Fitting

The term *fitting*, is related to assembly of parts, after bringing the dimension or shape to the required size or form, in order to secure the necessary fit. The operations required for the same are usually carried out on a work bench, hence the term *bench work* is also added with the name *fitting*.

As a part of the workshop practice, fitting process is studied by all engineering students. This gives the basic knowledge about engineering materials, cutting tools, measuring tools, different fitting operations, behaviour of metals, importance of geometry of shapes, etc.

3.1 Introduction to Bench Work and Fitting

The fitting operations are generally done by using hand tools, after holding and placing the workpiece on a work bench. The tools and related equipment used for fitting processes can be classified as given below.

(a) *Work holding devices:*

1. Work bench
2. Bench vice
3. Hand vice
4. V-block with clamp

(b) *Cutting tools:*

1. Files
2. Hack saws
3. Chisels
4. Hammers
5. Scrapers
6. Drills
7. Reamers
8. Tap and die
9. Drilling machine
10. Tool grinding machine

(c) *Measuring and marking tools:*

1. Surface plate
2. Engineer's try-square
3. Scribers
4. Punches
5. Steel rule
6. Vernier caliper
7. Outside and inside calipers
8. Dividers
9. Combination set
10. Micrometers
11. Vernier height gauge
12. Miscellaneous gauges

(d) *Tools for assembling and inspection:*

1. Spanners
2. Pliers
3. Screw drivers
4. Allen keys

The operations done in fitting processes can be classified as given below:

1. Marking out
2. Hack sawing
3. Chipping
4. Filing
5. Scraping
6. Drilling and reaming
7. Tapping and dieing
8. Assembling

3.2 Work Holding Devices

3.2.1 Work Bench

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 *work bench*. The work bench is a strong, heavy and rigid table made up of hard wood. The size of the work bench required is about 150 to 180 cm length, nearly 90 cm width and approximately 76 to 84 cm height. *Bench vice,* is the device used to hold the workpiece and it is rigidly clamped on the top of the table as shown in Figure 3.1. Lockup drawers, to keep the tools used for fitting, are also usually provided below the table top.

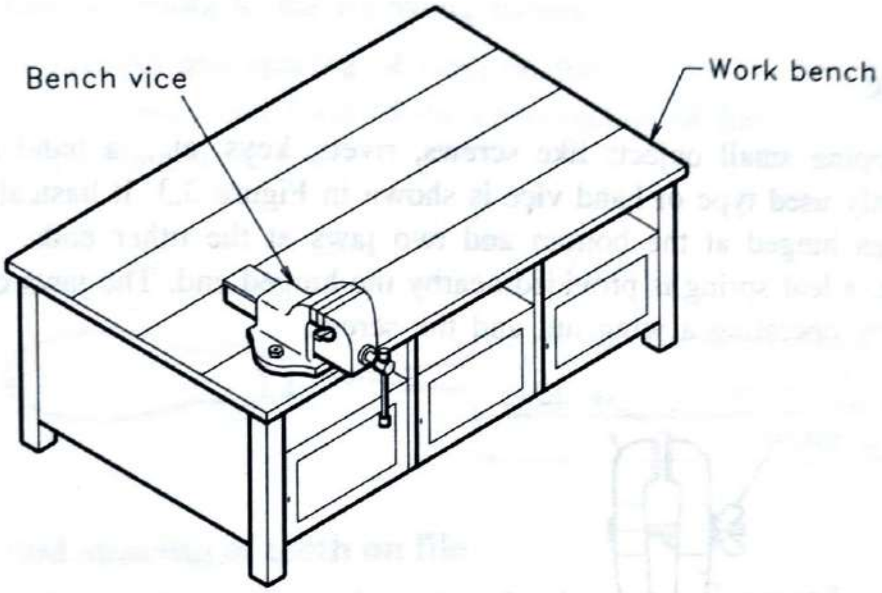


FIGURE 3.1
Work bench with vice.

3.2.2 Bench Vice

Bench vice is the most widely used device for holding the workpiece in position during various operations which are carried out in a fitting shop. It consists of one movable jaw and one fixed jaw as shown in Figure 3.2. The body of the vice is made up of iron or steel by casting. The threaded screw which is made to pass through the movable jaw at the outer end carries a handle at its end. Cast steel plates (known as *jaw plates*) are screwed to the jaw for holding the work rigidly. The gripping property of the jaw plates is increased by serrations provided with them. The base of the vice is bolted on the top of the work bench, nearby the edge.

A work is gripped between the parallel jaws by rotating the screw inside the nut, using the handle. The desired pressure is obtained by tightening or loosening the screw. In order to avoid the gripping marks on a finished surface of the workpiece, soft liners may be used on the jaw surfaces. The size of the vice is usually specified by the width of the jaws. The jaw size varies from 80 to 140 mm and the maximum opening ranges from 95 to 180 mm.

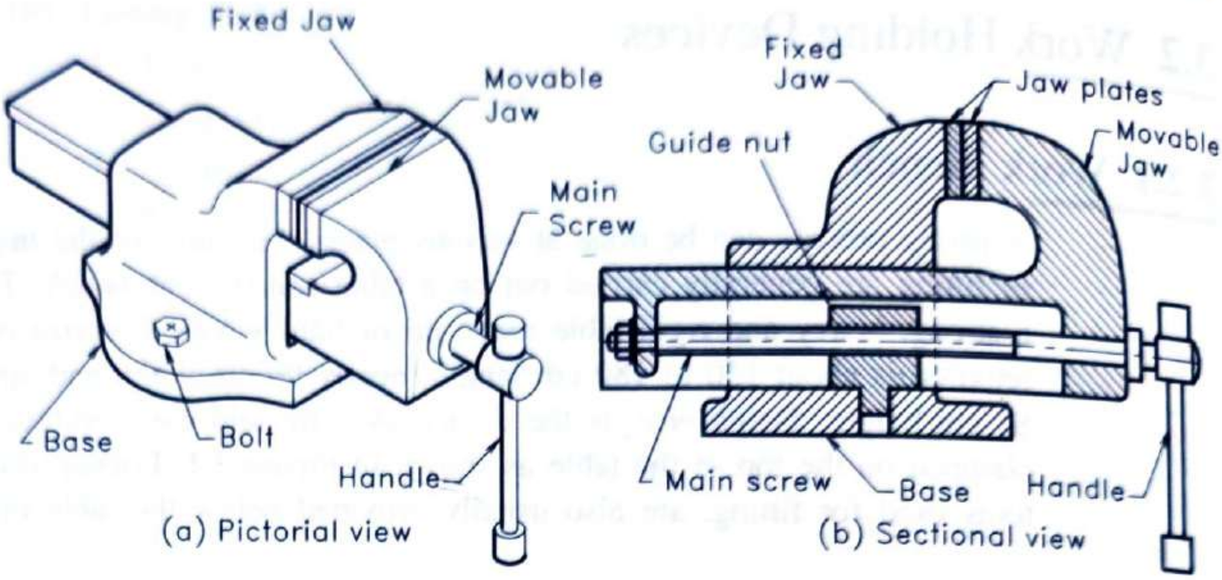


FIGURE 3.2
Bench vice.

3.2.3 Hand Vice

For gripping small objects like screws, rivets, keys, etc., a hand vice is used. The commonly used type of hand viçe is shown in Figure 3.3. It basically consists of two steel legs hinged at the bottom and two jaws at the other ends. To keep the jaws separate, a leaf spring is provided nearby the hinged end. The jaws can be opened and closed by operating a wing nut and the screw.

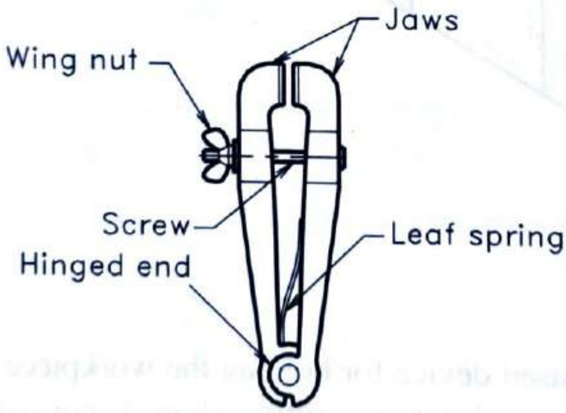


FIGURE 3.3
Hand vice.

3.2.4 V-block with Clamp

Cylindrical objects can be clamped for drilling or similar operations by using a V-block and a U-clamp as shown in Figure 3.4. By keeping the round bar on the

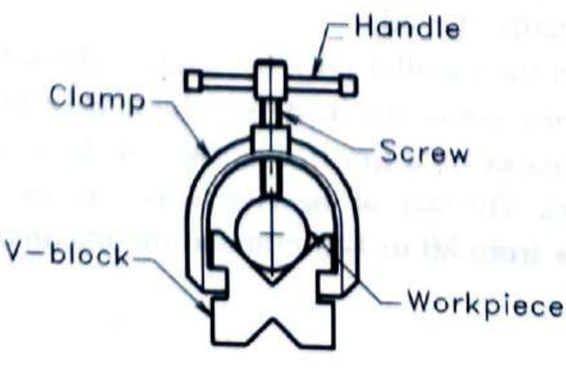


FIGURE 3.4
V-block with clamp.

V-groove, the longitudinal axis of the bar coincides with that of the grove. This enables the marking of centre line, drilling of holes along the centre, etc., accurately.

3.3 Cutting Tools

3.3.1 Files

A file is a hardened piece of steel containing a high percentage of carbon or tungsten. Fine teeth are cut on the surface of the piece in slanting rows. Figure 3.5 shows the standard form of a file with wooden handle in detached position. The end called heal has a pointed portion called *tong*, which is used to fix the wooden handle. Files are classified according to the following factors:

1. The cut and spacing of teeth on file.
2. The shape and form of the cross-section of file.
3. The length of file.

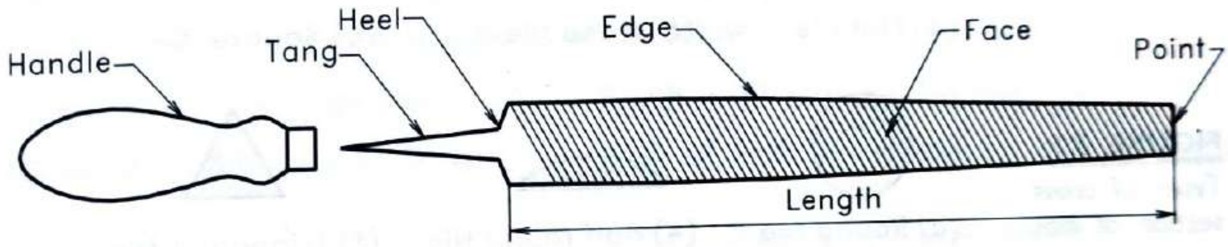


FIGURE 3.5
Parts of a file.

Cut and spacing of teeth on file

The teeth on a file may be of single cut or double cut. A single cut file will be having parallel teeth at 60° inclination to the centre line and is also known as flat files. Double cut files have two times cut-teeth; one similar to those of single cut (at 60°) and the other running diagonally across, making an angle of 80° to the centre line as shown in Figure 3.6. The spacing between teeth is known as the *pitch* and that has importance

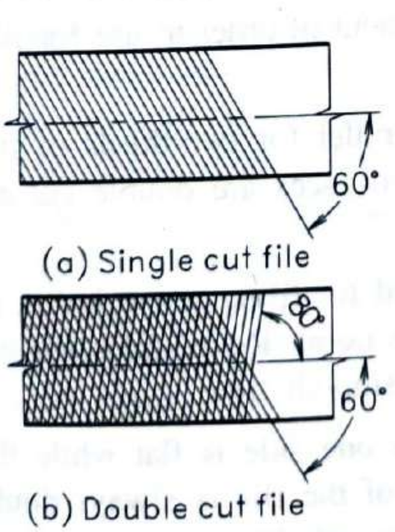


FIGURE 3.6
Types of cutting on files.

in the performance of the file. According to the spacing of teeth, files are classified into the following types:

1. Rough (R) 8 teeth/cm
2. Bastard (B) 12 teeth/cm
3. Second cut (Sc) 16 teeth/cm
4. Smooth (S) 24 teeth/cm
5. Dead smooth (DS) 35 teeth/cm
6. Super smooth (SS) 50 teeth/cm

Shape or form of cross section of file

Files are also grouped according to the cross section of them. Different cross sections are required for shaping contour of different forms. For example, a round hole can be shaped only by a round file. Figure 3.7 gives the common cross sections of the files used.

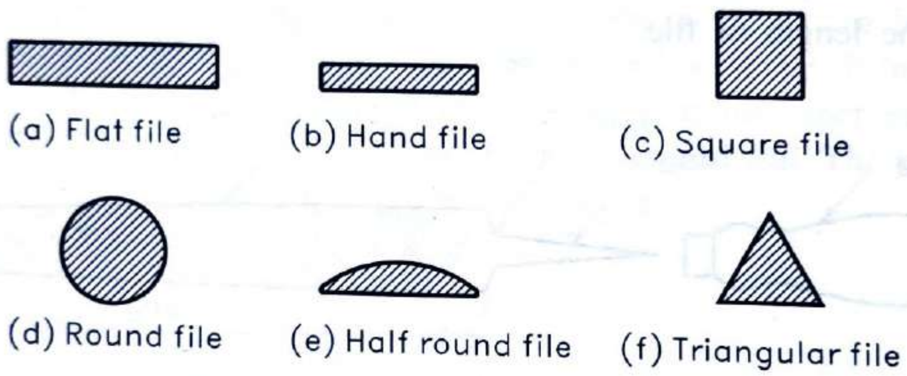


FIGURE 3.7 Types of cross section of files.

The type of files that are generally used for workshop practice are:

1. *Flat file:* This file has parallel edges for about two-thirds of the length and then it tapers in width and thickness. The faces are double cut while the edges are single cut.
2. *Hand file:* For a hand file the width is constant throughout, but the thickness tapers as given in flat file. Both faces are double cut and one edge is single cut. The remaining edge is kept uncut in order to use for filing a right-angled corner on one side only.
3. *Square file:* A square file is parallel for two-thirds of its length and then tapers off like a flat file. The four faces are double cut and is used to file corners and slots.
4. *Round files:* Round files are used for filing round holes, corners, slots, etc. They are also tapered towards the point. Round files are usually double cut, but single cut teeth are used for smooth files.
5. *Half round files:* For these files one side is flat while the other side is a portion of a circle. The flat side of the file is always double cut, while the curved surface is single cut for smooth files.

6. *Triangular (three-square) file:* For filing corners of angles less than 90°, triangular files are used. The three faces are double cut.
7. *Needle files:* These files are miniature forms of the above types avilable in sets, used for smaller size precision jobs.

Effective length of files

The size of a file is its effective length. The distance from the point to the heal (excluding the tang) is considered as the effective length of a file. The length of files used for heavy works varies from 200 to 450 mm, while that for medium works varies from 150 to 250 mm. For fine works, files of length 100 to 150 mm are preferred.

3.3.2 Hack Saw

For cutting off and for making thin cuts, a hack saw is frequently used by a fitter. It mainly consists of a metal frame with a wooden handle on one end, a metal clip with a wing nut on the other end and the cutting blade as shown in Figure 3.8. The hack saw blade is the most important part for the cutting process. It is specified by its length (distance between pin holes) width, thickness and the pitch of teeth. The specification of a hack saw blade commonly used is given below.

Length = 250 and 300 mm	Width = 13 mm and 16 mm
Thickness = 0.63 and 0.80 mm	Pitch of teeth = 1.8 and 1.4 mm

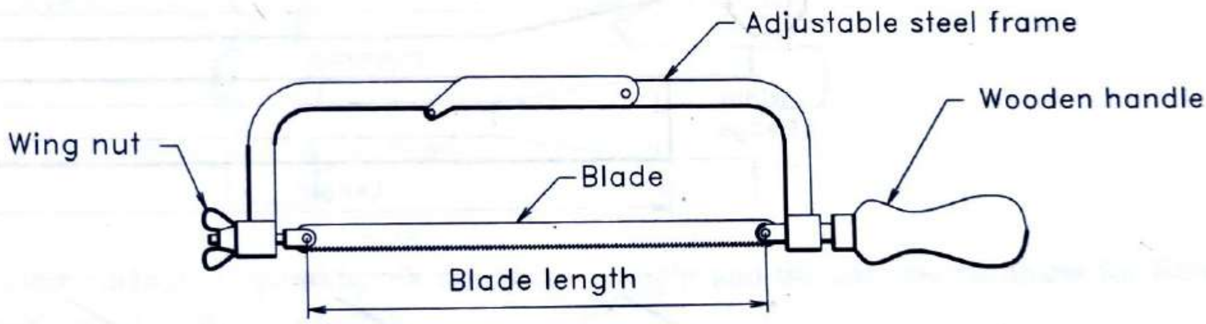


FIGURE 3.8
Hack saw.

The material used for hack saw blade is high carbon steels, H.S.S. or low alloy steels. They are made as *all hard* or *flexible*. All hard blades are hard for the whole body and can cut hard metals without difficulty. But they may break very easily. Flexible blades are made with hard teeth on a soft body, so that a slight bending cannot break them. They are suitable to cut comparatively soft metals like mild steel or aluminium. The breaking of the blade will be less and even an unskilled worker can use it. The sharp points of the teeth are bent alternately to sides to cut wide groove and thus provide clearance for the blade to move. This bending of teeth to sides is called the *set* of the blade.

3.3.3 Chisels

Chisels are used to cut or chip off metal from workpiece. If the metal is cut in the cold state (below the recrystallization temperature), the chisel used for that is called *cold chisel*. Cold chisels usually have rectangular, hexagonal or octagonal cross section of body. They are made of high carbon steel and shaped by forging process. Depending on the shape of the cutting end, the commonly used cold chisels are classified into the following types:

1. Flat cold chisel
2. Crosscut cold chisel
3. Diamond-pointed cold chisel
4. Half-round cold chisel

The included angle for the cutting edge usually varies from 40° to 70° (from aluminium to steel) depending on the strength of metal. An angle of 60° in the most common one.

1. Flat cold chisel: This is the most common type of chisel used in fitting shop. It is used to chip off excess metal from the surface of the job. It can also be used for cutting sheets, rods, bars, wires and similar metallic pieces. The length varies from 100 to 400 mm while the cutting edge length is kept between 16 to 32 mm [Figure 3.9(a)].

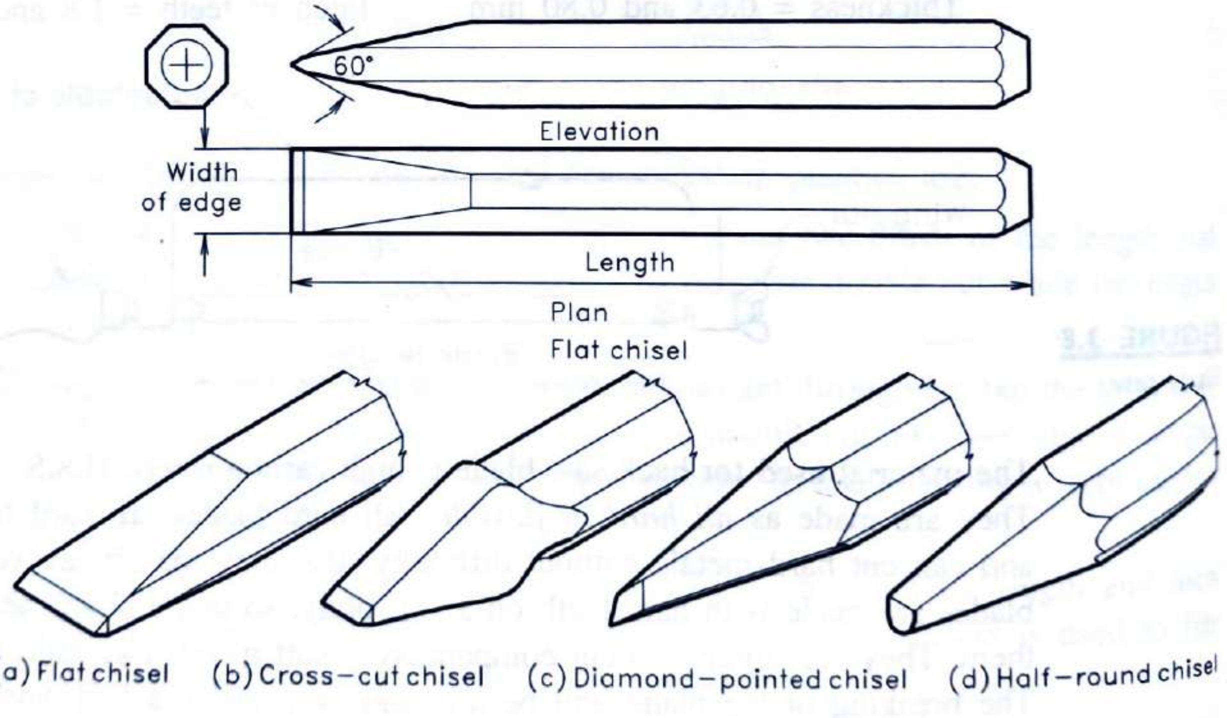


FIGURE 3.9
Cold chisels.

2. Crosscut cold chisel: A cross cut chisel is also known as *cape chisel*. It has a slightly wider cutting end than the body but narrow in thickness as shown in figure. It is used to cut groves, key ways, etc. The size is similar to flat chisel but, the width of cutting edge varies from 4 to 12 mm.

3. Diamond pointed cold chisel: This is a special purpose chisel used to cut V-grooves, cleaning of corners and squaring of holes. The cutting edge has a diamond shape as shown in Figure 3.9(c). The size of the chisel is similar to the flat one, but width of cutting edge varies from 6 to 16 mm.

4. Half round cold chisel: This chisel has a half round end as shown in figure. They are used to cut curves, bottom grooves used for oil circulation in bearings or for cleaning rounded corners. The half round chisel is also known as *round nose chisel.* The length of the chisel varies from 150 to 250 mm.

There are cold chisels of various shapes other than the specified above and they are made to suit the special requirement. The chisels are sharpened by grinding on a tool grinding machine. A tool grinder mainly consists of a high speed motor fitted with two grinding wheels of different diameters and grain size on both ends of the extended shaft.

3.3.4 Hammers

Hammers are used to strike on a tool, fastener or workpiece. They are made up of steel by forging process. Wooden or bamboo handle is fitted in the elliptical eye hole of the hammer. Figure 3.10 shows the parts of a hammer used by a fitter. One end of the hammer head, called face, is hardened and polished well. It is having a slightly

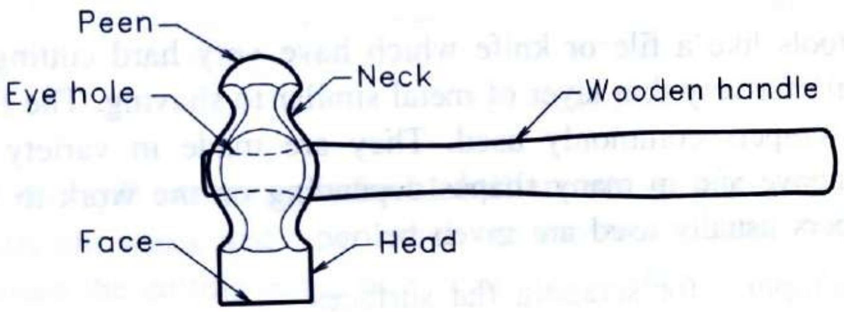


FIGURE 3.10
Hand hammer nomenclature.

convex surface. Depending on the shape, weight and the use, the hammers for fitting work are classified as below:

1. Ball peen hand hammer
2. Cross peen hand hammer
3. Straight peen hand hammer
4. Soft hammer (mallet)

1. Ball peen hand hammer: This is the most common form of hammer used for fitting works [Figure 3.11(a)]. The peen has the shape of a ball and the other end called face has cylindrical shape. The weight of the hammer varies from 0.11 to 0.91 kg. A ball peen hammer is used for hammering during the operations like chipping, riveting, nailing, etc.

2. Cross peen hand hammer: The hammer is similar to the above with a difference that the ball peen is replaced by a peen in the cross direction of the edge hole. This hammer is used for bending, straightening, hammering inside curves, etc. The size varies from 0.22 to 0.91 kg [Figure 3.11(b)].

3. Straight peen hand hammer: This hammer is similar to the cross peen type. The peen is positioned parallel to the axis of the eye hole. The use of the hammer is similar to that of cross peen type. The size of hammer varies from 0.11 to 0.91 kg [Figure 3.11(c)].

4. Soft hammer (mallet): For giving soft blows which cannot damage the machined surfaces, soft hammers or mallets are used. The material used may be lead, copper, brass, plastic, hard rubber or wood. Wooden mallets of this type are widely used for sheet metal work [Figure 3.11(d)].

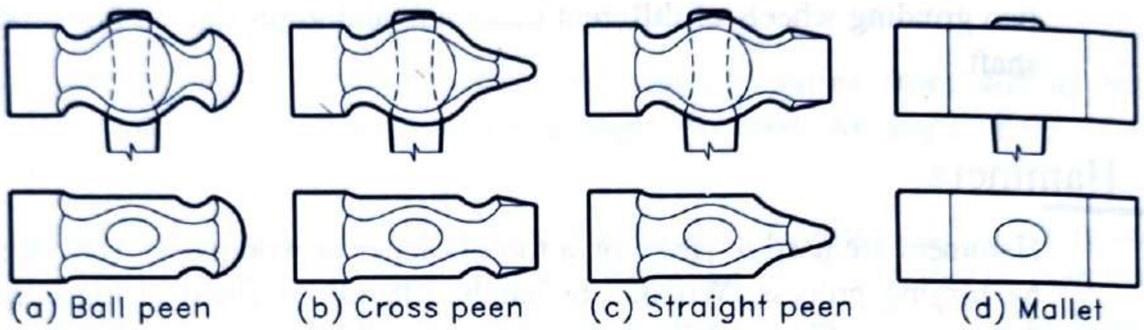


FIGURE 3.11 Types of hand hammers.

3.3.5 Scrapers

Scrapers are tools like a file or knife which have very hard cutting edges. Scraping means removal of a very thin layer of metal similar to shaving. The Figure 3.12 shows the types of scrapers commonly used. They are made in variety of lengths from 100 mm and above and in many shapes depending on the work to be executed. The shape of scrapers usually used are given below:

1. *Flat scraper*—for scraping flat surfaces.
2. *Triangular scraper*—for curved surfaces and corners.
3. *Half round scraper*—for round and curved surfaces.

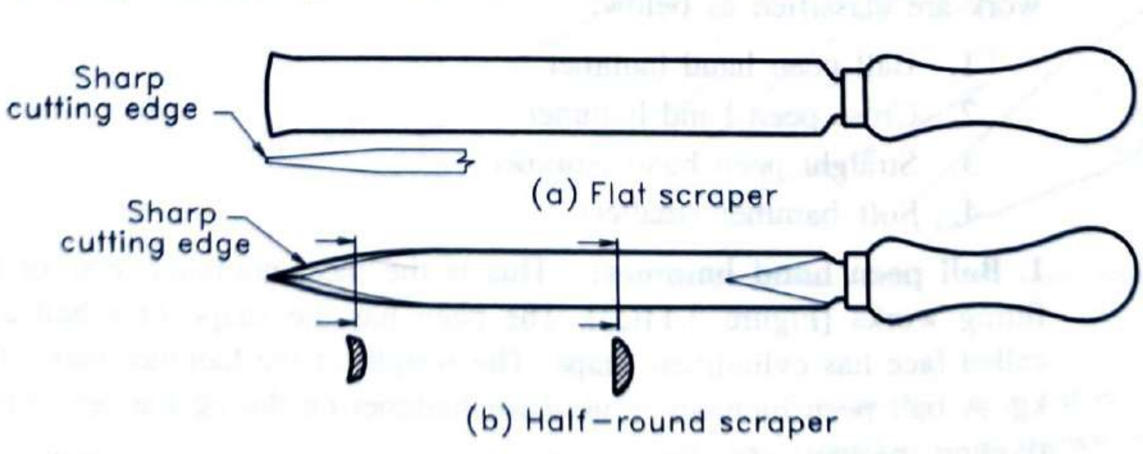


FIGURE 3.12 Types of hand scrapers.

3.3.6 Drills and Reamers

Drill is a tool used to make cylindrical holes by rotating and pressing the tool against a work piece. The two-cutting edges positioned at an angle of about 59° to the axis, remove metal simultaneously while it rotates. Depending on the shape, there are three types of drills [see Figure 3.13(a)].

1. Flat drill
2. Straight fluted-drill
3. Twist drill

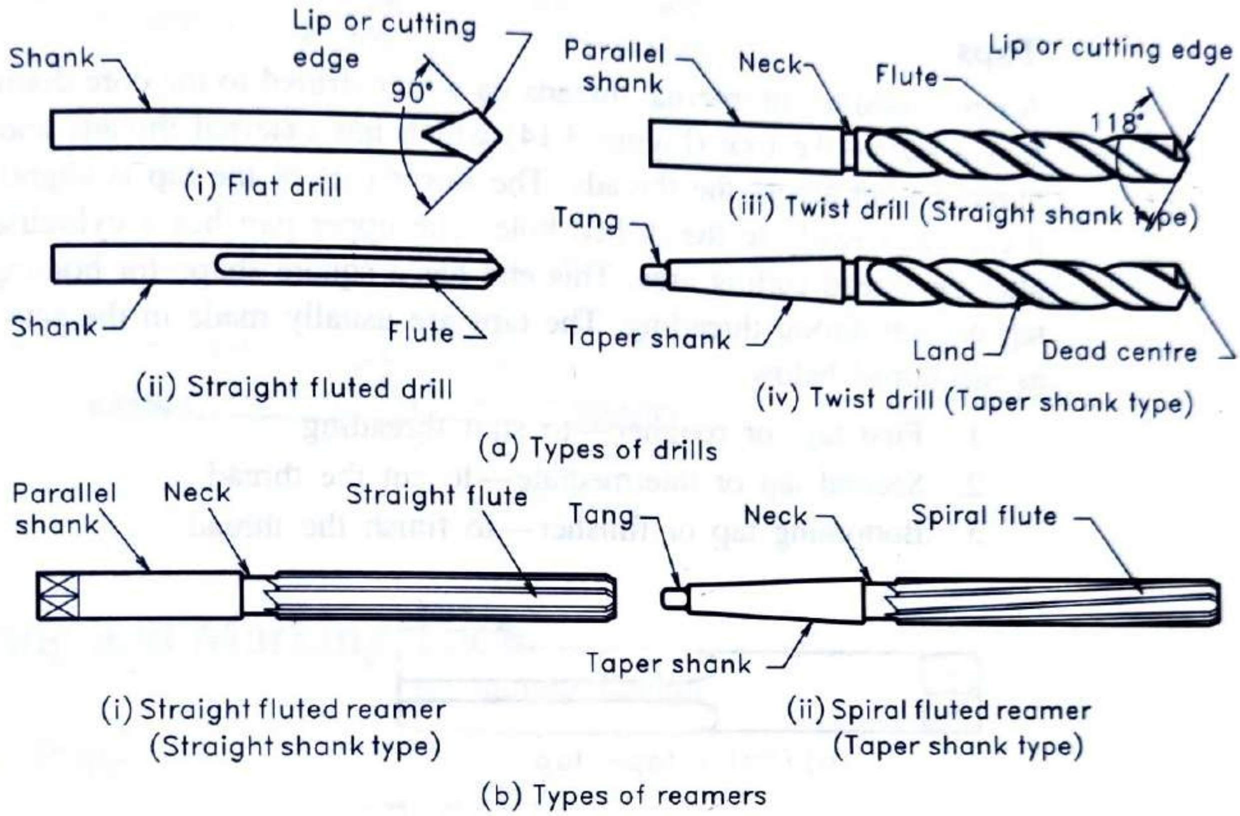


FIGURE 3.13
Types of drills and reamers.

Flat drill and straight-fluted drill are not usually used in a fitting shop. Twist drill of straight shank and taper shank are commonly used for drilling. The included angle between the cutting edges of a twist drill is kept at 118°. The parallel shank type twist drill bits are made for diameter 0.20 to 40 mm size. The taper shank type twist drills range from 3 to 100 mm diameter. The taper of the shank is made as per *Morse Standard Taper* and it keeps the tool tightly inside the socket by friction. To take the drill bit out from the socket, a taper cotter called *drift key* is used. For larger size drills, the drill diameter is marked on it, but for small size drills, the size is determined by inserting it in gauges having standard hole diameters.

Drilled surface of hole may not be smooth and may have dimensional variation. To correct this a process called *reaming* is done using the tool called *reamer*. A reamer is a tool similar to drill, which removes a very thin layer of metal about 0.05 to 0.15 mm from the hole surface using long cutting edges on the reamer, which forms the cylindrical shape [see Figure 3.13(b)]. The cutting edge forming the flutes on the cylindrical surface may be of straight or spiral type. Similar to drills, reamers may have straight or taper shank. The reaming process can be done by hand or by using the drilling machine.

3.3.7 Taps and Dies

Internal and external threads are cut on machine parts by using taps and dies respectively. They can also be used to correct the damaged threads. For each size of thread and thread forms, a set of taps and dies is required. They are made of hard steel similar to other tools.

Taps

A tap is used to cut internal threads on a hole drilled to the core diameter of the thread. It is a screw-like tool (Figure 3.14) which has external threads and flutes (3 or 4 in numbers) cut across the threads. The lower part of the tap is slightly tapered, so that it can enter easily to the drilled hole. The upper part has a cylindrical shank portion, after the thread cutting area. This end has a square shape for holding the tap with the tap wrench during threading. The taps are usually made in the sets of three numbers as mentioned below:

1. First tap, or rougher—to start threading
2. Second tap or intermediate—to cut the thread
3. Bottoming tap or finisher—to finish the thread

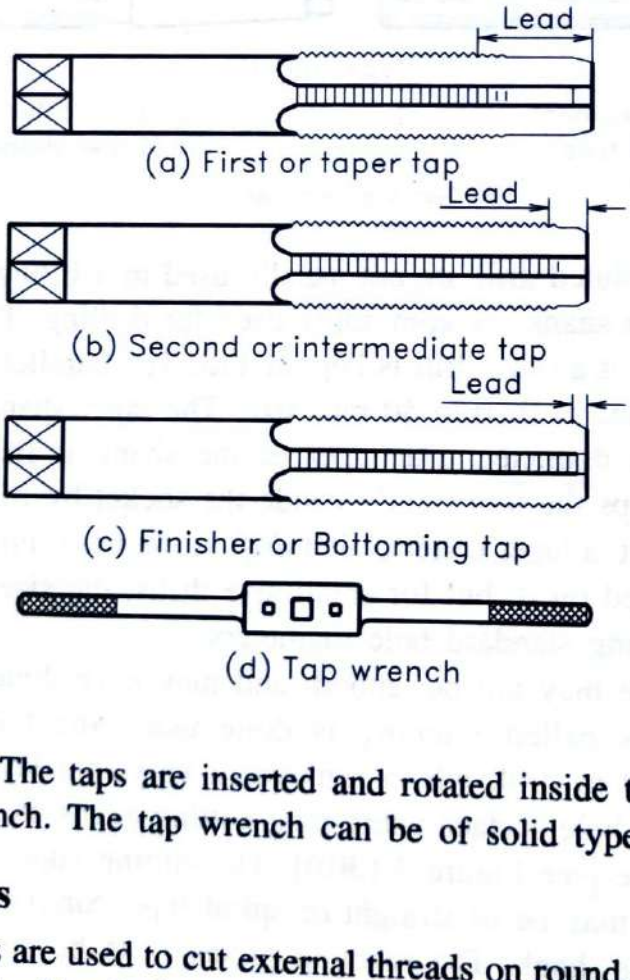


FIGURE 3.14
Taps.

The taps are inserted and rotated inside the drilled hole by holding it in the tap wrench. The tap wrench can be of solid type or adjustable type.

Dies

Dies are used to cut external threads on round rods. A die is a round block of hardened steel with a hole having internal threads and flutes across the threads. The die is fitted inside a die holder called *die stock* and is used for cutting external threads

(Figure 3.15). In the case of cutting external threads, only one die is enough to finish the thread. To cut threads on diameter, slightly varying from the nominal diameter, an adjustable die can be used. Here, the die is split into two and a screw can be used to adjust the gap between the die pieces.

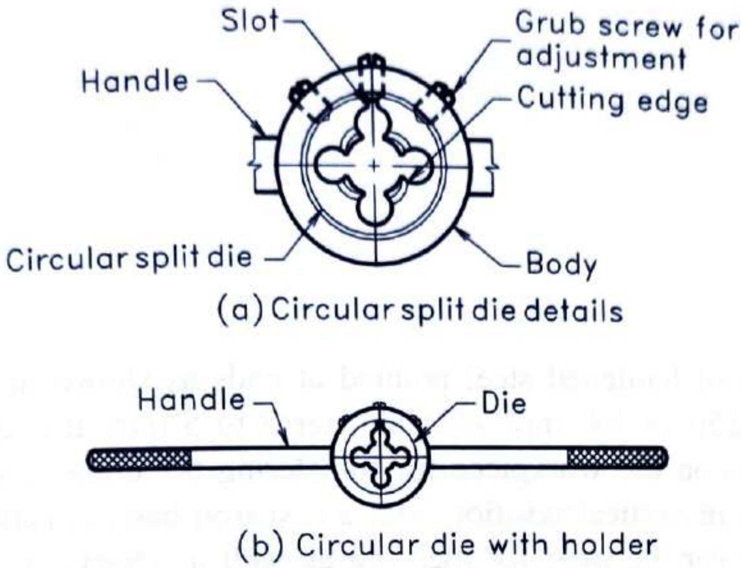


FIGURE 3.15
Die.

3.4 Measuring and Marking Tools

3.4.1 Surface Plate

It is a cast iron plate having perfectly smooth and flat surface, used as a reference surface for measuring and marking (Figure 3.16). The flat surface is finished by grinding and scraping. The bottom legs of the plate are also machined to keep the surface of the plate in perfect horizontal plane. To protect the surface of the plate from dust and dirt, it is kept covered, when out of use.

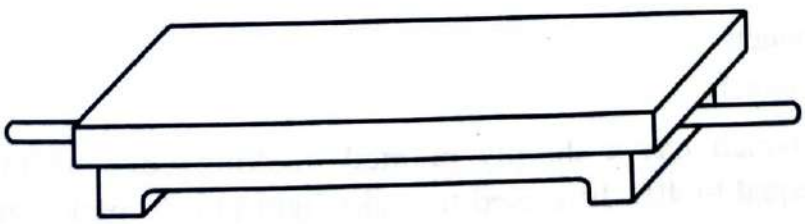


FIGURE 3.16
Surface plate.

3.4.2 Engineer's Try Square

The try square of shape shown in Figure 3.17 is used in fitting shops for scribing straight lines at right angles to a true surface. It can also be used to test the trueness of mutually perpendicular surfaces. It consists of a steel stock of rectangular cross section and a steel blade fitted perpendicular to it.

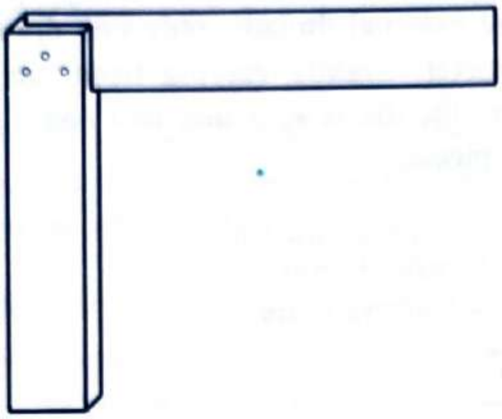


FIGURE 3.17
Try square.

3.4.3 Scribers

A scriber is a piece of hardened steel pointed at ends as shown in Figure 3.18. The length ranges from 150 to 300 mm and diameter 3 to 5 mm. It is used like a pencil to mark scratch lines on the workpiece for transfering the drawing on it. The scriber fitted on an iron rod in vertical position with a cast iron base, is called *scribing block* or *surface gauge*. It can be used for marking as well as checking.

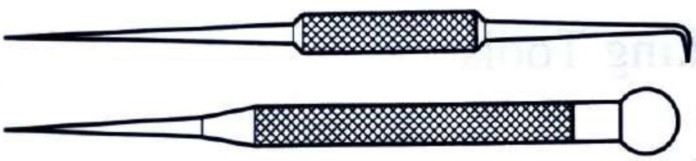


FIGURE 3.18
Scribers.

3.4.4 Punches

A punch is a tool similar to a chisel, but the cutting edge is replaced by a pointed edge. Punches are used to locate the line drawn by a scriber as a permanent mark. Depending on the use and the shape of the marking edge, punches can be classified as (Figure 3.19):

1. Prick punch
2. Centre punch

The prick punch has a sharply pointed marking edge having included angle approximately equal to 40°. It is used to make light punch marks on layout lines. The centre punch has an included angle of about 60°. They are usually used to mark heavy punch indentation to start drilling a hole. The size of the punch varies from 90 to 150 mm length and diameter 8 to 13 mm.

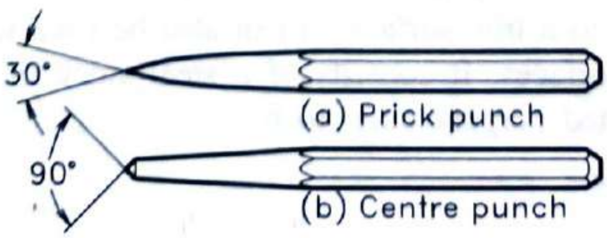


FIGURE 3.19
Punches.

3.4.5 Steel Rule

Steel rule is the scale used in fitting shops for taking measurements up to 0.5 mm accuracy. One side is marked in millimetre and the other side in inches. The material used for making the scale is stainless steel. Steel rules are usually of 150 mm or 300 mm in length (Figure 3.20). For large length measurements, rules of length 600 mm or above are also available in the market. It is to be noted that the marking on scale starts exactly from the left end. This enables to measure the distance by an outside or inside caliper from that end for better accuracy.

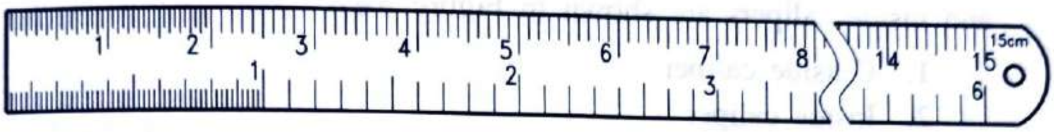


FIGURE 3.20
Steel rule.

3.4.6 Vernier Caliper

For more precise measurement of length, vernier calipers are used. There are vernier calipers to measure length with an accuracy of 0.02 mm or 0.001 inch. Figure 3.21 shows a vernier caliper to measure length in mm and inch.

A vernier caliper basically consists of a bar having the main scale marked on it and the fixed jaw for external and internal measurements. The adjustable vernier head having the vernier scale, is positioned over the main scale and carries the movable jaw as shown in Figure 3.21. There is an auxiliary head, connected to the main head by micrometering screw for fine adjustments. Both the heads are provided with locking screws to lock them firmly at any desired position.

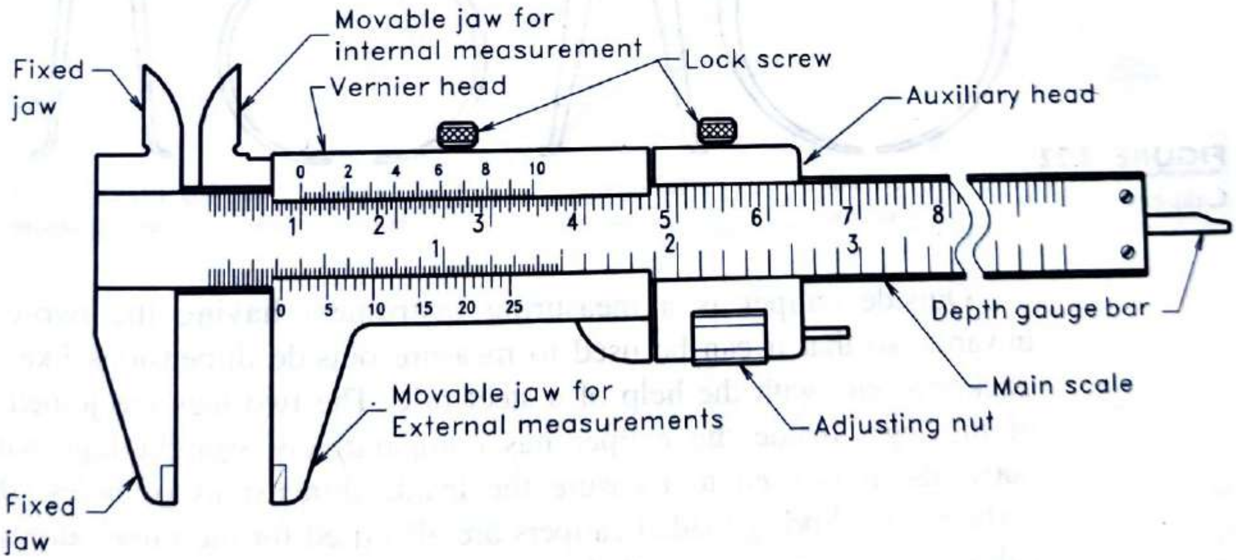


FIGURE 3.21
Vernier caliper.

The vernier scale for 0.02 mm least count has the scale length of 49 mm and it is divided to 50 equal divisions. Hence, one division of vernier scale is 1/50 mm less than 1 mm. This gives a least count of 0.02 mm. The reading of the vernier caliper is similar to any vernier scale. For example, if a dimension measured contains the main scale divisions (say, 12) and the vernier scale division coinciding with main scale (say 42), then the measured dimension

$$= 12 + (0.02 \times 42) = 12 + 0.84 = 12.84 \text{ mm}$$

3.4.7 Outside and Inside Calipers

To measure the size of or to transfer a dimension to a component, calipers are used. A reasonable accuracy in dimension is obtained by using calipers. The precision in the measurement depends mainly on the skill of the person. The commonly used outside and inside calipers are shown in Figure 3.22.

1. Outside caliper
2. Inside caliper
3. Outside spring caliper
4. Inside spring caliper
5. Hermaphrodite (Jenny or odd leg) caliper

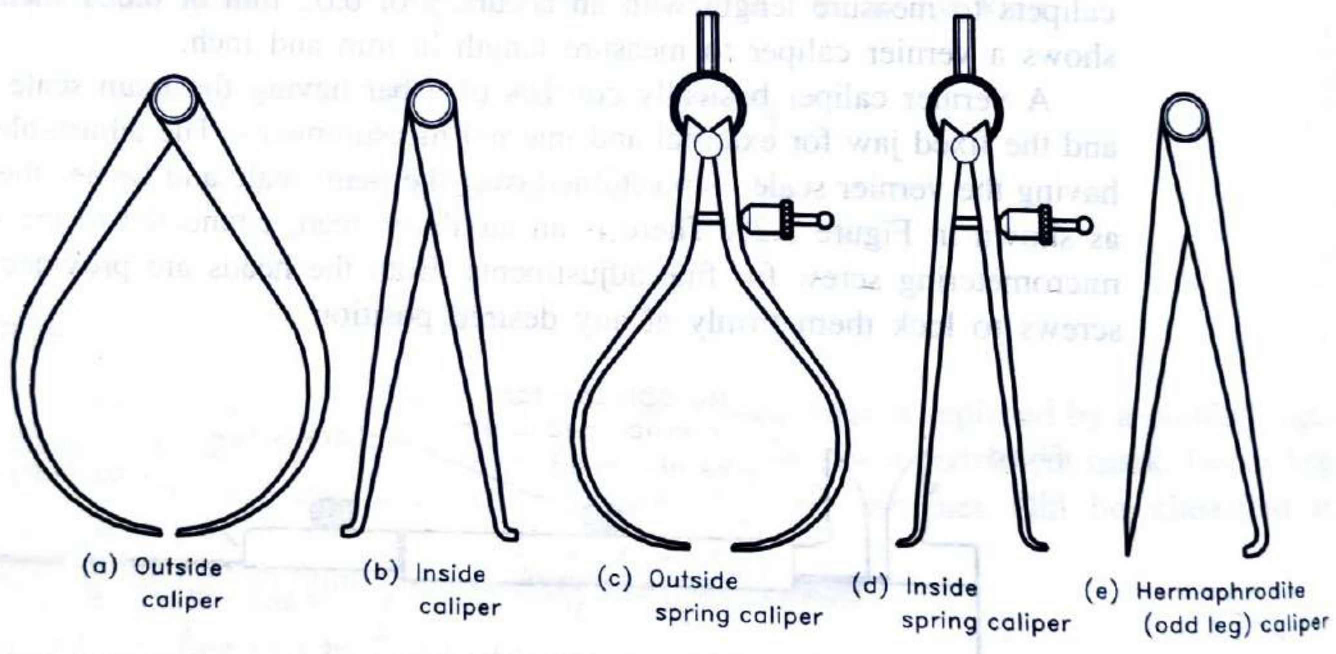


FIGURE 3.22
Calipers.

Outside caliper is a measuring instrument having the two-curved legs, bent inwards, so that it can be used to measure outside dimensions like diameter of rods, thickness, etc. with the help of a steel rule. The two legs are joined stiff at the hinge of the legs. Inside the caliper has comparatively straight legs with the ends bent outwards. It is used to measure the inside dimensions of holes, shoulders, parallel surfaces, etc. Spring-loaded calipers are also used for the same purpose as of the above calipers. The screw controlled spring calipers are more easy to adjust measurement. The odd leg caliper is used in the same way as that of outside caliper. It is extremely useful for scribing parallel lines about a straight edge of the workpiece or to find the centre of a cylindrical work.

3.4.8 Dividers

A divider used in a fitting shop is similar to that of an inside spring caliper, except that both legs are straight and sharp (Figure 3.23). This tool is used to transfer dimensions, scribing circles and for laying out the drawing in a work.

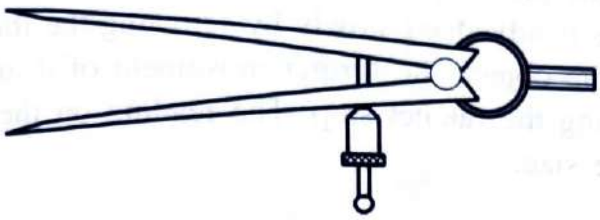


FIGURE 3.23
Divider.

3.4.9 Combination Set

This is an instrument used in fitting shops for measuring, marking or checking angles, perpendicularity, centre, etc. The combination set consists of a marked steel rule with a slot along the centre line and carries three heads (Figure 3.24).

1. Square head
2. Bevel protractor
3. Centre head

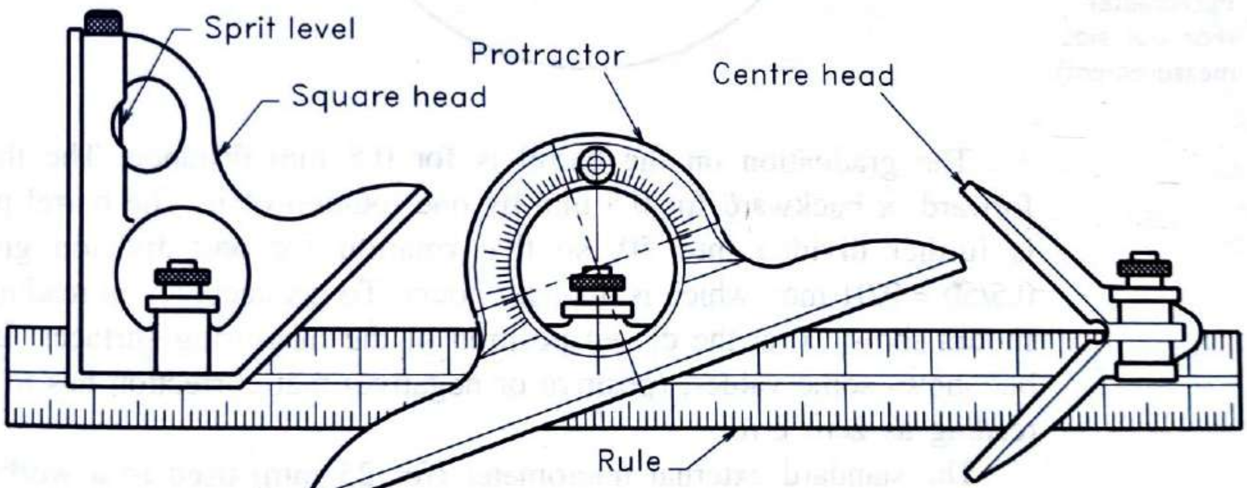


FIGURE 3.24
Combination set.

The square head is used to measure or mark the 90° and 45° angles. There is a spirit level provided on this head and this enables to check the horizontality of a surface. The bevel protractor head is used for measuring angles. With the help of the spirit level fitted with it, the slope of a surface can be determined. The vernier attached to the bevel protractor gives better accuracy in angle measurement. The centre square which is the third part has two arms at right angles. This is used to find the centre of a round rod or shaft. Each head can be moved to the required position and fixed by a clamping screw on the main scale for measurements.

3.4.10 Micrometer

Micrometer is a precision instrument used to measure the size up to an accuracy of 0.01 mm. It consists of a semicircular frame having a cylindrical extension at its right end and hardened anvil inside at the left end (Figure 3.25). To measure the size of a part using the micrometer, the part is placed between the measuring face (anvil) and the spindle. Then the spindle is advanced slowly by screwing the thimble forward. As the anvil is about to touch the object, the further movement of it and the pressure of touching is applied by rotating the ratchet stop. The reading on the barrel as well as thimble are noted to get the size.

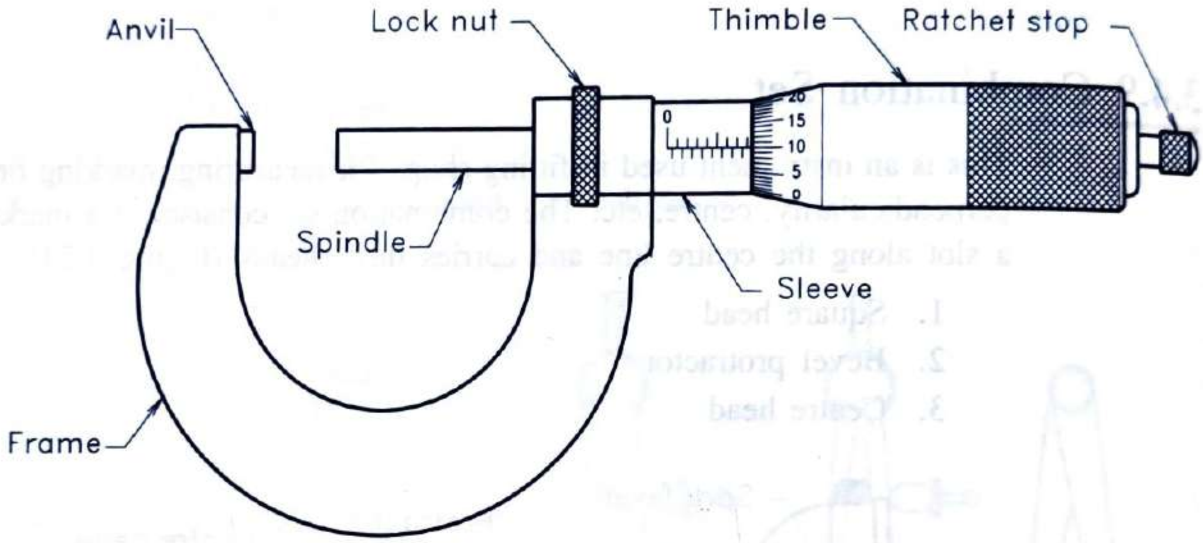


FIGURE 3.25
Micrometer (For out side measurement).

The graduation on the barrel is for 0.5 mm distance. The thimble will move forward or backward for 0.5 mm by one rotation of it. The barrel portion of thimble is further divided into 50, so that rotation for one division gives a movement 0.5/50 = 0.01 mm, which is the least count. To get accuracy in reading, the micrometer should show '0' at the closed position of the measuring surfaces. If it is not at zero but shows some values, (positive or negative) that correction has to be applied in the reading as zero error.

The standard external micrometer (for 25 mm) used in a workshop is shown in Figure 3.25. There are micrometers for measuring external dimensions 25, 50, 75, etc., up to 600 mm, available in the market. Similarly there are micrometers of different designs for measuring the inside diameter, depth, etc., in use.

3.4.11 Vernier Height Gauge

To measure the height of parts or to mark height accurately on an object, vernier height gauges are used. It mainly consists of a base, a vertical main scale, a sliding head with vernier and an auxiliary head. Depending on the type of measurement, the jaw can be replaced by another type. The base of the height gauge has flat and smooth surface. Usually measurement and marking are conducted after placing the workpiece and the gauge on a surface plate. The method of measurement is similar to that of a vernier caliper (Figure 3.26).

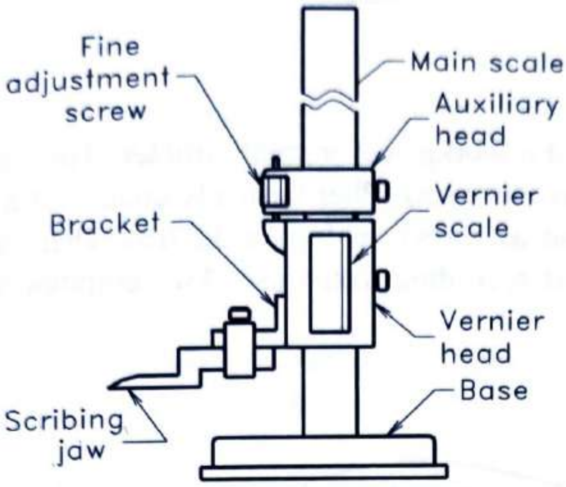


FIGURE 3.26 Vernier height gauge.

3.4.12 Miscellaneous Gauges

For comparing the dimensions of machine parts like thread pitch, thickness, diameter, gap, radius, etc., different types of gauges of standard dimensions are used in workshops.

1. *Screw pitch gauge:* This consists of a set of blades having standard thread forms for comparison of the pitch and the thread shape on screws.
2. *Plate and wire gauges:* These are circular discs having slots for comparing plate thickness and circular holes for comparing wire diameters.
3. *Feeler gauge:* This consists of blades of standard thickness to compare the gap between mating parts.
4. *Radius and fillet gauges:* These are gauges of blades similar to that of feeler gauge and are used to compare the radii of a curved surfaces and fillets.

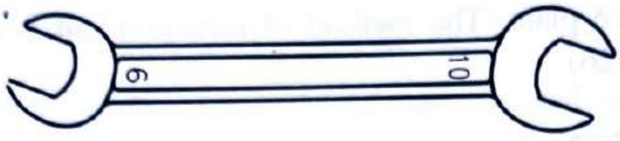
3.5 Tools for Assembling

3.5.1 Spanners

To tighten and loosen nuts, bolts and studs, spanners are used. They are tools made of forged steel. The size of a spanner is specified by the width across flats of a nut in mm or the diameter of the bolt in inches. Figure 3.27(a) gives the sketch of a double-end C-type spanner. Spanners can be grouped as given below:

1. Single-end C-type spanner
2. Double-end C-type spanner
3. Ring spanner
4. Box spanner

FIGURE 3.27(a)
Spanner.



3.5.2 Pliers

Pliers are mainly used to hold a workpiece or small articles. They are also used to cut or bend wire or similar thin components. Plier basically consist of a pair of steel arms, each having a jaw at one end as shown in Figure 3.27(b). There are different forms of pliers. The jaws are shaped according to the use. Two common types of pliers are:

1. Cutting pliers
2. Nose pliers.

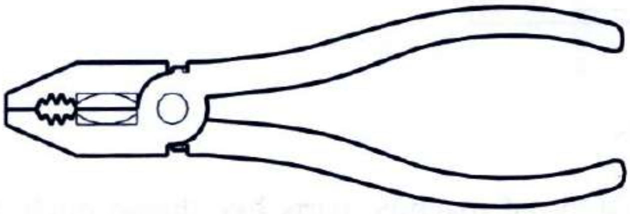


FIGURE 3.27(b)
Plier.

3.5.3 Screw Drivers

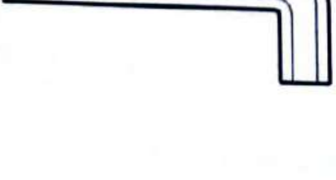
To tighten or loosen different types of screws, screw drivers are used. It consists of a hard steel rod flattened at one end and a wooden or plastic handle on the other end (Figure 3.28). The flat end of the tool is inserted into the slot provided on the head of the screw for rotating it. The length of the screw driver is made larger to get high screwing loads without slipping. Very small size screw drivers are sometimes called connecters, since they are used to tighten small screws of electrical fittings.

FIGURE 3.28
Screw driver.

3.5.4 Allen Keys

Screws or bolts with allen heads (hexagonal sockets) are tightened or loosened by using L-shaped tool called *allen key*. They are made of hard steel and have hexagonal cross-section (Figure 3.29).

FIGURE 3.29
Allen key.



3.6 Fitting Processes

3.6.1 Marking Out

Marking out is the process of scribing on the surface of the component to indicate the position of edges, centres, shape limit, etc., for cutting, drilling and finishing operations. This marking assists the machinist or fitter in setting up the work for various processes and the limit to which he may allow the removal of metal to proceed. Hence, the geometrical accuracy of the workpiece basically depends on the accuracy of the marking.

The tools used for marking out jobs in fitting shops include surface plate, V-block, scriber, measuring instruments, divider trisquare centre punch, hammers, etc. The surface on which the lines are marked, is prepared by cleaning. For cast surfaces, white washing is done in the marking areas. For machined surfaces copper sulphate solution is brushed to get a thin coating. For simple works, rubbing of white chalk on the surface will do the purpose of coating. The lines up to 0.2 mm thickness is drawn using scribers. Round objects are held in V-blocks while flat objects are placed on the surface plate and lines are marked.

Lines in horizontal directions are scribed using the scribing block or surface gauge. The lines perpendicular to them can be drawn easily after turning the workpiece for 90°. If machined straight surface is available, a trisquare can be used to draw a perpendicular line. The centres of round bar ends can be located by means of a hermaphrodite (odd leg) caliper. Dividers are used to scribe circles and arcs on the flat surfaces. The lines marked are converted into permanent indications by light punching at intervals exactly on the line, using a centre punch and a hammer. The metal is removed up to half of the circumferences of the punch mark for dimensional accuracy.

3.6.2 Hack Sawing

A workpiece can be cut to the approximate size by sawing using a hack saw. The workpiece or blank to be cut is rigidly clamped on the bench vice keeping the line of cut, a few millimetres outside the vice jaws. The hack saw, after tightening the blade, is placed over the cutting line of workpiece in such a way that the wooden handle in the right hand and the other end of the frame is on the left hand. The sawing is started with a backward stroke.

The first backward stroke makes a mark on the job surface. Along that mark the forward stroke is applied with slight pressure. The forward and backward strokes are repeated, giving more pressure during forward movement. This makes a cut called *kerf* on the work. Much care should be taken during the first few strokes for keeping the cutting without deviation from line. After forming the kerf, the cutting can be made fast as about 50 strokes per minute. During heavy cuts, care should be taken not to bend the blade side ways. Since the blade is hard and brittle, it may break. For easy starting of sawing, a sharp line can be filed at the cutting mark using a triangular file. To get better life of hack saw blade and for easiness in cutting, soap water is applied by squeezing a wet cotton waste over the cutting region.

3.6.3 Chipping

Thick layers of metal can be removed by the process called *chipping*. In this process the workpiece is fixed on the bench vice firmly and metal is removed by striking a cold chisel on the surface of the workpiece using hand hammer. The method of chipping is shown in Figure 3.30. The surface to be chipped is kept horizontal. The chisel is held at the middle at an angle of 35°to 70°to the surface by the left hand and the hammering is done in the same direction by right hand. In every blow of hammer a layer of metal is separated in the form of chips. Different types of cold chisels are used to produce various shapes like keyways, grooves, corners, etc. While chipping is ending nearby an edge, care should be taken not to have heavy blows in order to avoid damage of edge. In such cases, the direction of chipping can be reversed or turned 90°to the previous direction.

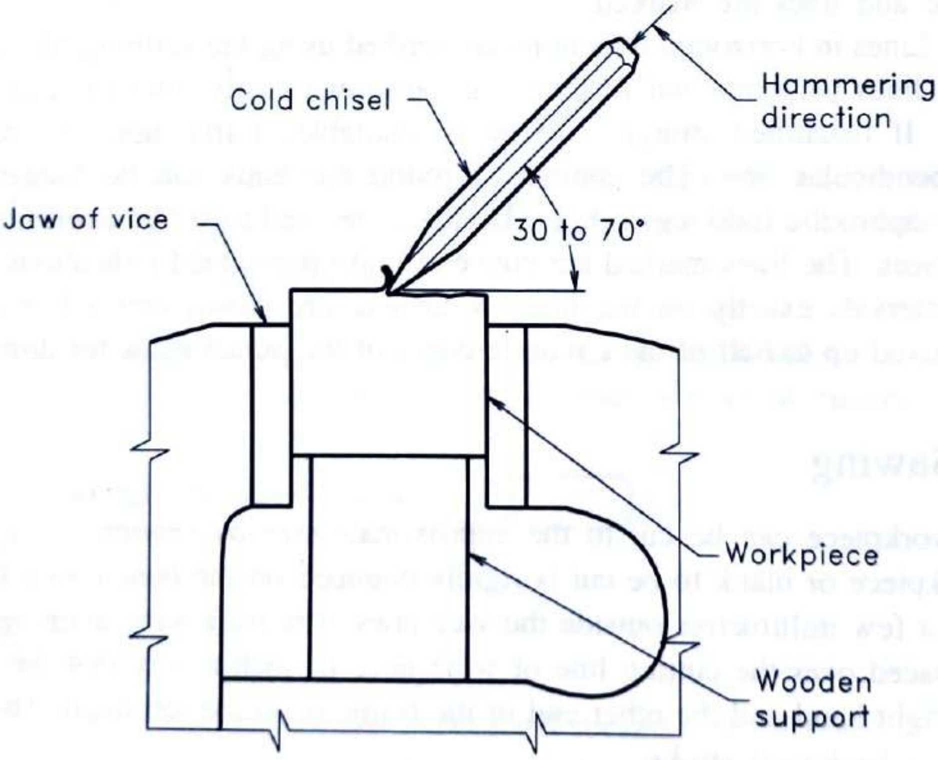


FIGURE 3.30
Chipping.

3.6.4 Filing

Filing is basically the production of flat surfaces by removal of metal in the form of fine chips using a tool called *file*. Filing is considered as the most important part of the fitting process and the skill of the operator in filing governs the geometrical accuracy and finish of the work. This process is applied after bringing the size of the job close to the required dimension by sawing or chipping. The allowance given for filing is about 0.6 mm. By perfect filing process an accuracy of 0.05 to 0.02 mm can be easily obtained.

To start filing, the job is fixed on the bench vice keeping the filing surface perfectly horizontal. The handle of the file is gripped by the right hand and the end of the file blade by the left hand, keeping the ball of the left hand thumb on the blade end. The right hand pushes the file in the forward direction while the left hand exerts pressure downwards in the forward motion. For light cuts, less pressure is to be applied. Hence, the end of the file blade is held by left hand finger tips. It is to be noted that the file cuts only in the forward strokes. The number of strokes of filing is maintained usually 50 to 60 per minute. Depending on the method of filing, the filing processes can be classified as:

1. *Cross filing:* In this filing the file strokes are made in diagonal form from right to left and then from left to right as shown in Figure 3.31(a). This is the most common type of filing and is used for medium and heavy cuts.
2. *Straight filing:* In this filing the file is pressed and moved forward approximately right angles to the length of the work as shown in Figure 3.31(b). On back stroke the file is lifted. This type of filing is suitable to the narrow pieces of work.
3. *Draw filing:* In this filing both the hands are kept on the two ends of the file blade and the blade is kept at right angles to the length of the work. The forward and backward strokes of the file will smoothen the surface produced by cross or straight filing [Figure 3.31(c)].

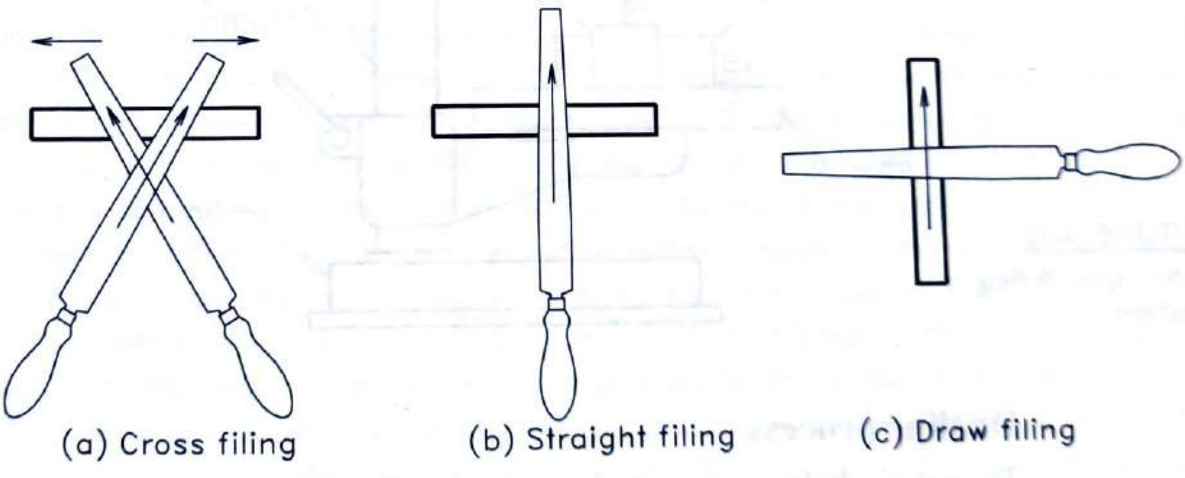


FIGURE 3.31 Types of filing processes.

3.6.5 Scraping

Scraping is a process of removing a very thin layer of metal by using the tool called *scraper* (Figure 3.12). After filing, a small irregularity of flat surface can be corrected by pressing and rubbing the cutting edge of the scraper. In order to identify the areas to be scraped, the smoothly finished surface is coated by a thin film of prussian blue or red lead oil. Then a perfectly flat surface is rubbed over it gently. This will identify the areas to the scraped. After scraping and removing a layer from theses areas, again the coating and scraping are repeated until the whole area is approximately rubbed off by the flat surface. During the scraping process, the tool is held in the right hand and the left hand is placed on the lower end of the scraper for controlling the pressure. Machine beds, surface plates, etc., are made perfectly flat by this hand process.

3.6.6 Drilling and Reaming

Drilling is the process of producing circular holes by pressing a rotating tool called *drill* against the workpiece. This is done with the help of a machine called *drilling machine*. For making holes up to 12 mm diameter, bench type drilling machines are used (Figure 3.32). Bench type drilling machine consists of a column fixed on the base. The spindle of drill head and the motor are connected by cone pulley and V-belt arrangement. The spindle is rotated when the motor is switched on and the downward movement of the rotating spindle is obtained by moving the handle in the anti-clock wise direction.

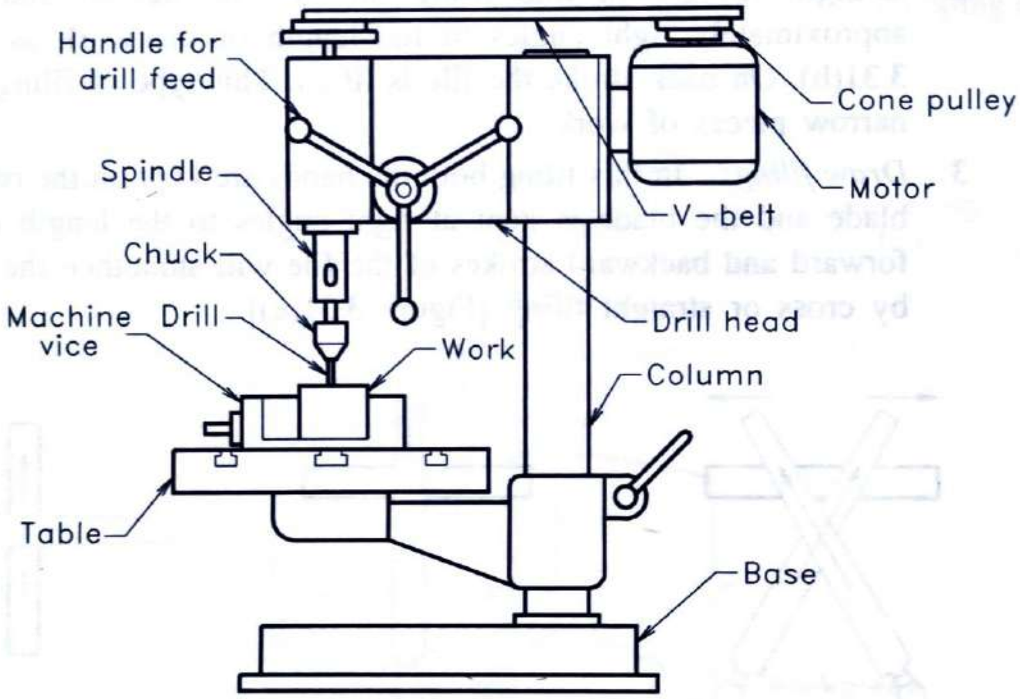


FIGURE 3.32
Bench type drilling machine.

Drilling process

To make a hole on a workpiece, the location of the centre of the hole is marked and a deep punch indentation is made using a centre punch. Then the twist drill of the required size is fixed on the drill chuck. The workpiece is clamped on the machine vice keeping the drilling surface horizontal and the drill bit is brought down to the exact drilling location by adjusting the drill table and rotating the handle for spindle movement. After completing the machine setting, the motor is switched on. The drill tip is brought slowly to the punch mark and gradually pressed to make the hole. As the nose of the drill bit enters the metal, check the accuracy of location. If correction is required, cut a groove with the round-nosed chisel towards that direction. This will help to bring the drill to the correct position. After starting the hole, the rotating drill is pressed gradually to complete the hole. While drilling hard metals, coolants like oil or soap water is applied at the cutting point to reduce the damage of the cutting edge due to friction and heat.

Reaming

To finish a drilled hole for more smoothness as well as dimensional accuracy, reaming is done. Reamers of required size are used for the purpose. The reaming process can be executed by hand or with the help of a drill press. The layer of metal removed may be about 0.1 mm for rough reaming and about 0.05 mm for finish reaming. The object is clamped on a vice and the end of reamer is inserted and rotated. As it is removing metal, it is fully inserted to the other end while in rotation, to get the final dimension and surface finish.

3.6.7 Tapping and Dieing

The process of cutting internal threads using a *tap*, is called *tapping*. A hole of the diameter equal to the core diameter of the screw thread is initially drilled. The work is clamped on the bench vice and the first tap end is inserted and rotated, applying slight downward pressure with the help of the tap wrench (Figure 3.14). This makes a rough thread form and moves forward making the thread of incomplete depth. Frequent forward and backward rotation of the tap is required for easy progress of the thread cutting. After completing the threading with the first tap, the second tap is inserted through the threaded hole to finish the thread size. If the hole is a blind one, the third finishing tap is to be used next in order to correct the thread at the bottom side of the hole. It is to be noted that, the application of the pressure and radial load on the wrench should be even and proportional to the thread size. Otherwise the tap may break very easily, because they are made of very hard and brittle steel.

Similar to tapping, dieing is the cutting of external thread on round rod using a tool called *die* (Figure 3.15). The rod called blank is made to the correct size of the thread diameter and the end is slightly tapered for easy entrance of the die. To start the thread cutting, the rod is clamped on the bench vice keeping the axis vertical and the die with the holder is kept over the rod keeping the holder horizontal.

Then the die is turned forward applying slight pressure from the top similar to the tapping process. When the cutting is started, the die should be turned backward and forward several times until threading is complete. Using an adjustable type split die, the depth of thread can be initially adjusted to a lower value and then to the full size.

3.6.8 Assembling

The process of assembling is joining of finished parts together to form the required component or subassembly of a machine or equipment. The parts produced may be in a batch production or mass production shop. The assembly process may be of any one of the types given below.

1. Assembly of interchangeable parts
2. Assembly by selection of matching parts
3. Assembly with the use of compensating elements
4. Assembly by individual fitting

Here, the last type of assembly (individual fitting) requires full use of the various fitting processes. The assembly process may involve slight modification of dimensions, cleaning of surfaces and burs of holes, threading, drilling of small holes, tightening of screwed fasteners, bending of split pins, etc. Various assembling tools like spanners, pliers, allen keys, etc., are used for tightening the screwed fasteners. After the assembly, the machine part is checked for its geometrical accuracy and working using various measuring tools. If any correction or modification is necessary, it is completed in the fitting shop using various fitting tools.