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

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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

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This has a slot cut to permit slight va iations in size.

When held in the die stock, variation in the size can b adjusting screws.

Both pieces should have the same se ial 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.

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

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

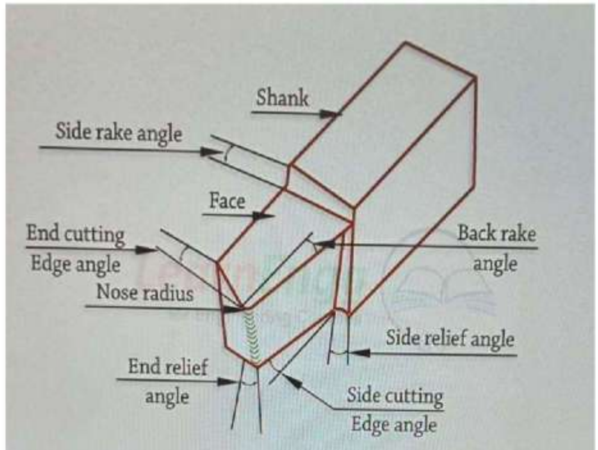

Fig 5: Cutting tool geometry

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:

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- 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.

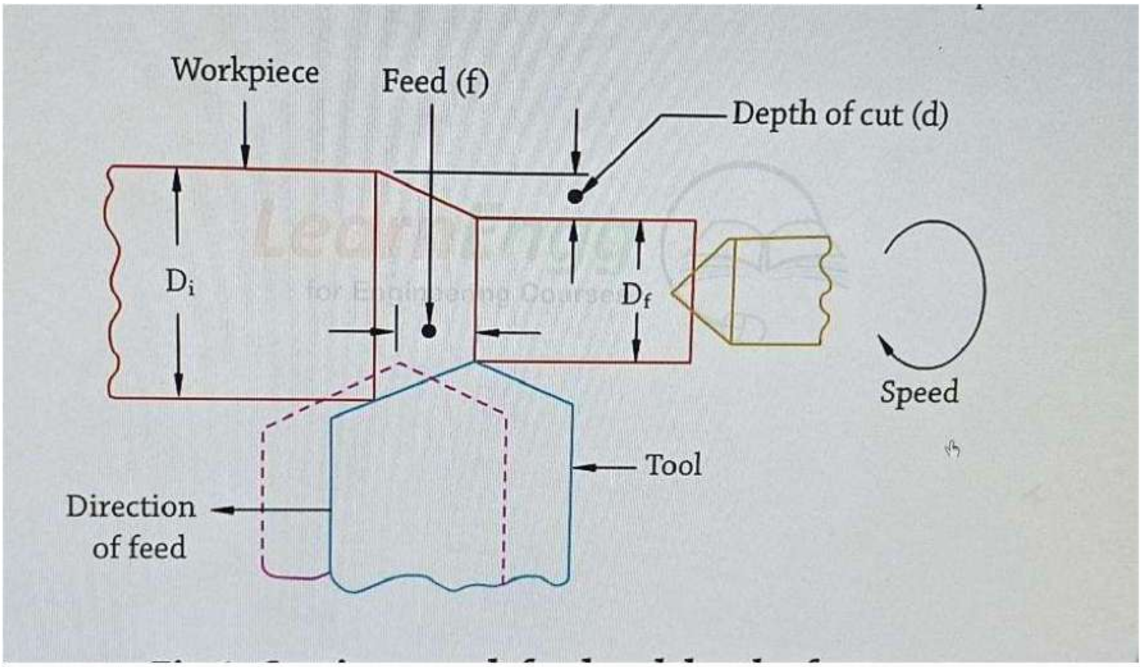
Negative rake angle:

- 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.

- Feed is expressed in mm/revolution.

  Feed (f) may be calculated as follows:

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

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,

$$MRR = \pi\ Di \times d \times f \times N\ mm^3/min$$

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

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

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,

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

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, $F = K \times d \times f$

Where,

K is a constant that depends on the work material

Power required, P=F x V

Combining the above two equations,

$$\text{Power, } P = K \times d \times f \times V$$

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.

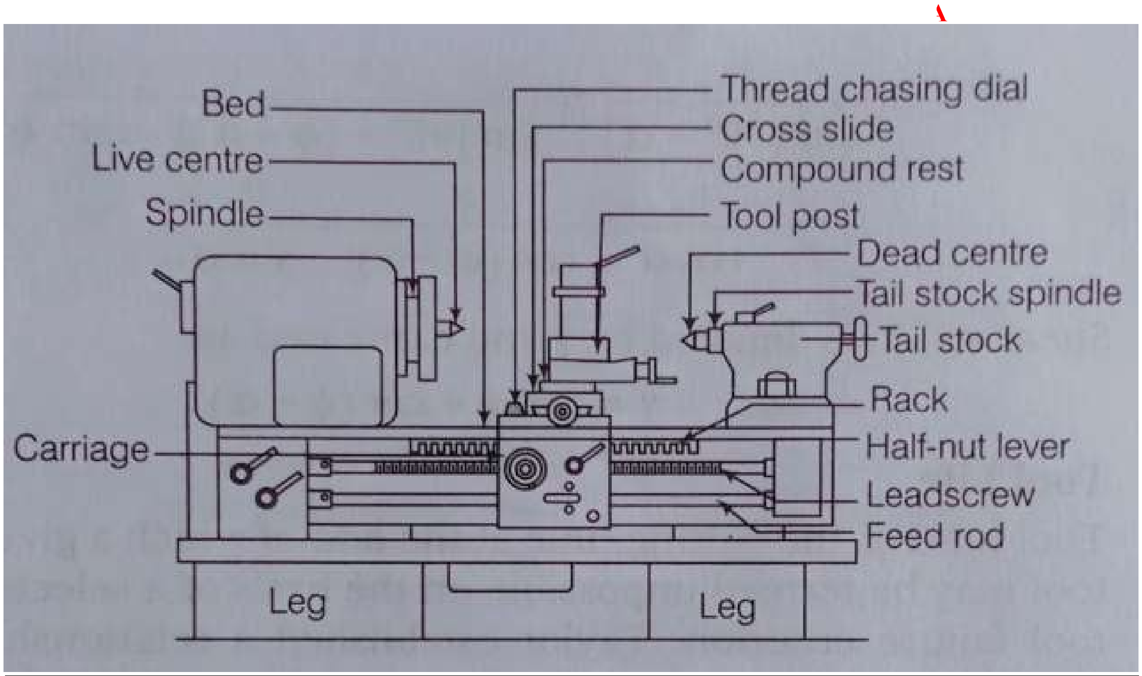
Lubricant:

- 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.

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- 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.

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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 ho ding the work.

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Face plate or Chuck are mounted on the machine spindle.

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

iv. External grooving: In externa turning operations diameter of the workpiece.

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2. Facing:

- Threads can be produced either on internal or cylindrical bar.

9. Grooving:

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.

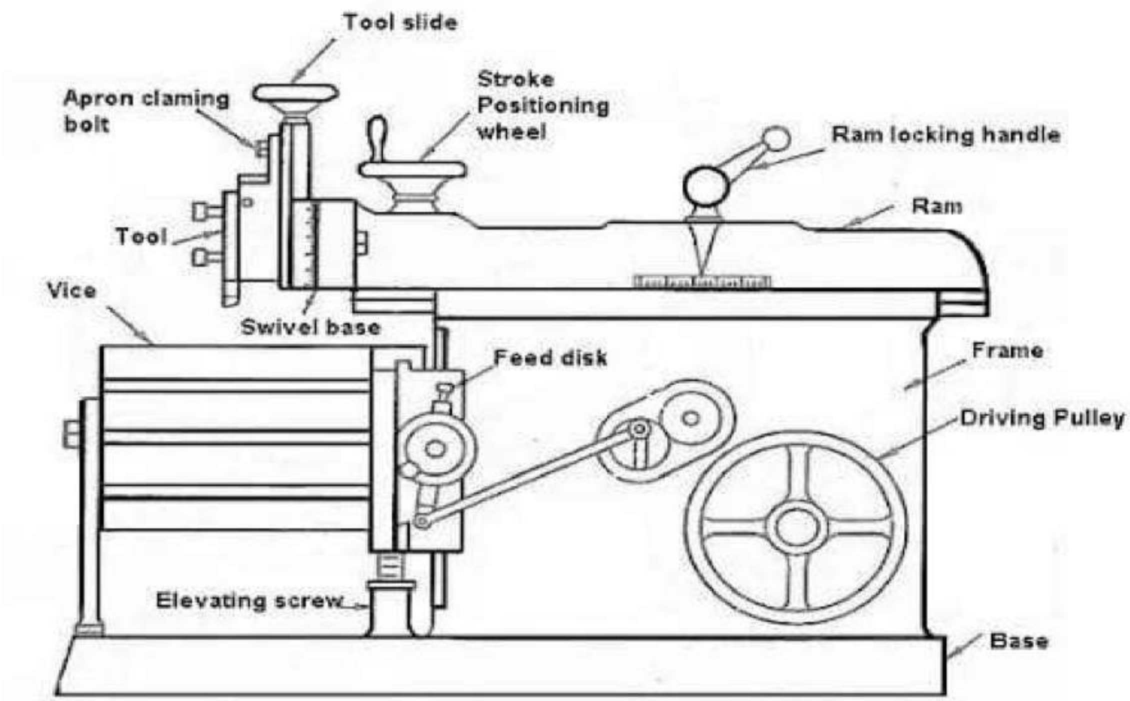
Cross rail:

- 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

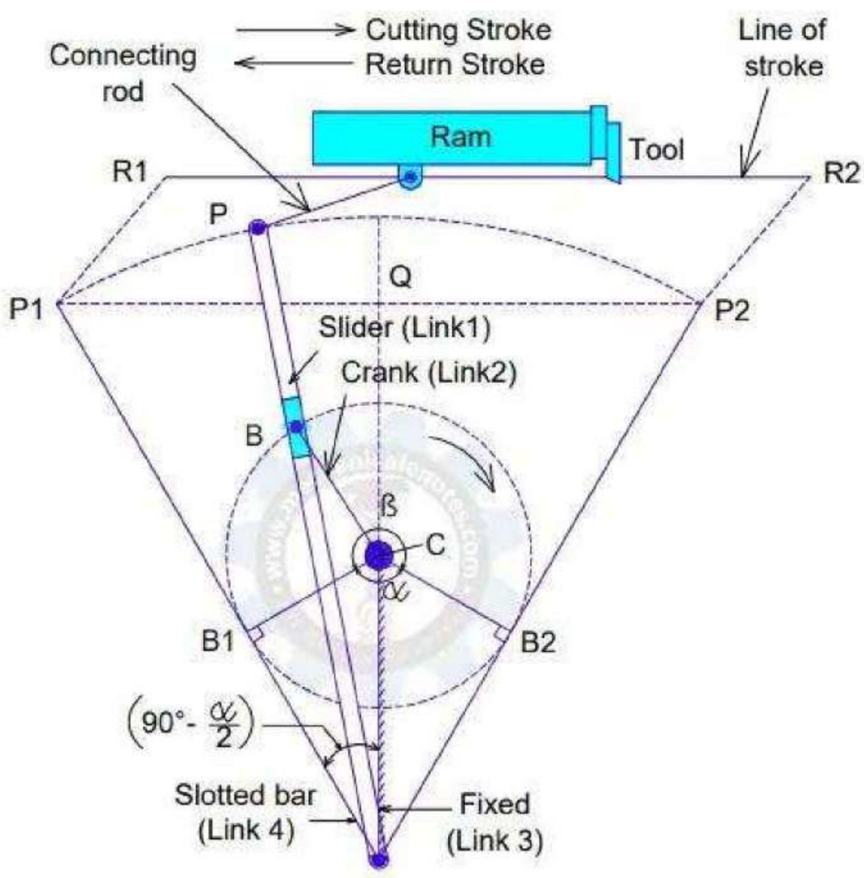
It consists of 3 turning pairs and one sliding pair.

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.

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.

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.

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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.

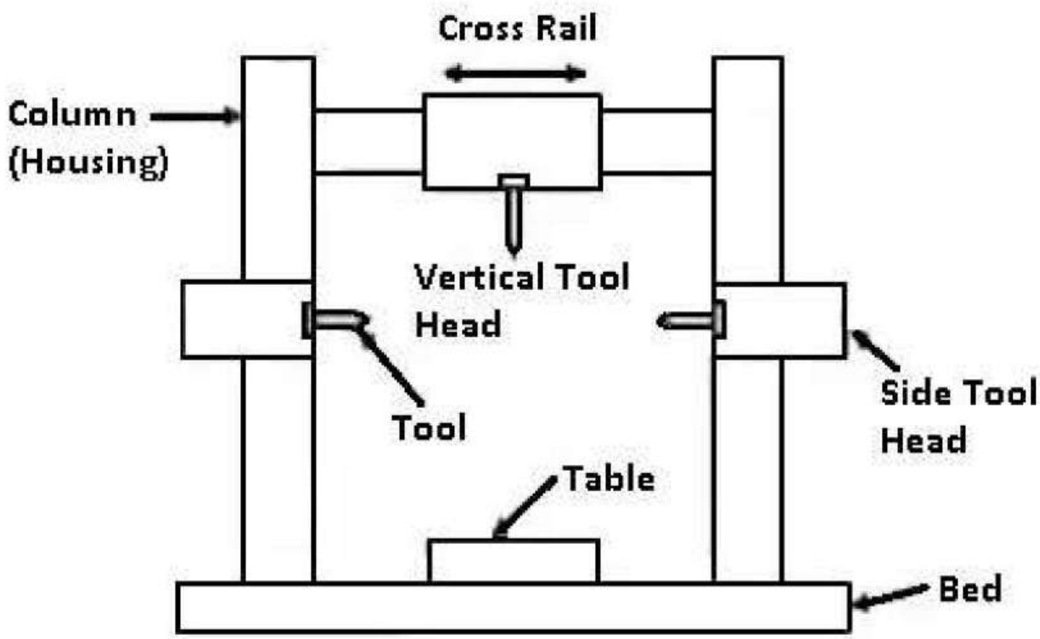
5.4 Working Principle of Planer Machine:

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:

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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.

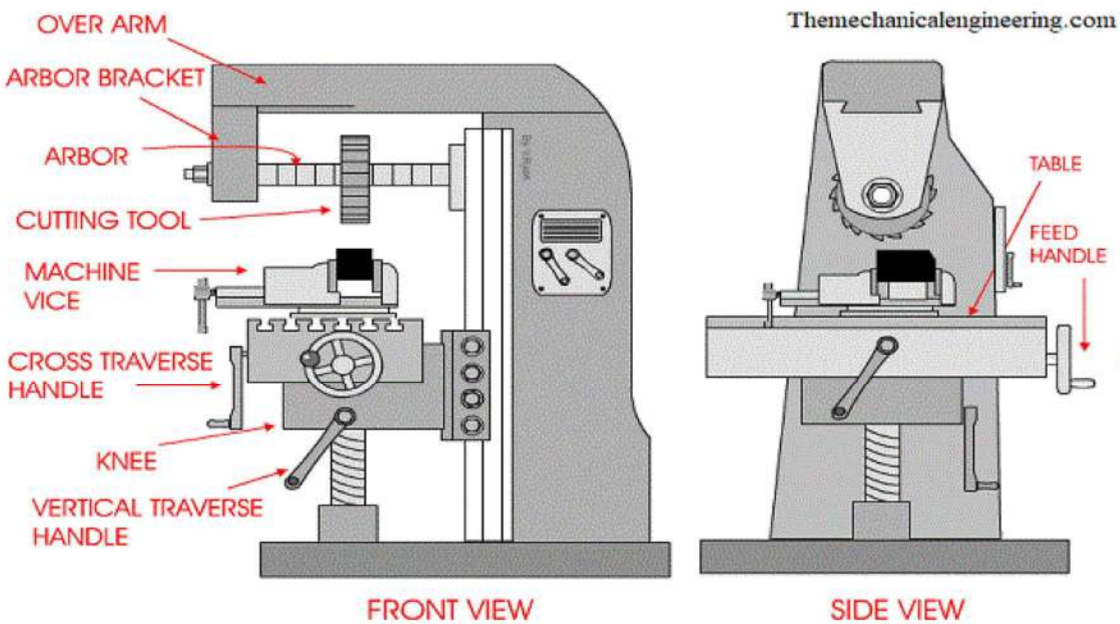
4. End Milling Operation:

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.

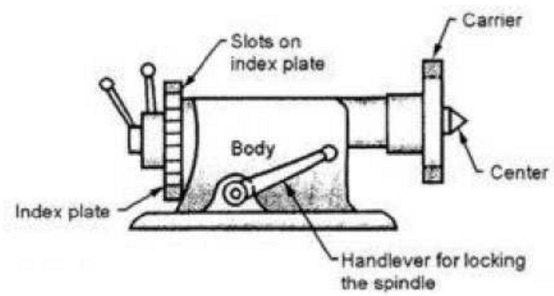
Indexing is the process of evenly dividing the circumference of a circular workpiece into equally spaced divisions, such as in cutting splines, cutting gear teeth, milling grooves in taps and reamers, and spacing holes on a circle.

Plain Dividing Head:

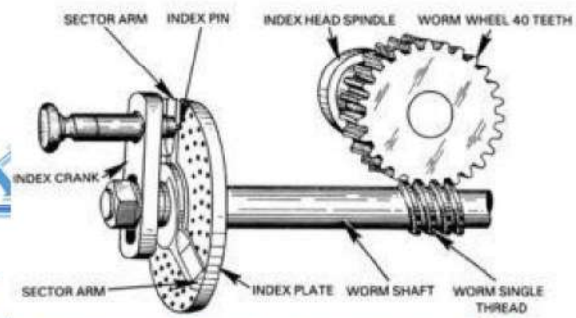
Plain dividing head is the simplest of all types of dividing heads. Plain dividing head is classified into two types.

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:

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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:

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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.

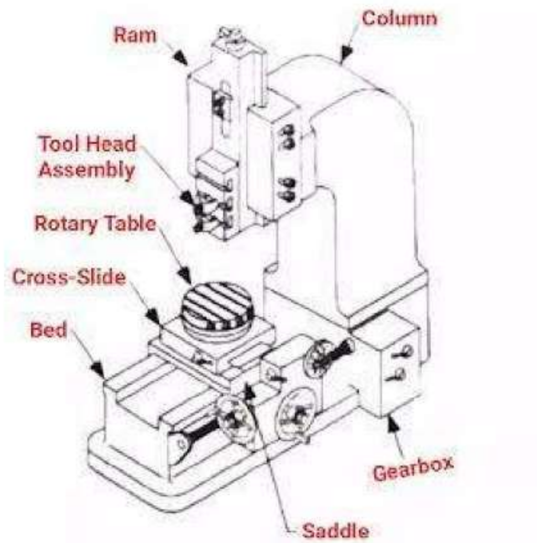
The table may be graduated in degree for indexing or dividing the periphery of the jobs.

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,