LECTURE NOTE

CHANDRASEKHAR DASH

MECHANICAL ENGG DEPT.

SUBJECT: MANUFACTURING TECHNOLOGY

MANUFACTURING TECHNOLOGY

1.0 TOOL MATERIAL

To remove chips from a workpiece, a cutting tool must be harder than the workpiece and must maintain a cutting edge at the temperature produced by the friction of the cutting action.

1.1 Composition of Various Tool Materials

A. Carbon Steel:

Carbon tool steel is one of the inexpensive metal cutting tools used for low-speed machining operations.

These plain carbon steel cutting tools have a composition of (0.6 – 1.5) % carbon and very small Mn and Si.

Carbon steel possesses good machinability.

This material loses its hardness rapidly at a temp of about 250c.

Carbon steel tools are used in twist drills, milling tools, turning and forming tools, and used for soft materials such as brass, aluminum, magnesium, etc.

Temp up to 450c and hardness up to HRC 65.

B. High-Speed Steel (HSS)

High Carbon Steel with a significant amount of alloying elements such as tungsten, molybdenum, chromium, etc to improve hardenability, toughness, and wear resistance.

It gives a higher metal removal rate.

It loses its hardness at a moderate temp about 650c.

A coolant should be used to increase tool life.

HSS tools are used in drills, milling cutters, and single-point lathe tools.

Cutting speed range 30-50m/min, temperature up to 650c, and hardness up to HRC 67.

Surface Treatment used in HSS:

- Superfinishing – Reduce friction.
- Nitriding – Increase the wear resistance.
- Chromium electroplating
- Oxidation

C. Cemented Carbide Tool

The cemented carbide tool is produced by the powder metallurgy technique.

It consists of tungsten, tantalum, and titanium carbide with cobalt as a binder.

Cemented carbide tools are extremely hard they can withstand very high cutting-speed operations.

A high cobalt tool is used for a rough cut while a low cobalt tool is used for finishing operation.

Cutting speed range 60- 200m/min. temperature up to 1000c, and hardness up to HRC 90.

D. Ceramics

The most common ceramic materials are aluminum oxide and silicon nitride.

Powder of ceramic material Compacted in insert shape, then sintered at high temperature.

Ceramic tools are chemically inert and possess corrosion resistance.

They have high compressive strength.

They are stable up to a temperature of 1800°C. They are ten times faster than HSS.

The friction between the tool face and chip is very low and possesses low heat conductivity, usually, no coolant is required.

They provide a very excellent surface finish.

Cutting speed range 300- 600m/min. temperature up to 1200c, and hardness up to HRC 93.

E. Cubic boron nitride (CBN)

It is the second hardest material after diamond.

They are generally used in hand machines.

They offer high resistance to abrasion and use as an abrasive in grinding wheels, Sharp edges are not recommended.

Speed 600-800m/min and Hardness higher than HRC 95.

F. Diamond

It is the hardest material known and it is also expensive.

It possesses very high thermal conductivity and melting point.

Diamond offers excellent abrasion resistance, low friction coefficient, and low thermal expansion.

It is used in machining very hard materials such as carbides, nitrides, glass, etc.

Diamond tools give a good surface finish and dimensional accuracy.

They are not recommended for machining steel.

1.2 Physical Properties & uses of Such tool Materials.

A. Physical Properties of Carbon Steel

Low hot hardness

Poor hardenability

Can withstand cutting temperature 200°C.

Carbon tool steel is harder than many HSS.

Uses:

It can be used most economically under these conditions.

The carbon steels are used for making certain taps and drills.

For making woodworking tools.

B. Physical Properties of High-Speed Steel (HSS)

High hot hardness

Cutting tools retain the cutting ability up to 600°C.

High wear resistance.

The hardenability is good.

Uses:

Drills

Broaches

Milling cutters

Lathe cutting tools.

Taps, etc.

C. Physical Properties of Cemented Carbide Tool

- Wear resistance/hardness.
- Compressive strength.
- Impact strength.
- Transverse rupture strength.
- Tribological properties.
- Specific weight.
- Magnetic properties.
- Young's modulus (modulus of elasticity)/rigidity

Uses: Cemented carbide is used mainly in cutting, abrasion resistance, impact resistance, and mining tools, as well as various other fields to utilize its corrosion resistance and other characteristics. We mainly produce high-precision thin blades, high-precision polishing plates, and cemented carbide rods.

D. Physical Properties of Ceramics

- High hardness.
- High elastic modulus.
- Low ductility.
- Good dimensional stability.
- Good wear resistance.
- High resistance to chemicals.
- High weather resistance.
- Relatively high melting point.

Uses: Ceramics are also used to make objects as diverse as spark plugs, fiber optics, artificial joints, space shuttle tiles, cooktops, race car brakes, micro positioners, chemical sensors, self-lubricating bearings, body armor, and skis.

2.0 CUTTING TOOL

A cutting tool or cutter is typically a hardened metal tool that is used to cut, shape, and remove material from a workpiece using machining tools as well as abrasive tools by way of shear deformation.

2.1 Cutting Action of Various Tools.

1. Chisel:

Chipping is an operation of removing excess metal with the help of a chisel and hammer.

It is a cutting tool used in fitting.

Made of good-grade tool steel with a hardened cutting edge and a beveled head at the opposite end.

It is used for:

- Cutting thin sheets.
- Removing the excess material from large surfaces.

Surface finish and accuracy obtained by chiseling are usually poor.

chisel has the following parts, Head, Body, and Point or cutting edge.

Chisels are made from high-carbon steel or chrome vanadium steel.

The cross-section of a chisel is usually hexagonal or octagonal.

The cutting edge is hardened and tempered.

Angles of chisels

Point angles and materials:

The correct point/Cutting angle of the chisel depends on the material to be chipped.

Sharp angles are given for soft materials and wide angles for hard materials.

The correct point angle and angle of inclination generate the correct rake and clearance angles.

Rake angle

Rake angle 'y' is the angle between the top face of the cutting point, and normal to the work surface at the cutting edge.

Clearance angle

Clearance angle 'a' is the angle between the bottom face of the point and tangent to the work surface originating at the cutting edge.

If the clearance angle is too low or zero, the rake angle increases.

The cutting edge cannot penetrate the work, the chisel will slip.

If the clearance angle is too great, the rake angle reduces. The cutting edge digs in, and the cut progressively increases.

2. Hacksaw

A hacksaw is a common tool used in fitting shops to cut metals.

It is also used to cut slots and contours.

A hacksaw consists of a metal frame fitted with a wooden handle.

Types of hacksaw frames

Solid frame: Only a particular standard length of the blade can be fitted to this frame.

The adjustable frame (Flat type): Different standard lengths of blades can be fitted to this frame.

The adjustable frame (Tubular type): It gives a better grip and control while sawing. For proper working, it is necessary to have frames of rigid construction.

Hacksaw blades

A hacksaw blade is a thin narrow steel band with teeth, and two pin holes at the ends. It is used along with a hacksaw frame.

The blade is made of either low alloy steel (LA) or high-speed steel (HS) and is available in standard lengths of 250 mm and 300 mm.

Types of hacksaw blades:

- Hard blades: These are hardened to the full width between the pinholes.
- Flexible blades: For these types of blades, only the teeth are hardened. Because of their flexibility, these blades are useful for cutting along curved lines.

Specification of Blades:

A. Material:

- Tool steel
- Low tungsten alloy steel
- High-speed steel

B. Types:

- Made of high-speed steel arrangement.
- Used for cutting harder metals such as alloy steels.
- Has a soft back and hard cutting edges.
- These flexible blades are less liable to break and are used for general work.

C. Length:

- The length of a hack saw blade is the distance between the holes.
- It varies from 250 mm to 300 mm.

D. Thickness: It is the thickness of the blade (Generally 0.65 mm).

E. Width: It is the width of the blade (Generally 12.5 mm).

F. Number of teeth per cm: Number of teeth on the blade in a unit length of 5 to 12.

G. Pitch: It is the distance between two teeth on the blade.

3. Dies

Used to cut external threads on cylindrical parts.

It is a circular disc of hardened tool steel having a threaded hole and flutes that form cutting edges.

Specifications of a die

It is specified by the nominal diameter and pitch of the thread to be cut.

The size is generally marked on the face of the die place.

Types of dies

- Circular split die
- Half die
- Adjustable two-plate die.
- Solid die.

Circular split die

This has a slot cut to permit slight variations in size.

When held in the die stock, variation in the size can be made by using the adjusting screws.

This permit increasing or decreasing the depth of the cut. O When the side screws are tightened the die will close slightly.

For adjusting the depth of the cut, the center screw is advanced and locked in the groove.

This type of die stock is called button pattern stock.

Half dies:

Half dies are stronger in construction.

Adjustments can be made easily to increase or decrease the depth of the cut.

These dies are available in matching pairs and should be used together.

By adjusting the screw of the die stock, the die pieces can be brought closer together or can be moved apart.

They need a special die-holder.

Adjustable two-plate die:

This is another type of a two-piece die similar to the half die.

This provides greater adjustment than the split die.

The two die halves are held securely in a collar by means of a threaded plate (guide plate) which also acts as a guide while threading.

The guide plate is tightened after placing the die pieces in the collar.

The die pieces are correctly located and rigidly held.

The die pieces can be adjusted, using the adjusting screws on the collar.

This type of die stock is called quick-cut stock. The bottom of the die halves is tapered to provide the lead for starting the thread.

On one side of each die head, the serial number is stamped.

Both pieces should have the same serial numbers.

Solid die (Die nuts):

The die nut is used for chasing or re-conditioning the damaged threads.

Die nuts are not to be used for cutting new threads.

Die nuts are available for different standards and sizes of threads.

The die nut is turned with a spanner.

Reamers:

A reamer is a multipoint cutting tool used for enlarging by finishing previously drilled holes to accurate sizes.

Advantages of 'reaming':

- High-quality surface finish.
- Dimensional accuracy to close limits.
- Small holes that cannot be finished by other processes can be finished.

Reamers are classified as:

Hand reamers: Reaming by using hand reamers is done manually for which great skill is needed.

Hand reamers have straight shanks with a 'square' at the end, for holding with tap wrenches.

Machine reamers: Machine reamers are fitted on spindles of machine tools and rotated for reaming.

Machine reamers are provided with morse taper shanks for holding on machine spindles.

2.3 TURNING TOOL GEOMETRY AND PURPOSE OF TOOL ANGLE

For cutting tools, geometry depends mainly on the properties of the tool material and the work material.

A cutting tool must possess a shape that is suited to the machining operation.

The size of the tool is generally square or rectangular in cross-section.

For single-point tools, the most important angles are the rake angles and clearance angles.

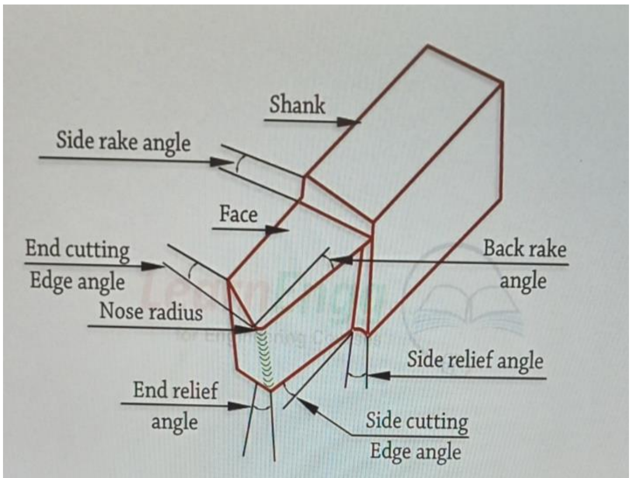


Fig 5: Cutting tool geometry

A. Rake:

- It is defined as the slope given to the tool.
- Rake angles are provided for the following functions,
- Allow chip flow in any direction.
- Provide keenness to the cutting edge.
- Reduce the required cutting force.
- Improve the surface finish.

i. Front rake:

- It is given on the front portion of the tool.
- When a tool removes metal from its cutting edge, it influences machining.

ii. Side rake: When a tool removes metal on its cutting edge, it influences machining.

iii. True rake:

- The resultant slope of the combined front and side rake is provided on the tool.
- The rake or slope of the face generally may be positive, zero, or negative rake.

iv. Positive rake:

- The face of the tool slopes away from the cutting edges and slants towards the back or side of the tool.
- Most tools have a positive rake angle.

v. Zero rakes: The face of the tool has no slope and is in the same plane as the upper surface of the shank.

B. Clearance or relief angle:

- The face of the tool slopes away from the cutting edges and slants upward towards the back or side of the tool.
- These are the slopes ground downwards from the cutting edges.

i. Front clearance angle:

- It prevents the front flank from rubbing against the work.
- Minimum clearance is needed to support the tool cutting edges. It should be increased for large-diameter work.

ii. Side clearance angle:

- It prevents the side of the tool from rubbing against the work when longitudinal feed is applied.
- It varies depending on the amount of feed and increases with an increase in feed.

iii. Nose radius:

- It is the junction of the side and ends cutting edges.
- A slightly curved profile is provided at this junction called nose radius.
- Nose angle is the angle between side cutting edge and the end cutting edge.

iv. Cutting edge angles:

There are two cutting edge angles namely the side cutting edge angle and the end cutting edge angle.

- Side cutting edge angle: It is the angle given on the side cutting edge between the edge and the axis of the tool.
- End cutting edge angle: It is the angle between the face and end surface of the tool.

Lip angle: It is also called the cutting angle. It is the angle between the face and end surface of the tool.

Principal Tool Angles:

Functions and influence of tool angles

Rake angles:

- Control the direction of chip flow.

- Reduce friction.
- Provide keenness to the tool.
- Prolong tool life.
- Decrease power consumption. Increase the surface finish.

Positive rake angles:

- General machining work.
- Small rake angles- hard metals.
- Larger rake angles-soft metals.

Zero rake angle: Relatively softer materials like brass.

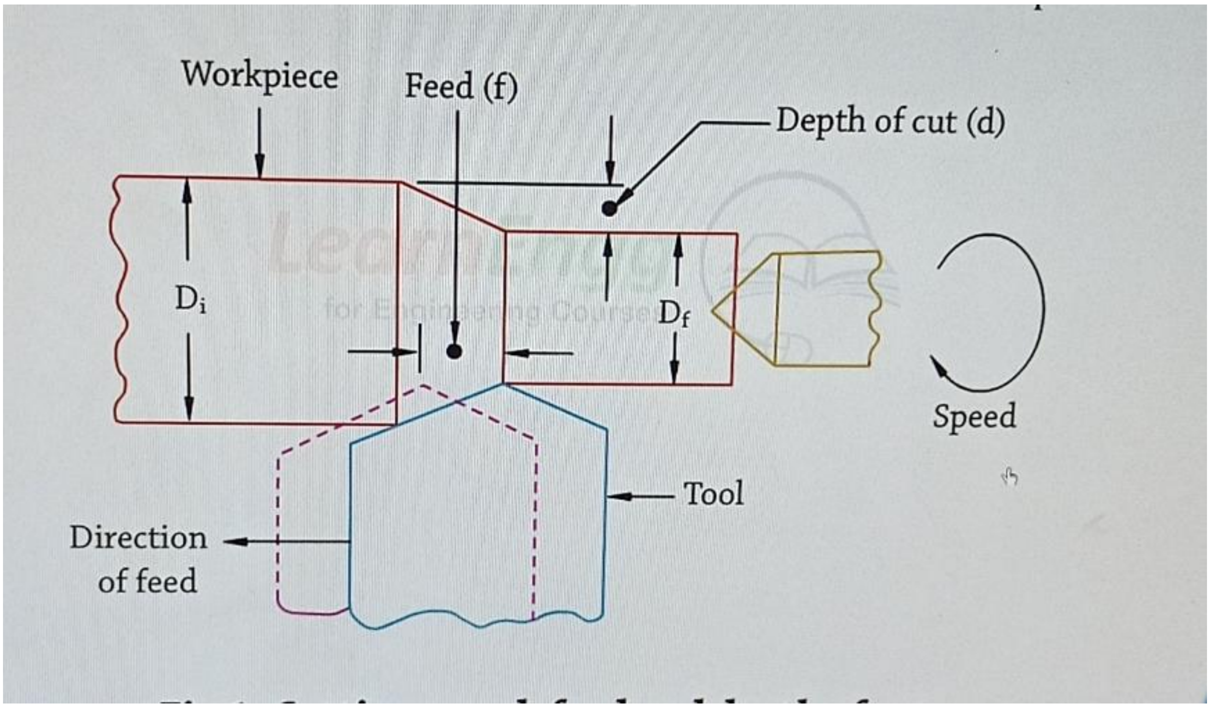
Negative rake angle:

- Provided carbide-tipped tools.
- Increases the strength of the cutting tool.
- Application of higher cutting speeds.

Clearance angles:

- Keeps the tool flanks clear of the work surface.
- Prevents rubbing between work and flank.
- Higher clearance
- Reduces the wear.
- Results in a clean cut.
- For low-strength metals.

2.4 MACHINING PROCESS PARAMETERS (SPEED, FEED AND DEPTH OF CUT)



A. Cutting speed (V):

It is the speed at which the metal is removed by the tool from the workpiece.

In a lathe, it is the peripheral speed of the work past the cutting tool expressed in meters/min.

Mathematically,

$$\text{Cutting Speed(V)} = \frac{\pi DN}{1000} m/min$$

Where,

V=Cutting/peripheral speed, m/min

D= Diameter of the job, mm

N= Job or spindle speed, r.p.m.

B. Feed (F):

The feed of a cutting tool in a lathe work is the distance the tool advances for each revolution of the work or headstock spindle.

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Feed is expressed in mm/revolution.

Feed (f) may be calculated as follows:

$$Feed(F)= \frac{L}{N*T_m}$$

Where,

L= Length of cut, mm.

Tm = Machining/cutting time, min

N = Job or spindle speed, r.p.m.

C. Depth of cut (d):

It is the perpendicular distance measured from the machined surface to the uncut surface of the workpiece.

For turning operations in a lathe, depth of cut is expressed as:

$$d = \frac{D_i - D_t}{2}$$

where,

D_i= Initial/original diameter of the workpiece, mm

D_t= Final diameter of the workpiece, mm.

Material Removal Rate (MRR):

It is the volume of material removed per unit time.

Volume of material removed is a function of speed, feed, and depth of cut. Higher the values of these properties, more is the material removal rate.

- Let, D_i Initial diameter of the workpiece, mm.
- d = Depth of cut, mm
- f=Feed, mm/revolution

Higher the values of these properties, more is the material removal rate.

Material removed per revolution is the volume of chip whose length is πDi and whose cross-sectional area is d x f.

Volume of material removed in one revolution = π Di x d x f mm^3

Since the job is making N r.p.m, the MRR in mm3/min is given by,

$$MRR = \pi \, Di \times d \times f \times N \text{ mm}^3/\text{min}$$

In terms of cutting speed V in m/min, MRR is given by,

$$MRR = 1000 \times V \times d \times f \text{ mm}^3/\text{min}$$

Machining time:

The machining time in lathe work can be calculated for a particular operation if the speed of the job, feed, length of the job is known.

Let,

"f" be the feed of the job per revolution expressed in mm/rev.

"L" be the length of the job in mm.

"N" be the speed of work in r.p.m

Machining time is given by,

$$T_m = \frac{L}{fN} \min per\ cut$$

Also, $$V = \frac{DN\pi}{1000} m/mm$$

Or, $$N = \frac{1000V}{D\pi}$$

Therefore, machining time is also expressed as,

$$Tm \text{ (per cut)} = \frac{L}{f*(\frac{1000V}{D\pi})} = \frac{D\pi L}{1000Vf}$$

Power estimation:

The power required at the spindle for turning depends on the cutting speed, depth of cut, feed rate, and the workpiece material hardness and machinability.

The power required depends on the cutting force which is a power function of "f" and "d".

Cutting force, F = K x d x f

Where,

K is a constant that depends on the work material

Power required, P=F x V

Combining the above two equations,

$$P = K \times d \times f \times V$$

Power, P= K x d x f x V

2.5 COOLANTS AND LUBRICANTS IN MACHINING AND PURPOSE

Coolant:

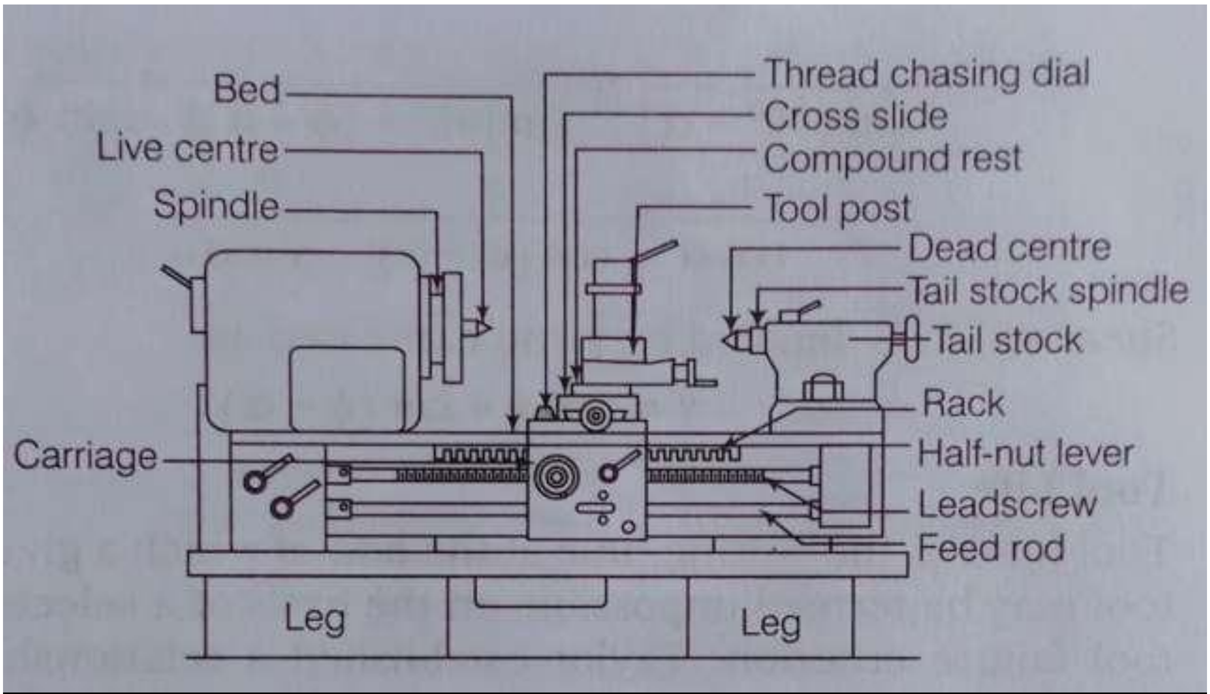
- The cutting fluid used to cool the tool and workpiece is called a coolant.
- Water-based coolants are most effective due to their high specific heat and thermal conductivity.
- Sometimes it is also called a cutting fluid.

Lubricant:

- The substance which is used to reduce the friction between two moving or sliding parts of the machine is known as a lubricant.
- Oil-based fluids are better lubricants, as they are stable at high temperatures.

Difference Between Coolant and Lubricant

Coolant	Lubricant
The basic purpose of coolant is to remove the cutting heat generated from the cutting zone, and thus to keep the cutting zone temperature low.	The basic purpose of the lubricant is to reduce the coefficient of friction between the cutter and the rake surface of the chip and thus reduce the rate of heat generation.
The coolant acts on the generated heat. It cannot reduce the rate of heat production.	Lubricants can reduce the rate of heat generation, with no effect on the removal of previously generated heat.
It reduces the heat produced by Cutting tools and work.	It reduces friction between moving parts.
Oxidation occurred due to the presence of water.	Oxidation does not occur in lubricants.



It Contains soluble oil with water.	It does not contain any soluble oil or water
It also helps in cutting.	It serves as protective films

3.0 LATHE MACHINE

A lathe is a machine tool that rotates a workpiece about an axis of rotation to perform various operations such as cutting, sanding, knurling, drilling, deformation, facing, and turning, with tools that are applied to the workpiece to create an object with symmetry about that axis.

3.1 Construction and working of lathe and CNC lathe:

The machine tool that is used to remove unwanted metals from the workpiece to give the desired shape and size is so-called the Lathe machine.

Functions of lathe Machine:

- The main function of the Lathe machine is to remove excess material in the form of chips by rotating the workpiece against a stationary cutting tool.

- This is accomplished by holding the work securely and rigidly on the machine and then turning it against the cutting tool which will remove metal from the work.
- To cut the material properly the tool should be harder than the material of the workpiece, should be rigidly held on the machine, and should be fed or progress in a definite way relative to the work.

Main Parts of lathe Machine:

1. Bed

- The Bed forms the base of a machine.
- It is mounted on the legs of the lathe machine, which are bolted to the floor.
- It is made up of cast iron and its top surface is machined accurately and precisely.

2. Head Stock

- Headstock is an important part of a lathe machine, which is mounted permanently on the inner guide – ways at the left-hand side of the bed.
- It consists of a main spindle, a chuck fitted at the spindle nose, a back gear drive, and a gear drive.

3. Main Spindle:

- A main spindle is a hollow cylindrical shaft.
- Its face has a standard morse taper.
- It is used for holding the live Centre or collet.
- The spindle rotates on two large bearings housed on the headstock casting.

4. Tail Stock:

- A tail stock is located on the inner guide – ways at the right side of the bed opposite to the headstock.
- The body of the tail stock is bored and houses the tail stock spindle.
- The spindle moves front and back inside the hole.
- It has a tapered hole to receive the dead Centre or chunk of tools such as a drill or reamer.
- Its body is made up of cast iron.

5. Lead Screw: It is used to transmit power to the carriage through gear and clutch arrangement in the carriage apron.

6. Live Center:

- A Live Center is mounting on bearings and rotates with the work.
- Live centers are used to hold or support a workpiece.

7. Dead Center:

- A dead center may be used to support the workpiece at either the fixed or rotating end of the machine.
- Dead centers are typically fully hardened to prevent damage to the important mating surfaces of the taper and to preserve the 60° angle of the nose.

8. Carriage:

- A carriage is located between the headstock and tailstock on the lathe bed guideways.
- It can be moved along the bed either towards or away from the headstock.
- It has several parts to support, move and control the cutting tool.

9. Tool Post:

- It is located on the top of the compound slide. It is used to hold the tools rigidly.
- Tools are selected according to the type of operation and mounted on the tool post and adjusted to a convenient working position.

10. Feed Mechanism: There are several mechanisms to make the carriage and cross slide move automatically to change the direction of their movement.

Working Principle of lathe machine:

A lathe is a machine tool which use to remove unwanted materials from a workpiece in the form of chips with the help of a tool that travels across the workpiece and can be fed deep into work.

When the tool is moved parallel to the workpiece then the cylindrical surface is formed.

If the tool is moved inclined to the axis then it produces a tapered surface which so calls taper turning.

It holds the work between two supports so call as centers.

Face plate or Chuck are using for holding the work.

Face plate or Chuck are mounted on the machine spindle.

The cutting tool is holding with the help of Tool post.

The movement of the job is rotating about the spindle axis.

Against the revolving work, the tool is feed.

The tool moves either parallel or inclination to the work axis.

Operations of Lathe Machine:

1. Turning:

Turning is the operation of reducing the diameter of a work piece to produce a cone -shaped or a cylindrical surface.

A simple single point cutting tools are use for turning operations.

Turning can be different types like

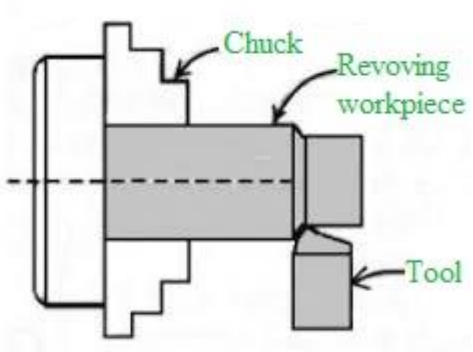
- Tapers and Taper Turning
- Straight turning
- Profiling
- External grooving, etc.

i. 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.
- In a lathe, taper turning means to produce a conical surface by a gradual reduction in diameter from a cylindrical workpiece.

ii. Straight turning: Straight turning produces a cylindrical surface by removing excess metal from the workpiece.

iii. Profiling: In profiling, the cut can vary with regard to cutting depth, feed, and speed.



Turning operation

iv. External grooving: In external turning operations machines the outer diameter of the workpiece.

2. Facing:

- Facing is an operation of reducing the length of a workpiece to produce a flat surface square with the axis.
- A regular turning tool may also be used for facing a large workpiece.

3. Drilling: Drilling is an operation of producing a cylindrical hole in a workpiece by the rotating cutting edge of a cutter known as the drill.

4. Boring:

- Boring is the operation of enlarging a hole or cylindrical cavity to produce circular internal grooves.
- Holes may be bore straight and tapered.

5. Reaming:

- Reaming is the operation of finishing and sizing a hole which has been previously drilled or bored.
- The tool used so call the reamer, which has multiple cutting edges.

6. Knurling:

- Knurling is the process of embossing a diamond-shaped pattern on the surface of a workpiece.
- The purpose of knurling is to provide an effective gripping surface on a workpiece to prevent it from slipping when operated by hand.

7. Parting:

- Parting is the operation of cutting a workpiece after it has been machined to the desired size and shape.
- This process involves rotating the workpiece on a chuck or face plate at half the speed that of turning and feeding by a narrow parting–off tool perpendicular to the axis by rotating the cross-slide screw by hand.

8. Threading:

- Threading is an operation to produce a helical groove on a cylindrical or conical surface by feeding the tool longitudinally when the job is revolved between centers or by a chuck.

- Threads can be produced either on internal or external surface of a cylindrical bar.

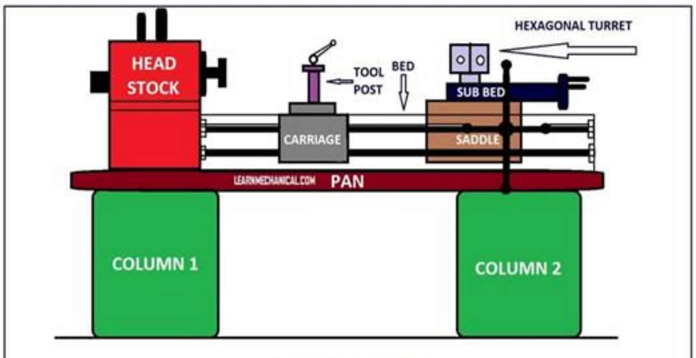
9. Grooving:

- Grooving is the process of reducing the diameter of a work piece over a very narrow surface.
- It is often done at the end of a thread or adjacent to a shoulder to leave a small margin.

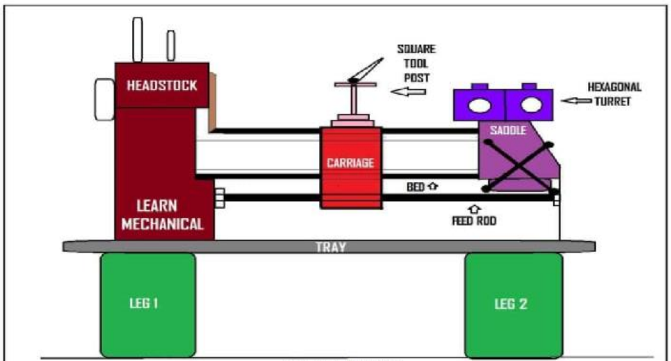
Safety measures during machining

- Correct dress is important, remove rings and watches, and roll the sleeves above the elbows.
- Always stop the lathe before making adjustments.
- Do not change spindle speeds until the lathe comes to a complete stop.
- Always wear protective eye protection.
- Never lay tools directly on the lathe ways. If a separate table is not available, use a wide board with a cleat on each side to lay on the ways.

CAPSTAN LATHE AND TURRET LATHE



CAPSTAN LATHE



TURRET LATHE

Capstan Lathe	Turret Lathe
It is a light-duty machine.	It is a heavy-duty machine.
The turret head is mounted on the ram and the ram is mounted on the saddle.	The turret head is directly mounted on the saddle and the saddle slides over the bed ways.
The lengthwise movement of the turret is less.	The lengthwise movement of the turret is more.

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Short workpieces only can be machined.	Long workpieces can be machined.
It is easy to move the turret head as it slides over the ram.	It is difficult to move the turret head along with the saddle.
It is used for machining workpieces up to 60mm diameter.	It is used for machining workpieces up to 200mm diameter

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4.0 SHAPER MACHINE

Shaper Machine is a production machine in which the single point cutting tools are attached and the workpiece is fixed moving forward the tool cuts the workpiece and in return, there is no cut on the workpiece and used for producing flat and angular surfaces.

4.1 Application of Shaper Machine:

- A shaper Machine is used to make Internal splines.
- It generates straight and flat surfaces either horizontal, vertical, or angular planes.
- It also makes gear teeth.
- Make keyways in pulleys or gears.
- It also Produces contour of concave/convex or a combination of these

4.2 Shaper Machine Parts:

Base:

- The base is the most important part of the shaper because it holds all the loads of the machine.
- It is made up of cast iron.
- It absorbs vibration and other forces that occur while performing shaping operations.

Column:

- The column is mounted on the base. It is also made up of cast iron.
- The column supports the ram that is moving forward and backward for operation.
- It also acts for covering the drive mechanism.

Table:

- It is mounted on the saddle. It is also one of the important parts of the machine.
- The table can be moved crosswise by rotating the crossfeed rod and also vertically by rotating the elevating screw.
- It is a box-like casting with an accurately machined side and top surfaces.

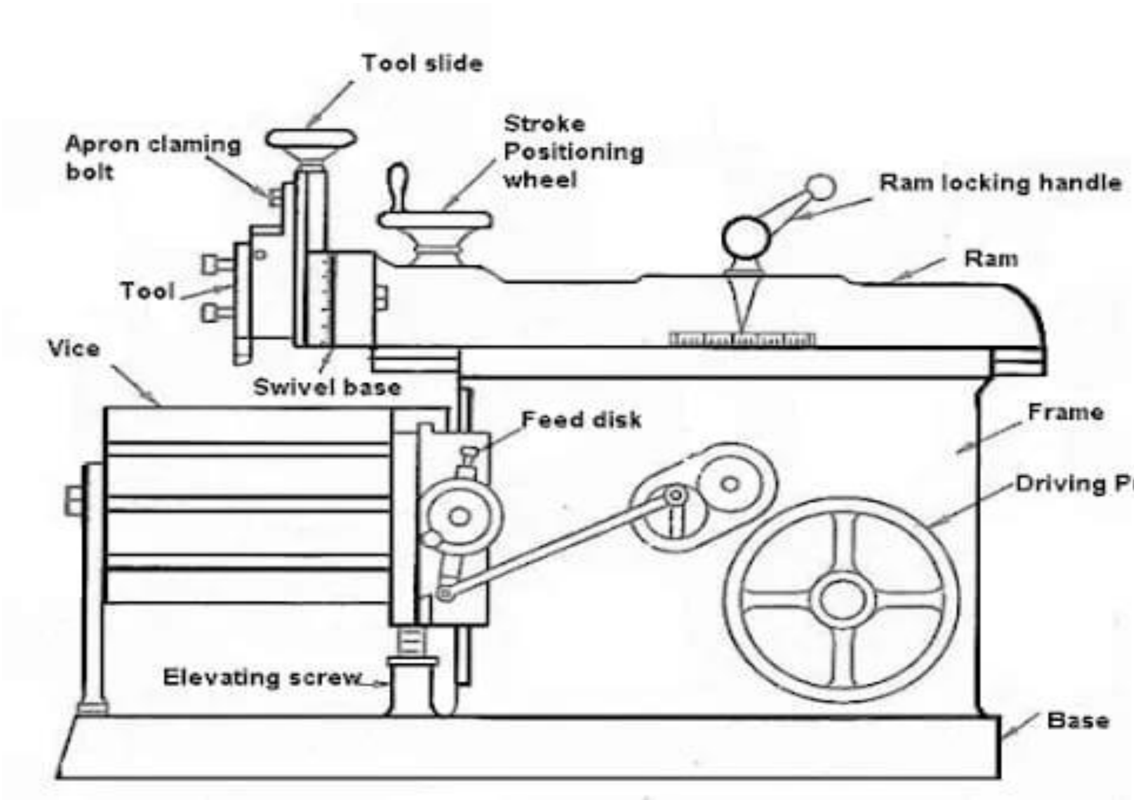
Cross rail:

- It is also mounted on the column on which the saddle is mounted.

- The vertical movement and Horizontal movement are given to the table by raising or lowering the cross rail using the elevating screw and by moving the saddle using the cross-feed screw.

Ram:

- The Ram reciprocates and it carries the tool head to which the single-point cutting tool is attached.



- The tool head is in the clapper box, which causes cutting action only in a forward stroke of the ram. The feed or depth of cut of the tool is given by down the feed screw.

4.4 Working Principle of the Shaper Machine:

In the Shaper machine, a single-point cutting tool is rigidly mounted on the tool holder, which is mounted on the ram.

The workpiece is held rigidly in a vice (or clamped directly on the table).

The ram reciprocates and thus cutting tool held in the tool holder moves backward and forward on the workpiece.

In a standard shaper, cutting takes place during the forward stroke of the ram and the backward stroke remains idle.

The forward and backward motion is obtained by the "Quick Return Mechanism".

The depth of the cut is adjusted by moving the tool downwards towards the workpiece.

Shaper Machine Operation:

Generally, there are Four types of Operations performed on Shaper that are:

- Vertical Cutting Operation
- Horizontal Cutting Operation
- Inclined Cutting and
- Angular or Irregular Cutting Operation

4.5 The Quick Return Mechanism

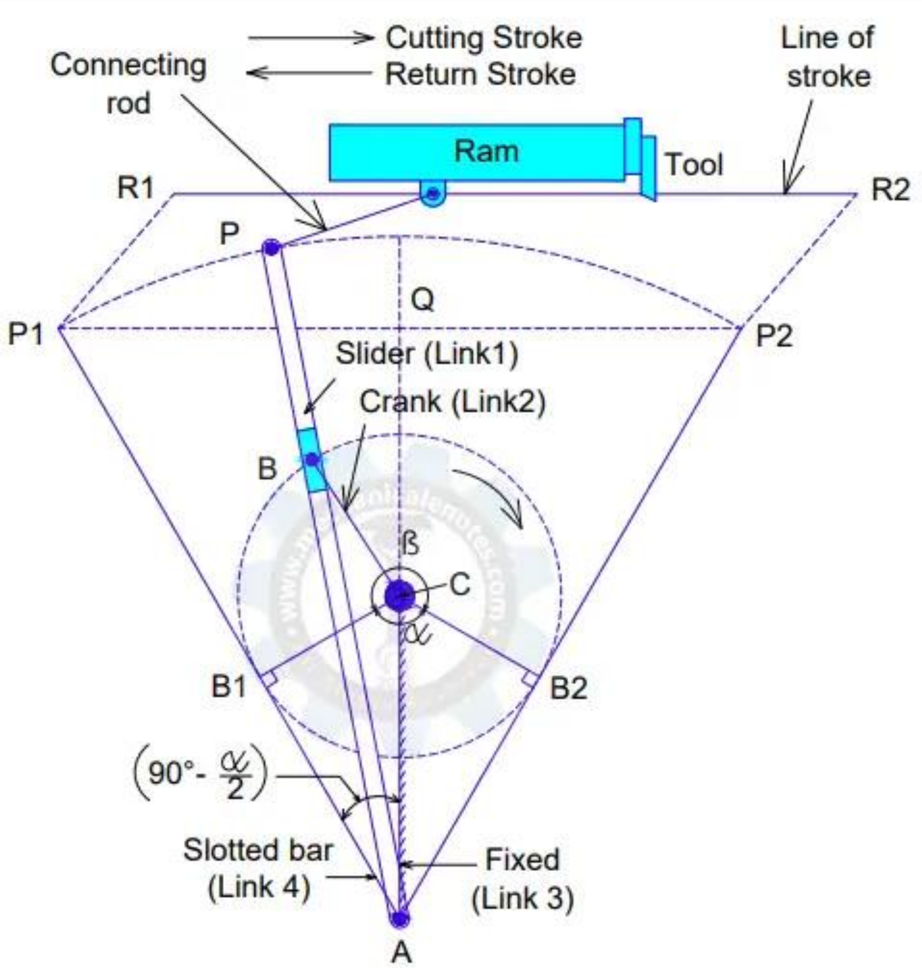
It consists of 3 turning pairs and one sliding pair.

In this mechanism, the link AC is fixed and forms a turning pair with a crank and slotted lever.

The driving crank CB revolves with respect to the fixed center C with a uniform angular speed.

A sliding block B is attached at point B and slides on the slotted lever AP. A connecting rod is pivoted at the end of the AP and the Ram.

The ram carries a single-point cutting tool that moves forward and backward on the line of stroke R1R2 and the AC is perpendicular to the line of stroke.



A sliding block B is attached at point B and slides on the slotted lever AP. A connecting rod is pivoted at the end of the AP and the Ram.

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The ram carries a single-point cutting tool that moves forward and backward on the line of stroke R1R2 and the AC is perpendicular to the line of stroke.

In the case of the Shaper Machine, the Workpiece is fixed in the machine vice and the Tool is under the Reciprocating motion of the ram and the material removal takes place from the surface of the workpiece in the form of layers.

4.6 Shaper Machine Specification:

- Weight of the Machine.
- Floor space required.
- Maximum stroke of Ram
- Drive types (Hydraulic, Gear, and Crank type)
- Input Power
- Cutting to Return Stroke ratio
- Angular Movement of the table and
- Feed

Advantages of Shaper Machine:

- The tool (Single Point cutting tool) cost is low.
- The workpiece can be held easily in this machine.
- It produces flat or angular surfaces.
- Setup of Shaper is very easy and tool changing is also easy.

Disadvantages of Shaper Machine:

- The cutting speed is not much high.
- Only one cutting tool can be fixed. There is no option for more than one cutting tool.

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5.0 PLANNING MACHINE

A planer machine is a type of metalworking machine that uses linear relative motion (reciprocation) between the workpiece and a single-point cutting tool to cut the workpiece.

5.1 Application Area of a Planer and Its Difference With Respect To a Shaper

Applications of Planer machine

- Cutting slots and grooves
- Generating accurate flat and curved surfaces
- Cutting at an angle and machining dovetails

Difference Between Shaper and Planer

Shaper machine	Planer machine
It is a comparatively light-duty machine.	It is a heavy-duty machine.
It requires less floor area.	It requires more floor area.
Cutting takes place by moving the cutting tool over the job.	Cutting takes place by reciprocating the work under the tool.
Used for machining relatively small surfaces.	Used, for, machining large flat surfaces.
Light, small, and has less cost.	Heavier, large, and costlier.

5.2 Major Components and Their Functions:

i. Bed:

A bed is a box-like casting that supports all the moving parts of the column and the machine.

The bed is made slightly larger than twice the length of the table.

On its entire top surface, precision guideways are made on which the table slides.

ii. Table

A table is the parts of the planer machine which is made of good quality cast iron, it holds to the work and reciprocates on the guideways of the bed. The 'T' slots are made over the entire length of the table so that the bolt gates can be fitted to hold the work or means of work on them.

iii. Housing or column

Housing is a strong vertical structure like a box that is applied on each side of the bed.

Precision guideways are made on the front face of each housing on which the cross-rail can move up and down.

iv. Overarm Support

It is part of a planer machine that is used to support both side columns or housing.

v. Cross Rail

Cross rail is a box-like casting that connects two housings.

The cross rail can be moved up and down and clamped to any fixed position.

Types Of Planer Machines:

- Double Housing Planner Machine
- Open Side Planer Machine
- Pit Planer Machine
- Edge or Plate Planer Machine
- Divided Table Planer Machine

Operation Can Be Performed on Planer Machine

- Planing Flat horizontal surfaces
- Flat vertical surfaces
- Planking angular surfaces and machining dovetails
- Curved surfaces
- Planing slots and grooves.

5.3 The Table Drive Mechanism:

The table of the planer is made level with the floor, so that very heavy work can be loaded very easily.

The cross rail carries two tool heads, and these can be moved horizontally and vertically to give the cut.

The driving screw is used for driving the column by means of a motor.

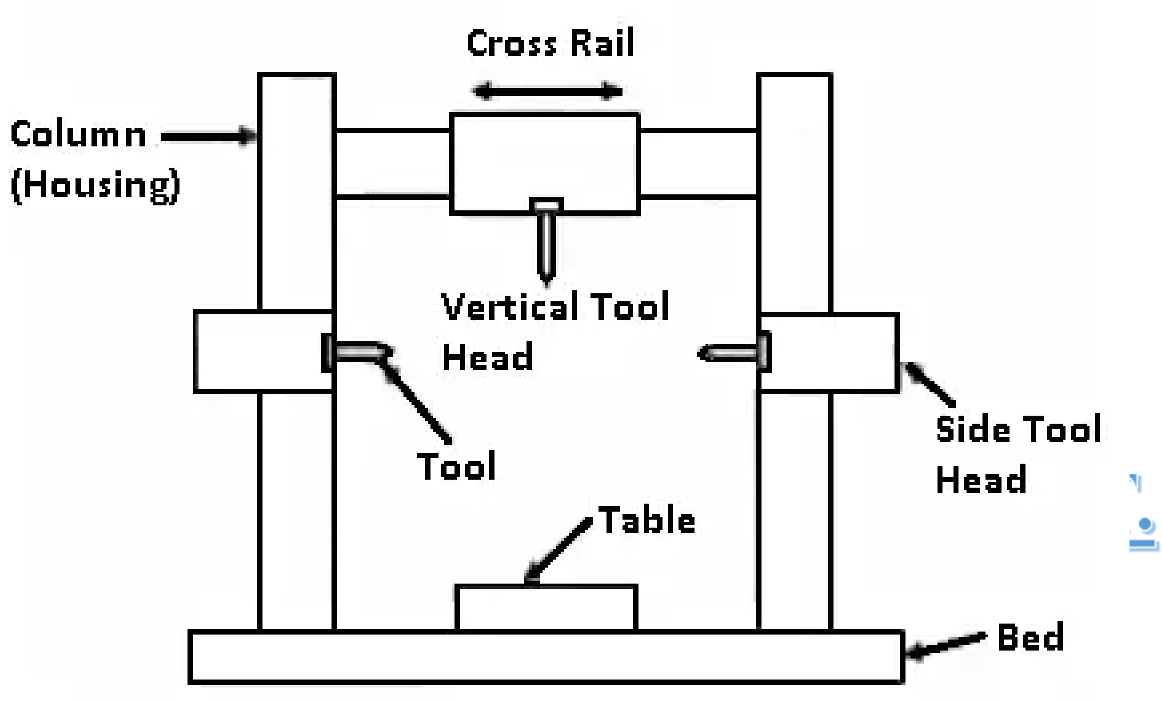
5.4 Working Principle of Planer Machine:

In a Planer Machine**,** the job is fixed rigidly on the machine table. A **single-point** cutting tool held properly in the tool post mounted on the reciprocating ram.

The reciprocating motion of the ram is obtained by a quick return motion mechanism.

As the ram reciprocates, the tool cuts the material during its forward stroke. In return stroke, there is no cutting action and this stroke is called the idle stroke.

5.5 Clamping of Work Through Sketch:



PLANER MACHINE

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6.0 MILLING MACHINE

The milling machine is a type of machine that removes the material from the workpiece by feeding the work past a rotating multipoint cutter**.**

The metal removal rate is higher very high as the cutter has a high speed and many cutting edges.

It is the most important machine in the tool room as nearly all the operations can be performed on it with high accuracy.

MRR (Material Removal Rate) can be further increased by increasing the number of teeth on the cutter.

6.1 Types of Milling Machines and Operations Performed By Them And Also Same For CNC Milling Machines:

TYPES OF MILLING MACHINES:

i. Column Milling Machines:
Often used for creating car parts, a column milling machine is one of the simplest types of milling machine. They consist of 5 key parts the worktable, head, saddle, knee, and over an arm, and use a vertically suspended drill.

ii. Turret Milling Machines:
A turret machine is a versatile milling machine that can be used in the creation of many parts. Also, known as a Bridgeport-type milling machine, these machines can be repositioned opening a broader range of uses.

C-Frame Milling Machines
C-frame milling machines are sturdy and powerful. They use a hydraulic motor and are best utilized in industrial settings.

iii. Horizontal Milling Machines:
Named as it is positioned horizontally to the ground, horizontal milling machines work by moving the bench the workpiece is placed sideways whilst the cutting tool moves vertically.

iv. Tracer-Controlled Milling Machines:
Designed to produce duplicate parts based on a master model, tracer-controlled milling machines can be used for machining grooves and contoured surfaces.

v. Bed Type Milling Machines:

The worktable of a bed type milling machine is placed on the bed itself, as opposed to on top as with other milling machines. On a bed-type machine, the knee is omitted to allow for longitudinal movement.

vi. Planer-Style Milling Machines:

A planer-style milling machine is similar to a bed-type machine. However, this type of milling machine offers more milling capabilities due to the addition of cutters and heads.

vii. Gantry Milling Machines:

Gantry milling machines are essential for precision engineering, creating molds, dies, models, and styling machining. These machines can often be found in the Aerospace and Power Generation industries.

vii. Travelling Column Machines:

Traveling column milling machines are capable of handling larger parts and multitasking. With elements that move, pivot, and tilt, traveling column machines are often used in the automotive, aerospace, defense, energy, and oil industries.

MILLING MACHINE OPERATIONS:

1. Plain Milling or Slab Milling Operation:

Plain or slab milling is a process in which plain, horizontal, or flat surfaces are produced, which are parallel to the axis of the rotation of the cutter. A peripheral mill cutter is used for performing the slab milling operation.

2. Up Milling and Down Milling:

Up milling is a method of milling operation in which the cutter and the workpiece both move in the opposite direction.

Down Milling is a method of milling operation in which the direction of the rotation of the cutter coincides with the direction of the work feed.

3. Face Milling Operation:

It is a type of milling operation in which the layer of material is removed from the face of the material. The end milling cutter is preferred for performing face milling operations.

In a Face Milling operation, the teeth for cutting are present on both the periphery and the face of the cutter.

The axis of rotation of the cutter is perpendicular to the work surface. In face milling most of the cutting is done by the periphery portions of the teeth, the face portion provides finishing the action.

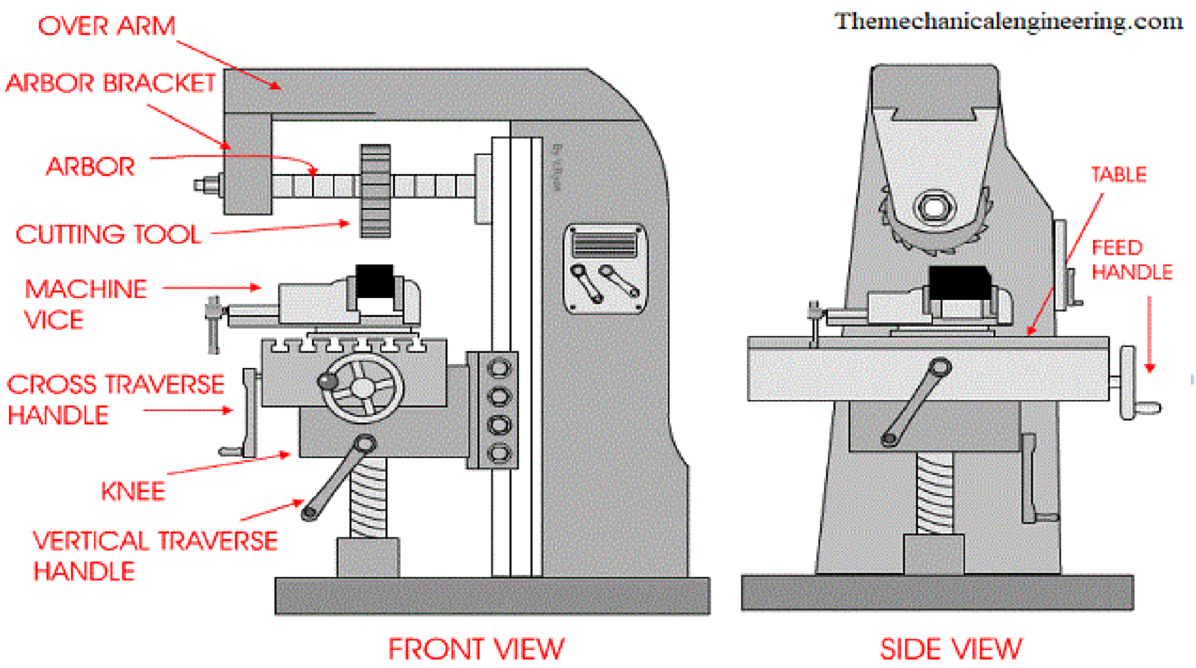
4. End Milling Operation:

This type of operation is the combination of the slab milling and face-milling operation used for creating slots in the workpiece and is mostly used for handling the complicated profile.

5. Straddle Milling Operation:

The straddle is the type of milling process in which milling is performed on two surfaces simultaneously. T-slot milling is a unique example of straddle Milling.

6.2 Explain Work Holding Attachment:



1. Base:

The base is the part upon which the whole machine parts are being mounted.
It is a type of foundation for the machine.
The base is mostly made up of cast iron, so it has good strength and rigidity. It also helps in the absorption of shocks. Cutting fluid can also be stored in the base.

2. Column:

The main supporting frame which consists of all the driving mechanisms and the motor is called the column.

The driving mechanism usually consists of a cone pulley mechanism in which the v-belt is being used to connect it to the motor.

3. Knee:

The knee shape is quite similar to that of the human body knee.

This is an important part of this machine that supports the other parts like the saddle and table.

It is attached to the column and has guideways by which it can move up and down with the help of the elevating screw for adjusting its height.

4. Saddle:

The saddle is present on the top of the knee which further carries the table.

Its basic function is to support the table.

A saddle can slide on the guideways which are exactly 90 degrees to the column face.

The saddle moves crosswise (in or out) on guideways provided on the knee.

5. Table:

The table is present on the top of the saddle.

The table consists of T-slots or sometimes fixtures are used for holding up the workpiece on the table. A table can travel longitudinally in a horizontal plane.

6. Over-arm:

It is also called the overhanging arm.

Overarm is present at the top of the column. The basic function of the over-arm is to support the arbor and spindle.

7. Spindle or Arbor:

The top portion of the column contains the spindle.

The spindle is also an important part of the machine as it is the part where the multipoint cutter is attached.

Power required for the rotation of the spindle is obtained from the motor through the belt, gear, and clutch assembly.

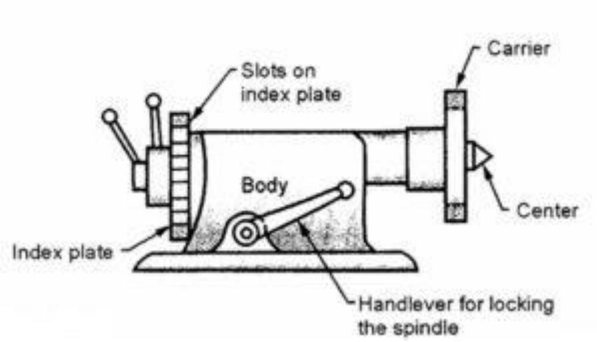
6.3 Construction & Working of Simple Dividing Head, Universal Dividing Head:

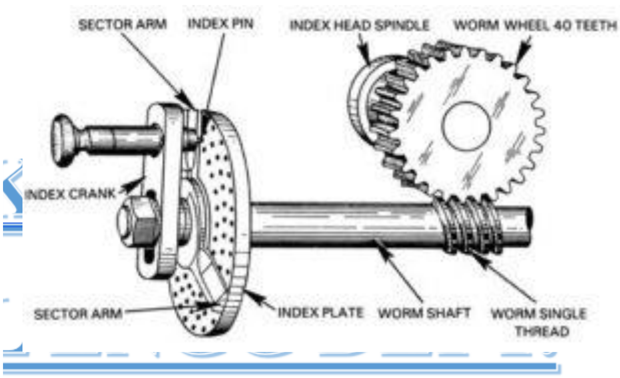
The dividing head is also known as the indexing head.

Indexing is the process of evenly dividing the circumference of a circular workpiece into equally spaced divisions, such as in cutting splines, cutting gear teeth, milling grooves in taps and reamers, and spacing holes on a circle.

Plain Dividing Head:
Plain dividing head is the simplest of all types of dividing heads. Plain dividing head is classified into two types.

First type Plain Dividing Head:





- The first type carries an indexing plate directly mounted on its spindle and there is no use of worm and worm wheel.
- The index plate carries 12-24 equispaced slots on its periphery.
- The workpiece is held between two centers i.e., one on the dividing head spindle and the other on the tailstock.
- For locking the spindle in its position hand lever is used.
- The plate, together with the spindle can be rotated by means of hand i.e. provided on the left-hand side of the dividing head.

Second Type Plain Dividing Head:
- The second type of plain dividing head uses a worm and worm wheel mechanism.
- In this indexing, the plate movement is obtained by the worm which is rotated by hand.
- Plain dividing head is commonly used in operations where average accuracy is required such as fluting taps, reamers, milling rectangles, squares, hexagons, etc.

Universal Dividing Head:
- Universal Dividing Head/Indexing Head consists of a robust body and a worm drive is enclosed in it.
- It is having a worm and worm wheel.
- This worm carries a crank at its outer end.

- The index pin works inside the spring-loaded plunger, which can slide radially along a slot provided in the crank.
- This plunger can slide, adjust the pin position along a desired hole circle on the index plate.
- The index plate is mounted on the same spindle as the crank, but on a sleeve, hence the crank and worm spindle can move independently on the index plate.
- To set a definite distance along the desired hole circle, sector arms are used. Sector arms are of a detachable type and can be set at the desired angles with one another. The index plates are available in a set of two or three, with a number of hole circles generally on both sides.

6.4 Procedure of Simple and Compound Indexing:

Simple or Plain Indexing:

- In this case, different index plates with varying number of holes are used to increase the range of indexing.
- The index is fixed in position by a pin called lockpin.
- The spindle is then rotated by rotating the handle which is keyed to the worm-shaft.

The following relation is used for simple indexing:

$$T = 40/N$$

where T gives the number of turns or parts of a turn through which the index crank must be rotated to obtain the required number of divisions (N) on the job periphery.

Question: A gear blank on which 24 teeth are to be cut by using the Simple or Plain indexing method.

Given, N = 24

$$T = \frac{40}{24} = 1.66 = 1\frac{2}{3}$$

i.e., the worm is to be rotated by the handle through one complete rotation and two-third of the number of holes of any circle.

Compound Indexing:

The principle of operation of compound indexing is the same as that of simple indexing, but the only difference is that compound indexing uses two different circles of one plate and hence also sometimes referred to as hit and trial method.

The principle of compound indexing is to obtain the required division in two stages:

- By rotating the crank or handle in usual way keeping the index plate fixed.
- By releasing the back pin and then rotating the index plate with the handle.

6.5 Illustration of Different Indexing Methods:

1. Direct Indexing:

In this case, the dividing head has an index plate, fitted directly on the spindle.

The intermediate use of worm and worm-wheel is avoided.

The index plate has 24 holes and the periphery of job can be divided into 2, 3, 4, 6, 8 and 12 equal parts directly.

This type indexing is most used for indexing fixture.

2. Simple or Plain Indexing:

In this case, different index plates with varying number of holes are used to increase the range of indexing.

The index is fixed in position by a pin called lockpin.

The spindle is then rotated by rotating the handle which is keyed to the worm-shaft

3. Compound Indexing:

The principle of operation of compound indexing is the same as that of simple indexing, but the only difference is that compound indexing uses two different circles of one plate and hence also sometimes referred to as hit and trial method.

4. Differential Indexing:

Available number of index plates with different hole circles, sometimes confine the range of plain indexing.

In such cases, differential indexing is found to be more suitable.

Between the indexing plate and spindle of dividing head, a certain set of the gears is incorporated extra.

Dividing heads are provided with a standard set of gears.

5. Angular Indexing:

Instead of rotating the job through a certain division on its periphery, sometimes it may be needed to rotate the job through a certain angle.

Angular indexing is used for this purpose. Since the crank and spindle ratio is 40: 1 and hence when the crank moves through one revolution, the spindle or the job moves through 1/40 of the revolution, i.e., the job will revolve through an angular movement of 9°.

7.0 SLOTTER

A slotter machine is a machine tool in which material is removed for producing desired shapes.

It is used for producing Machining cylindrical surfaces and flat surfaces.

7.1 Major components and their function:

Base or Bed:
It is a rigid cast iron casting built to take up all the cutting forces and the entire load of the machine.

The top surface of the bed is accurately machined to provide guideways on which the saddle is mounted and slides. These guideways are perpendicular to the column face.

Column:
It is a vertical member and cast integral with the base. Column houses the ram driving and feeding mechanisms.

Accurately machined guideways are provided on the front face of the column on which the ram is made to reciprocate.

Saddle:
The saddle is box-like casting mounted over the guideways on the bed surfaces and it moves toward or away from the column and either by hand or power control to give the longitudinal feed to the work.

The top surface of the saddle is provided with accurately machined guideways perpendicular to the guideways on the bed for moving the cross-slide.

Cross-slide:
It is mounted over the saddle guideways and made to move parallel to the column face. The movement of the slide may be controlled either by the power to give the cross feed.

Rotating or Rotary table:
The slotter is provided with a circular table mounted on the top of the cross slide. It can be rotated by rotating the worm which meshes with a worm gear connected at the underside of the table.

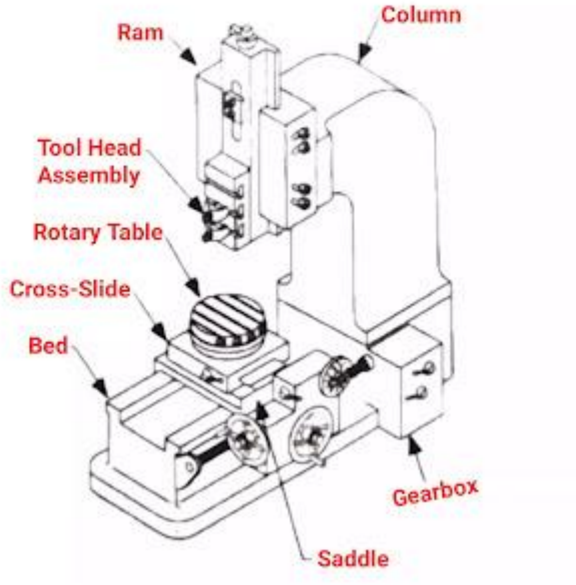
The table may be graduated in degree for indexing or dividing the periphery of the jobs.

T-slots are cut on its top surface for holding the work by clamping devices. The rotation of the table may be affected either by hand or power

Ram and Tool head assemble:

The ram is mounted on the guideways of the column and reciprocates by holding the tool at the bottom end of the tool head.

7.2 Construction and Working of Slotter Machine:



The working of the slotter machine is very similar to the shaper machine. Their major difference is that shaper machines work horizontally whereas slotter machines work vertically.

The ram is connected to the crank and the crank is connected to the gears.

This allows the increase or decrease of the gear speed and takes effect on the rotation of the crank speed.

It also allows the ram to move up and down.

The workpiece is attached to the workable and the ram will be manually taken to the workpiece.

The worktable is designed to be adjusted and has the workpiece clamp on it. the crank rotates as soon as power is supplied to the machine and the crank is connected to the ram which moves up and down.

During the up and down movement of the ram, the cutting stroke occurs in the upstroke and there is no cut in the return stroke.

7.3 Application of Slotter Machine:

- It is used for cutting keyways,
- Grooves and slots of various shapes,

- For making regular and irregular surfaces both external and internal,
- Cutting internal and external gears,
- For holding large, awkward jobs.

8.1 Significance of grinding operations

A grinder is commonly used to precisely shape and finish the given materials with low surface roughness and high surface quality. A grinding machine is a type of machine used to grind workpieces. It basically uses emery or an abrasive wheel as the cutting tool.

The grinding process is truly a chip-producing machining process. The rough surface of the abrasive wheel spreads into small portions of the workpiece as required. It is also known as a grinder.

The grinding process is capable of producing very accurate sizes, equally accurate geometry like flatness or circles, and an extremely good surface finish. It is capable of machining hard, high-speed steel, which cannot be done by other machining processes.

Abrasive wheels are an impure form of aluminum oxide. A grinding wheel or bonded abrasive is made up of thousands of tiny abrasive particles inserted in a matric called as 'bond'.

In bonded abrasives, porosity is essential to provide clearance for the chips being produced and to provide cooling. Otherwise, chips would interfere with the grinding process.

Parts of Grinding Machine

Base or Bed

The horizontally positioned grinding machine bed, which is the machine's bottom, supports all of the grinding components. Starting up a machine causes some vibration, so the base acts as a vibration absorber.

Column

The abrasive wheel, wheel head, and wheel guard are kept in the column, which resembles a vertical pillar of the machine.

Worktable

The workpiece is mounted on a flat surface called a worktable and is used for grinding. The workpiece is held by a worktable, which functions like a magnetic chuck.

Wheel Head

The component of the machine that houses the worktable and grinding wheel spindle is called the wheel head. We can change the wheel head by using a feed hand. In order for the grinding wheel to make contact with the workpiece, lower this wheel head.

Grinding or Abrasive Wheel

The rotating component of the machine that grinds the workpiece is called the grinding wheel. The wheel is constructed from abrasive grains that have been bonded together.

Cross-feed Handwheel

To make a cut, the grinding wheel is moved across the workpiece by the cross-feed handwheel. Crossfade moves the wheel head up and down or left and right. It is another crucial component of this machine.

Coolant System

During grinding, the coolant system helps in keeping the workpiece and grinding wheel cool. Additionally, it facilitates clearing away chips and debris.

Working Principle of Grinding Machine

A grinding machine operates by feeding the workpiece against a rotating abrasive wheel. The material is removed because of the rubbing or friction that occurs between the workpiece and the tool.

1. It would be best if you began by cleaning the machine with a fresh brush.
2. Workpieces are attached to the worktables, and tools are attached to the tool holders at the bottom of the worktables. The grinding wheel is attached to the tool holders as well.
3. We now adjust the tool and workpiece with the help of the traversing wheel, bring them into contact, and check that there is only a small gap since the machine has not yet started.
4. To ensure that the coolant supply nozzle works as intended, you should make sure to place the tool between the workpiece and the tool and fill the nozzle with liquid so that when the operation begins, the liquid can be supplied automatically or manually as needed.
5. The power is now being supplied to the system.

6. Upon starting the wheel, the tool is brought into contact with the workpiece by the rotation of the wheel. You need to gradually increase the amount of feed as you get closer to your desired dimension.

8.2 Manufacturing of Grinding Wheels:

Commonly grinding wheels are made of aluminum oxide, silicon carbide, cubic boron nitride, and diamond.

A grinding wheel consists of a composite material**.**

These coarse particles press and then bond together by the cementing matrix called a bond.

This results in the formation of the sold circular shape of various types of grinding wheels**.**

Depending on the usage of the wheel, there are various profiles and cross sections of the precision grinding wheel available.

Nowadays there are various types of materials used for making grinding wheels. This depends on the usage of the grinding wheel.

These are generally constructed out of solid steel and aluminum steel. The particle bonds with the help of natural composite stones like millstones.

8.3 Criteria for selecting grinding wheels:

It means choosing the most appropriate wheel for a particular grinding machine operation. Wheel selection would depend on what abrasive is required, and characteristics of the wheels, and also on operating conditions like a wheel and work speed, type, and conditions of machines used.

The thumb rule is to use a hard wheel for soft material and a soft wheel for hard material. A hard wheel retains the abrasives as they do not get dulled easily on soft materials.

Bond and Types of Bonds

Bond refers to the substance of which the matrix of the grinding wheel is made. The following bonds are generally used in the manufacture of grinding wheels. The bond hardness or grade is usually represented by the letters of the English alphabet.

A represents the very soft grade, while Z is very hard M and N represent medium grade hardness.

1. Vitrified Bond

2. Silicated Bond
3. Shellac Bond
4. Rubber Bond
5. Resinoid Bond

1. Vitrified Bond

- It is denoted by letter V.
- About 80% of the wheels used in the industry are of this bond.
- It is also called as ceramic bond.
- They are strong, stiff, porous, and resistant to oils, acids, and water. They are brittle and lack resistance to mechanical and thermal shock.

2. Silicate Bond

- It is denoted by letter S.
- Silicate of soda (commonly known as water glass) is the main component of this bond.

3. Shellac Bond

- It is denoted by the letter E.
- Shellac (a naturally available material) is the main component of the bond.

4. Rubber Bond

- It is denoted by the letter R.
- This process involves mixing crude rubber, sulfur, and abrasive grains, rolling them into sheets, cutting out circles, and heating them under pressure to vulcanize the rubber.
- The wheels can be made like this and used as saws for cutting-off operations.

5. Resinoid Bond

- It is denoted by the letter B.
- Resoniod bonding materials are thermosetting resins, and the bond is an organic compound, so the wheels with resinoid bonds are also called as organic wheels.
- Some of these wheels are made from bakelite and other resinous material.

8.4 Selection of Abrasives in Grinding

- Emery and corundum are no longer used in modern grinding wheels.

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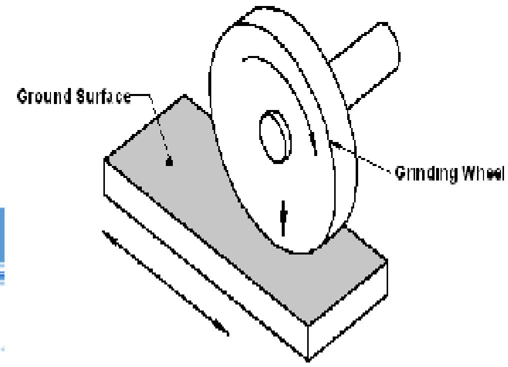
- Instead, artificially manufactured abrasives are used due to their high purity. And they include silicon carbide and aluminum oxide.

1 Silicon carbide

- Silicon carbide is greenish-black in color.
- It is harder and more brittle than alumina. For this reason, it is used for grinding materials of low grinding resistance, like cast iron, brass, and copper.
- The code for silicon carbide is C.

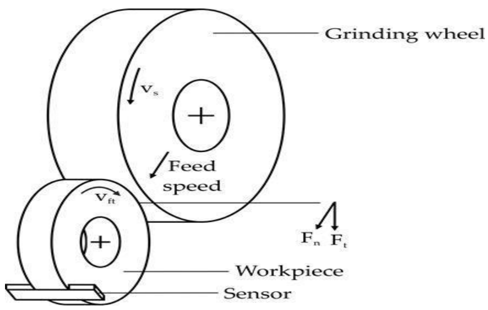
2 Aluminium oxide

- It is reddish-brown in color.
- Aluminum oxide abrasive is more suitable for grinding most steels because of its greater toughness to cope with the increased grinding resistance offered.
- Aluminum oxide wheels it is A.



i. Cylindrical Grinder:

The rotating cylindrical workpiece reciprocates laterally along its axis in a grinder used for the large and long workpieces. The grinding wheel reciprocate called roll grinder cylindrical grinders are identified by the maximum diameter and length of the workpiece that can be ground like engine lathes.



In universal grinders, both the workpiece and the wheel axes can be moved and swiveled around a horizontal plane permitting the grinding of tapers and other shapes. These typical applications include crankshaft bearing spindle pins, bearing rings, and rolls for rolling mills.

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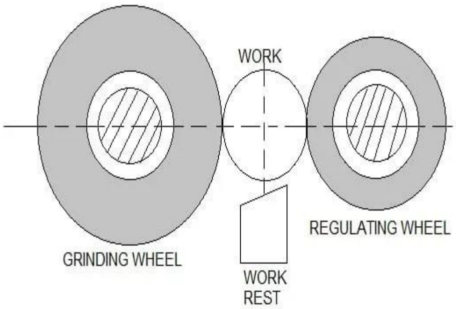
ii. Surface Grinder:

Surface grinding involves grinding flat surfaces and is one of the most common grinding operations. Typically, the workpiece is secured on a magnetic Chuck attached to the worktable of the grinder. Nonmagnetic materials generally are needed by vises special fixtures, vacuum Chuck's.



A straight wheel is mounted on the horizontal spindle of the grinder. Transverse grinding occurs as the table reciprocates. Longitudinally and feels latterly after each stroke. In plunge grinding the wheel is moved radially into the workpiece as it is when grinding a groove.

iii. Centreless Grinder:

In this operation there are two wheels are fitted parallel with a 5–10-degree angle, and this angle is provided to get a longitudinal motion of the workpiece.

Here the workpiece is supported blade, not by centers or chucks.

A cylindrical rod is placed between the two-wheel due to the tilted angle the workpiece is automatically passed through the wheels, and we got a smooth surface.

9.0 INTERNAL MACHINING OPERATIONS

DRILLING MACHINE:

It is a machine that is used to drill holes in the components or workpieces with the help of drill bits.

The drill bits are also called Multi-point cutting tools which can have a rapid impact on the Material Removal Rate (MRR) i.e. a single-point cutting tool (like the one used in a lathe machine) can remove the material slowly whereas, a multi-point cutting tool removes the material at a faster rate and thereby increases MRR

CLASSIFICATION OF DRILLING MACHINES:

1. Radial drilling machine
2. Upright drilling machine
3. Automatic drilling machine
4. Multiple Spindle drilling machine
5. Deep hole drilling machine
6. Sensitive drilling machine
7. Portable drilling machine
8. Gang drilling machine

9.1 WORKING OF

A. BENCH DRILLING MACHINE:

Construction: The machine has only a hand feed mechanism for feeding the tool into the workpiece. This enables the operator to feel how the drill is cutting and accordingly, he can control the down-feed pressure. Sensitive drill presses are manufactured in bench or floor models, *i.e.*, the base of the machine may be mounted on a bench or floor.

The main operating parts of a sensitive machine/drill press are the Base, Column, Table, and Drill Head.

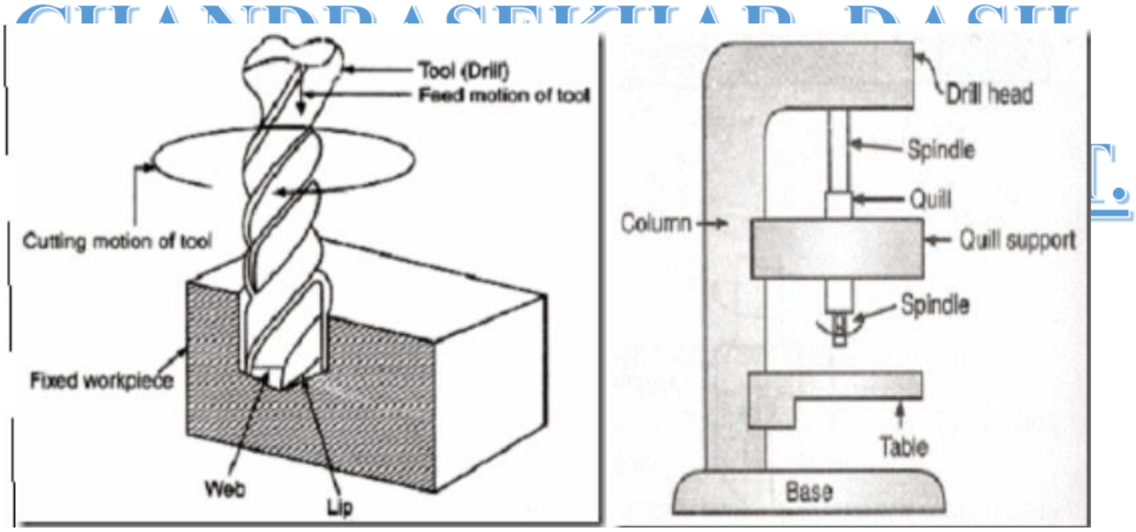
1. **Base**: The base is a heavy casting that supports the machine structure; it provides rigid mounting for the column and stability for the machine. The base is usually provided with holes

and slots which help to Bolt the base to a table or bench and allow the work-holding device or the workpiece to be fastened to the base.

2. **Column**: The column is a vertical post that Column holds the worktable and the head contains the driving mechanism. The column may be round or a box section.

3. **Table**: The table, is either rectangular or round. The drill machine/press shape supports the workpiece and is carried by the vertical column. The table's surface is 90 degrees from the column and can be raised, lowered, and swiveled around it. The table can be clamped/hold the required workpiece. Slots are provided in most tables to allow the jigs, fixtures, or large workpieces to be securely fixed directly to the table.

4. **Drilling Head**: The drilling head, mounted close to the top of the column, houses the driving arrangement and variable speed pulleys. These units transmit rotary motion at different speeds to the drill spindle. The hand feed lever is used to control the vertical movement of the spindle sleeve and the cutting tool.



B. PILLAR DRILLING MACHINE

A pillar drill machine is a heavy-duty, high-powered tool. Its head can be adjusted to accommodate different heights. This machine is equipped with a depth stop that prevents it from drilling too deeply. It also comes with a base plate with screw holes for attaching it to a workbench. For safety purposes, you should always read the instruction manual thoroughly. You must also ensure that the material to be drilled is appropriate for the tool's speed.

It has a working table attached to the column, which can be moved up or down a column. Once you've placed the material to be drilled on the table, you can then move the table in an up or down motion. It is important to clamp the material on the table to ensure that it doesn't move. This is an essential safety feature in pillar drilling, as it will prevent any unnecessary damage or injuries to yourself or the environment.

WORKING

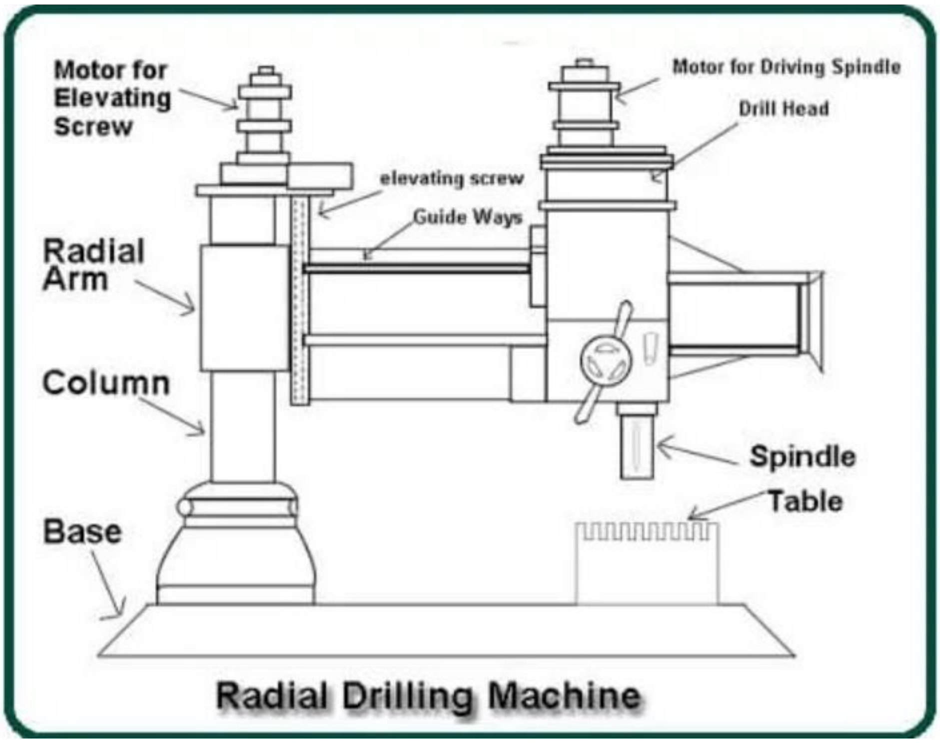
When using a pillar drill machine, be sure to read all the instructions carefully. While you should never rush when drilling a pillar, you should make sure you're aware of possible safety risks. The swarf and spinning materials can cause damage to your hands and eyes. Ultimately, you'll be glad you chose a pillar drill machine that can safely meet your needs. Its safety features and quality are unmatched in the market today.

When using a pillar drill, it's important to use it properly. This machine is designed to drill most materials. A pillar drill should be used to drill a single stud. In addition to the stud, the pillar should be placed at the same level with the other hammer. If you're drilling a hole in an already-drilled pier, you should clamp the material to avoid any injury.

C. RADIAL DRILLING MACHINE

Radial drilling machines are used to drill mediums to large and heavy workpieces. these machines are used to drill holes in a given radial distance. It is mainly used when the component's size is larges in height.

Radial drilling machines are primarily designed for drilling holes in heavy jobs or workpieces. Since heavy work cannot move much, the radial drilling machine is made in such a way that the machine tool can move any part of heavy work without doing much work.



Radial Drilling Machine

[1] **Base:** This is the bottommost part of the radial drilling machine. It is made of cast iron because cast iron has high corrosive strength. The base is used to support the assembly of parts on it. It also absorbs vibrations and shocks induced by machine parts.

[2] **Column:** There is a column at one end of the base. It is a vertical column that acts as a support to rotate the radial arm in 360 degrees.

[3] **Table:** It is placed above the column. It is provided with a slot to mount the workpiece directly to its face. It is usually round or rectangular in shape.

[4] **Radial Arm:** This is the part that is attached to the column. This part can rotate 360 degrees around the column. The face of the radial arm is accurately machined, and the head slides over it. This arm moves up and down the column. In larger machines, hydraulics are used to move the arm up and down.

[5] **Drill Head:** The drill head is mounted on the radial arm and drives the drill spindle. It engages all mechanisms to drive and feed the drill at different speeds.

[6] **Spindle:** The motor is present at the top of the drill head, which drives the horizontal axis.

[7] **Motor:** The motor is present at the top of the drill head, which drives the horizontal axis.

[8] **Chuck:** Chick is present below the axis. It is used to hold the drill bit in its place.

[9] **Tool or Drill Bit:** Drill bits are used to drill holes in the workpiece. This is the part that rotates and enters the workpiece, creating holes.

WORKING OF RADIAL DRILLING MACHINE:

Initially, when a power supply is given, the spindle rotates, which is driven by the motor. Since the radial arm can move up and down in the column, the radial arm is adjusted according to the operation and height of the workpiece.

The spindle is attached to the chuck, and the drill bit is placed in the jaw of the chuck. The head of the drilling machine is also adjusted so that the tool is in the correct position to make a hole in the workpiece.

After that, a suitable feed is given, and then the drill bit easily moves into the workpiece. the drive mechanism used in the drilling machine is the rack and pinion mechanism.

In rack and pinion mechanisms, gears are used to convert rotation to linear motion. When the handwheel is rotated, the pinion that is attached to the rack also rotates, which converts the rotation to linear motion and therefore moves towards the drill bit workpiece.

9.2 BORING

Boring is a process of producing circular internal profiles on a hole made by drilling or another process. It uses a single-point cutting tool called a boring bar.

In boring, the boring bar can be rotated, or the work part can be rotated. Machine tools that rotate the boring bar against a stationary workpiece are called boring machines (also boring mills).

Boring can be accomplished on a turning machine with a stationary boring bar positioned in the tool post and a rotating workpiece held in the lathe chuck as illustrated in the figure. In this section, we will consider only boring on boring machines.

PRINCIPLE OF BORING

In a horizontal boring machine, the workpiece is held on the machine table and kept stationary, while the boring tool revolves.

At the same time, the tool may be moved forward or backward in a direction parallel to its axis of rotation and can also be offset in a direction perpendicular to its axis of rotation.

The end supporting block and the headstock might be moved down and up.

The spindle may be rotated at different speeds.

The spindle may be moved in or out by power or hand for feeding.

The saddle and the table may be moved by hand or power.

The columns might be moved by hand or force.

- All these movements may be given independently or in combination.
- All the controls are housed in a particular position of the machine and the operator may give closer attention to the work while controlling the machine.

PARTS OF THE BORING MACHINE

1. Bed

- The bed of a boring machine consists of a hollow circular casting grouted on the floor.
- The top of the bed is finished to provide a bearing surface for the table.
- It houses the spindle and a pinion for rotating the table.

2. Table

- The table which may be rotated is a circular casting mounted on the top of the bed.
- The horizontal surface of the table is finished and is provided with **T -slots** or chuck jaws for holding and clamping the work.
- Underside of the table may be provided with bevel gear teeth which meshes with a driving pinion.
- In large machines, a helical pinion meshes with a gear attached to the underside of the table.

3. Housing

- The housings are two vertical members which rise from the two sides of the bed.
- They are made of ribbed construction to ensure rigidity of the machine.
- The housings are joined at the top by a cross member.
- The vertical front face of the housings are accurately machined to form guide ways on which the cross rail slides.

4. Cross rail

- The cross rail is the horizontal member of the rectangular casting mounted on the two front faces of the housings.
- The cross rail may be moved up and down by rotating screws for accommodating different heights of work.

- The vertical front face of the housings are accurately finished for holding and sliding the saddle of the tool head.

5. Boring bars

- The boring bar supports the cutter for boring operations on jobs having huge bore distances across.
- For short holes the bar might be supported on the headstock spindle end only, whereas for long work the bar is supported on the spindle end and on the column bearing block.

6. Tool head assembly

- It comprises saddle, ram and tool post.
- The saddle is mounted on the cross rail and may be made to slide on it to generate flat horizontal surface by the tool.
- The ram holding the tool post may be made to slide up and down in the saddle perpendicular to the table to generate cylindrical surface or at an angle to the table surface to generate taper.
- The rams are also counter balanced for ease of operation.

OPERATIONS OF BORING MACHINES

1. Boring operation

- In this operation holes are bored by using boring bars.
- Multiple holes may be bored one after another by changing the position of the workpiece and aligning it each time with the boring bar.
- To bore a hole, the boring bar is fitted to the spindle and the cutter is adjusted in the boring bar to the required dimension and a light cut is then taken.
- The bore is measured, required speed and feed adjusted and the cut is then completed.

2. Forming operation

- This operation is performed by cross feed movement of the saddle.

3. Machining flat surface

- For performing this operation, the cross rail and the ram is locked at the desired position.
- Then, the saddle is fed cross wise while the work revolves on the table.
- The depth of cut is given by the ram.

4. Taper boring operation

- The taper and conical surfaces are turned by swiveling the tool head to the required angle.
- When a conical surface having a large included angle which is beyond the range of the swiveling arrangement of the tool head is turned, a combined cross and down feed is applied simultaneously on the tool to cut the required taper.

5. Turning cylindrical surface

- In this activity, the saddle is clamped to prevent any horizontal movement of the ram, and the ram is fed downwards.
- The larger diameter holes are bored by feeding the tool head directly within the work and the smaller diameter holes are bored by using a boring bar attached to the tool head.

DIFFERENT BETWEEN BORING AND DRILLING

Drilling	Boring
Drilling is performed to originate a hole.	Boring is performed to enlarge the diameter of an existing hole.
Cutting tool used for drilling is known as drill.	Cutting tool used for boring is known as boring bar.
Drill is a double point cutting tool.	Boring bar is a single point cutting tool.
Drilling is first phase of hole fabrication. It does not require any special feature prior to operation.	A pre-drilled hole (or a hollow portion made by casting) is mandatory for performing boring.
Drilling can increase length of the hole but not diameter (limited to drill diameter).	Boring can increase diameter of an existing hole but not length.
Surface quality of drilled hole is not very good.	Here surface quality is better than drilling.
Material Removal Rate (MRR) in drilling operation is higher.	MRR is lower than drilling but higher than reaming.

9.3

BROACHING

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

In broaching machine, the tool of the machine is pulled or pushed through the surfaces to be finished. With the help of broaching, finishing is done on flat or contoured and either internal or external surfaces. Broaching is limited to the removal of about 6mm of stock or less.

The term broaching may have derived from an ancient Roman word braces, which means an object having projecting teeth. The operation itself dates only to the 1850s when broaching tools when called "drifts" were hammered in blacksmith shops through the work or pushed with an arbor press.

BROACHING METHODS

Following are the classification of broaching methods:

1. Pull Broaching
2. Push Broaching
3. Surface Broaching
4. Continuous Broaching.

Pull Broaching

In the pull broaching the work is held fixed and the broach is pulled through the work. Usually, broaches are very long and are held in a special head. Pull broaching method is used for internal broaching but it also used for some surface broaching.

Push Broaching

In the push broaching the work is fixed and the broach is pushed through the work. Hand and hydraulic arbor presses are commonly used for push broaching. This method is used for sizing holes and cutting keyways.

Surface Broaching

In surface broaching either the work or the broaching tool moves across the other. This method has become an important means of surface finishing. Many irregular or intricate shapes can be broached by surface broaching, but the tools must be specially designed for each job.

Continuous Broaching

In continuous broaching the work is moved continuously and the broach us held stationary. The movement of work may be either straight horizontal or circular. The continuous broaching method is mostly used for broaching a number of similar works at the same time.

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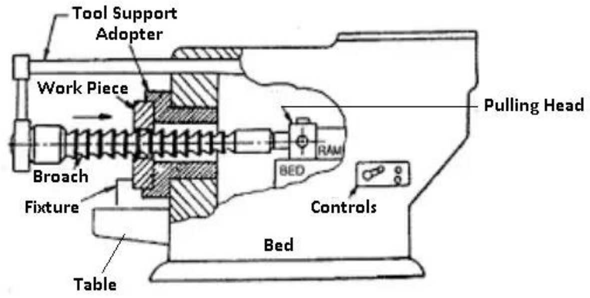
LECTURE NOTE

TYPES OF BROACHING MACHINE

1. Horizontal Broaching Machine:

Nearly all horizontal machines are of the pull type. They may be used for either internal or external broaching, although internal work is the most common.



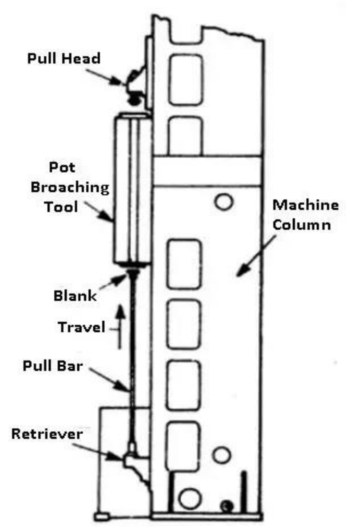
HORIZONTAL BROACHING MACHINE

A horizontal broaching machine is shown in the figure. It consists of a bed or a base a little more than twice the length of the broaching stroke, a broach pilot and the drive mechanism for pulling the broach.

Horizontal broaching machines are used primarily for broaching keyways, splines, slots, round holes, and other internal shapes or contours. They have the disadvantage of taking more floor space than do the vertical machines. However, long broaches and heavy workpieces are easily handled.

2. Vertical Broaching Machine

The vertical types may be obtained in either push or pull type. The push type is the most popular. A vertical broaching machine is shown in the figure.



VERTICAL BROACHING MACHINE

Vertical machines are used in multiple operations since they are convenient to pass work from one machine to another. Of the three models available, pull down, pull up, and push down, the pull-up type is the most popular. Vertical machines require an operator platform or a pit and are more economical of floor space than the horizontal type.

3. Surface Broaching Machine

Surface broaching machines have their broaching tools attached to a ram or rams forced in a straight path along guideways past the workpiece. On some surface broaching machines, the ram travels horizontally, on others, the ram travels vertically. When two rams are used, the machine is called a duplex broach.

ADVANTAGES OF BROACHING

- The rate of production is very high.
- Skill is required from the operator to perform a broaching operation. In most cases, the operator merely loads and unloads the workpiece.
- High accuracy and a high class of surface finish are possible. A tolerance of ±0.0075mm and a surface finish of about 0.8 microns (1 micron=0.001mm) can be easily obtained in broaching.
- Both roughing finishing cuts are completed in one pass of the tool.
- The broaching process is used for internal and external surface finishing.
- Any form or shape that can be reproduced on a broaching can be machined.
- Cutting fluid may be readily applied where it is most effective because a broach tends to draw the fluid into the cut.

APPLICATION

Broaching is used for producing a variety of shapes, internal and external, and regular and irregular profiles.

The examples of components produced by broaching are as follows: 1. Bearing caps 2. Bearing bodies 3. Cylinder blocks 4. Connecting rods 5. Gears and Turbine 6. Keyways 7. Splines