

CHAPTER - 1

Tool Material

- (i) The purpose of cutting tool material is to remove metal under controlled condition.
- (ii) The tool must be harder than the material which it is cut.
- (iii) The tools are made up of different materials.
- (iv) The material chosen for a particular application depends on the material to be machined, type of machining, quantity & quality of production.
- (v) According to the material used the tools are classified into various types.

1- carbon steel (high carbon steel)

2- High Speed Steel (HSS)

3- cemented carbides.

4- ceramics

5- Diamonds.

1- Carbon steel (High carbon steel)

(i) carbon steel are limited used the tools of small section operation at lower speed.

(ii) This material starts losing its hardness about 250°C.

(iii) The maximum cutting speed 5m/min.

(iv) composition :-

Carbon (C) = 0.8 - 1.3 %

Silicon (Si) = 0.1 - 0.4 %

Manganese (Mn) = 0.1 - 0.4 %

(v) This material used for soft material like:-
Aluminium, copper, brass.

2- High speed steel :- (HSS)

(i) High speed steel tool give improve cutting performance & higher material remove rate.

(ii) It is widely used for drills, milling cutters & single point tool.

(iii) Several types of high speed steel are used in cutting tools but 18-4-1 high speed steel contain tungstone - 18%, Chromium - 4% & vanadium - 1%.

(iv) This type of material gives excellent performance over a grate range material & cutting speed.

(v) It's hardness upto around 600°C.

(vi) maximum cutting speed 40-50 m/min.

3- Cemented carbide :-

(i) The basic ingredient (constituent) of most cemented carbide is tungstone carbide which is extremely hard.

(ii) It is manufacture by powder metallurgy technique.

(iii) This material starts losing its hardness at 1000°C.

(iv) The maximum cutting velocity 300-350 m/min.

(v) carbide tools in three types

(a) P type (machining for ferrous material)

(b) K type (machining for non-ferrous material)

(c) M type (machining for general purpose)

4- Ceramic tools :-

- (i) ceramic tools made by aluminium oxides powder (Al_2O_3).
- (ii) it is used for continuous cutting only.
- (iii) it can with stand upto approx 1200°C.
- (iv) The maximum cutting velocity 400-500 m/min.
- (v) Good surface finished is possible to produce ceramic tools.
- (vi) ceramic tool are made only powder metallurgy technique.

5- Diamonds :-

- (i) Diamond is the hardest material known.
- (ii) it has low coefficient of friction high compressive strength & extremely wear resistance.
- (iii) Diamond tool produce a very good surface finished at high speed with good dimensional accuracy.
- (iv) cutting tool ranging from 200-500 m/min.
- (v) it can with stand up to 2000°C.
- (vi) it is used turning boring, milling cutting & grinding wheel.

Properties :-

- (i) The material must remain harder than the work material.
- (ii) The material must withstand excessive wear even through the relative hardness of the tool work material changes.
- (iii) The material must have sufficient toughness to with stand & vibration & to prevent breakage.

- (iii) It should be resist high temperature.
- (iv) It should be resist high easily form to the required cutting shape.

The End

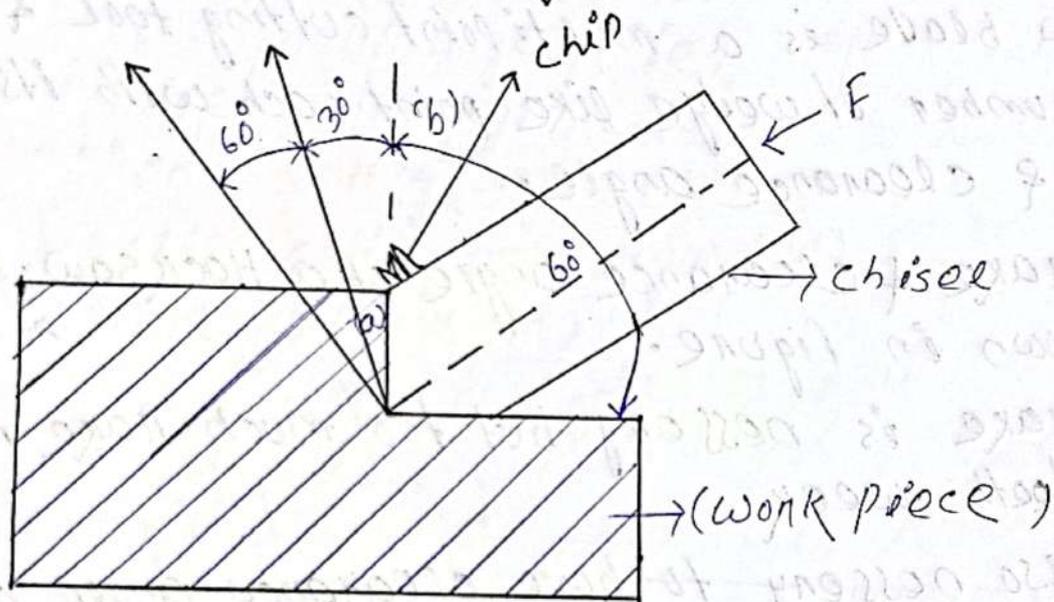
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CHAPTER - 2

CUTTING TOOLS:-

cutting action of various tools such as chisel, Hacksaw blade, die, reamer:-

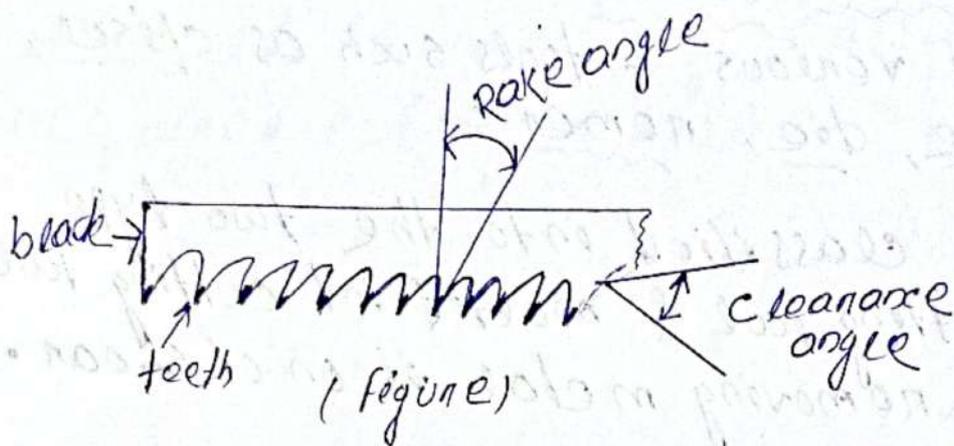
All hand tools classified into the two type single point cutting tool & multipoint cutting tool & the action of removing metal is on of shear.



(Figure)

- (i) A chisel is a single point cutting tool used at the bench & the point is considered as a wedge.
- (ii) The diagram of a chisel point in the action of cutting is shown in figure.
- (iii) where the angle of nake & wedge angle are indicated.
- (iv) For mild steel rake angle of 30° & wedge angle 60° are recommended.
- (v) The energy required to shear to metal will be the shearing force along the shear plane 'ab' & this force is proportional to the length of the shear plane.

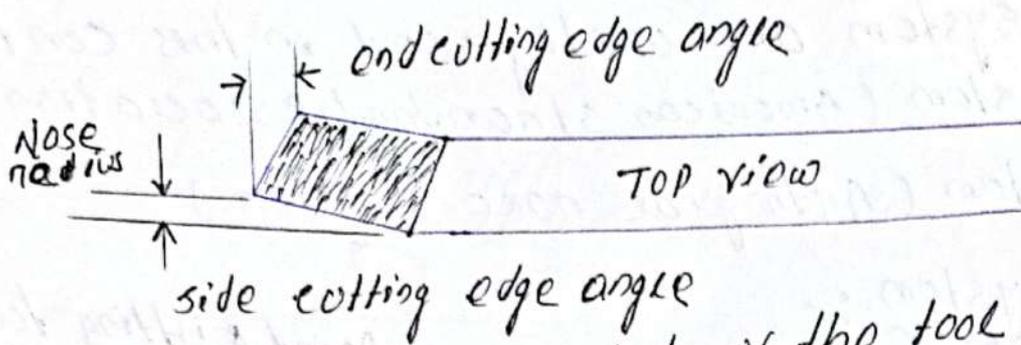
Hacksaw blade :-



- (i) Hacksaw blade is a multi point cutting tool & use large number of wedge like point each with its own rake & clearance angle.
- (ii) The rake & clearance angle of a Hacksaw blade is shown in figure.
- (iii) The rake is necessary but too much rake makes the teeth weak.
- (iv) It is also necessary to have clearance angle on these wedge like point a large amount of energy would be lost in overcoming the frictional forces set up if there were no clearance.
- (v) The hollow space between each tool is sloped more sharply.

Turning tool geometry :-

- (i) In turning operation a single point cutting tool is used.
- (ii) Single point cutting tool can be affected by six angles of tool the nose radius of tool.
- (iii) The arrangement of all these in a particular order is called single point cutting tool nomenclature.



Shank :- It is the main body of the tool

Face :- It is the surface on which the chip is cut.

Flank :- It is the surface below and adjacent to the cutting edge.

Heel :- It is the intersection of flank in the base tool.

Nose :- It is the intersection of side cutting edge & end cutting edge.

Cutting edge :- It is the edge on the face of the tool which remove the material from the work piece.

Lip angle :- It is the angle between tool face & ground end surface the lip angle of a single point cutting tool is usually $60-80^\circ$.

Cutting angle :- It is the angle between the face of the tool & line tangent to the machined surface at the cutting point.

Rake angle :- The angle made by the face on the tool plane to the parallel to the cutting tool.

ASA system :-

According to the ASA system the single point cutting tool design as :-

Back rake angle :-

Fig :-

- (i) It measures the downward slope of the top surface of the tool from the nose to the mean angle the longitudinal axis.
- (ii) Its purpose is to guide the direction of chip.

It is the angle made by the rake face of the tool with respect to the horizontal plane measure in the length direction.

(iii) The size of the angle depends upon the material to be machined.

(iv) Back rake angle may be positive or negative.

(v) Positive rake angle are used for cutting low tensile strength at non-ferrous material.

(vi) Negative rake angle are used for machining high tensile strength material.

Side rake angle :-

- (i) It is measure the slot the top surface of the tool to the side in is direction, perpendicular to the longitudinal axis.
- (ii) It also guided the direction of the chip away from the job.
- (iii) Large side rake angle produce smooth surface finish.

End relief angle :-

Fig: -

- (i) It is the angle between a plane perpendicular to the base & the end flank.
- (ii) This angle prevent to the cutting tool from rubbing again the job.
- (iii) If the angle is very large the cutting of tool will unsupported & will breakoff.
- (iv) Where as if the angle is very small the tool will rubbed the job cutting will be proper & poor finish.

Side relief angle :-

Fig: -

(i) It is the angle made by the flank of the tool and a plane perpendicular to the base just under to the side of cutting edge.

(ii) This angle permits to the tool to be feed side way into the job so that it can avoid rubbing.

End cutting edge angle :-

Fig:-

(i) It is the angle between face of the tool & a plane perpendicular side of the work.

(ii) It act as a relief angle that it always small section of the end cutting edge to the contact the machine surface & prevent vibration.

Side cutting edge angle :-

Fig:-

$$\frac{WCT}{OB} = r$$

(i) It is the angle between side cutting edge angle & longitudinal axis of the tool.

(ii) It avoid formation of built up edge, control the direction of the chip flow & distribute the cutting force & heat produce over large cutting edge.

Nose radius :-

(i) The nose radius is provided to increase finish on strength of the cutting tip of the tool.

- (i) Small radius will produce smooth finish & are used on thin cross section of work.
- (ii) Large radius provide strength. the tool are used on cast iron.

Machanical process parameter :-

(i) The machining process parameter are :-

- 1 - cutting speed.
- 2 - Feed.
- 3 - Depth of cut.

1- Cutting speed :-

- (i) It is defined as the distance travel by the cutting tool along circumference of the work piece in one minutes.
- (ii) It is expressed in m/min.
- (iii) mathmatically

$$V = \frac{\pi DN}{60}$$

where

D → work piece of the diameter

N → speed

V → cutting speed.

- (iv) from surface finish consideration higher speed is better but it reduces tool life because.

2- Feed :-

- i- It is the distance that tool bit advance along the work piece for each revolution of the (spindle) on work piece.

(i) It is expressed in term of mm/rev.

(ii) It is denoted by 'F'

(iii) mathematically

$$F_M = F_N$$

where

F = Feed

N = spindle speed in RPM.

(iv) Higher feed are used in rough cut.

(v) Lower feed are used for finishing.

(vi) Normally feed varies from D.1 - 1.5 mm.

3- Depth of cut:-

(i) It is the perpendicular distance measured from the machining surface to the uncut surface of the work piece.

(ii) Depth of cut is always perpendicular to the direction of the feed motion.

(iii) mathematically,

$$\frac{D-d}{2}$$

where,

D → original diameter of the work piece.

d → diameter of the work piece after machining.

Coolants & Lubricant in machining & propose

(i) proper cutting speed depth of cut & even right tool geometry may give excellent result in the absent of correct fluid.

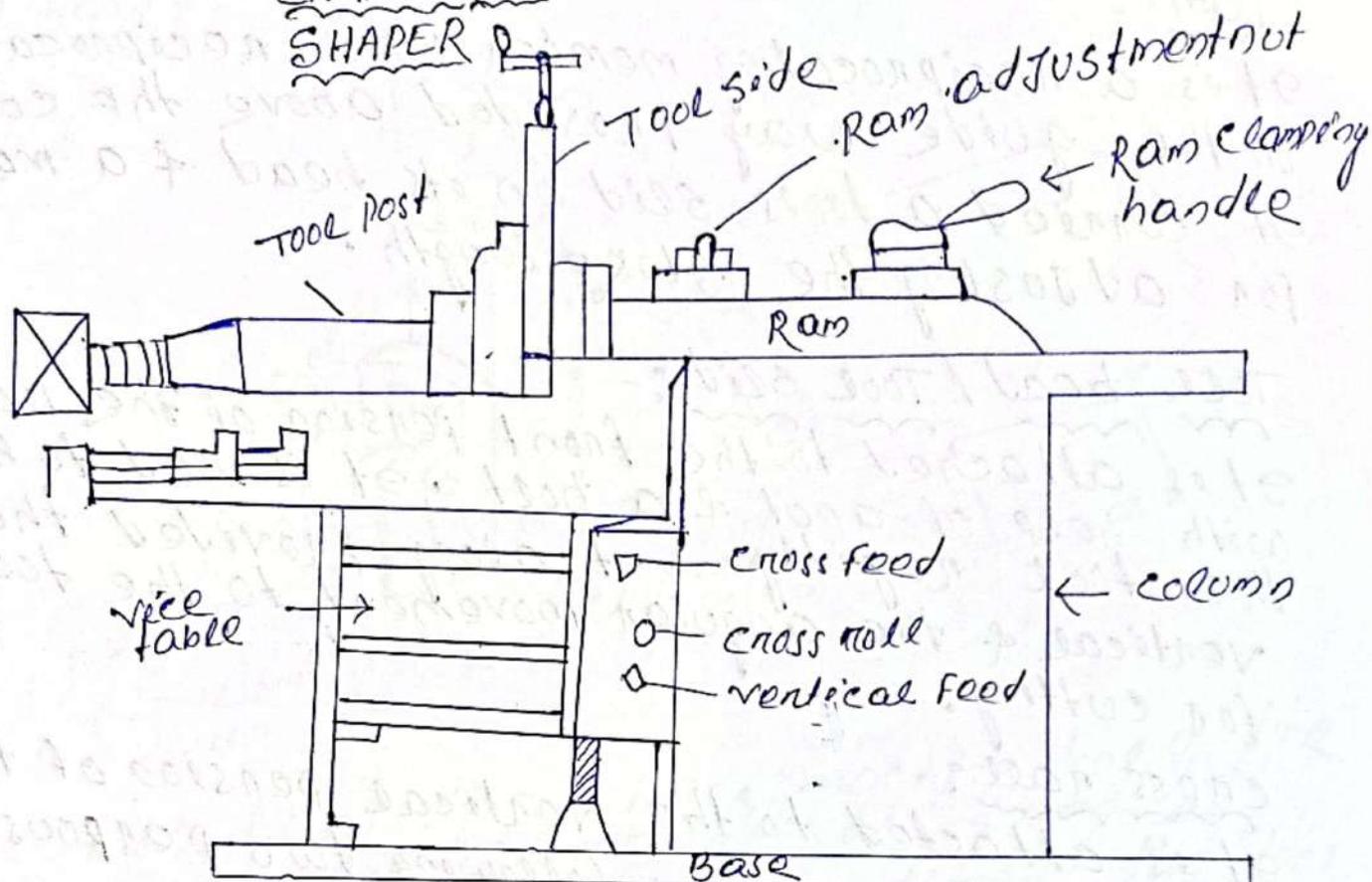
(ii) During metal cutting heat & wear are produce due to friction & shearing action both heat & wear are cutting fluid is provide during cutting operation to reduce the heat.

Properties of cutting fluid:-

- (i) It should have a high specific heat high heat conductivity & high coefficient.
- (ii) It should be non-corrosive to work & machine.
- (iii) It should possess good lubricating properties to reduce frictional forces & to decrease the power consumption.
- (iv) It should be non-toxic to operating personnel.
- (v) It should have low viscosity to permit free flow after liquid.
- (vi) It should permit clear view of the work.

$$\frac{D-d}{c}$$

CHAPTER-3 SHAPER



- (i) Shaper is a reciprocating type of machine tool used for producing small flat surface with the help of single point cutting tool reciprocating over the stationary work piece.
- (ii) The flat surface may be horizontal inclined or vertical.
- (iii) The tool is held in the tool post of reciprocating ram & performs the cutting ram & performs the cutt. operation during its forward stroke.
- The measure component shaper machine are :-

Base :-

It is a heavy structure of cast iron which supports other part of a shaper.

Column :-

It is a box like structure made of cast iron & mounted upon the base contains the driving mechanism & its provided with two machine guide way on the top of on which the ram reciprocates.

Ram:-

It is a reciprocating member which reciprocates on the guide way provided above the column. It carries a tool slid on its head & a mechanism for adjusting the stroke length.

Tool head / Tool slid:-

It is attached to the front portion of the ram with help of a nut & a bolt. It is used to hold the tool rigidly. It also provides the vertical & the angular movement to the tool for cutting.

cross rail:-

It is attached to the vertical portion of the column. It is used for following two purposes.

- (1) It helps in elevating the table over the column in the upward direction.
- (2) The table can move in a direction perpendicular to the axis of ram over the cross rail.

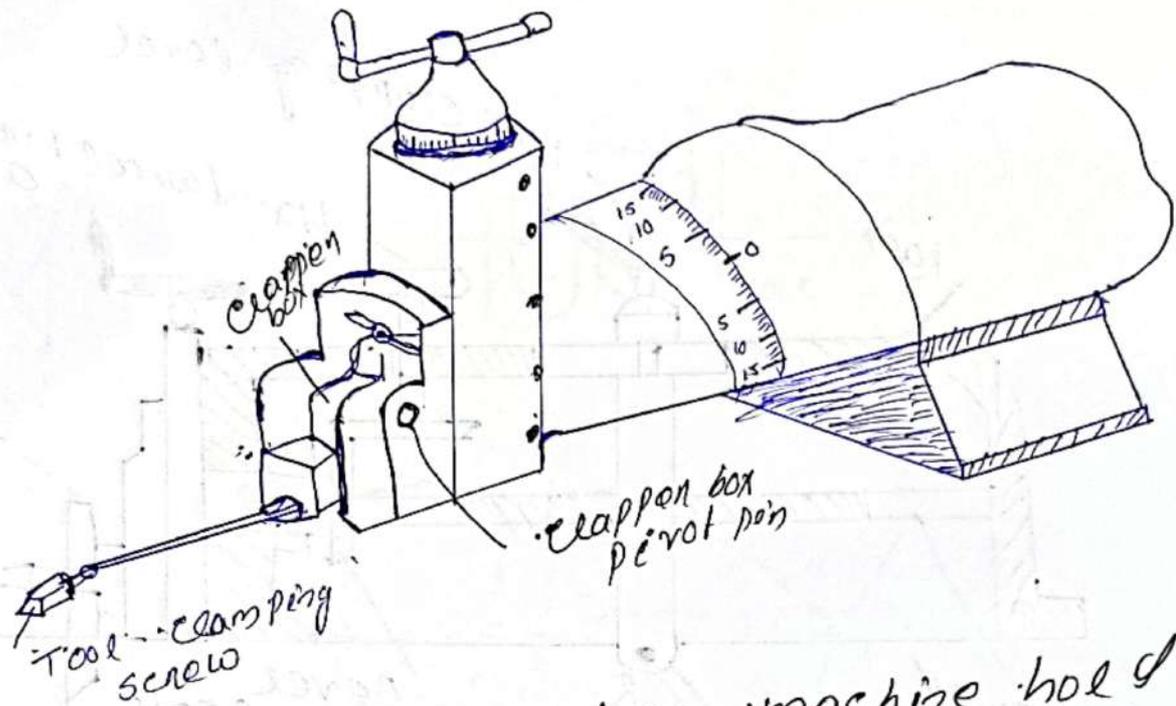
Table:-

It is used for holding the work piece. It can be adjusted horizontally or vertically both with the help of spindle.

Saddle:-

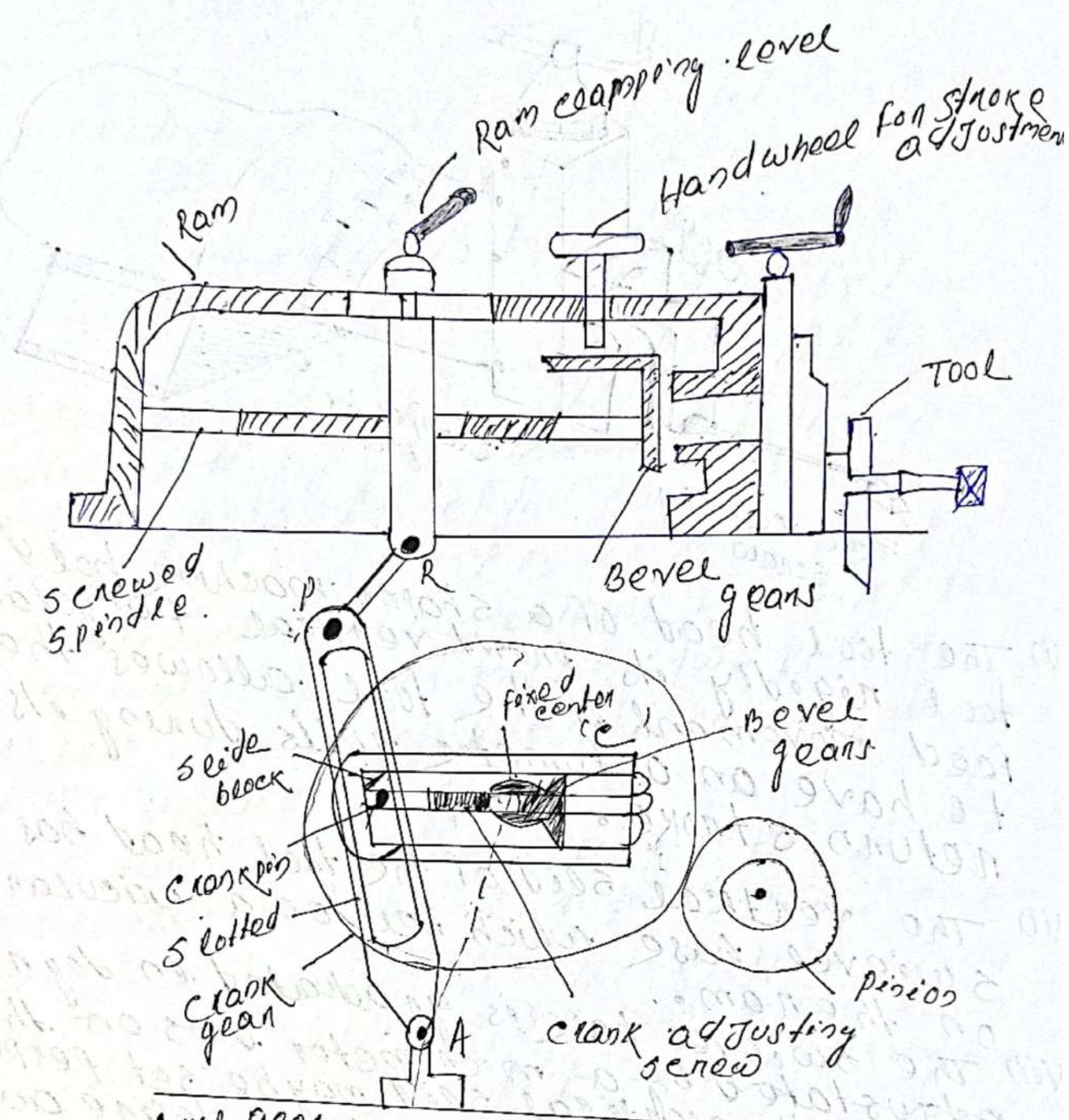
The saddle is mounted on the cross rail with hold the table on its top.

Tool Head :-



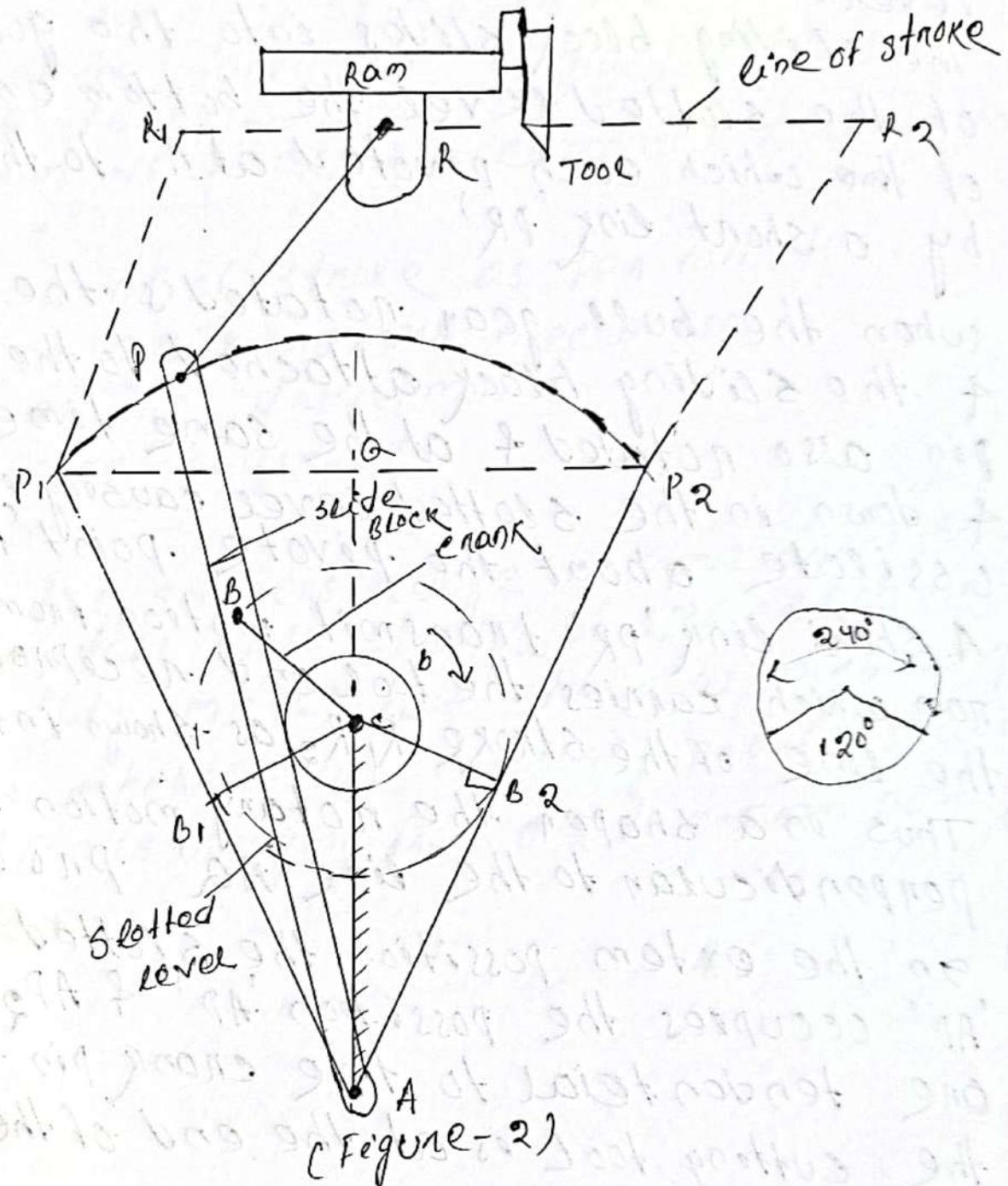
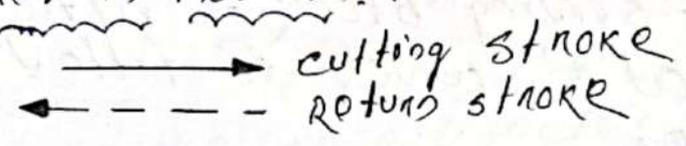
- (i) The tool head of a shaper machine hold the tool rigidly its provided vertical & angular feed movement of the tool allows the tool to have an automatic return during its return stroke.
- (ii) The vertical slid of the tool head has a swivel base which help on a circular seat on the ram.
- (iii) The swivel base is graduated in degrees & adjusted by a micrometer dial on the top so that the vertical slid may be set perpendicular to the work surface or at any desired angle.
- (iv) The amount of feed or depth of cut may be adjusted by a micrometer dial on the top of the down feed screw.
- (v) Apparatus consisting of clapper box clapper block & tool post is clamp upon the vertical slid of the screw.
- (vi) The tool post is mounted upon the clapper block its allowed the cutting tool to lift on the return stroke so that the tool not engaged through the work surface.

Quick return mechanism :-



(figure - 1)

Principle of quick return motion:



(Figure-2)

Working Principle :-

- (i) A electric motor drives the pinion at a uniform angular speed which turn drives bull gear.
- (ii) The crank 'CB' is connected the bull gear & may be adjusted in length by screw mechanism
- (iii) The crank rotates at a uniform angular speed with the bull gear about the fixed center.

- (iv) The sliding block is attached to the crank pin at 'B' which is fitted with a slotted lever.
- (v) The sliding block slides into the guide ways of the slotted lever, the bottom end base of the which each pivoted at 'A' to the end 'P' by a short link 'PR'.
- (vi) When the bull gear rotates the crank & the sliding block attached to the crank pin also rotates & at the same time slides up & down in the slotted lever causing it to oscillate about the pivot point 'A'.
- (vii) A short link 'PR' transmits motion from 'AP' to ram which carries the tool end reciprocate along the line of the stroke R_1R_2 as shown in the fig-2.
- (viii) Thus in a shaper the rotary motion is perpendicular to the line 'AQ' produced.
- (ix) In the extreme position the slotted lever 'AP' occupies the position 'AP₁' & AP₂ which are tangential to the crank pin circle & the cutting tool is at the end of the stroke.
- (x) The forward or cutting stroke occurs when the crank rotates from the position 'CB₁' to CB₂ (through the angle β) in the clockwise direction.
- (xi) The backward or return stroke occurs when the crank rotates from the position 'CB₂' to 'CB₁' (through the angle α) in the clockwise direction.

Specification of a shaper machine:-

shaper is specified as follows:-

- (i) maximum length of stroke in millimeter.
 - (ii) size of the table i.e. length width & depth of the table.
 - (iii) maximum vertical & horizontal travel in table.
 - (iv) maximum no. of stroke as per minutes.
 - (v) type of quick return mechanism.
 - (vi) power of the drive motor.
 - (vii) floor space required.
 - (viii) weight.
- (x) Horizontal shapers range in size from small bench models with stroke of 175 or 200 mm to heavy duty model with stroke as much as 900 mm. Shaping machine are commonly provides with power feeds ranging from 0.2 to 0.5 mm per stroke.

Chapter :- 4

Planning machining

measure component of the function :-

Bed :-

- (i) Bed is a large heavy casting strength ened with cross - ribs provide a stiff heavy support for this heavy machine.
- (ii) The length of the bed is about to wise length of the table.

Table

- (i) The table is used to clamp work & it reciprocates along the ways of the bed.
- (ii) It has T-slots in a upper surface for clamping the work piece.
- (iii) ~~It~~ has the table is power from a variable speed motor through a ~~reducing~~ gear & a rack & pinion arrangement.

Housing:-

- (i) At the sides of the bed two vertical housing columns or upright are arranged.
- (ii) The front face of each column is machined as a set of ways on which travel the cross-rail which carries two tool heads.
- (iii) Most of the planers carry two side tool heads.
- (iv) The housing enclose the various mechanisms which transmit power to the upper part of the machine from the main motor drive. This includes the vertical feed shaft, rail elevating screw feed bar ~~for~~ for cross feed etc.

cross-rail:-

- (i) The cross-rail is a horizontal member of heavy cross-section connecting the two housing to increase the rigidity of the machine.
- (ii) Its face is machined to provide ways for the two cross-rail tool heads.
- (iii) The housing are connected together at the top by a cross member called a craw.
- (iv) It provides additional strength & rigidity to the structure.
- (v) cross-rail can be traversed vertically along ways on the housing by means of a drive power from a separate motor.

Tool head:

- (i) There maximum of four tool heads on double housing planer, two on the cross-nail & two on the upright.
- (ii) They are mounted by means of saddles.
- (iii) The cross-nail tool heads are used for planing horizontal surface.
- (iv) The side tool head are used for planing vertical surface.

Definition:

- (i) Planer is used to produce horizontal vertical or inclined flat surface but its work piece that are too large to be accommodated on shaper.
- (ii) The work piece is clamped into the work table.
- (iii) The work table rides on the groove on the base of the planer & is accurately guided as it travel back.
- (iv) Cutting tool are held on the tool head that can travel from side to side i.e. in a direction at right angle to the direction motion of the work table.
- (v) Tool head are mounted on a horizontal cross-nail that can be move up & down.
- (vi) Cutting is achieved by applying the load in primary motion of the work piece & feeding the tool at right angle to the motion.

(vii) A primary motion of the work piece is normally accomplished by rack & pinion drive using a variable speed motor.

Clamping of work:-

- (i) A planer table is used to hold very large heavy job & in many case large no. of identical piece together.
- (ii) Together of the work of a planer table requires sufficient amount of skill.
- (iii) The following three points are very carefully considered to hold the work correctly.
 - (a) The work should be rigidly connected to the table so that it may not be slip the out of its position while cutting activity progress.
 - (b) Proper clamping should be done all round the work but undue clamping pressure should not be applied to cause distortion of the work. The work may spring back when the clamps are removed resulting in accuracy in the machined surface.

(c) The work should be so held that the surface planed should remain in proper position with other surface.

Different types of clamps:-

Different types of clamps are used for different types of work.

- 1 - Step blocks.
- 2 - Angle plates.
- 3 - Planer Jack.

1. Step blocks

(i) Step blocks are used to lend support to the other end of the clamp.

(ii) Work piece of different heights may be supported by using different steps of the step blocks.

2. Angle plates:-

(i) Angle plates are used for holding 'L' shaped work on job which can not be conveniently held on a planer table directly.

3. Planer Jacks:-

(i) planer jack are used for supporting the over hanging part of a work to prevent it from bending.

(ii) planer centres are used for holding work betⁿ two centres & cutting grooves & slots on the work.

(iii) stops are used to prevent the work from moving edwise or on side view under the thrust of the cut.



Assignment:-

Difference between

- 1- Heavier ^{planes} more rigid & costlier machine.
- Requires more floor area.
- Work reciprocates horizontally.
- Tool is stationary during cutting.
- Heavier cuts & coarse feed can be employed.
- Used for machining large size work piece.

sawen & planer:-

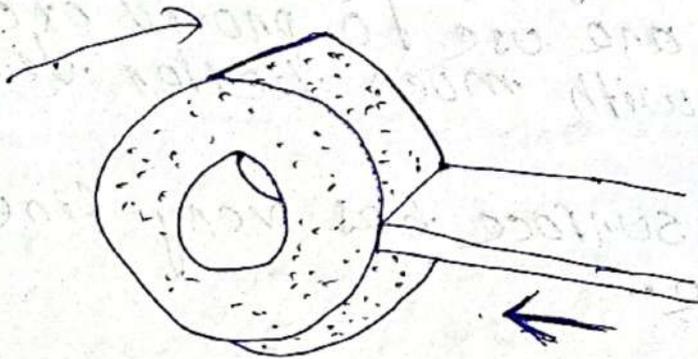
- 1- A comparatively lighter & cheaper machine.
- Requires less floor area.
- Tool reciprocates horizontally.
- Work is stationary during cutting.
- Very heavy cuts & coarse feed can not be employed.
- Used for machining small size work piece comparatively.

0 ————— The End ————— 0

Chapter - 7 Grinding

- (i) Grinding is a metal cutting process in which the unwanted material is removed from the work piece.
- (ii) It is a finishing process which provides very close tolerance with the help of a rotating wheel against the work piece.
- (iii) The wheels are made up of fine grains of Abrasive material held together by a bonding material (Silicon carbide, or aluminium oxide) (artificial). (diamond & sand stone) (Natural)
- (iv) The work piece which is rotated at a very high speed the grinding wheel to remove excess material from the work piece surface.

Fig:-



- (1) According to the quality of surface finish
 - (a) Rough on non-precision grinding.
 - (b) Precision grinding on fine grinding.
- (2) According to the type of surface generated.
 - (a) surface grinding.
 - (b) cylindrical grinding (external or internal)
 - (c) internal grinding.

1(a) Rough or non-precision grinding :- (without measuring)

- (i) These grinding are used for removal of material without any reference to the quality of finish required.
- (ii) This process does not possess very good surface finish.
- (iii) Rough grinding is commonly used for removing excess material from casting, forging & weldment.
- (iv) The most commonly used rough grinding are:
 - 1 - Bench grinding.
 - 2 - Portable grinding.
 - 3 - Abrasive grinding.

(b) Precision or fine grinding :- (with measuring)

- (i) These grinders are used to provide excellent surface finish with much better dimension accuracy.
- (ii) The resultant surface has very fine & very good tolerance.

3(a) Surface grinders :-

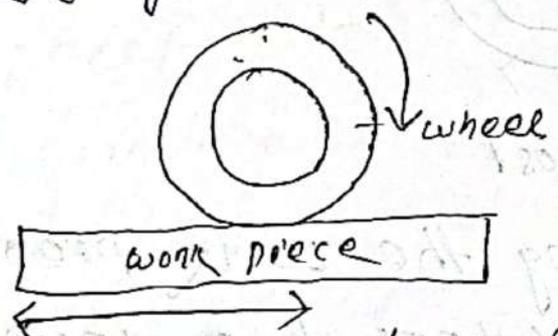
- (i) Surface grinder produce flat surface by employing a revolving abrasive wheel.
- (ii) Surface grinding operation similar to shaper or milling machine.
- (iii) Surface grinder is basically a moveable table with horizontal spindle grinding wheel mounted about of grinding.
- (iv) The grinding wheel is mounted on a column which allows it to be raised & lowered at least 300mm & more on the larger machine.

- (v) The table can move longitudinally cross wise.
- (vi) work forming is usually by means of a magnetic
- (b) cylindrical grinding :- (External & internal)
- (i) cylindrical grinding provides a cylindrical or conical shape on a work piece. The work piece is mounted between centres on in a chuck & the face of the grinding wheel passes over the external of the revolving work piece.
- (c) internal grinding :-
- (i) A internal grinding is design on facelate the finishing of holes.
- (ii) This finishing is generally for the purpose of bringing the hole to the correct size & to give it good surface quality.

2 mark Grinding operation :-
 Grinding operation are three types :-

- 1 - surface grinding.
- 2 - cylindrical grinding.
- 3 - centerless grinding.

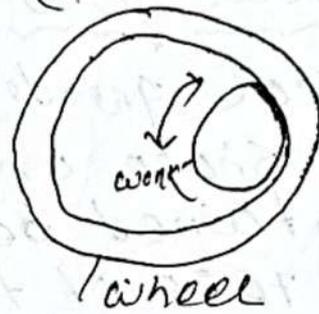
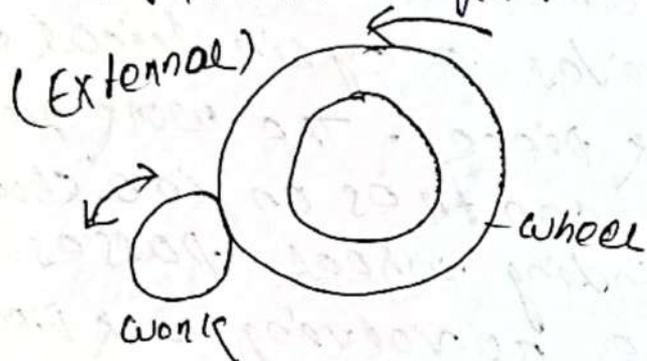
1. Surface grinding :-



- (i) It is used to produce flat angular surface by feeding the work in a horizontal plane under a rotating grinding wheel.
- (ii) The work attached a reciprocating or rotating table.

(iii) Most surface grinding machine use a horizontal spindle with can be move up & down.

2. Cylindrical grinding :- (Internal)

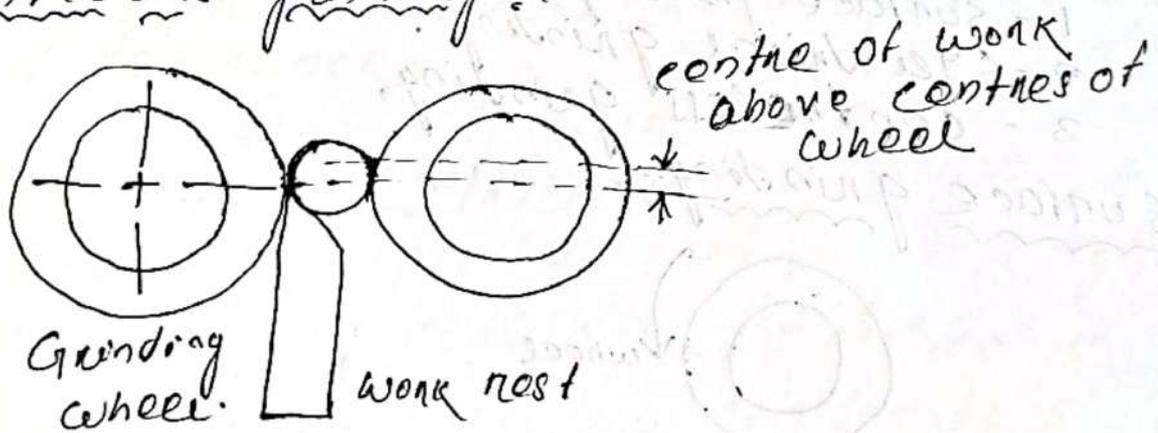


(i) cylindrical grinding used for produce cylindrical or conical shape on a work piece.

(ii) The cylindrical work piece rotated about a fixed axis in a way that the surface to be grinded are connective to the axis of rotating.

(iii) cylindrical grinding consist of a wheel head which include the spindle & drive motor & cross - slide that move the wheel head to and from the work piece form grinding.

3. centreless grinding :-



(i) in centreless grinding the work piece rotated between a grinding wheel & a reciprocating wheel.

(ii) The work is separated from below by a fixed work rest blade.

(iii) The cutting tool has sharp edge.

- (iv) Removal of material is achieved by moving the cutting tool & the part relative to each other.
- (v) The sharp edge of the cutting tool penetrate the work piece & produce a small cut by a shearing action.
- (vi) The process is repeated no. of time increasing the depth of cut of the tool each time to achieve the desired size reduction the work piece.

Grinding wheel:

- (i) Grinding wheel is a multi-tool cutter made of many hard particle known as Abrasive held together by a suitable agent called bond.
- (ii) The wheel consist of an piece or a of segment of abrasive block built up into specific a solid wheel.

Specification of grinding wheel:

- (i) The standard method of designing different element & used in different condition used in manufacturing of grinding wheel is called as specification of grinding wheel.
- (ii) The grinding wheel specified by using five standard codes consist of alphabet & number alternatively with prefix & suffix & selected codes of manufacturing.

Alphabet	New material	Alphabet	N	A
Abrasive	grain size	grade	structure	bonding

Type of Abrasive:-

- a - Aluminium oxide (Al_2O_3)
 - b - Boron carbide (B_4C)
 - c - Silicon carbide (SiC)
 - d - Diamond
- | |
|---|
| A |
| B |
| C |
| D |

Grain size:-

- 10 - 24 → coarse grain.
- 30 - 60 → medium grain.
- 80 - 180 → fine grain.
- 220 - 600 → very fine grain.

Grade

- A - H → soft grade wheel.
- I - D → medium grade wheel.
- A - Z → Hard grade wheel.

Structure:-

- 0 - 7 → Dense structure (close)
- 8 - 16 → open structure

Bonding:-

- V → vitrified
- B → Bake lite
- S → silicate
- F → Shellac
- R → Rubber

Example 51 A 36 L 5 V 23

- 51 → Natural of the abrasive
- A → Abrasive
- 36 → medium grain.

L → medium grade wheel.

S → dense structure.

V → vitrified.

23 → manufacture reference.

Abrasive :-

Abrasive are the substance that are used to clean the surface of other material.

(i) Abrasive may be classified into two type

(a) - Natural.

(b) - artificial.

(a) Natural :- sand stone

1 - Diamond :- Diamond abrasive wheel are used extensively for sharpening carbide & ceramic cutting tool.

Artificial :-

Aluminium oxide (Al_2O_3)

Silicon carbide (SiC)

Grain size :-

(i) The size of abrasive grain - required in grinding wheel depend on following factor.

1 - Amount of material to be remove

2 - Finish desired

3 - Hardness of material being ground.

(ii) The grain size of the abrasive is denoted by number representing the number of meshes per inch through which the grain of abrasive + passed for grinding.

Grade :-

- (i) Grade indicate the strength with which the bonding material holds the abrasive grains on the grinding wheel.
- (ii) The degrees of hardness are specified by the use of letters of the alphabet.
- (iii) The selection of particular grade of wheel is largely governed by the nature of work & composition size & hardness.

Structure :-

- (i) It indicates the spacing betⁿ the abrasive grains or other words density of the wheel.
- (ii) The structure of grinding wheel is designed by number.
- (iii) The higher no. the wider the spacing.
- (iv) There are two type of structure with their numbers.
 - (a) Dense structure.
 - (b) Open structure.

Bonding :-

- (i) Bonding material are used as binders to hold the abrasive particles in place.

(ii)

(i) 5 type of bonding material commonly used:- vitrified
bake lite, silicate, shellac, rubber.

Selection of grinding wheel:-

(i) The proper selection of grinding wheel is way
important to achieve optimum grinding efficiency.

(ii) As per india standard (IS) 1249-1958 the
factors may serve as a guide for wheel
selection.

(i) constant factors:-

- material to be ground.
- Amount of stock to be removed & finish.
required.
- Area of contact.
- work speed.

(ii) variable factors:-

- wheel speed
- work speed.
- condition of the machine - capacity &
rigidity.
- personal factor.

(iii) Besides the factors listed above as per
Indian standards other factor which may
also be considered for selection of
grinding wheel are

- severity of grinding operation.
- Type of bond to be used.
- Abasive grain size grade &
structure.
- whether grinding is wet to dry.

material to be ground :-

- (i) for soft material uses coarse grit so the wheel will not load up as quickly & the harder grades since they will stay sharp longer because of the lower force needed.
- (ii) for hard material it uses finer grits so more grains are cutting at once & a softer grade so that the wheel will break & stay sharp.
- (iii) for H.S.S tools use aluminium oxide or borazon wheel.
- (iv) for grinding steel & alloy steel use aluminium oxide wheel.
- (v) for cast iron, brass, aluminium use silicon carbide wheel.
- (vi) for carbide tool use silicon carbide or diamond wheels.

Amount of stock to be removed for the finish required :-

- (i) coarse grit wheels are used for rapid stock removal where finish is not important.
- (ii) fine grits give high finishes. Excellent finishes can be achieved with 60 to 80 grit.
- (iii) Resinoid, rubber or shellac bonded wheels are used for highest finishes.

Area of contact:-

- (i) small contact areas such as those occurring in external grinding generally use finer & harder wheel.
- (ii) large contact areas (between the work & grinding wheel) as those occurring in internal grinding require the use of coarser & softer grades of grinding wheels.

Type of grinding machine & its conditions:-

light machines subject to vibration & machines in poor conditions requires harder wheel. is than heavy rigidly constructed & well-maintained machines. loose spindle bearing, shaky foundations etc. cause much trouble in grinding because hard wheel have to be used to overcome rapid wheel wear & thus cutting efficiency is sacrificed.

1.0.11 Wheel speed

- (i) wheel speed is limited by the strength of the bond. The maximum safe RPM is marked on each grinding wheel & this is often the best running speed.
- (ii) slower wheels speed will cause the wheel to act as if it were harder.

Work speed:-

A high work speed means more material ground in a given time & greater wear on the wheel. Hence the higher the work speed on the harder the wheel is forced in off hand grinding the

hander must be the bond in off hand grinding work piece is held in hand on hand for rough grinding and when sharpening certain cutting tools.

condition of the machine:-

It has been discussed along with the type of grinding machine.

Personal factor:-

- (i) A skilled worker can work with softer wheels than one who is not so skilled & hence obtain better & more economical production.
- (ii) piece work grinding usually necessitates the use of harder wheels than when day work.

Severity of grinding operation:-

- (i) severe grinding operations such as those involving deep cuts at high feed rates require through (not friable) abrasive wheels.
- (ii) fine finishing cuts can often be best done with more friable abrasive compositions.

Grade or strength of bond:-

If bond is strong the wheel is said to be hard & vice versa. Hard wheel are recommended for soft material & soft wheels for hard materials.

Grain size:-

- (i) coarse grained wheels are used for fast removal of metal & soft material.
- (ii) fine-grained wheels are used for finishing purposes & for hard & brittle materials.

Structure or grain spacing:-

A fine finish requires a wheel with a close spacing of the abrasive particles where as soft ductile materials require a wide spacing.

Kind of abrasive:-

- (i) Silicon carbide wheels are recommended for materials of low tensile strength such as cast iron; brass, stone, rubber & cemented carbides.
- (ii) Aluminium oxide wheels are best used on material of high tensile strength like hardened steel H.S.S alloy steel etc.

Wet dry grinding:-

- (i) most grinding work better if done wet this also may permit the use of one grade harder wheel giving longer life of the grinding wheel.
- (ii) soluble oils, sulphurized oil & synthetic compound are used to cool & clean the work & the grinding wheels.

Bonding types:-

There are 5 type of bonding material as

1- vitrified:-

- (i) vitrified made of clay & water.
- (ii) vitrified bond are used most extensively.

(iii) vitrified abrasive wheel have a high production capacity & are moisture proof.

(iv) About 75% of grinding wheel have vitrified bond.

2. Silicate :-

(i) This bond is produce by mixing abrasive grains with Silicate of soda.

(ii) The mixture is given the desired wheel shape & backed at about 260°C for a day on more.

(iii) The silicate bonded made are soft low production capacity.

(iv)

Shellac :-

(i) shellac bond wheel are made by mixing the abrasive grains with shellacs in a mixture.

(ii) shellac bond wheel can produce high polish & are use in grinding such parts as cam shaft & mill roll.

(iii)

3. Rubber :-

(i) The rubber bond is made by the mixture of rubber softends by gessoes & sulphur 30%.

(ii) A rubber bonded wheel has high strength & elasticity & is moisture proof.

(iii) They are commonly use for snagging work in foundries & for thin cut-off wheel.

Drilling is an operation for producing holes in a work piece by using a rotating tool known as a drill.

Working principle:-

- (i) In drilling operation a hole is produced by feeding the rotating drill in a direction parallel to its axis into a work piece fixed to the table.
- (ii) Drill bits are cutting tools for creating holes.
- (iii) It is made of tool materials has three principle part:-
 - (a) point
 - (b) body
 - (c) shank
- (iv) The drill is held & rotated by its shank.
- (v) During an operation the metal comes in contact with two cutting edges of the tool & remove the metal stock.

Bench drilling machine:-

- (i) This are light duty machine used on work piece.
- (ii) These are normally mounted on work benches & hence the name.
- (iii) It consist of cast iron base with a vertical column is made of hollow steel pipe on which the table slide up & down.
- (iv) The table can be fixed to the required position by means of a table clamp.
- (v) The top of the column houses the drive consisting of endless belt running over the V - cooling based on the speed of spindle required.
- (vi) V - belt can be shifted to different grooves of the pulleys to drill small diameter holes.
- (vii) A twist drill is fitted at a drill chuck which is turned fits into the spindle of the machine.

Table Drilling machine

Parts

Base plate -

It is a solid non angular close grain cast iron plate.

(ii) It is below penstock is properly machined & roller is fitted in its back side position.

Roller Drive of machine

- (i) A radial drill machine used to perform the drilling operation on the work piece which are too heavy & also maybe too large to mount them on the work table.
- (ii) It consist of heavy & a vertical column with a long horizontal radial arm extending from it & can be rapidly raised, lowered & swing in horizontal plane about the main column to any desired location.
- (iii) The drilling head can be move to & from along the arm & can be swivelled only in the universal radial machine to drill at an angle.
- (iv) The main advantage of the radial drilling machine is that the drill can be carried on heavy work piece in any position without moving them.

(v) This type of drill machine is used in tool rooms & in large scale die manufacturing unit.

Boring :-

Definition :-

- (i) It is an operation of enlarging an existing hole.
- (ii) Boring is the process of using a single point cutting tool to enlarge & locate a previously made hole.
- (iii) The boring tool on a boring machine is usually a single point cutting tool made up of H.S.S. or carbide & its mounted in the tool head.
- (iv) It is capable of vertical movement & radial movement guided by a cross rail.

Difference between Boring & Drilling:-

Boring

- (i) Boring is performed to enlarge the diameter of an existing hole.
- (ii) cutting tool used for boring is known as boring bar.
- (iii) Boring bar is a single point cutting tool.
- (iv) A pre-drilled hole (or, a hollow portion made by casting) is mandatory for performing boring.
- (v) Boring can increase diameter of an existing hole but not length.
- (vi) Here surface quality is better than drilling.
- (vii) material removal rate (MRR) is lower than drilling but higher than reaming.

Drilling

- (i) Drilling is performed to originate a hole.
- (ii) cutting tool used for drilling is known as drill.
- (iii) Drill is a double point cutting tool.
- (iv) Drill is first phase of hole fabrication. It does not require any special feature prior to operation.
- (v) Drilling can increase length of the hole but not diameter (limited to drill diameter).
- (vi) surface quality of drilled hole is not very good.
- (vii) material removal rate (MRR) in drilling operation is higher.

Comparison between boring & reaming:-

- (i) Boring can correct hole location size or alignment & can produce a good finish if a fine feed & a correct tool are used.
- (ii) The reamer follows the hole already in the workpiece & so cannot correct location.
- (iii) Reaming involves the use of a tool of fixed size which is different for each size of hole & a large hole would require an expensive reamer. While a boring tool can make a hole of any size.
- (iv) Reaming is faster than boring but boring operation often preferred because of location correction advantage.

Classification of Boring machines :-

Boring machines are manufactured in various designs & sizes. They can be broadly be classified as.

(1) Horizontal boring machines (HBM)

(i) table type (HBM)

(ii) Planer type (HBM)

(iii) floor type (HBM)

(iv) multiple spindle (HBM)

(2) Vertical boring machines (VBM)

(3) Jig boring machines (JBM)

1 - Horizontal boring machines :- (HBM)

- (1) Head stock
- 2 Pulley for counter balancing weight of head stock
- 3 Head stock elevating screw. (6) work.
- 4 Boring head. (7) End supporting column.
- (5) Boring cutter on boring bar. (8) Bearing block.
- (9) Saddle

- 10- cross slide on table
- (i) The table type or universal type is the most versatile & commonly used horizontal boring machine.
 - (ii) A horizontal boring machine nick named a 'bar Jiffens' from the vertical boring mill is that the work is stationary & tool is revolved.
 - (iii) It is adapted to the boring horizontal holes & these holes & components are generally large.
 - (iv) If these conditions of component size & hole size are not met other smaller machines are used.
 - (v) The principle features of these machines are :-

(a) Bed	(d) Horizontal spindle
(b) columns	(e) Lead bearing end support.
(c) Head stock	(f) Horizontal table.

(a) Bed :-

A heavy & strong bed carries the entire load of different parts, work piece & tooling over it.

(b) columns :-

Two vertical columns one on each end of the table.

(c) Head stock :-

The head stock can be moved vertically along the main column.

(d) Horizontal spindle :-

It is suitably housed in the head stock & can be rotated & fed forward & back ward according to requirement.

(e) Lead bearing end support :-

It supports the end of a long boring bar & can be adjusted vertically along the end support column.

(1) Horizontal table :-

It is mounted on a saddle & can be moved horizontally forward & back work & sideways by moving the saddle.

(2) Vertical boring machine (VBM)

- (i) A vertical boring machine is some times called a rotary planer & its cutting action on flat discs is identical with a planer.
- (ii) These machines rated according to their table diameter vary in size from 9m to 12m most machines also have a slide tool head.
- (iii) The parts whose length or height is less than diameter are machined for convenience on vertical boring machines.
- (iv) On a vertical boring machines the work is fastened on a horizontal revolving table & the cutting tool or tools which are stationary advance vertically into it as the table revolves.

- (v) There are two designs of a vertical boring machine
- (i) single column VBM
 - (ii) Double column VBM
- (vi) The work is accommodated on the horizontal revolving table at the front of the machine. The circular work can be clamped on to the table with the help of jaw chucks. Whereas the T-slots can be used with bolts & clamps for setting up & holding irregular work.
- (vii) A Horizontal cross-rail is carried vertically sideways & carries the tool holder, slide on slides.
- (viii) on machines designed for working on long batches of similar articles a single slide with turret may be employed.

Jig boring machine :-

- (i) A Jig boring machine is a very precise vertical type boring machine.

(i) It is a schematic of a machine designed for locating & boring holes in jigs fixture dies gauges & other precision parts.

(ii) Jig boring machines are constructed with greater precision & are equipped with accurate measuring devices for controlling table movements on typical machines positioning to $\pm 0.003\text{mm}$ can be dialled directly from drawing.

(iii) These machines are also operated by numerical control by putting part design on tape accurate repetition is ensured jig & fixture are eliminated & precision boring become practical for small lot manufacturing.

(iv) To prevent the influence of ambient temperature changes on machining jig boring machines should be installed in special environmental enclosures with temp. maintained at a level of 20°C .

(v) Jig borers are used as coordinate measuring machines for inspections & precision layout operations.

Size of Boring machines:-

(i) The size of boring machines is given by the diameter of the spindle (75 mm to 350 mm)

(ii) In case of vertical boring machines, the dimension of column height & table size (diameter) 11200 mm to 3600 mm.

Boring operation:-

counter boring:-

- (i) It is an operation of enlarging a drill hole practically.
- (ii) The counter boring forms a large size and a sudden to existing hole.
- (iii) The cutting tool will have a small cylindrical projection known as pilot.
- (iv) The diameter of the pilot will always be equal to diameter of the provides drill hole.

counter sinking:-

- (i) It is an operation of forming conical shape at the end of a drill hole.
- (ii) It is done using a counter sinking tool.
- (iii) The cutting speed for counter sinking must be about $1\frac{1}{2}$ of that used in a drill size.
- (iv) The counter sink hole are used when the counter sink screw are to be screwed into the hole so that they -
- (v) Top face have to be in finish with the top surface of the work piece.

Broaching:-

- (i) Broaching is a method of removing metal by pushing or pulling of metal a cutting tool called a broaching.

or
Broaching is a machining process that uses a toothed tool which is the more common process; the broaching is run linearly against a surface of the work piece to ~~be~~ effect the cut.

- (ii) The tool may be push & pushed through the surface to be finished.

Broachess:-

A Broach is a multiple point edges cutting tools that has successively higher cutting edges along the length of the tool.

Types of Broaches:

Broaches may be classified in various ways according to.

1. Type of operation
(Internal or external)
2. method of operation
(Push & pull)
3. Types of construction.
(Solid mounted tooth progressive used)
4. Function
(Surface, Key way, Round hole)

Type of Broaching:-

There are two types of broaching.

- (i) pull type broaching.
- (ii) push type broaching.

SLOTTER

Chapter - 9

Definition:-

- (i) The slotting machine is a reciprocating machine tool in which the ram holding the tool reciprocates in a vertical axis & the cutting action of the tool is only during the downward stroke.
- (ii) slotting machine are generally used to machine internal surfaces (flat formed groove & cylindrical).
- (iii) On the other hand the vertical shaper sometimes called a slotter has vertical ram.
- (iv) The tool moves vertically rather than in a horizontal direction.
- (v) It has a vertical ram & a hand or power operated rotary table. The stroke of ram is smaller in slotting machines than in shapers.

Operation of slotter:-

- (i) A slotter machine or slotter may be considered as a vertical shaper. The chief difference between a shaper or slotter is the direction of the cutting action.
- (ii) The machine operation is in a manner similar to the slotter however the tool machines vertically rather than in a horizontal direction.
- (iii) The job is held stationary the slotter has a vertical ram & a hand or power operated rotary table.
- (iv) On some machines the ram may be inclined as much as 10° to either side of the vertical position when cutting inclined surface.

USES OF SLOTTER:-

- (i) A slotted is a very economical machine tool when used for certain classes of work.
- EX:- Springs, Key ways both internal & external.

MILLING MACHINE :-

- (i) milling machine is a machine tool that removes metal as the work piece is fed against a rotating multi point cutter.
- (ii) The cutter rotates at a high speed & because of the multi point cutting edges.
- (iii) It removes metal at very fast rate.
- (iv) The machine can also hold one or more no. of cutters at a time.

TYPES of milling machine :-

According to a design :-

- (i) column & knee type milling machine
 - (a) head milling,
 - (b) plane milling machine,
 - (c) universal milling machine,
 - (d) vertical milling machine.
- (ii) planer - milling machine
- (iii) fixed - bed type milling machine.
 - (a) simplex milling machine.
 - (b) Duplex milling machine.
 - (c) Triplex milling machine.
- (iv) special type of milling machine
 - (a) Rotary table machine
 - (b) planetary milling machine
 - (c) profiling milling machine
 - (d) B & B milling machine
 - (e) pantagraph milling machine
 - (f) continuous milling machine.

Column & Knee type milling machine:

- (i) For general shop work the most commonly used is the column & knee type where the table is mounted on the knee casting.
- (ii) The knee is vertically adjustable on the column so that the table can be moved up & down to accommodate work of various heights.

(a) Head milling machine:

- (i) The simplest of all types of milling machine is the head miller in which the feeding movement of the table is supplied by hand control.
- (ii) The machine is relatively smaller in size than that of other types & is particularly suitable for light & simple milling operation such as machining slots, grooves & key ways.

(b) plain milling machine :-

- (i) The plain milling machine is much more rigid & sturdy than hand mills for accomplishing heavy work pieces.
- (ii) A plain milling machine having horizontal spindle is also called horizontal spindle milling machine.
- (iii) on a plain milling machine the table may be fed in a longitudinal, cross or vertical directions.
- (iv) when the table is moved parallel to the spindle & the feed is vertical when the table is adjusted in the vertical plane.
- (c) universal milling machine :-
- (i) A universal milling machine is so named because it may be adapted to a very wide range of milling operations.
- (ii) The table can be swivelled to any angle upto 45° on either side of normal position.
- (iii) The capacity of a universal milling machine is considerably increased by the use of special attachment such as vertical milling attachment, rotary attachment, slotting attachment etc.
- (iv) A universal machine is essentially a tool room machine designed to produce a very accurate work.

(i) A vertical milling machine can be distinguished from a horizontal milling machine by the position of its spindle which is vertical or perpendicular to the work table.

(ii) The machine may be of plain or universal type & has all the movements of the table for proper setting & feeding for machining the work.

(iii) The machine is adopted for machining grooves, slots, & flat surface.

(iv) plano - milling machine:

- (i) The plano-millon as it is called is a massive machine built up for heavy duty work having spindle heads adjustable in vertical in transverse directions.
- (ii) There may be a number of independent spindle carrying cutters on the nose as well as two heads on the up rights.
- (iii) modern plano-millions are provided with high power driven spindles powered to the extent of 100 h.p. & the rate of metal removal is tremendous.
- (iv) The use of the machine is limited to production work only & is considered ultimate in metal removing capacity.
- (v) fixed bed type milling machine :-
- (i) The fixed type milling machine are comparatively large heavy & rigid & differ radically from column & knee type milling machines by the construction of its table mounting.
- (ii) The table is mounted directly on the way of fixed bed.
- (iii) The cutter mounted on the spindle head may be moved vertically on the column & the spindle may be adjusted horizontally to provide cross adjustment.
- (vi) simplex milling machine :-

DUPLEX
on a duplex milling machine the spindle heads are arranged one on each side of the table.

(c) triplex milling machine:-
(i) on triplex machine type the third spindle is mounted on a cross rail.
(ii) The usual feature of these machines is the automatic cycle of operation for feeding the table.

(iv) special type of milling machine:-
(i) milling machines of non-conventional design have been developed to suit special purposes.
(ii) The features that they have in common are the spindle for rotating the cutter & provision for moving the tool on the work in different direction.

(a) Rotary table machine:-
(i) The construction of the machine is a modification to a vertical milling machine & is adopted for machining flat surface at production rate.
(ii) The cutters may be set at different height relative to the work so that when one of the cutter is roughing the piece the other is finishing them.

(b) Planetary milling machine:-
(i) In a planetary milling machine the work is held stationary while the revolving path to finish a cylindrical surface on the work either internally or externally or simultaneously.
(ii) The machine is particularly adopted for milling internal or external threads of different pitches.

(c) Profiling machine :-

- (i) A profiling machine duplicates the full size of the template attached to the machine.
- (ii) This is practically a vertical milling machine of bed type in which the spindle can be adjusted vertically & the cutter head horizontal across the table.
- (iii) The longitudinal movements of the table & cross wise movement of the cutter head follow the movements of the guide pin on the template.

(d) Panograph milling machine :-

- (i) A panograph machine can duplicate a job using a panograph mechanism which permits the size of the work piece reproduced to be smaller than, equal to or greater than the size of a template or model used for the purpose.

(ii) The facing stylus is moved manually on the contour of the model to be duplicated & the milling cutter mounted on the spindle moves in a similar path on the work piece.

Construction & working of simple dividing head, universal dividing head.

- (i) The dividing head & an indexing head is one of the most important of the milling machine accessories without it the utility of the milling machine is very restricted.
- (ii) The dividing head is a mechanical device used to divide the circumference or periphery of a job into specified distance or angular separation. It also provides

(iii) The dividing head rotates the work piece through a certain number of degrees on a fraction part of a complete revolution for the purpose of graduating the part. This operation is called indexing.

(iv) The complete dividing head has two parts.
a) the head.
b) The tail stock.

(v) The head of a universal indexing head consists of a base plate swivel block, spindle, worm & worm wheel, a direct index plate side index plate & sector.

(vi) The tail stock is used for supporting the outer end of the stock being milled. The tailstock center can be moved longitudinally by means of a hand-wheel also by adjusting the block which holds it the center may be moved vertically in either a horizontal or an inclined plane.

Types of dividing heads :

There are four types of dividing heads :-

- (a) plain or simple dividing head.
 - (b) Universal dividing head.
 - (c) Helical dividing head.
 - (d) optical dividing head.
- (a) plain or simple dividing head :-

(i) A plain dividing head has a fixed spindle axis i.e. the spindle rotates about a horizontal axis only.

(ii) The worm wheel has 40 teeth & is keyed to the spindle. The worm meshes with the worm wheel. The worm has a single thread.

- (iii) Every turn of the index (crank) pin turns the worm one revolution moving the worm wheel one tooth or $1/48$ of a worm will turn the index head spindle & the job one complete revolution.
- (iv) Fractional parts of a turn are obtained by utilizing index plates that are supplied with each head.
- (v) The sector marks are used to mark off the number of holes on the index plate. This makes it possible to move the index crank pin the same number of holes without having to count the holes on each turn.
- (vi) Plain dividing heads are used for direct indexing in to a small number of parts. plain dividing head may be intended for divisions to 2, 3, 4, 6, 8, 12, & 24 parts.
- (vii) plain dividing heads are used for milling different surface & flutes of cutting tools for machining work pieces of simple shape with faces in mass production.

(b) Universal dividing head :-

- (i) where as a plain dividing head has a fixed spindle axis while in the universal metal the spindle can be located at any angle from horizontal to vertical.
- (ii) A universal dividing head has the following purpose.
- (i) Turning the work periodically (index through a given angle by the direct plain compound or differential methods?

- (2) Imparting a continuous rotary motion to the workpiece for milling helical groove (flutes of drill; reamers milling cutters etc)

WORK HOLDING DEVICES:-

- (i) It is necessary that the work should be properly & securely held on the milling machine table for effective machining operations.

T-bolts & clamp:-

- (i) Bulky work piece of irregular shapes are clamped directly on the milling machine table by using T-bolts & clamps.
- (ii) Different designs of clamps are used for different patterns of work;

Angle plates:-

- (i) When work surface are to be milled at right angle to another face angle plate are used for supporting the work.
- (ii) The angle plate is bolted on the table & the work piece is supported on its face

by bolts & clamps.

- (ii) Adjusting type angle plate in which one face can be adjusted relative angle is also some times used.

V-blocks :-

- (i) The V-block are used for holding shafts on milling machine table in which key ways slots & ϕ flats are to be milled.
- (ii) The blocks are clamped on the machine table by straps & bolts.
- (iii) V-blocks are provided with tongue at its base which fits in to the T-slots of the table & prevents the block from any sideways movement.

Vices :-

- (i) Vices are the most common appliances for holding work on milling machine table due to its quick loading & unloading arrangement.
- (ii) There are mainly three types of vice commonly used in milling machine.

(iii) They are

- (a) plain vice
- (b) swivel vice
- (c) tool makers universal vice.

(a) plain vice :-

(i) The plain vice bolted directly on the milling machine table ~~direct~~ is the most common type of milling vice used for plain milling machine.

(ii) The vice may be fastened to the table with the jaw & for holding workpiece of set either parallel or at right angle to the table T-slots.

(iii) work is clamped between the fixed & moving of irregular shape. special jaws are sometimes used.

(b) Swivel vice :-

(i) The swivel vice is used to mill an angular surface in relation to a straight surface without removing the work from the vice.

(ii) In construction it may be considered as a plain vice which is mounted on a circular base ~~is clamped on the table by~~ graduated ~~on the~~ in degrees.

(iii) The base is clamped on the table by means of T-slots.

Tool makes universal vice:-

- (i) The universal vice can be swivelled in a horizontal plane similar to swivel vice & can also be tilted in any vertical position for angular cuts.
- (ii) The vice not being rigid in construction is used mainly in tool room work.

Special fixtures:-

- (i) The fixtures are special device designed to hold work for specific operations more efficiently than standard work holding device.
- (ii) fixture are specially useful when large number of identical parts are being produced.
- (iii) By using fixtures loading, locating clamping & unloading time is greatly minimized.

Milling process of method:-

(i) The various milling process perform by the different milling cutters it may be divided under two separate heading.

(a) peripheral milling.

(b) Face milling.

(ii) peripheral milling:-

(i) In peripheral milling the cutters process a machine surface parallel to the axis of rotation of the cutter.

(ii) The quality of surface generated & the shape of chip formed depends upon the rotation of the cutter relative to the direction of the feed movement of the work.

(iii) According to the relative movement between the tool & the work peripheral milling is classified into two type.

(iv) (a) up milling.

(b) down milling.

(v) up milling:-

(i) It is also called conventional milling.
(ii) It is the process of removing metal by cutting which is notated against the direction of travel of the work piece.

(iii) The thickness of the chip is minimum at the beginning of the cut & it reaches to the maximum when the cut at the end of the cut.

(b) Down milling :-

(i) It is also called climb milling in this process of removing metal by the cutter which is notated in the same direction of the work.

(ii) The maximum chip thickness of the chip at the start of cut & it reduce to the minimum when the cut at the end.

(b) Face milling :-

(i) Face milling is the operation performed by a milling cutter to produce a flat machine surface perpendicular to the axis of rotation of the cutter.

(ii) The thickness of the chip is minimum at the beginning & at the end of the cut & it is maximum when the work passes through the center line of the cutter.

Indexing :-

(i) It is one of the most important attachment for milling machine.

(ii) It is used to divide circumference of the work piece into equal space division such as in cutting gear teeth.

(iii) It is also used to rotate work piece at ~~pre~~ pre-determined ratio to table feed rate.

Index plate :-

(i) circular plate provided with series of equally spaced holes in to which index crank pin engagement.

It's fit on front of plate & may be set to any ~~position~~ portion of a complete turn.

Index plate types :-

Brown & Sharpe Index plate
(consist of three plate of six circles is drilled)

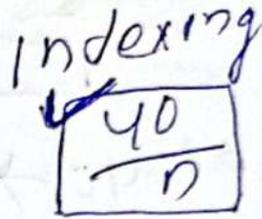


plate - 1

15, 16, 17, 18, 19, 20

plate - 2

21, 23, 27, 29, 31, 33

plate - 3

37, 39, 41, 43, 47, 49,

Type of indexing :-

- (i) simple or plain indexing.
- (ii) compound indexing.
- (iii) Angular indexing.
- (iv) Differential indexing.

Simple or plain indexing :-

(i) In simple or plain indexing an index plate is selected for the particular application is fitted on the worm shaft & locked through a locking pin.

(ii) To index the work through any required angle, the index crank pin is with shown the hole of the index plate then the work indexed through the required angle by turning the index crank through a calculated no. of whole revolution & holes on one of the whole revolution.

After which the index pin which re located in the required hole.

(ii) If the no. of turn the crank must be rotated for each indexing can be found from the formula rule for simple indexing crank movement.

$$Z = \frac{40}{n}$$

$$\frac{40}{n \times 2}$$

Where $40 \rightarrow$ no. of teeth on the worm wheel.

$n \rightarrow$ no. of division or indexing needed of the work.

For example :-

set the dividing head to mill cutting teeth on a spur wheel.

$$\text{Index crank movement} = \frac{40}{30}$$

(1) rotation crank

$$(2) \text{ (two hole in circle)} = \frac{4}{3} = 1\frac{1}{3}$$

$$(3) \text{ hole circle} = 1\frac{1}{3} \times \frac{7}{7}$$

$$= 1\frac{7}{21}$$

for indexing one complete turn of five hole 15 hole circle on the index plate will have to moved by index crank.

(ii) Compound indexing :-

(i) The indexing method is called compound due to two separate movement of the index crank in two different hole circle of an index plate to obtain a crank movement not obtainable by plane indexing.

(ii) The index plate is normally held stationary by a crank pin which engages with one of the hole circle of the index plate from the back.

(iii) While indexing the crank pin is rotated through a regulated no. of spaces in one of the hole circle of the index plate & then the crank pin is engaged with the plate.

(iv) The first movement is now performed similar to the plane indexing.

(v) The second movement is now performed by removing the rear lock pin & then rotating the plate together with the index crank forward or backward through the calculated number of spaces of another hole circle & lock is engaged.

Rule of compound indexing :-

$$\frac{40}{N} = \frac{n_1}{N_1} \pm \frac{n_2}{N_2}$$

where N = no. of division required

N_1 = The hole circle used by the crank pin.

N_2 = The hole circle used by the lock pin.

n_1 = The hole spaces moved by the crank pin in the hole circle.

N_2 = The hole spaces moved by the plate & the crank pin hole circle.

Example :-

Index 69 division by compound indexing

Using formula = $\boxed{\frac{40}{49} = \frac{N_1}{N_1} \pm \frac{N_2}{N_2}}$

To determine the value of n_1, N_1, n_2 & N_2 the above mentioned procedure is followed in step by step.

1 - $69 = 23 \times 3$

2. Index circles

23 & 33 are chosen.

(3) $33 - 23 = 10$

(4) $10 = 2 \times 5$

5) $69 = 23 \times 3$

$10 = 2 \times 5$

(6) $40 = 2 \times 2 \times 2 \times 5$

$23 = 23 \times 1$

$33 = 3 \times 11$

7) & (8) $69 = 23 \times 3$

$10 = 2 \times 5$

$40 = 2 \times 2 \times 2 \times 5$

$23 = 23 \times 1$

$33 = 3 \times 11$

As all the factors can be called above the horizontal line the hole circle 23 & 33 can be used for indexing.

Thus $N_1 = 23$ & $N_2 = 33$.

9) $2 \times 2 \times 11 = 44$

\therefore 44 is the number of hole spaces to be moved for indexing. The for number 12.300

how be measured as

$$\frac{40}{69} = \frac{44}{23} - \frac{44}{33} = 1 \frac{21}{23} - 1 \frac{11}{33}$$

$$= \frac{21}{23} - \frac{11}{33}$$

Angular indexing :-

- (i) Angular indexing is the process of dividing the periphery of a work in angular measurement.
- (ii) The indexing method is similar to the plane indexing.
- (iii) There are 360 degrees in a circle & when index crank is rotated by 40 no. of revolutions the spindle rotates through 1 complete revolution or 360 degrees.
- (iv) Therefore one complete run of the crank will cause the spindle & the work, rotated through $\frac{360}{40} = 9^\circ$.

Rule of angular indexing :-
 Index crank movement = $\frac{\text{Angular displacement of work in degrees}}{9}$

Example :- 45°

$$\Rightarrow \frac{45^\circ}{9} = \frac{45 \times 2}{9 \times 2} = \frac{90}{18}$$

\therefore It is five complete turns.

(ii) 122°

$$\Rightarrow \frac{122^\circ}{9} = 13.55 = 13 \frac{5 \times 2}{9 \times 2}$$

(revolutions)

$$= 13 \cdot \frac{10}{18} \frac{(\text{no. of hole})}{(\text{hole circle})}$$

The index crank should be move 13 complete turn and 10 holes of 18 hole circles.

- 148 - hole circle
- 13 - Revolution
- 10 - no. of holes circle

Differential indexing:

- (i) The indexing method is called differential because the required division is obtained by a combination of two movements.
- (ii) The rotation on differential motion of index plate may be takes place in the same direction as the crank or opposite to its may be neg.
- (iii) ~~The rotation is differential~~
- (iv) The result is that the actual movement of the crank at very indexing is automatically increased or decreased giving the required index movement of the spindle.
- (v) For this reason the differential indexing may be considered as an automatic method of performing compound indexing.

The rule for differential gear ratio indexing movement of the crank & the number of holes required.

When $A =$ The stored no which can be indexed by plain indexing & the no. is a approx; mostly equal to N .

$N =$ The required no of divisions to be indexed.

EXAMPLE :

$$\frac{40}{N} = \frac{40}{70}$$

A SSUME $\Rightarrow A = 86$

$$(A - N) = \frac{40}{A}$$

$$= (86 - 83) \times \frac{40}{86}$$

$$\Rightarrow 3 \times \frac{40}{86}$$

$$= 1.3953$$

The end

Surface finishing

- * Surface finishing is an operation using bonded abrasive stones in a particular way to produce an extremely high quantity of surface finish in conjunction with an almost complete absence of defect on the surface layer.
- * This operation may be applied for external & internal surface of parts made of steel, cast iron & non ferrous alloys.

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- * The relation betⁿ the smoothness & Roughness of a component is called surface finish
- * The study of surface is called topography. surface finish is a part of topography.

Advantage:-

- (i) Reduce friction
 - (ii) Reduce wear & tear.
 - (iii) Increase machine speed
 - (iv) For facilitates free flow of lubricant.
- * Different type of surface finishing are
 - (1) Grinding
 - (2) Honing
 - (3) Lapping
 - (4) Buffing & polishing.

* Lapping Abrasive:-

soft material
Aluminium oxide, silicon carbide, boron carbide
Diamond dust | Hard steel part.
↳ Extremely hard

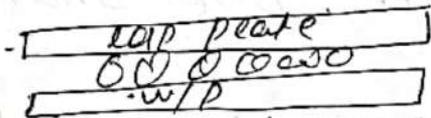
Lapping :-

In this process two surfaces are rubbed together with an abrasive between them.

It is an abrading process employed for improving the surface finishing by reducing roughness; waviness & other irregularities on the surface.

It is used on both heated & non-heated threaded metal parts.

It should be used only where accuracy is a vital consideration in addition to the surface finish.



* The lubricant used to hold on & retain the abrasive grains during the operation is called vehicle.

* Some common vehicles used in lapping include the vegetable or olive oil, mineral oil & heavy grease.

* Lapping is done in the following two ways,

- (1) By hand → called hand lapping.
- (2) By machine → called machine lapping.

Hand Lapping :-

* In hand lapping either the lap or the work piece is held by hand & motion of the other enables the rubbing of two surfaces in contact.

* In some cases lapping compound is placed in both the two surfaces & the two are

robbed & oughter by moving one of them by hand. the other remaining stationary.

* EX:- (i) lapping of surface plate

(ii) Engine valve & valve set.

(2) machine lapping:-

* machine lapping is performed for obtaining a high finished surface on many articles like, races of base & roller bearing gears, crank shaft, piston & augo block various automobile engine part.

* A typical vertical spindle machine consist of two wheels, one above & other below

* The work piece are placed betw the two & the loose abrasive grains with recirculate are fed.

* A centreless grinding machine can be conveniently adopted to perform lapping operation for round object.

Broaching is a method of removing metal by pushing or pulling a cutting tool called broach which cuts in fixed path.

The surface to be cut may be external or internal.

Broaches:-

A broach is a multiple-edge cutting tool that has successively higher cutting edges along the length of the tool.

Types of broaches:-

Broaches may be classified in various ways according to

- (1) Type of operation: internal or external
- (2) Method of operation: push or pull
- (3) Type of construction: - solid, built-up
insulated tooth progressive cut.
- (4) Function: surface, keyway, round hole
spiral spiral

Broaching methods:-

Pull broaching:- The work is held stationary & the broach is pulled through the work.
Pull broaching is ~~used~~ used mostly for internal broaching but it can do some surface broaching.

Push broaching:-

- * The work is held stationary & the broach is pushed through on the work.
- * Hand & hydraulic ~~bar~~ presses are popular for push broaching.
- * This method is used mostly for sizing holes & cutting keyways.

Advantage:-

- (1) Rate of production is very high
- (2) Little skill is required to perform a broaching operation.
- (3) High accuracy & high close of surface finish.
- (4) Both roughing & finishing cut are complete in one pass of the tool.