Workshop is a facility equipped with machinery, tools, and equipment for manufacturing and repairing mechanical devices, such as machines, engines, and structures. It is a place where engineers and technicians work to design, build, test, and maintain mechanical systems and components.

The workshop may also have specialized areas for specific activities such as metalworking, woodworking, electrical and electronics assembly, and 3D printing. engineers and technicians may work together in teams to complete projects, with each member responsible for different aspects of the design, fabrication, and assembly process.

Chapter 2

Fitting Shop

2.1 Introduction to Fitting Shop:

Fitting is a hand machining process of bringing the metal pieces to desired shape and size by removal of excess material from its surface and using hand tools such that, the work pieces are made into perfect assembly and is fit for the purpose it is being made. Fitting is thus defined as a process of assembling various parts manufactured in the machine shop after filling them to proper shape and size. The place where the fitting of work pieces is performed is termed as fitting shop.

2.2 Fitting tools and equipment: There are various categories of tools used by the fitter. Some of the common tools used by the fitter in fitting shop are briefed under the following categories.

- **Measuring Tools used in Fitting:** Calipers, Vernier Calipers, Vernier Height Gauge, Micrometer, Engineers Protractor, Combination Set, Dial Indicator, Steel Rule.
- **Marking Tools used in Fitting:** Scriber ,Try Square ,Dividers and Punches Surface Plate.
- **Holding Tools used in Fitting:** Work Bench, Bench Vice, V-Block , Angle plate.
- **Cutting Tools used in Fitting:** Files, Hacksaw, Chisels, Twist Drill, Reamer, Tap and Tap Wrench, Die and Die Stock.
- **Striking Tools used in Fitting:** Hammers.

2.2.1 Measuring Tools used in Fitting Shop:

Manufacturing of a component from raw material to final finishing stage, there lies several stages of machining. Therefore, to make a component of desired shape and size, its proper measurement must be carried out during every stage of machining. With the help of proper measurement at every stage, the component never goes undersize and is made within fit limits and it is the primary requirement of any manufacturer.

2.2.1.1 Calipers: Calipers are used with a steel rule for the measurement or comparison of linear dimensions in the accuracy of +0.05mm to -0.05mm. Calipers are classified into two types.

Inside Calipers: Inside calipers (Figure 2.1(a)) are used for measuring internal dimensions such as the diameter of a hole, or the width of a slot etc.

Outside Calipers: Outside calipers (Figure 2.1(b)) are used for measuring external dimensions such as the length, diameter, or even the thickness of a solid. Outside diameter of cylindrical piece is measured by opening the legs of outside caliper and sliding against cylindrical piece outer surface as shown in Figure 2.1(c).

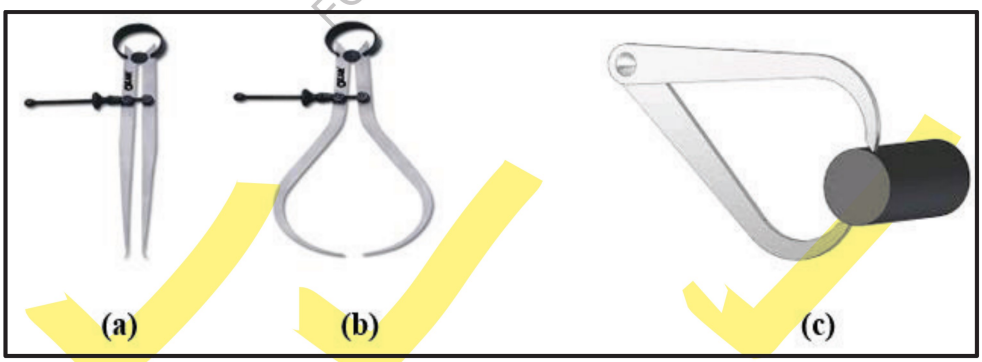


Figure 2.1 (a) Inside and **(b)** Outside Calipers and **(c)** its use

2.2.1.2 Vernier Calipers: Vernier Calipers (Figure 2.2) can more precisely measure the external dimensions, internal dimensions, and depths. It has two scale named as main scale and a vernier scale for measurement with their relative movement. The least count of a vernier scale is the measurement difference of the one division on the main scale and one division on the vernier.

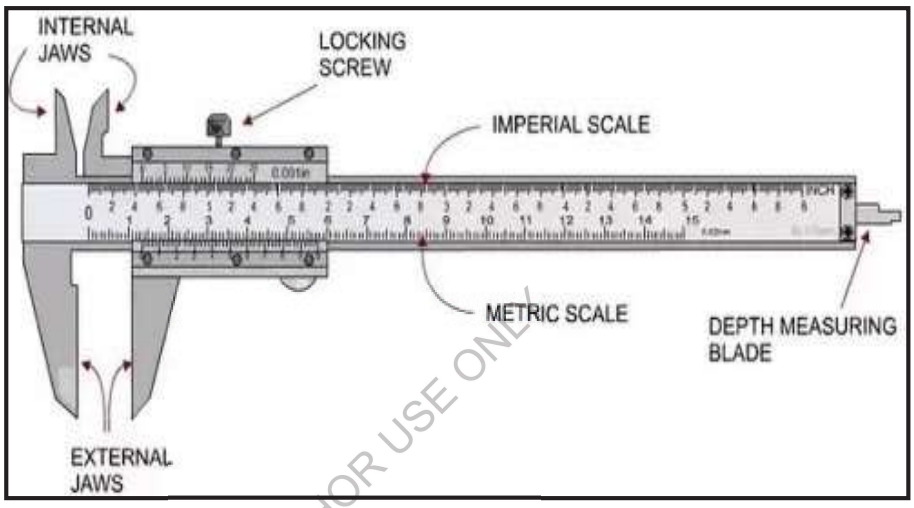


Figure 2.2 Vernier Calipers

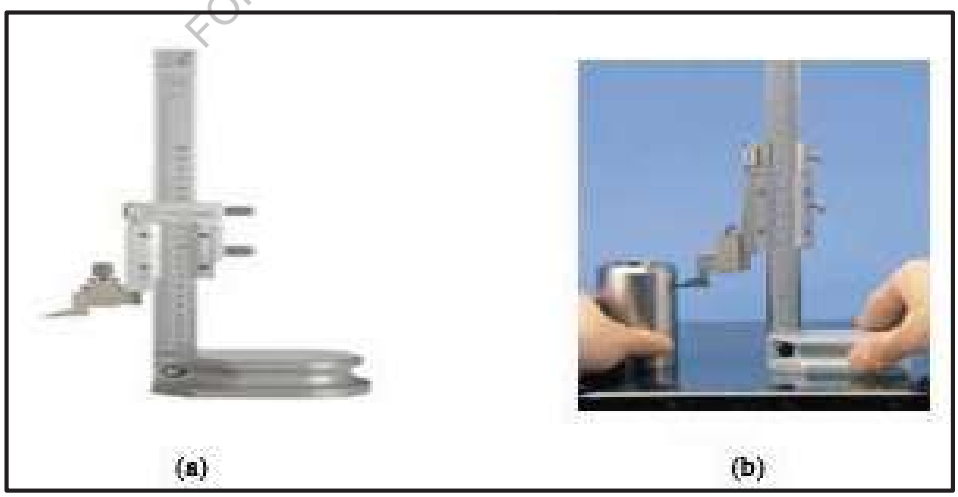


Figure 2.3 (a) Vernier Height Gauge and **(b)** its use

2.2.1.3 Vernier Height Gauge: A vernier height gauge (Figure 2.3 (a)) is used for measuring height of an object or for marking lines onto an object of given distance from a datum base. Object to be measured and the vernier height gauge are kept on the surface plate for accurate measurements as shown in Figure 2.3 (b).

2.2.1.4 Micrometer: It has more precise measurements compared to the vernier calipers. Common types of micrometers used in the workshops are:

Outside Micrometer: An outside micrometer (Figure 2.4 (a)) is used for measuring external dimensions. The work to be measured is placed between the anvil and the tip of the spindle.

Inside Micrometer: This is similar in structure to an outside micrometer and is used for measuring internal dimensions as shown in Figure 2.4 (b).

Depth Micrometer: A depth micrometer (Figure 4 (c)) is used for measuring the depth of a hole, slot, and keyway etc.

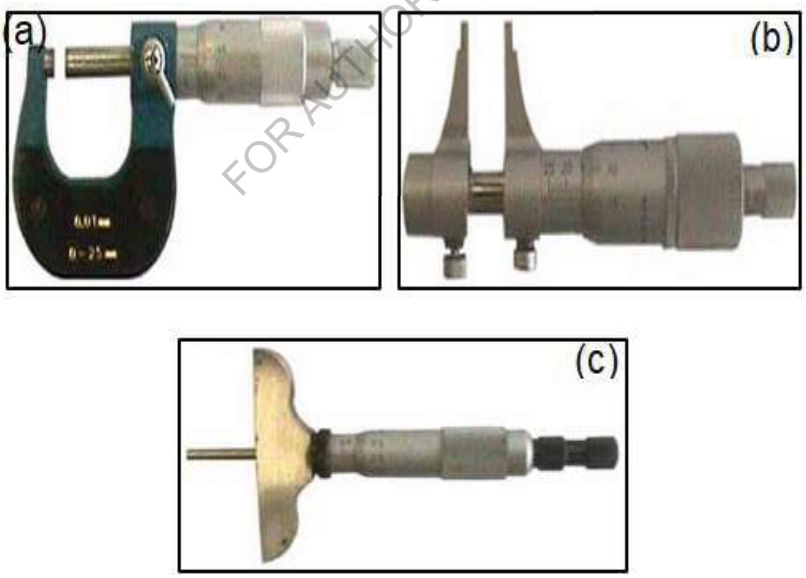


Figure 2.4 (a) Outside Micrometer **,(b**) Inside Micrometer, **(c)** Depth Micrometer

2.2.1.5 Engineer's Protractor : It is an angle measuring tool as shown in figure 2.5 and used for the checking of angles of drill head, cutting tool, and marking of angles.

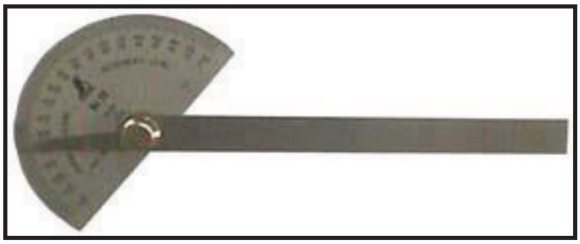


Figure 2.5 Engineer's Protractor

2.2.1.6 Combination Set: As shown in figure 2.6 (a) and (b)) is a multipurpose measuring tool have functions of protractor, try square, steel rule, center finder, level rule, and scriber.

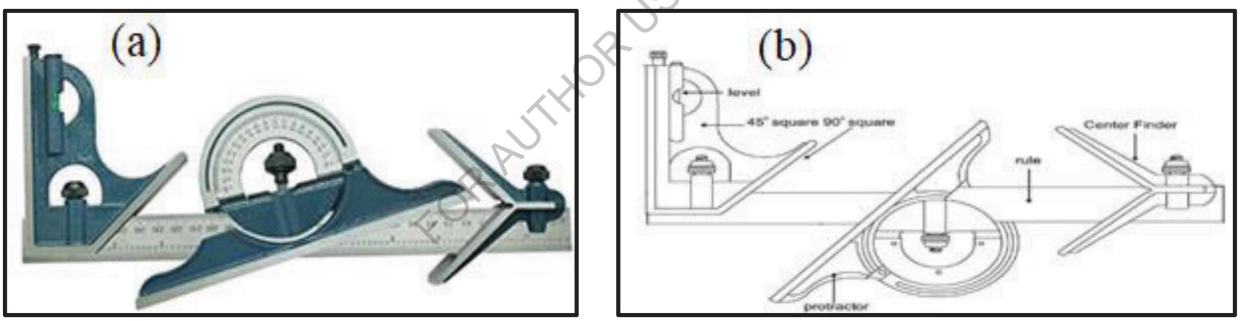


Figure 2.6(a) Combination Set**, (b)** Combination Set with label

2.2.1.7 Steel Rule: The steel rule is a basic measuring tool used to measure along straight lengths as shown in figure 2.7. It is also used to mark straight lines when used along with a scriber.

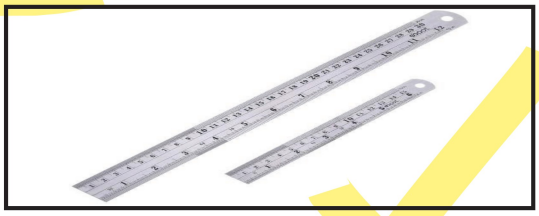


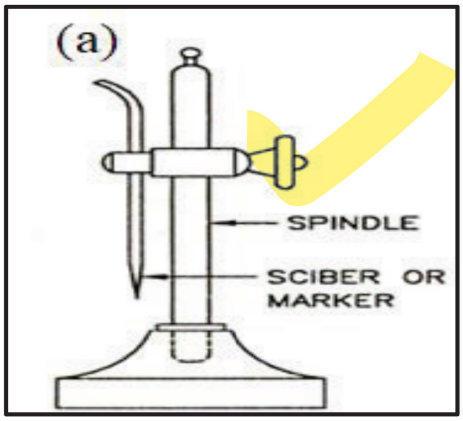
Figure 2.7 Steel Rule

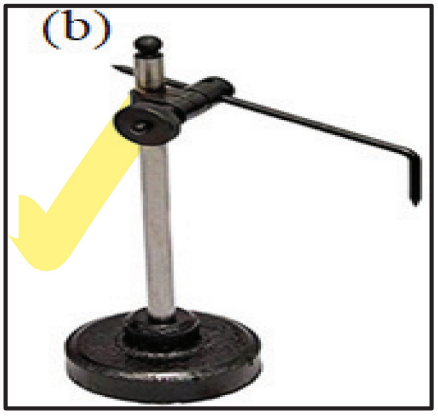
2.2.1.8 Dial Indicator: This tool helps to magnified and read the very fine linear movement. It is made up of a stylus and a pointer on dial as shown in figure 2.7. The accuracy of dial indicator can be up to three decimal points. It is usually used for calibration of machine.

Figure 2.8 Dial Indicator

2.2.2 Marking tools of fitting shop: The marking of exact dimensions of drawing on workpiece is an important primary work as this gives reference lines and centers on the workpiece. The marked work piece can further cut or machined to the required shapes and sizes. The tools used for marking out are as follow:

2.2.2.1 Scriber: A scriber as shown in figure 2.8 (a-b) is used for marking lines on the work piece. It is made of hardened tool steel. It is generally mounted on a cast iron sliding base (Figure 8 (b) fitted with a vertical steel rod in form of scribing block. It also helps to locate centers of round rods held in V-block (Figure 8 (c)).





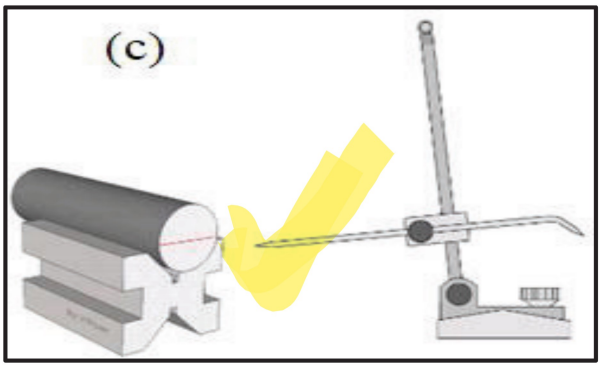
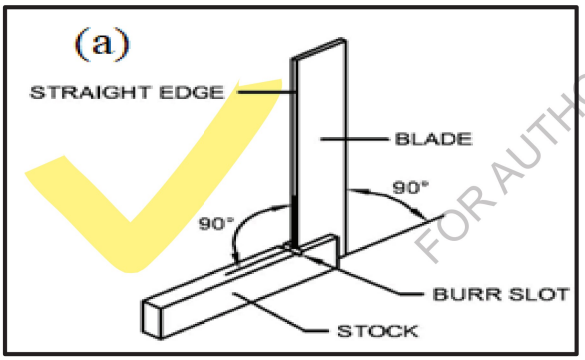


Figure 2.8 (a) Scriber, **(b)** Scriber, and **(c)** its use

2.2.2.2 Try Square : It is also known as try square (Figure 2.9 (a)) and is a very common tool used for scribing straight lines at right angles to a true surface (Figure 9 (b)). It is generally falls in the category of both marking as well as measuring tool.



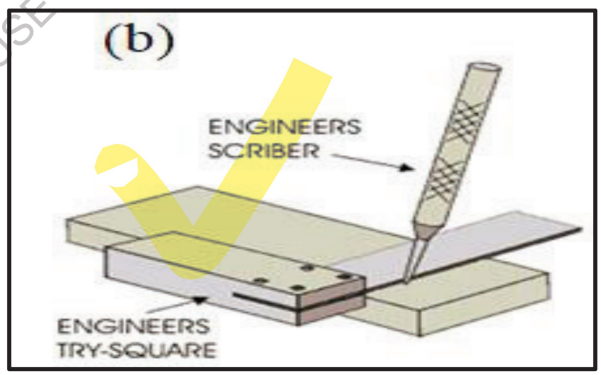


Figure 2.9 (a) Try Square, and **(b)** its use

2.2.2.3 Divider and Punches: Dividers are used to mark arcs or circles on mild steel work pieces. They are generally made of medium carbon steel (Figure 2.10 (a)). The punch is used for making indentations on a work piece already marked with scriber. Most common type of punch used in fitting shop is center punch (Figure 2.10 (b)) with its tip pointed at 90 degrees angle. They are manufactured from carbon steel.

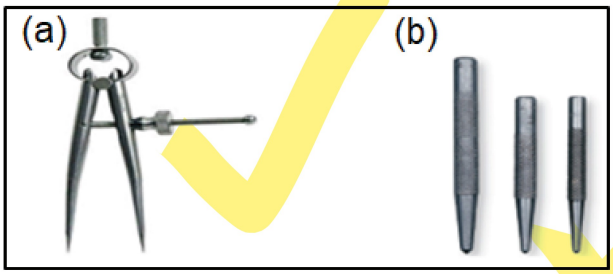


Figure 2.10 (a) Divider , **(b)** Center Punches

2.2.2.4 Surface Plate :Surface plate (Figure 2.11 (a) is made of malleable cast iron or granite stone (Figure 2.11 (b)). It has a high degree of surface smoothness and flatness. The flat surface is used as a reference surface for measurements.

Figure 2.11(a) Surface Plate, **(b)** Surface Plate of different sizes

2.2.3 Holding and Supporting Tools used in Fitting :

2.2.3.1 Work Bench: All the basic fitting operations are performed by either holding or supporting the work piece in some holding or supporting devices. These devices are further mounted on some rigid base that is termed as a workbench (Figure 2.12). In addition to supporting holding devices, the tools, which are used in performing different fitting operations, can also be placed on the workbench for their easy and efficient access.

Figure 2.12 Work Bench

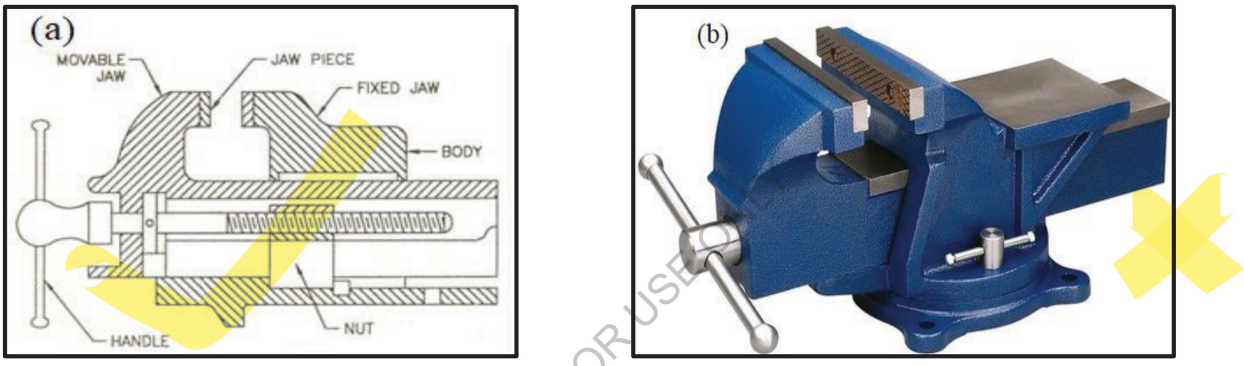


Figure 2.13 (a) Detail of Bench Vice, **(b)** Solid view of Bench Vice

2.2.3.2 Bench Vice: A bench vice (Figure 2.13 (a) and (b)) is the holding tool for the work piece. The body of the vice is made of cast iron while the two clamping jaws are made of hardened tool steel. Some bench vice has a swivel base, which can set the work piece at an angle to the table. The work piece should be held tightly at a proper height in the vice jaws before performing any fitting operation upon it.

2.2.3.3 V-Block: V-Blocks as shown in figure 2.14 (a) and (b) usually are made of steel in casehardening. It is used for holding cylindrical work piece for marking out or machining operations such as drilling a hole in cylindrical work piece. V-Block are used along with U-Clamps or C-Clamps, which are used to support the cylindrical work piece on V-Block.

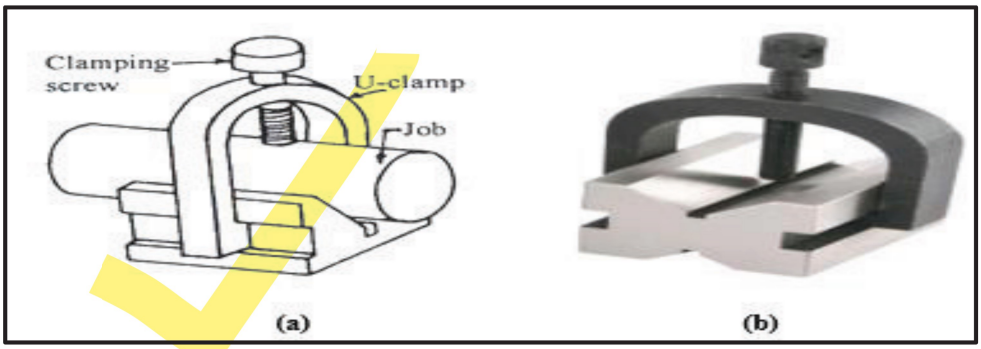


Figure 2.14 (a) V- Block with U-Clamp, and **(b)** its use

2.2.3.4 Angle Plate :An angle plate (Figure 2.15 (a) and (b)) is a right-angle plate with holes and slots. It is used for supporting the workpiece vertically on the wall of angle plate with bolts through holes and slots. It is made up of cast iron with high degree of accuracy.

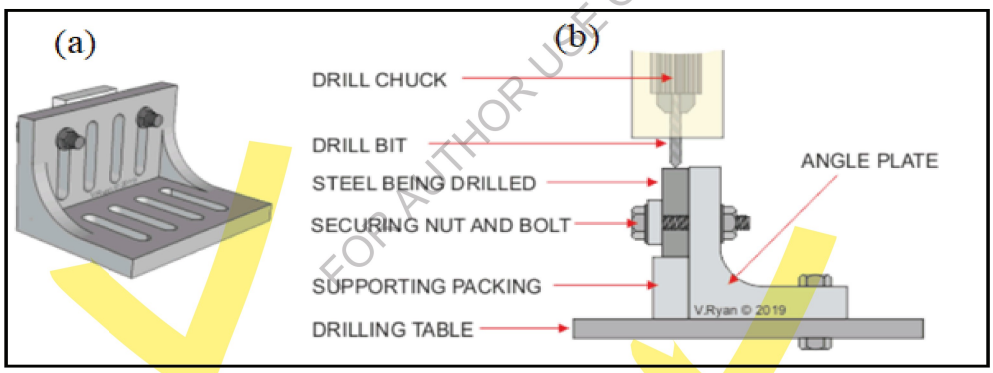


Figure 2.15: (a) Angle Plate, and (b) its use

2.2.4 Cutting tools used in fitting: After the initial measurement and marking operation, the next most important operation that is carried out in fitting shop is the cutting and sawing operation. Work piece is brought to required shape and dimension by removing excess material from its surface with the help of cutting tools. The material is removed in form of fine chips from the work piece surface due to primarily wearing off the work piece surface and due to abrasive action of

the hard cutting tool. The cutting tools based upon their use are categorized as under.

2.2.4.1 Files: Files are the highly vital hand tools for the fine removal and smooth surfaces of raw materials. They has hardened high carbon steel body with a soft 'tang', for a handle to fix on it. Different parts of file are shown in the Figure 2.16. Files are categorized on the following basis:-

i. Based on Length
ii. Based on Shape
iii. Based on Grade
iv. Based on Type of Cut

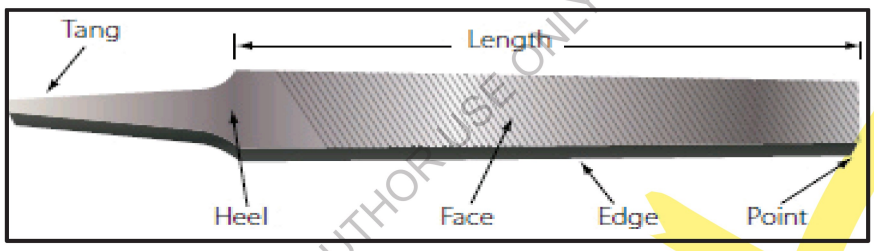


Figure 2.16 File specification

i. **Based on Length** - Length of a file is measured from the heel to the tip. Files generally comes in the length ranges of 100 mm to 200 m for finer work and 200 mm to 450 mm for general purpose work.
ii. **Based on Shape** - Files are specified based upon the shape of its cross section. Further, they are classified in this category as under.

(a). Hand File – It is used for roughing and finishing. It has a rectangular cross section and parallel in width as shown in Figure 2.17(a). It has double cut teeth on two faces, single cut teeth on

Figure 2.17 (a) Hand File

one edge, and one save edge.

(b). Flat File - It is like a hand file in cross section as shown in Figure 2.17 (b), But slightly tapered slightly in width and thickness towards the tip. It has double cut teeth on two faces and single cut teeth on two sides.

Figure 2.17 (b) Flat File

(c) Half-round File - The cross section is a chord of a circle with its taper towards the tip as shown in Figure 2.17 (c). It is used for forming radii, grooves, etc. and the flat side is used for finishing flat surfaces.

Figure 2.17(c) Half-round File.

(d) Round File - This has round cross section (Figure 2.17 (d)) tapering toward the end. It is used for enlarging holes, producing internal round corners. Usually, double cut in the larger sizes, and single cut for the smaller sizes.

Figure 2.17 (d) Round File

(e) Square File - This has square cross section as shown in Figure 2.17 (e), with tapered towards the tip, and usually double cut on all four faces. It is used for filing rectangular slots or grooves.

Figure 2.17 (e) Square File

(f) Triangular File - This has triangular cross section as shown in Figure 2.17 (f), with tapered towards the tip with double cut on both faces. It is used for filing corners or angles less than 90°

Figure 2.17 (f) Triangular File

(g) Needle Files - Needle files are a set of files with small and fine cross sections, their shapes made in a way like the large ones. They are generally used for small and delicate works such as the repair of small instruments. Use of different shapes of files used to file of excess material for generating different shape of contours is shown in Figure 2.18 (a) and (b).

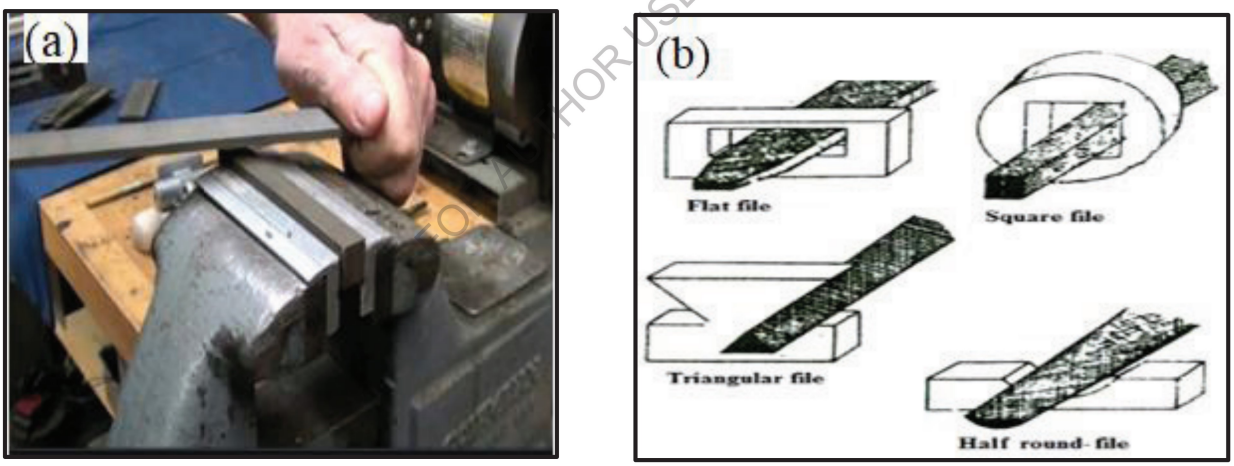


Figure 2.18 Uses of Files

iii. **Based on Grade** - Grade of the files are specified based upon the spacing between the consecutive teeth also termed as pitch. This refers to the pitch (spacing) of the teeth that spread throughout the whole length of the file. Files with a rougher grade of cut give a faster metal removal rate but a poorer surface finish or the vice versa. It should be noted that, for the same

grade of cut, a longer file would have a coarser pitch than a shorter one. The grades are as follows:

(a) Bastard cut – It has medium teeth and suitable for general purpose work on mild steel.

(b) Second cut – It has finer teeth and used for cutting hard metals.

(c) Smooth cut – It has fine teeth and used for finishing work.

iv. **Based on Type of Cut pattern**- Files are classified based upon the type of cut pattern cut on its cutting surface. The cutting patterns are further classified as given under.

(a) Single Cut - There is only one set of cutting teeth to one edge as shown in Figure 2.19 (a). It has less efficient cutting but good surface finish. It is appropriate for the soft metal.

(b) Double Cut - It has two set of teeth one at 70 degrees to one edge, and another at 45 degrees to the other edge as shown in figure 2.19 (b). It is thus more efficient in cutting. The problem of clogging observed when used with the soft metal.

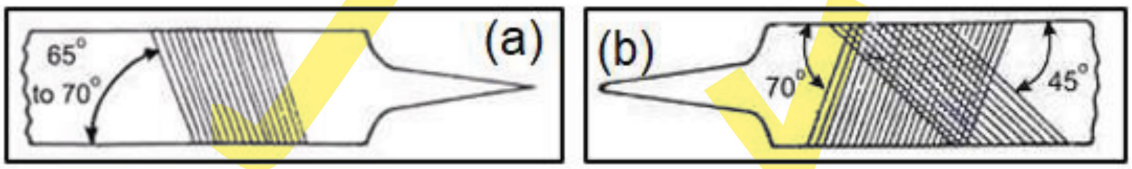


Figure 2.19 (a) Single cut file, **(b)** Double cut file

2.2.4.2 File Card : The problem of file clogging when working with soft metal is very common and known as pinning. The pinning can be removed with a File card as shown in Figure 2.20, which is a wire brush mounted on a block of wood.

Figure 2.20 File Card

2.2.4.3 Hacksaw: It is a hand operated metal cutting tool used for small jobs in workshop. The cutting action of hacksaw is termed as sawing operation. It consists of a "U" shaped steel frame and a saw blade as shown in figure 2.21. The frame may be adjustable to take different blade lengths. It has a wing nut to adjust the tension of the blade.

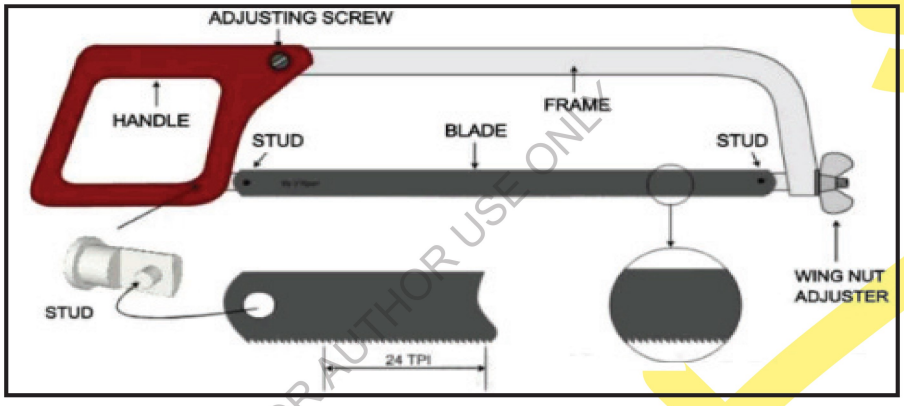


Figure 2.21 Hack Saw

2.2.4.4 Saw Blade : It is an important accessory of hacksaw. It has some specification based on material, hardening, length and pitch.

(a). **Material** - The saw blade is made up of High Carbon Steel (HCS),High Speed Steel (HSS) and alloy steel. The HCS will annealed from the heat generated by fraction of cutting. The HCS, saw blade will lose its hardness when cutting the hard metal. The HSS can keep its hardness unless improper use.

(b). Hardening - The saw blade is provided with all hard or flexible grade. The all hard is very brittle, and it is suitable for the skillful user only. The flexible

grade is tough, so it can twist an angle. It is suitable for cutting a curve or for the beginner to use.

(c). Length - The length of the blade is determined by the distance between the outside edges of the holes, which fit over the pegs.

(d). Pitch - It is the number of teeth per 25mm.

Coarse blade (18T) is appropriate for soft and thick work material.

Medium blade (24T) is appropriate for steel pipe.

Fine blade (32T) is suitable for the thin metal sheet and pipe.

Figure 2.22 Pitches of saw blade

(e). Set - The teeth have a "set" to either side alternately, which causes the blade to cut a slit wider than the thickness of the blade, to prevent jamming.

2.2.4.5 Chisels: Chisel is primarily used to cut different profiles in metal pieces known as chipping or chiseling operation; they generally range from flat, round or any angular section. It is most used in chipping off the undesirable material from the work pieces. Chipping is generally performed with the help of cutting edge of chisels while striking them at back end known as the head with help of a hammer. The chisel cuts are mostly rough. Therefore, it needs filling after performing chipping with chisels. Chisels are used both on hot and cold metals. Different parts of chisel are classified as head, body, forging angle, cutting edge, and cutting angle as shown in figure 2.23.

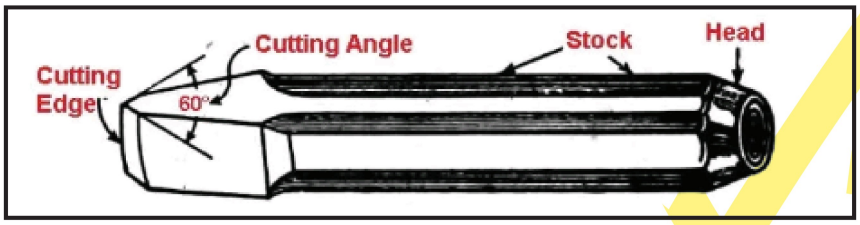


Figure 2.23 Chisel

There are following types of chisel used in fitting shop as shown in figure 23(a-e):

a. Flat chisel
b. Cross cut chisel
c. Side cut chisel
d. Round Nose Chisel
e. Diamond point chisel

(a). Flat chisel- It is an all-metal chisel used for obtaining a flat surface on metal by chipping. This chisel is used to cut wires, thin sheets, and round rods etc. The edge of this chisel is in "V" shape and is flat, which is raised from the centre. Because of this projected parts, it does not get stuck into the cut surface, while chipping.

(a)

Figure 2.23 (a) Flat Chisel

(b). Cross Cut Chisel- It is mainly used to cut square slots and channels. Keyway on a shaft is made with this chisel. Its cutting edge is

(b)

Figure 2.23 (b) Cross Cut Chisel

from 3 mm to 12 mm in width.

(c). Side Cut Chisel- Where other types of chisel cannot be used easily, side cut chisels are used. The keyway and cotter way is cleaned with this chisel.

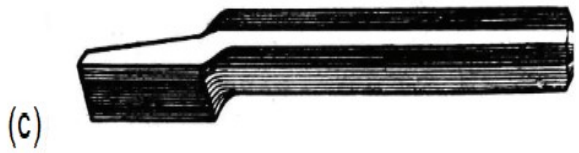


Figure 2.23 (c) Side Cut Chisel

(d). Round Nose Chisel - Its edge is round. It is used for making an oil groove in a bearing and for cutting slits at corners. Its forging angle is at and cutting angle is of 35 ° to 40 °. In such jobs where the drill is dislocated at the time of drilling and some substance is left, the leftover metal is set right with this chisel.

Figure 2.23 (d) Round Nose Chisel

Figure 2.23 (e) Diamond Cut Chisel

(e). Diamond Point Chisel- Its shape is square and it is tapered. Its edge is pointed and of the shape of a diamond. Based on its square ends, its measurement is determined. Square corners and triangle corners are cleaned with it. We can make a groove in plain surface with this chisel.

2.2.4.6 Drill and Drilling Operation

It is the process of cutting holes in metals by using a drilling machine as shown in figure 2.24. Drills are the tools used to cut holes as the drill progresses in a rotational motion through the material.

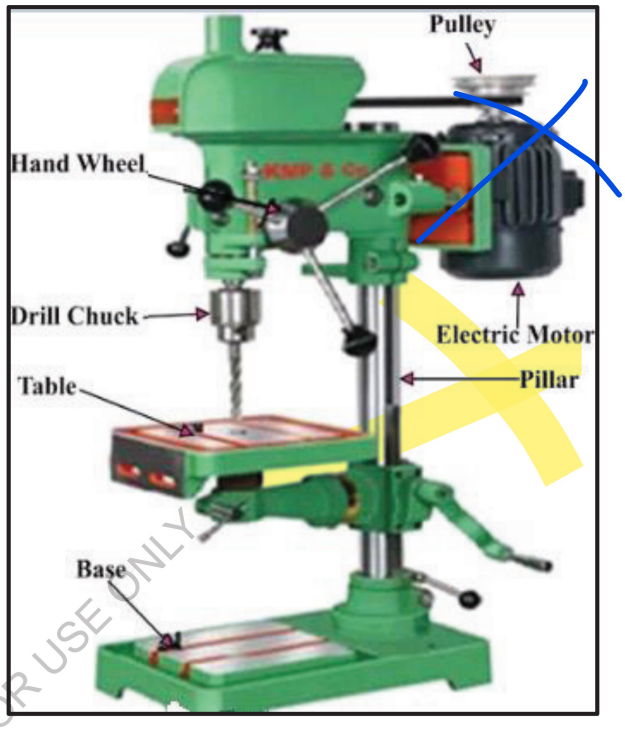


Figure 2.24 Drilling Machine

(a). Twist Drill: As shown in figure 2.25 (a), it has helical flutes on it body with a cutting edge at one end and tang on the other end. The helical flutes are included to carry away the chips of metal and the outside surface is relieved to produce a cutting edge along the leading side of each flute. Drilling operation to produce hole is shown in Figure 2.25 (b).

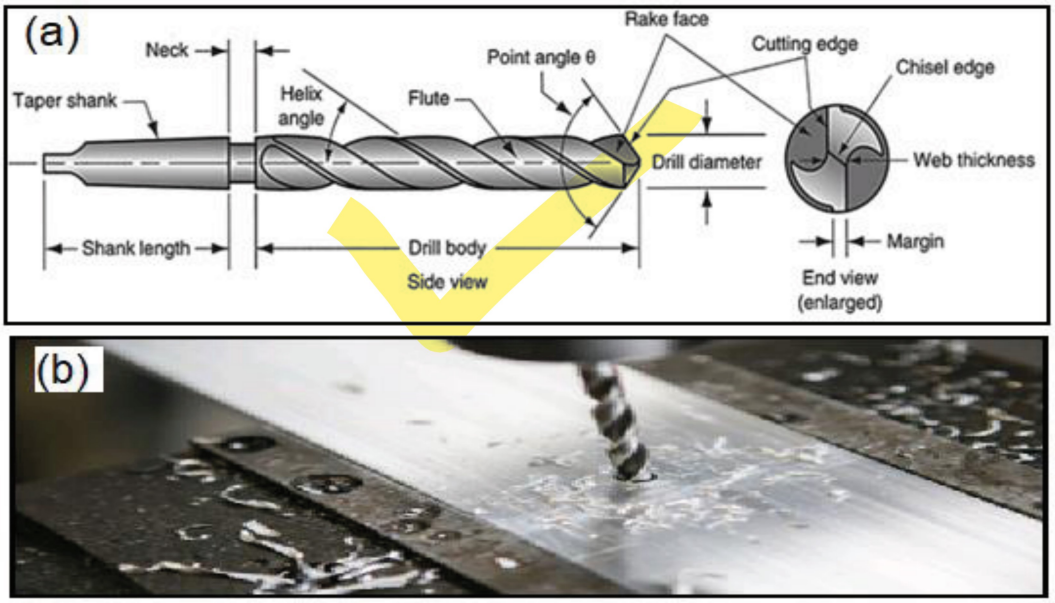


Figure 2.25 (a) Twist Drills, **(b)** Drilling Operation

2.2.4.7 Reamer : Reamer is used to control the diameter of a hole already drilled. It is also used to improve the internal surface finish of the drilled hole and improves the roundness of the hole. Reamer is made of hardened High Carbon Steel or High-Speed Steel. It is classified into hand reamer and machine reamer. Hand reamer (Figure 2.26) has two types of flutes: - straight and spiral flutes. The spiral flutes hand reamer has a left-hand spiral flutes. The purpose of the design is to prevent the reamer "screw in" the hole.

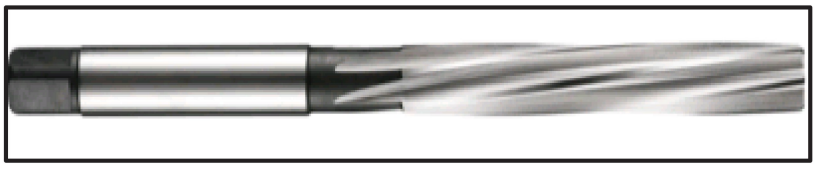


Figure 2.26 Hand Reamer

2.2.4.8 Tap and Tap Wrench : Taps (Figure 2.27) are used to cut the internal screw threads. Taps are made of hardened High Carbon Steel or High-Speed Steel. The ends of the shank are square to fit a wrench (Figure 2.28). Usually taps are provided in set of three -- taper, plug and bottoming tap. Tapping

operation of producing internal threads in work piece with already drilled hole is shown in Figure 2.29.

(a). Taper Tap- It is tapered off for a length of 8 to 10 threads. It is the first tap to be used in a hole to start the thread form.

(b). Plug Tap- It is tapered off for a length of 3 to 5 threads to facilitate picking up the threads cut by the taper tap.

(c). Bottoming Tap- This is fully threaded throughout its length and is called a 'bottoming' tap. This tap used to cut the bottom of a blind hole.

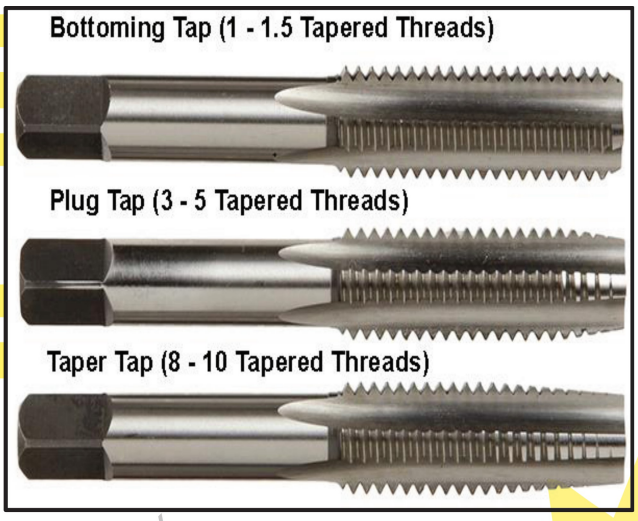


Figure 2.27 Set of Taps

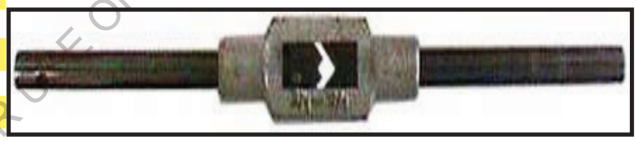


Figure 2.28 Tap Wrench

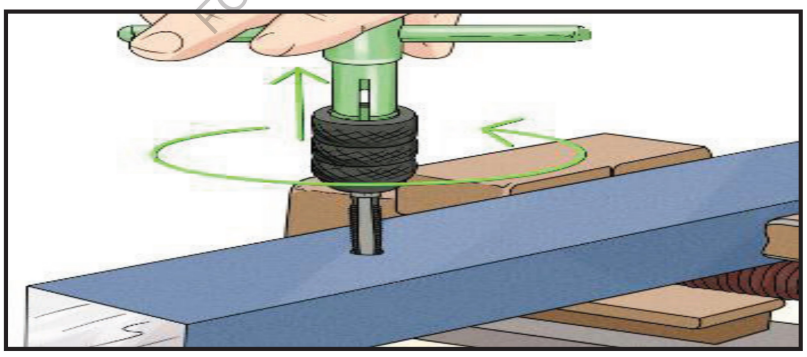


Figure 2.29 Tapping operation

2.2.4.9 Die and Die Stock: Dies are used for cutting external threads on round bar or tubes. Dies are made of hardened High Carbon Steel or High-Speed Steel.

(a). Split Die or Button Die: It is held in place in the stock as shown in Figure 2.30. The split permits a small amount of adjustment in the size of the die by adjusting the screws in the stock. Since split dies cut their thread complete in one cut, the die thread are tapered and back off for one third of their length.

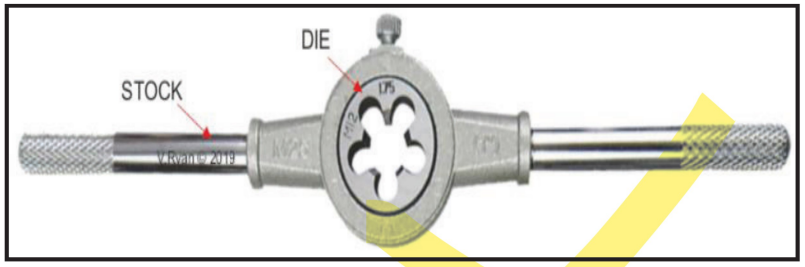


Figure 2.30 Split Die and Die Stock

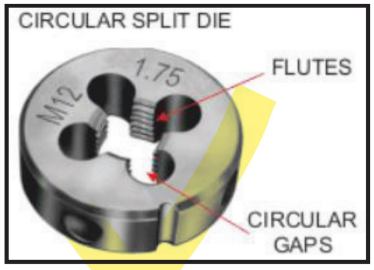


Figure 2.31 Die Nut

(b).Die nuts: Die nuts (Figure 2.31) are not capable of any adjustment. They are usually employed for rectifying any damage to existing threads. They are externally formed to hexagonal shape for use with a spanner. Manually external thread cutting operation over a cylindrical work piece, with the help of a die and diestock is shown in Figure 2.32.

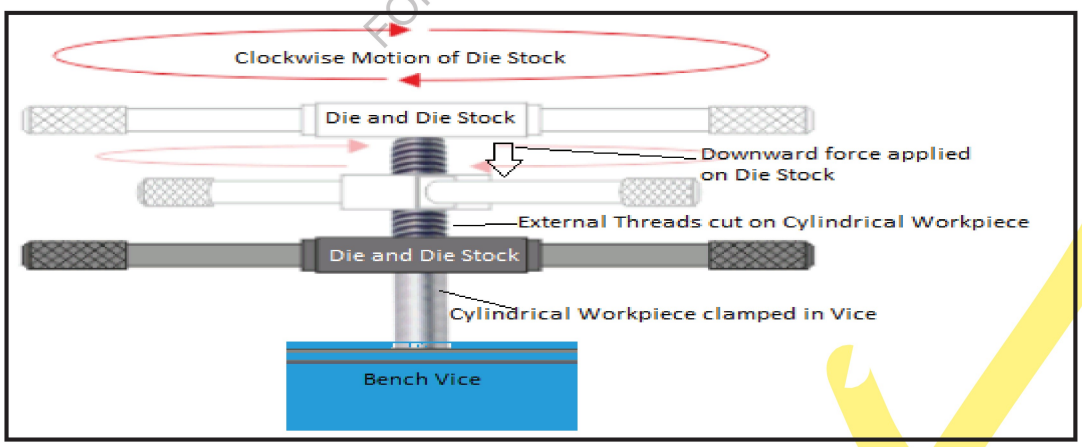
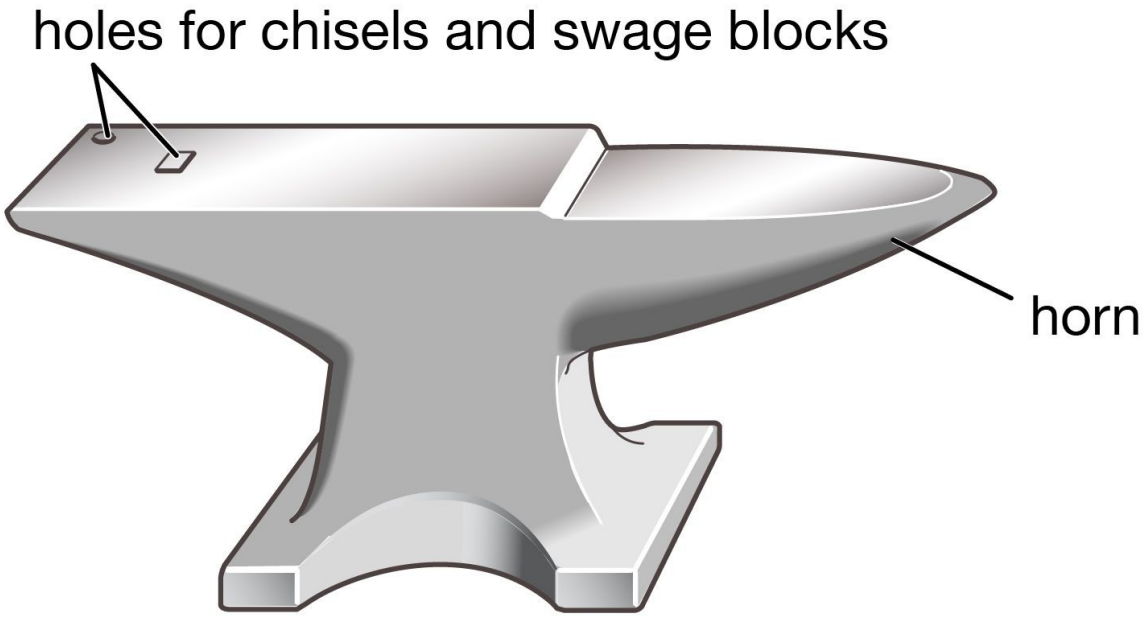


Figure 2.32 Die and Die Stock and its use

2.2.5 Striking tools used in Fitting :

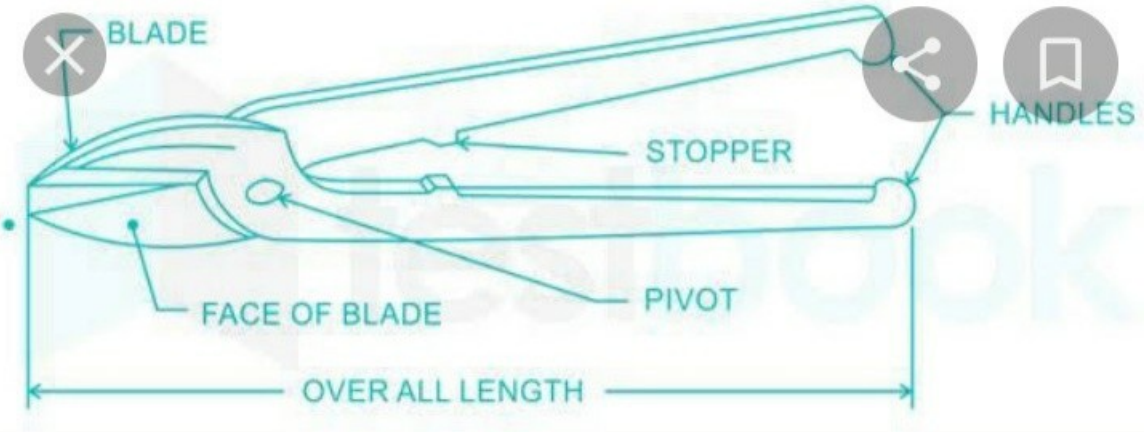
2.2.5.1 Hammers: Hammers are used in fitting shop to perform hammering operation while cutting with chisels. They are also used to plastically deform the work piece either to straighten or bend it while striking it against the edges of swage block or anvil. There are three types of hammers used in fitting shop based upon the shape of its peen. These are: Ball peen, cross peen and straight peen hammers as shown in Figure 2.33 . Out of these ball peen hammer is very common in use. It has a flat striking face and a ball-shaped end (call the peen). Hammerheads are made from medium carbon steel. The two ends must be hardened and tempered, the centre of the head with the eye being left soft. It is specified according to its weight.

Figure 2.33 Different types of Hammer



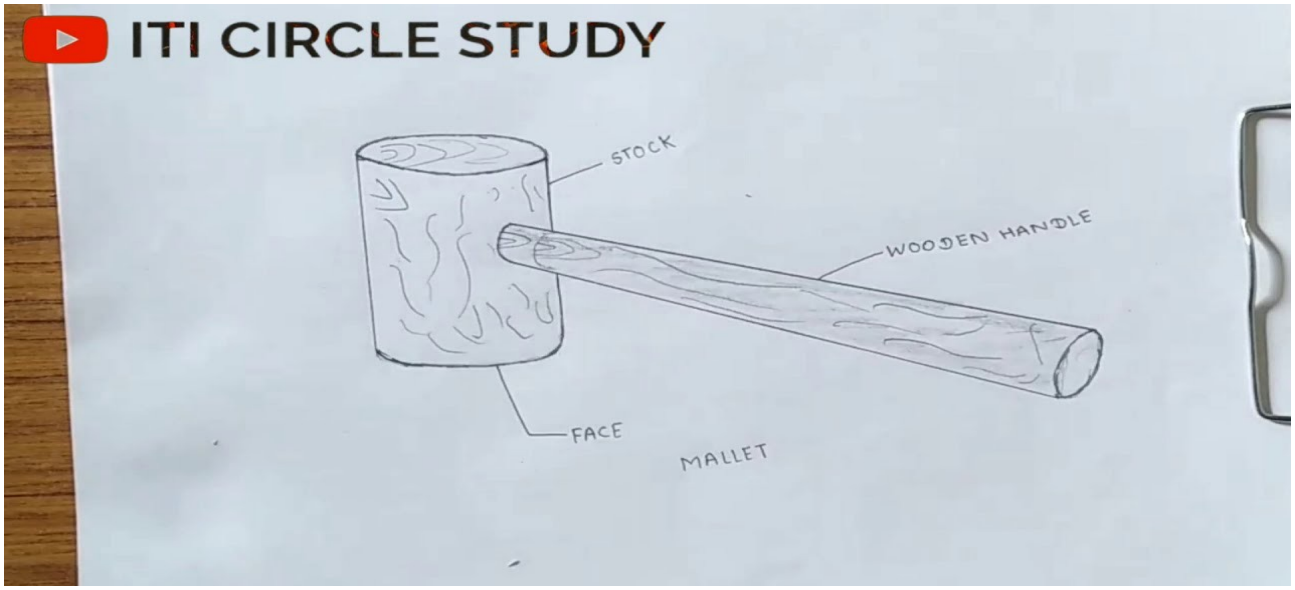
An **anvil** is a heavy block of metal, typically made of steel or iron, that is used as a tool in metalworking and blacksmithing. It typically has a flat top surface, called the face, and a horn or beak on one end. Anvils come in various shapes and sizes, but most have a rectangular shape with a flat top surface, and a pointed or rounded horn on one end.

The primary purpose of an anvil is to provide a surface on which metal can be shaped by hammering. The flat face is used for general-purpose work, while the horn is used for shaping curved or rounded objects such as horseshoes or metal bowls. The base of the anvil is usually secured to a sturdy stand or bench to prevent it from moving during use.



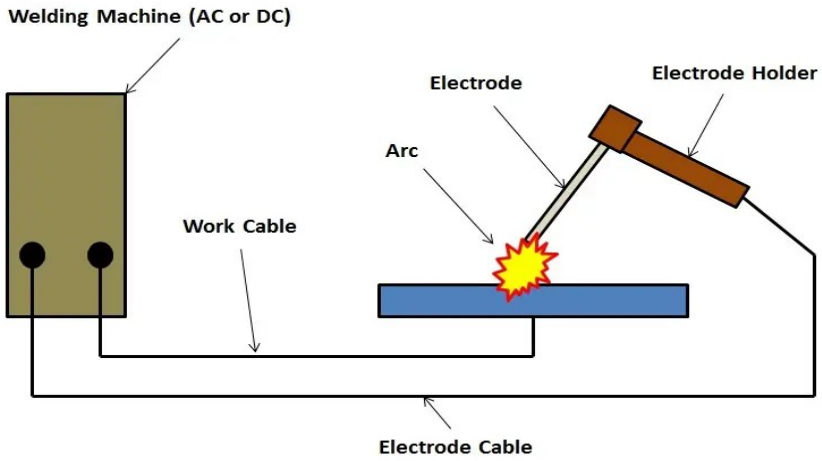
A **snip** is a type of cutting tool used in metalworking, sheet metal fabrication, and other similar applications. Snips are designed to make clean, precise cuts in thin sheets of metal, plastic, or other materials.

Snips typically have a pair of sharp blades that are used to cut through the material being worked on. The blades may be straight or curved, and they can be either offset or parallel to each other. The handles of snips are usually made of metal, plastic, or rubber, and they may be coated with a non-slip material to provide a secure grip



A **mallet** is a type of hammer that is used for a variety of purposes in woodworking, metalworking, and other trades. Unlike a traditional hammer, which has a metal head and a handle, a mallet typically has a wooden or rubber head and a handle that is integrated into the head.

The head of a mallet is typically larger and softer than the head of a hammer, and it is designed to deliver a softer blow. Mallets are often used to strike chisels and other cutting tools, as the soft head helps to prevent damage to the blade of the tool. They can also be used for assembly work, such as tapping wooden joints together, or for driving wooden dowels or pegs into place.



Basic Arc Welding Circuit Diagram

A welding machine is a device that is used to join two pieces of metal together by melting the metal at the point of contact and allowing it to cool and solidify, creating a strong and permanent bond. Welding machines come in many different types and configurations, but most consist of a power source, a control system, and a welding torch or electrode.

Arc welding , also known as stick welding or shielded metal arc welding (SMAW), is a type of welding that uses an electric arc to create heat and melt the metal being welded. The electric arc is created between the welding electrode, which is made of a metal alloy, and the metal being welded. The electrode melts and forms a molten pool of metal, which cools and solidifies to create the welded joint.

Arc welding machines typically consist of a power supply that delivers a high-current, low-voltage electric arc to the welding electrode. The electrode is held in a welding torch or electrode holder, which is used to control the position of the electrode and direct the arc to the point where the metal is to be welded. The welder can control the intensity of the arc and the rate of metal deposition by adjusting the welding current and voltage.

Electrodes used in welding are typically made from a metal alloy that is specifically designed for the welding process being used. The composition of the electrode depends on the type of metal being welded and the welding process being used, as different alloys have different properties that make them more suitable for certain applications.

Electrodes are designed to meet specific specifications, which may include the type of metal being welded, the diameter and length of the electrode, and the type of welding process being used. These specifications ensure that the electrode is compatible with the welding machine being used, and that it will produce a strong and reliable weld.

In addition to these specifications, electrodes may also be designated with a classification system that provides information about their composition, intended use, and performance characteristics. For example, electrodes used in shielded metal arc welding (SMAW) are classified according to their coating and the type of welding current they use, such as E6011 or E7018.

Gloves are a type of protective equipment that is worn on the hands to protect them from cuts, punctures, and abrasions. They are typically made from materials such as leather, rubber, or synthetic materials, and they may be lined with insulation to protect against heat or cold. Gloves may be designed for specific applications, such as welding or handling chemicals, and they may be available in different sizes and styles to fit different hand sizes and preferences.

Eye **shields**, also known as safety glasses or goggles, are a type of protective eyewear that is worn to protect the eyes from flying debris, dust, sparks, and other hazards. They are typically made from shatter-proof materials, such as polycarbonate, and they may be designed to provide additional protection from UV radiation or chemical splashes. Eye shields may be available in different styles, such as wraparound glasses or goggles that fit snugly against the face.