MCP 101

Product Realization by Manufacturing

Lab Manual

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Chapter 1

MACHINE SHOP

In a machine shop, metals are cut to shape on different machine tools. The work is performed due to relative motion between the job and tool. A machine tool generally consists of a number of parts as following.

1. Base
2. Power source with arrangement of gear box or other power transferring mechanism
3. Work piece holding component like chuck, table, vice, etc.
4. Tool holding device like tool post, arbor etc.

Following are the machine tools which are used in machine shop for different types of operations and shapes.

1. Lathe machine: A lathe is used to cut and shape the metal by revolving the work against a cutting tool. The work is clamped either in a chuck, fitted on to the lathe spindle or in-between the centers. The cutting tool is fixed in a tool post, mounted on a movable carriage that is positioned on the lathe bed. The cutting tool can be fed on to the work, either lengthwise or cross-wise. While turning, the chuck rotates in counter-clockwise direction, when viewed from the tail stock end.

2. Shaper machine: Shapers are intended to produce horizontal, vertical or inclined flat surfaces by means of a reciprocating single point cutting tool. Tool is given reciprocating motion with the help of mechanism. In shaper the tool is held in the tool post of reciprocating ram and the work piece is held in a vice. Cutting takes place in the forward stroke and no material is removed in the return stroke. Work piece is given indexed feed perpendicular to the direction of ram at the end of return stroke.

3. Planer machine: Planer is used to produce large flat surfaces which are almost impracticable to be machined on a shaper. In planer the work piece reciprocates past the stationary single point cutting tool as compared to shaper in which the cutting tool reciprocates past the stationary work.

4. Slotter machine: The vertical position of shaper machine is known as slotting machine which is used to produce splines, slots etc. The slotting machine is a reciprocating machine tool in which, the ram holding the tool reciprocates in a vertical axis and the cutting action of the tool is only during the downward stroke.

5. Drilling machine: Drilling is an operation of producing circular holes in a work piece by using a rotating tool known as drill. In drilling operation hole is produced by feeding the rotating drill in a direction parallel to its axis into a work piece fixed to the table. During cutting the metal comes in contact with the two cutting edges of the tool and removes the metal stock.

6. Grinding machine: Grinding is the metal cutting process in which the material is removed from the work piece by the abrasive action of a rotating cutting tool known as grinding wheel. In grinding wheel abrasive grains are held together by a binding material called bond. Abrasive grains of the grinding wheel act as cutting tool and remove the material in the form of small chips. Grinding is used in finishing operations because it imparts high surface finish by removing a very small amount of material.

7. Surface grinding machine: Surface grinders are used to produce flat surfaces. According to the type of table these can be classified as planer type or rotary type. In planer type grinder is rectangular and may have horizontal or vertical spindles.

8. Power saw: Power saw is power operated saw which is used to shear the metal in large quantity in a short time**.** They are used to cut large sizes (sections) of metals such as steel. Cutting diameters of more than 10 to 15mm is very hard work with a normal hand held hacksaw. Therefore power hacksaws have been developed to carry out the difficult and time consuming work. The heavy 'arm' moves backwards and forwards, cutting on the backwards stroke

10. Milling machine: The milling machine is used to produce, mainly on prismatic components, flat, curved, parallel, stepped, square and inclined faces as well as slots, grooves, threads and tooth systems. The milling cutter performs a rotary movement (primary motion) and the workpiece a linear movement (secondary motion).

Detail of Lathe Machine: Lathe is one of the most versatile and widely used machine tools all over the world. It is commonly known as the mother of all other machine tool. The main function of a lathe is to remove metal from a job to give it the required shape and size. The job is secure1y and rigid1y held in the chuck or in between centers on the lathe machine and then turn it against a single point cutting tool which wi1l remove meta1 from the job in the form of chips. Fig. shows the working principle of lathe. An engine lathe is the most basic and simplest form of the lathe. It derives its name from the early lathes, which obtained their power from engines. Besides the simple turning operation as described above, lathe can be used to carry out other operations also, such as drilling, reaming, boring, taper turning, knurling, screw thread cutting, grinding etc.

The term “engine” is associated with this lathe due to the fact that in the very early days of it development it was driven by steam engine. This lathe is the important member of the lathe family and is the most widely used. Similar to the speed lathe, the engine lathe has all the basic parts, e.g., bed, headstock, and tailstock. But its headstock is much more robust in construction and contains additional mechanism for driving the lathe spindle at multiple speeds. An engine lathe is shown in Fig. Unlike the speed lathe, the engine lathe can feed the cutting tool both in cross and longitudinal direction with reference to the lathe axis with the help of a carriage, feed rod and lead screw. Centre lathes or engine lathes are classified according to methods of transmitting power to the machine. The power may be transmitted by means of belt, electric motor or through gears.

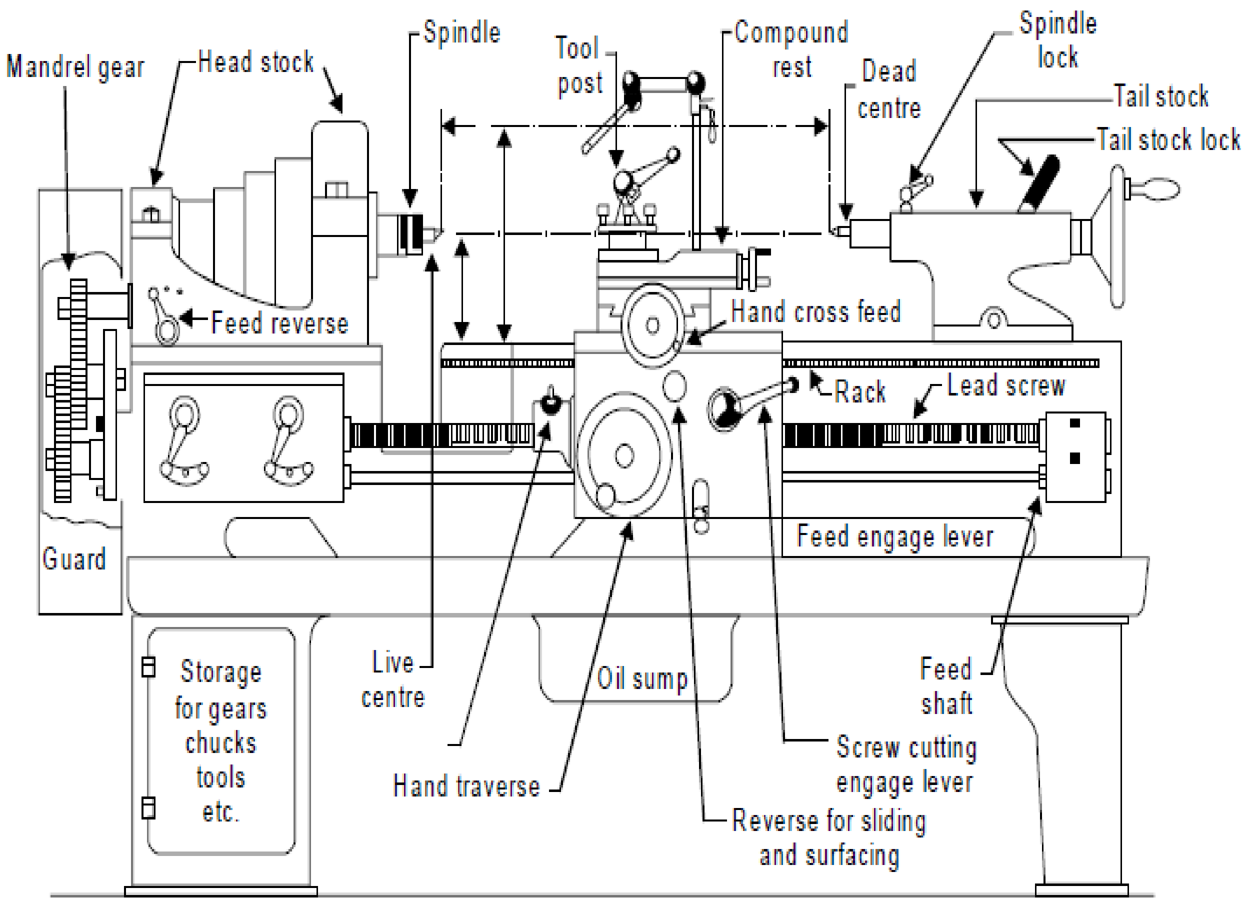


Figure Different parts of engine lathe or centre lathe

LATHE OPERATIONS

1. Straight turning
2. Taper turning
3. Facing
4. Chamfering
5. Thread cutting
6. Grooving
7. Knurling
8. Under cutting
9. Filing
10. Spinning
11. Forming
12. Polishing
13. Solder turning
14. Spring winding
15. Boring

    Drilling

Straight Turning:
Work piece become cylindrical. Motion of tool is parallel to the work piece surface.

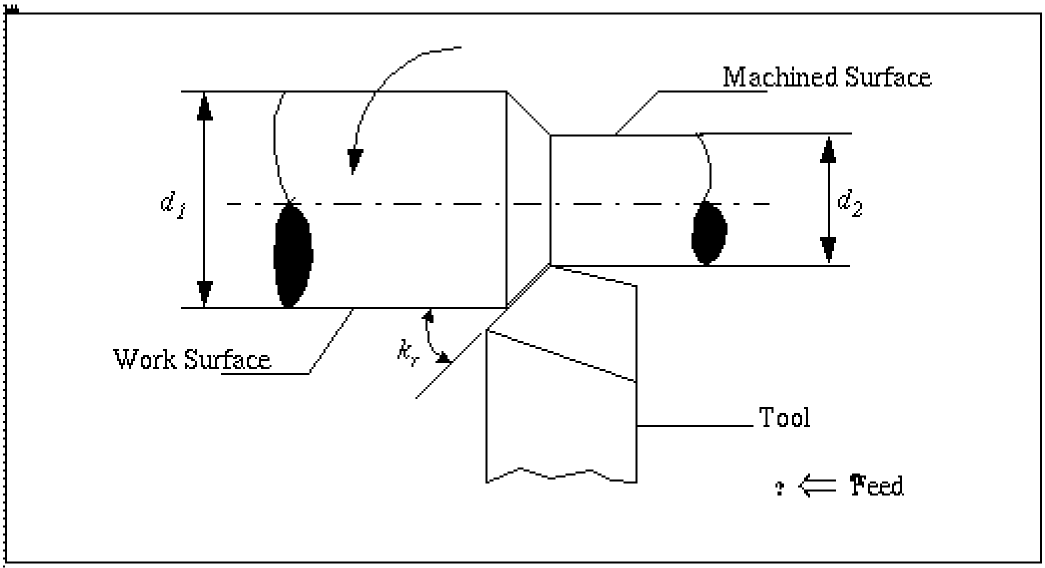
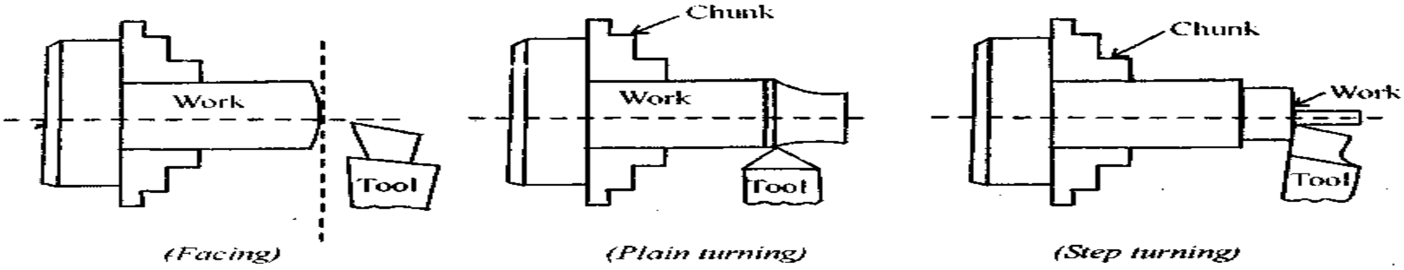


Figure: Straight Turning

Facing:
To make side surface perpendicular via cutting tool .Motion of tool is perpendicular to the work piece surface.

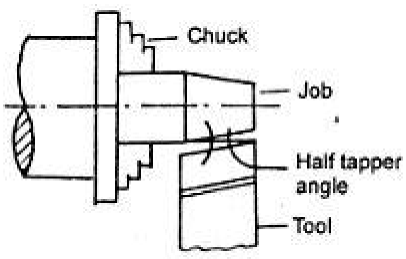


Taper Turning:
Dia. of cylindrical work piece decreasing or increasing gradually is called as taper turning
Types of taper turning:

- By using form tool.
- By setting over tailstock centre.
- By swivelling the compound rest.
- By using taper turning attachment.

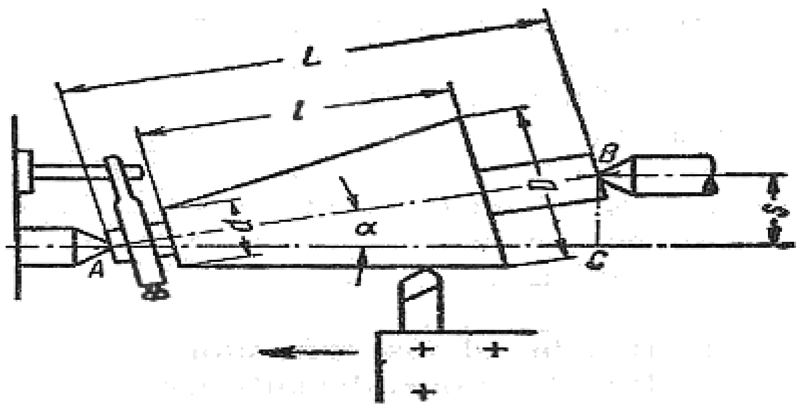
Taper Turning by using form tool:
A broad nose form tool having straight cutting edge makes half taper angle with the axis of work.

- The toll is fed right angle to the work axis.
- Work is held in chuck or face plate.
- Use to turn short length of taper only



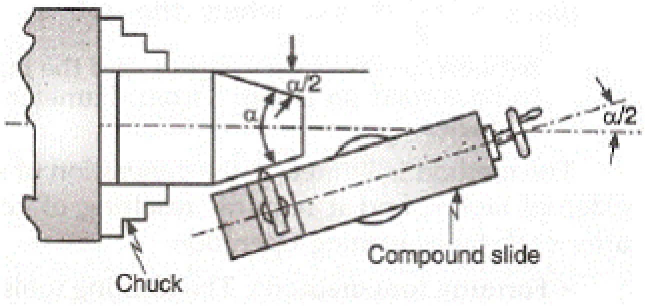
Taper Turning by setting over tail stock:
The method is suitable when the work is held between the centres.

- The work pieces is rotated at an angle to the lathe axis and tool fed parallel to the lathe axis.
- Desired conical surface obtained.
- Use to turn small external taper in long work piece.



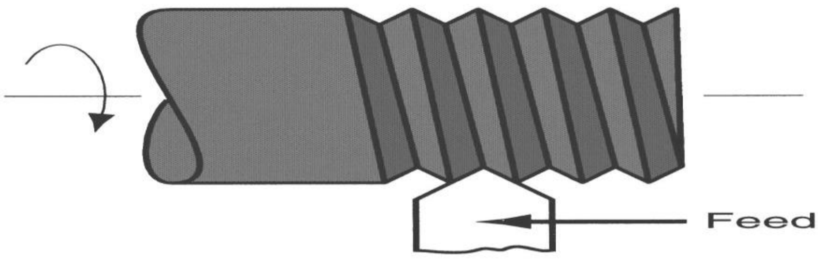
***Taper Turning by swiveling the compound rest*:**

The work piece is rotated at lathe axis and tool is fed at an angle to the axis of rotation of work piece. Tool is mounted on compound rest. The tool can be fed at angle of compound slide as compound rest is mount at half taper angle.



Threading:

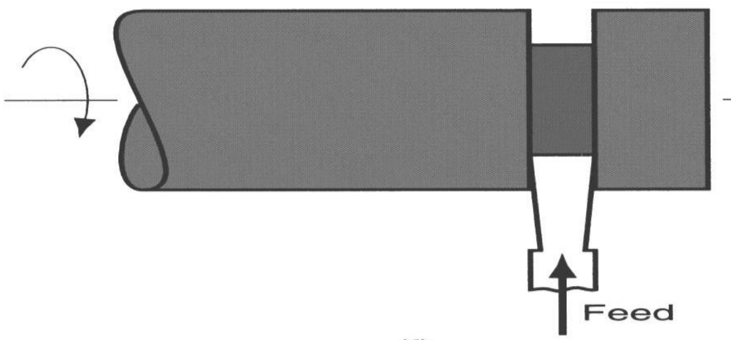
Pointed form tool is fed linearly across surface of rotating work part parallel to axis of rotation at a large feed rate, thus creating threads.



(g)

Grooving:

Tool is fed radially into rotating work at some location to cut off end of part, or provide a groove.



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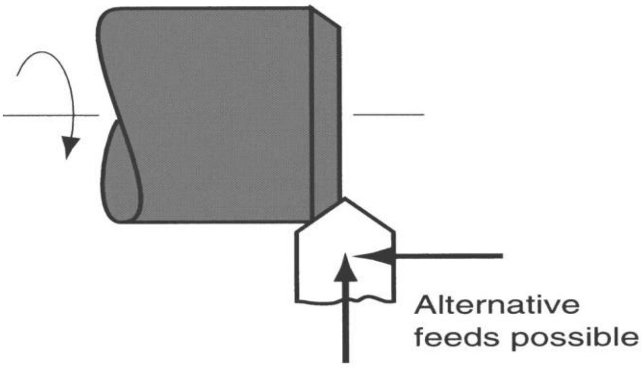
Chamfering:
Cutting edge cuts an angle on the corner of the cylinder, forming a "chamfer"



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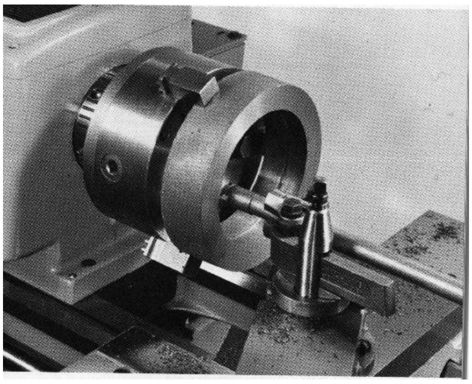
Boring:
Boring produces circular internal profiles in hollow work pieces

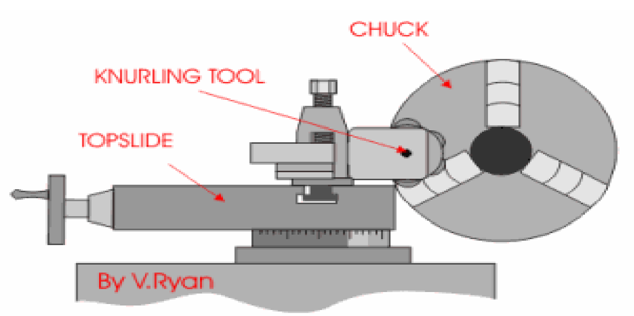


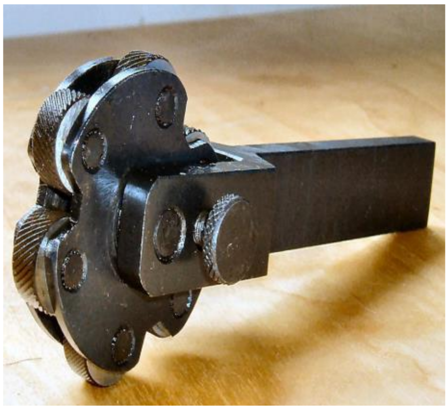
- Boring mills are used for large work pieces
- Holes can be bored up to 20M if needed
- Machines are available with a variety of features

  Horizontal boring machines

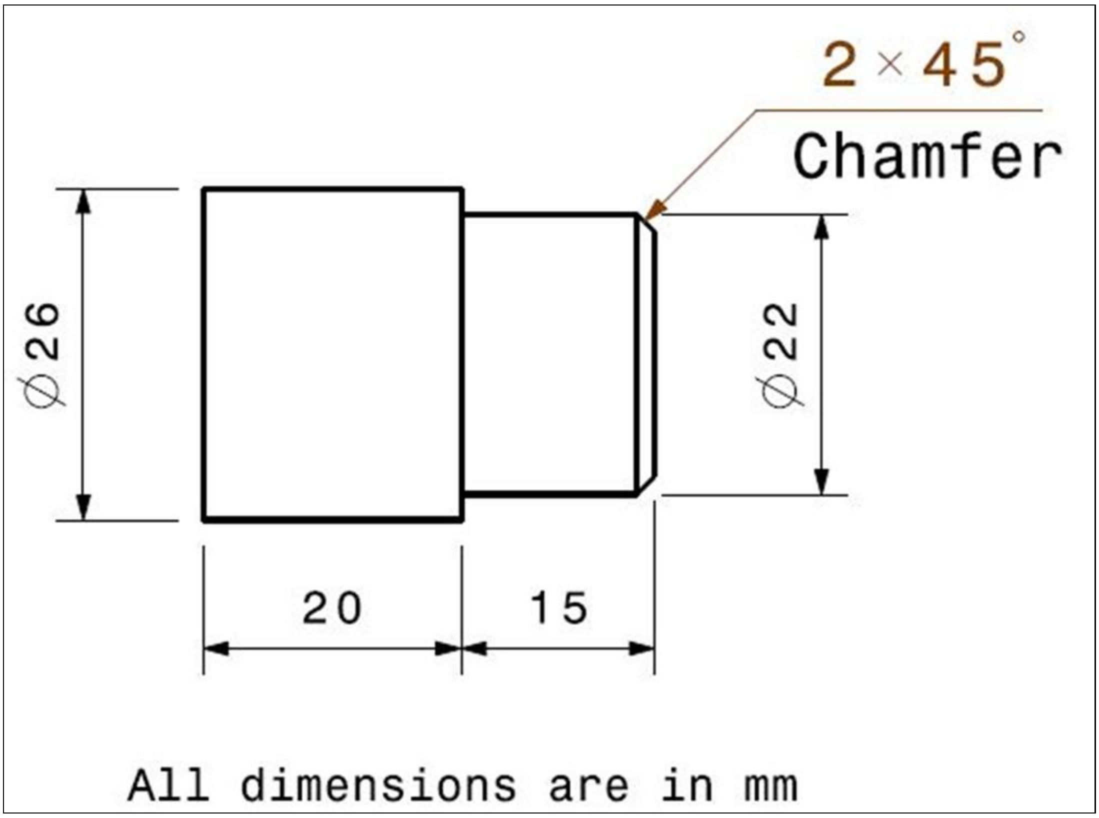
  Jig borers

Knurling:
Knurling is a process of impressing a diamond shaped or straight line pattern into the surface of a workpiece by using specially shaped hardened metal wheels to improve its appearance and to provide a better gripping surface. Straight knurling is often used to increase the workpiece diameter when a press fit is required between two parts.





Machine Shop Job Description



Sequence of Operation:

1. TRUEING (Centering)
2. TOOL CENTERING
3. FACING
4. TURNING
5. MARKING A LINE OF 15mm
6. CHAMFERING

Cutting tool material: HSS (High Speed Steel)

Composition: 18:4:1 (Tungsten: Chromium: Vanadium)

Job Material: Mild Steel, Carbon: 0.25% to 0.35%

Safety precautions

- Learn how to operate machine before using the machine
- Students are advised not to wear chappals/sandals but to be in shoes
- No adjustment, change in speed, repair or oiling should be attempted while machine is running
- Adjustment and secure tool, fasten the workpiece in vice and chuck properly
- If you are not sure of correct & safe method of procedure ask your instructor
- Don't touch any moving part and cutting edge of the tool when machining is in progress
- Machine should not be left unattended whine machine is running.
- Always wear tight clothes, as loose clothes is likely to be caught in machine
- While working on machine. Grinding machine always wear goggles
- When you have finished using the machine release all automatic levers and clean it

Chapter 2

CARPENRY SHOP

Introduction
Carpentry may be defined as the process of making wooden components. It starts from a marketable form of wood and ends with finished products. It deals with the building work, furniture, cabinet making etc. joinery, i.e., preparation of joints is one of the important operations in all woodworks. It deals with the specific work of carpenter like making different types of joints to form a finished product.

Marking and Measuring Tools
Accurate marking and measurement is very essential in carpentry work, to produce parts to exact size. To transfer dimensions onto the work; the following are the marking and measuring tools that are required in a carpentry shop.

1. *Steel rule and Steel tape*
Steel rule is a simple measuring instrument consisting of a long, thin metal strip with a marked scale of unit divisions. It is an important tool for linear measurement. *Steel tape* is used for large measurements, such as marking on boards and checking the overall dimensions of the work.

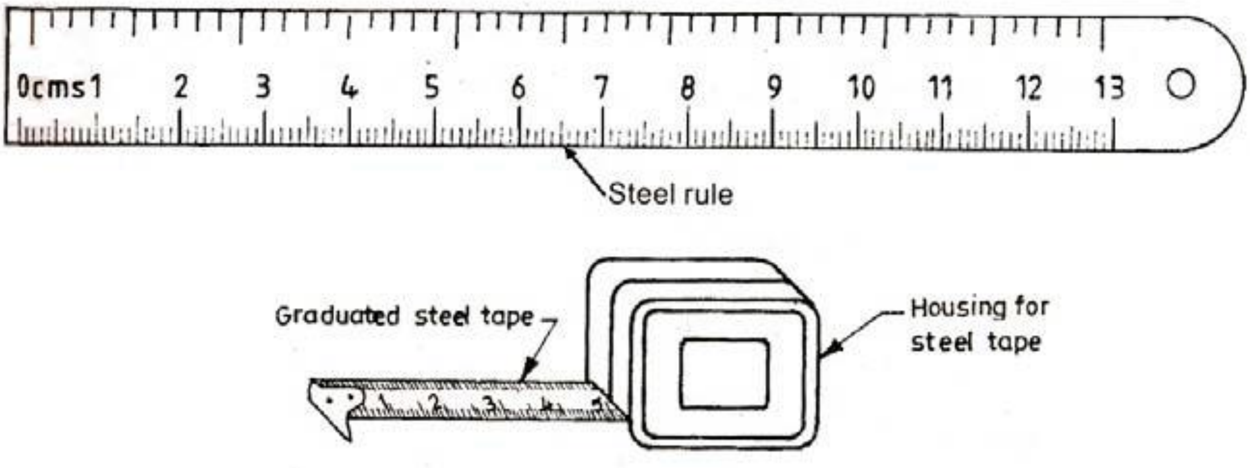
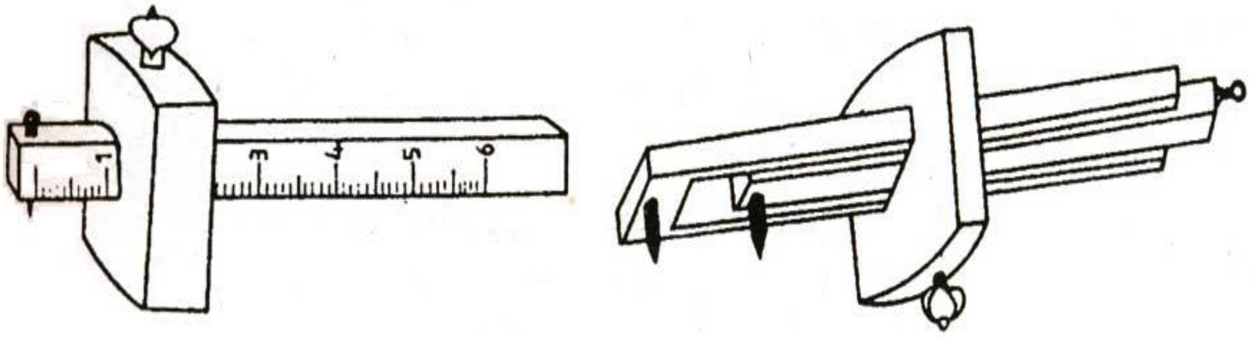


Figure Steel rule and Steel tape

2. ***Marking gauge***
It is a tool used to mark lines parallel to the edge of a wooden piece. It consists of a square wooden stem with a sliding wooden stock (head) on it. On the stem is fitted a marking pin, made of steel. The stock is set at any desired distance from the marking point and fixed in position by a screw. It must be ensured that the marking pin projects through the stem, about 3 mm and the end are sharp enough to make a very fine line. A *mortise gauge* consists of two pins. In this, it is possible to adjust the distance between the pins, to draw two parallel lines on the stock.



a. Marking gauge b. Mortise gauge

Figure Marking gauges

3. ***Try-square***
It is used for marking and testing the squareness and straightness of planed surfaces. It consists of a steel blade, fitted in a cast iron stock. It is also used for checking the planed surfaces for flatness. Its size varies from 150 to 300 mm, according to the length of the blade. It is less accurate when compared to the try-square used in the fitting shop.

Figure Try square

4. ***Compass and divider***

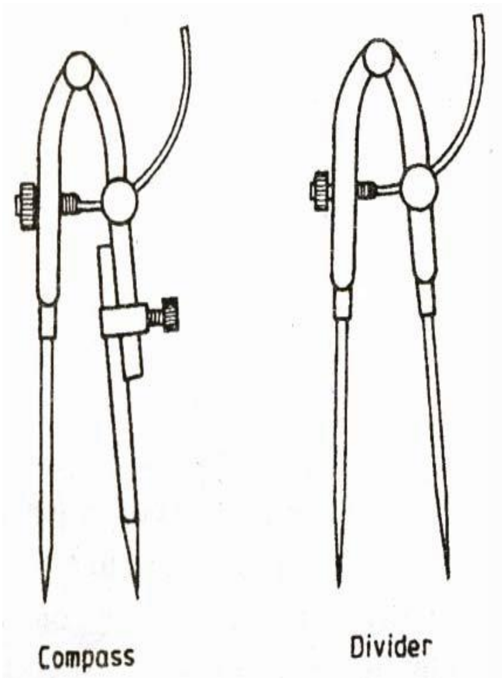
Compass and divider, are used for marking arcs and circles on the planed surfaces of the wood.

5. ***Scriber or marking knife***

It is used for marking on timber. It is made of steel having one end pointed and the other end formed into a sharp cutting edge.

6. ***Bevel***

It is used for laying-out and checking angles. The blade of the bevel is adjustable and may be held in place by a thumb screw. After it is set to the desired angle, it can be used in much the same way as a try-square. A good way to set it to the required angle is to mark the angle on a surface and then adjust the blade to fit the angle.



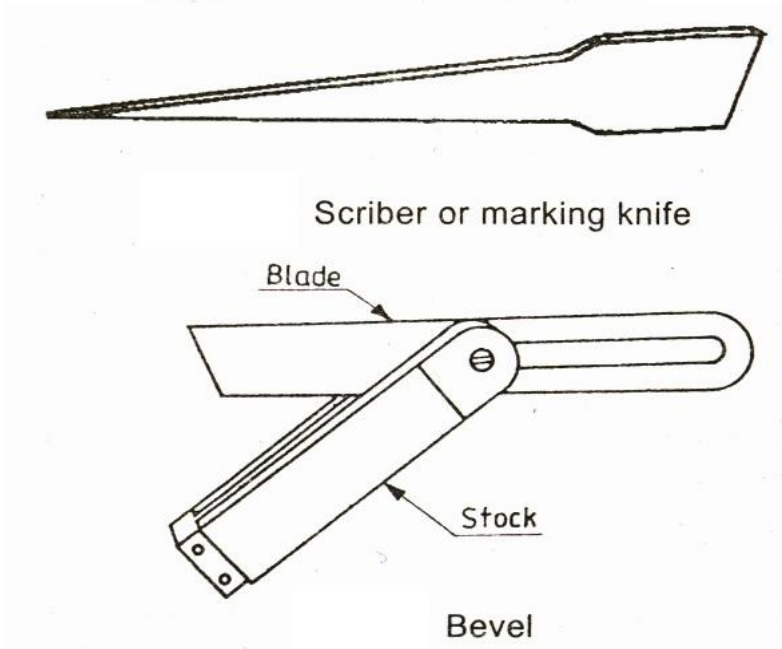


Figure Compass and Divider

Figure Scriber and Bevel

Holding tools

1. ***Carpenter's vice***
Figure shows the carpenter's bench vice, used as a work holding device in a carpenter shop. Its one jaw is fixed to the side of the table while the other is movable by means of a screw and a handle. The Carpenter's vice jaws are lined with hard wooden' faces.

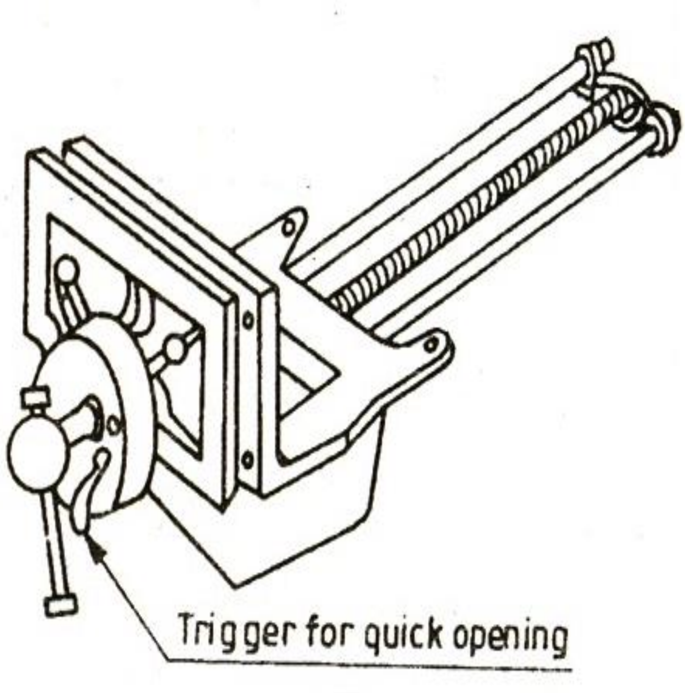


Figure Carpenters vice

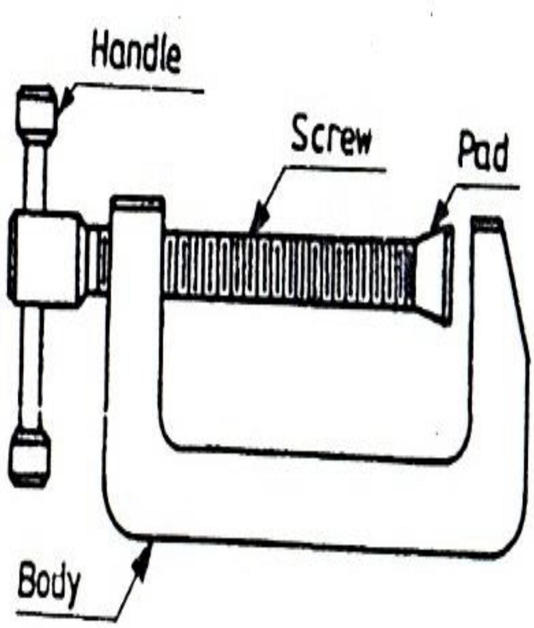


Figure C-clamp

2. ***C-clamp***
Figure 2.7 shows a C-clamp, which is used for holding small works.

3. ***Bar cramp***
Figure 2.8 shows a bar cramp. It is made of steel bar of T-section, with malleable iron fittings and a steel screw. It is used for holding wide works such as frames or tops.

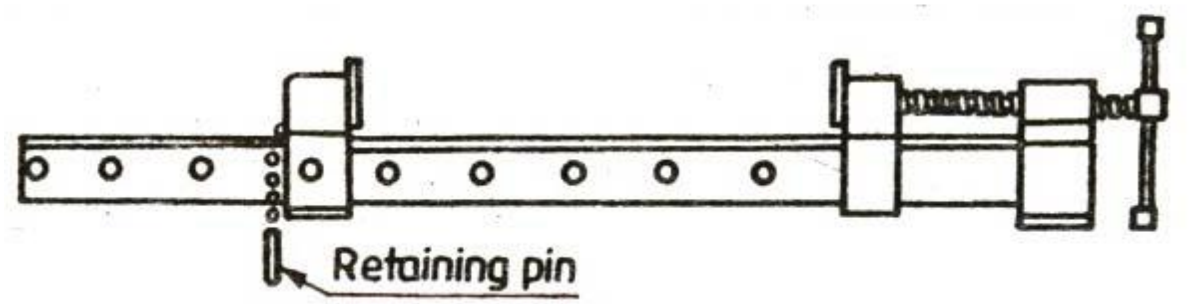


Figure Bar cramp

Planing tools

Planing is the operation used to produce flat surfaces on wood. A plane is a hand tool used for this purpose. The cutting blade used in a plane is very similar to a chisel. The blade of a plane is fitted in a wooden or metallic block, at an angle.

1. *Jack plane*

It is the most commonly used general purpose plane. It is about 35 cm long. The cutting iron (blade) should have a cutting edge of slight curvature. It is used for quick removal of material on rough work and is also used in oblique planning.

2. *Smoothing plane*

It is used for finishing work and hence, the blade should have a straight cutting edge. It is about 20 to 25 cm long. Being short, it can follow even the slight depressions in the stock, better than the jack plane. It is used after using the jack plane.

3. *Rebate plane*

It is used for making a rebate. A rebate is a recess along the edge of a piece of wood, which is generally used for positioning glass in frames and doors.

4. *Plough plane*

It is used to cut grooves, which are used to fix panels in a door. Figure shows the various types of planes mentioned above.

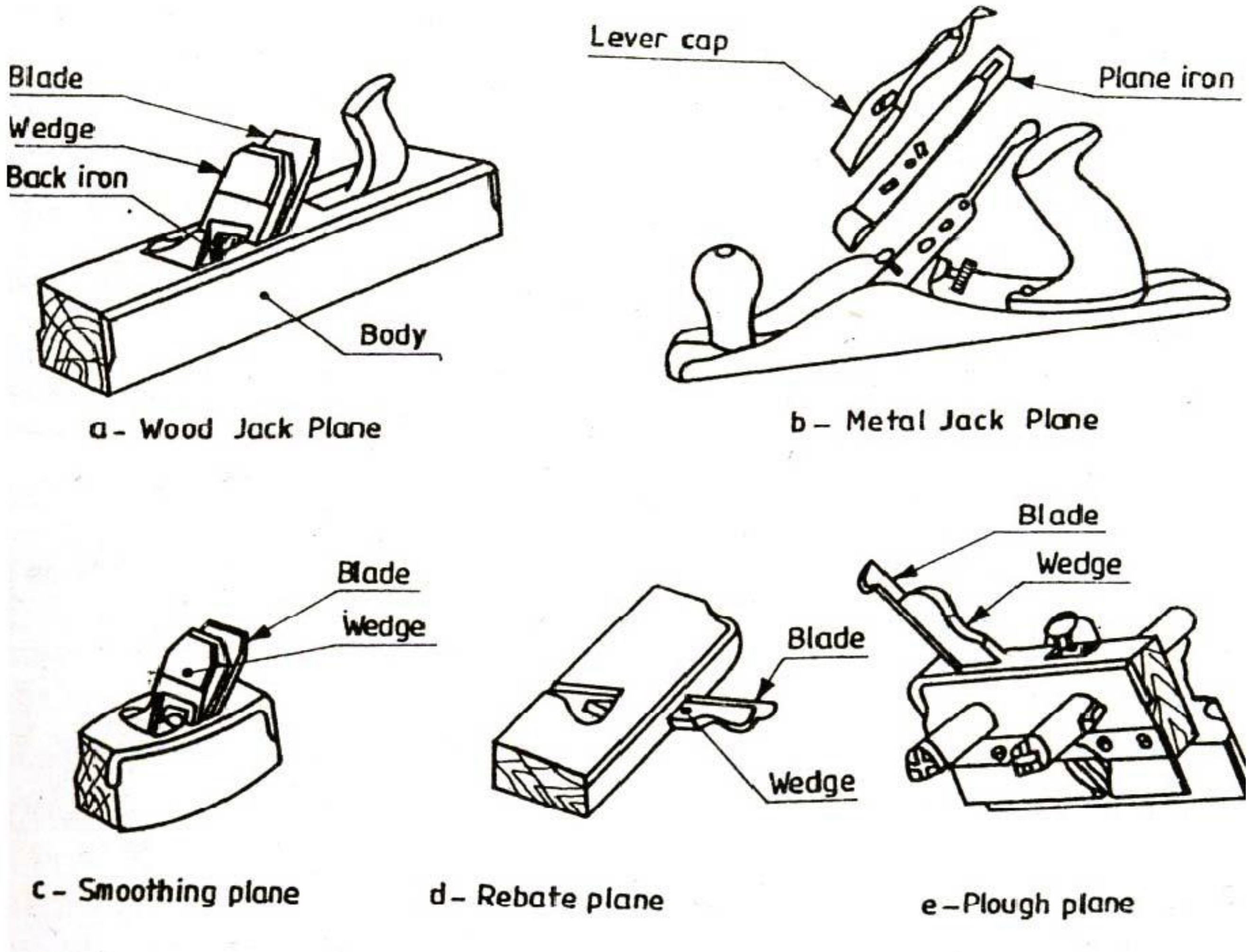


Figure Types of planes

Cutting tools

1. ***Saws***

A saw is used to cut wood into pieces. There are different types of saws, designed to suit different purposes. A saw is specified by the length of its toothed edge.

1.1 ***Cross-cut or hand saw***

It is used to cut across the grains of the stock. The teeth are so set that the saw kerf will be wider than the blade thickness. This allows the blade to move freely in the cut, without sticking.

1.2 ***Rip saw***

It is used for cutting the stock along the grains. The cutting edge of this saw makes a steeper angle, i.e., about 60° whereas that of crosscut saw makes an angle of 45° with the surface of the stock.

1.3 ***Tenon saw***

It is used for cutting the stock either along or across the grains. It is used for cutting tenons and in fine cabinet work. However, it is used for small and thin cuts. The blade of this saw is very thin and so it is stiffened with a thick back steel strip. Hence, this is sometimes called as back-saw. In this, the teeth are shaped like those of cross-cut saw.

1.4 ***Compass saw***

It has a narrow, longer and stronger tapering blade, which is used for heavy works. It is mostly used in radius cutting. The blade of this saw is fitted with an open type wooden handle.

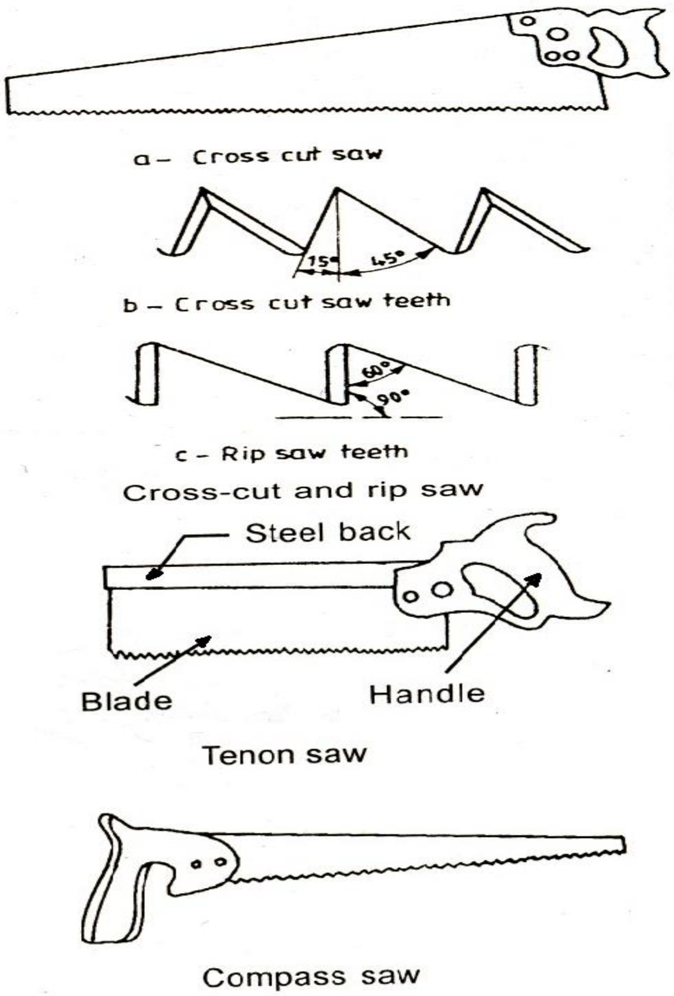


Figure Types of saws

2. *Chisels*

Chisels are used for cutting and shaping wood accurately. Wood chisels are made in various blade widths, ranging from 3 to 50 mm. They are also made in different blade lengths. Most of the wood chisels are made into tang type, having a steel shank which fits inside the handle. These are made of forged steel or tool steel blades.

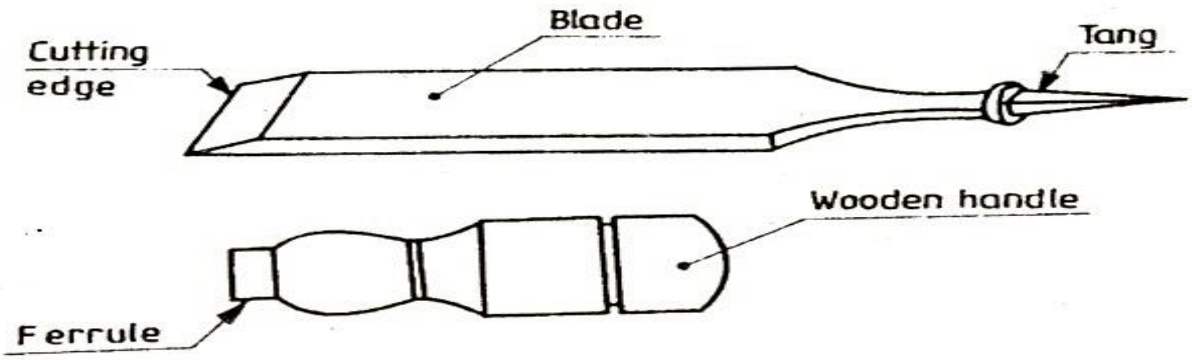


Figure Parts of chisel

2.1 *Firmer chisel*

The word 'firmer' means 'stronger' and hence firmer chisel is stronger than other chisels. It is a general purpose chisel and is used either by hand pressure or by a mallet. The blade of a firmer chisel is flat, as shown in Figure

2.2 Bevel/*Dovetail chisel*

It has a blade with a beveled back, as shown in Figure, due to which it can enter sharp comers for finishing, as in dovetail joints.

2.3 *Mortise chisel*

It is used for cutting mortises and chipping inside holes, etc. The cross-section of the mortise chisel is proportioned to withstand heavy blows during mortising. Further, the cross-section is made stronger near the shank.

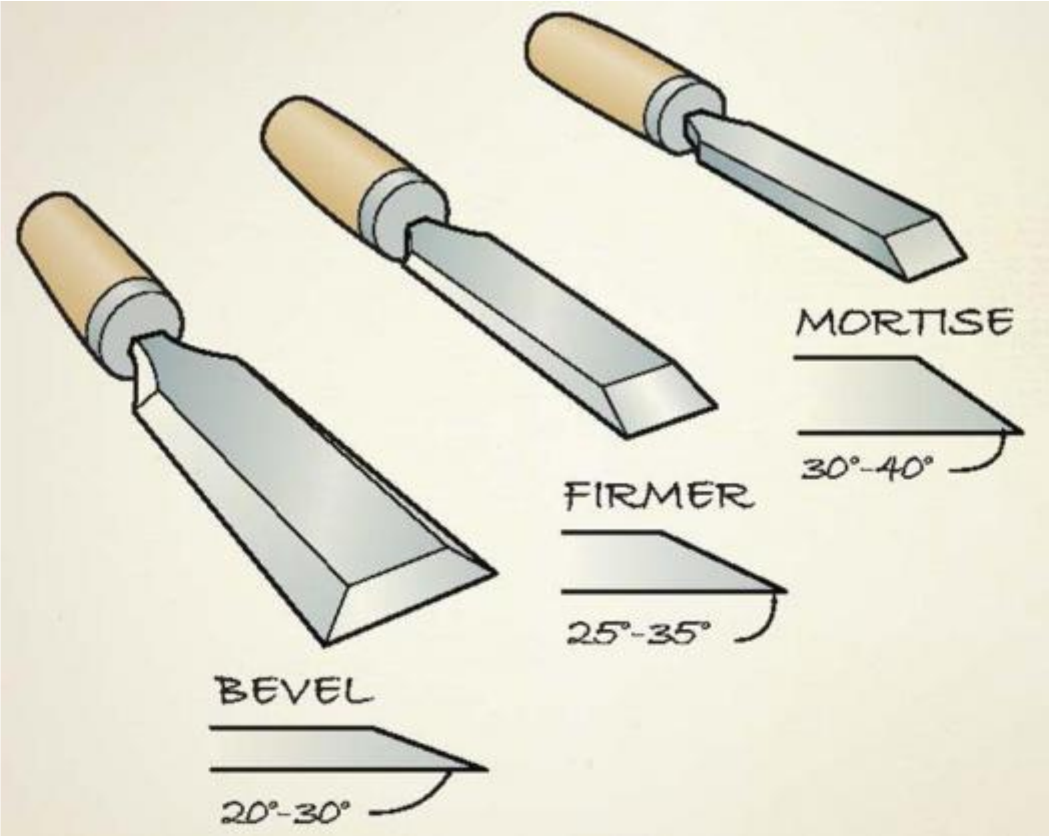


Figure: Types of chisels

Drilling and Boring tools

1. *Carpenter's brace*

It is used for rotating auger bits, twist drills, etc., to produce holes in wood. In some designs, braces are made with ratchet device. With this, holes may be made in a corner where complete revolution of the handle cannot be made. The size of a brace is determined by its sweep.

2. *Auger bit*

It is the most common tool used for making holes in wood. During drilling, the lead screw of the bit guides into the wood, necessitating only moderate pressure on the brace. The helical flutes on the surface carry the chips to the outer surface.

3. *Hand drill*

Carpenter's brace is used to make relatively large size holes; whereas hand drill is used for drilling small holes. A straight shank drill is used with this tool. It is small, light in weight and may be conveniently used than the brace. The drill bit is clamped in the chuck at its end and is rotated by a handle attached to gear and pinion arrangement.

4. *Gimlet*
It has cutting edges like a twist drill. It is used for drilling large diameter holes with the hand pressure.

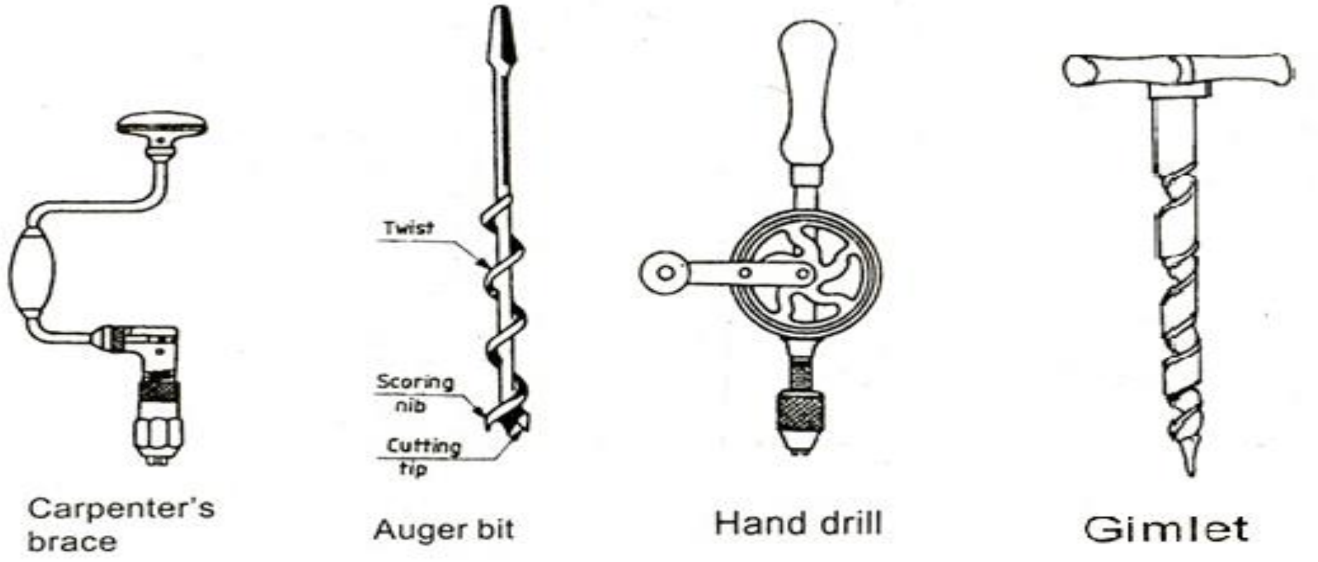


Figure Drilling tools

Wood Joints
There are many kinds of joints used to connect wood stock. Each joint has a definite use and requires lay in-out, cutting them together. The strength of the joint depends upon amount of contact area. If a particular joint does not have much contact area, then it must be reinforced with nails, screws or dowels. The figure 2.15 shows some commonly used wood joints.

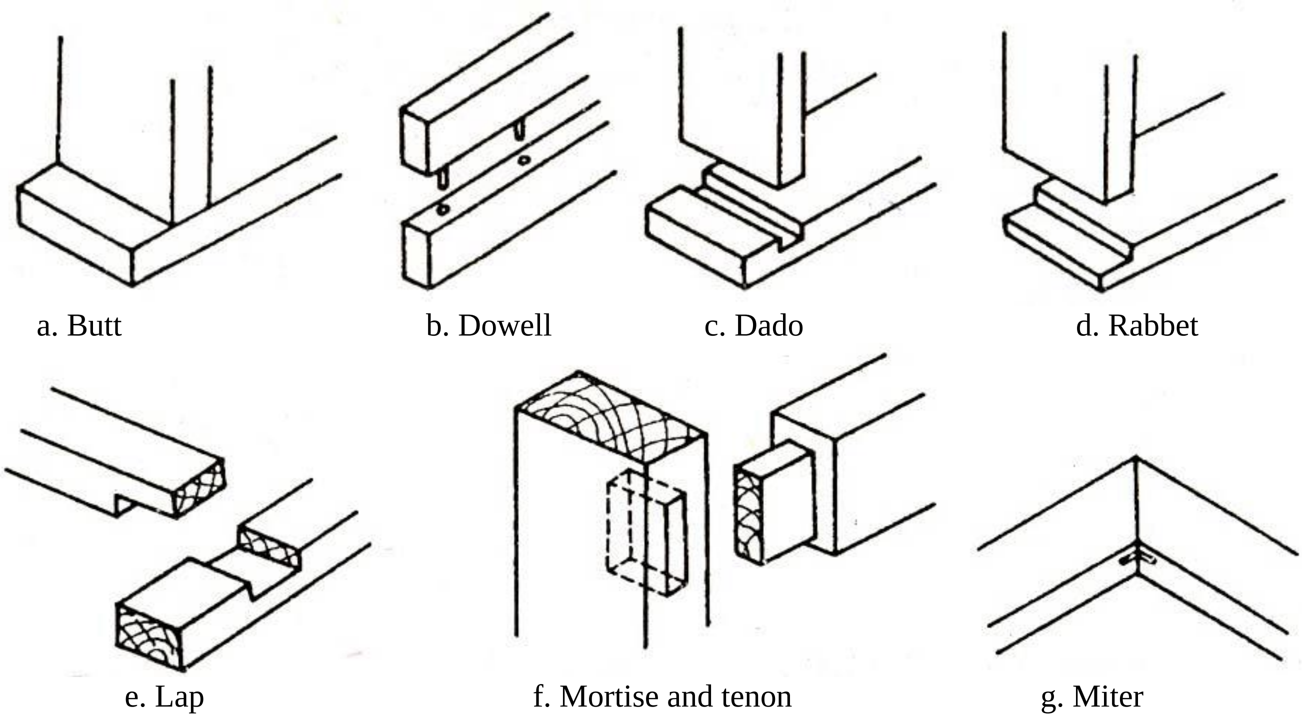


Figure Common wood joints

1. *Lap joints*

In lap joints, an equal amount of wood is removed from each piece, as shown in figure. Lap joints are easy to layout, using a try-square and a marking gauge. Follow the procedure suggested for sawing and removing the waste stock. If the joint is found to be too tight, it is better to reduce the width of the mating piece, instead of trimming the shoulder of the joint. This type of joint is used for small boxes to large pieces of furniture.

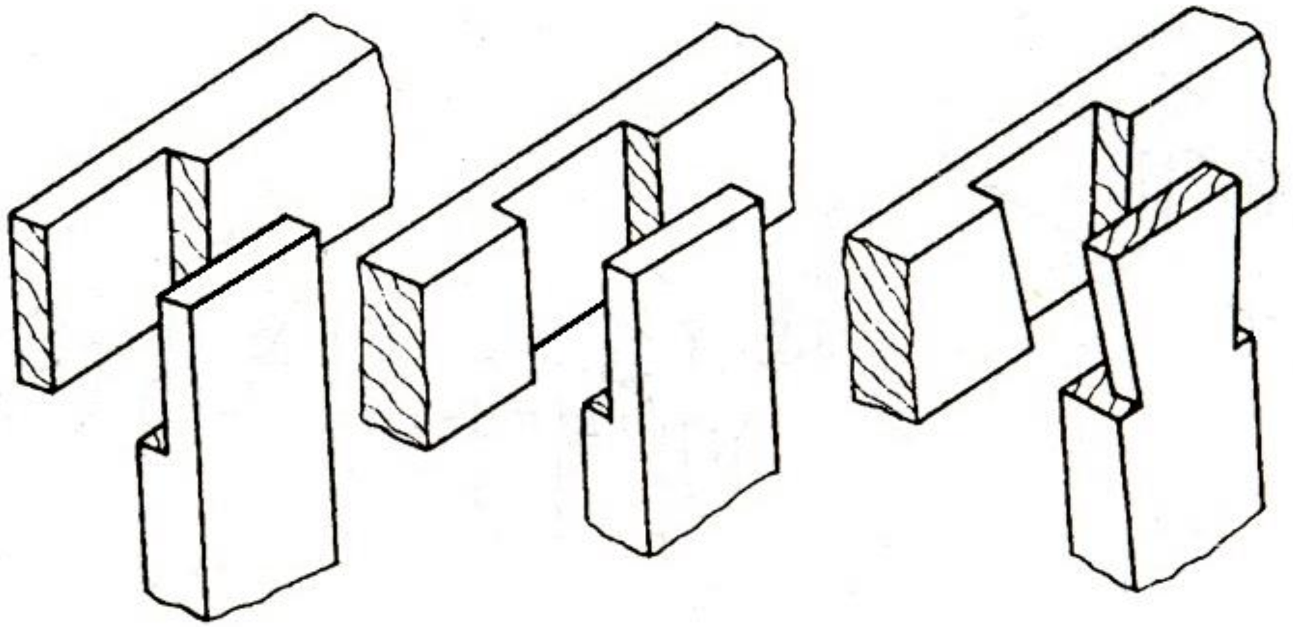


Figure Lap joints

2. *Mortise and Tenon Joints*

It is used in the construction of quality furniture. It results in a strong joint and requires considerable skill to make it. The following are the stages involved in the work.

a. Mark the mortise and tenon layouts.

b. Cut the mortise first by drilling series of holes within the layout line, chiseling out the waste stock and trimming the corners and sides.

c. Prepare the tenon by cutting and chiseling.

d. Check the tenon size against the mortise that has been prepared and adjust it if necessary.

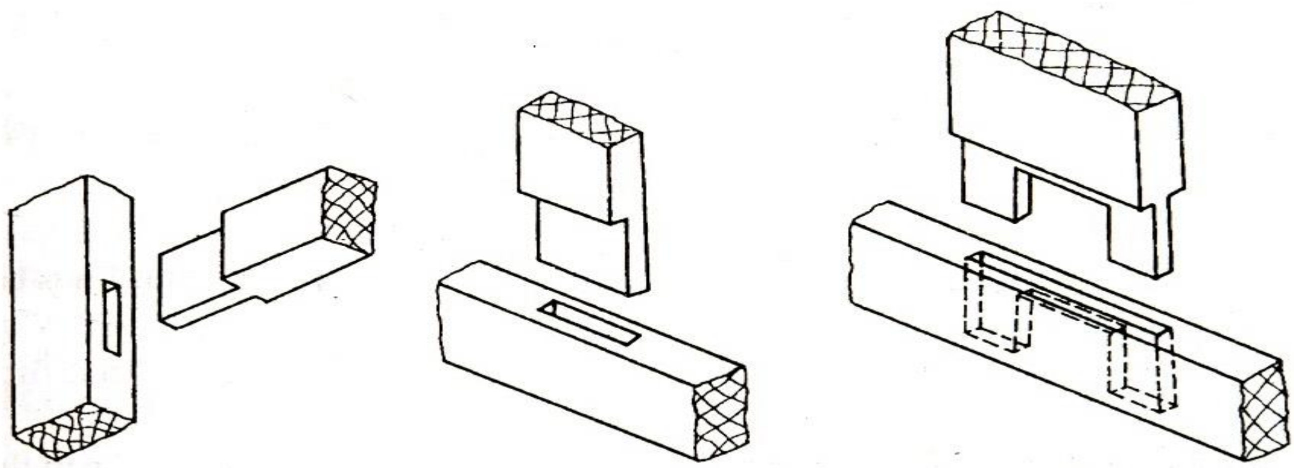


Figure Mortise and Tenon joints

3. *Bridle joint*

This is the reverse of mortise and tenon joint in form. The marking-out of the joint is the same as for mortise and tenon joint. This joint is used where the members are of square or near square section and unsuitable for mortise and tenon joint.

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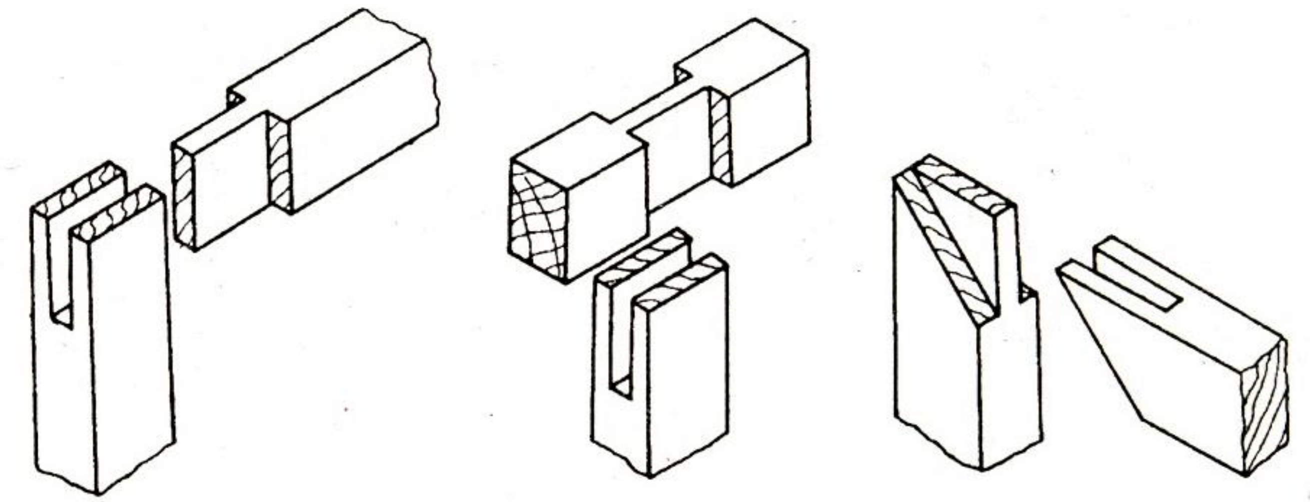


Figure Bridle joint

Safety Precautions

1. Tools that are not being used should always be kept at their proper places.
2. Make sure that your hands are not in front of sharp edged tools while you are using them.
3. Use only sharp tools. A dull tool requires excessive pressure, causing the tool to slip.
4. Wooden pieces with nails, should never be allowed to remain on the floor.
5. Be careful when you are using your thumb as a guide in cross-cutting and ripping.
6. Test the sharpness of the cutting edge of chisel on wood or paper, but not on your hand.
7. Never chisel towards any part of the body.
8. Do not use chisels where nails are present. Do not use chisel as a screw driver.
9. Do not use a saw with a loose handle.
10. Always use triangular file for sharpening the teeth.
11. Do not use a saw on metallic substances.
12. Do not use mallet to strike nails.

Job Description

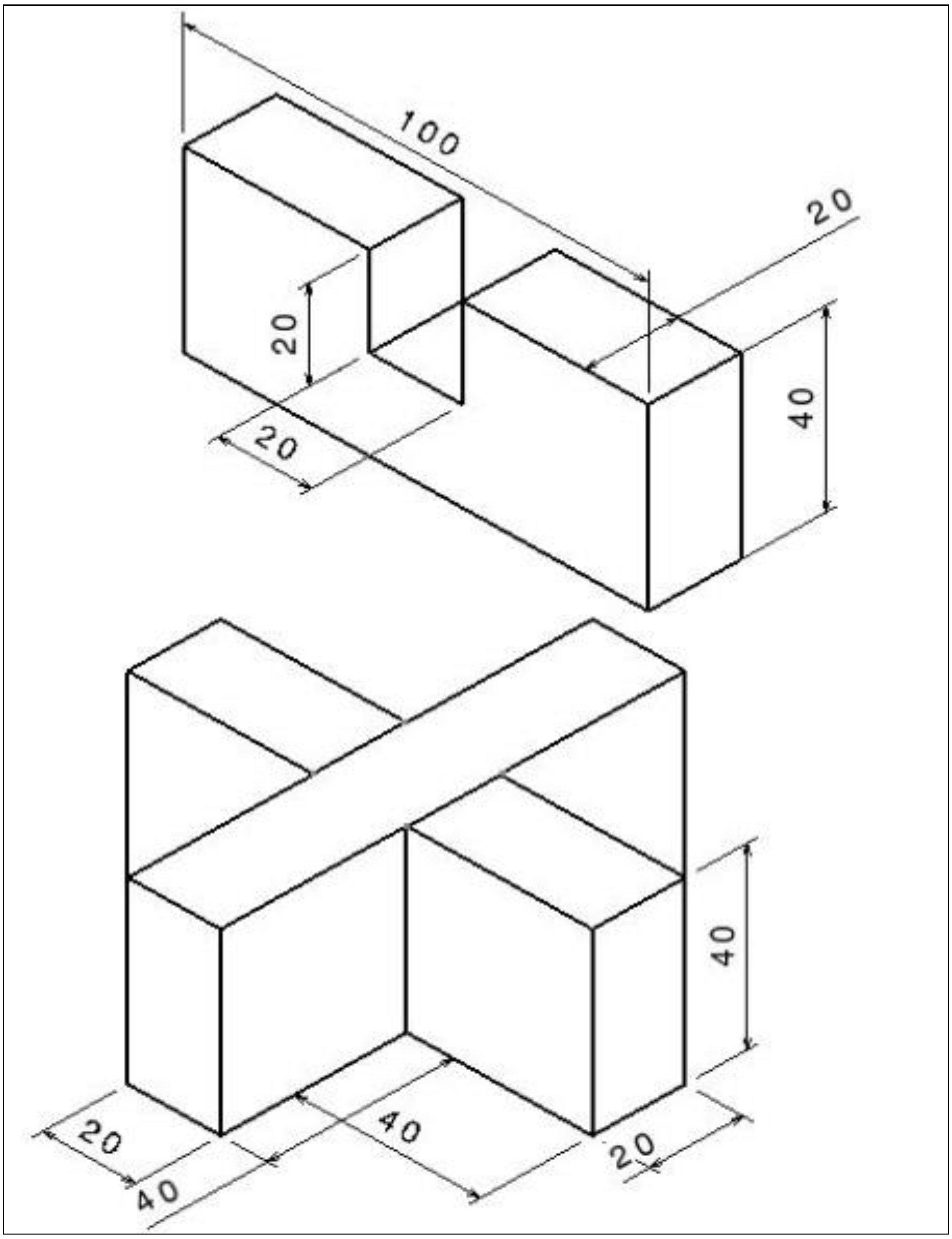


Figure: Cross Halved Joint

Sequence of Operations

1. Plane up the block of wood to correct width & thickness.

   a. plane the face side & test, put on face side mark.

   b. plane the face edge & test,put on the face edge mark.

   c. gauge the width and plane of waste.

   d. gauge the thickness and plane off waste.

2. Mark off lengths leaving the waste at each end centre.
3. Mark off lines on face edge of one section and on the reverse side of other section for grooves forming joint.
4. Gauge lines for the depth of grooves on both sides.
5. Saw down for depth of grooves.
6. Remove waste by chisel.
7. Saw off the waste pieces at each end and the centre
8. Fit together and clean off with smoothening plane.

Chapter 3

FITTING SHOP

Introduction

Machine tools are capable of producing work at a faster rate, but, there are occasions when components are processed at the bench. Sometimes, it becomes necessary to replace or repair component which must be fit accurately with another component on reassembly. This involves a certain amount of hand fitting. The assembly of machine tools, jigs, gauges, etc, involves certain amount of bench work. The accuracy of work done depends upon the experience and skill of the fitter.

The term 'bench work' refers to the production of components by hand on the bench, where as fitting deals which the assembly of mating parts, through removal of metal, to obtain the required fit. Both the bench work and fitting requires the use of number of simple hand tools and considerable manual efforts. The operations in the above works consist of filing, chipping, scraping, sawing drilling, and tapping.

Holding Tools

1. *Bench vice*

The bench vice is a work holding device. It is the most commonly used vice in a fitting shop. The bench vice is shown in Figure.

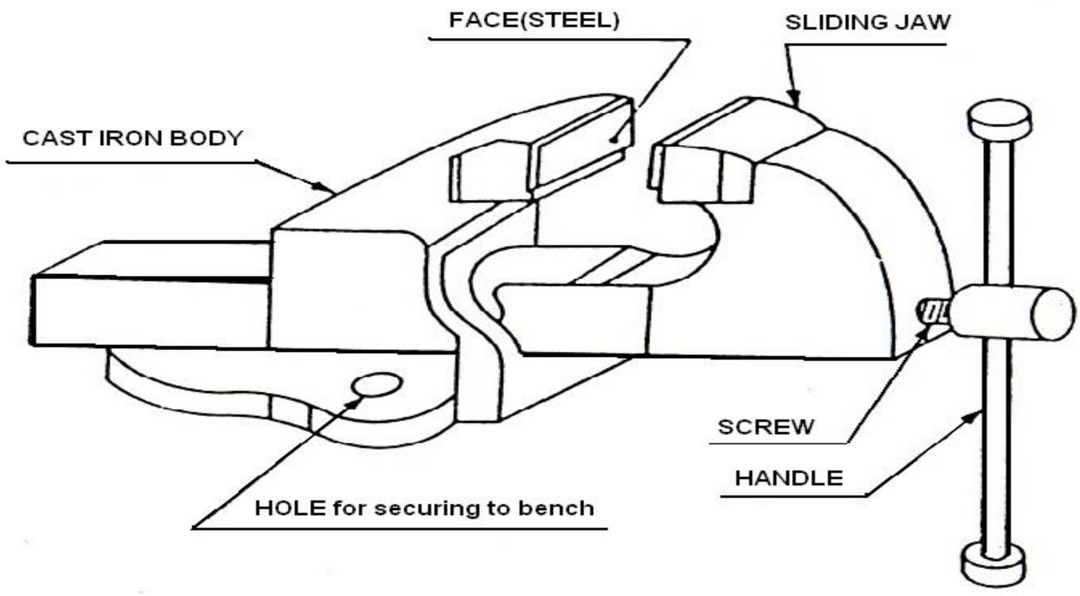


Figure: Bench Vice

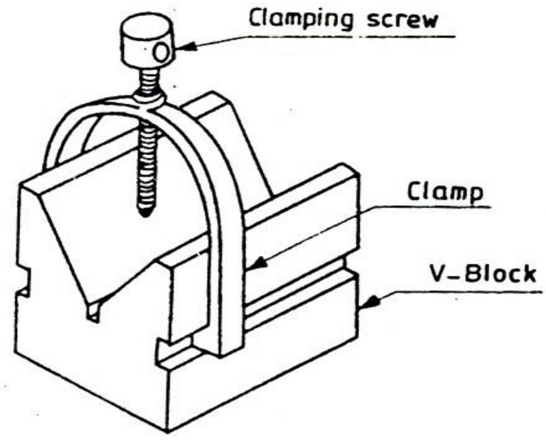
It is fixed to the bench with bolts and nuts. The vice body consists of two main parts, fixed jaw and movable jaw. When the vice handle is turned in a clockwise direction, the sliding jaw forces the work against the fixed jaw. Jaw plates are made of hardened steel. Serrations on the jaws ensure a good grip. Jaw caps made of soft material are used to protect finished surfaces, gripped in the vice. The size of the vice is specified by the length of the jaws. The vice body is made of cast Iron which is strong in compression, weak in tension and so fractures under shocks and therefore should never be hammered.

2. ***V-block***

V-block is rectangular or square block with a V-groove on one or both sides opposite to each other. The angle of the 'V' is usually 900. V-block with a clamp is used to hold cylindrical work securely, during layout of measurement, for measuring operations or for drilling for this the bar is faced longitudinally in the V-Groove and the screw of V-clamp is tightened. This grip the rod is firm with its axis parallel to the axis of the v-groove.

3. ***C-Clamp***

This is used to hold work against an angle plate or v-block or any other surface, when gripping is required. Its fixed jaw is shaped like English alphabet 'C' and the movable jaw is round in shape and directly fitted to the threaded screw at the end .The working principle of this clamp is the same as that of the bench vice.



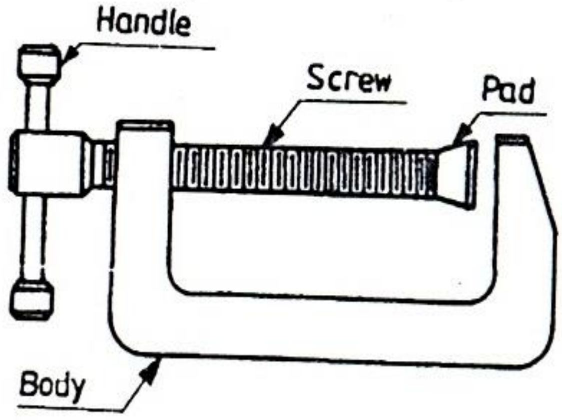


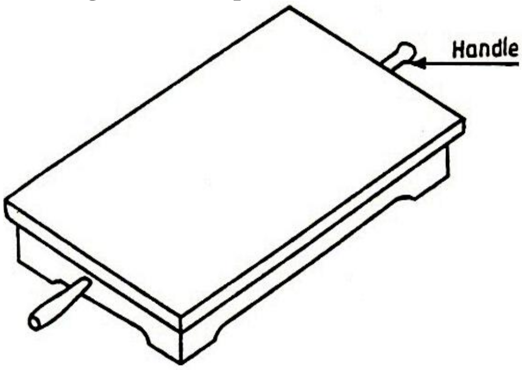
Figure V-block

Figure C-clamp

Marking and Measuring Tools

1. ***Surface plate***

The surface plate is machined to fine limits and is used for testing the flatness of the work piece. It is also used for marking out small box and is more precious than the marking table. The degree of the finished depends upon whether it is designed for bench work in a fitting shop or for using in an inspection room; the surface plate is made of Cast Iron, hardened Steel or Granite stone. It is specified by length, width, height and grade. Handles are provided on two opposite sides, to carry it while shifting from one place to another.



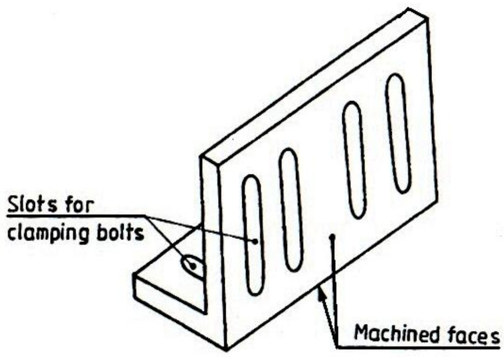


Figure Surface plate

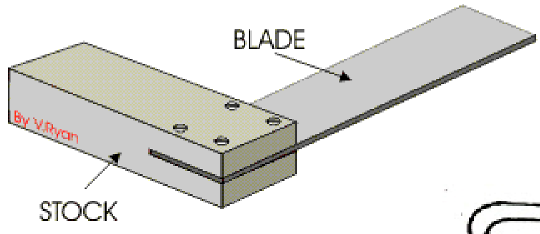
Figure Angle plate

2. ***Try square***

It is measuring and marking tool for 900 angle .In practice, it is used for checking the squareness of many types of small works when extreme accuracy is not required .The blade of the Try square is made of hardened steel and the stock of cast Iron or steel. The size of the Try square is specified by the length of the blade.

3. ***Scriber***

A Scriber is a slender steel tool, used to scribe or mark lines on metal work pieces. It is made of hardened and tempered High Carbon Steel. The Tip of the scriber is generally ground at 12o to 15o It is generally available in lengths, ranging from 125mm to 250mm. It has two pointed ends the bent end is used for marking lines where the straight end cannot reach.



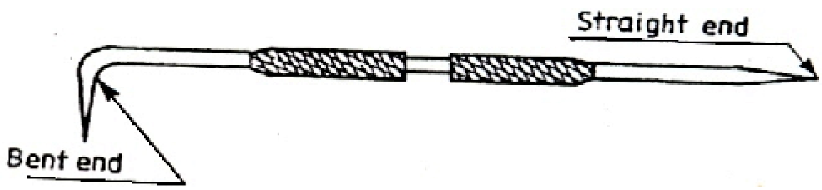
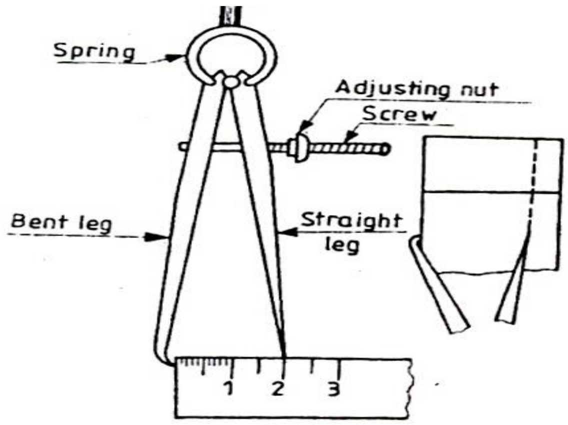


Figure Try square **Figure** Scriber

4. *Odd leg Caliper*
This is also called 'Jenny Caliper' or Hermaphrodite. This is used for marking parallel liners from a finished edge and also for locating the center of round bars; it has one leg pointed like a divider and the other leg bent like a caliper. It is specified by the length of the leg up to the hinge point.

5. *Divider*
It is basically similar to the calipers except that its legs are kept straight and pointed at the measuring edge. This is used for marking circles, arcs laying out perpendicular lines, by setting lines. It is made of case hardened mild steel or hardened and tempered low carbon steel. Its size is specified by the length of the leg**.**



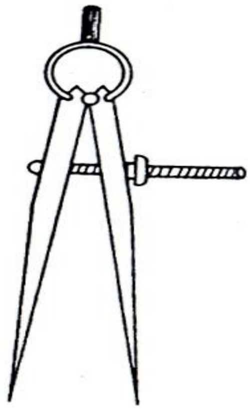


Figure Odd leg caliper and divider

6. *Trammel*
Trammel is used for drawing large circles or arcs.

7. *Punches*
These are used for making indentations on the scribed lines, to make them visible clearly. These are made of high carbon steel. A punch is specified by its length and diameter (say as 150' 12.5mm). It consists of a cylindrical knurled body, which is plain for some length at the top of it. At the other end, it is ground to a point. The tapered point of the punch is hardened over a length of 20 to 30mm. *Dot punch* is used to lightly indent along the layout lines, to locate center of holes and to provide a small center mark for divider point, etc. for this purpose, the punch is ground to a conical point having 60° included angle. *Center punch* is similar to the dot punch, except that it is ground to a conical point having 90° included angle. It is used to mark the location of the holes to be drilled.

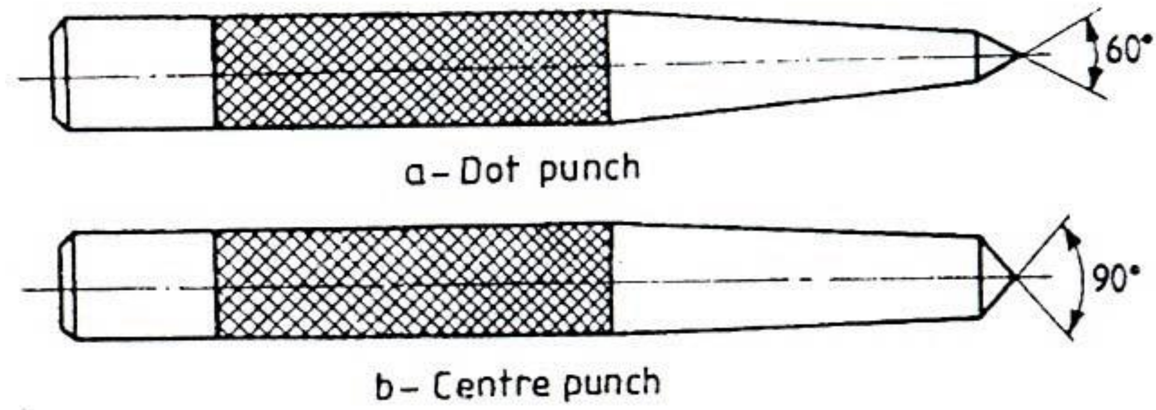


Figure Punches

8. ***Calipers***

They are indirect measuring tools used to measure or transfer linear dimensions. These are used with the help of a steel Rule to check inside and outside measurements. These are made of Case hardened mild steel or hardened and tempered low carbon steel. While using, but the legs of the caliper are set against the surface of the work, whether inside or outside and the distance between the legs is measured with the help of a scale and the same can be transferred to another desired place. These are specified by the length of the leg. In the case of outside caliper, the legs are bent inwards and in the case of inside caliper, the legs bent outwards.

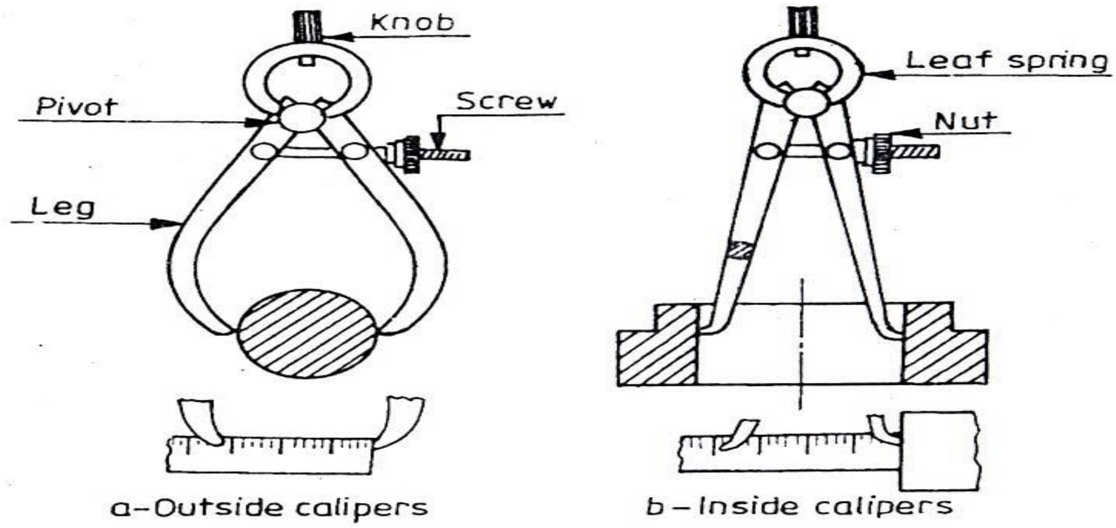


Figure 1.10: Calipers

9. ***Vernier Calipers***

These are used for measuring outside as well as inside dimensions accurately. It may also be used as a depth gauge. It has two jaws. One jaw is formed at one end of its main scale and the other jaw is made part of a vernier scale.

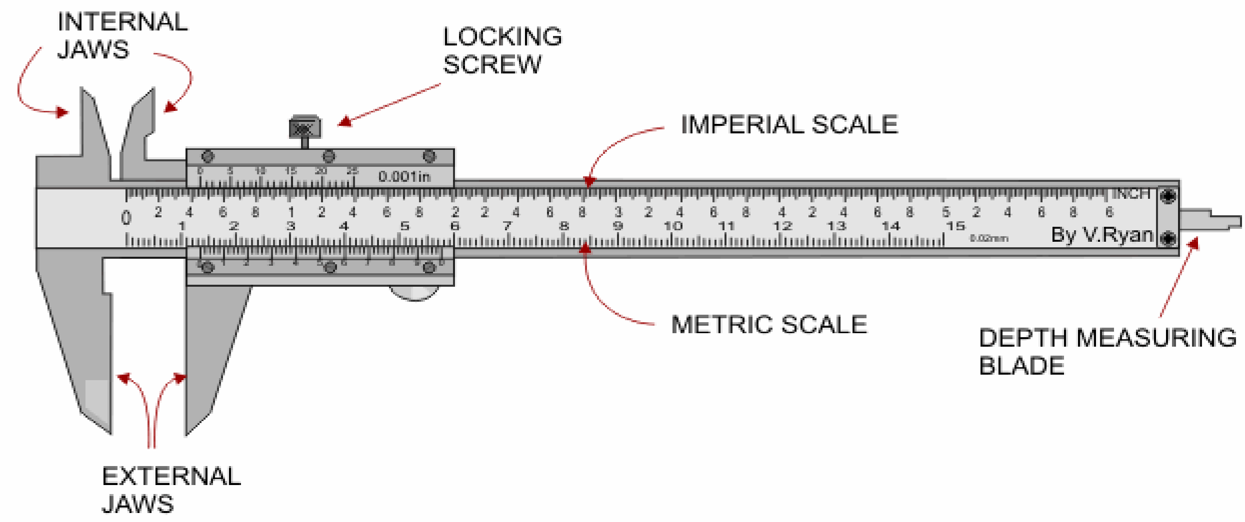


Figure 1.11: Vernier caliper

10 Vernier Height Gauge

The Vernier Height gauge clamped with a scriber. It is used for Lay out work and offset scriber is used when it is required to take measurement from the surface, on which the gauge is standing. The accuracy and working principle of this gauge are the same as those of the vernier calipers. Its size is specified by the maximum height that can be measured by it. It is made of Nickel-Chromium Steel.

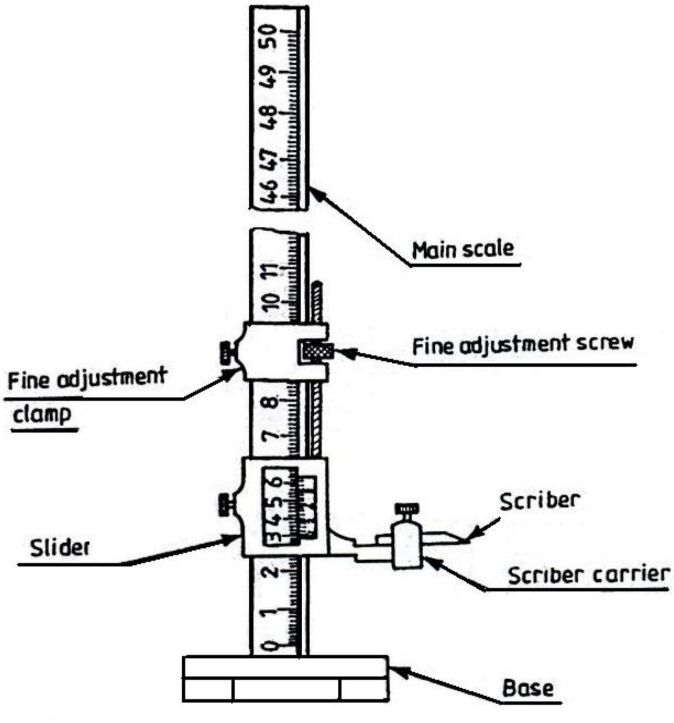


Figure Vernier Height gauge

Cutting Tools

1. *Hack Saw*

The Hack Saw is used for cutting metal by hand. It consists of a frame, which holds a thin blade, firmly in position. Hacksaw blade is specified by the number of teeth for centimeter. Hacksaw blades have a number of teeth ranging from 5 to 15 per centimeter (cm). Blades having lesser number of teeth per cm are used for cutting soft materials like aluminum, brass and bronze. Blades having larger number of teeth per centimeter are used for cutting hard materials like steel and cast Iron. Hacksaw blades are classified as (i) All hard and (ii) flexible type. The all hard blades are made of H.S.S, hardened and tempered throughout to retain their cutting edges longer. These are used to cut hard metals. These blades are hard and brittle and can break easily by twisting and forcing them into the work while sawing. Flexible blades are made of H.S.S or low alloy steel but only the teeth are hardened and the rest of the blade is soft and flexible. These are suitable for use by un-skilled or semi-skilled persons.

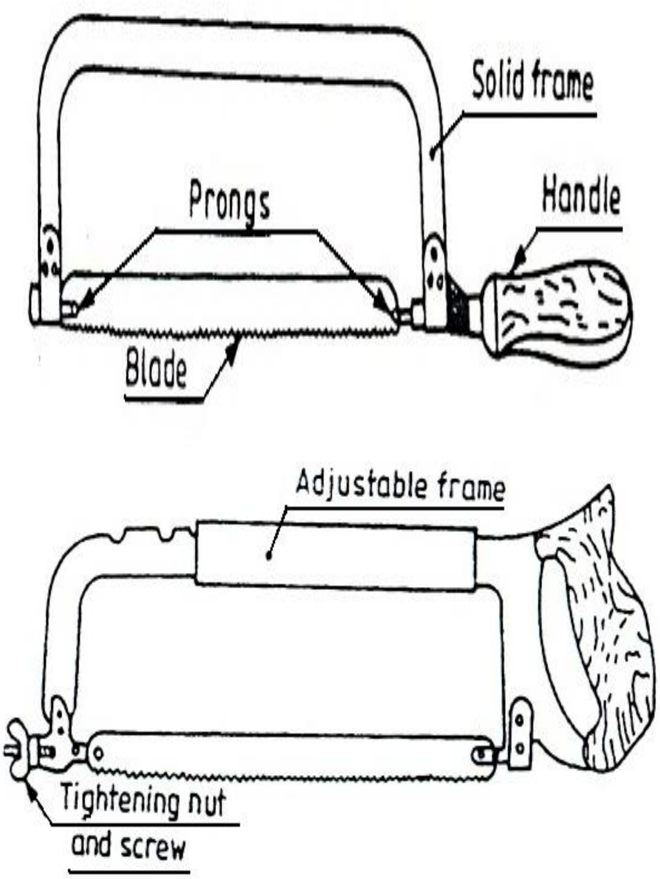


Figure Hacksaw frame with blade

The teeth of the hacksaw blade are staggered, as shown in figure and known as a ‘set of teeth’. These make slots wider than the blade thickness, preventing the blade from jamming.

2. *Chisels*

Chisels are used for removing surplus metal or for cutting thin sheets. These tools are made from 0.9% to 1.0% carbon steel of octagonal or hexagonal section. Chisels are annealed, hardened and tempered to produce a tough shank and hard cutting edge. Annealing relieves the internal stresses in a metal. The cutting angle of the chisel for general purpose is about 60°.

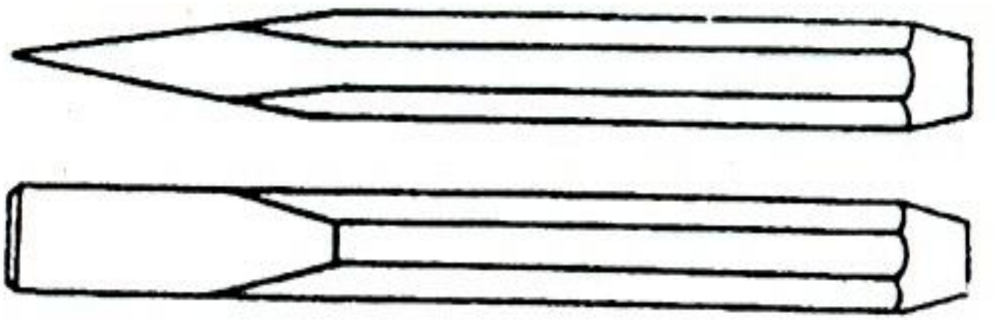


Figure Flat chisel

3. ***Twist Drill***

Twist drills are used for making holes. These are made of High speed steel. Both straight and taper shank twist drills are used. The parallel shank twist drill can be held in an ordinary self – centering drill check. The tapper shank twist drill fits into a corresponding tapered bore provided in the drilling machine spindle.

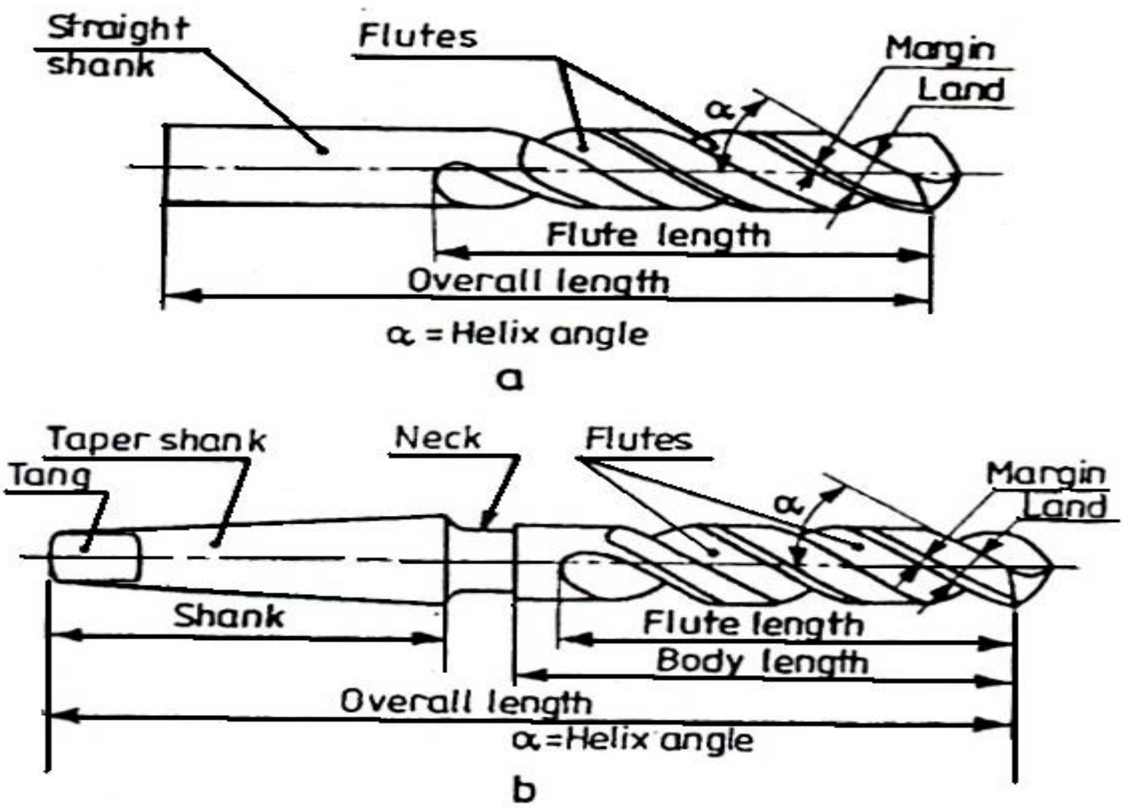


Figure Twist drills

4. ***Taps and Tap wrenches***

A tap is a hardened and steel tool, used for cutting internal thread in a drill hole. Hand Taps are usually supplied in sets of three in each diameter and thread size. Each set consists of a tapper tap, intermediate tap and plug or bottoming tap. Taps are made of high carbon steel or high speed steel.

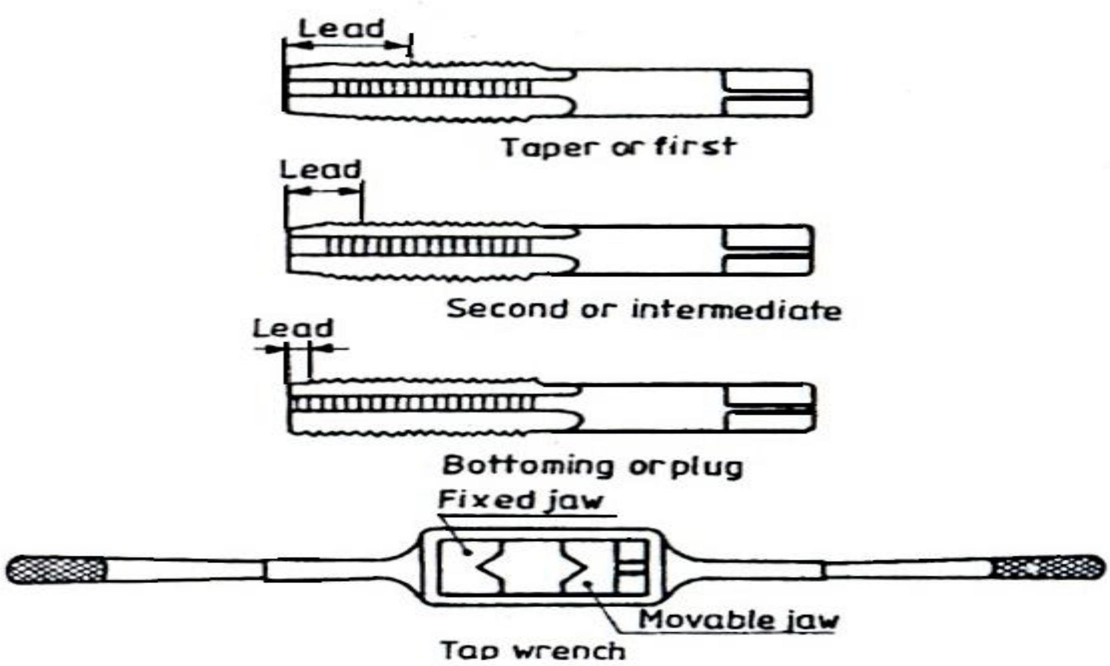


Figure Taps and tap wrench

5. ***Dies and die-holders***

Dies are the cutting tools used for making external thread. Dies are made either solid or split type. They are fixed in a die stock for holding and adjusting the die gap. They are made of Steel or High Carbon Steel.

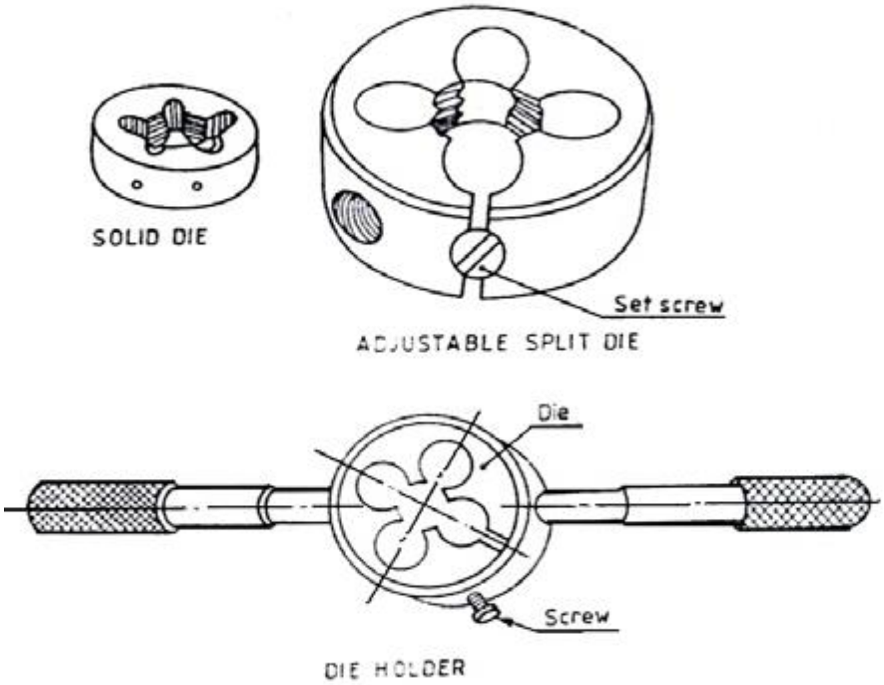


Figure 1.18: Dies and die holder

6. ***Bench Drilling Machine***

Holes are drilled for fastening parts with rivets, bolts or for producing internal thread. Bench drilling machine is the most versatile machine used in a fitting shop for the purpose. Twist drills, made of tool steel or high speed steel are used with the drilling machine for drilling holes.

Following are the stages in drilling work

1. Select the correct size drills, put it into the check and lock it firmly
2. Adjust the speed of the machine to suit the work by changing the belt on the pulleys. Use high speed for small drills and soft materials and low speed for large diameter drills and hard materials.
3. Layout of the location of the pole and mark it with a center punch.
4. Hold the work firmly in the vice on the machine table and clamp it directly on to the machine table.
5. Put on the power, locate the punch mark and apply slight pressure with the Feed Handle.
6. Once Drilling is commenced at the correct location, apply enough pressure and continue drilling. When drilling steel apply cutting oil at the drilling point.
7. Release the pressure slightly, when the drill point pierces the lower surface of the metal. This prevents the drill catching and damaging the work or drill.
8. On completion of drilling retrace the drill out of the work and put-off the power supply.

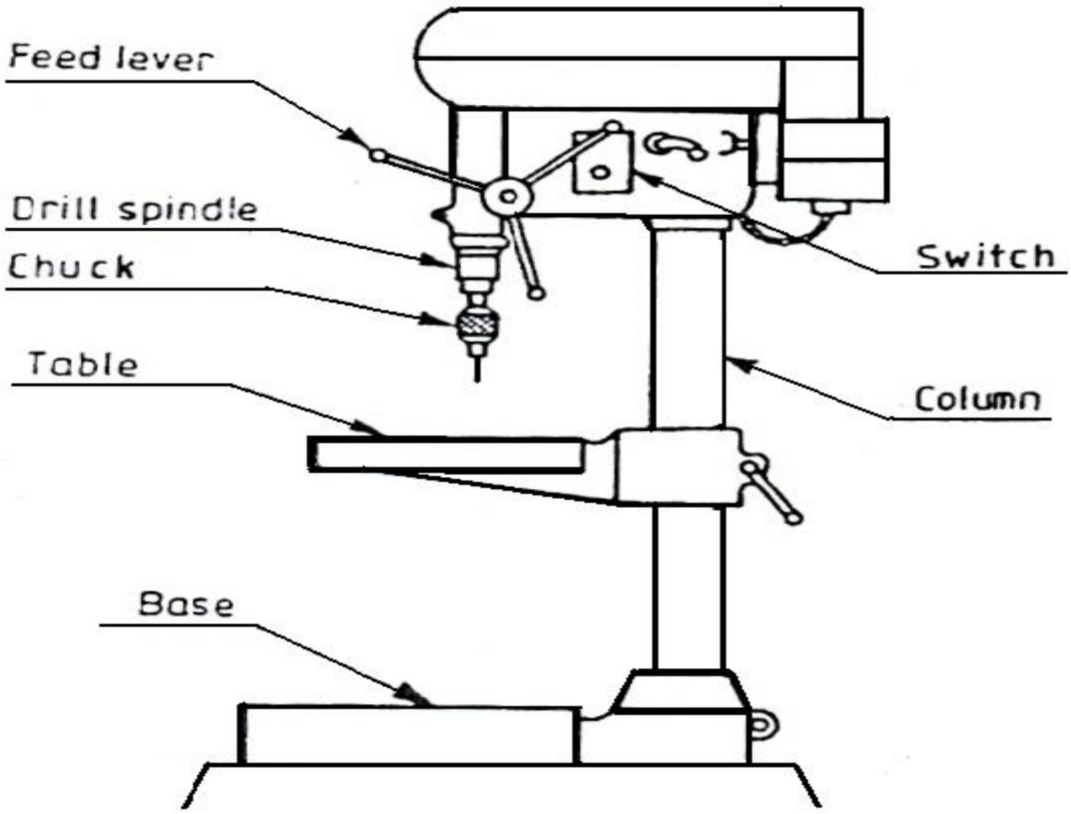


Figure Bench drill

Finishing Tools

1. *Reamers*

Reaming is an operation of sizing and finishing a drilled hole, with the help of a cutting tool called reamer having a number of cutting edges. For this, a hole is first drilled, the size of which is slightly smaller than the finished size and then a hand reamer or machine reamer is used for finishing the hole to the correct size.

Hand Reamer is made of High Carbon Steel and has left-hand spiral flutes so that, it is prevented from screwing into the whole during operation. The Shank end of the reamer is made straight so that it can be held in a tap wrench. It is operated by hand, with a tap wrench fitted on the square end of the reamer and with the work piece held in the vice. The body of the reamer is given a slight tapper at its
working end, for its easy entry into the whole during operation, it is rotated only in clock wise direction and also while removing it from the whole.

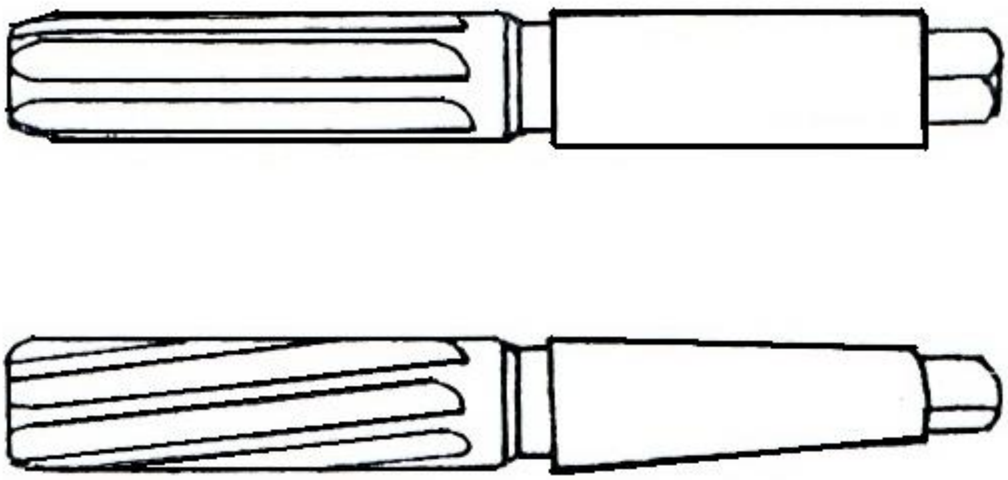


Figure Reamers

2. *Files*

Filing is one of the methods of removing small amounts of material from the surface of a metal part. A file is hardened steel too, having small parallel rows of cutting edges or teeth on its surfaces. On the faces, the teeth are usually diagonal to the edge. One end of the file is shaped to fit into a wooden handle. The figure shows various parts of a hand file. The hand file is parallel in width and tapering slightly in thickness, towards the tip. It is provided with double cut teeth. On the faces, single cut on one edge and no teeth on the other edge, which is known as a safe edge.

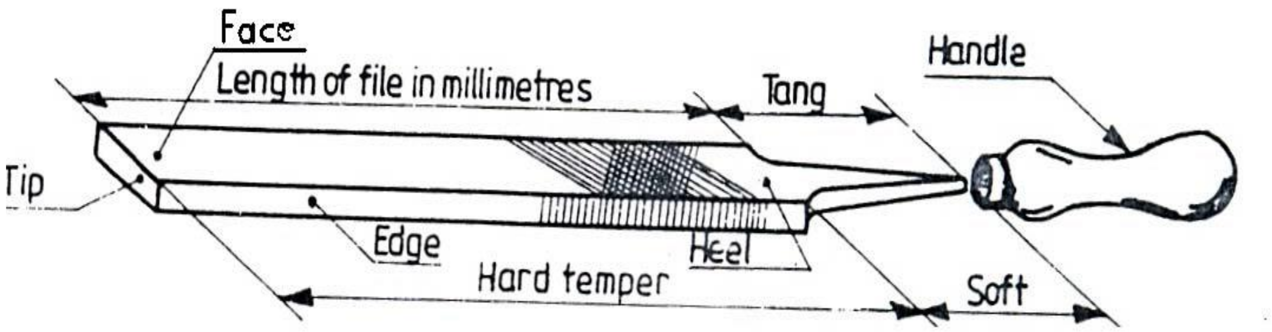


Figure Parts of a hand file

Files are classified according to their shape, cutting teeth and pitch or grade of the teeth. The figure shows the various types of files based on their shape.

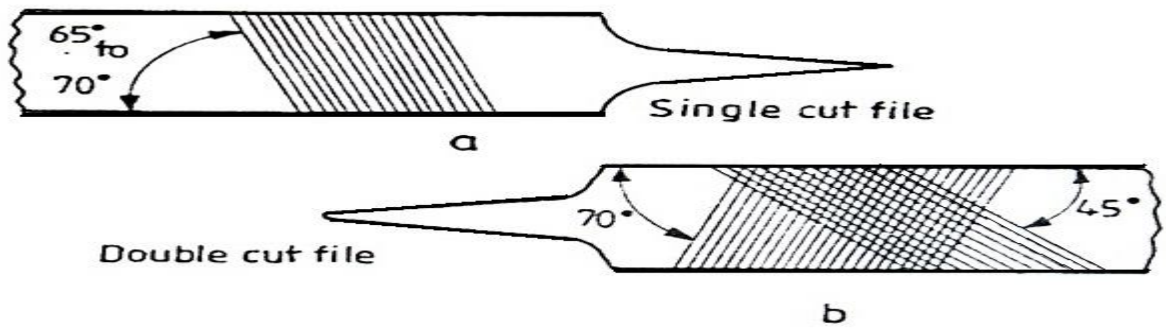


Figure Single and double cut files

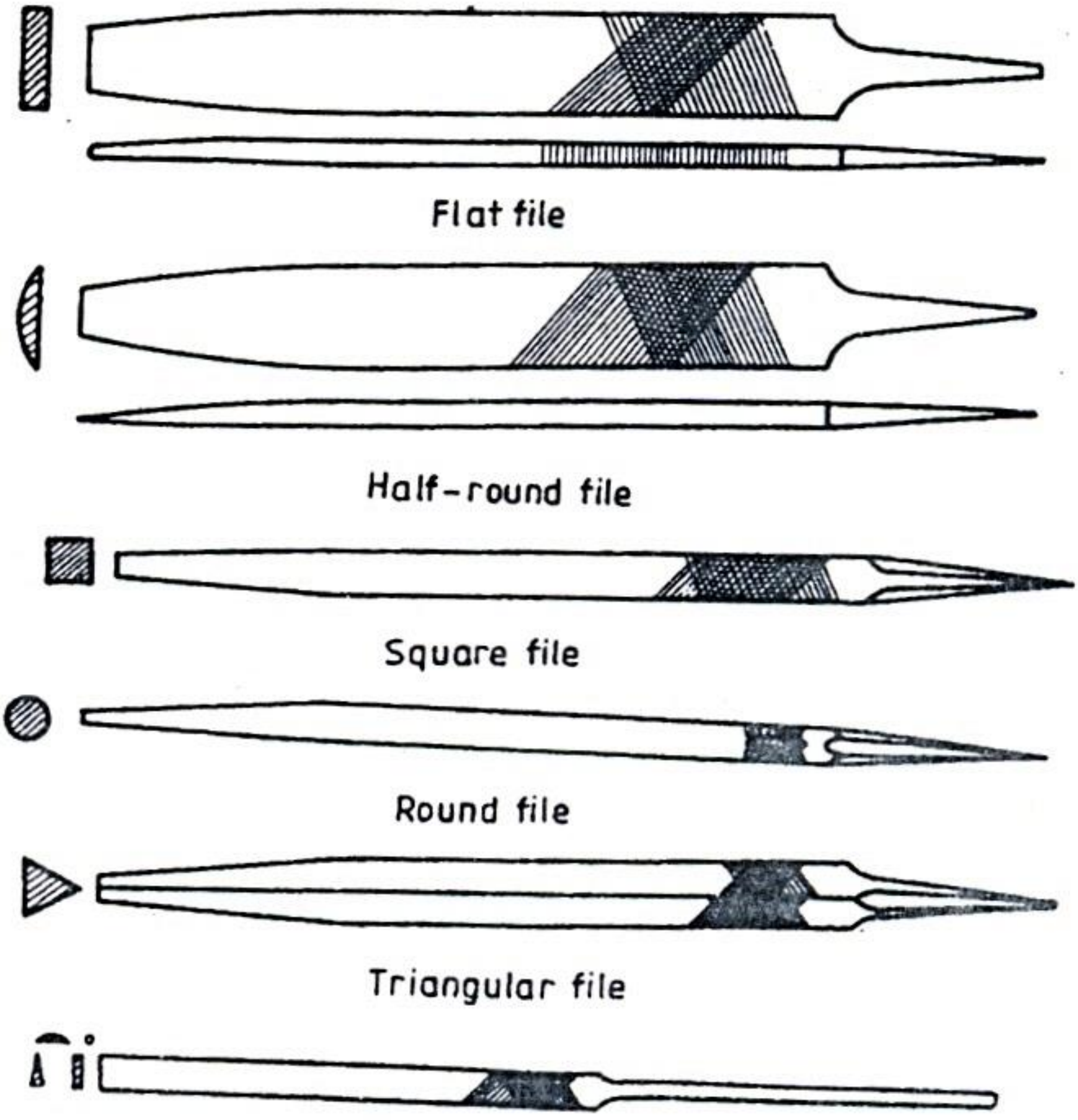


Figure Types of files

Miscellaneous Tools

1. ***File card***

It is a metal brush, used for cleaning the files, to free them from filings, clogged in-between the teeth.

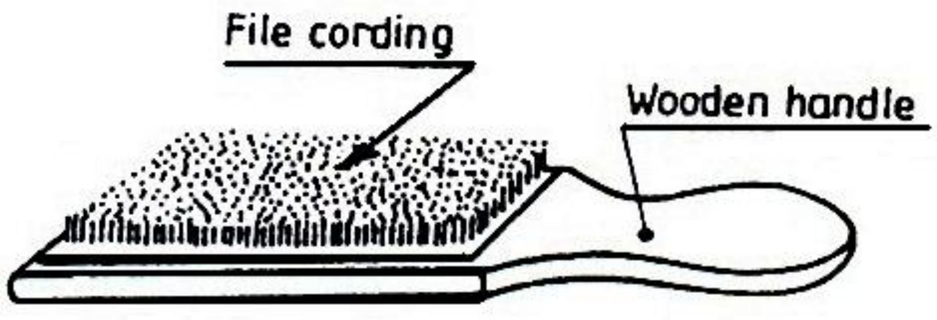


Figure 1.24: File card

2. ***Spirit level***
It is used to check the leveling of machines.

3. ***Ball- Peen Hammer***
Ball- Peen Hammers are named, depending upon their shape and material and specified by their weight. A ball peen hammer has a flat face which is used for general work and a ball end, particularly
used for riveting.

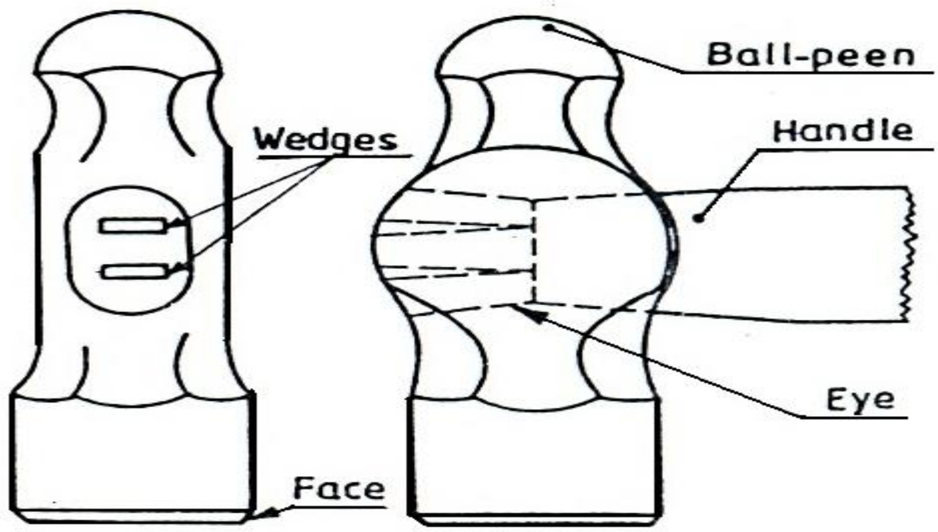


Figure Ball peen hammer

4. ***Cross-Peen Hammer***
It is similar to ball peen hammer, except the shape of the peen. This is used for chipping, riveting, bending and stretching metals and hammering inside the curves and shoulders.

5. ***Straight-Peen Hammer***
This is similar to cross peen hammer, but its peen is in-line with the hammer handle. It is used for swaging, riveting in restricted places and stretching metals.

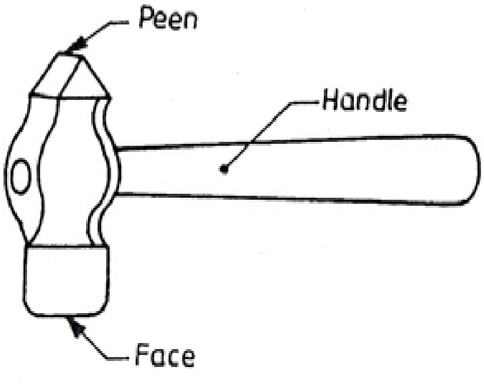


Figure Cross peen hammer

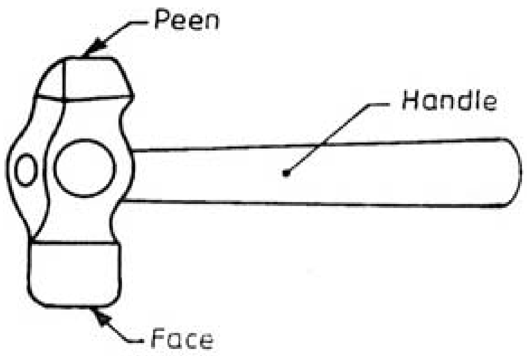


Figure Straight peen hammer

6. *Screw driver*

A screw driver is designed to turn screws. The blade is made of steel and is available in different lengths and diameters. The grinding of the tip to the correct shape is very important. A star screw driver is specially designed to fit the head of star screws. The end of the blade is fluted instead of flattened. The screw driver is specified by the length of the metal part from handle to the tip.

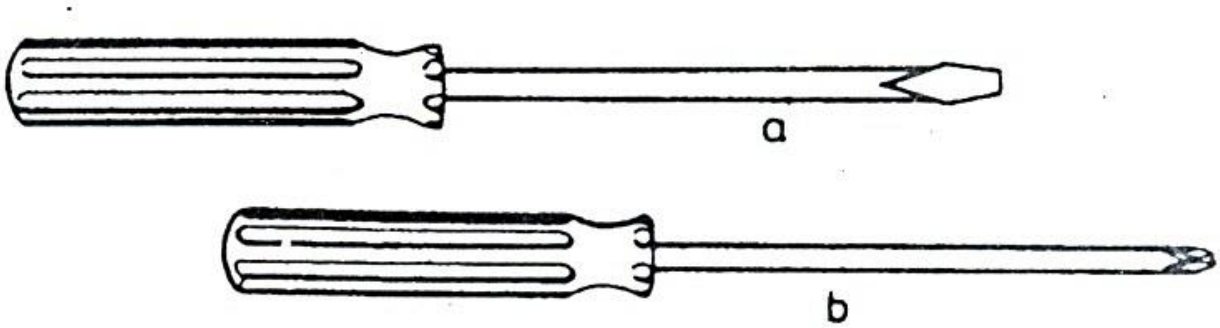
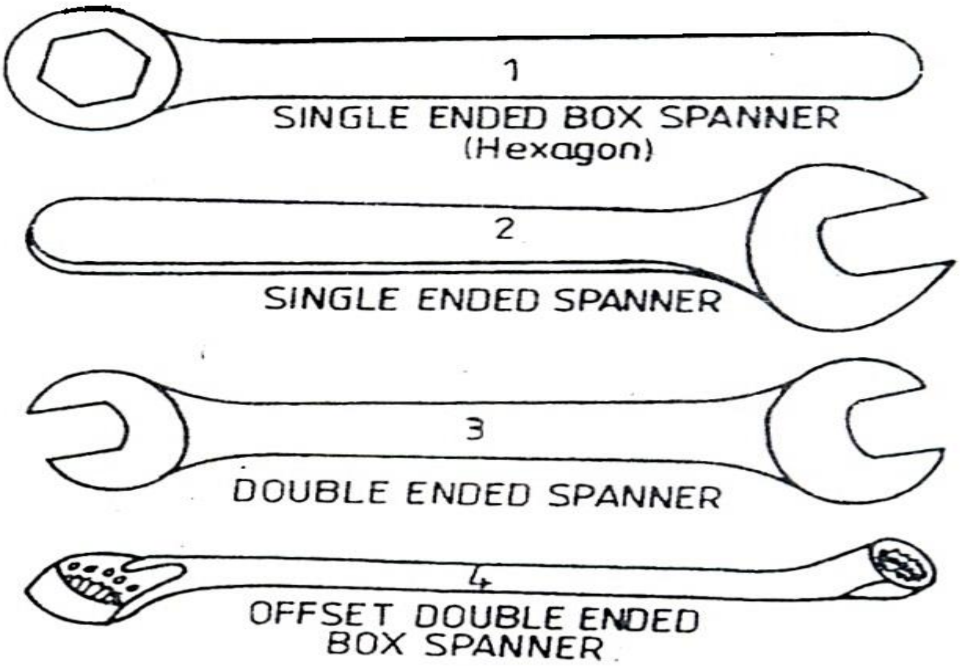


Figure Screw drivers

7. *Spanners*

A spanner or wrench is a tool for turning nuts and bolts. It is usually made of forged steel. There are many kinds of spanners. They are named according to the application. The size of the spanner denotes the size of the bolt on which it can work.



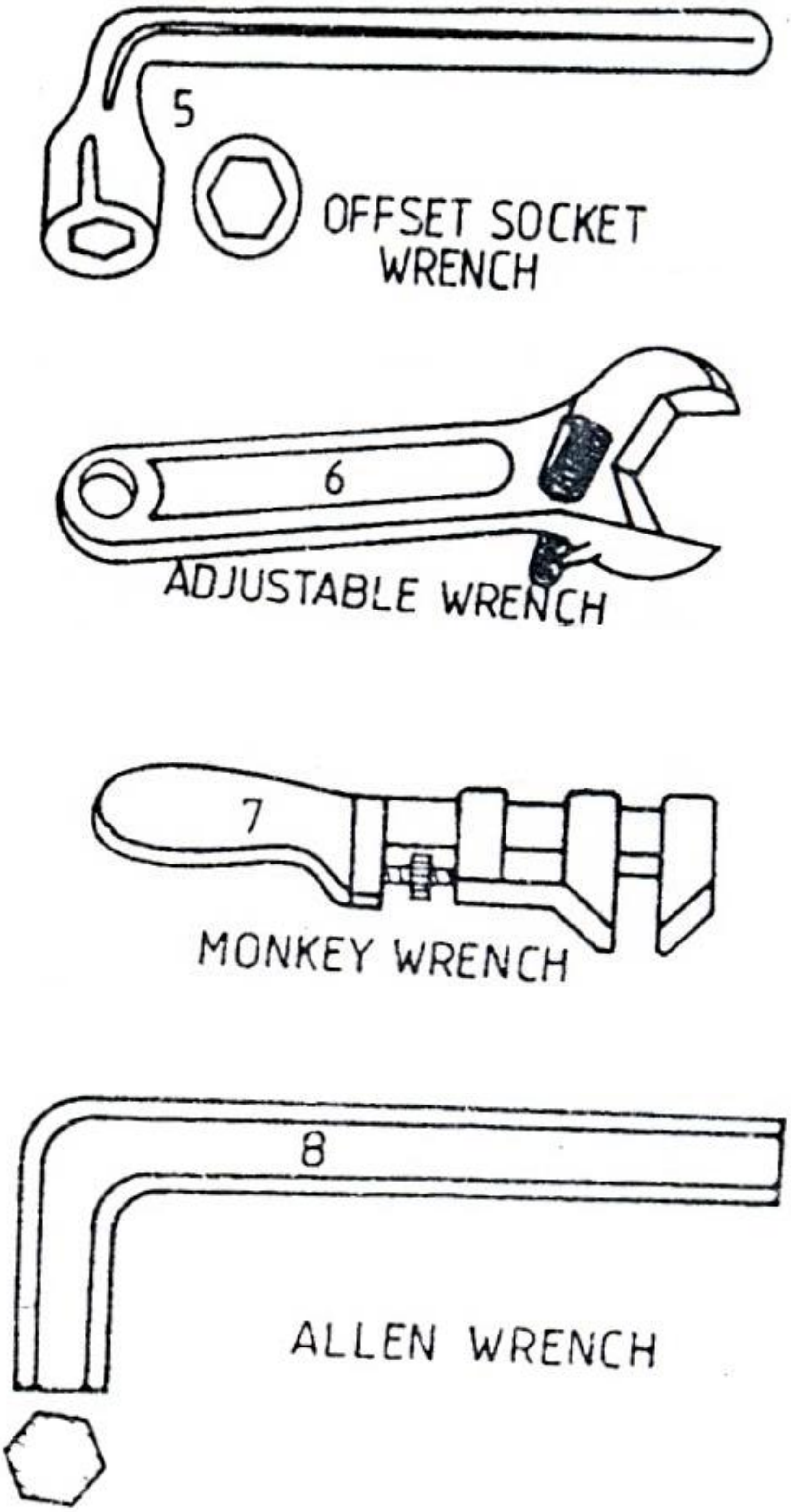
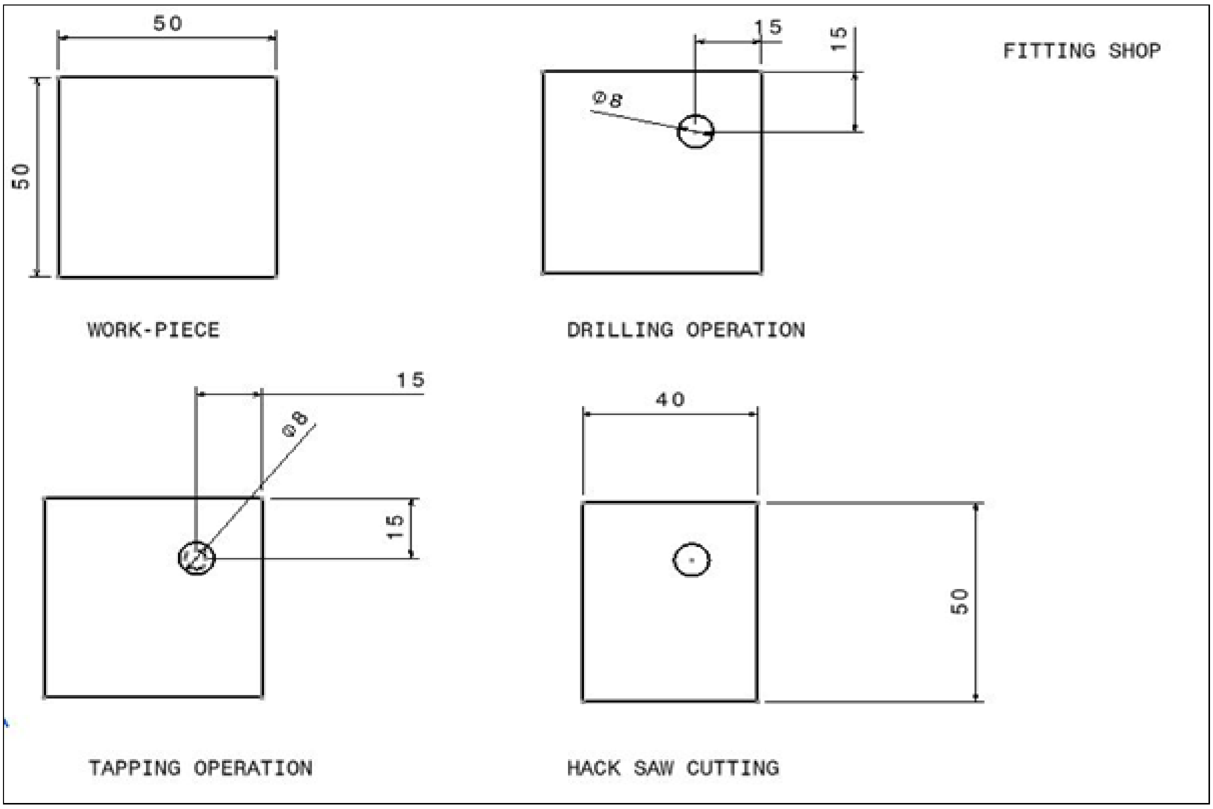


Figure Spanners

Job Description



Sequence of Operation

1. Marking- Marking means setting out dimensions with the help of a working drawing or directly transferring them from a similar part.

2. Filing- Filing is a material removal process in manufacturing. Similar, depending on use, to both sawing and grinding in effect, it is functionally versatile, but used mostly for finishing operations, namely in deburring operations. Filing operations can be used on a wide range of materials as a finishing operation. Filing helps achieve work-piece function by removing some excess material and deburring the surface. Sandpaper may be used as a filing tool for other materials, such as glass. The filing operation consists of the following steps:

i. The work should be held tightly in the vice. The amount of projection of the workpiece from the vice should be minimum to reduce the noise.

ii. The file handle is held by the right hand. Left hand palm is pressed against the end of the file.

iii. The file must remain horizontal throughout the stroke. The stroke should be long, slow and steady. Pressure should be applied only in the forward direction.

iv. The pressure is relieved during the return stroke but file should remain in contact with the workpiece.

v. When quantity of material removal is more, use rough files and for finishing cut use smooth files. Surface smoothness is generated progressively.

3. Drilling- The operation of making round holes in metal pieces is known as drilling. It is done with the help of drilling machine. The drilling operation is carried out as below:

i. The work is marked with a centre punch at the centre of the hole to be drilled.

ii. Hold the job properly in a vice or in other suitable holding device.

iii. The drill is fitted in the chuck.

iv. The hand lever lowers the spindle with the chuck and it is ensured that the point of the drill is in exact alignment with the previously marked centre of the hole.
v. The pressure should be frequently relieved during the drilling operations, otherwise the cutting edges of the drill will be damaged.
vi. A coolant should be used constantly during the drilling operations. Coolant is not used for drilling in Brass and Cast iron.
vii. For drilling large size hole, first produce the small sized holes then produce large holes.

4. Tapping- The process of cutting internal threads into a drilled hole by using a tap is known as tapping. The procedure is described below:
i. First of all a hole is drilled to a diameter smaller than the outside diameter of the thread on the tap.
ii. After drilling, the taper tap is fixed in the tap wrench and screwed in the hole. The tap is held with its axis vertical.
iii. The tap is not turned continuously, but after every half turn, it should be reversed slightly to clear the threads.
iv. When the hole is through, the reduction of resistance on the tap indicates the cutting of a full thread by taper tap.
v. When large no. of holes are to be tapped, in that case tapping is done by drilling machine with slow speed.

5. Sawing- It is the cutting operation to remove the unwanted parts from the given work-piece. The procedure is as given below:
i. The work is held tightly in the vice.
ii. Blade is fixed with its teeth facing forward so that cutting stroke is forward stroke. The blade is tensioned sufficiently by a wing nut.
iii. The desired cut is marked and a notch is made with a file.
iv. The frame is held by one hand just above the wing nut and the handle by another hand.
v. Cutting is started by keeping the blade slightly inclined.
vi. Pressure is applied during the forward stroke only and it should be relieved during the return stroke.

Chapter 5

BLACK SMITHY SHOP

Introduction

Forging is an oldest shaping process used for the producing small articles for which accuracy in size is not so important. The parts are shaped by heating them in an open fire or hearth by the blacksmith and shaping them through applying compressive forces using hammers. Thus forging is defined as the plastic deformation of metals at elevated temperatures into a predetermined size or shape using compressive forces exerted through some means of hand hammers, small power hammers, die, press or upsetting machine. The shop in which the various forging operations are carried out is known as the smithy or smith's shop. Forging operation can be accomplished by hand or by a machine hammer. Forging processes may be classified into hot forging and cold forgings. Hand forging process is also known as black-smithy work which is commonly employed for production of small articles using hammers on heated jobs. It is a manual controlled process even though some machinery such as power hammers can also be sometimes used. Black-smithy is, therefore, a process by which metal may be heated and shaped to its requirements by the use of blacksmith tools either by hand or power hammer.

Applications of forging

Almost all metals and alloys can be forged. The low and medium carbon steels are readily hot forged without difficulty, but the high-carbon and alloy steels are more difficult to forge and require greater care. Forging is generally carried out on carbon alloy steels, wrought iron, copper-base alloys, alumunium alloys, and magnesium alloys. Stainless steels, nickel based super-alloys, and titanium are forged especially for aerospace uses. Producing of crank shaft of alloy steel is a good example which is produced by forging. Forging processes are among the most important manufacturing techniques utilized widely in manufacturing of small tools, rail-road equipments, automobiles and trucks and components of aeroplane industries.

COMMON HAND FORGING TOOLS

1. Tongs - The tongs are generally used for holding work while doing a forging operation.
2. Flatter -It is commonly used in forging shop to give smoothness and accuracy to articles which have already been shaped by fullers and swages.
3. Swage-Swage -is used for forging work which has to be reduced or finished to round, square or hexagonal form.
4. Fuller-Fuller -is used in forging shop for necking down a forgeable job.
5. Punch-Punch -is used in forging shop for making holes in metal part when it is at forging heat.
6. Rivet header-Rivet header - is used in forging shop for producing rivets heads on parts.
7. Hot chisel - Chisels are used for cutting metals and for nicking prior to breaking. the edge of a hot chisel is 30° and the hardening is not necessary. The edge is made slightly rounded for better cutting action.

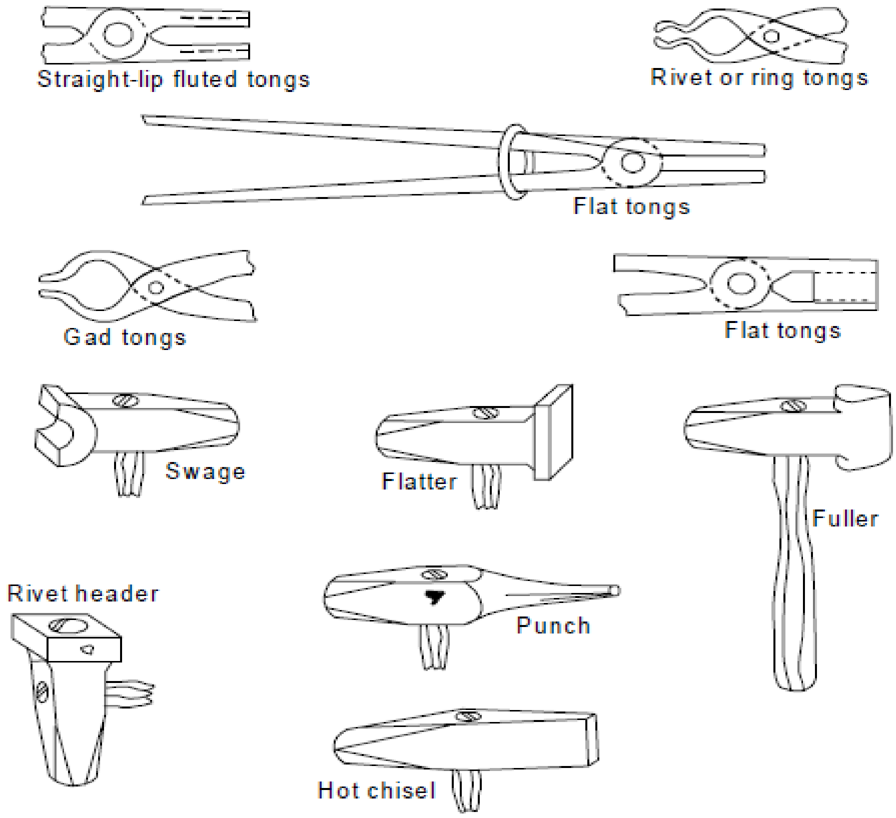


Fig. Different types of forging tools

8. Hammers-There are two major kinds of hammers are used in hand forging: (1) the hand hammer used by the smith himself and (2) the sledge hammer used by the striker. Hand hammers may further be classified as (*a*) ball peen hammer, (*b*) straight peen hammer, and (*c*) cross peen hammer. Sledge hammers may further be classified as (*a*) Double face hammer, (*b*) straight peen hammer, and (*c*) cross peen hammer. Hammer heads are made of cast steel and, their ends are hardened and tempered. The striking face is made slightly convex. The weight of a hand hammer varies from about 0.5 to 2 kg where as the weight of a sledge hammer varies from 4 to 10 kg.

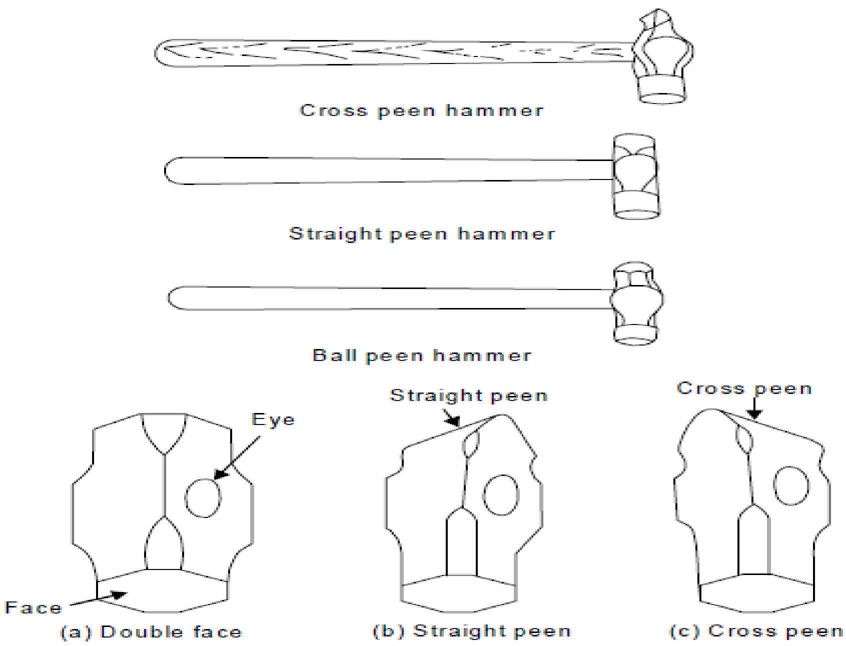


Fig. different types of hammers

9. Anvil -An anvil is a most commonly tool used in forging shop. It acts as a support for blacksmith's work during hammering.
10. Swage block-. It is mainly used for heading, bending, squaring, sizing, and forming operations on forging jobs.

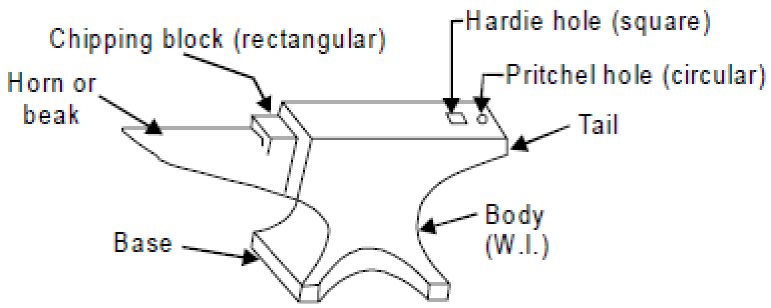


Fig. Anvil

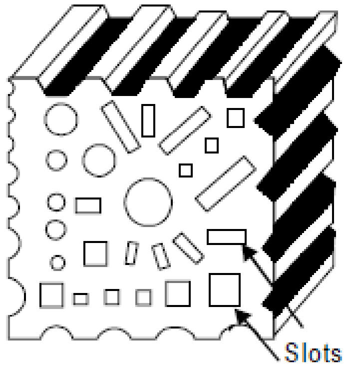


Fig. Swage block

11. Drift -It is a tapered rod made of tool steel. Holes are opened out by driving through a larger tapered punch called a drift.
12. Set-hammer-It is used for finishing corners in shouldered work where the flatter would be Inconvenient. It is also used for drawing out the gorging job.

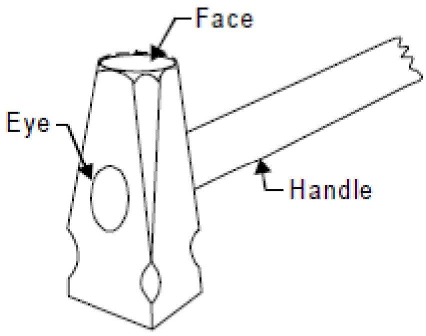


Fig. Set-hammer

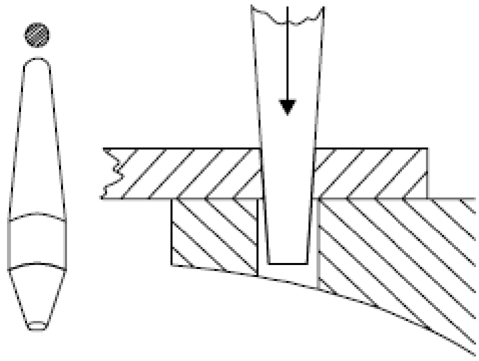


Fig. Drift

Type of forging

1. **Hand forging**
2. **Drop forging**
3. **Machine forging**

1. Hand forging

This is the traditional forging operation done openly or in-openly dies by the village black smith or modern shop floor by manual hammering or by the power hammer. The process involves heating the stock in the black smith hearth and then beating it over the anvil. To get the desired shape the operator has to manipulate the component in between the blows.
The types of operation available are fullering, flattering, bending, upsetting and swaging.

2. Drop forging

This is the operation done in closed impression dies by means drop hammer here the force for shaping the component is applied by dropping the hammer. Drop forging utilizes a closed impression die to obtain the desire shape of the component, the shaping is done by the repeated hammering given to the material in the die cavity. The equipment use for delivering for blows are called drop hammers. The drop forging die consists of two halves. The lower halve of the die is fixed to the anvil of the machine, while the upper halve is fixed to a hammer which is raised and then "dropped" onto the workpiece to deform it according to the shape of the die. There are two types of drop forging: *open-die drop forging* and *closed-die drop forging*. As the names imply, the difference is in the shape of the die, with the former not fully enclosing the workpiece, while the latter does. The heated stock is kept in the lower die, hammer is dropped from above allows the metal to spreads and completely fill the die cavity. When the two die of halves closed the complete is formed. The typical products obtained in drop forging are cranks, crank shaft, connecting rods, wrench, crane hooks etc. This is generally done for large scale production in industries.

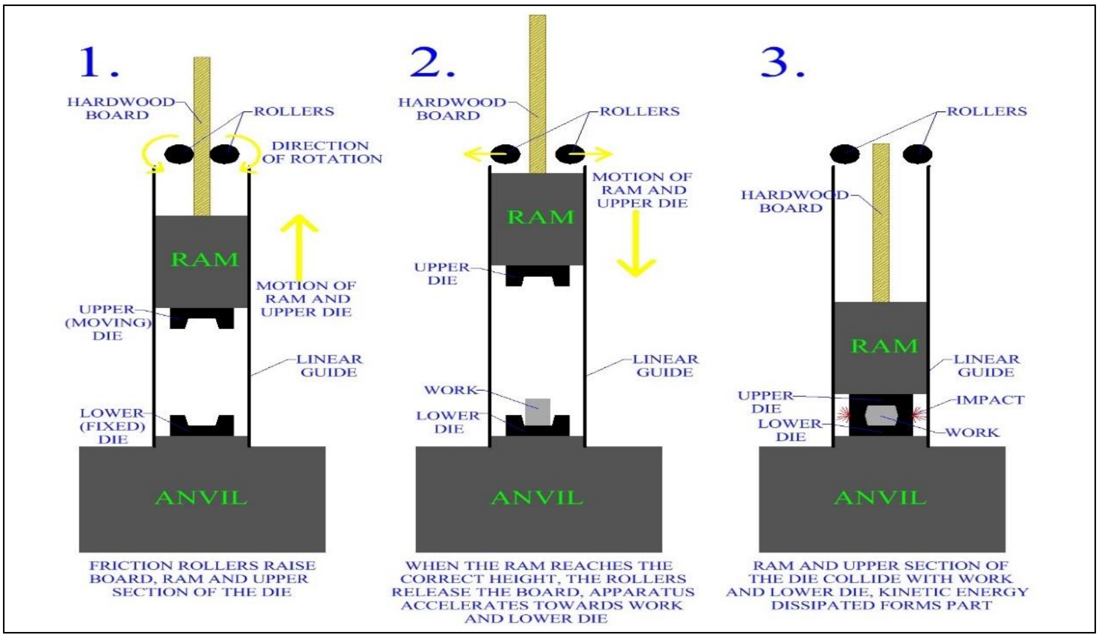


Figure Schematic of drop forging

3. Machine forging

This is the operation done pneumatic operated hammer here the force for shaping the component is applied in a series of blows. This is generally performed to obtain flat products by applying compressive forces by pneumatic operated hammer. The heated stock is kept on the anvil of the machine, while the pneumatic hammer delivers 4-5 blows on the metal in order to obtain the desired shape.

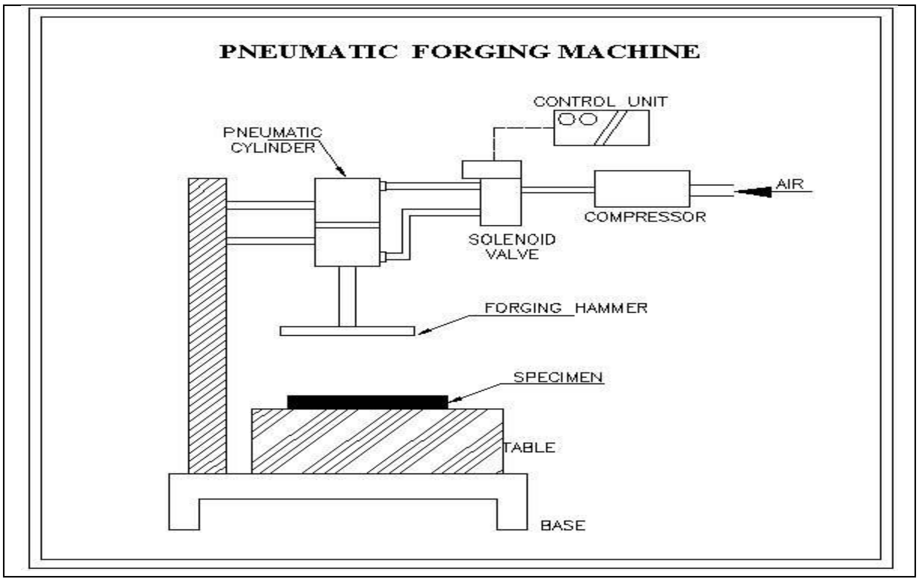


Figure Schematic of machine forging

Forging operations

Drawing out: Drawing lengthens the metal by reducing one or both of the other two dimensions. As the depth is reduced, or the width narrowed, the piece is lengthened or "drawn out". As an example of drawing, a smith making a chisel might flatten a square bar of steel, lengthening the metal, reducing its depth but keeping its width consistent. Drawing does not have to be uniform. A taper can result as in making a wedge or a woodworking chisel blade. If tapered in two dimensions, a point results. Drawing can be accomplished with a variety of tools and methods like hammering on the heated metal which is placed on anvil face using cross peen hammer.

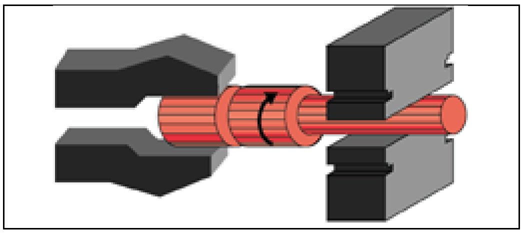


Figure 1 Diagram of drawing operation

Jumping: Jumping is the process of making metal thicker in one dimension through shortening in the other. One form is to heat the end of a rod and then hammer on it as one would drive a nail: the rod gets shorter, and the hot part widens. An alternative to hammering on the hot end is to place the hot end on the anvil and hammer on the cold end.

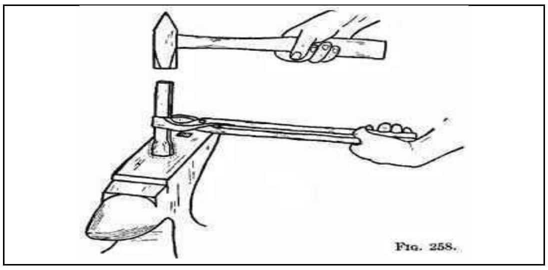
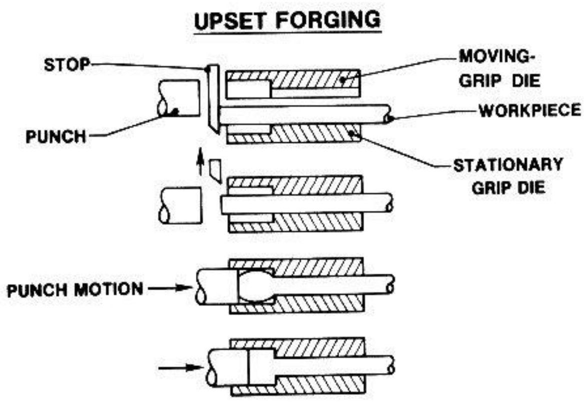
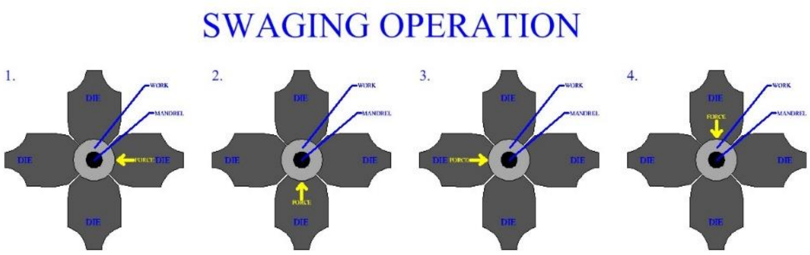


Figure 2 Diagram of jumping operation

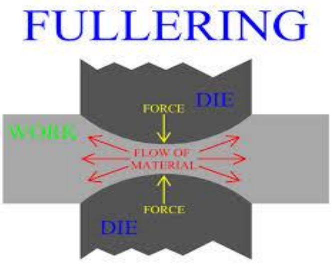
Upsetting: Upset forging increases the diameter of the workpiece by compressing its length. Based on number of pieces produced, this is the most widely used forging process. A few examples of common parts produced using the upset forging process are engine valves, coupling, bolts, screws, and other fasteners. Upset forging is usually done in special high-speed machines called *crank presses,* but upsetting can also be done in a vertical crank press or a hydraulic press. The machines are usually set up to work in the horizontal plane, to facilitate the quick exchange of workpieces from one station to the next. The initial workpiece is usually wire or rod, but some machines can accept bars up to 25 cm (9.8 in) in diameter and a capacity of over 1000 tons. The standard upsetting machine employs split dies that contain multiple cavities. The dies open enough to allow the workpiece to move from one cavity to the next; the dies then close and the heading tool, or ram, then moves longitudinally against the bar, upsetting it into the cavity. If all of the cavities are utilized on every cycle, then a finished part will be produced with every cycle, which makes this process advantageous for mass production.



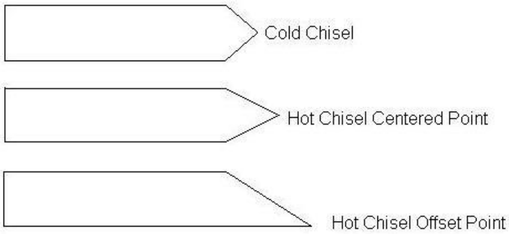
Swaging: Metal swaging or radial forging involves the forging of a work piece by use of die that exert compressive forces by impacts that act around the work's circumference. In manufacturing industry, swaging is usually performed as a cold working process. In addition to the exterior geometry imparted by the impacting die, interior part geometry can also be forged by use of a mandrel. In metal swaging manufacture, the work material is not completely restricted by the die. This is important to note when considering the metal flow that will occur during this forging process. Many impacts from each die may be required to completely forge the work to the geometry of the die and mandrel. In a typical metal swaging process, the work may receive several forging blows per second.



Fullering: A typical open die forging process performed in metal forging manufacture is fullering. Fullering is mostly used as an earlier step to help distribute the material of the work in preparation for further metal forging operations. In fullering, open die with convex surfaces are used to deform the work piece. The result is to cause metal to flow out of one area and to both sides.



Cutting: Cutting, as implied, is a method of cutting to length the piece of metal that you are working on. A hot cut chisel is ground or forged to thirty degrees instead of the sixty degrees a common cold chisel is. The point may be centered in the chisel or offset to one side. Both chisels have their uses. When hot cutting with the point in the center of the chisel, metal will be pushed equally to both sides. When the point is offset to one side, metal is pushed one way only so a straighter, squarer cut may result.



Punching and Drifting: Punching may be done to create a hole in the work piece. For example, in preparation for making a hammer head, a smith would punch a hole in a heavy bar or rod for the hammer handle. This is accomplished by using a punch which can be of any cross sectional shape, depending upon type of hole required. Hole generated from punching operation has tapered walls, which was then removed by performing **drifting** operation.

Bending: Bending can be done with the hammer over the horn or edge of the anvil or by inserting a bending fork into the Hardy Hole (the square hole in the top of the anvil), placing the work piece between the tines of the fork, and bending the material to the desired angle. Bends can be dressed and tightened, or widened, by hammering them over the appropriately shaped part of the anvil.

Tapering: It is a process of producing tapered shape across the length of the forged piece. It is accomplished by repeatedly hammering along, and working towards the tip of a bar; its thickness being slowly reduced as it is worked.

Flattering: This operation is performed to obtain flat surface on the work piece. This is performed by using a flatter, which is used with Sledge hammer. This is also performed to remove hammer marks form the forged surface.

Welding: Welding is the joining of the same or similar kind of metal. In forge welding the pieces to be joined are heated to what is generally referred to as "welding heat". For mild steel most smiths judge this temperature by color: the metal will glow an intense yellow or white. At this temperature the steel is near molten. Any foreign material in the weld, such as the oxides or "scale" that typically form in the fire, can weaken it and potentially cause it to fail. Thus the mating surfaces to be joined must be kept clean. To this end a smith will make sure the fire is a reducing fire: a fire where at the heart there is a great deal of heat and very little oxygen. The smith will also carefully shape the mating faces so that as they are brought together foreign material is squeezed out as the metal is joined.

Finishing: It is the final step of forging process, which is performed to achieve desired surface texture and shape. Depending on the intended use of the piece a blacksmith may finish it in a number of ways.

a. A rap on the anvil to break off scale and a brushing with a wire brush.

b. Files can be employed to bring a piece to final shape, to remove burrs and sharp edges, and to smooth the surface.

c. The wire brush - either as a hand tool or as a power tool - can further smooth, brighten and polish surfaces.

d. Grinding stones, abrasive paper, and emery wheels can further shape, smooth and polish the surface.

Chapter 5: CNC Shop

Introduction

Modern precision manufacturing demands extreme dimensional accuracy and surface finish. Such performance is very difficult to achieve manually, if not impossible, even with expert operators. In cases where it is possible, it takes much higher time due to the need for frequent dimensional measurement to prevent overcutting. It is thus obvious that automated motion control would replace manual "handwheel" control in modern manufacturing. Development of computer numerically controlled (CNC) machines has also made possible the automation of the machining processes with flexibility to handle production of small to medium batch of parts.

In the 1940s when the U.S. Air Force perceived the need to manufacture complex parts for high speed aircraft. This led to the development of computer-based automatic machine tool controls also known as the Numerical Control (NC) systems. Commercial production of NC machine tools started around the fifties and sixties around the world. Note that at this time the microprocessor has not yet been invented.

Initially, the CNC technology was applied on lathes, milling machines, etc. which could perform a single type of metal cutting operation. Later, attempt was made to handle a variety of workpieces that may require several different types machining operations and to finish them in a single set-up. Thus CNC machining centres capable of performing multiple operations were developed. To start with, CNC machining centres were developed for machining prismatic components combining operations like milling, drilling, boring and tapping. Gradually machines for manufacturing cylindrical components, called turning centers were developed.

Numerical Control

Formerly, the machine tool operator guided a cutting tool around a work piece by manipulating hand wheels and dials to get a finished or somewhat finished part. In his procedure many judgments of speeds, feeds, mathematics and sometimes even tool configuration were his responsibility. The number of judgments the machinist had to make usually depended on the type of stock he worked in and the kind of organization that prevailed. If his judgment was an error, it resulted in rejects or at best parts to be reworked or repaired in some fashion. Decisions concerning the efficient and correct use of the machine tool then depended on the craftsmanship, knowledge and skill of the machinist himself. It is rare that two expert operators produced identical parts using identical procedure and identical judgment of speeds, feeds and tooling. In fact even one craftsman may not proceed in same manner the second time around.

Automatically controlling a machine tool based on a set of pre-programmed machining and movement instructions is known as numerical control, or NC. In a typical NC system the motion and machining instructions and the related numerical data, together called a part program, used to be written on a punched tape. The part program is arranged in the form of blocks of information, each related to a particular operation in a sequence of operations needed for producing a mechanical component. The punched tape used to be read one block at a time. Each block contained, in a particular syntax, information needed for processing a particular machining instruction such as, the segment length, its cutting speed, feed, etc. These pieces of information were related to the final dimensions of the workpiece (length, width, and radii of circles) and the contour forms (linear, circular, or other) as per the drawing. Based on these dimensions, motion commands were given separately for each axis of motion. Other instructions and related machining parameters, such as cutting speed, feed rate, as well as auxiliary functions related to coolant flow, spindle speed, part clamping, are also provided in part programs depending on manufacturing specifications such as tolerance and surface finish. Punched tapes are mostly obsolete now, being replaced by magnetic disks and optical disks.

Computer Numerical Control

Computer Numerically Controlled (CNC) machine tools, the modern versions of NC machines have an embedded system involving several microprocessors and related electronics as the Machine Control Unit (MCU). Initially, these were developed in the seventies in the US and Japan. However, they became much more popular in Japan than in the US. In CNC systems multiple microprocessors and programmable logic controllers work in parallel for simultaneous servo position and velocity control of several axes of a machine for contour cutting as well as monitoring of the cutting process and the machine tool. Thus, milling and boring machines can be fused into versatile machining centers. Similarly, turning centers can realize a fusion of various types of lathes. Over a period of time, several additional features were introduced, leading to increased machine utilization and reduced operator intervention. Some of these are:

(a) Tool/work monitoring: For enhanced quality, avoidance of breakdowns.

(b) Automated tool magazine and palette management: For increased versatility and reduced operator intervention over long hours of operation

(c) Direct numerical control (DNC): Uses a computer interface to upload and download part programs in to the machine automatically.

Advantages of CNC machine tools

1. Reduced lead time: Lead time includes the time needed for planning, design and manufacture of jigs, etc. This time may amount to several months. Since the need for special jigs and fixtures is often entirely eliminated, the whole time needed for their design and manufacture is saved.

2. Elimination of operator errors: The machine is controlled by instructions registered on the tape provided the tape is correct and machine and tool operate correctly, no errors will occur in the job. Fatigue, boredom, or inattention by operator will not affect the quality or duration of the machining. Responsibility is transferred from the operator to the tape, machine settings are achieved without the operator reading the dial.

3. Operator activity: The operator is relieved of tasks performed by the machine and is free to attend to matters for which his skills and ability are essential. Presetting of tools, setting of components and preparation and planning of future jobs fall into this category. It is possible for two work stations to be prepared on a single machine table, even with small batches. Two setting positions are used, and the operator can be setting one station while machining takes place at the other.

4. Lower labor cost: More time is actually spent on cutting the metal. Machine manipulation time, gear changing and often setting time are less with CNC machines and help reduce the labor cost per job considerably.

5. Smaller batches: By the use of preset tooling and presetting techniques downtime between batches is kept at a minimum. Large storage facilities for work in progress are not required. Machining centers eliminate some of the setups needed for a succession of operation on one job; time spent in waiting until each of a succession of machine is free is also cut. The components circulate round the machine shop in a shorter period, inter department costs are saved and ‘program chasing’ is reduced.

6. Longer tool life: Tools can be used at optimum speeds and feeds because these functions are controlled by the program.

7. Elimination of special jigs and fixtures: Because standard locating fixtures are often sufficient of work on machines, the cost of special jigs and fixture is frequently eliminated. The capital cost of storage facilities is greatly reduced. The storage of a tape in a simple matter, it may be kept for many years and manufacturing of spare parts, repeat orders or replacements is made much more convenient.

8. Flexibility in changes of component design: The modification of component design can be readily accommodated by reprogramming and altering the tape. Savings are affected in time and cost.

9. Reduced inspection: The time spent on inspection and in waiting for inspection to begin is greatly reduced. Normally it is necessary to inspect the first component only once the tape is proved; the repetitive accuracy of the machine maintains a consistent product.

10. Reduced scrap: Operator error is eliminated and a proven tape results in accurate component.

11. Accurate costing and scheduling: The time taken in machining is predictable, consistent and results in a greater accuracy in estimating and more consistency in costing.

Limitations of CNC

1. High initial investment.
2. High maintenance requirement.
3. Not cost-effective for low production cost.

Classification of CNC Systems

CNC machine tool systems can be classified in various ways such as:

1. **Point-to-point or contouring:** depending on whether the machine cuts metal while the workpiece moves relative to the tool

2. Incremental or absolute: depending on the type of coordinate system adopted to parameterize the motion commands

Point-to-point systems

Point-to-point (PTP) systems are the ones where, either the work piece or the cutting tool is moved with respect to the other as stationary until it arrives at the desired position and then the cutting tool performs the required task with the motion axes stationary. Such systems are used, typically, to perform hole operations such as drilling, boring, reaming, tapping and punching. In a PTP system, the path of the cutting tool and its feed rate while traveling from one point to the next are not significant, since, the tool is not cutting while there is motion. Therefore, such systems require only control of only the final position of the tool. The path from the starting point to the final position need not be controlled.

Contouring systems

In contouring systems, the tool is cutting while the axes of motion are moving, such as in a milling machine. All axes of motion might move simultaneously, each at a different velocity. When a nonlinear path is required, the axial velocity changes, even within the segment. For example, cutting a circular contour requires sinusoidal rates of change in both axes. The motion controller is therefore required to synchronize the axes of motion to generate a predetermined path, generally a line or a circular arc. A contouring system needs capability of controlling its drive motors independently at various speeds as the tool moves towards the specified position. This involves simultaneous motion control of two or more axes, which requires separate position and velocity loops. It also requires an interpolator program that generates the position and velocity setpoints for the two drive axes, continuously along the contour. In modern machines there is capability for programming machine axes, either as point-to-point or as continuous (that is contouring).

Before the next type of classification is introduced, it is necessary to present the basic coordinate system conventions in a machine tool.

Coordinate Systems

The coordinate system is defined by the definition of the translational and rotational motion coordinates. Each translational axis of motion defines a direction in which the cutting tool moves relative to the work piece. The main three axes of motion are referred to as the X, Y. and Z axes. The Z axis is perpendicular to both X and Y in order to create a right-hand coordinate system, such as shown in figure 2. A positive motion in the Z direction moves the cutting tool away from the workpiece. The location of the origin is generally adjustable. Figure 1 shows the coordinate system for turning as in a lathe while figure 2 shows the system for drilling and milling.

For a lathe, the infeed/radial axis is the x-axis, the carriage/length axis is the z-axis. There is no need for a y-axis because the tool moves in a plane through the rotational center of the work. Coordinates on the work piece shown below are relative to the work.

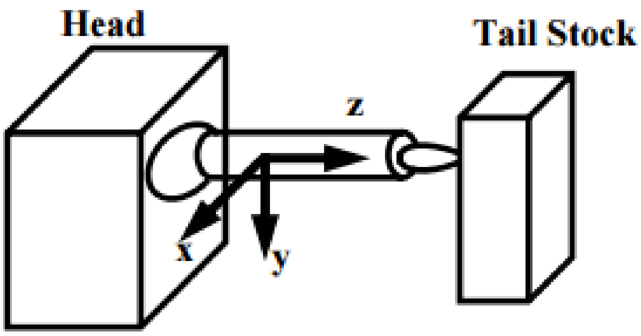


Figure 1: Co-ordinate system for turning

In drilling and milling machines the X and Y axes are horizontal. For example, a positive motion command in the drill moves the X axis from left to right, the Y axis from front to back, and the Z axis toward the top. In the lathe only two axes are required to command the motions of the tool. Since the spindle is horizontal, the Z axis is horizontal as well. The cross axis is denoted by X. A positive position command moves the Z axis from left to right and the X axis from back to front in order to create the right-hand coordinate system.

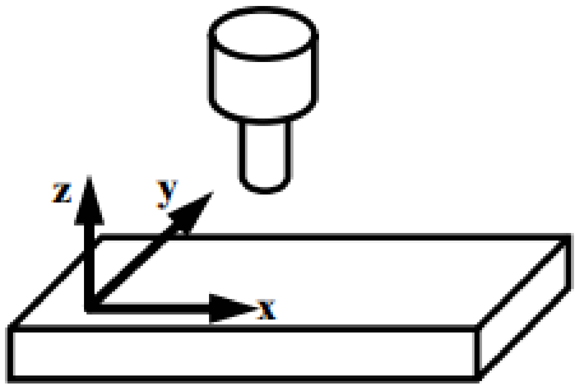


Figure 2: Co-ordinate system for drilling and milling

For a tool with a horizontal spindle the x-axis is across the table, the y-axis is down, and the zaxis is out. In addition to the translational motion, rotary motions around the axes parallel to X, Y, and Z can also be defined. Similarly, in addition to the primary motion coordinates, secondary coordinates can also exist.

Incremental Systems

In an incremental system the movements in each Part program block are expressed as the displacements along each coordinate axes with reference to the final position achieved at the end of executing the previous program block.

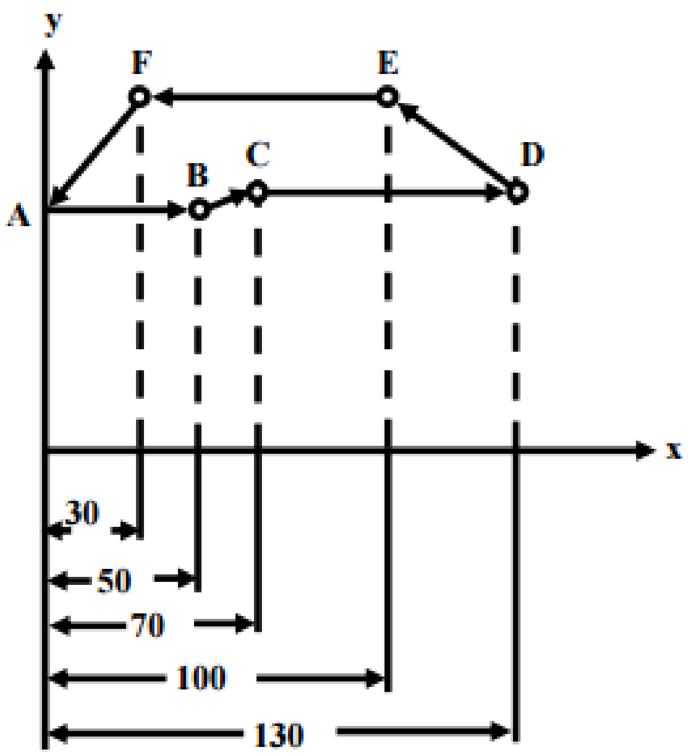


Figure 3: A trajectory for drilling

Consider, for example, the trajectory of rectilinear motions shown in Figure 3 for a PTP system. In an incremental system, the motion parameters, along the X-axis, for the segments, A-B, B-C, C-D, D-E, E-F and F-A, would be given as, 50, 20, 60, -30, -70 and –30, respectively.

Absolute System

An absolute NC system is one in which all position coordinates are referred to one fixed origin called the zero point. The zero point may be defined at any suitable point within the limits of the machine tool table and can be redefined from time to time. Any particular definition of the zero point remains valid till another definition is made. In Figure 3, considering the X-coordinate for point A as zero, the X-coordinate for points B and C would be 50 and 70, respectively, in an absolute coordinate system.

Most modem CNC systems permit application of both incremental and absolute programming methods. Even within a specific part program the method can be changed These CNC systems provide the user with the combined advantages of both methods.

Part Programming

As mention earlier, a part program is a set of instructions often referred to as blocks, each of which refers to a segment of the machining operation performed by the machine tool. Each block may contain several code words in sequence. These provide:

1. Coordinate values (X, Y, Z, etc.) to specify the desired motion of a tool relative to a work piece. The coordinate values are specified within motion codeword and related interpolation parameters to indicate the type of motion required (e.g. point-to-point, or continuous straight or continuous circular) between the start and end coordinates. The CNC system computes the instantaneous motion command signals from these code words and applies them to drive units of the machine.
2. Machining parameters such as, feed rate, spindle speed, tool number, tool offset compensation parameters etc.
3. Codes for initiating machine tool functions like starting and stopping of the spindle, on/off control of coolant flow and optional stop. In addition to these coded functions, spindle speeds, feeds and the required tool numbers to perform machining in a desired sequence are also given.
4. Program execution control codes, such as block skip or end of block codes, block number etc.

5. Statements for configuring the subsystems on the machine tool such as programming the axes, configuring the data acquisition system etc.

A typical block of a Part program is shown below in Figure 4 Note that the block contains a variety of code words such G codes, M codes etc. Each of these code words configure a particular aspect of the machine, to be used during the machining of the particular segment that the block programmes.

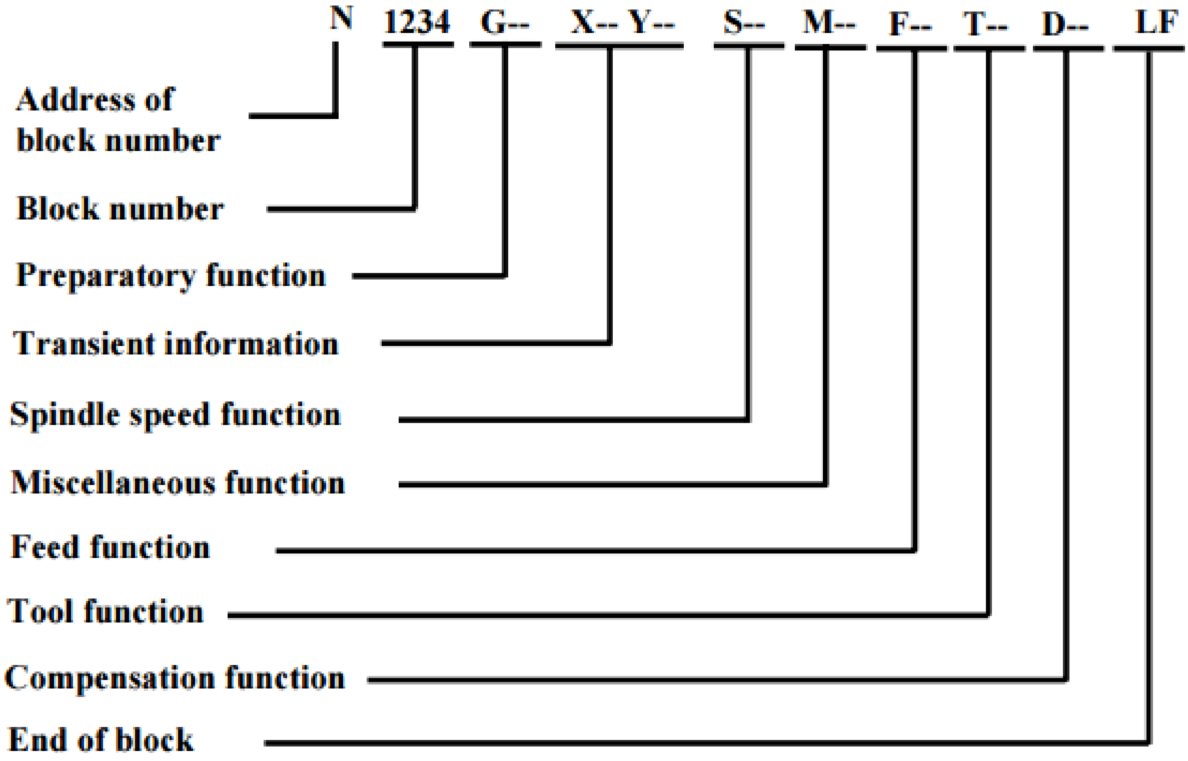


Figure 4: Structure of a block in a part program

Some common Preparatory NC Codes

G00 Linear Movement (rapid)

G01 Linear Movement (feed)

G02 Circular Movement (cw)

G03 Circular Movement (ccw)

G90 Absolute dimensions

G91 incremental dimensions

G94 Feed in mm/min

Some common Miscellaneous NC Codes

M02 End of program

M03 Clockwise rotation of spindle

M04 Counter-clockwise rotation of spindle

M05 Stop rotation of main spindle

M30 Machine stop

Chapter 6: Foundry Shop

Casting process is one of the earliest metal shaping techniques known to human being. It means pouring molten metal into a refractory mold cavity and allows it to solidify. The solidified object is taken out from the mold either by breaking or taking the mold apart. The solidified object is called casting and the technique followed in method is known as casting process.

HAND TOOLS USED IN FOUNDRY SHOP

1. Hand riddle: It consists of a screen of standard circular wire mesh equipped with circular wooden frame. It is generally used for cleaning the sand for removing foreign material such as nails, shot metal, splinters of wood etc. from it.

2. Shovel: It consists of an steel pan fitted with a long wooden handle. It is used in mixing, tempering and conditioning the foundry sand by hand. It is also used for moving and transforming the molding sand to the container and molding box or flask.

3. Rammers: These are required for striking the molding sand mass in the molding box to pack or compact it uniformly all around the pattern.

4. Sprue pin: Sprue pin is shown in Fig. 11.1(d). It is a tapered rod of wood or iron which is placed or pushed in cope to join mold cavity while the molding sand in the cope is being rammed. Later its withdrawal from cope produce a vertical hole in molding sand, called sprue through which the molten metal is poured into the mould using gating system. It helps to make a passage for pouring molten metal in mold through gating system

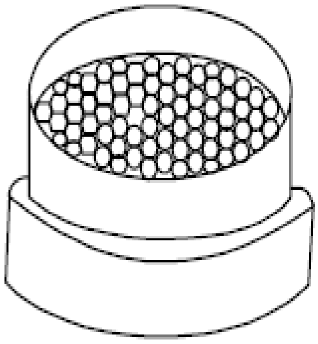


Fig: Hand riddle

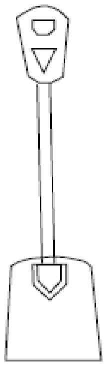


Fig: Shovel

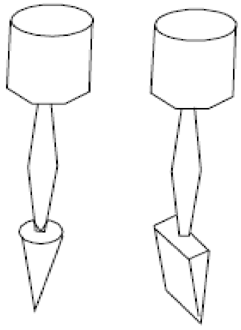


Fig: Rammers

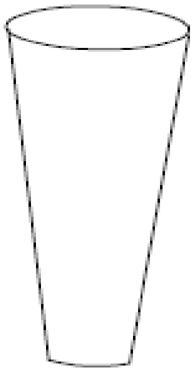


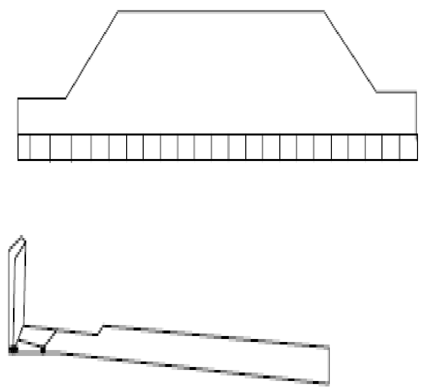
Fig: Sprue pin

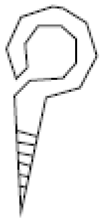
5. Strike off bar: Strike off bar (Fig. 11.1(e)) is a flat bar having straight edge and is made of wood or iron. It is used to strike off or remove the excess sand from the top of a molding box after completion of ramming thereby making its surface plane and smooth.

6. Draw spike: Draw spike is shown Fig. 11.1(f). It is a tapered steel rod having a loop or ring at its one end and a sharp point at the other. It may have screw threads on the end to engage metal pattern for it withdrawal from the mold. It is used for driven into pattern which is embedded in the molding sand and raps the pattern to get separated from the pattern and finally draws out it from the mold cavity.

7. Vent rod: Vent rod is a thin spiked steel rod or wire carrying a pointed edge at one end and a wooden handle or a bent loop at the other. After ramming and striking off the excess sand it is utilized to pierce series of small holes in the molding sand in the cope portion.

8. Lifters: Lifters are also known as cleaners or finishing tool which are made of thin sections of steel of various length and width with one end bent at right angle. They are used for cleaning, repairing and finishing the bottom and sides of deep and narrow openings in mold cavity after withdrawal of pattern.





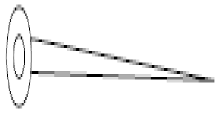


Fig. Strike off bar Fig. Draw spike Fig. Vent rod Fig. Lifter

9. Trowels: Trowels are utilized for finishing flat surfaces and joints and partings lines of the mold. They consist of metal blade made of iron and are equipped with a wooden handle. The common metal blade shapes of trowels may be pointed or contoured or rectangular oriented. The trowels are basically employed for smoothing or slicking the surfaces of molds.

10. Slicks: Slicks are shown in Fig. 11.1(o, p, q, and r). They are also recognized as small double ended mold finishing tool which are generally used for repairing and finishing the mold surfaces and their edges after withdrawal of the pattern.

11. Smoothers: Smothers are shown in Fig. 11.1(s and t). According to their use and shape they are given different names. They are also known as finishing tools which are commonly used for repairing and finishing flat and round surfaces, round or square corners and edges of molds.

12. Swab: Swab is shown in Fig. 11.1(u). It is a small hemp fiber brush used for moistening the edges of sand mould, which are in contact with the pattern surface before withdrawing the pattern.

13. Gate cutter: Gate cutter (Fig. 11.1(v)) is a small shaped piece of sheet metal commonly used to cut runners and feeding gates for connecting sprue hole with the mold cavity.

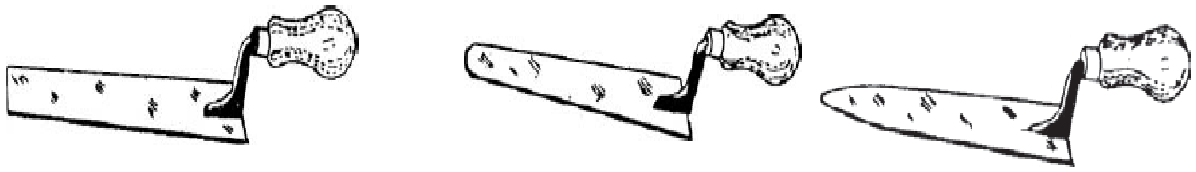
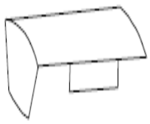
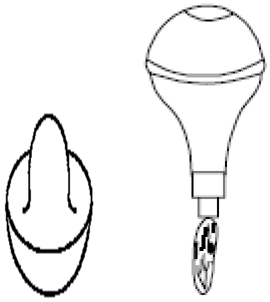


Fig. Trowels

Fig. Slicks





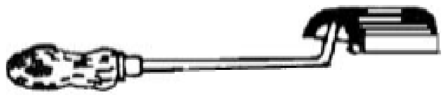


Fig. Smoothers Fig. Swab Fig. Gate cutter

Pattern

A pattern is a model or the replica of the object (to be casted). It is embedded in molding sand and suitable ramming of molding sand around the pattern is made. The pattern is then withdrawn for generating cavity (known as mold) in molding sand. Thus it is a mould forming tool. It may be defined as a model or form around which sand is packed to give rise to a cavity known as mold cavity in which when molten metal is poured, the result is the cast object. When this mould/cavity is filled with molten metal, molten metal solidifies and produces a casting (product). So the pattern is the replica of the casting. The common materials used for making patterns are wood, metal, plastic, plaster, wax etc.

Types of Pattern:-

1. Single-piece or solid pattern

Solid pattern is made of single piece without joints, partings lines or loose pieces. It is the simplest form of the pattern. Typical single piece pattern is shown in figure below.

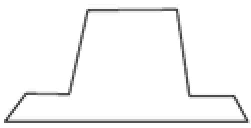


Fig: Single piece Pattern

2. Two-piece or split pattern

When solid pattern is difficult for withdrawal from the mold cavity, then solid pattern is split in two parts. Split pattern is made in two pieces which are joined at the parting line by means of dowel pins. The splitting at the parting line is done to facilitate the withdrawal of the pattern. A typical example is shown in figure below.

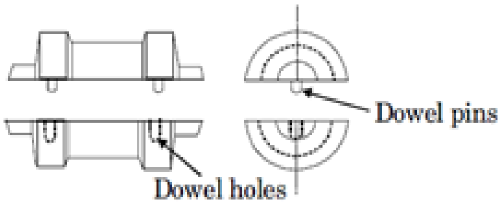


Fig: Two piece Pattern

3. Cope and drag pattern

In this case, cope and drag part of the mould are prepared separately. This is done when the complete mould is too heavy to be handled by one operator. The pattern is made up of two halves, which are mounted on different plates. A typical example of match plate pattern is shown in figure below.

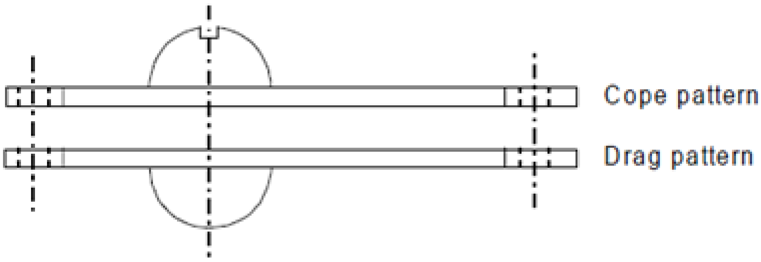


Fig. Cope and drag pattern

4. Three-piece or multi-piece pattern

Some patterns are of complicated kind in shape and hence cannot be made in one or two pieces because of difficulty in withdrawing the pattern. Therefore these patterns are made in either three pieces or in multi-pieces. Multi molding flasks are needed to make mold from these patterns.

5. Loose-piece Pattern

Loose piece pattern is used when pattern is difficult for withdrawal from the mould. Loose pieces are provided on the pattern and they are the part of pattern. The main pattern is removed first leaving the loose piece portion of the pattern in the mould. Finally the loose piece is withdrawal separately leaving the intricate mould.

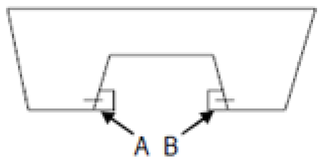
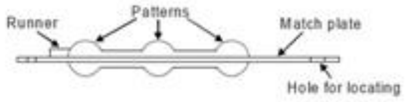


Fig. Loose piece pattern

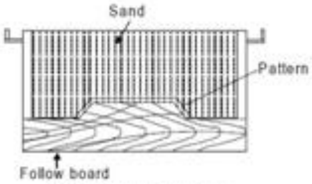
Some other types of pattern are:

6. Match plate pattern
7. Follow board pattern
8. Gated pattern
9. Sweep pattern
10. Skeleton pattern
11. Segmental or part pattern

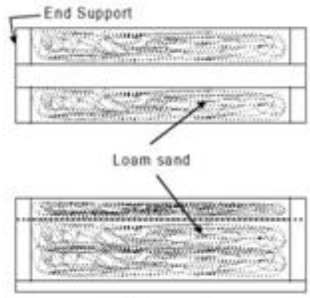
These are shown in the figure below:



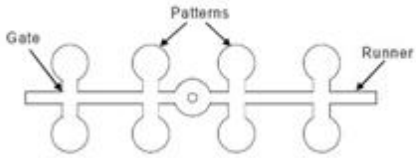
Match plate pattern



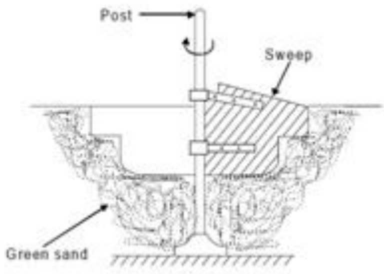
Follow board pattern



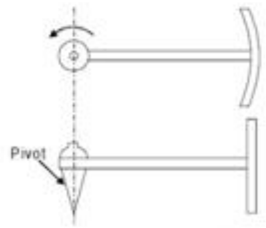
Skeleton pattern



Gated pattern



Sweep pattern



Segmental or part pattern

Pattern allowances: The size of a pattern is never kept the same as that of the desired casting because of the fact that during cooling the casting is subjected to various effects and hence to compensate for these effects, corresponding allowances are given in the pattern. These various allowances given to pattern can be enumerated as,

- ***Allowance for shrinkage,***
- ***Allowance for machining***,
- ***Allowance for draft,***
- ***Allowance for rapping or shake,***
- ***Allowance for distortion and allowance for mould wall movement.***

Mold: A suitable and workable material possessing high refractoriness in nature can be used for mould making. Thus, the mold making material can be metallic or non-metallic. But, out of all, the molding sand is the most common utilized non-metallic molding material because of its certain inherent properties namely refractoriness, chemical and thermal stability at higher temperature, high permeability and workability along with good strength.

Molding sand: Molding sands may be of two types namely natural or synthetic. Natural molding sands contain sufficient binder. Whereas synthetic molding sands are prepared artificially using basic sand molding constituents (silica sand in 88-92%, binder 6-12%, water or moisture content 3-6%)

and other additives in proper proportion by weight with perfect mixing and mulling in suitable equipments.

Properties of moulding sand

1. ***Refractoriness:*** Refractoriness is defined as the ability of molding sand to withstand high temperatures

2. ***Permeability:*** It is also termed as porosity of the molding sand in order to allow the escape of any air, gases or moisture present or generated in the mould when the molten metal is poured into it.

3. ***Cohesiveness*****:** It is property of molding sand by virtue which the sand grain particles interact and attract each other within the molding sand.

4. ***Green strength***: The green sand after water has been mixed into it, must have sufficient strength and toughness to permit the making and handling of the mould.

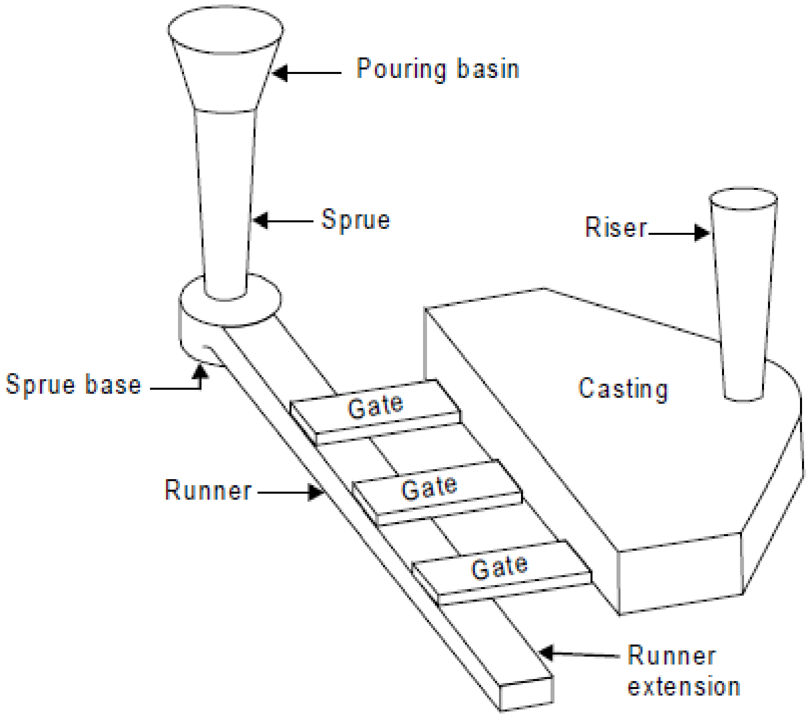
5. ***Dry strength***: As soon as the molten metal is poured into the mould, the moisture in the sand layer adjacent to the hot metal gets evaporated and this dry sand layer must have sufficient strength to its shape in order to avoid erosion of mould wall during the flow of molten metal.

6. ***Flowability or plasticity:*** It is the ability of the sand to get compacted and behave like a fluid.

7. ***Adhesiveness:*** It is property of molding sand to get stick or adhere with foreign material such sticking of molding sand with inner wall of molding box.

8. ***Collapsibility:*** After the molten metal in the mould gets solidified, the sand mould must be collapsible so that free contraction of the metal occurs and this would naturally avoid the tearing or cracking of the contracting metal.

Gating system in mold



1. Pouring basin

It is the conical hollow element or tapered hollow vertical portion of the gating system which helps to feed the molten metal initially through the path of gating system to mold cavity. It may be made out of core sand or it may be cut in cope portion of the sand mold. It makes easier for the ladle operator to direct the flow of molten metal from crucible to pouring basin and sprue. It helps in maintaining the required rate of liquid metal flow. It reduces turbulence and vertexing at the sprue entrance. It also helps in separating dross, slag and foreign element etc. from molten metal before it enters the sprue.

2. Sprue

It is a vertical passage made generally in the cope using tapered sprue pin. It is connected at bottom of pouring basin. It is tapered with its bigger end at to receive the molten metal the smaller end is connected to the runner. It helps to feed molten metal without turbulence to the runner which in turn reaches the mold cavity through gate. It sometimes possesses skim bob at its lower end. The main purpose of skim bob is to collect impurities from molten metal and it does not allow them to reach the mold cavity through runner and gate.

3. Gate

It is a small passage or channel being cut by gate cutter which connect runner with the mould cavity and through which molten metal flows to fill the mould cavity. It feeds the liquid metal to the casting at the rate consistent with the rate of solidification.

4. Choke

It is that part of the gating system which possesses smallest cross-section area. In choked system, gate serves as a choke, but in free gating system sprue serves as a choke.

5. Runner

It is a channel which connects the sprue to the gate for avoiding turbulence and gas entrapment.

6. Riser

It is a passage in molding sand made in the cope portion of the mold. Molten metal rises in it after filling the mould cavity completely. The molten metal in the riser compensates the shrinkage during solidification of the casting thus avoiding the shrinkage defect in the casting. It also permits the escape of air and mould gases. It promotes directional solidification tool and helps in bringing the soundness in the casting.