# CHAPTER FIVE

# USE OF HAND TOOLS

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*Objectives*

The objectives of this chapter are to:

i. Introduce and define the term tools as applied to engineering discipline,
ii. Categorise hand tools based on their operations and usage,
iii. List and briefly describe the categories of hand tools,
iv. Identify the purpose of a range of simple hand tools, and
v. Select and apply appropriate hand tools, and tool attachments for particular applications.

## 5. Introduction

Tools, as applied to the engineering discipline, refer to any device or instrument, in particular, one held in the hand, which is used to carry out a particular function, like the production of a product or any related activities. It ranges from simple hand tools, such as a file, to the very complex machine tools, such as a computer numerical control (CNC) machine. Hand tools are tools that are manually controlled. Examples of hand tools are the screwdrivers, spanners, pliers, hammers, wrenches, Allen keys, etc. There are different types of hand tools used in the engineering workshop, which is often dependent on the operation to be performed. These hand tools can be classified into five categories based on their operations and usage, which are measuring and marking, holding and supporting, cutting, finishing, and miscellaneous tools.

### *5.1 Measuring and Marking Tools*

Measuring and marking out are the preliminary work for providing outlines and centres, giving the detailed dimension of required shapes and their parts geometry before cutting and machining. The desired parts could then be cut or machined to the required shape and size. There are numerous numbers of measuring and marking tools, used for taking measurements, markings, and transferring and checking dimensions. The commonly used measuring and marking tools are vernier calipers, calipers, micrometers, scriber and surface gauges, try squares, spring dividers, centre and dot punches, and surface plate, among others. Some of these tools perform specialised function, while others perform a common function.

### *5.1.1 Vernier Calipers*

Vernier caliper is a linear measuring tool, used to measure accurately the outer dimensions of round, flat, and square components as well as the inner size of holes and bores. It has a narrow blade, usually made of stainless steel, used as a depth gauge for measuring the depth of bar slots, keyways, grooves, etc. The vernier caliper has two jaws - the external jaws, which are located at one end of its main scale and internal jaws, which is made as part of a vernier scale. Besides both pair of measuring jaws, the depth gauge has the main features including main and vernier scales. The reading accuracy in metric system is 0.0254 mm and British system is 0.001 inch. It takes a little practice to read a vernier caliper properly. The caliper often has a dial or digital readouts. To read a vernier caliper, read the large number division first, followed by the small number division, and the number of smaller subdivisions. Each represents 0.635 mm (0.025 inches) to be added to the measurement. Afterwards, read the line on the vernier lines that coincide with a line on the main scale. For each line, a thousandth must be added to the measurement. Figure 5.1 illustrates a vernier caliper, indicating it essential features.

### *5.1.2 Calipers*

A caliper is a very simple tool with inward or outward-facing points, used to measure the distance between two symmetrically opposing points. To take measurement with a caliper, its tips are adjusted to fit across the points to be measured. The caliper is then removed and the distance between its tips together with a measuring tool, such as a ruler or steel rule is then taken for measurement or comparison of linear dimensions. In the hands of a skilled user, the caliper could achieve ±0.05 mm accuracy in linear measurements. There are two types of calipers, which are:

i. Outside calipers, used to measure external dimensions such as length, external diameter of holes and thickness of a bar; and
ii. Inside calipers, used to measure internal dimensions such as internal diameter of holes, width of slot or grooves, etc. Figure 5.2 illustrates the outside and inside calipers.

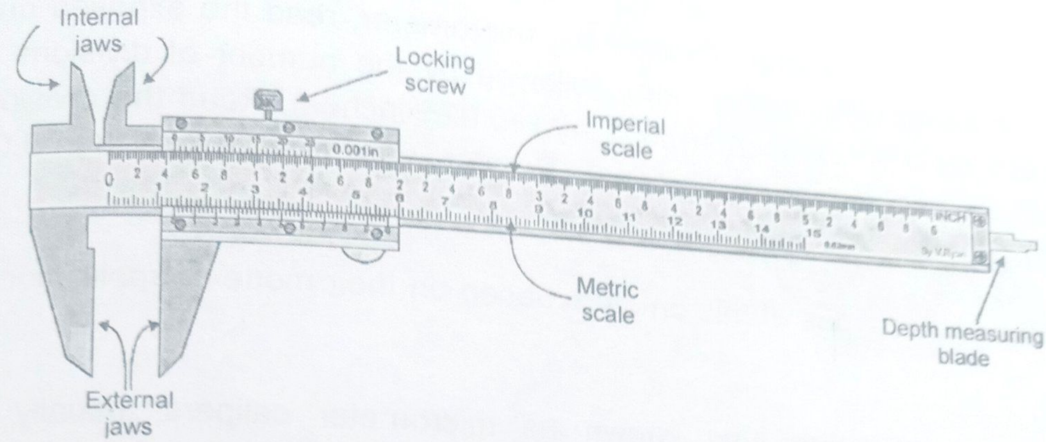
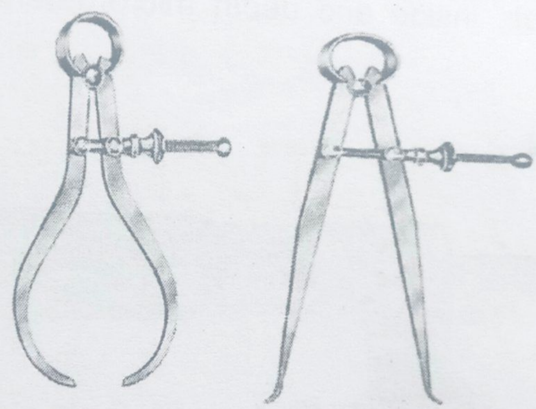



**Figure 5.1**: Schematic illustration of a vernier caliper, showing its essential features
*Source: (Ryan, 2010)*



(a) Outside caliper (b) Inside caliper

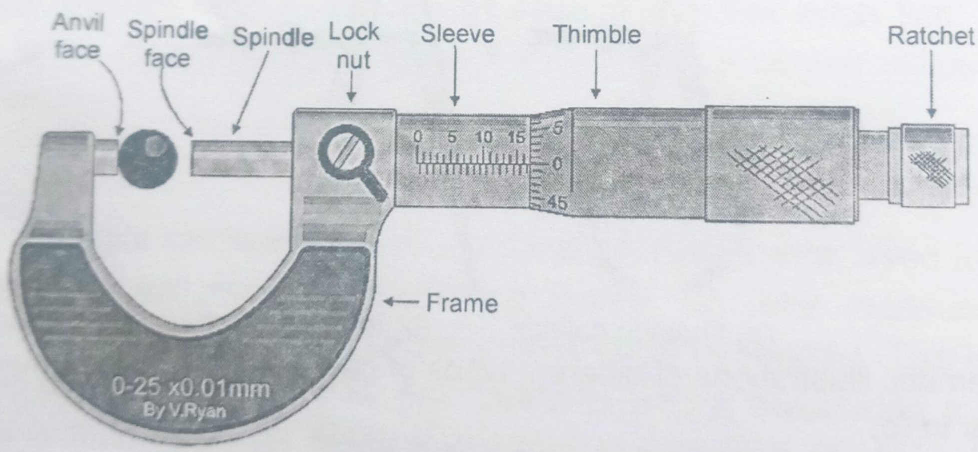
**Figure 5.2**: Schematic illustrations of different types of caliper, showing the outside caliper in (a) and inside caliper in (b)

### *5.1.3 Micrometers*

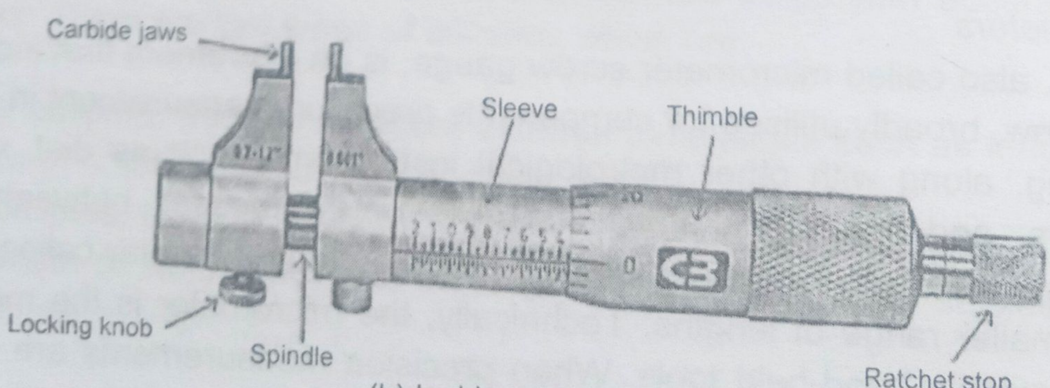
A micrometer, also called micrometer screw gauge, is an instrument that incorporates a calibrated screw, broadly utilised for components precision measurement in engineering and machining, along with other metrological instruments such as dial, vernier, and digital calipers; and measuring small distances or thicknesses between two faces among others. Generally, it provides greater precision than a vernier caliper, and could measure a smaller range of lengths. Technically, the micrometer is the most accurate among the available hand-held tools. When precision measurements are needed, the micrometer is the ideal tool for the job because the dimension and reading are on the same axis, supported by a strong frame at the anvil end. To use a micrometer, place the part to be measured within the opening between the anvil and spindle faces. Afterwards, turn the thimble until the spindle contacts the work. To apply a consistent pressure to the part, use the ratchet stop and the clamp ring to hold the thimble in place while you read the micrometer. To read the micrometer, read the exposed number on the sleeve or barrel (with main scale), followed by the number of divisions past the number. Each division represents 0.635 mm (0.025 inches). Read the division on the thimble (with rotating vernier graduations). These usually read to less than 0.0254 mm (0.001 inch).

There are three basic types of micrometers based on their mode of applications. These are:

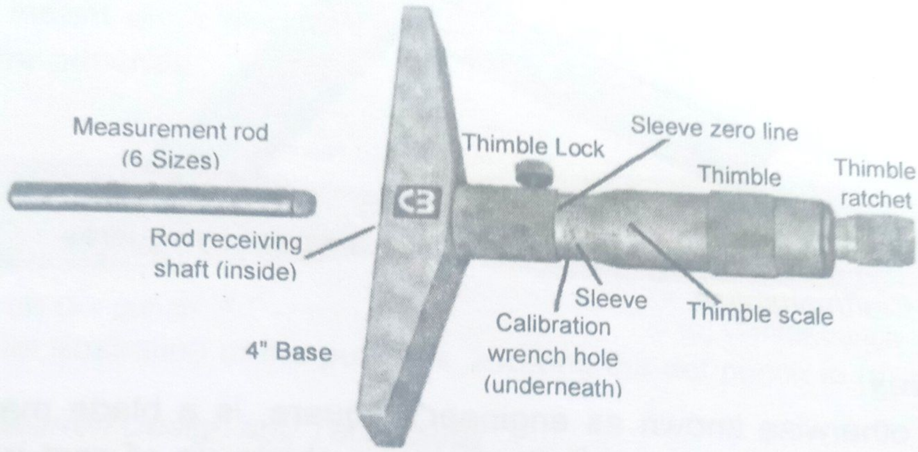
i. Outside micrometers also known as micrometer calipers, usually used to measure the external diameter of wires, spheres, and blocks among others;
ii. Inside micrometers, used to measure the diameter of holes; and
iii. Depth micrometers, used to measure the depths of slots and steps. Figure 5.3 illustrates the outside, inside and depth micrometers, indicating their essential features.




(a) Outside micrometer




(b) Inside micrometer



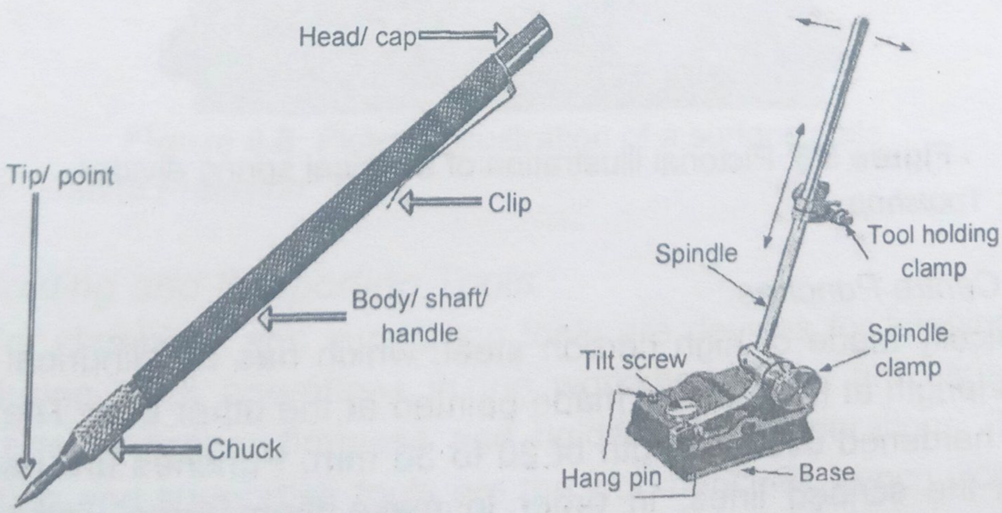

(c) Depth micrometer

**Figure 5.3**: Pictorial illustration of the different types of micrometers and their essential features, showing the outside micrometer in (a), inside micrometexvc1er in (b) and depth micrometer in (c)

*Source: (Ryan, 2009a)*

### *5.1.4 Scriber and Surface Gauges*

A scriber is a slender hardened and tempered high carbon steel tool, tempered to a suitable hardness at its front edge and its tip is generally ground to about 12 to $15^0$. The length of the scriber, usually range between 125 to 250 mm. Scribers are used for scribing or marking lines onto the surface of a workpiece, or for locating the centres of round bars. Surface gauge consists of a cast iron base on the centre in which a steel rod is fixed vertically. Figure 5.4 illustrates the scriber and surface gauge, indicating their essential parts.




(a) Scriber (b) Surface gauge

**Figure 5.4**: Schematic illustration of a scriber in (a) and surface gauge in (b), showing their essential features

*Courtesy: Woonkee Donkee Tools*

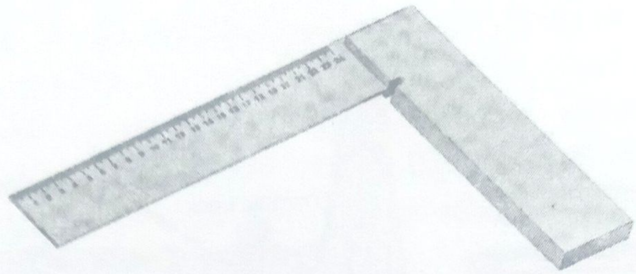


**Figure 5.5**: Pictorial illustration of a typical try squares
*Courtesy: Craftmanspace*

## *5.1.5 Try Squares*

The try square, otherwise known as engineer's square, is a blade made of hardened tool steel, attached to a base at $90^0$. The base is made up of cast iron or steel. Try squares are used for marking out right angles, measuring straightness of surfaces, and used during work inspection, for checking squareness and straightness of two surfaces when extreme accuracy is not required. Figure 5.5 illustrates the typical try squares.

## *5.1.6 Spring Dividers*

A spring divider is a tool made of hardened steel, which is basically similar to the calipers except that its legs are kept straight and pointed at the measuring edge. The legs are used for scribing arcs or circles onto a workpiece, and laying out perpendicular lines, by setting lines. The length of the leg specifies its size. Figure 5.6 illustrates a typical spring divider.

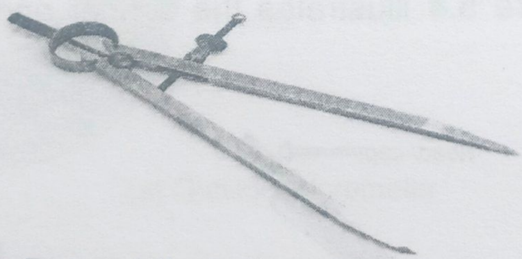


**Figure 5.6**: Pictorial illustration of a typical spring divider
*Courtesy: Toolshop*

## *5.1.7 Dot and Centre Punches*

A punch is basically made of high carbon steel, which has a cylindrical knurled body with some plain length at the top and made pointed at the other end. The tapered point of the punch is hardened over a length of 20 to 30 mm. Punches are used for making indentations on the scribed lines, in order to make them more visible. A punch is specified by its length and diameter. There are two types of punches, which are the dot and centre punches. A dot punch has a point angle of either 30 or $60^0$, used for marking small dots on reference line while a centre punch has a point angle of $90^0$, used for making a large indent on a workpiece before drilling operations. Figure 5.7 illustrates the dot and centre punches.

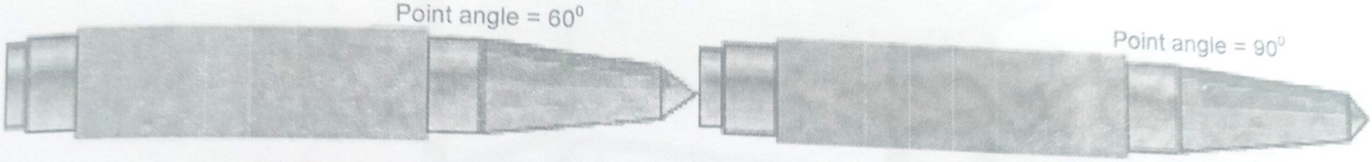



**Figure 5.7**: Pictorial illustration of the punches, showing the dot punch in (a) and centre punch in (b)

*Courtesy: Warren Design and Technology*

### *5.1.8 Surface Plates*

A surface plate is a tool made of malleable cast iron or graphite, machined and scraped to a high degree of flatness, which is used for testing the flatness and trueness of surfaces. Surface plates are specified by length, width, height and grade. The surface plate's degree of finishing depends upon whether it would be used for bench work in a fitting shop or inspection during quality control job. The flat surface is used as a datum surface measuring and marking out purposes. Large surface plate that can stand on the floor is known as surface table. Figure 5.8 illustrates a surface plate.

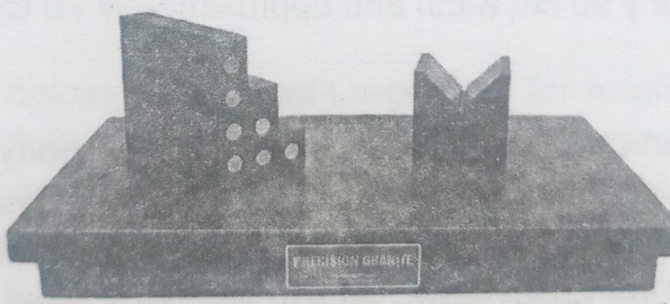


**Figure 5.8**: Pictorial illustration of a surface plate

*Courtesy: Granite Precision® USA*

## 5.2 *Work Holding and Supporting Tools*

Work holding (or clamping) and supporting tools are devices for keeping workpiece in firm position during work operations in the workshop. They are usually located on workbench to ensure proper firmness and rigidity during operations. The commonly used work holding and supporting tools are the workbenches, bench vices, vee blocks, c-clamps and angle plates, among others.

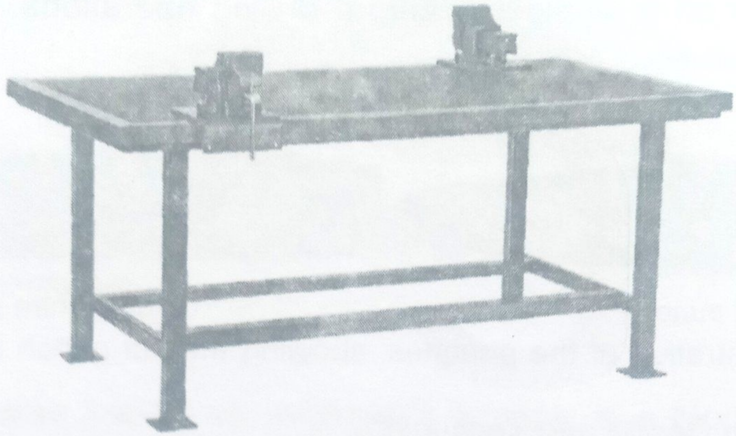


**Figure 5.9**: Pictorial illustration of a typical workbench, mounted with bench vices
*Courtesy: bfx Furniture*

### 5.2.1 *Workbench*

The workbench is a strong, heavy and rigid table like-structure, which is made of hard wood or metal, usually situated in the workshop, in particular, for fitting operations. A fitting process can be done at various places, but most of the important operations of fitting are generally carried out on a table called workbench. Figure 5.9 illustrates a typical workbench, mounted with bench vices. The workbench is a strong, heavy and rigid table, made of hard wood or metal. The required size of the workbench is about 150 to 180 cm length, nearly 90 cm width and approximately 76 to 84 cm height.

### 5.2.2 *Bench Vices*

A bench vice is a mechanical device, made of a cast iron body and jaws for holding workpiece during working operation in the workshop. Bench vices are firmly fixed to the bench with the help of bolts and nuts. The jaw comprises two main parts, the stationary (or fixed) and sliding (or movable) jaws, which are both fitted with jaw plates. The stationary jaw is fixed to the body while the sliding jaw slides on a square threaded screw with the help of a handle. The jaws are opened up to required length where workpiece is placed in between the two jaws and it is firmly tightened with the help of the handle, which is used to move the movable jaw to ensure firmness over the workpiece. The holding surface of the jaw plates is knurled in order to increase gripping. Jaw plates are made up of carbon steel and are wear resistant. Figure 5.10 illustrates a typical bench vice.

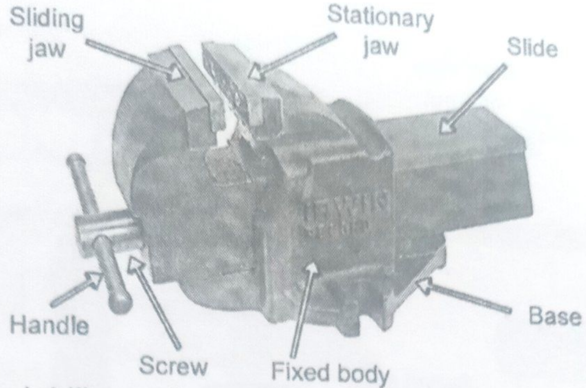



**Figure 5.10**: Pictorial illustration of a bench vice, showing its essential parts
*Courtesy: Woonkee Donkee Tools*

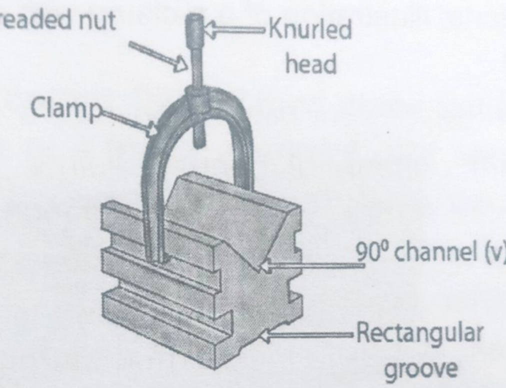



**Figure 5.11**: Pictorial illustration of a vee block attached with clamp
*Courtesy: Woonkee Donkee Tools*

### *5.2.3 Vee Blocks*

A vee block is a work holding device with v-grooves for holding and supporting round objects longitudinally. With a clamp, the vee block is generally used to hold circular workpiece for marking out or machining. The screw of the clamp applies the holding pressure. When the handle is rotated, there is movement in the screw, which clamps the workpiece firmly to the v-grooves. Vee blocks, usually, in a couple, are made of cast iron or casehardening steel. Figure 5.11 illustrates a vee block attached with a clamp.

### *5.2.4 C-Clamps*

A c-clamp is a device used for holding workpiece against an angle plate, v-block or any other surface, when gripping is required. For instance, c-clamp is used for holding planks after gluing, most in particular, in wood workshop. Its fixed jaw is shaped like the English alphabet 'C' or 'G', with a round shaped movable jaw, which is directly fitted to the threaded screw at the end. The working principle of this clamp is the same as that of the bench vice. These clamps are available in sizes varying from 70 to 800 mm. Figure 5.12 illustrates a c-clamp with alternative wing nut.

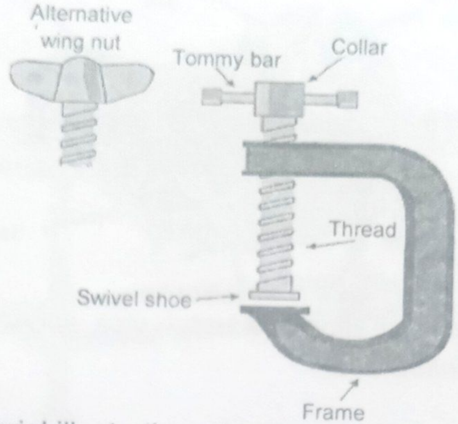



**Figure 5.12**: Pictorial illustration of a c-clamp with alternative wing nut
*Source: (Ryan, 2009b)*

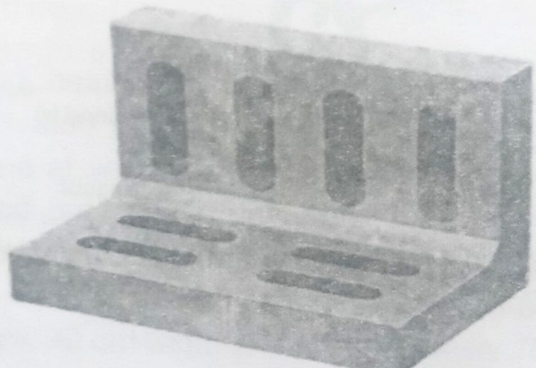


**Figure 5.13**: Pictorial illustration of a typical angle plate
*Courtesy: Indiamart*

### *5.2.5 Angle Plates*

An angle plate is a tool made of cast iron in different sizes, ground to a high degree of accuracy, with two planed surfaces at right angles to each other and various slots on each surface for mounting and holding workpiece. The workpieces are held with aid of bolts and nuts. Angle plates are used for supporting or setting up work vertically. Figure 5.13 illustrates a typical angle plate.

## *5.3 Cutting Tools*

Cutting tools, in engineering workshop range, from hand held cutting tools to cutting tools employed in sophisticated machine tools like lathe, milling machines, CNC machines and so on. However, the commonly used hand cutting tools in engineering workshop are the hacksaws, chisels, twist drills, and taps and dies among others.

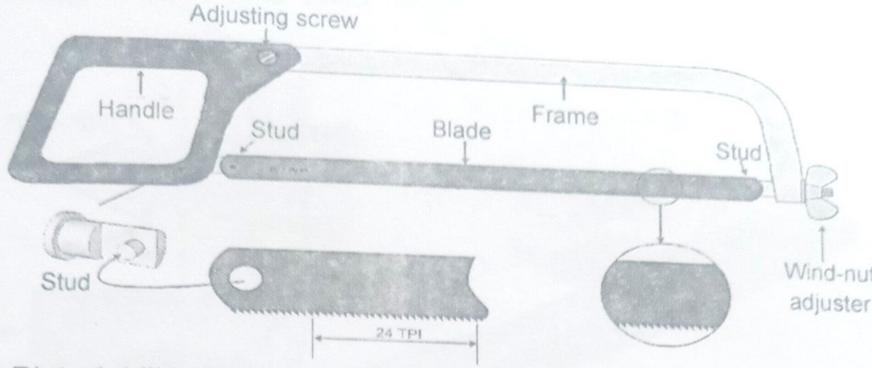



**Figure 5.14**: Pictorial illustration of a typical hacksaw, indicating its essential features
*Source: (Ryan, 2009c)*

### *5.3.1 Hacksaws*

A hacksaw is a saw with a narrow fine-toothed blade set in a frame, used in particular, for cutting metal. It consists of a frame, made of mild steel and a blade, made of high carbon steel or high-speed steel, which is set in the frame and tightened with the help of a flange nut. There are two types of frame, namely the fixed type of frame, which only takes one length of blade, and the adjustable type, which could take different blade lengths. It has a wing-nut to adjust the tension of the blade. The arrangements of the teeth are made in a zig-zag form, to cut a wide groove and prevent the body of the blade from rubbing or jamming in the saw cut. The blades can be classified as forward or backward cut, depending upon the direction of cut. The teeth of the blades are generally forward cut such that, the pressure is applied in the forward direction only while the backward direction is idle. The classification can also be done depending on the pitch of the teeth, that is, the distance between the two consecutive teeth for coarse (8 - 14 teeth per inch), medium (16 - 20 teeth per inch) and fine (24 - 32 teeth per inch). Hacksaws are used for cutting of rods, bars, pipes, flats, etc. Figure 5.14 illustrates a typical hacksaw and its essential features.

### *5.3.2 Chisels*

A chisel is a long-bladed hard steel cutting tool with a bevelled cutting edge and a handle, which is struck with a hammer or mallet when used to cut or shape wood, stone or metal. It is used for removing surplus metal, cutting thin sheets or chipping any material softer than the chisel itself. It can also be used in restricted areas for such work as shearing rivets, splitting seized or damaged nuts from bolts. Usually, chisels are made of eight-sided tool steel bar stock, carefully hardened and tempered. Since the cutting edge is slightly convex, the centre portion receives the greatest impact when cutting and the weaker corners are protected. The cutting angle should be 60 to $70^0$ for general use, cutting wire, strap iron, or small bars and rods. Figure 5.15 illustrates a chisel, showing its cutting edge geometry.

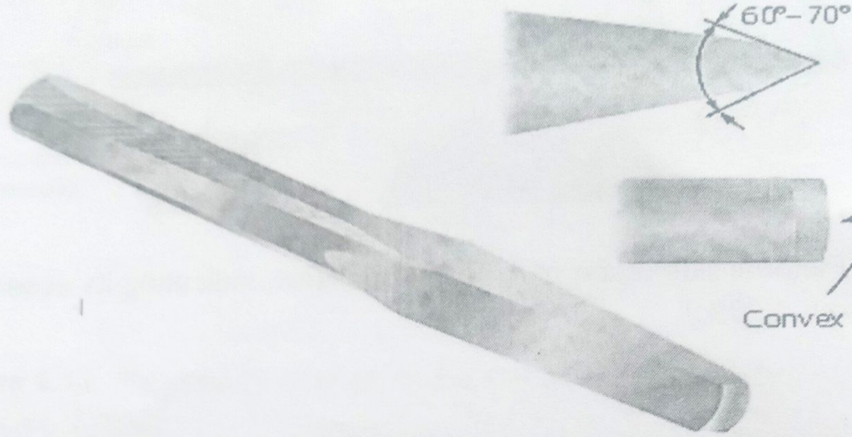



**Figure 5.15**: Schematic illustration of a chisel, indicating its cutting edge geometry
*Source: (AMT, 2017)*

### *5.3.3 Twist Drills*

A twist drill is a pointed tool that is rotated to cut holes in a material. It is made of a cylindrical hardened steel bar with spiral flutes (grooves) running throughout the length of the body, and a conical point with cutting edges formed by the ends of the flutes. Flutes are incorporated 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. Twist drill is made of carbon steel or high-speed alloy steel. It is tempered to give maximum hardness throughout the parallel cutting portion. Twist drills could have from one to four spiral flutes. Drills with two flutes are used for most drilling while those with three or four flutes are used principally to follow smaller drills or to enlarge holes. The principal parts of the twist drill are the shank, body and heel (see Figure 5.16). The drill shank is the end that fits into the chuck of a hand or power drill. The two shank shapes most commonly used in hand drills are straight and square or bit stock shanks. The straight shank generally is used in hand, breast, and portable electric or pneumatic drills while the square shank is made to fit into a carpenter's brace. The tapered shanks are generally used in drill presses.

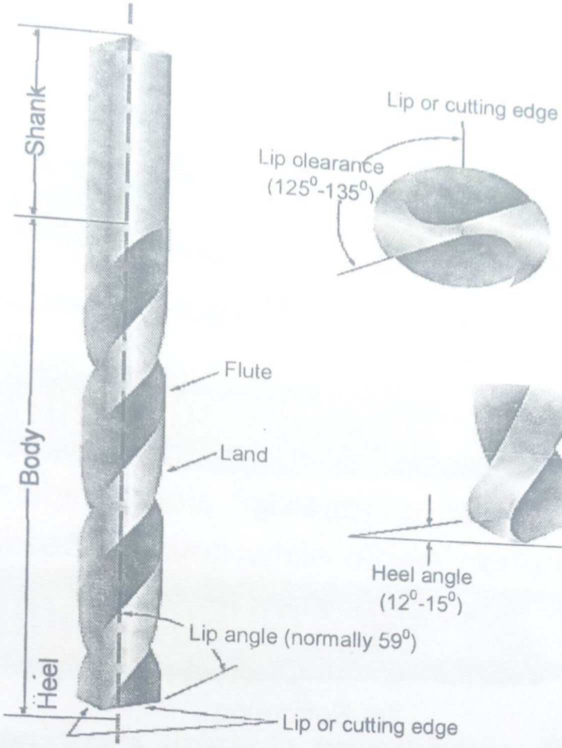
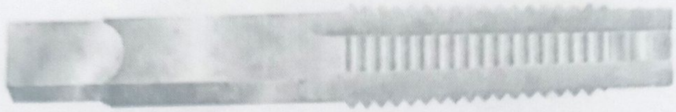


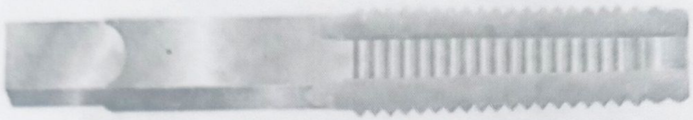

**Figure 5.16**: Pictorial illustration of a twist drill, indicating its essential cutting edge features
*Source: (AMT, 2017)*

### *5.3.4 Taps and Dies*

Taps and dies are made of hard tempered steel, which are ground to an exact size. A tap is a cutting tool used for cutting internal threaded holes in a material while a die is a cutting tool used for cutting external threads on round stock. The process of producing the internal thread by taps is known as tapping. The hand taps are typically supplied in sets of three taps for each diameter and thread series to cut any particular size. Each set consists of a taper or first tap, intermediate, second, or plug tap and bottoming tap. The taps in a set are identical in diameter and cross section, but differ only in their amount of taper. The taper tap is used to begin the tapping process, because it is tapered back for 6 to 7 threads. This tap cuts a complete thread when it is cutting above the taper. It is the only tap needed when tapping holes that extend through thin sections. The plug tap supplements the taper tap for tapping holes in thick stock. The bottoming tap is not tapered. It is used to cut full threads to the bottom of a blind hole. Figure 5.17 illustrates the taper, plug and bottoming taps. Dies may be classified as adjustable round-split die and plain round-split die. The adjustable split die has an adjusting screw that can be tightened so that the die is spread slightly. By adjusting the die, its diameter and fit of the thread can be controlled. Plain dies are not adjustable, making it difficult to perform variety of thread with this type of die. Figure 5.18 shows the pictorial illustrations of adjustable and plain round-split dies. There are many types of wrenches for turning taps and dies. These include the T-handle, adjustable tap wrench, and diestock for round split dies, are a few of the more common types. Dies are fixed in a diestock (die holder), which comprises a holder for the die, turned using the long handles. Figure 5.19 illustrates the diestock and tap wrenches.



(a) Taper

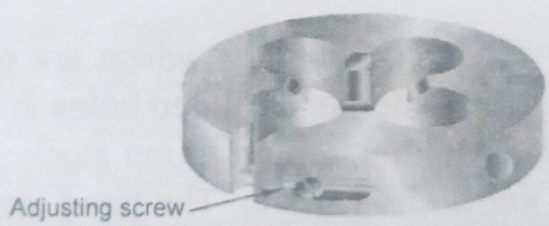


(b) Plug

(c) Bottoming

**Figure 5.17**: Pictorial illustration of hand taps, showing the taper in (a), plug in (b) and bottoming in (c)

*Source: (AvStop, 2017)*




(a) Adjustable round-split die

(b) Plain round-split die

**Figure 5.18**: Pictorial illustration of the different types of dies, showing the adjustable round-split die in (a) and plain round-split die in (b)

*Source: (AvStop, 2017)*

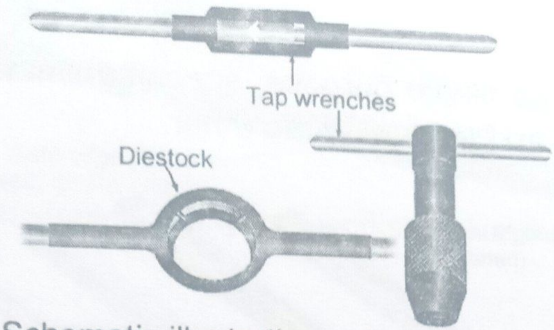



**Figure 5.19**: Schematic illustrations of tap wrenches and diestock
*Source: (AvStop, 2017)*

## 5.4 *Finishing Tools*

There are a number of finishing tools for carrying out finishing operations. Some of these tools perform specialised function while others perform a common function. The commonly used finishing tools are the reamers, files, etc.

### *5.4.1 Reamers*

A reamer is a tool for widening or finishing drilled holes. Reaming is an operation of sizing, widening or finishing drilled holes, with the help of a cutting tool called reamer, having a number of cutting edges. For this operation, a hole is first drilled, in which its size is slightly smaller than the desire finished size and then a hand or machine reamer is used for finishing the hole to the correct size. The hand reamer is made of high carbon steel and has left-hand spiral flutes so that, it is prevented from screwing into the hole during operation. Hand reamers have square end shanks, so that they can be turned with a tap wrench or similar handle. It is operated by hand, with a tap wrench fitted on the square end of the reamer and with the workpiece held in a vice. The body of the reamer is given a slight tapper at its working end. For its easy entry into the hole during operation, it is rotated only in clockwise direction and also while removing it from the hole. Reamers are used to finish and enlarge already drilled holes to exact size with smoothened surface. Holes produced by drilling are seldom accurate in size and usually have rough surfaces. Such a hole, which is to be reamed to exact size, must be drilled at about 0.003 to 0.007 inches undersize. A cut that removes more than 0.007 inch places too much load on the reamer and should not be attempted. Reamers are available in different standard sizes. Figure 5.20 illustrates the various types of reamers. The straight fluted reamer is less expensive than the spiral fluted reamer, but the spiral type has fewer tendencies to chatter. Both types are tapered for a short distance at the back end to aid in starting. Bottoming reamers have no taper and are used to complete the reaming of blind holes. Figure 5.21 illustrates an adjustable hand reamer, indicating its main features. The adjustable hand reamer is adjustable to precisely fit a range of sizes, eliminating the need for single purpose, special diameter reamers. It expands by loosening one adjusting nut and tightening the other.

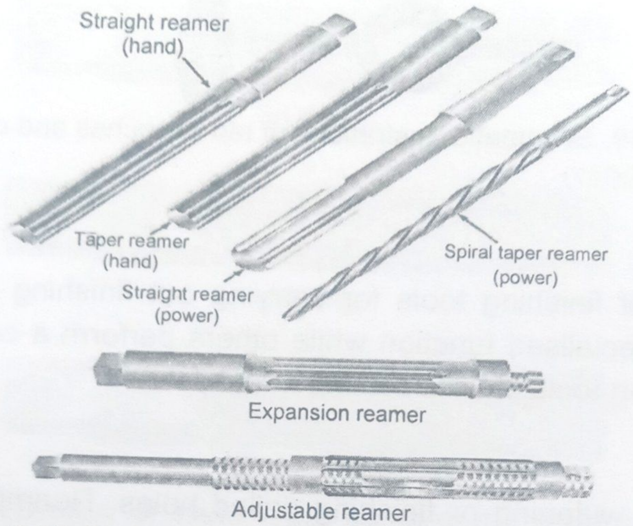



**Figure 5.20**: Pictorial illustration of different types of reamers
*Courtesy: Groz Engineering Tools*

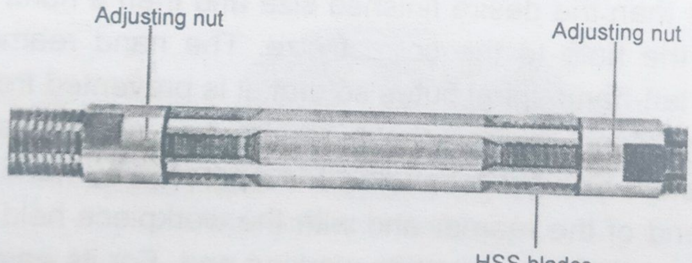



**Figure 5.21**: Pictorial illustration of an adjustable hand reamer, showing its main features
*Courtesy: Groz Engineering Tools*

### *5.4.2 Files*

A file is a multi-point cutting tool, which is used to put finishing touches on a machined workpiece. Filing is one of the methods of removing small amounts of material from the surface of a metal part. Files are made of hardened steel, with small parallel rows of cutting edges or teeth on its surfaces. They are manufactured in variety of shapes and sizes with different degree of coarseness. The cuts on the files must be considered when selecting them for various types of work and materials. Files are used to square ends, file rounded corners, remove burrs and slivers from metal, and straighten uneven edges, filing of holes and slots, and smooth rough edges. They are used to remove the material by rubbing them on the metals. Figure 5.22 illustrates a typical workshop file, indicating its main features.

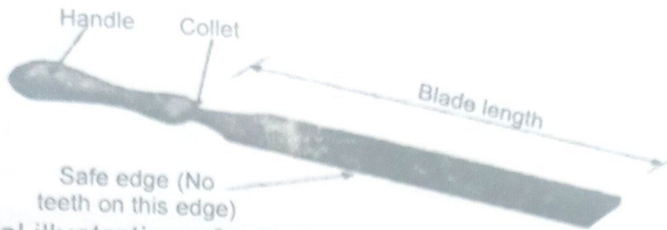



**Figure 5.22**: Pictorial illustration of a typical workshop file, indicating its main features
*Source: (Ryan 2016)*

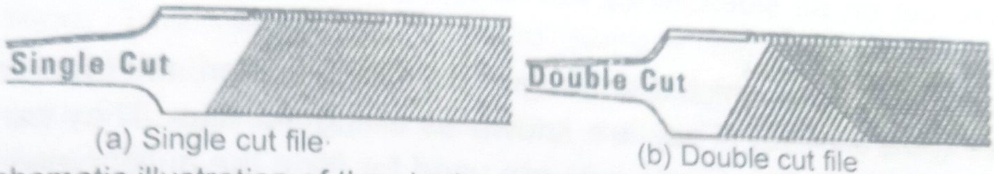



**Figure 5.23**: Schematic illustration of the single cut file in (a) and double cut file in (b)
*Source: (Nicholson®, 2014)*

Files can be classified according to the number of cuts on its surface. These include:

i. Single-cut files, whose teeth are cut in a parallel row at an angle of 60° to the face (see Figure 5.23 (a)),
ii. Double-cut files, which have another row of teeth, added in an opposite direction to the single cuts (see Figure 5.23 (b)). Material removal is more when using double cut files, and
iii. Rasp-cuts files, which are generally used on wood, PVC and rubber materials. They possess very coarse teeth and usually used on soft material.

Files can be classified on the basis of grades or coarseness as rough (R) (20 teeth per inch), bastard (B) (30 teeth per inch), second cut (Sc) (40 teeth per inch), smooth (S) (50 teeth per inch) and dead smooth (DS) (100 teeth per inch) files. Rough and bastard files are the larger cut files, used when so much material removal is required. As a result of the larger surface cut, the work produced is normally rough. Smooth and dead smooth files have smaller teeth and are used for finishing work. Second cut file has degree of finish in between bastard and smooth file. File can also be classified on the basis of shape and size. Files are made in different range of lengths from 4 to 18 inches. These include:

i. Hand files, which are common file used for roughing and finishing (see Figure 5.24 (a)). It is rectangular in cross-section and parallel in width. It has double cut teeth on both faces, single cut teeth on one edge, and one save edge,

ii. Flat files, which have parallel edges for about two-thirds of the length and tapered in width and thickness to the point edge (see Figure 5.24 (b). The faces are double cut while the edges are single cut,

iii. Square files, which have squared cross-section (see Figure 5.24 (c)). They are parallel for two-thirds of their length and then tapered towards the tip. They are double cut on all sides. They are used for filing squared corners, grooves and slots,

iv. Three square files, which are triangular in cross-section and taper towards the tip (see Figure 5.24 (d). They are known as triangular files. They can be single or double cut teeth. The single cuts are used for filing the gullet between saw teeth, while the double cut may be used for filling internal angles, clearing out corners and filling taps and cutters, and

v. Round files, which are circular in cross-section (see Figure 5.24 (e)). They are tapered or blunt, single or double cut. They are used principally for filing circular openings or concave surfaces, otherwise known as rattail files.

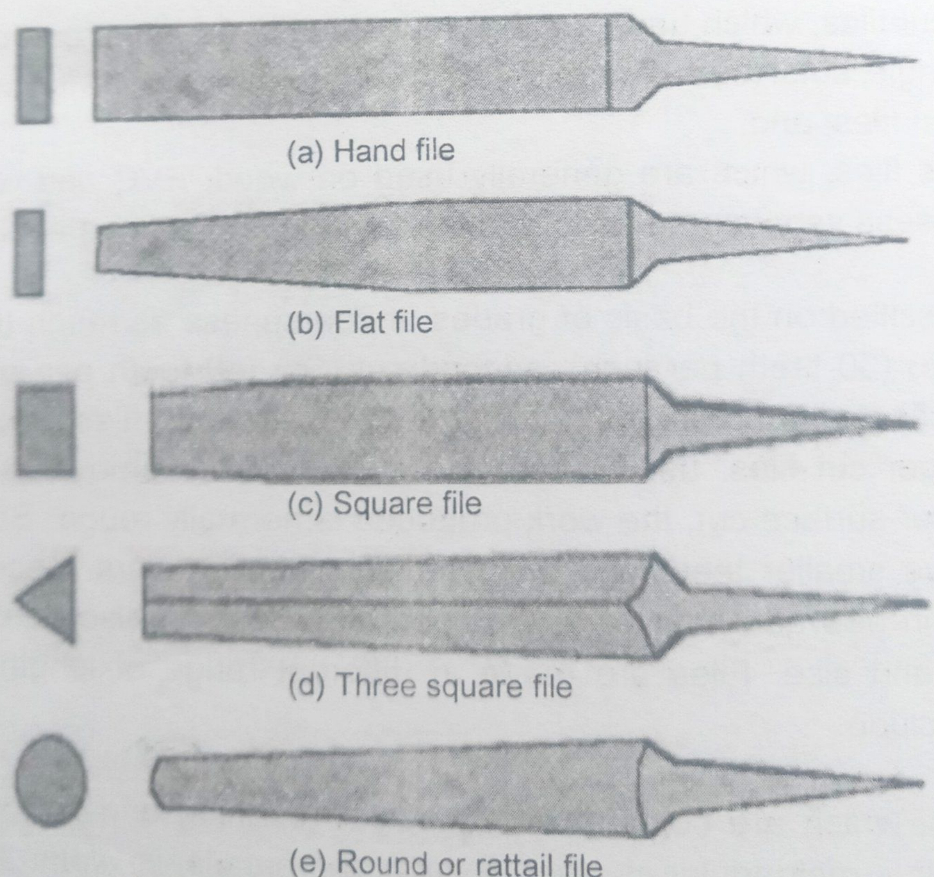
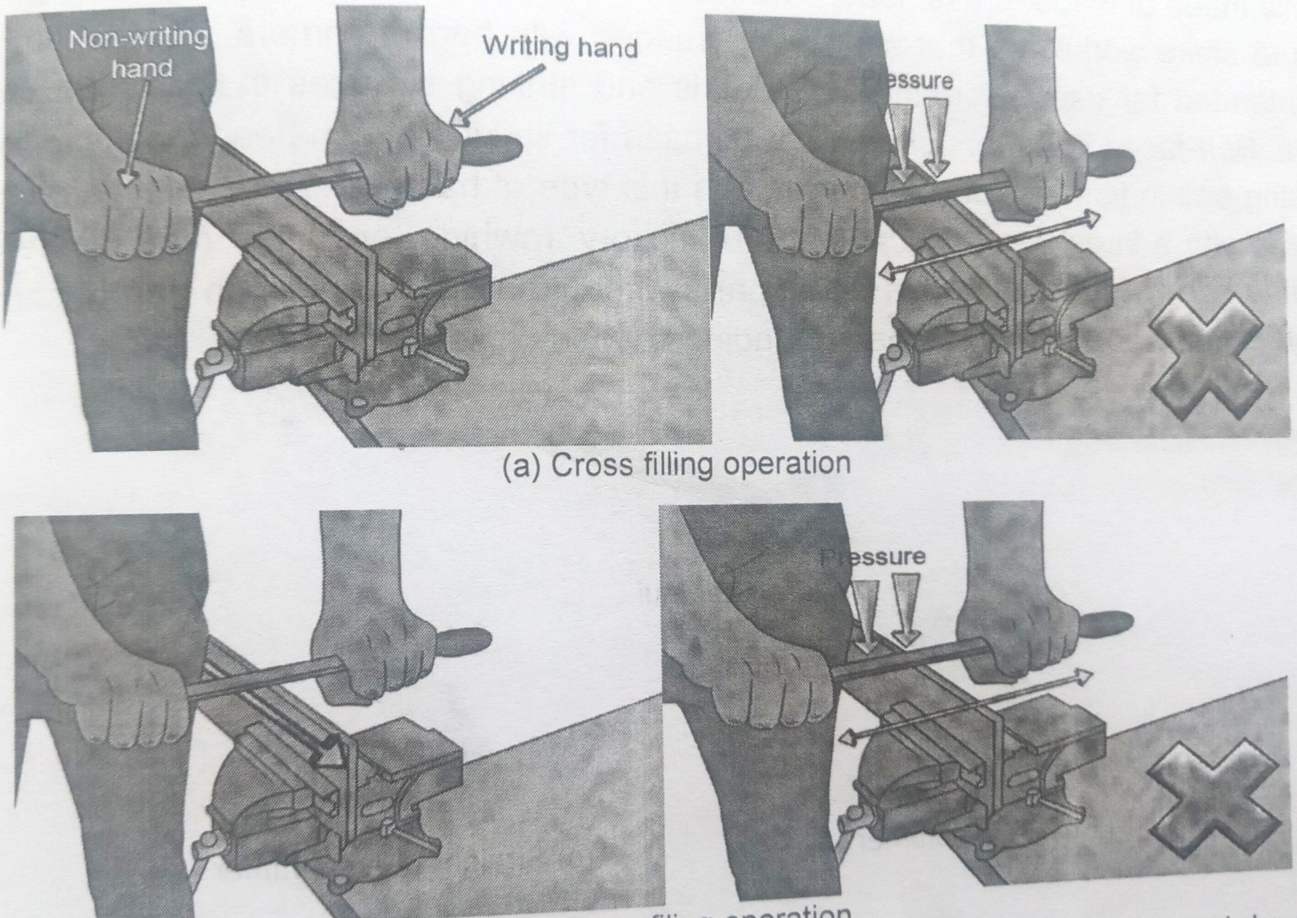



**Figure 5.24**: Schematic illustration of different files classification, showing hand file in (a), flat file in (b), square file in (c), three square file in (d) and round or rattail file in (e)

*Source: (Nicholson®, 2014)*

The methods that may be used for filing operation depend on nature of the work to be carried out. These are the

i. Cross filing: This method is used for efficient removal of maximum amount of metal in the shortest possible time. It may be noted that the file must remain horizontal throughout the stroke (long, slow and steady) with pressure only applied on the forward motion (see Figure 5.25 (a)).
ii. Draw filing: This method is used to remove file marks and for finishing operations. Here, the file is gripped as close to the work as possible between two hands (see Figure 5.25 (b)). In this filing method, a fine cut file with a flat face should be used.




(a) Cross filling operation

(b) Draw filing operation

**Figure 5.25**: Pictorial illustration of filing operation, showing the cross filling in (a) and draw filing in (b)

*Courtesy: Woonkee Donkee Tools*

## 5.5 *Miscellaneous Tools*

Miscellaneous tools are regarded as general-purpose tools that are commonly found in engineering workshop. These include the hammers, screwdrivers, set of spanners, wrenches, pliers and crowbars, among others.

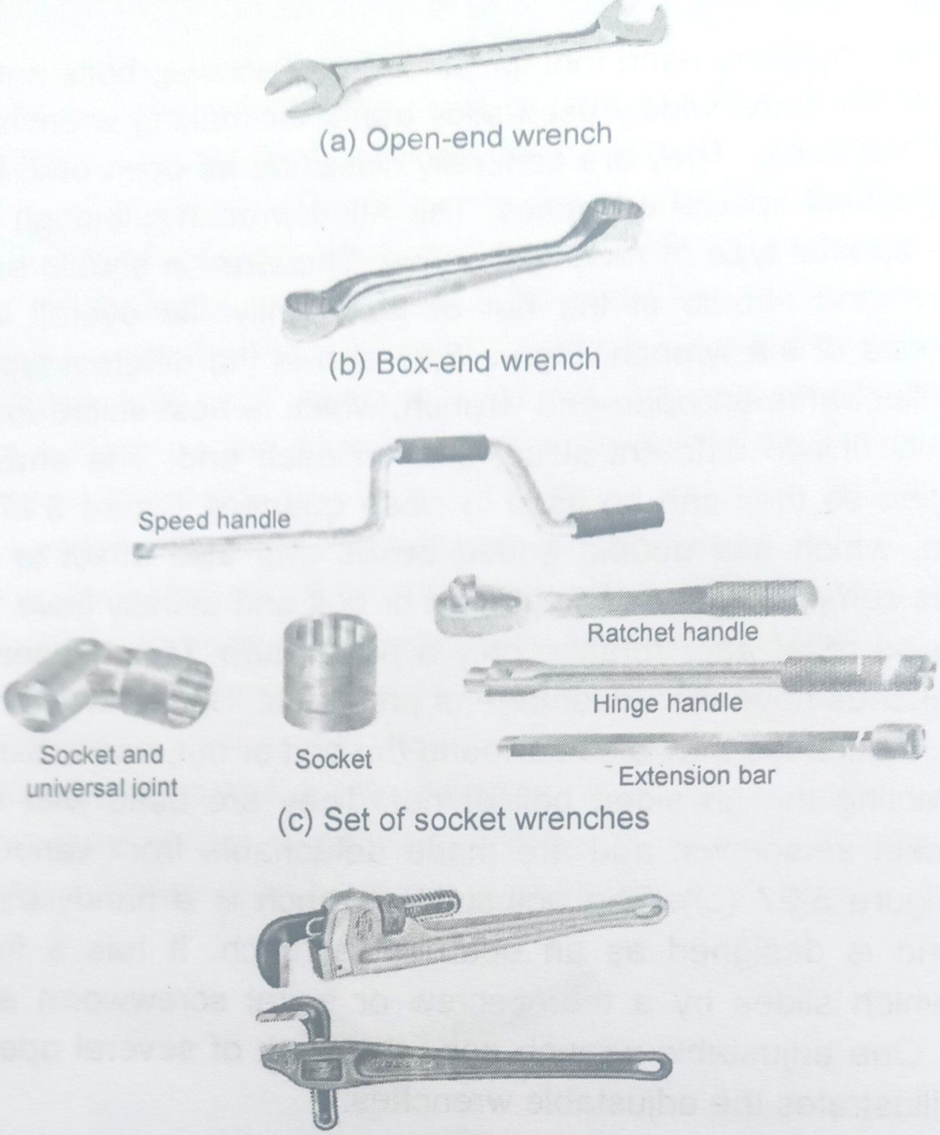
### 5.5.1 Hammers

Hammers are striking tools with a heavy soft or hard head, mounted at right angles at the end of a handle, used for jobs such as driving in nails. The striking head can be made of soft or hard materials depending on the usage. Hammers are classified as either hard or soft. Hard hammers have steel heads such as blacksmith types or mauls made for heavy hammering (see Figure 5.26 (a)). The ball-peen hammer is the commonest hammer, used by the machinists. It has a rounded surface on one end of the head (see Figure 5.26 (b)), which is used for upsetting or riveting metal, and a hardened striking surface on the other. Two other workshop hammers are the straight-peen and cross-peen hammers (see Figures 5.26 (c) and (d)). Softheaded hammers, usually made of wood, brass, lead, rawhide, hard rubber or plastic striking surfaces, are used to strike workpiece that could be damaged with hard hammers. These hammers are intended for use in forming soft metals and striking surfaces that are considered fragile. Soft-faced hammers should not be used for striking punch heads, bolts, or nails, as using one in this fashion will quickly ruin this type of hammer. A mallet is a hammer-like tool with a large head typical made of hickory, rawhide, or rubber (see Figure 5.26 (e)). It is handy for shaping thin metal parts without causing dents with abrupt corners. Always use a wooden mallet when pounding a wood chisel or gouge.


**Figure 5.26**: Different kinds of hammer, showing the maul hammer in (a), ball-peen hammer in (b), straight-peen hammer in (c), cross-peen hammer in (d) and mallet in (e)
*Source: (AvStop, 2017)*

### 5.5.2 *Wrenches*

A wrench is a multi-purpose hand tool for turning cap screws, bolts and nuts. Chrome-vanadium steel is the most widely used alloy metal for making wrenches, which made them, almost unbreakable. They are generally classified as open-end, box-end, socket, adjustable, ratchet and special wrenches. The Allen wrench, although seldom used, is required on one special type of recessed screw. The wrench should be rotated toward the movable jaw and should fit the nut or bolt tightly. Its overall length in inches determines the size of the wrench. Figure 5.27 shows the different types of wrenches. Figure 5.27 (a) illustrates an open-end wrench, which is best suited for square-headed bolts, and usually fit two different sizes, one on each end. The ends of this type of wrench are angled so they can be used in close quarters. Figure 5.27 (b) illustrates a box-end wrench, which has double ended boxes and also offset to clear the user's hand. The boxes completely surround the nut or bolt and usually have 12 points so that the wrench can be reset after rotating only a partial turn. Mostly used on hex-headed bolts, these wrenches have the advantage of precise fit. Socket wrenches are similar to the box wrenches because they also surround the bolt or nut, and are usually made with 12 points, contacting the six-sided bolt or nut. They are used with socket head cap screws and socket setscrews, and are made detachable from various types of drive handles (see Figure 5.27 (c)). The adjustable wrench is a handy utility tool that has smooth jaws and is designed as an open-end wrench. It has a fixed jaw and the movable jaw, which slides by a thumbscrew or spiral screwworm adjustment in the wrench handle. One adjustable wrench does the work of several open-end wrenches. Figure 5.27 (d) illustrates the adjustable wrenches.




(a) Open-end wrench

(b) Box-end wrench

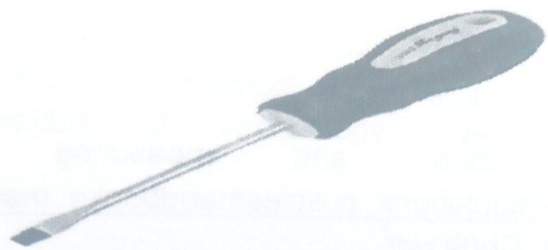
(c) Set of socket wrenches

(d) Adjustable wrenches

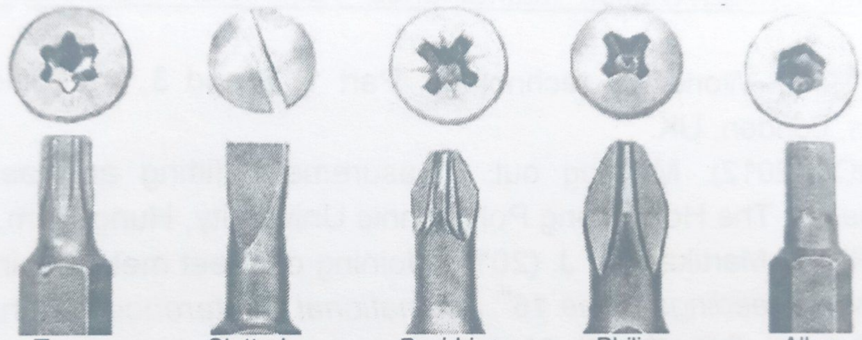
**Figure 5.27**: Pictorial illustrations of different types of wrenches, showing the open-end wrench in (a), box-end wrench in (b), socket-end wrench in (c) and adjustable wrenches in (d)
*Source: (AvStop 2017)*

### *5.5.3 Screwdrivers*

These are hand tools used for tightening and loosening screws or screw-head bolts. They can be classified by their shape, type of blade, and blade length. It is important to use the right width blade when installing or removing screws. The shape of the tip is also important. If the tip is badly worn or incorrectly ground, it will tend to jump out of the slot, consequently damaging the tip head of the driver or the slot of the screw head. The two types of recessed head screws in common use are the Phillips and slotted. Others include torx, pozidrive and allen. A common screwdriver must fill at least 75 per cent of the screw slot. If the screwdriver is wrongly sized, it cuts and burrs the screw slot, making it worthless. The damage may be so severe that the use of screw extractor may be required. A screwdriver with the wrong size blade may slip and damage adjacent parts of the structure. Figure 5.28 illustrates a flat head screwdriver and types of recessed head screws (or screwdriver blade shapes), commonly found in the engineering workshop.



(a) Flat-head screwdriver




(b) Types of recessed head screws

**Figure 5.28**: Pictorial illustration of a screwdriver, showing the flat head screwdriver in (a) and types of recessed head screws in (b)

*Courtesy: Universal Screwdriver*

### *5.5.4 Crowbars*

A crowbar, also known as a wrecking bar, pry bar, pinch-bar, or occasionally a prise bar, is a tool consisting of a metal bar with a single curved end and flattened points, often with a small fissure on one or both ends. The tool is called a crowbar in modern American usage or a jemmy in British/ Australian/ New Zealand usage. Crowbars are used as a lever either to force apart two objects or remove nails. Crowbars are commonly used to open nailed wooden crates, remove nails or pry apart boards. Crowbars can be used as any of the three lever classes, but the curved end is usually used as a first-class lever, and the flat end as a second-class lever. In mining, crowbars are used to break blasted rocks and to remove loose rock on roof sides and the working face, but not as much in modern mining. Figure 5.29 illustrates a crowbar.

**Figure 5.29**: Pictorial illustration of a crowbar

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