UNIT-3 MACHINE TOOLS

(Lathe, Drilling Machine, Milling Machine & Grinding Machine)

Production or manufacturing can be simply defined as value addition processes by which raw materials of low utility and value due to its inadequate material properties and poor or irregular size, shape and finish are converted into high utility and valued products with definite dimensions, forms and finish imparting some functional ability. The products are made by a combination of manual labor, machinery, tools and energy.

The word manufacturing is derived from the Latin word " *manufactus"* meaning made by hand; The word manufacture first appeared in AD 1567 and the word manufacturing in 1683. The word production and manufacturing is used interchangeably.

The conversion of resources into raw materials is normally taken care of by two sub disciplines of engineering – mining and metallurgy. The real conversion starts from the stage where the material is obtained in the raw form. There are many process involved in converting an available raw material into final product. These processes of conversation are known as manufacturing process.

Machine tool: A machine tool may be defined as a power driven machine which can be used for machining operations.

Machine tools are

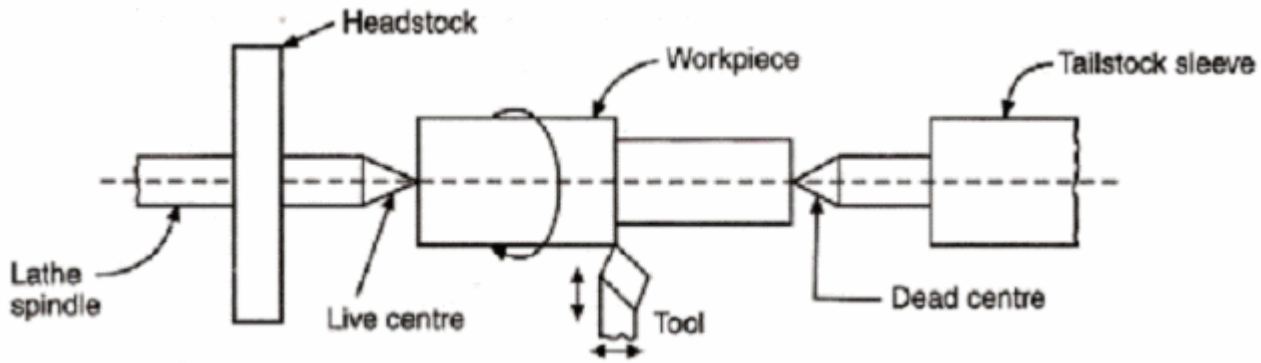
1. **LATHE,**
2. **DRILLING MACHINE**
3. **MILLING MACHINE**
4. **GRINDING MACHINE** etc.

1. LATHE

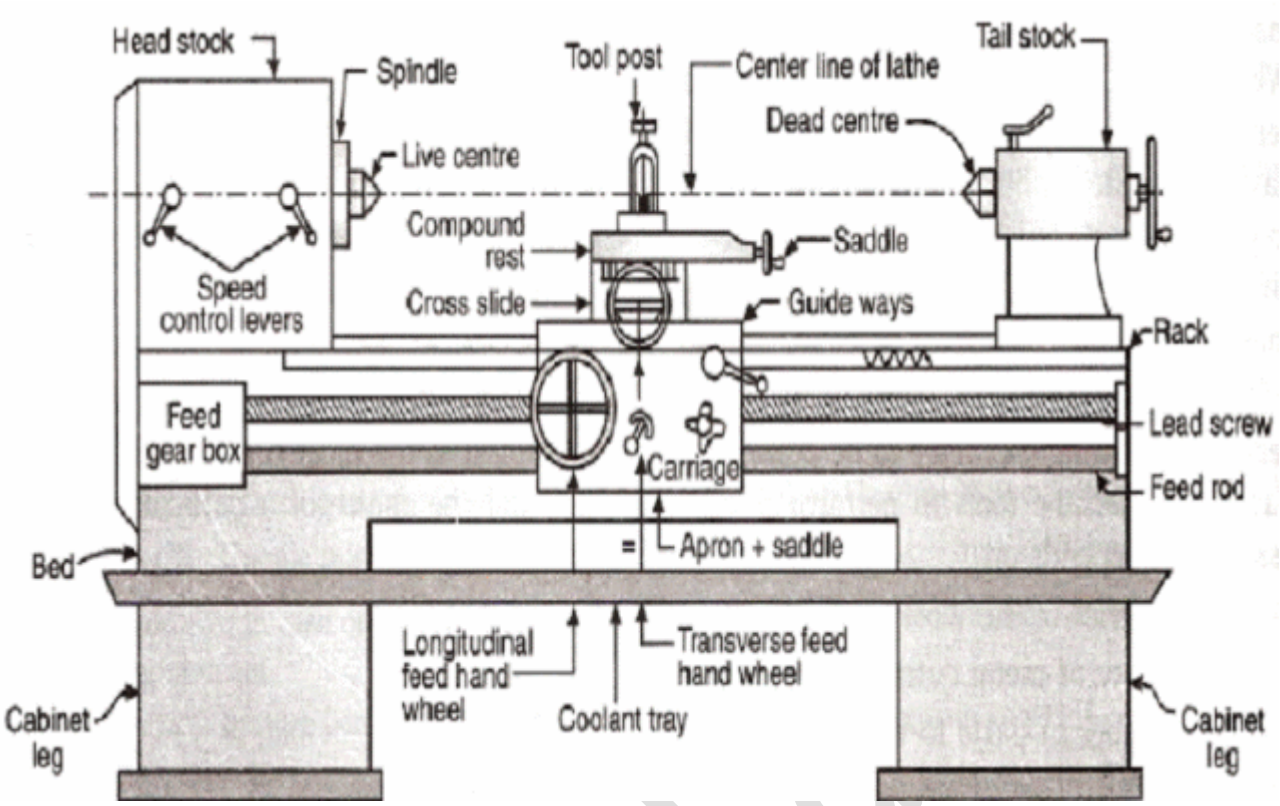
Lathe is a machine tool used to remove metal from the work piece, to produce circular objects in required shape and size.

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

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



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



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

2. Legs: The legs carry the entire load of machine and are firmly secured to floor by foundation bolts.

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

4. Gear Box: The quick-change gear-box is placed below the headstock and contains a number of different sized gears.

5. Carriage: The carriage is located between the headstock and tailstock and serves the purpose of supporting, guiding and feeding the tool against the job during operation. The main parts of carriage are:

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

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

c). The compound rest is fitted on the top of cross slide and is used to support the tool post and the cutting tool.

d). The tool post is mounted on the compound rest, and it rigidly clamps the cutting tool or he proper height relative to the work centre line.

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

6. Tailstock: The tailstock is a movable casting located opposite the headstock on the ways of the bed. The tailstock can slide along the bed to accommodate different lengths of workpiece between the centers. A tailstock clamp is provided to lock the tailstock at any desired position. The tailstock spindle has an internal taper to hold the dead centre and the tapered shank tools such as reamers and drills.

❖ **LATHE OPERATIONS:** Different types of operations that can be carried out

1. Straight Turning
2. Facing
3. Knurling
4. Thread cutting
5. Taper turning
6. Drilling
7. Boring

1. Straight Turning

Straight Turning is the removal of metal from the outer diameter of a rotating cylindrical work piece. Turning is used to reduce the diameter of the work piece, usually to a specified dimension, and to produce a smooth finish on the metal. Often the work piece will be turned so that adjacent sections have different diameters.

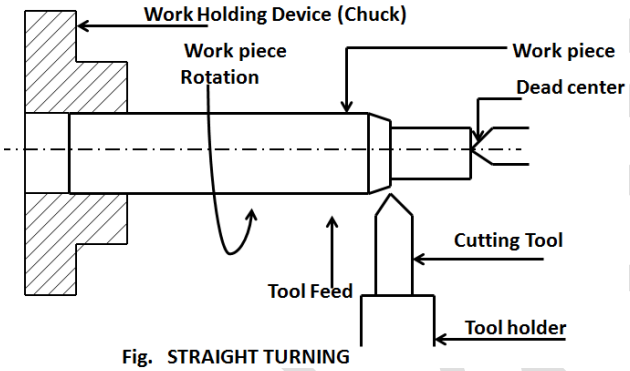


Fig. STRAIGHT TURNING

2. Facing

Facing is the process of removing metal from the end of a work piece to produce a flat surface. It is some time called squaring. The facing tool used is of round edge; if the tool is pointed then the work piece will not have good finishing. The work piece rotates about its axis and the facing tool is fed perpendicular to the axis of lathe. Most often, the work piece is cylindrical, but using a 4-jaw chuck you can face rectangular or odd-shaped work to form cubes and other non-cylindrical shapes.

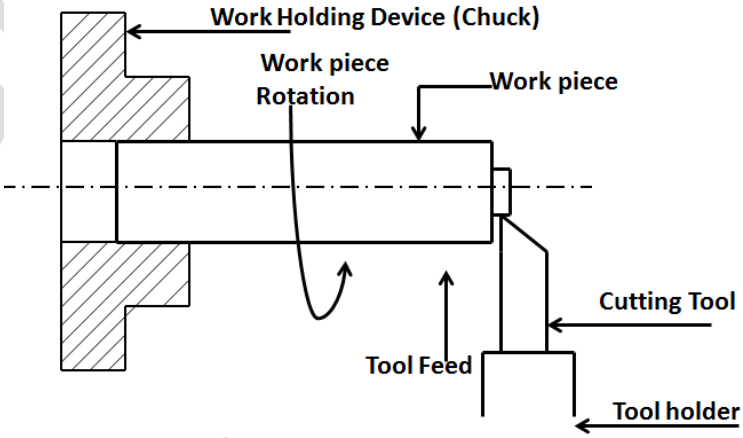


Fig. FACING

3. Knurling

Knurling is the process of embossing a required shaped pattern on the surface of the work piece. This diagram shows the knurling tool pressed against a piece of circular work piece. The lathe is set so that the chuck revolves at a **low speed**. The knurling tool is then pressed against the rotating work piece and pressure is slowly increased until the tool produces a pattern on the work piece.

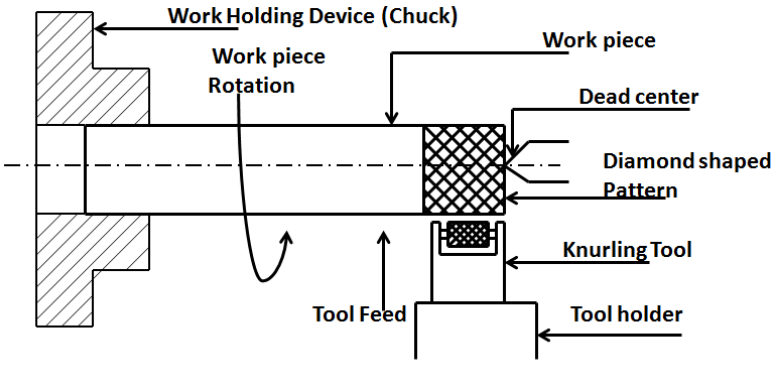


Fig. KNURLING

4. Thread cutting

Thread cutting is the operation of producing helical groove on a cylindrical surface. Threads may be square or v threads can be cut on a cylindrical work piece. The threads of any pitch, shape and size can be cut on a lathe. A single point cutting tool (V-tool or square tool) is used to cut threads on the work piece.

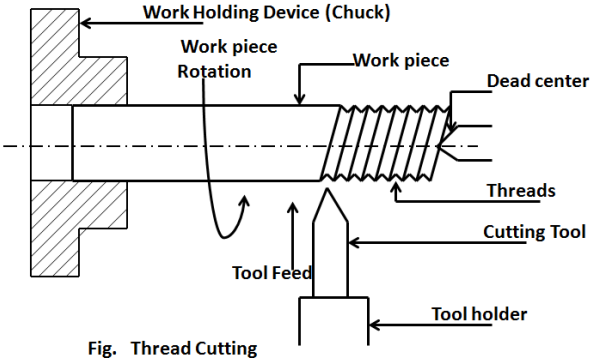


Fig. Thread Cutting

For thread cutting operation, the tool is moved automatically in longitudinal direction. The longitudinal feed should be equal to the pitch of the thread to be cut per revolution of the work. During thread cutting, both work piece and lead screw rotate at the same speed. The pitch of the lead screw is equal to pitch of work piece. To cut the threads,

the tool is brought in contact with work piece. The carriage is brought in contact with lead screw by operating half nut lever. The tool is moved along the axis, generates the threads on the work piece. This process is repeated several times till the required depth, pitch and finish is obtained.

5. Taper Turning by Swivelling Compound Rest

In this method of taper the half taper angle is calculated. The compound rest has rotating base graduated in degrees, which can be rotated to any angle (according to the taper angle). In this method the tool is advanced by rotating the compound rest and hand wheel so that the tool moves according to set taper angle. This method produces taper length larger than form tool method.

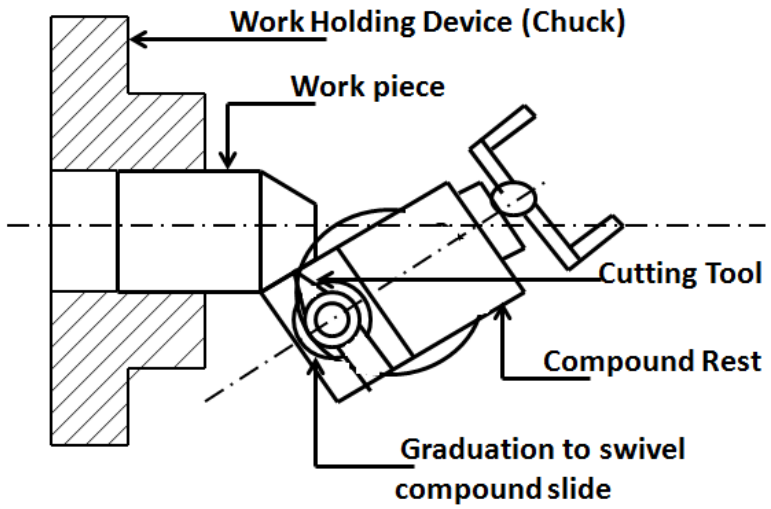


Fig. Taper Turning by swivelling the compound rest

Formula which is used to calculate taper angle is $\tan \alpha = \frac{D - d}{2L}$

α = Half taper angle
D= Large diameter
d= Small diameter
L= Length of taper

6. Drilling

Drilling is the operation of producing a cylindrical hole in a work piece using a drill. The work piece is held in the chuck and the drill is held in the tailstock. The feed is

provided by means of moving the sleeve of the tailstock. The figure shows the drilling operation.

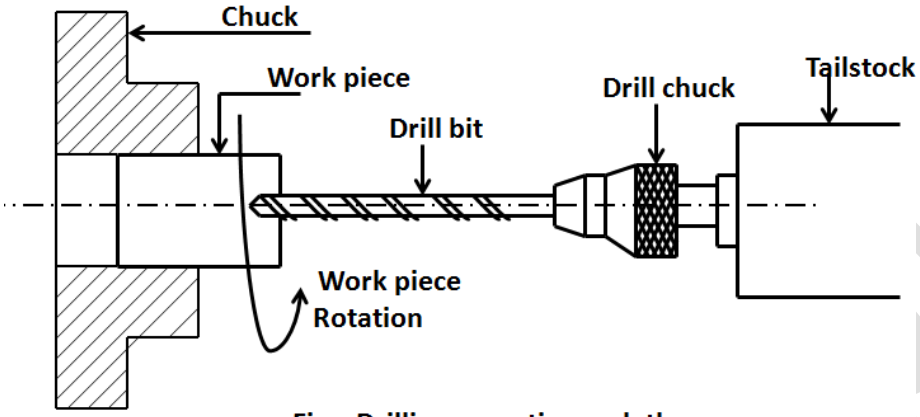


Fig. Drilling operation on lathe

Drill bit

Drill Attachment

7. Boring

Boring is the operation of enlarging the previously drilled hole. The operation is carried out by using a single point cutting tool known as boring tool. The tool is supported on a tool post. The depth of cut is given by the cross slide and the feed is given by moving the carriage. (Why boring is done in lathe or drilling machine. Example to drill a hole of diameter 9.35 mm, the standard drill available in the market is 9 mm or 10mm. First 9 mm hole is drilled using a drill; afterwards using boring tool 9mm hole is enlarged to 9.35mm using boring tool)

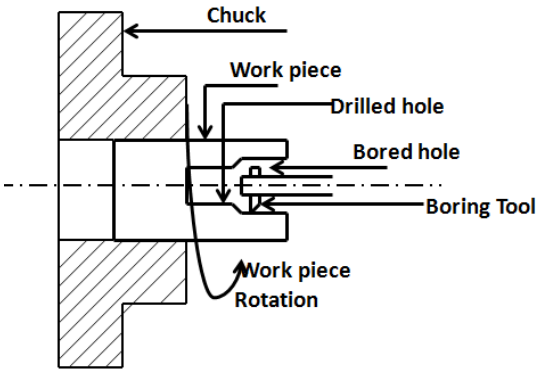


Fig. Boring operation on lathe

2. DRILLING

Drilling is the operation of producing circular hole in the work-piece by using a rotating cutter called drill.

Types of drilling operation

1) Based on construction:

1. Portable drilling machine
2. Sensitive drilling machine
3. Radial drilling machine
4. up-right drilling machine
5. Gang drilling machine
6. Multi-spindle drilling machine

2) Based on Feed:

1. Hand driven drilling machine
2. Power driven drilling machine

2. Sensitive or Bench Drilling Machine (Fig. 1)

- This type of drill machine is used for very light works. Fig.1 illustrates the sketch of sensitive drilling machine.
- The vertical column carries a swiveling table the height of which can be adjusted according to the work piece height.
- The table can also be swung to any desired position.
- At the top of the column there are two pulleys connected by a belt, one pulley is mounted on the motor shaft and other on the machine spindle.
- Vertical movement to the spindle is given by the feed handle by the operator.
- Operator senses the cutting action so sensitive drilling machine.
- Drill holes from 1.5 to 15mm

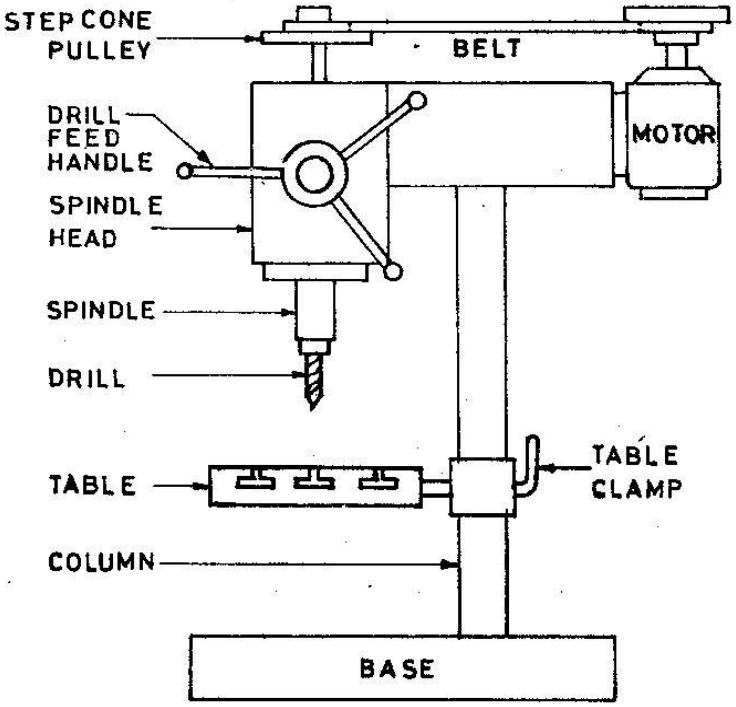


Fig.1. Sensitive or bench Drilling Machine

3. Radial Drilling Machine (Fig. 3)

- It the largest and most versatile used for drilling medium to large and heavy work pieces.
- Radial drilling machine belong to power feed type.
- The column and radial drilling machine supports the radial arm, drill head and motor. Fig.3 shows the line sketch of radial drilling machine.

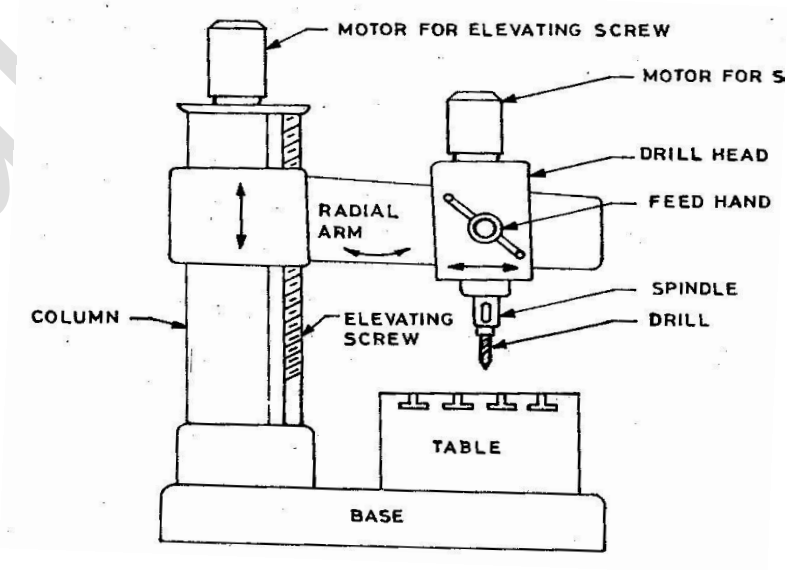


Fig. 3 Radial Drilling Machine

- The drill head is equipped with a separate motor to drive the spindle, which carries the drill bit. A drill head may be moved on the arm manually or by power.
- Feed can be either manual or automatic with reversal mechanism.

❖ Drilling Operations

The different operations that can be performed in a drilling machine are

1**) Drilling**
2) **Boring**
3) **Reaming**
4) **Counter sinking**
5) **Counter boring**
6) **Spot facing**
7) **Tapping**

1. Drilling

The cutting tool, which is used for making holes, is known as drill. The drill is a multipoint cutting tool.The drilling is one of the simplest methods of producing a hole. Before drilling a hole, the center point of the hole has to be marked on the work piece. The center point of the hole is marked by just drawing two cross lines or by using instruments. The mark is indented using a center punch. The hole to be drilled may be a through hole or a blind hole. Through hole can be drilled on any machine, but to drill a blind hole we need a sophisticated machine.

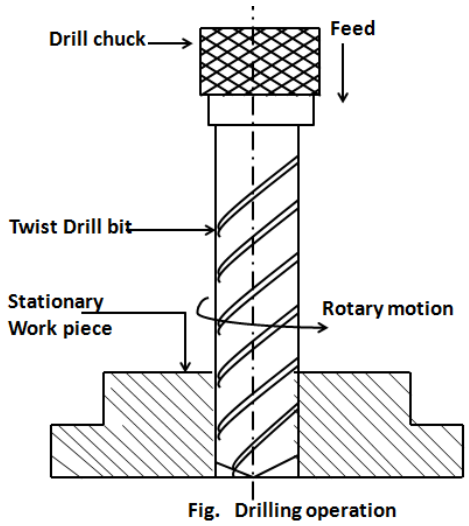


Fig. Drilling operation

2. Boring

The boring operation is done to finish a drilled hole. It is a process of enlarging the already drilled hole. Boring operation is carried out on a single point cutting tool. This becomes necessary where suitable sized drill is not available or where diameter is so large that it cannot be ordinarily drilled. Boring corrects the roundness of the hole to accurate size. The cutter is held in a boring bar which is connected to the spindle of the drilling machine. The boring speed is one fourth of the speed of the drilling. The process is very slow compared to any other drilling operations.

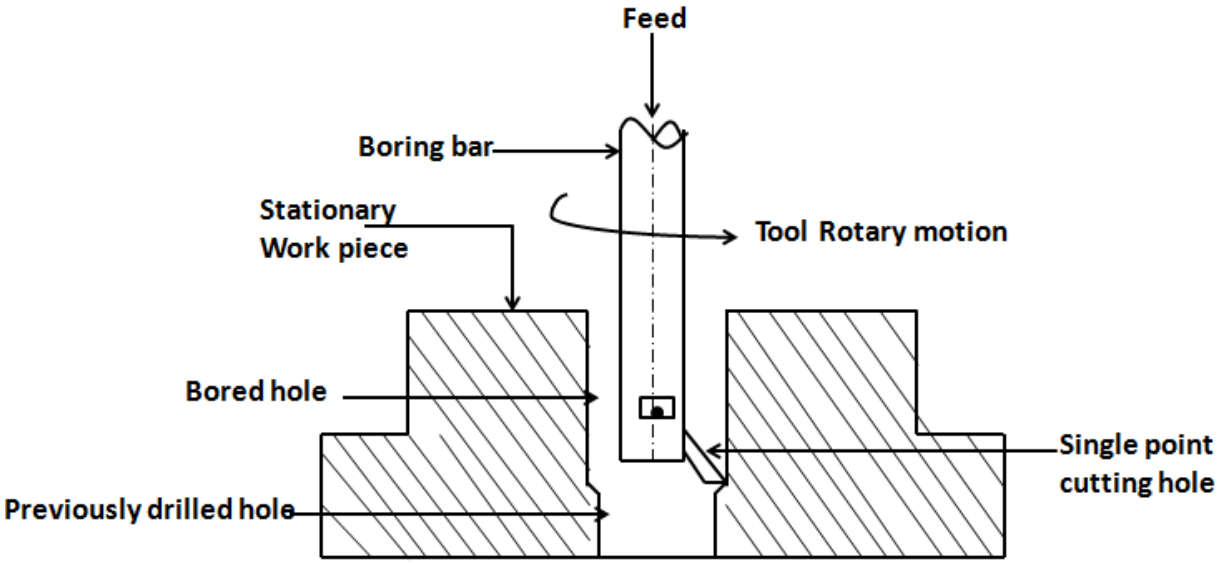


Fig. Boring operation

3. Reaming

Reaming is a sizing and finishing operation performed on a previously drilled hole. The tool used for reaming operation is known as reamer, which has multiple cutting edges. The spindle speed is half compared to drilling operation. Reamers cannot produce hole, but follow the path already defined by the drilling. The metal removed in this process is small, range is about 0.35 mm

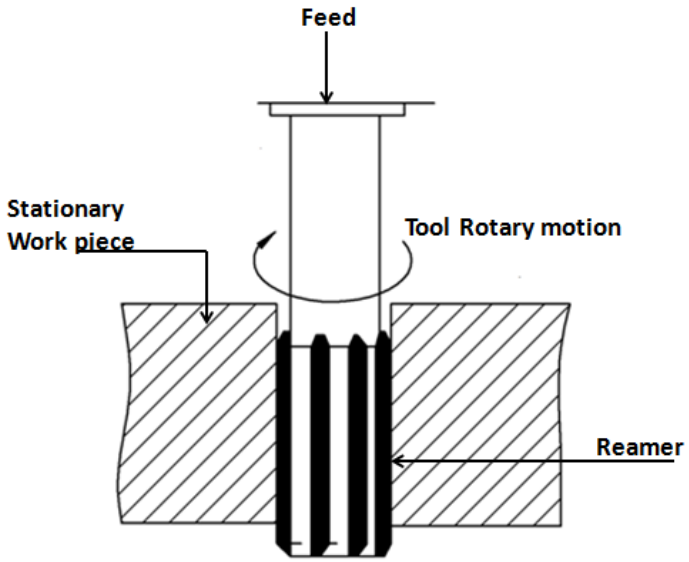


Fig. Reaming operation

4. Tapping

Tapping is the forming of internal screw threads by means of a tool called a tap. A tap is a multipoint cutting tool having screw on it. Tapping can be done manually or machine. Machine tapping is widely used on production work.

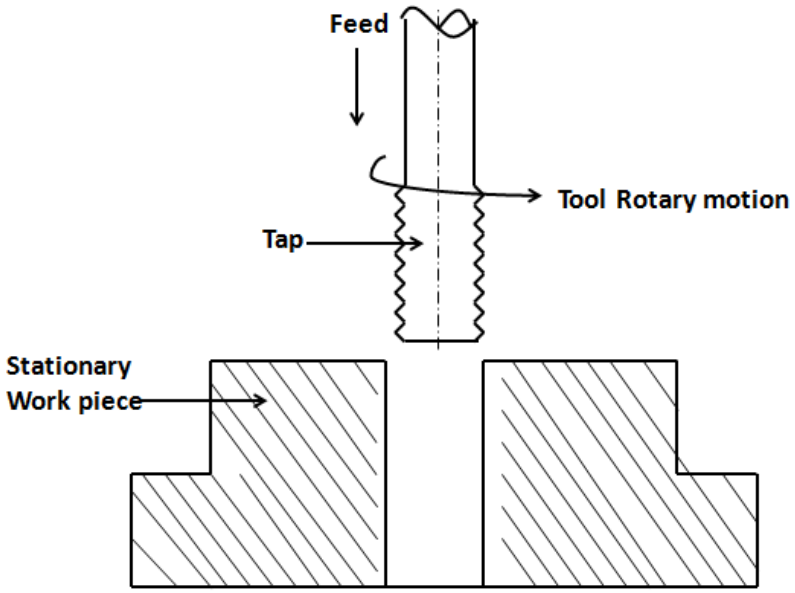
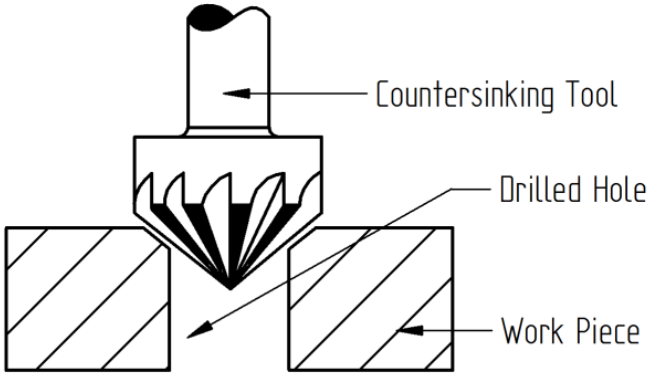


Fig. Tapping operation

5. Counter Sinking

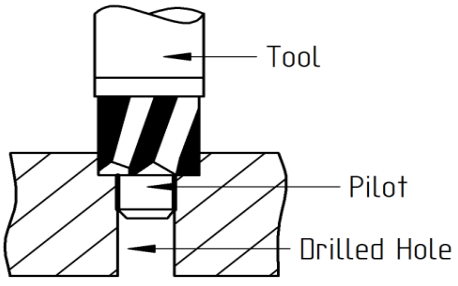
Counter sinking is the operation of making a conical shaped at the top of the hole in a previously drilled cylindrical hole. Countersinking is done to fit in a screw or a countersink rivet. The top of the hole is conical in shape compared to square shape in counter boring. Initially a hole is drilled in the work piece using a drill bit. Then the counter sinking tool is used to make cone shaped hole at the top.



Countersinking

6. Counter Boring

It is the operation of enlarging the top end of a hole cylindrically. This forms a square shoulder to the original hole. This is necessary in some cases to accommodate the heads of bolts, studs and pins. The counter boring tool is a multi point cutting tool. The counter boring operation is carried out at much lesser speed compared to drilling. At the tip of the tool a pilot, extends beyond cutting edge guides, the tool for proper alignment with the work piece.

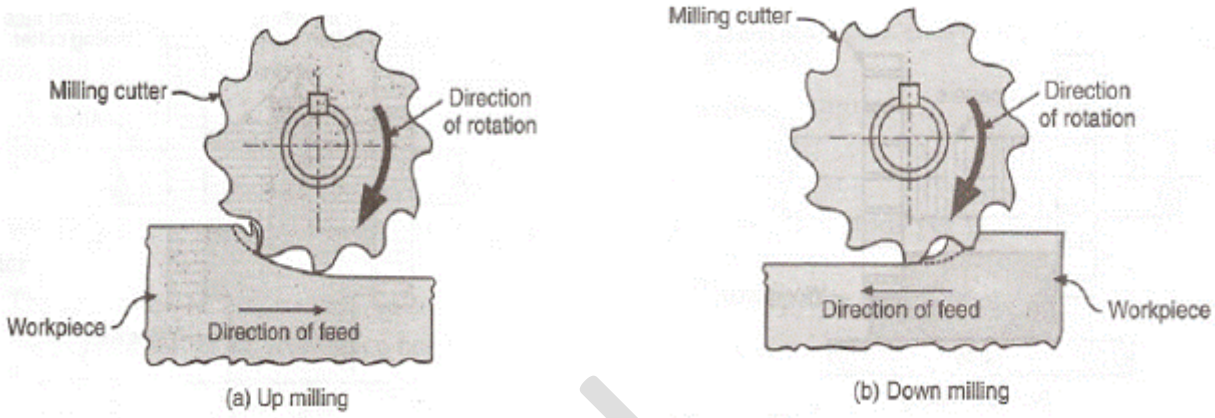


Counterboring

3. MILLING

Milling is one of the most versatile machining processes or a metal cutting process for removing excess material from a work piece with a rotating multiple cutting tools

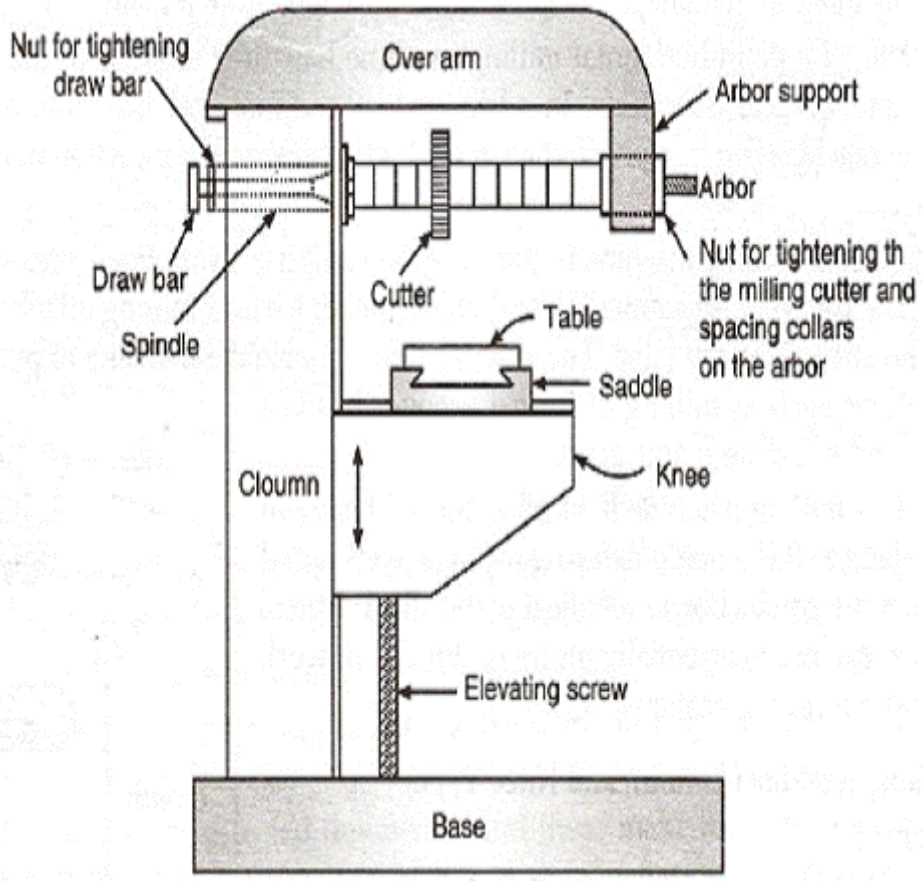
Methods of Milling:



1. Up milling: It is the process of removing metals by cutter which is rotated in the opposite direction of travel of the work piece.

2. Down milling: It is the process of removing metals by cutter which is rotated in the same direction of travel of the work piece.

Horizontal Milling Machine Construction: The main part of machine is base, Column, Knee, Saddle, Table, Overarm, Arbor Support and Elevating Screw.



1. **Base**: It gives support and rigidity to the machine and also acts as a reservoir for the cutting fluids.

2. **Column**: The column is the main supporting frame mounted vertically on the base. The column is box shaped, heavily ribbed inside and houses all the driving mechanisms for the spindle and table feed.

3. **Knee**: The knee is a rigid casting mounted on the front face of the column. The knee moves vertically along the guide ways and this movement enables to adjust the distance between the cutter and the job mounted on the table. The adjustment is obtained manually or automatically by operating the elevating screw provided below the knee.

4. **Saddle**: The saddle rests on the knee and constitutes the intermediate part between the knee and the table. The saddle moves transversely, i.e., crosswise (in or out) on guide ways provided on the knee.

5. **Table**: The table rests on guide ways in the saddle and provides support to the work. The table is made of cast iron, its top surface is accurately machined and carriers T-slots which accommodate the clamping bolt for fixing the work. The worktable and hence the job fitted on it is given motions in three directions

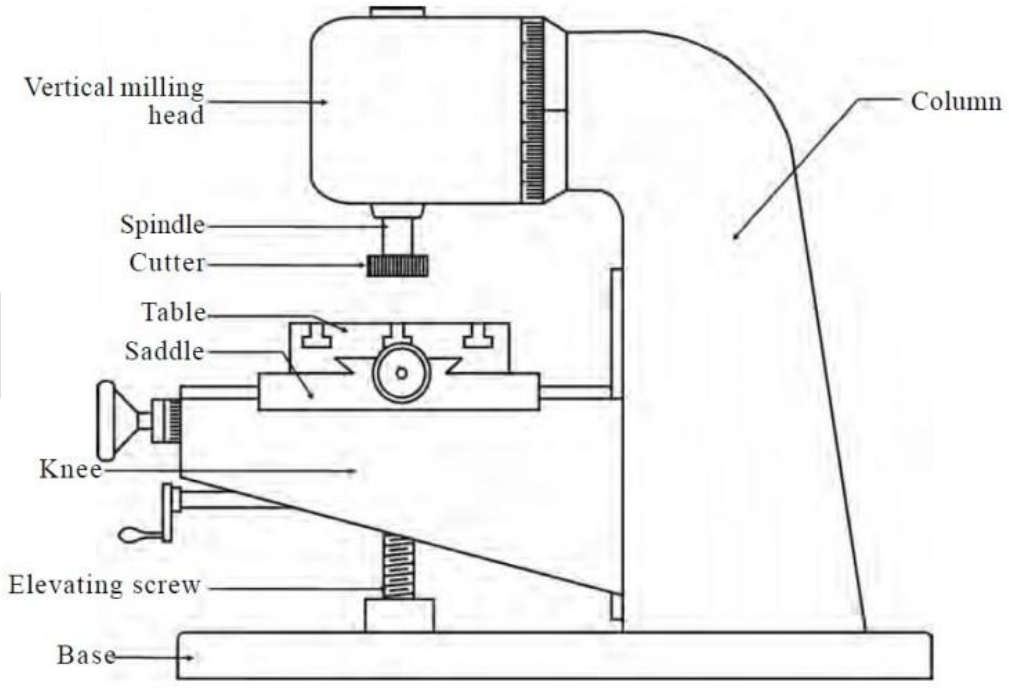
6. **Overarm**: The Overarm is mounted at the top of the column and is guided in perfect alignment by the machined surfaces. The Overarm is the support for the arbor.

7. **Arbor support**: The arbor support is fitted to the Overarm and can be clamped at any location on the Overarm. Its function is to align and support various arbors. The arbor is a machined shaft that holds and drives the cutters.

8. **Elevating screw**: The upward and downward movement to the knee and the table is given by the elevating screw that is operated by hand or an automatic feed

2. **Vertical Milling Machine Construction**

It is very similar to a horizontal milling machine in construction as it has the same parts of base, column, knee, saddle and table. The spindle of the machine is positioned vertically. The cutters are mounted on the spindle. The spindle is rotated by the power obtained from the mechanism placed inside the column. Angular surfaces are machined by swiveling the spindle head.



Vertical Milling Machine

❖ MILLING OPERATIONS

The different types of milling operations that can be carried out on a milling machine are

1) Slab or plain milling
2) End milling
3) Slotting
4) Face milling
5) Angular milling
6) Straddle milling
7) Form milling
8) Gang milling

1. Slab or plain milling

The slab milling is the operation of producing flat, horizontal surface parallel to the axis of rotation of a slab-milling cutter. Slab milling is done to remove the material from the upper surface of the work piece. The slab milling cutters is held in the arbor and it may have straight or helical teethes. Both cutters can be used to generate flat surfaces. The require depth of cut can be adjusted by raising the table or the knee and the feed is given by moving the saddle.

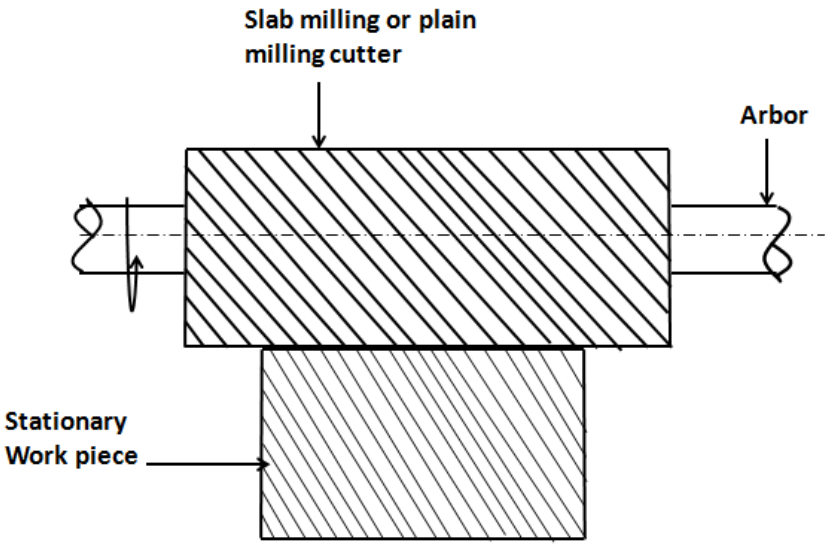


Fig. Slab milling or plain milling

2. **End milling**

These are shank cutters with teeth on the end face as well as periphery. Main types are shell end mills and solid shank. Used for profiling, slotting, keyways and surface milling.

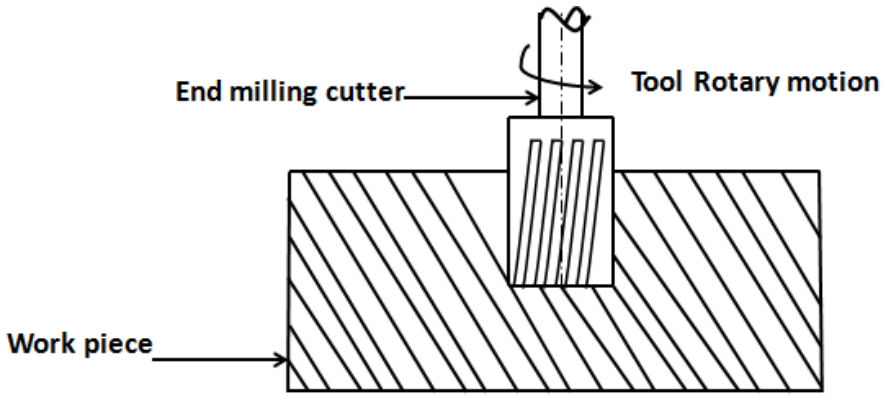


Fig. End milling

3. **Slot milling**

The process of producing keyways grooves and slots of varying shapes and sizes is known as slotting. The side milling cutter is mounted on to the arbor of a horizontal milling machine when slotting had to be done on Horizontal milling machine. T – Slots and dovetail slots are carried out on a vertical milling machine.

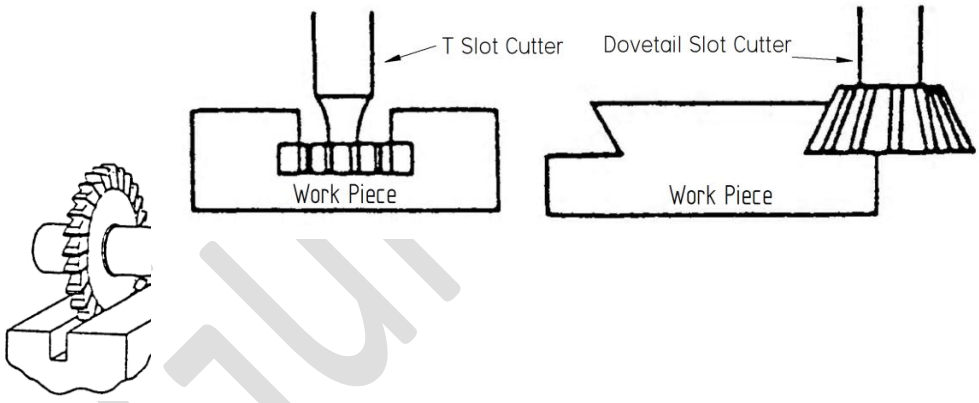
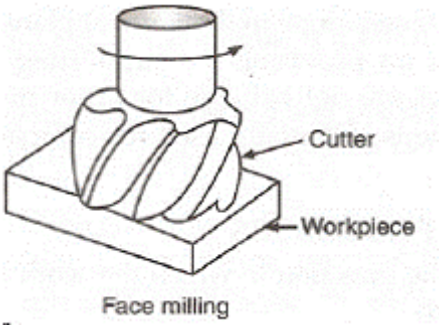


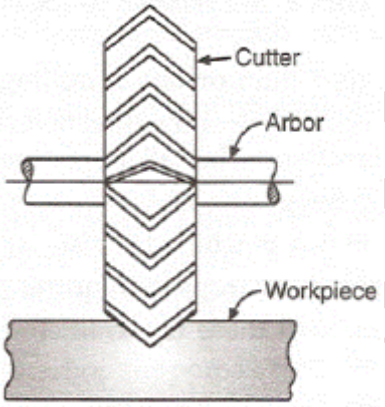
Fig. Simple slotting of key way using side milling cutter

4. **Face milling:** Machining of a flat surface which is at right angles to the axis of the rotating cutter.



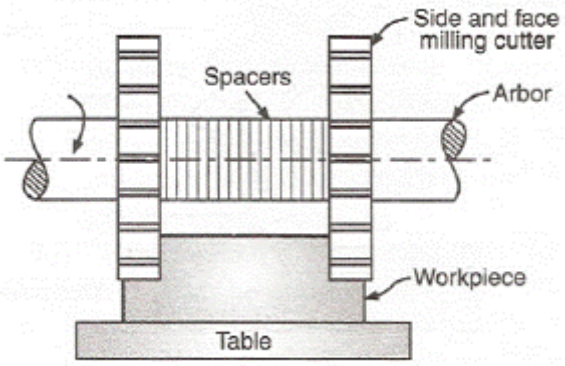
Face milling

5. **Angular milling**: Machining of a flat surface at an angle, other than a right angle, to the axis of revolving cutter.



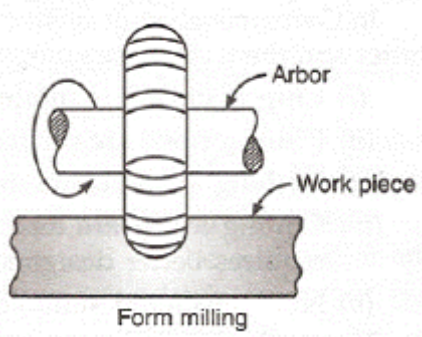
Angular milling

6. **Straddle milling**: Simultaneous machining of two parallel vertical faces of the work-pieces by a pair of side milling cutters.



Straddle milling

7. **Form milling:** Machining of surfaces which are of irregular shape. The teeth of the form milling cutter have a shape which corresponds to the profile of the surface to be produced.



8. **Gang milling:** Simultaneous machining of a number of flat horizontal and vertical surfaces of a workpiece by using a combination of more than two cutters mounted on a common arbor.