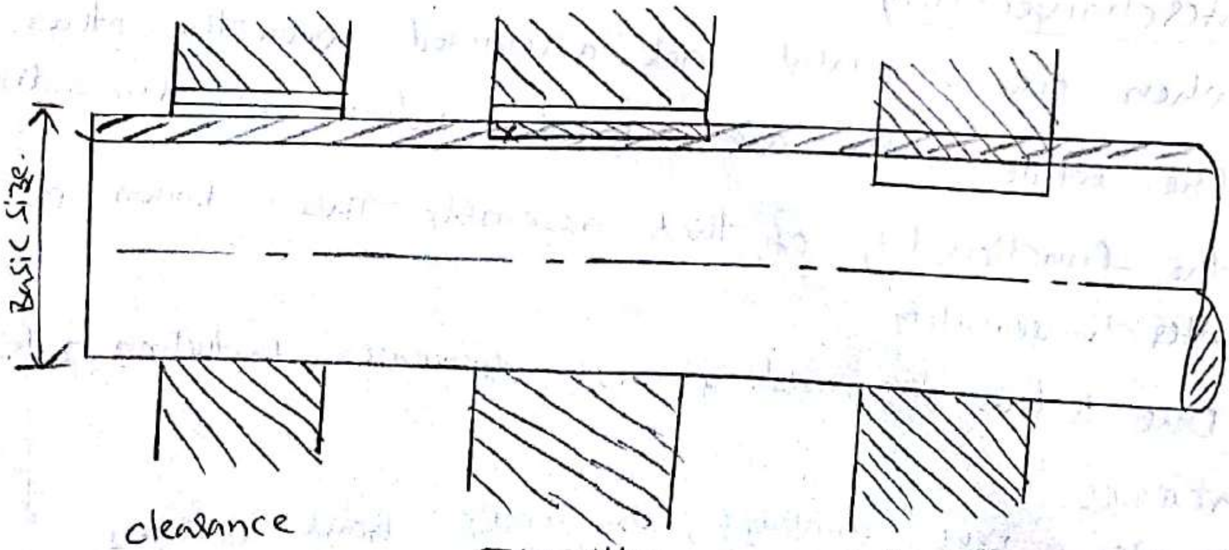
→ Lower Deviation of hole is zero
→ Algebraic B/w mini. limit size to corresponding basic size.
→ size of the Hole is kept constant, shaft size is Varied to get different fits.

sHaft Basis system

→ upper deviation of shaft is zero.
→ Algebraic b/w the max. limit size to corresponding basic size.
→ size of the shaft is kept constant, Hole size is Varied to get different fits.

— Hole Base system





shaft base system

Basic size :-

Limits of size are fixed the limits of size are Derived by the application Upper and lower deviations.

Maximum Limit :-

The greater value is taken as maximum limit.

minimum limit :-

The smaller Value is taken as minimum limit.

Nominal size :-

It is the size of a Part specified in the drawing as a matter of convenience.

Mean Deviation :-

It is Arthemetic mean B/w Upper and lower deviation.

Fundamental deviation

It is one of the Two deviations which is Conventionally chosen to define the position of the Tolerance zone in Relation To zero line.

Interchangeability

when one component get assembled with the other when one component get assembled with the other one while both are selected randomly and also satisfies the functionality of that assembly. This is known as Interchangeability.

→ Due to this assembling cost decreases, Production rate increases.

Examples :- Keys, Couplings, Pin joints, Gears, clutches.

Selective Assembly :-

→ There are cases in which accuracy and uniformity is the prime

→ This all the parts produced are graded into groups in the range of dimensions which are within the tolerance limits.

→ The discussion so far has been in connection with full interchangeability or random assembly in which any component assembles with any other component.

Taylor's Principle

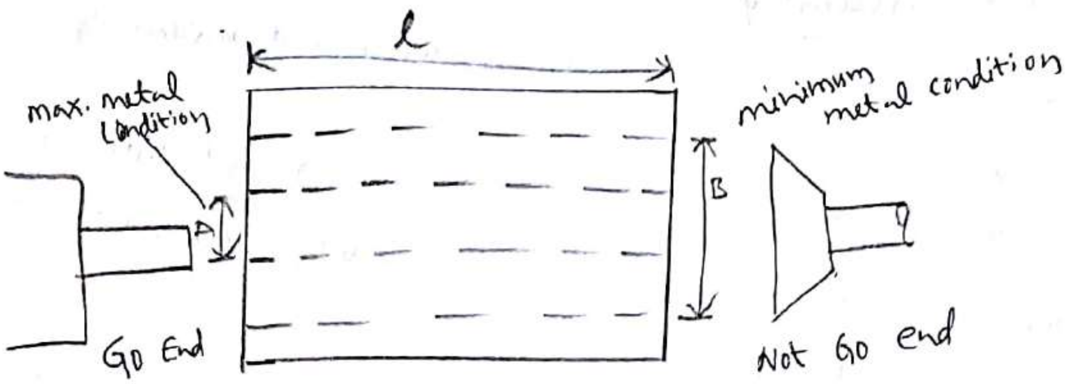
→ Go gauge is designed to check the maximum metal limit while No Go gauge should be designed to check minimum metal limit

→ Go gauges should check all related dimension. (roundness, size etc)

→ No Go gauges should check one element of dimension at a time.

→ In case of a hole the max. metal condition obtains when the hole is machined to the low limit of size and min. metal condition results when the hole is made to the high limit of size.

→ In case of shaft the limits taken would be inverse of hole.



Go and No Go Gauge

→ It refers to an inspection tool used to check a w/p against its allowed tolerances

→ Its name is derived from two tests.

→ The check involves the w/p having to pass one tese (Go) and Fail the other (NO - Go)

→ It is made with a chrome coat or with a carbide insert for greater wear resistance.

→ It is used for citilized for checking hole sizes.

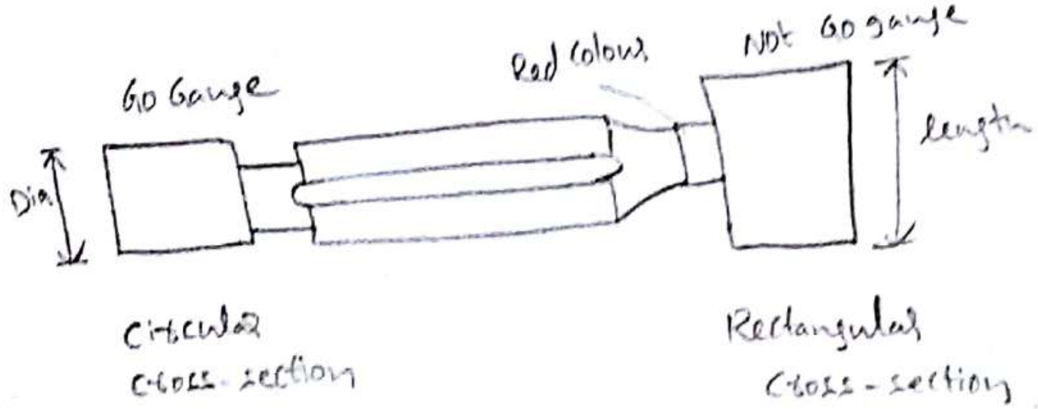
→ proper use of plug gauges there ~~fore~~ elimates the need for complex and Expensive,

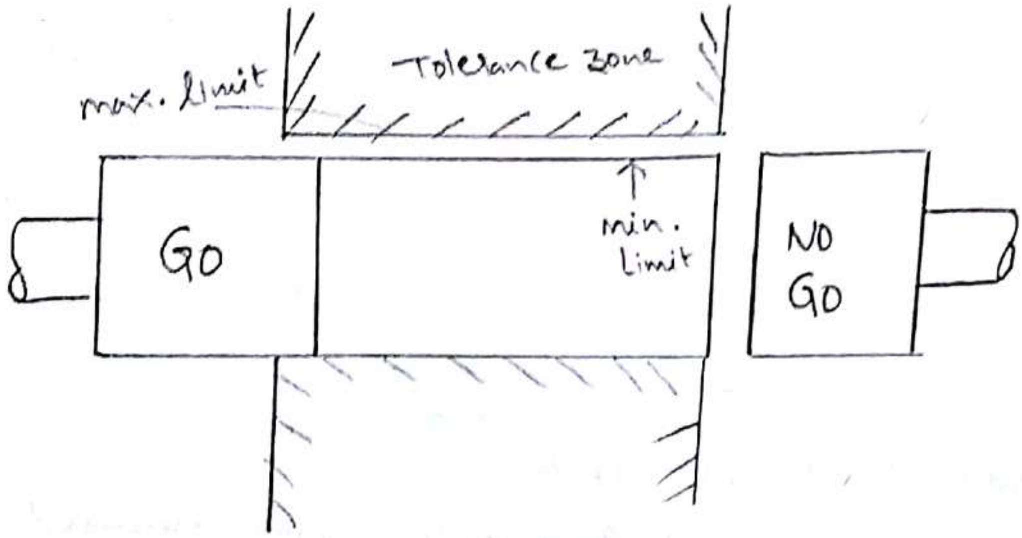
→ Go gauge is used to verify the lower limit

→ NO GO gauge is used to verity the upper limit

→ Go gauge is indicates → 'T'

→ NO Go gauge is indicates → 'Z'





Bevel Protractor :-

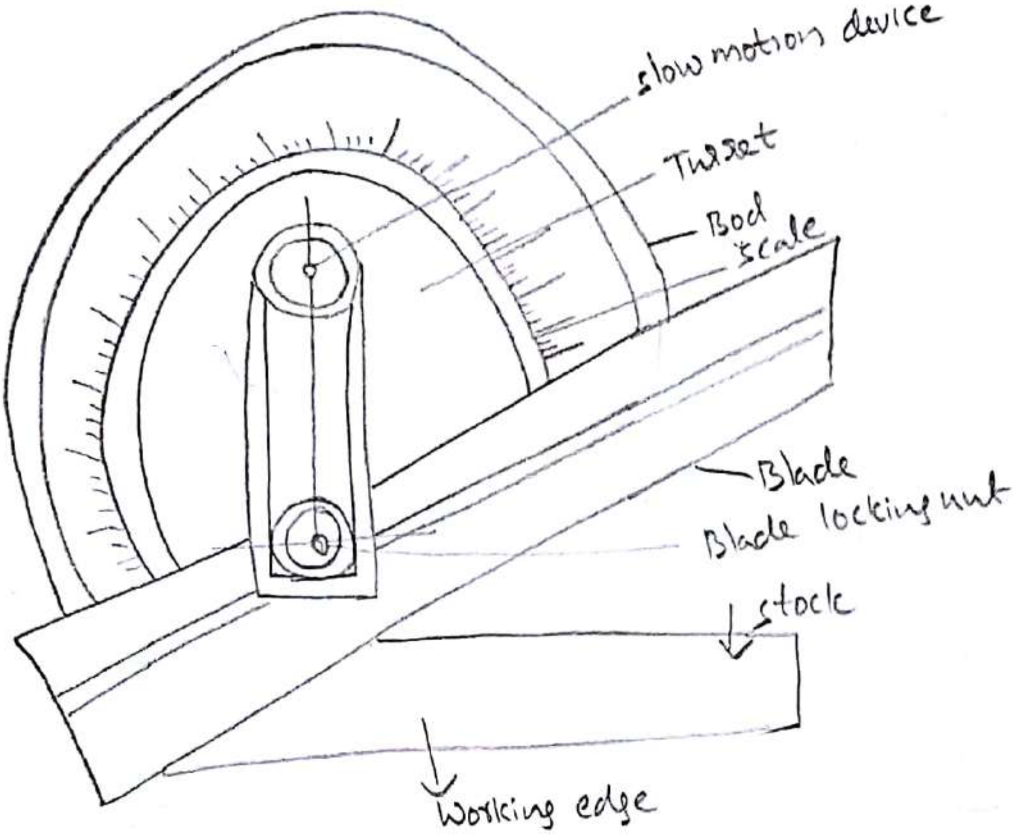
→ It consists of a beam, graduated dial and blade which is connected to swivel plate (with vernier scale) by thumb nut and clamp.

→ It is graduated circular protractor with one pivoted arm used for measuring or marking

→ Bevel protractor is used to measure angle of the objects.

→ 3 types of Bevel protractors.

1. Vernier bevel protractor
2. Universal protractor
3. Optical protractor.



1) Vernier Bevel Protractor.

→ It is measured in 'V' type angle, angles measured.

→ It is a attached with acute angle attachement the body is designed. its back is flat and no projections beyond its back.

→ The base plate is attached to the main body and an adjustable blade is attached to the circular plate containing vernier scale.

→ The main scale is graduated in degrees from 0° to 90° in both directions. the adjustable can be made to rotate freely about the center of the main scale and it can be locked at any position. for measuring accurate angle.

$$\text{least count} = \frac{\text{One main scale division}}{\text{No. of. devision on Vernier}}$$

Least count $= \frac{1}{12}$ degrees

$= \frac{1}{12} (60)$

$= 5$ m/sec.

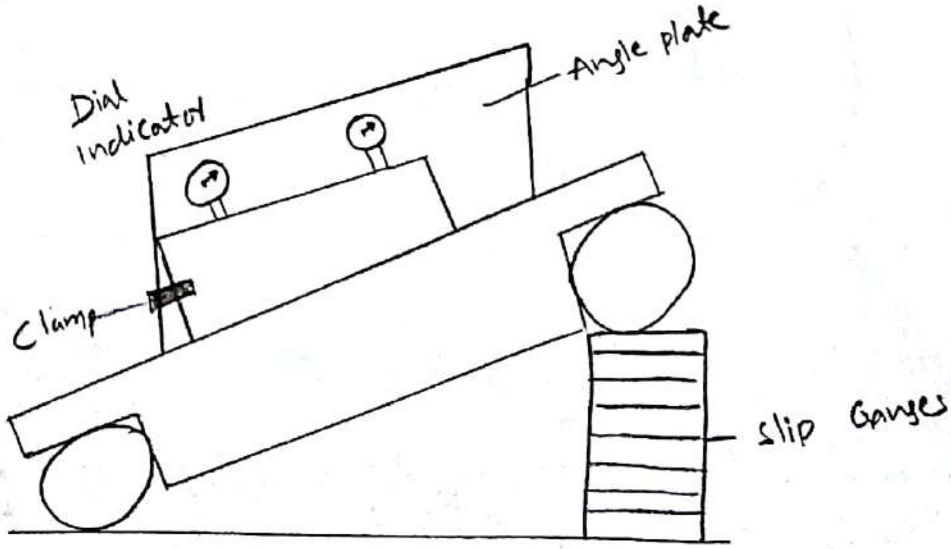
Optical protractor :- angle ~~diffe~~ deflection plane surface inspection.

- micrometer
- micro scope
- collimating lens

Sine Bar :-

→ It consists of a hardened precision ground body with two precision ground cylinders fixed at the ends.

→ The distance B/w the centers of the cylinders is precisely controlled & the top of the bar is parallel to a line through the centers of the two rollers.



$$\sin\theta = \frac{H}{L}$$

$$\theta = \sin^{-1}\left(\frac{H}{L}\right)$$

Sine plate used to determine the tapers.

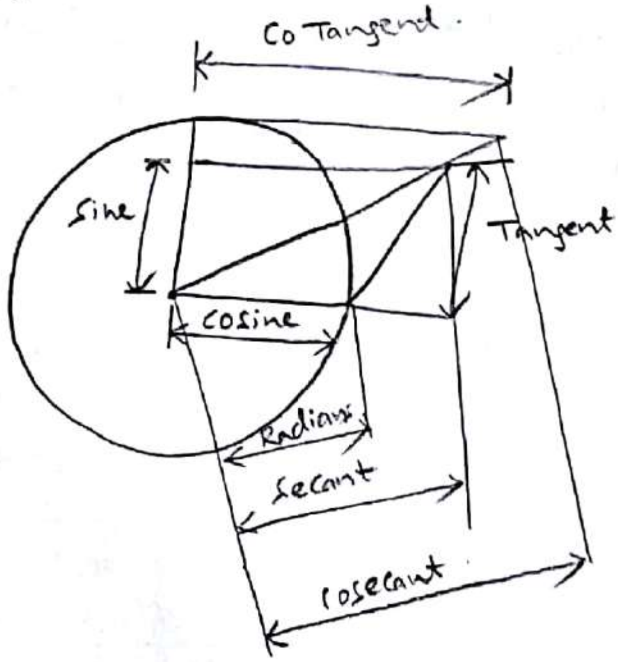
→ Sinebar or sine plate usually have a length of 5 inches or 10 inches These standards lengths are commonly used by the Tool maker or inspector

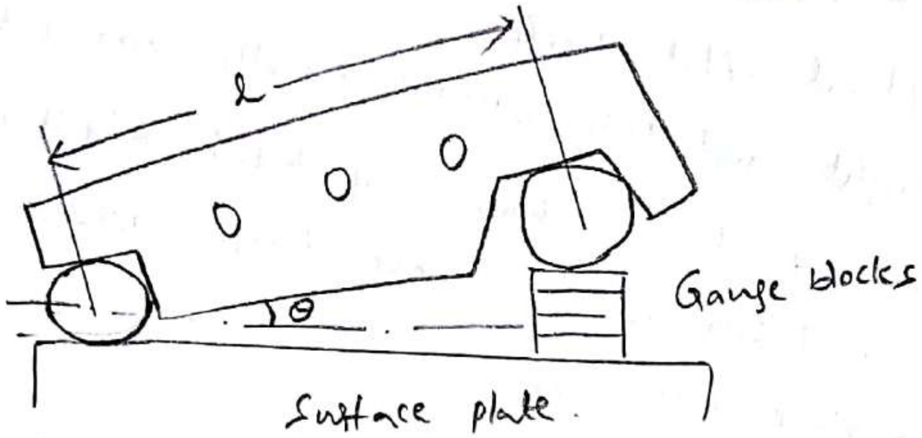
→ Sine bar is used for accuratly setting up work for machining or for inspection

→ Gauge blocks are usually for establishing the height.

→ Rule for determining the height of the sine bar setting for a given angle. multiply the sine of the angle by the length of the sine bar.

→ The sine angle is taken from the tables of trigonometric functions.

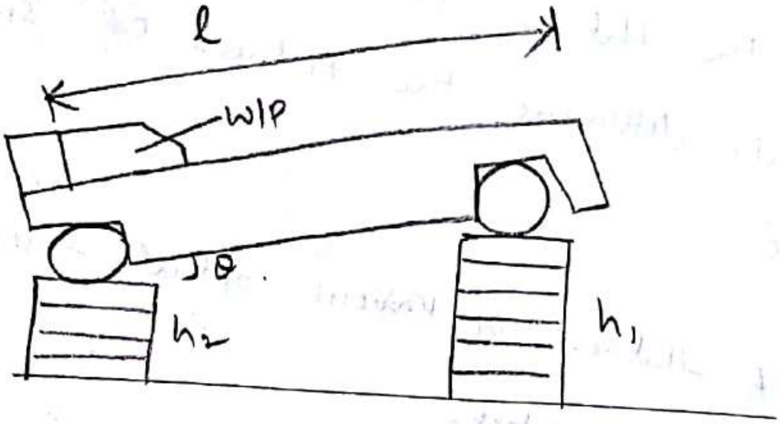




L = distance b/w centers of ground cylinders (5" to 10")

h = height of the gauge blocks

θ = angle of the plate.



$$\theta = \sin^{-1}\left(\frac{h}{l}\right)$$

$$\therefore \theta = \sin^{-1}\left(\frac{h_1 - h_2}{l}\right)$$

Measurement of flat surfaces

Measuring flatness using an optical flat entails direct contact between the specimen to be measured and the optical flat itself.

→ The light and dark patterns visually represent the flatness of the surface being tested, and it is the curve and spacing b/w these fringes which indicate the surface accuracy.

Optical Flat's:-

→ An optical flat is an optical grade piece of glass lapped and polished to be extremely flat on one or both side usually with in a few lens of nanometers. (Billionth of a meter)

→ Determining the flatness of various optical surfaces

→ optical flats determine the flatness of surfaces by interference.

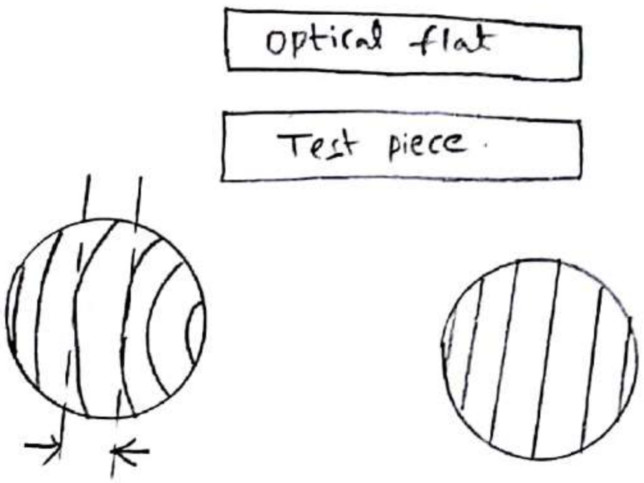
Application:-

→ calibration of flatness of various optical surfaces

→ inspection of gauge blocks

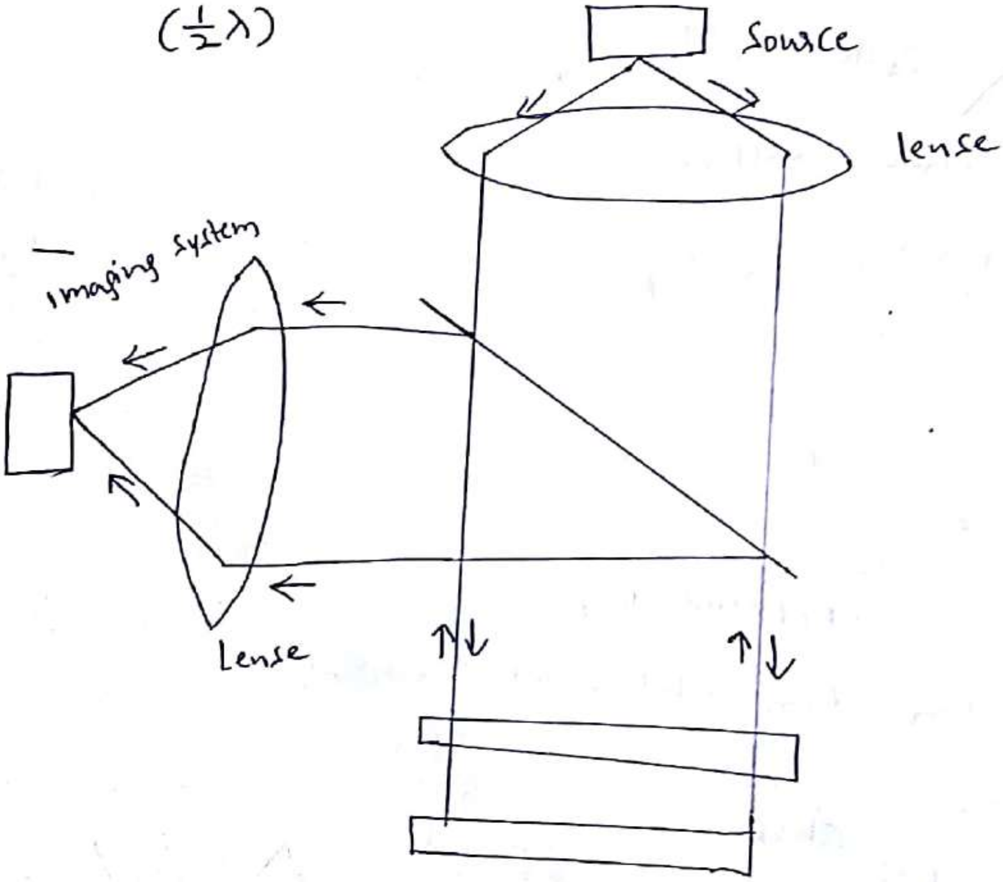
→ spectrophotometry.

→ testing filters, mirrors, prisms.



Flatness Error
of one fringe
$(\frac{1}{2}\lambda)$

Test piece perfectly flat



— Reference flat

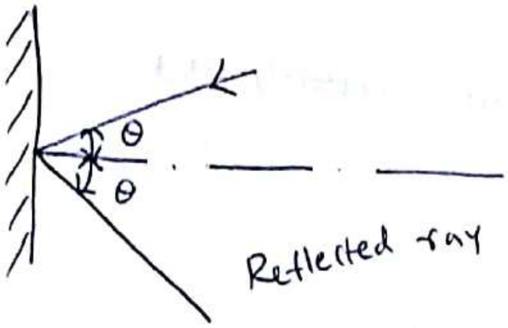
Optical :-

Equipments

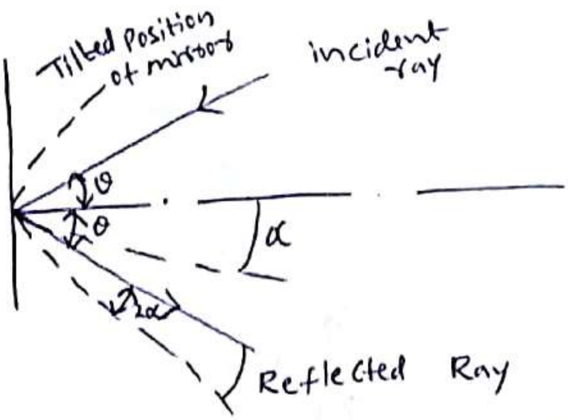
1) Reflection

2) Refraction

3) Interference

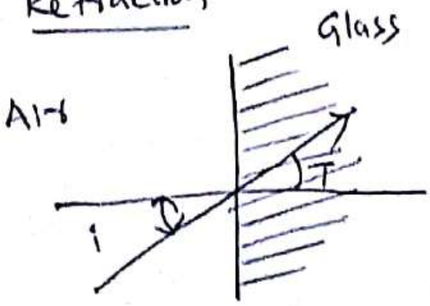


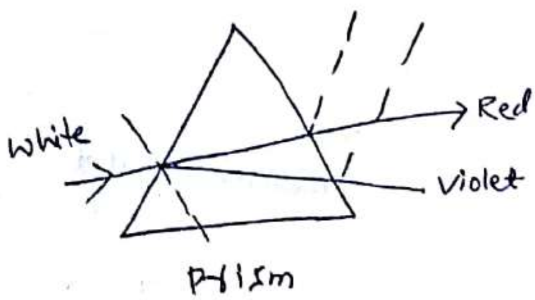
Reflection For plane surface



Reflection from tilted mirror.

Refraction





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Collimator

→ It is a device that narrows a beam of Particles or waves

→ A collimator may be described as a device that focuses or narrows a light beam or a stream of Particles to be aligned in a different direction or reduce its cross seltion.

→ The Collimator focuses a beam of light and aligns it to a different direction making it parallel or collimated

→ collimators can also be used for reducing the their by spatial cross section of a light beams making it norrower.

→ It is made from lead

→ maintains the quality of image

→ spaces b/w holes known as specta.

→ collimator consisting of a series of holes in a lead plate can be used to select the direction of the rays falling onthe crystal

4 types of collimator

1) Parallel - hole collimator
2) pin hole collimator
3) Diverging
4) converging

most of the used Parallel hole collimates.

1

Straight edges

→ A straight edge is a tool used for drawing straight lines. or checking their straightness.

→ If it has equally spaced marking along its length, it is usually called a rules.

→ straightedges are used in the automotive service and machining industry to check the flatness of machined mating surfaces.

→ True straightness can in some cases be checked by using a laser line level as an optical straightedge : it can illuminate an accurately straight line on a flat surface such as the edge of a plank or shelf.

Surface plate

→ A surface plate is a solid, flat plate used as the main horizontal reference plane for precision inspection marking out (layout) tooling setup.

→ The surface plate is often used as the baseline for all measurements to a w/p.

→ surface plates are a very common tool in the manufacturing industry and are often permanently attached to robotic-type inspection devices such as a co-ordinate - measuring machine. plates are typically square or rectangular.

Autocollimator

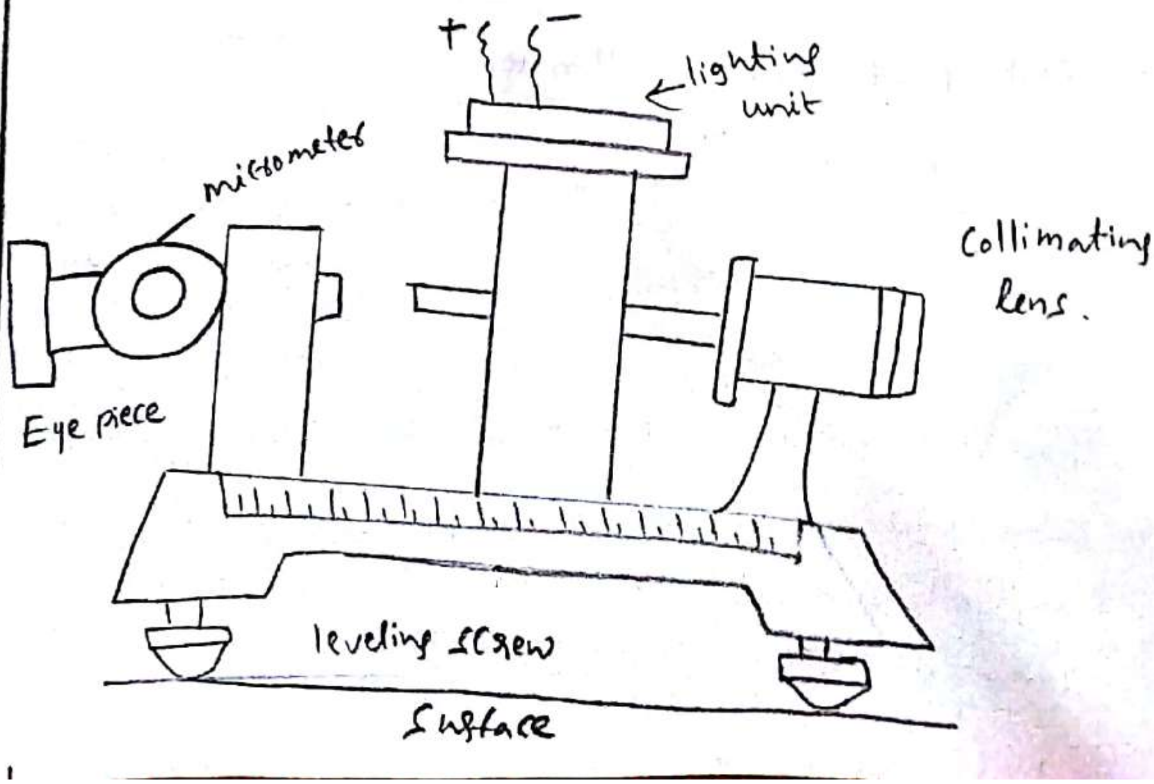
An Autocollimator is an optical instrument for non-Contact measuring of angles

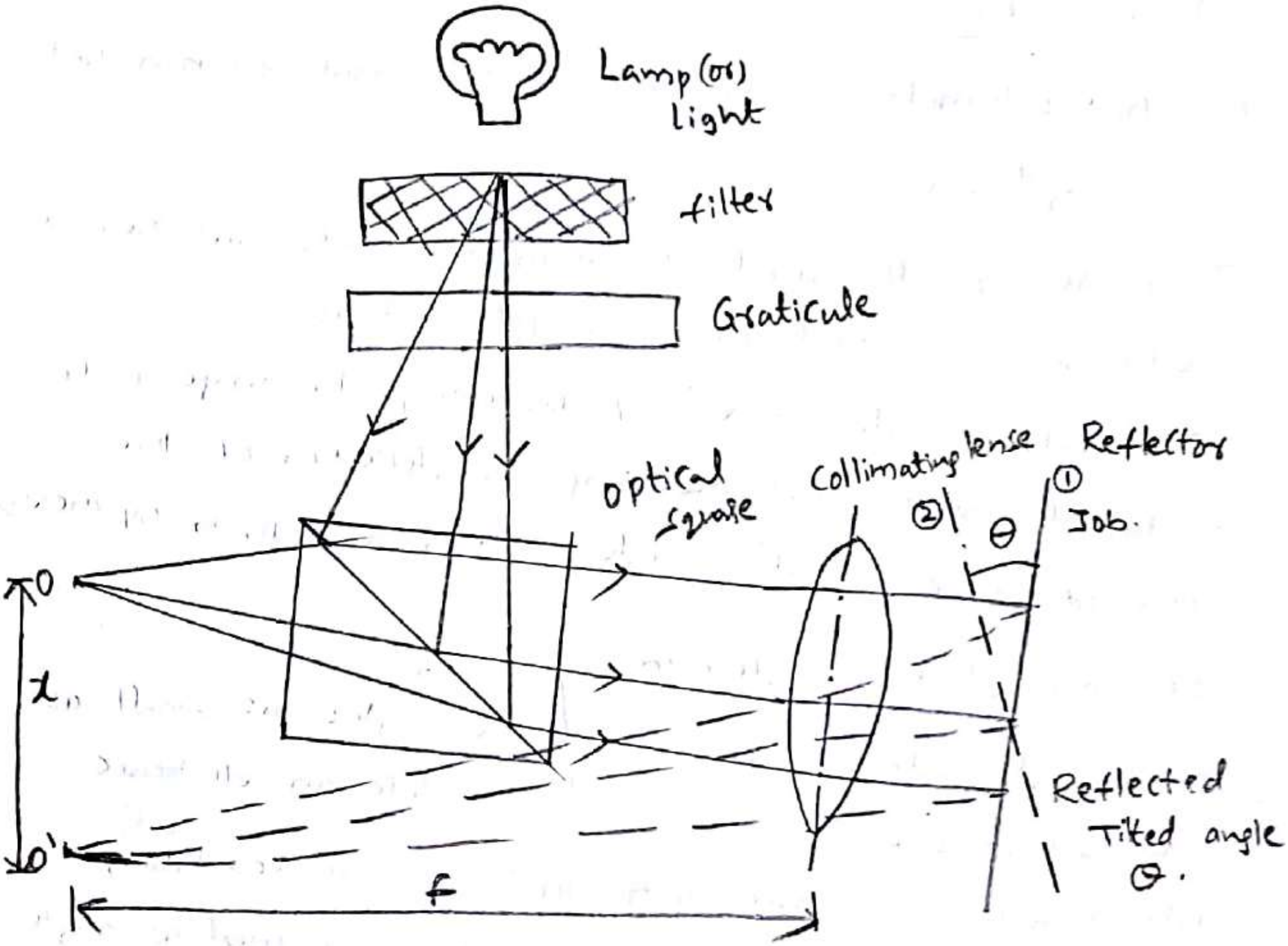
They are typically used to align components and measure deflections in optical or mechanical systems.

An autocollimator works by projecting an image onto a target mirror and measuring the deflection of the returned image against a scale, either visually or by means of an electronic detector.

-> A visual autocollimator can measure angles as small as 1 arc-second (4.85 micro-indians), while an electronic autocollimator can have up to 100 times more resolution.

-> Electronic and digital autocollimators are used as angle measurement standards, for monitoring angular movement over long periods of time and for checking angular position repeatability in mechanical system.





$$x = 2f\theta$$

f = Focal distance

θ = tilted angle 'θ'

— working of inside collimater.

Scanned by CamScanner

→ A shaft of 35 ± 0.004 mm is to be checked by means of GO–NOGO gauge. Design the required dimensions for gauge. Draw the diagrammatic representation.

Sol:– Given data.

Shaft size $= 35 \pm 0.004$ mm

find Design the Go and NoGo gauge.

Step-1 :- Calculate the upper and lower limit of the shaft.

Upper limit (UL) $= 35 + 0.004 = 35.004$ mm

Lower limit (LL) $= 35 - 0.004 = 34.996$ mm

Step-2 :- Calculate the work tolerance and gauge maker's tolerance.

Work tolerance = Upper limit – Lower limit

$= 35.004 - 34.996 = 0.008$ mm.

Gauge maker's tolerance is calculated as,

Gauge maker's tolerance = 10% of work tolerance

$\therefore$ Gauge maker's tolerance $= 0.1 \times 0.008 = 0.0008$ mm.

Step-3 :- Calculate the wear allowance

wear allowance is 10% of gauge makers tolerance

Wear allowance $= 0.1 \times$ Gauge maker's tolerance

$= 0.1 \times 0.0008 = 0.00008$ mm.

Step-4 :- Calculate the dimensions of GO–NoGO gauge for shaft

Dimension of GO gauge = Upper limit – wear allowance

$= 35.004 - 0.00008$

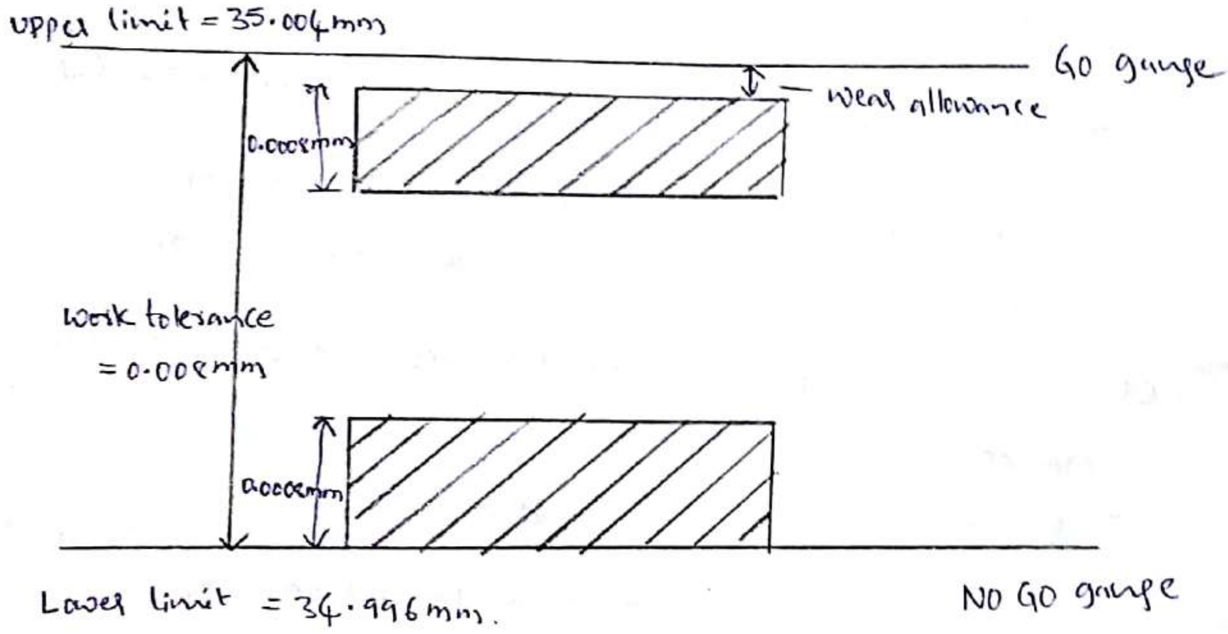
$= 35.00392$ mm

Dimension of NOGO gauge = Lower limit
$= 34.996\ mm$.

Step-5 :- Design a GO - NOGO gauge.

GO gauge, size $= 35.00392$

Tolerance $= 0.0008\ mm$



Limits for Go gauge $= 35.00392^{+0.0000}_{-0.0008}\ mm$

For NOGO gauge, size $= 34.996\ mm$

Tolerance $= 0.0008\ mm$

Limits for NOGO gauge $= 34.996^{+0.0008}_{-0.000}\ mm$.

Scanned by CamScanner

→ Design and make drawing of general purpose GO - NO GO Ring gauge for inspection of a shaft of 30 f_8. given data with usual notations: Tolerance unit = $i = 0.45\sqrt[3]{D} + 0.001D$, The value Fundamental deviation for shaft 'f' = $-5.5D^{0.41}$, Dia. step = 18 to 30mm. for tolerance for IT8 = 25i, IT9 = 40i, Dia. step = 18 to 30mm.

Sol:- given data:- Diameter step = 18 to 30 mm

Shaft size = 30 f_8, $f = -5.5D^{0.41}$,

Tolerance values for IT8 = 25i and for IT9 = 40i

$$i = 0.45\sqrt[3]{D} + 0.001D.$$

find Design the GO and NO GO ring gauge.

Step-1 Calculate the tolerance unit (i)

Diameter step is 18 to 30 mm the minimum and maximum diameter are 18 mm & 30mm.

$$\therefore D = \sqrt{D_{min} \times D_{max}} = \sqrt{18 \times 30}$$

$$= 23.2379 \text{ mm}$$

we have, $i = 0.45\sqrt[3]{D} + 0.001D$.

$$= 0.45\sqrt[3]{23.2379} + 0.001 \times 23.2379$$

$i = 1.3073$ microns $= 0.001307$ mm.

step 2:- Calculate the fundamental deviation for shaft.

$$f = -5.5D^{0.41} = -5.5 \times (23.2379)^{0.41}$$

$$f = -19.9757 \text{ microns}$$

$$= -0.01997 \text{ mm}$$

Step 3:- Calculate the upper and lower limit for shaft.

Upper limit = Basic size + Fundamental deviation

$= 30 + (-0.01997) = 29.9800\ mm.$

Calculating standard tolerance for shaft, standard

tolerance $= IT8 = 25i$

Standard Tolerance $= 25 \times 0.001307 = 0.03267\ mm.$

Calculate lower limit for shaft

Lower limit = Upper limit − standard tolerance

$= 29.9800 - 0.03267 = 29.9473\ mm.$

Step 4:- Calculate the work tolerance and gauge maker's tolerance.

Work tolerance = Upper limit − lower limit.

$= 29.9800 - 29.9473 = 0.0327\ mm.$

Gauge maker's tolerance is calculated

= 10% of work tolerance

$= 0.1 \times 0.0327 = 0.00327\ mm.$

Step 5:- Calculate the wear allowance.

Wear allowance is 10% of gauge makers tolerance.

$= 0.1 \times$ Gauge maker's tolerance.

$= 0.1 \times 0.00327\ mm.$

Step-6:- Calculate the dimensions of GO-NOGO gauge for shaft.

Dimension of GO gauge = Upper limit − wear allowance

$= 29.9800 - 0.000327$

$= 29.9796\ mm$

Dimension of NOGO gauge = Lower limit
= 29.9473 mm.

Step 7:- Design the GO-NOGO gauge.

GO gauge, size = 29.9796 mm.

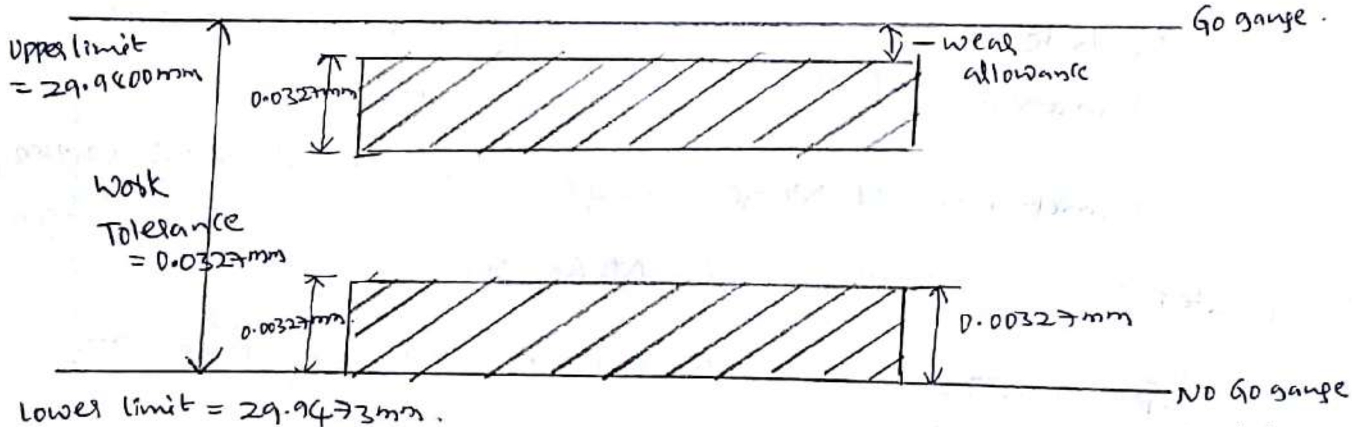
Tolerance = 0.00327 mm.

limits for GO gauge = $29.9796^{+0.0000}_{-0.00327}$ mm.

For NOGO gauge, size = 29.9473 mm

Tolerance = 0.00327 mm

Limits for NOGO gauge = $29.9473^{+0.00327}_{0.0000}$ mm.



→ Design the GO and NOGO limit gauge for checking of a hole. having size $40^{+0.04}_{-0.00}$ mm. Assume gauge maker's tolerance and wear allowance equal to 10% equal to 10% of work tolerance and Draw the diagrammatic presentation of gauge maker's tolerance.

Given data:-

Hole size = $40^{+0.04}_{-0.00}$ mm.

find Design the GO and NOGO gauge.

Step 1:- calculate the upper and lower limit of the shaft.

Upper limit = (UL) = 40 + 0.04 = 40.04 mm.

Lower limit = (LL) = 40 + 000 = 40.00 mm

Step 2:- Calculate the work tolerance and gauge maker's tolerance

Work tolerance = Upper limit − Lower limit

$= 40.04 - 40.00 = 0.04$ mm

Gauge maker's tolerance = 10% of work tolerance

$= 0.1 \times 0.04 = 0.004$ mm.

Step 3:- Calculate the wear allowance

Wear allowance is 10% of gauge maker's tolerance

Wear allowance = 0.1 × Gauge maker's tolerance

$= 0.1 \times 0.004 = 0.0004$ mm.

Step 4:- Calculate the dimensions of GO-NOGO gauge for hole.

Dimension of GO gauge = Lower limit + wear allowance

$= 40.00 + 0.0004 = 40.0004$ mm.

Dimension of NOGO gauge = Upper limit = 40.04 mm

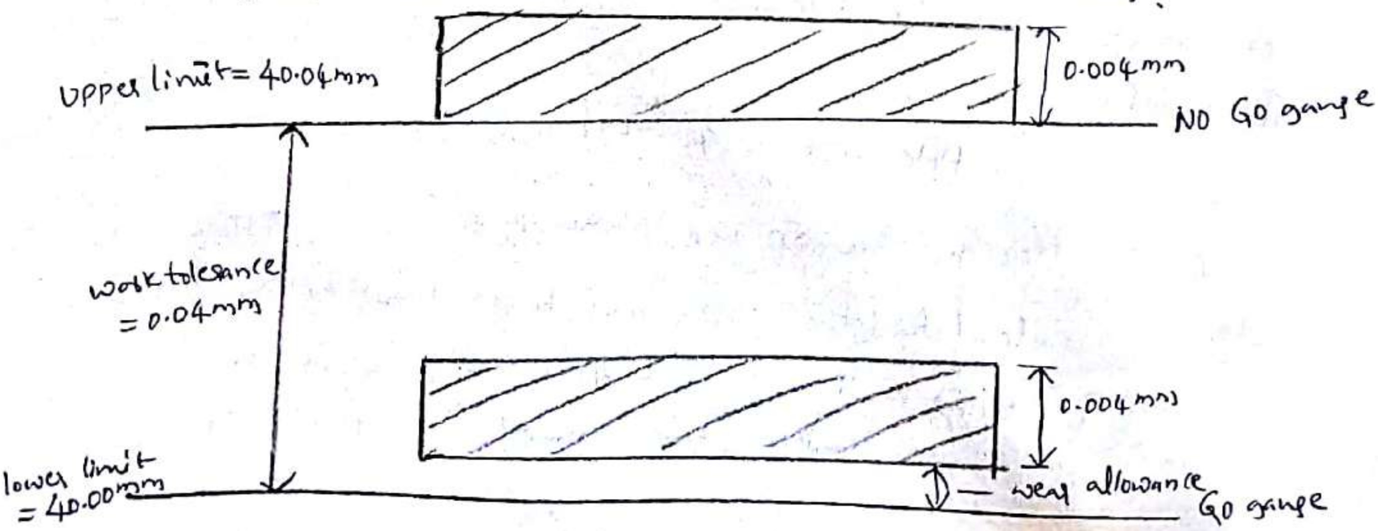
Step 5:- Design a GO - NO GO gauge.

GO gauge, size = 40.0004 mm, Tolerance = 0.004 mm

∴ Limits for GO gauge $= 40.0004^{+0.004}_{-0.000}$ mm

for NOGO gauge, size = 40.04 mm & Tolerance = 0.004 mm.

Limits for NOGO gauge $= 40.04^{+0.004}_{-0.000}$ mm.



Design general type of 'GO' and 'NO GO' gauge for components having 40 $H_8 d_9$ fit. Given data 40mm falls in diameter steps of 30 – 50mm

upper deviation for 'f' type of shaft = $-16 D^{0.44}$, ~~f~~

$i = 0.45 \sqrt[3]{D} + 0.001 D$, $IT8 = 25i$, $IT9 = 40i$, wear allowance = 10% of gauge tolerance.

Sol:- Given data

Shaft and hole size = 40 $H_8 d_9$, $i = 0.45 \sqrt[3]{D} + 0.001 D$.

Diameter step = 30 to 50 mm.

$IT8 = 25i$, $IT9 = 40i$, $f = -16 D^{0.44}$, wear allowance = 10% gauge maker's ~~tolerance~~ tolerance.

find the Design GO & NO GO gauges.

Step-1 :- Calculate the tolerance unit (i)

Diameter step 30 to 50mm

max. Dia = 50mm

min Dia = 30mm

$$D = \sqrt{D_{min} \times D_{max}} = \sqrt{30 \times 50} = 38.7298 \text{ mm}$$

$$i = 0.45 \sqrt[3]{D} + 0.001 D,$$

$$= 0.45 \sqrt[3]{38.7298} + 0.001 \times 38.7298$$

$$= 1.5612 \text{ microns} = 0.001561 \text{ mm}$$

Case i for a hole

step 2:- Calculate the fundamental deviation for hole. the fundamental deviation for a hole of 'H' type is equal to zero. $(f)_{hole} = 0$

Step-3 :- Calculate the Upper ~~&~~ lower limit for hole

Lower Limit (LL) = Basic size + Fundamental deviation

= 40 + 0 = 40 mm.

Calculate standard tolerance for hole,

standard tolerance grade IT8 = 25i = 25 × 0.001561

= 0.039025 mm.

Calculate upper limit for hole

Upper limit = Lower limit + Standard tolerance

= 40 + 0.039025 = 40.039025 mm

Step 4:- Calculate the work tolerance & gauge maker's tolerance.

work tolerance = Upper limit − Lower limit.

= 40.039025 − 40 = 0.039025 mm

Gauge maker's tolerance is 10% of work tolerance

= 0.1 × 0.039025 = 0.0039025 mm.

Step-5:- Calculate the wear allowance

wear allowance is 10% of gauge makers tolerance

= 0.1 × gauge maker's tolerance.

= 0.1 × 0.0039025 = 0.00039025 mm

Step-6:- Calculate the dimensions of Go-NoGo gauge for hole

Dimension of Go gauge = Lower limit + wear allowance

= 40 + 0.00039025 = 40.00039025 mm

NoGo gauge = Upper limit = 40.039025 mm.

Step-7 :- Design the plug gauge for hole

GO gauge

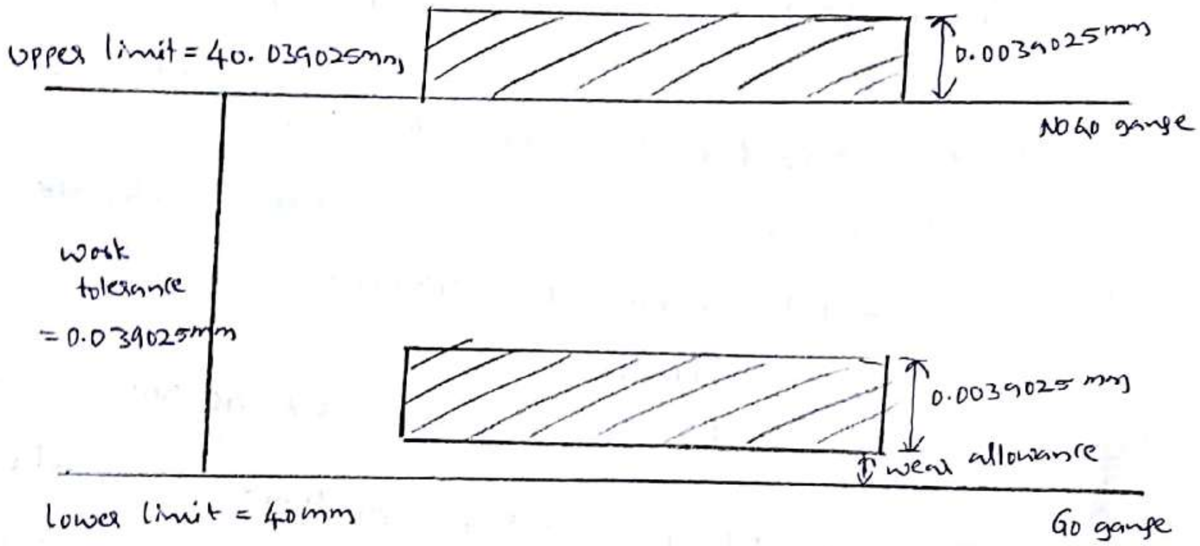
size = 40.00039025 mm, Tolerance = 0.0039025 mm

$$\text{Limits for GO gauge} = 40.00039025^{+0.0039025}_{-0.0000}\ mm$$

No GO gauge, size = 40.039025 mm

Tolerance = 0.0039025 mm

$$\text{Limits for NO GO gauge} = 40.039025^{+0.0039025}_{\pm 0.0000}\ mm.$$



Case II

For a shaft

Step-2 :- Calculate the fundamental deviation for shaft.

$$f = -16D^{0.44} = -16\,(38.7298)^{0.44}$$

$$= 79.9576 \text{ microns} = -0.07995\,mm$$

Step-3 :- Calculate the upper and lower limit for shaft.

Upper limit (UL) = Basic size + Fundamental deviation

$= 40 + (-0.07995) = 39.9200\,mm.$

standard tolerance grade $= IT8 = 25i$

$= 25 \times 0.001561$

$= 0.039025\,mm$

Calculate lower limit for shaft.

Lower limit (LL) = Upper limit − standard tolerance

$= 39.9200 - 0.039025$

$= 39.8809$ mm

Step 4:- Calculate the work tolerance and gaugemaker's tolerance

work tolerance = Upper limit − lower limit.

$= 39.9200 - 39.8809$

$= 0.0391$ mm

Gauge maker's tolerance is 10% of the work tolerance

$= 0.1 \times 0.0391 = 0.00391$ mm

Step 5:- Calculate the wear allowance

wear allowance is 10% of gauge maker's tolerance.

$= 0.1 \times$ Gauge maker's tolerance

$= 0.1 \times 0.00391 = 0.000391$ mm

Step 6 :- Calculate the dimensions of GO NO GO gauge for shaft

Dimension of GO gauge = Upper limit − wear allowance

$= 39.9200 - 0.000391 = 39.9196$ mm.

NO GO gauge = Lower limit $= 39.8809$ mm

Step 7 :- Design the GO NO GO gauge for shaft.

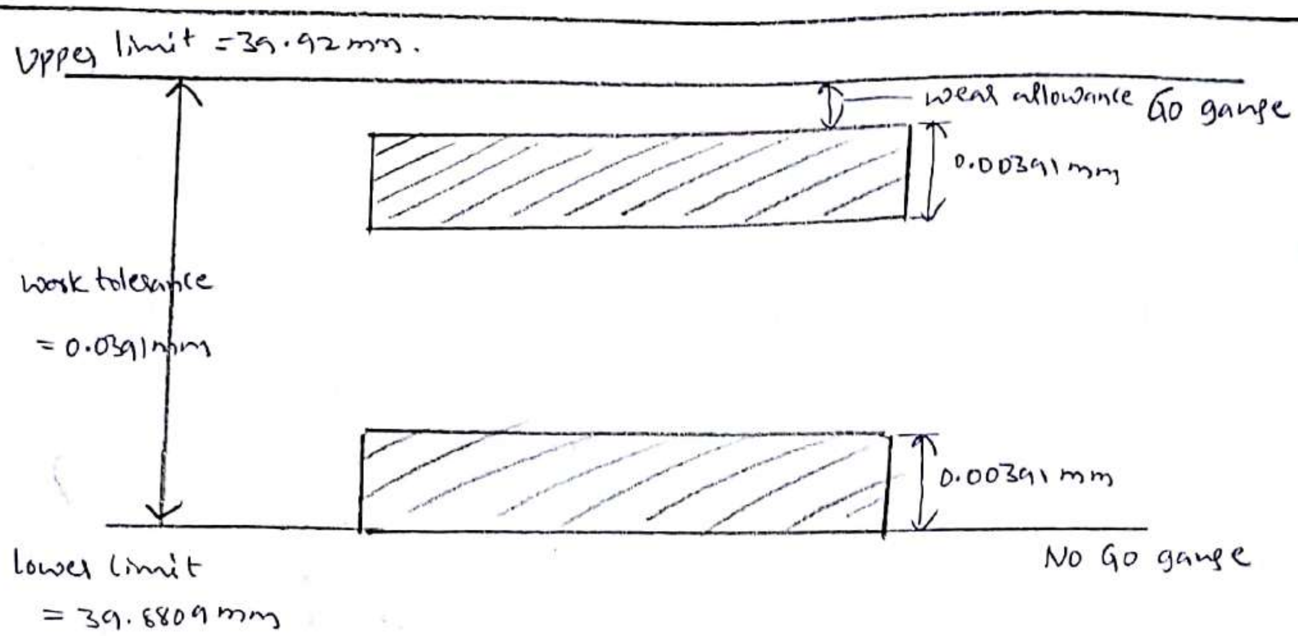
GO gauge, size = 39.9196 mm, Tolerance = 0.00391 mm

Limits for GO gauge $= 39.9196^{+0.0000}_{-0.00391}$ mm

NO GO gauge, size = 39.8809 mm

Tolerance = 0.00391 mm

limits for NO GO gauge $= 39.8809^{+0.00391}_{-0.0000}$ mm.


Upper limit = 39.92 mm.
wear allowance
Go gauge
0.00391 mm
work tolerance
= 0.0391 mm
0.00391 mm
lower limit
= 39.8809 mm
No Go gauge

Unit - V

Surface Roughness measurements

Roughness :-

→ Surface roughness often shortened to roughness, is a Component of surface texture. It is quantified by the deviations in the direction of the normal vector of a real surface from its ideal form. if these deviations are large, the surface is rough. if these deviations are small, the surface is smooth.

→ It is the measure of the finely spaced micro- irregularities on the surface texture which is composed of three components Roughness, waviness, form.

→ Ra and RMS are both representations of surface roughness, but each is calculated differently. Ra is calculated as the Roughness Average of a surfaces measured microscopic peaks and valleys.

→ RMS is calculated as the Root mean square of a surfaces measured microscopic peaks and valleys.

Terminalogy as per Indian standards

Real surface :- is the surface limiting the body and separating it from the surrounding surface.

Geometrical surface :- Is the surface prescribed by the design or by the process of ~~Meas~~ manufacture, neglecting the errors of form and surface roughness.

Effective surface :- Is the close representation of real surface obtained by instrumental means.

Surface Texture :- Repetitive or random deviations from the nominal surface which form the pattern of the surface. Surface Texture includes roughness, waviness, lay and flaws.

Surface Roughness :- It concerns all those irregularities which form surface relief and which are conventionally defined within the area where deviations of form and waviness are eliminated.

Primary Texture (Roughness)

It is caused due to the irregularities in the surface roughness which result from the inherent action of the production process. These are deemed to include transverse feed marks and the irregularities within them.

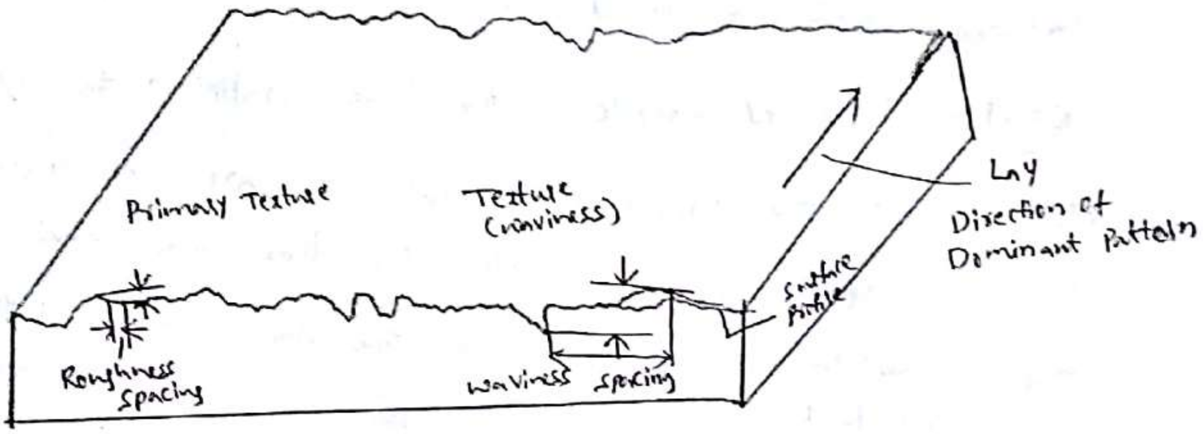
Secondary Texture (Waviness)

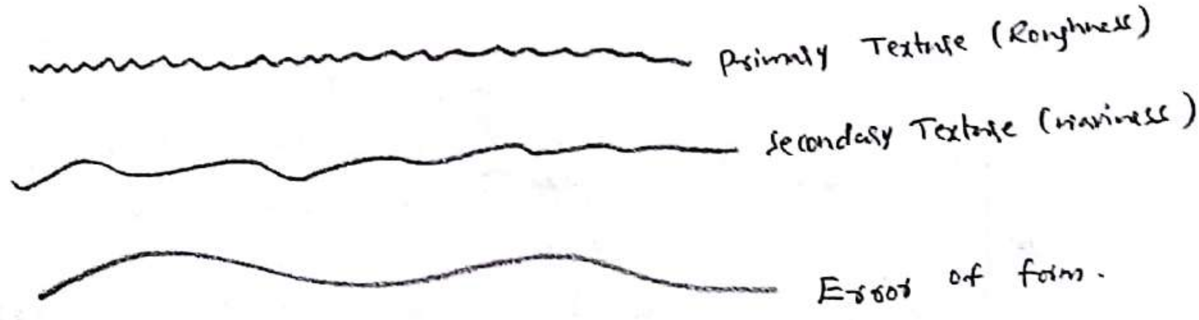
It results from the factors such as machine or work deflection, vibrations, chatter, heat treatment or warping strains. Waviness is the component of surface roughness upon which roughness is superimposed.

Flaws :- Flaws are irregularities which occur at one place or at relatively infrequent or widely varying intervals in surface (like scratches, cracks, random blemishes, etc.).

Centre line :-
The line about which roughness is measured

Lay. it is the direction of the 'predominant surface pattern' ordinarily determined by the method of production used.





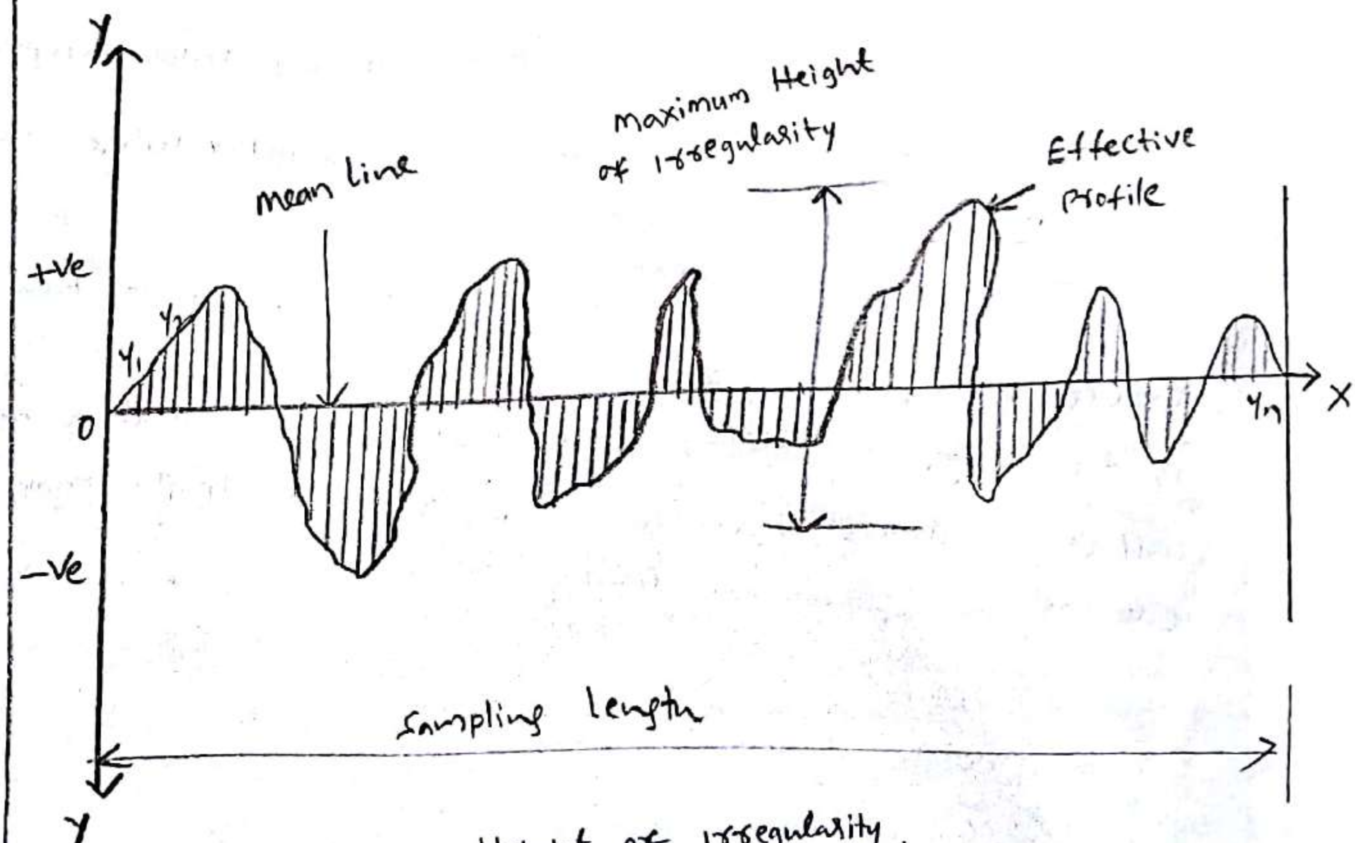
Traversing length :-
is the length of the profile necessary for the evaluation of the surface roughness parameters. The traversing length may include one or more sampling lengths.

Sampling length (l) is the length of profile necessary for the evaluation of the irregularities to be taken into account. This is also known as the 'cut-off' length in regard to the measuring instruments.

Mean line of the profile:-

It is the line having the form of the geometrical profile and dividing the effective profile so that within the sampling length the sum of the squares of distances $(y_1, y_2, ---- y_n)$ between effective points and the mean line is a minimum.

Centre line of profile is the line parallel to the general direction of the profile for which the areas embraced by the profile above and below the line are equal. when the waveform is repetitive, the mean line and the centre are equivalent.



—Maximum Height of irregularity.

Spacing of the irregularities is the mean distance b/w the more ~~Rea~~ Prominent irregularities of the effective profile, within the sampling length.

Arthemetical mean deviation from the mean line of Profile (R_a) is defined as the average value of the ordinates ($y_1, y_2 \cdots y_n$) from the mean line.

The ordinates are summed up without considering their algebraic sign,

$$\text{i.e.,} \quad R_a = \frac{1}{n} \int_0^L |y| \, dx$$

Approximately:

$$R_a = \frac{\sum_0^n |y_i|}{n}$$

where n is the no. of divisions over the sampling length 'L'

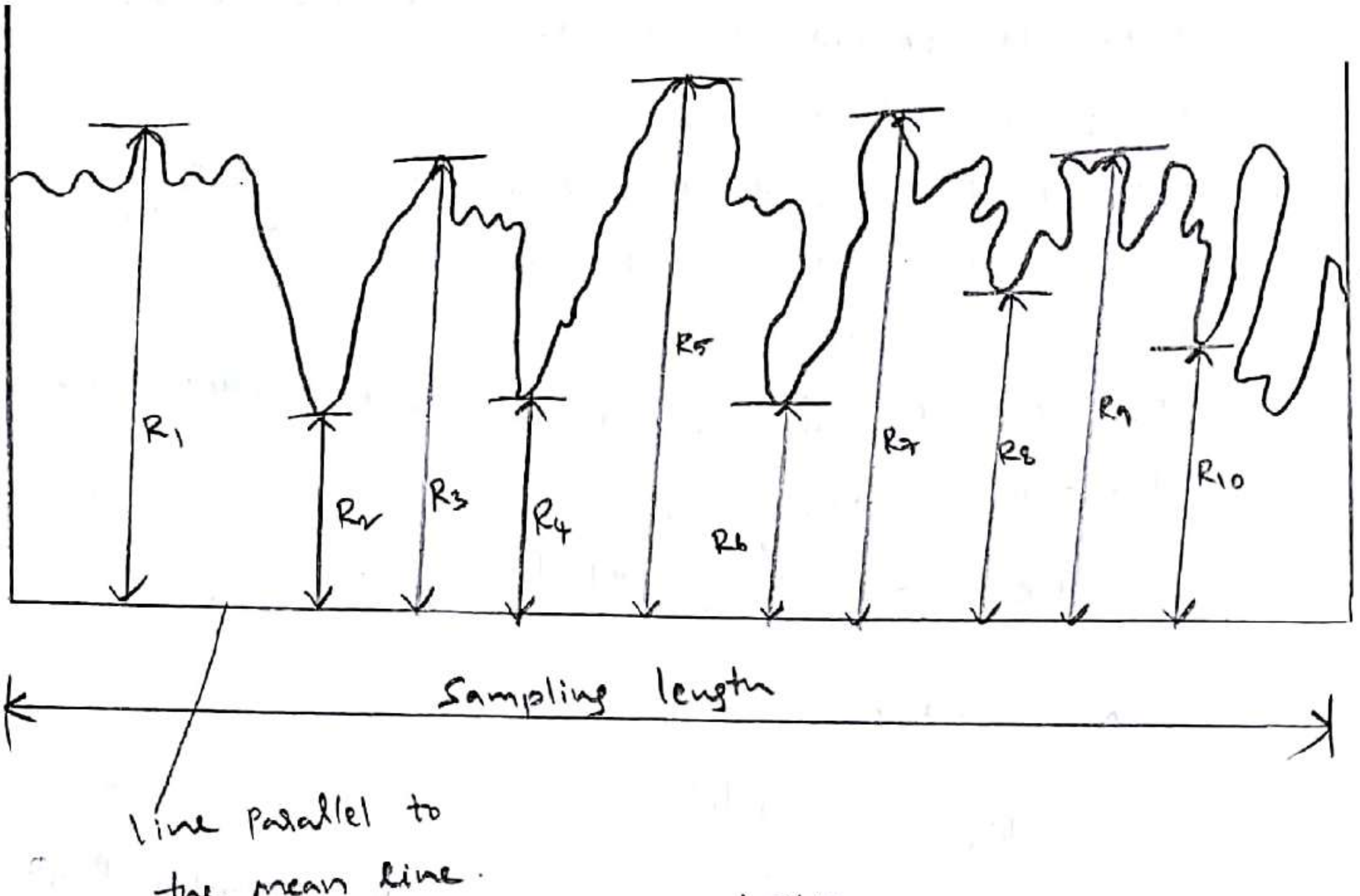
in most surface finish control Ra readings serve well for instances.

Maximum height of irregularity (R_{max})

the distance b/w two lines Parallel to the mean line and touching the profile at highest points within the sampling length.

Ten point height of irregularities (R_z)

the average difference b/w the five highest peaks and the five deepest valleys within the sampling length measured from a line, Parallel to the mean line and not crossing the Profile.



- Ten Point Height of irregularities

$$R_z = \frac{(R_1 + R_3 + R_5 + R_7 + R_9) - (R_2 + R_4 + R_6 + R_8 + R_{10})}{5}$$

Arthematic average roughness

$$Ra = \frac{1}{L}\int_0^L |h|\,dx$$ over 2-20 consecutive sampling lengths.

Average peak-to-valley height R_z. This is the average of single peak-to-valley heights from five adjoining sampling lengths.

R_t Measurement

It is the maximum peak to valley height within the assessment length.

Average wavelength = $2\pi \times R_a$ / Mean slope

Bearing area (fraction) This is the fraction of surface at a given height above or below the mean line.

Depth of surface smoothness,

$$R_p = \frac{1}{L} \int_0^L (h_{max} - h)\, dx.$$

R_p value indicates amount of material to be removed from a workpiece to obtain 50% bearing area.

Effective Profile :- The contour that results from the intersection of the effective surface by a plane conventionally defined with respect to the geometrical surface.

Effective Surface :- The close representation of real surface obtained by instrumental means.

Lay :- The direction of the predominant surface pattern, ordinarily determined by the production method used.

Least squares mean line : A reference line representing the form of the geometrical profile within the limits of the sampling length, and so placed that within the sampling length the sum of the squares of the deviations of the profile from the mean line is a minimum.

Levelling depth R_u. Distance b/w mean line and a parallel line through highest peaks.

Max. Peak-to-Valley height. R_{max}. largest single peak-to-Valley height in five adjoining sampling lengths.

Mean Depth (R_m). Distance b/w mean line and a Parallel line through the deepest valley.

Mean Roughness step. mean roughness wavelength or frequency. $A_R = \frac{1}{n} \sum_{i=1}^{n} h_i$ (n is within measuring length)

Mean waviness step :-

mean waviness wavelength or frequency.

$$A_w = \frac{1}{n} \sum_{i=0}^{n} L_i$$

Peak Roughness

$$R_p = \frac{1}{L} \int_0^L (h_{max} - h)\, dx.$$

Peak-to-valley height :- Separation of highest peak and lowest valley.

Real profile :- The contours that results from the intersection of the real surface by a plane conventionally defined with respect to the geometrical surface.

Real ~~profile~~ surface :- The surface limiting the body, separating it from the surrounding space

Reference line

A line chosen by convention to serve for the quantitative evaluation of the roughness of the effective profile.

Root-mean-square roughness

$$R_q = \sqrt{\frac{1}{L}\int_0^L h^2\,dx}$$

Bearing ratio (t_p) it the length of bearing surface and provides guidance for improving production. $t_p\%$ is the ratio at selected depth p.

$$t_p\% = \frac{b_1 + b_2 + b_3 + \cdots b_n}{L} \times 100.$$

Roughness :- The irregularities in the surface texture which are inherent in the production process, but excluding waviness and errors of form.

Roughness factor :-

Ratio of true to projected surface area

Roughness width :-

$$A_r = \frac{1}{n}\sum_{i=1}^{n} h_i$$ (n within roughness sampling length)

Sampling length :- The length of the effective profile selected for the evaluation of the surface roughness, without taking into account other types of irregularities.

Secondary texture

Irregularities outside the bandwidth of wavilengths of the Primary texture

Surface texture :-

Irregularities which, recurring many times across the surface tend to form on it a Pattern or texture. also known as Primary texture

Ten-point-height :-

Seperation of average of five heighest Peaks and five lowest Valleys within a single sampling length

waviness

That component of surface texture upon which roughness is superimposed. waviness may result from such factors as machine or work deflections, vibrations, chatter, heat treatment or warping strains.

waviness height

Seperation of heighest peak and lowest valley of waviness over a waviness sampling length, corrected for roughness.

Methods of measuring surface finish

There are 2 methods

1) Surface inspection of Comparison methods

2) Direct instrument measurements.

→ The surface texture is assessed by observation of the surface but these methods are not reliable as they can be misleading if comparison is not made with surfaces produced by same techniques. The various methods available under comparison methods are.

1) Touch inspection
2) Visual Inspection
3) Scratch inspection
4) microscopic inspection
5) surface photographs
6) micro - Interferometer
7) wallace surface Dynamometer.
8) Reflected light Intensity.

1) Touch inspection :—
The main limitation of this method is that the degree of surface roughness can't be assessed. also the minute flaws can't be detected. This method can simply tell which surface is more rough. In this method, the figer-tip is moved along the surface at a speed of about 25 mm per second and the irregularities as small as 0.01 mm can be easily detected. A modification of it is possible by using a table tennis ball, which is rubbed over the surface and vibrations from the ball transmitted to hand and surface roughness judged.

2) Visual Inspection :- it is naked eye is always likely to be misleading particularly when surfaces having high degree of finish are inspected. The method is, therefore, limited to rougher surfaces and results vary from person to person. more accurate inspection can be done by using illuminated magnifiers.

Scratch inspection :-

softer material like lead babbit or plastic is rubbed over
the surface to be inspected. By doing so it carries the impression
of the scratches on the surfaces which can be easily visualised.

Microscopic Inspection :-

This is probably the best method for examining the surface
finish but suffers due to limition that only a small portion
of the surface can be inspected at atime. Thus several
readings are required to get an average value.

In Another method a straight edge is placed on the surface to be
inspected and a beam of light projected at about 60° to the work
Thus the shadows cast into the surface scratches are magnified
and the surface irregularities can be studied.

Surface photographs :-

In this method magnified photographs of the surface are taken
with different types of illumination. In case we use vertical
illumination, then defects like irregularities and scratches
appear as dark spots and flat portion of the surface appears
as bright area.

Micro Interferometer :-

In this method, an optical flat is placed on the surface
to be inspected and illuminated by a monochromatic source
of ~~so~~ light

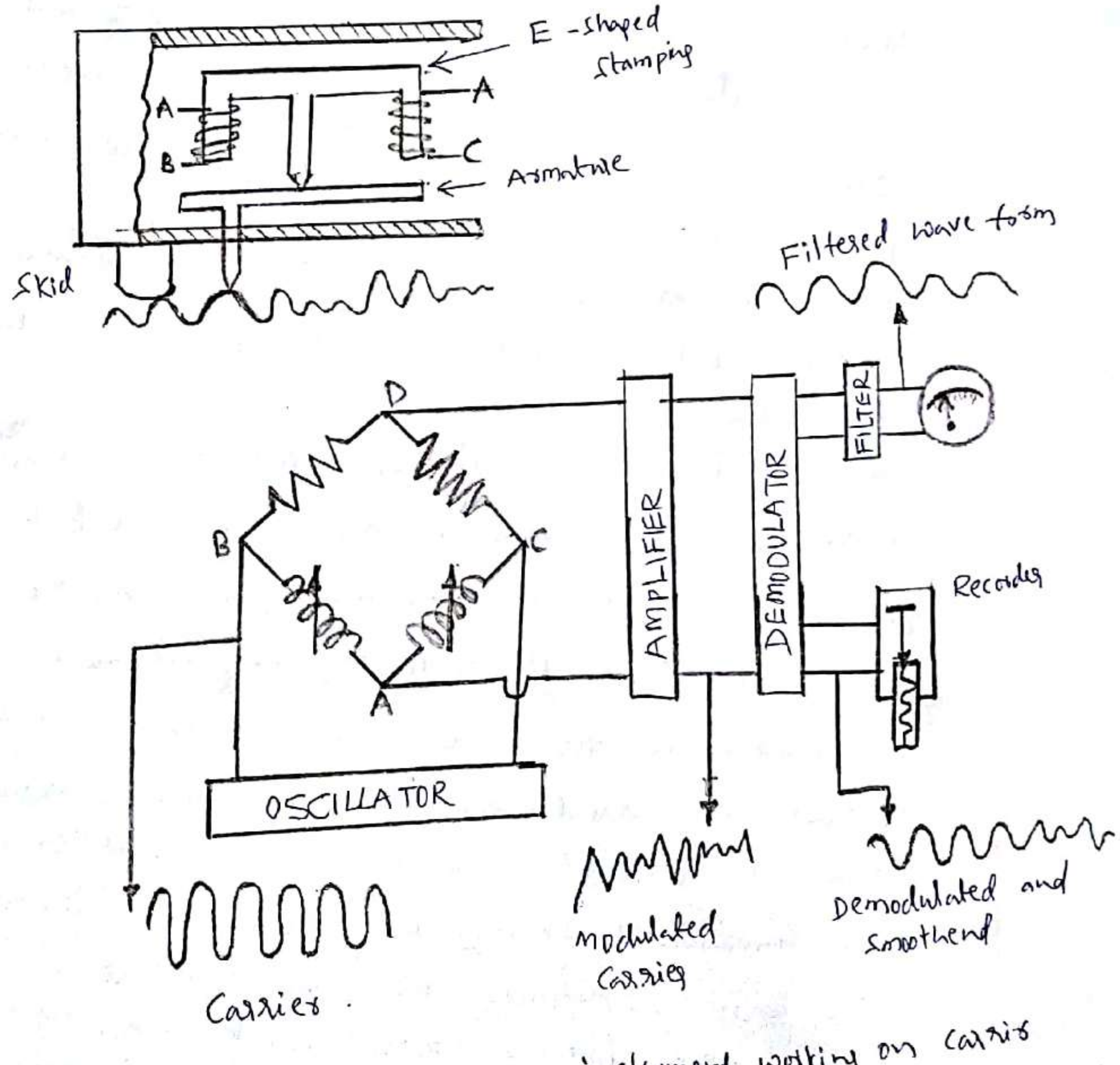
Wallace surface dynamometer :-

This is a sort of friction meter and consists of a pendulum
in which the testing shoes are clamped to a bearing surface
and a predetermined spring pressure can be applied.

Reflected light Intensity

In this method a beam of light of know quantity is projected upon the surface. The measured intensity changes are already calibrated by means of reading taken from surface of known roughness by some other suitable method.

Talysurf method



→ The Talysurf is an electronic instrument working on carrier modulating principle. This instrument also gives the same information as the previous instrument, but much more rapidly and accurately.

→ This instrument as also the previous one records the static displacement of the stylus and is dynamic instrument like Profilometer.

→ The measuring head of this instrument consists of a diamond stylus of about 0.002 mm tip radius and skid or shoe which is drawn across the surface by means of a motorised driving unit (Gear box), which provides three motorised speeds giving respectively x 20 x 100 horizontal magnification and a speed suitable for average reading. A neutral position in which the pick-up can be traversed manually is also provided. In this arm carrying the stylus forms an armature which pivots about the centre piece of E-shaped stamping as shown fig.

On two legs of (outer pole pieces) the E-Shaped stamping there are coils carrying an a.c. current. These two coils with other two resistances form an oscillator. As the armature is pivoted about the center leg, any movement of the stylus causes the air gap to vary and thus the amplitude of the original a.c. current flowing in the coils is modulated. The output of the bridge thus consists of modulation only.

→ This demodulated so that the current now is directly proportional to the vertical displacement of the stylus only.

→ Demodulated output is caused to operate a pen recorder to produce a permanent record and a meter to give a numerical assesment directly

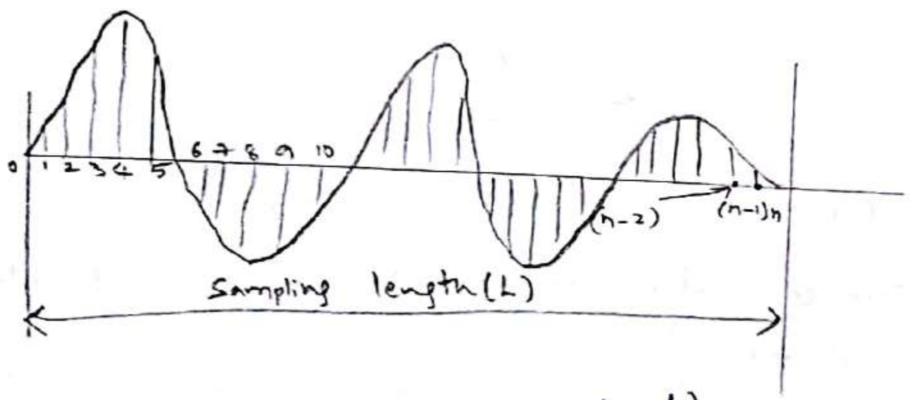
Root mean square method (Rms value)

The square root of arithmetic mean values of squares of ordinates of the surface measured from the mean line.

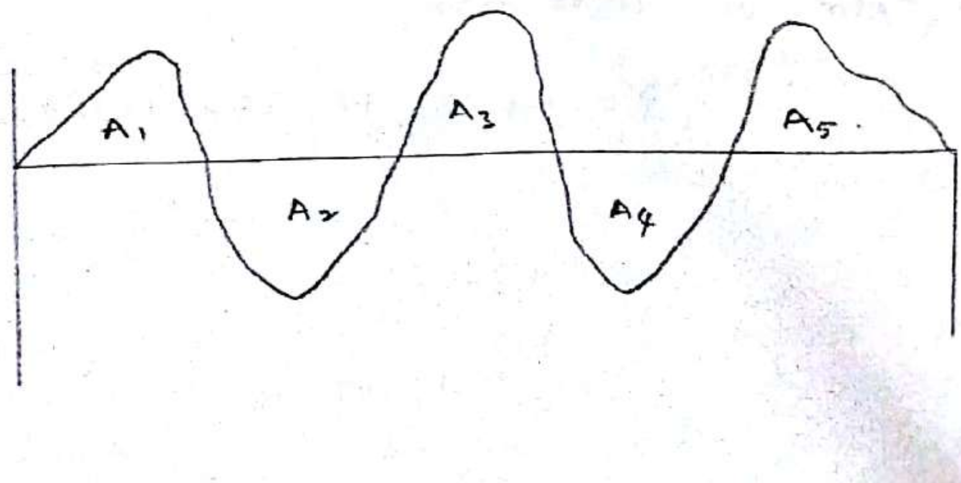
→ Consider a sampling length (L) which is divided into 'n' number of equal parts. (1, 2, 3, 4 ---- n) whose heights are $y_1, y_2, y_3 --- y_n$.

Rms value is

$$RMS = \sqrt{\frac{y_1^2 + y_2^2 + y_3^2 + --- y_n^2}{n}}$$



CLA (center line average method)



The Average height from mean line of all the ordinates of surface, irrespective of sign.

$$CLA = \frac{h_1 + h_2 + h_3 + \cdots + h_n}{n}.$$

This method gives wrong reading because the selected spacing may be such that imp. ordinates are likely to be neglected i.e.,

CLA values is given in terms of area

$$CLA\ \text{value} = \frac{A_1 + A_2 + A_3 + \cdots + A_n}{L}$$

$$= \frac{\Sigma A}{L}$$

Preferred Values of Ra and Rz

Preferred values for arithmetical mean deviation Ra in μm are selected from:

0.025, 0.05, 0.1, 0.2, 0.4, 0.8, 1.6, 3.2, 6.3, 12.5, 25

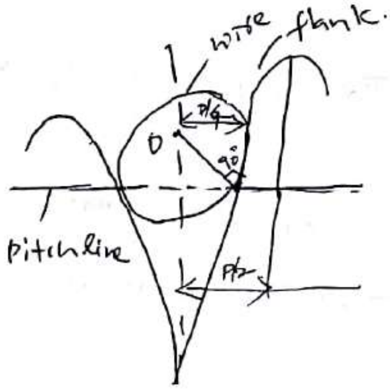
and the preferred values for ten point height of irregularities R_z in μm are selected from.

0.05, 0.1, 0.2, 0.4, 0.8, 1.6, 3.2, 6.3, 12.5, 25, 50 and 100.

Scanned by CamScanner

→ Problems

In a V-thread, a wire is fitted such that it makes contact with the flank of the thread on the pitch line as shown. If the pitch 'p' of the thread is 3mm and included angle is 60°, the diameter (in mm up to one decimal place) of the wire is ∴ Gate PI (2018)



Sol:- $P = 3mm$

$\theta = 60°$

$\therefore d_B = P/2 \sec(\theta/2)$

$= \frac{3}{2} \sec(\theta/2)$

$= \frac{3}{2} \sec 30° = \frac{\cancel{3}}{\cancel{2}} \times \frac{\cancel{2}}{\sqrt{3}}$

$\sqrt{3} = 1.732$ mm

→ Effective diameter = 30.3972 and thread error angle on right hand pitch error is 0.006 mm and left hand flanks are 8 and 10 minutes of arc then determine the virtual effective diameter.

Sol:- Virtual effective diameter $= E + 1.722\,\delta p + 0.0131 \times (8/60 + 10/60)$

$= 30.3972 + 1.722 \times 0.006 + 0.0131 \times 18/60$

$= 30.3972 + 0.01033 + 0.0039$

$= 30.\cancel{4}214$ mm

→ Calculate the CLA (Ra) Value of a Surface for which the Sampling length was 0.8 mm

The graph was drawn to a vertical magnification of 10,000 and a Horizontal magnification of 100, and the areas above and below the datum line were :

Above : 150 80 170 40 mm²

Below : 80 60 150 120 mm².

Sol:- The CLA or Ra Value Is given by

$$\frac{\text{Sum of area } (mm^2)}{\text{Sampling length } (mm)} \times \frac{1000}{\text{Vertical magnification}} \times \frac{1}{\text{Horizontal magnification}}$$

Sum of areas. = 150 + 80 + 170 + 40 + 80 + 60 + 150 + 120

= 850 mm²

$$\therefore \text{CLA or Ra Value} = \frac{850}{0.8} \times \frac{1000}{10,000} \times \frac{1}{100}$$

$$\text{CLA} = 1.06 \ \mu m.$$

→ In the measurement of surface roughness, heights of 20 successive peaks and troughs were measured from a datum and were 35, 25, 40, 22, 35, 18, 42, 25, 35, 22, 36, 18, 42, 22, 32, 21, 37, 18, 35, 20 microns.

If these measurements were obtained over a length of 20 mm, determine the CLA (Ra) and R.M.S. value of the rough surface.

Sol:-

Approximate C.L.A or R_a Value $= \dfrac{\int_{1=1}^{1} hi}{n}$

$$= \frac{35+25+40+ \text{----} +18+35+20}{20}$$

$$= \frac{280}{20} = 29 \text{ microns}$$

Approximate R.m.s Value.

$$= \sqrt{\frac{\int_{1}^{n} |h_1^2|}{n}}$$

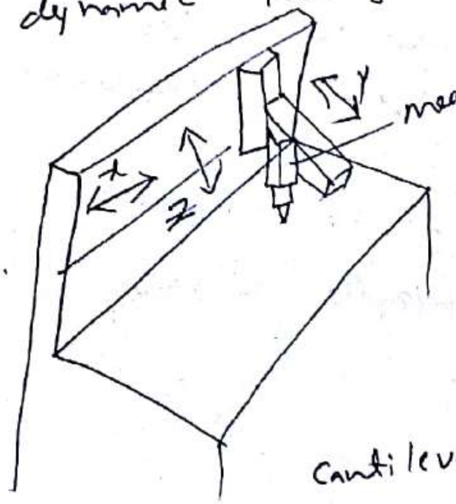
$$= \sqrt{\frac{(35)^2+(25)^2+ \text{----} (35)^2+(20)^2}{20}}$$

$$= \sqrt{\frac{182.32}{20}}$$

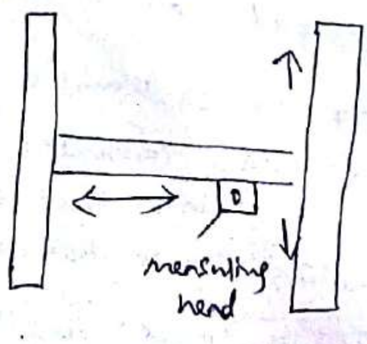
$= 31.18$ microns.

CMM (Co-ordinate Measuring Machines)

→ Three dimensional measurements are essential for various
Components. CMM's are useful for this Purpose.
→ These machines have precise movements in x-y-z co-ordinates
which can be easily controlled and measured.
→ Each slide in three directions is equipped with a precision
Linear measurement transducer which gives digital display and
senses +ve/-ve direction. These are manufactured in both manual
and computer controlled models and come in a wide range of sizes
to accomodate a variety of applications.
→ The measuring head incorporates a probe tip, which can be
different kinds like taper tip, ball tip etc.
→ All these have very low measuring uncertainty, computer
aided measuring runs, vibration-free mechanical structure,
and high rigidity. In addition all moving parts must be
set very accurately, driven by fast motors.
Incorporate sensitive drive unit for fine adjustment of the axis.
have rugged and precise probe system to facilitate exact
dynamic probing.

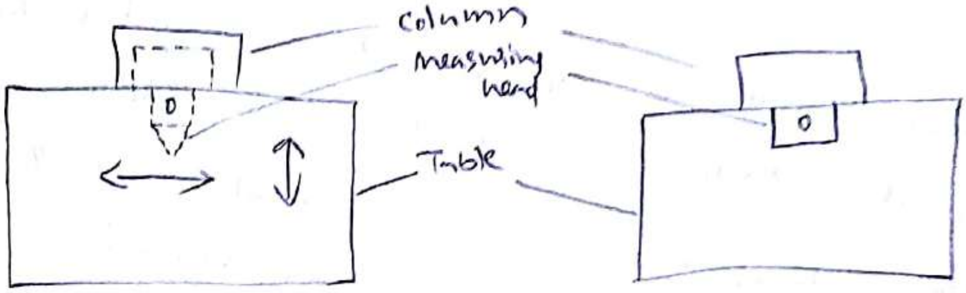


Cantilever



Bridge

— measuring head movement in plane perpendicular to paper



Horizontal Bore mill

Vertical Bore mill.

— Types of Cmms

Important features of Cmm

→ In order to meet the requirement of faster machines with higher accuracies, the stiffness to weight ratio has to be high in order to reduce dynamic forces. To give max. rigidity to machines without excessive weight, all the moving members, the bridge structure, Z-axis carriage and Z-column are made of Hollow box construction.

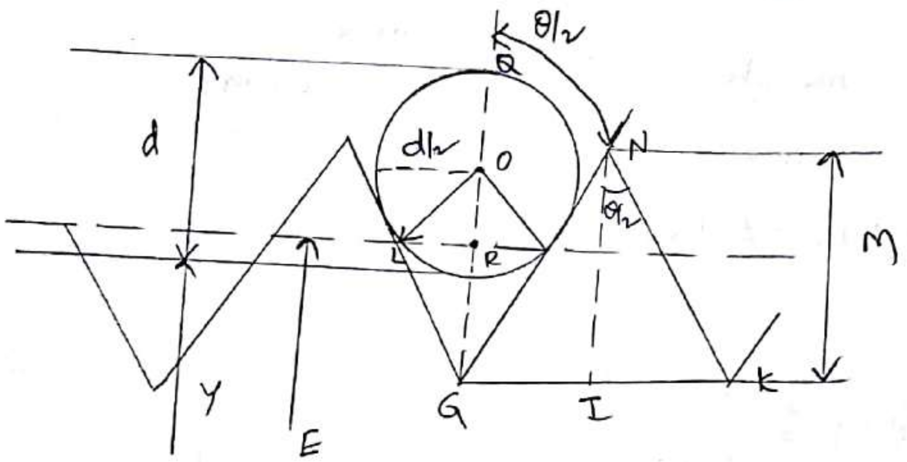
→ Principles of Kinematic design are used in the three master guideways and prob location.

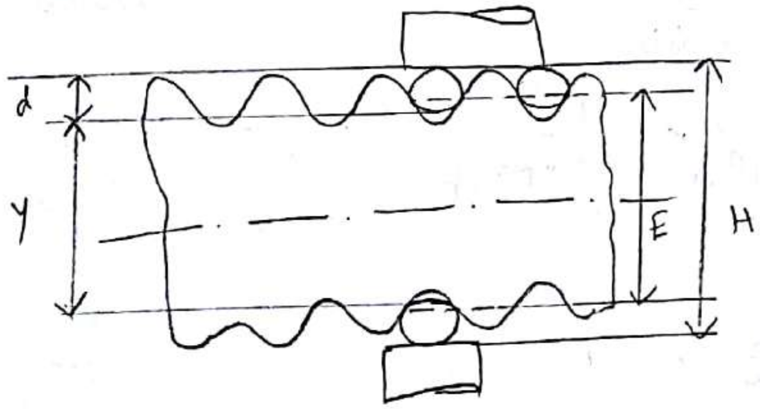
→ Even whole machine with its massive granite work table is supported on a three-point suspension.

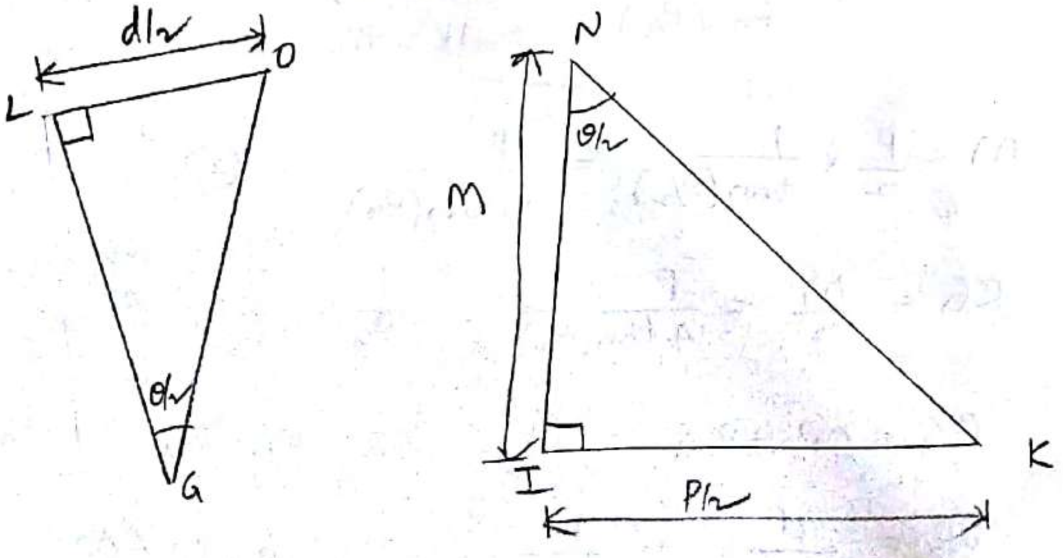
→ A map of systematic errors in machine is build up and fed into the computer system so that error compensation is built up into the software.

→ All machines are provided with their own computer with interactive dialogue facility and friendly software.

Effective diameter of 3-wire method







d = diameter of wire

E = Effective or pitch diameter of screw thread.

H = Diameter over wire (max)

y = Diameter under wire (minimum)

P = pitch of thread.

→ ΔOLG,

$$\sin(\theta/2) = \frac{OL}{OG}$$

$$OG = \frac{OL}{\sin(\theta/2)} \qquad (\because OL = d/2)$$

$$OG = \frac{d}{2} \times \frac{1}{\sin(\theta/2)} = \frac{d}{2\sin(\theta/2)} \quad \text{— } ①$$

lly ΔNIK.

$$\tan(\theta/2) = \frac{IK}{IN},$$

$$IN = \frac{IK}{\tan(\theta/2)}, \qquad IN = m, \quad IK = P/2$$

$$m = \frac{P}{2} \times \frac{1}{\tan(\theta/2)} = \frac{P}{2\tan(\theta/2)} \quad \text{— } ②$$

$$RG = \frac{m}{2} = \frac{P}{4\tan(\theta/2)} \quad \text{— } ③$$

$$OG = OR + RG \qquad \therefore OR = OG - RG$$

$$OR = \frac{d}{2\sin(\theta/2)} - \frac{P}{4\tan(\theta/2)} \qquad \because eq\ ① \ \& \ ③$$

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$$H = E + 2(OR) + 2(OQ)$$

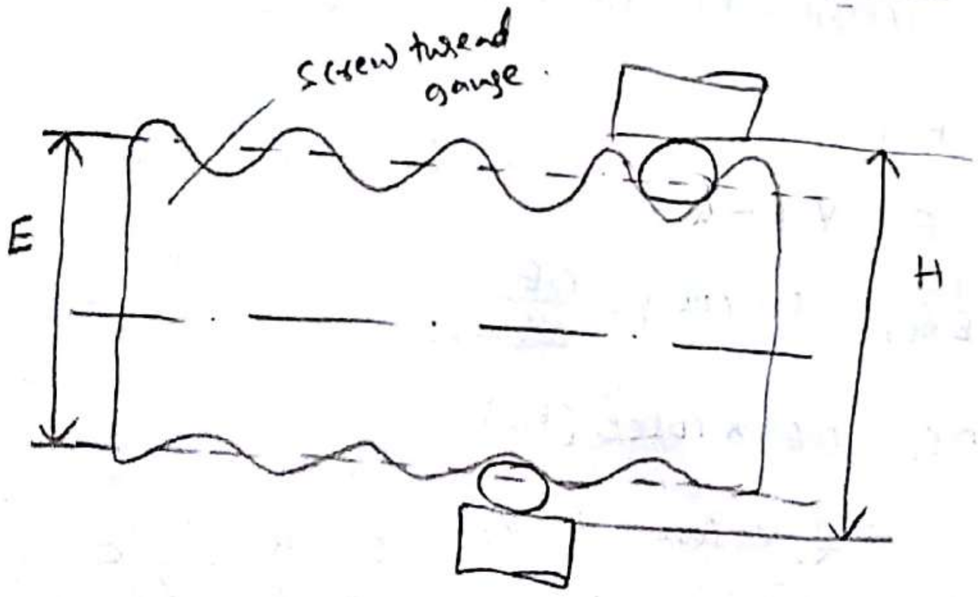
$$= E + 2\left[\frac{d}{2\sin(\theta/2)} - \frac{p}{4\tan(\theta/2)}\right] + 2\times\frac{d}{2}$$

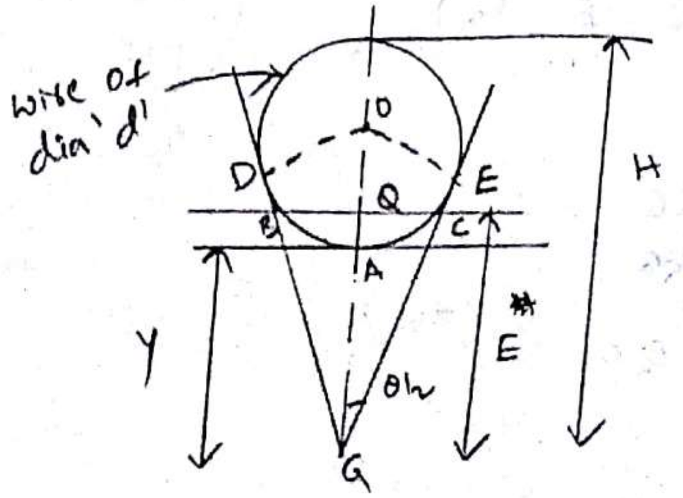
$$H = E + \left[\frac{d}{\sin(\theta/2)} - \frac{p}{2\tan(\theta/2)}\right] + d$$

(or)

$$H = E + d\left[\frac{1}{\sin(\theta/2)} + 1\right] - \frac{p}{2\tan(\theta/2)}$$

Two-wire method of Thread measurement





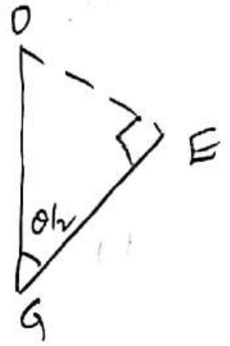
E = Effective diameter of screw threads

Y = Dimension under wires (minimum)

$= H - 2d$

H = Dimension over wires (max.)

d = diameter of wires.



Effective diameter of screw threads

$E = Y + P.$

where, P is the pitch value.

$P = 0.866\,p - d$ - (metric thread)

$P = 0.9605p - 1.1657d$ (whitworth thread)

from Fig,

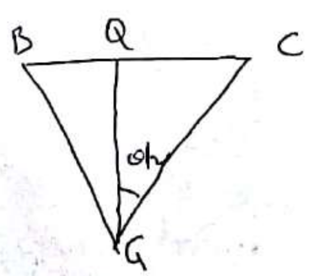
$E = Y + AQ$

ΔOEG, $\sin(\theta/2) = \frac{OE}{OG}$

$OG = OE \times \operatorname{cosec}(\theta/2)$

$= \frac{d}{2} \times \operatorname{cosec}(\theta/2)$

$= (\because OE \ d/2)$



ΔQCG,

$\tan(\theta/2) = \frac{QC}{QG}$

$QG = QC \cot(\theta/2)$

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$BC = \frac{1}{2} \times \text{pitch}$

$BC = \frac{1}{2} \times P = 2QC$

$QC = \frac{1}{2} BC = \frac{P}{4}$

$QG = \frac{P}{4} \cot(\theta/2)$

from fig, $OG = OA + AG$

$AG = OG - OA$

$= \frac{d}{2} \times \operatorname{cosec}(\theta/2) - \frac{d}{2}$

$= \frac{d}{2} [\operatorname{cosec}(\theta/2) - 1]$

$QG = QA + AG$

$QA = QG - AC$

$= \frac{P}{4} \cot(\theta/2) - \frac{d}{2} [\operatorname{cosec}(\theta/2) - 1]$

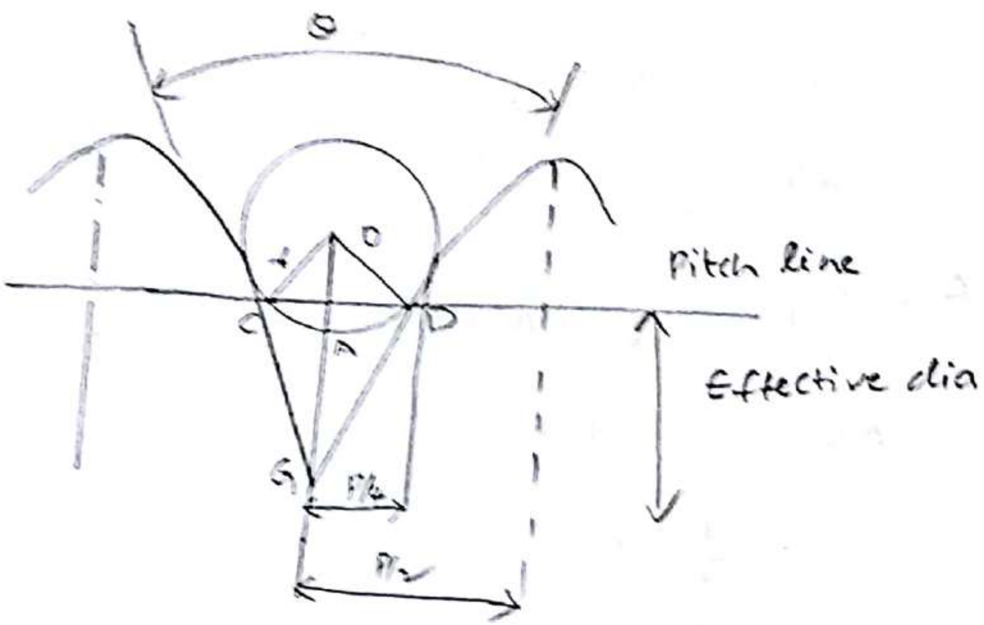
AQ is half of the pitch value

$\therefore P = 2AQ$

$P = 2 \left[\frac{P}{4} \cot(\theta/2) - \frac{d}{2} [\operatorname{cosec}(\theta/2) - 1]\right]$

$\therefore P = \frac{P}{2} \cot\left(\frac{\theta}{2}\right) - d[\operatorname{cosec}(\theta/2) - 1]$

Select best wire size for effective diameter measurement



- Best wire size

Best wire size, at points C and D the wire touching the flank of thread lies on the pitch line.

→ Also, OC and OD are '⊥' to CG and CD at points C and D and from fig.

$$\angle OGD = \theta/2$$

$$\angle ODG = 90°$$

$$\therefore \angle AOD = \angle GOD = 90 - (\theta/2)$$

∴ Δ OAD,

$$\sin(90 - (\theta/2)) = \frac{AD}{OD}$$

$$\cos(\theta/2) = \frac{AD}{OD} \qquad (\because \sin(90-\theta) = \cos\theta).$$

or $$OD = \frac{AD}{\cos(\theta/2)} = AD \times \sec(\theta/2) \quad \text{— (1)}$$

But $OD = OC = r = d_b/2$

where d_b = Best wire diameter.

Also $AD = \frac{P}{4}$ ($\because P$ = Pitch of thread)

substituting these values in eq (1)

$$d_b/2 = \frac{P}{4} \times \sec(\theta/2)$$

$$\therefore d_b = \frac{P}{2} \sec(\theta/2)$$

The above equation represents best wire diameter in terms of Pitch and thread angle.