$$= \frac{\qquad\qquad}{60} = 21.53 \text{ kW}$$

$$\eta_{mech} = \frac{BP}{IP}$$

$$BP = \eta_{mech} \times IP = 0.8 \times 21.53 = 17.53 \text{ kW}$$

Frictional power (FP)

$$FP = IP - BP$$

$$FP = 21.53 - 17.24 = 4.29 \text{ kW.}$$

MODULE-3
Machines & Machine Tools

Lecture 14:

Objective: Understanding about the meaning of “machine tools” and discussion about working of lathe and its parts.

Introduction

Machining is a material removal process in which a sharp cutting tool is used to mechanically cut away material to obtain desired geometry. The machine used for this purpose is known as a Machine Tool. So, **Machine tools** are defined as power driven cutting tools or machines which enable the removal of excess stock of material from the work piece. It holds both Work-piece (i.e. the one which has to be machined) and the Cutting tool, the one which is used to separate/remove material stock from the work piece. For Eg: hack saw, chisel etc

Machining operation is done by Relative motions between the tool and the work-piece.

There are two different types of Cutting tools and they are Single and Multipoint cutting tools. There are two Metal Cutting Process namely i) Orthogonal Cutting in which the cutting edge of tool is perpendicular to the workpiece axis. ii) Oblique Cutting: The cutting edge is inclined at an acute angle with normal to the cutting velocity vector.

Classification of machine tools based on the tools used:

I. Machine using single point tools

a) Lathe
b) Boring machine
c) Shaping machine
d) Planning machine

II. Machines using multi-point tools

a) Drilling machine
b) Milling machine
c) Broaching machine

III. Machine using abrasives

a) Grinding machine
b) Surface or micro finishing machine

Lathe

Lathes were developed as early as the 15th century and were known as "bow" lathes. The operator rotated the workpiece by drawing a bow back and forth, either by hand or with the use of a foot treadle. Next came Bessons lathe in 1568, which was driven by a cord passing over a pulley above the machine.

Lathes have allowed man to reshape, machine and manufacture many precision cylindrical components made of various types of metal, wood, plastics, and other materials. Without the lathe, man would still be trying to produce cylindrical components.

Some of the features of Lathe:

- Lathe is a machine tool employed generally to produce cylindrical objects.
- A lathe is a general purpose machine tool. Here the work piece is made to rotate at desired speed and the cutting tool is moved either manually or mechanically against the rotating job in specific direction to achieve the desired cutting action.
- By using necessary attachments and accessories, over 200 operations can be performed. Hence it is also popular as “king of machine tools”.

Classification of lathe

Lathes are classified on the basis of drive mechanism, process, purpose etc. the main type are:

a) Center lathe (engine lathe)
b) Speed lathe
c) Bench lathe
d) Tool room lathe
e) Production lathes (capstan and turret lathes)
f) Special purpose lathes
g) Automatic lathe

Construction of a center Lathe (Gear head lathe)

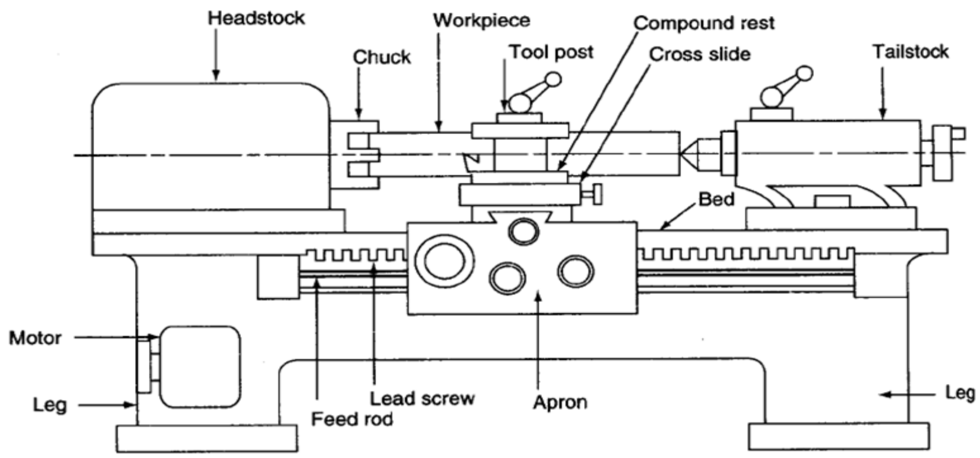


Figure 1: Lathe Machine

Parts of a lathe. (Construction)

1. Bed

The bed is the main component of a lathe. All the major components are mounted on the lathe bed, like tail stock, headstock, carriage, etc. Tailstock and carriage move over the guide ways provided on top face of the bed. The bed material should have high compressive strength and high wear resistance. Cast iron alloyed with nickel chromium forms a good material for bed.

2. Headstock

Headstock is mounted on the left hand side of the lathe bed. The head stock accommodates gear box, which helps to vary the spindle speed. The gear box also transmits the power to other parts like feed rod and lead screw. The chuck or face plate is attached to the spindle which provides mechanical means clutching and rotating the work piece. Head stock is also known as live center

3. Tailstock

The tailstock is mounted on the right hand side of the lathe bed. The function of the tailstock is to support the work piece, and to accommodate different tools like drill, reaming, boring and tapping, etc. The tailstock moves on the guide ways over the bed, to accommodate for different length of work piece. Tailstock is known as dead center.

4. Carriage

The carriage is mounted on the lathe bed, which slides on the guide ways of the bed. The carriage has various other parts like, cross slide, compound rest, and tool post.

5. Saddle

The saddle is mounted on the bed and slides along the ways. On the saddle the cross slide and tool post are mounted. The movement of the saddle is parallel along the axis of the lathe which is known as feed.

6. Cross-slide

The cross slide is mounted on the top of the saddle. This moves the tool at perpendicular to the work piece or machine axis. The cross slide can be moved either by rotating the cross slide hand wheel. The perpendicular distance moved by the cross slide is proportional to the amount of metal removed and it is known as depth of cut.

7. Compound-slide

The compound slide (compound rest) is mounted on the top of the cross slide. The rest part of the compound slide has graduations in degree. It is used to obtain taper on the work piece.

8. Tool-post

The tool post is mounted on top of the compound slide.The tool post holds the tool rigidly.

9. Apron

The apron is fastened to the saddle and hangs over the front of the bed. Apron is fitted with mechanism for both manual and powered movement of the saddle and the carriage. Split nut engages the Apron with lead screw, which is used to cut internal or external threads.

10. Feed rod

Feed rod is a long shaft extending from the feed box. The power is transmitted from a set of gears from headstock. The feed rod is used to move the carriage or cross slide for turning, boring and facing operations.

11. Lead screw

The lead screw is a long threaded shaft connected to the headstock. The lead screw is used only when thread cutting operation is to be carried out on the work piece. For normal turning operations the lead screw is disengaged.

Lecture 15:

Objective: Discussion about important Lathe operation principle and its operations with sketches.

Principle of lathe Operation:

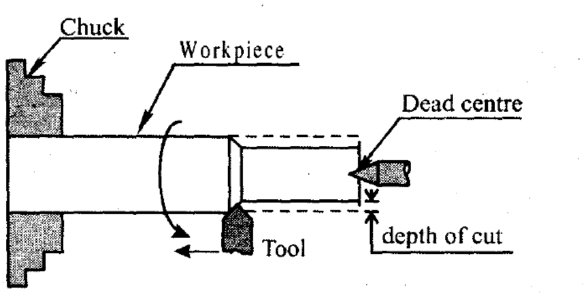


Figure 2: Working principle of Lathe

The principle of Working on a lathe is illustrated in above figure.

Generally a circular job is between the live center and the dead center. The head stock spindle provides the power to rotate the job with a chuck or catch plate. A single point tool is held on the tool post with the cutting edge at the level of the spindle axis and close to the job at its circumference. Cutting action is obtained by tool movement perpendicular to the axis of rotation (depth of cut) and simultaneously moving it parallel to the axis of rotation (feed) along the job. For a set depth of cut, the carriage is moved from right to the left, the tool is feed from the job and the carriage is moved back to the initial position. Depth of cut is set and the feed is given as explained.

Lathe Operations

1. Facing
2. Straight Turning
3. Knurling
4. Taper turning
5. Thread cutting

Facing

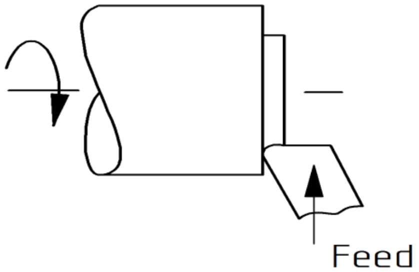


Figure 2: Facing operation

Facing is the process of removing metal from the end of a work piece to produce a flat surface. The work piece rotates about its axis and the facing tool is fed perpendicular to the axis of lathe.

Turning

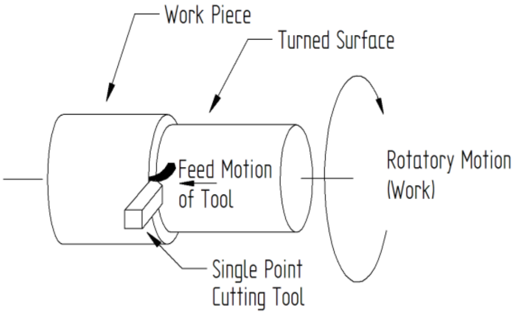


Figure 3: Turning operation

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. Here the cutting tool is fed against the revolving work piece and is then moved parallel to the lathe axis so as to produce a cylindrical surface.

Knurling-

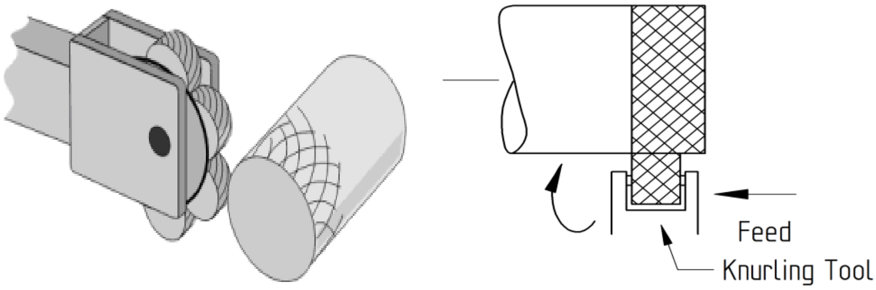


Figure 4: Knurling operation

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 pressed against the rotating work piece and pressure is slowly increased until the tool produces a pattern on the work piece. Sometimes more than one pass may be required to get a deep cut. Depending on the knurling tool selected, a variety of knurled patterns can be produced.

Lecture 16:

Objective: Discussion about different taper turning operations, thread cutting and lathe specifications.

Taper turning

A taper may be defined as a uniform increase or decrease in diameter of work piece measured along its length. Taper surface is generated on a cylindrical work piece. The amount of taper in a work piece is usually specified by the difference in diameters of the taper to its length.

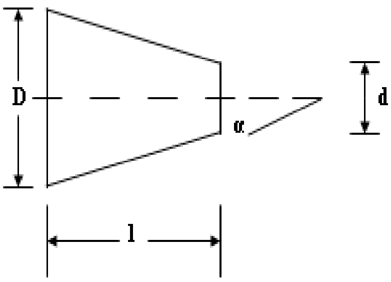


Figure 5: Taper

Where,

D- Large diameter of taper in mm.

d- Small diameter of taper in mm.

l- Length of tapered part in mm.

α- Angle of taper or half taper angle.

The taper turning is done on a lathe by different methods and the selection of method depends on length of taper to be generated on the work piece.

- The different methods of taper turning are

a) Taper turning by form tool method

b) Taper turning by swiveling the compound rest.

c) Taper turning by offsetting the tail stock

d) Taper-turning by taper turning attachment.

Taper Turning by Swiveling Compound Rest

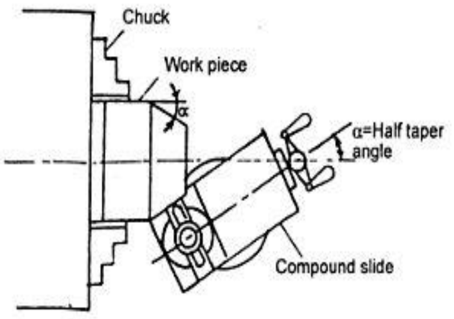


Figure 7: Taper Turning by Swiveling Compound Rest

Here the compound rest has rotating base graduated in degrees, which can be rotated to any angle (according to the taper angle). 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.

- Formula which is used to calculate taper angle is $\tan \alpha = (D - d) / 2L$
  Where
  α = Half taper angle

  D= Large diameter

  d= Small diameter

  L= Length of taper

Thread cutting-

Thread cutting or threading is an operation for cutting screw threads on metallic parts. Fig shows a thread cutting operation.

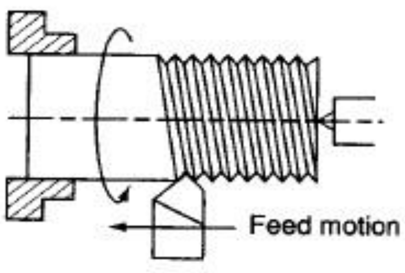


Figure 8: Thread cutting

SPECIFICATION OF LATHE:

The size of the lathe is specified by one or more of the following criteria.

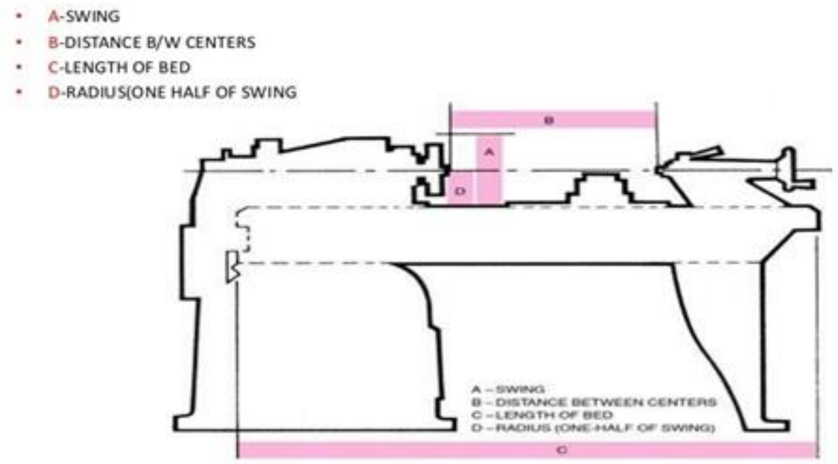


Figure 9: Lathe Specifications

- **Distance between centers:** It is the maximum length of the job that can be held between the centers, i.e., between live center and the dead center.
- **Swing diameter:** it is the maximum diameter of the work piece that can revolve without touching the guide ways.
- **Height of centers:** It is the height measured from the bed to the lathe center axis.
- **Length of bed:** It indicates the approximate floor space occupied by the lathe.
- **Range of Spindle speeds.**

Lecture 17:

Objective: Discussion about principle of drilling machine and their classification.

Drilling machines

Drilling is an operation of producing cylindrical holes in solid metal/nonmetals by means of a revolving tool called drill bit or twist drill. The machines employed for drilling holes are called drilling machines. Drilling machine is the one of the essential machine tool used in fabrication, production shop and tool rooms, for machining/producing holes. The machine consists of a spindle which provides rotary motion to the drilling tool (twist). The spindle may also produce motion to table on which the work rests.

Principle of operation

The hole is generated by the rotating drill bit, which exerts large force on the work piece clamped rigidly on the machine table. The figure below illustrates a cross section of a hole being cut by a common twist drill.

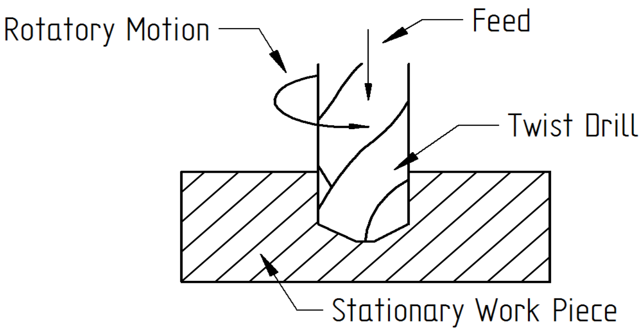
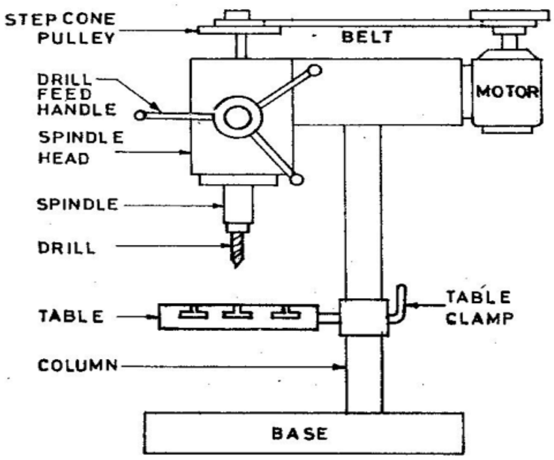


Figure10: Principle of drilling operation

Types / classification of Drilling Machines

1. Portable drilling machine
2. Bench Drilling Machine (Sensitive drilling machine)
3. Upright drilling machine
4. Radial drilling machine
5. Gang drilling machine
6. Multiple spindle drilling machine
7. Automatic drilling machine
8. Deep-hole drilling machine.

Bench drilling Machine (Sensitive drilling machine):



Bench drilling Machine & Radial drilling Machine

These are belt driven, general purpose, and small machine capable of drilling only small diameter holes. These are also called sensitive drilling machine because they require skilled operator who needs a sense of feeling of manual feed. The spindle speed will be around 20,000rpm.

Operation:

The hole location on the job/ work piece is made with a center punch. It is then made deeper using a combined drill and counter sink. It helps to guide the drill smoothly without any walk off the punch mark. The drill is fixed in the chuck using the key. The work piece is clamped on to the work table over a wooden piece with suitable fixture which can be raised and clamped at the required height, so that the drill can penetrate the job. The drill is slowly fed on to the center mark. With a sense of feeling suitable pressure is applied on the job for the right feed. As the drill starts to penetrate, the pressure should be reduced gradually on the down feed. Feeling the cutting action, the operation should be completed. The drill is withdrawn carefully by rotating the hand wheel in the reverse direction.

Radial drilling machine

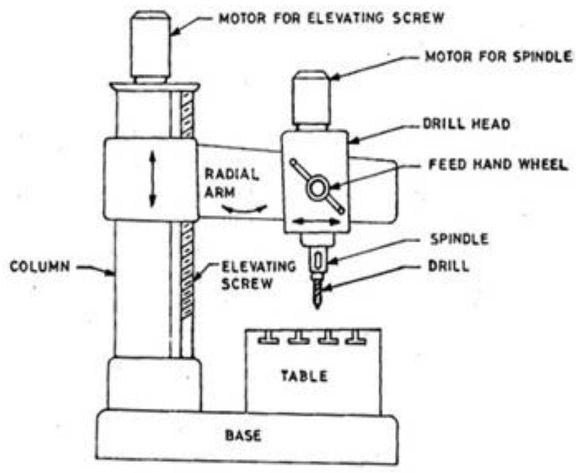


Figure 12: Radial drilling Machine

It is a heavy duty precision machine. Designed for universal movements of the arm with a tool head over a stationary work piece. Its arm will be automatically clamped on the vertical column when the elevating mechanism is stopped.

Operation:

After locating the hole positions, the work piece is mounted on the work table using suitable fixtures. Suitable drill and coolant are selected. The drill is fitted into the spindle. The tool head (drill) is brought over the work piece by swinging and moving the arm in the necessary up, down, left or right direction. The necessary feed and speed are calculated and set on the drill head drive mechanism. The machine is started and drilling may then be performed as usual.

Drilling machine operations

1) Drilling
2) Reaming
3) Boring
4) Counter boring
5) Counter sinking
6) Tapping

Lecture 18:

Objective: Discussion about different operations performed on drilling machine.

Drilling:

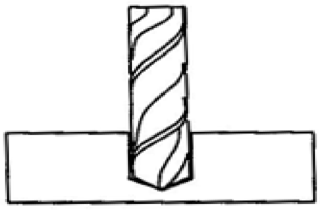


Figure 13: drilling operation

It is the operation of producing cylindrical holes in solid objects by means of a revolving tool called drill bit. Initially the center of the hole is marked by two cross lines, and a center punch is used to highlight the center. The hole is generated by the sharp edges of the rotating drill bit that is forced to move against the rigidly clamped work piece. The chips get curled and escapes through the helical grooves (flutes) provided in the drill bit. A drilled hole will have the rough size of the required hole and needs further sizing and finishing operations.

Reaming:

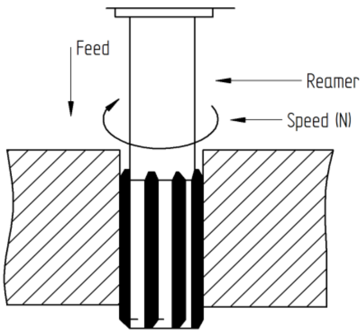


Figure 14: Reaming operation

It is a finishing operation of a predrilled hole using a reamer (tool) which has multi-longitudinal straight flutes. A reamer will have diameter equivalent to that of the hole diameter to be finished. The reaming speed is almost half that of the drilling speed. The material is removed in small amounts, and hence the surface of the drilled hole is finished with high accuracy. The amount of material to be removed should not exceed 0.125mm. It should be used only to remove small amounts of material. This ensures a long life for the reamer and also a superior finish to the hole.

Boring:

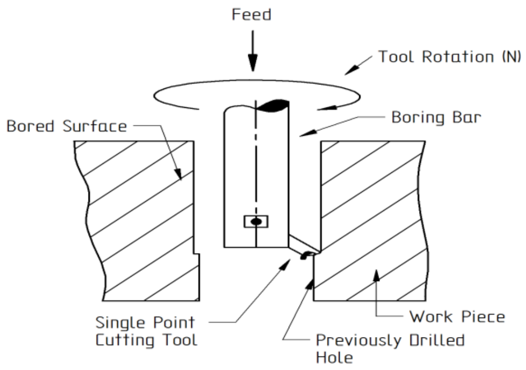


Figure 15: Boring operation

Boring is a hole enlarging operation performed on a previously drilled hole using a boring tool. Boring is also performed to finish a drilled hole, to machine rough surfaces of cast holes and to correct the hole center and roundness of a hole. This operation is performed at a very slow speed. This operation is performed when a drill bit of the required dimension is not available. In such case, a hole is first drilled to the nearest dimension, and then a single point cutting tool is fastened and adjusted to a boring bar to enlarge the size of the existing hole to the required dimension. In addition to enlarging a previously drilled hole, boring operation corrects the hole location and out-of-roundness, if any, as the tool can be adjusted to remove more metal from one side of the hole than the other.

Counter boring

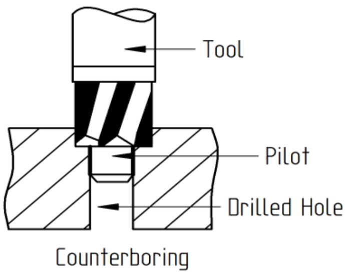


Figure 16: counter boring

It is an operation to enlarge one end of the predrilled hole concentrically to the required depth, using a counter bore tool, to form a square shoulder. A counter bore tool has two or more teeth, and straight or helical flutes that provide the passage for escape of chips and also inlet for passing coolant. The pilot of the tool helps to maintain concentricity with the original hole. Used to drive in the socket head screws, bolts, pins etc. It is replaceable depending on the required size.

Lecture 19:

Objective: Discussion about different operations performed on drilling machine like counter-sinking, tapping and spot facing. And specifications of drilling machine.

Counter sinking:

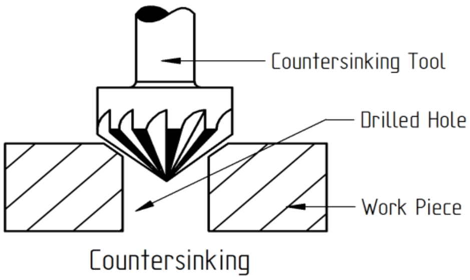


Figure 17: counter sinking operation

It is the operation of producing a conical shaped hole in a previously drilled cylindrical hole. The tool used for this operation is called as a counter sink. Counter sinking is also used for locating a center on the work piece and for deburring operation (Deburring- work pieces that are machined by certain processes consists of ragged edges or protrusions called burrs. The process by which burrs are removed is known as deburring). The tool used for the operation is called counter sink and are made in angles of 60° for centering, 82° for counter sinking flat headed screws, 90° for deburring, and 120° for chamfering operations.

Tapping:

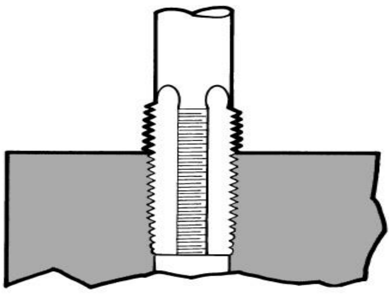


Figure 18: Tapping operation

Tapping is the process of cutting internal threads with a thread cutting tool called a Tap. Taps are fluted threaded tool and are available in standard sizes. Hence, to generate a specific size thread in the work piece, a hole with diameter smaller than the size of the tap is first drilled using a twist drill and then using a standard size tap; threads are cut in the same way as drilling. While tapping, the spindle has to rotate at slow speeds compared to drilling. Generally done on a drilling m/c when identical threading is required on large number of parts.

Spot facing:

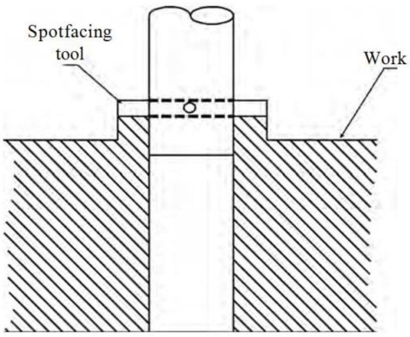


Figure 19: Spot facing

Spot facing is a finishing operation to produce a flat round surface around a hole to provide a seat for a bolt head, nut or washer as shown in the fig.

Specification of drilling machine:

- **Drill Capacity-** It is the depth of the hole that can be drilled Ex; 20 mm
- **Diameter of column**
- **Length of arm**
- **Number of spindle speeds** Ex: 8 (Gear drive)
- **Range of spindle speeds.** Ex: 80-1800rpm
- **Power required.** Ex: 1hp for spindle drive motor and 0.5hp for elevating motor.