SECTION *Fitting*

SAFETY PRECAUTIONS

1. Do not use a file without a handle.
2. Do not use punches and hammer with mushroom head.
3. Do not use hammer with a loose head.
4. Keep your hands away from moving parts.
5. Ensure that the work piece is clamped in the vice firmly and securely.
6. Keep the hand tools and vice clean
7. Always use a brush to remove any chips.
8. Always roll up your sleeves (or) wear short sleeves.
9. Tuck in your shirts before starting any operation.
10. Remove wristwatches, rings, bracelets, bangles etc., since they can lead to injuries.
11. Wear always safety shoes.

DEFINITION

Fitting is working a part to make it fit its mating part in a joint. This mating part should be completely finished.

SCOPE OF FITTING JOBS

Today, mechanical engineering cannot do anything without fitting operation. Any machine, mechanism of instrument requires the fitter for its assembly and adjustment. Fitting practice covers a great range of jobs including assembling, repairing, tool making and instrument setting, etc. Despite the various specialties, all fitters must be proficient in such typical metal working operations such as laying out, clipping, straightening, bending, cutting, filing, drilling, contour sinking, counter boring, reaming, threading, riveting, fitting, lapping, soldering, tinning and adhesive bonding.

TOOLS USED IN FITTING SHOP AND HANDLING OF THE TOOLS

1. Marking and Measuring Tools 2. Holding Devices 3. Striking Tools,
4. Cutting Tools / Chipping Tools 5. Finishing Tools

MARKING AND MEASURING TOOLS

These tools are generally used for setting or marking out and checking the work at various stages. Common tools used for the marking purposes are

1. Steel rule 2. Caliper 3. Divider and Trammel 4. Punch 5. Try-square 6. Scriber
7. Protractor 8. Surface plate 9. Surface gauge 10. Vernier height gauge
11. Angle plate 12. Marking hammer

STEEL RULE

It is the tool used for taking linear measurements to the nearest 0.5mm. For layout work in engineering, the commonly used unit of measurement is millimeter, which is 1/1000 part of a meter. Steel rules are available in different length. Steel rules of 600, 300 and 150mm lengths are most commonly used.

These steel rules are made from spring steel (or) stainless steel strip.

CALIPER

Inside caliper

It is a two-legged instrument with its legs *bent outwards*. By adjusting the screw, the movement of legs is controlled. It is used to measure internal diameters, width of slots, keyways, channels and other inner measurements of pipes, holes, bores, grooves, measuring gaps etc.

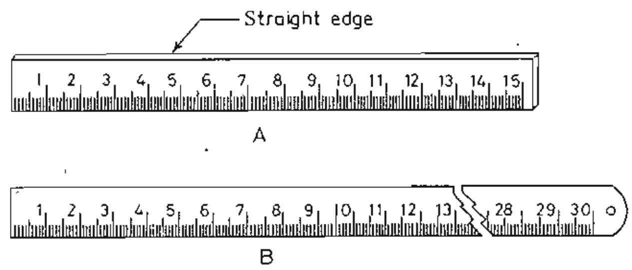
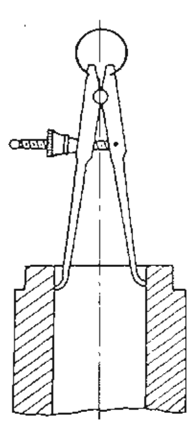
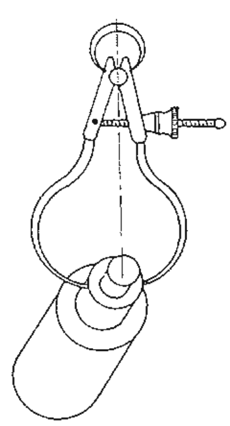


Fig 1.1. Steel rule A – Rigid: B – Flexible

Outside caliper

It is a two-legged instrument with its legs *bent inwards*. By adjusting the screw, the movement of legs is controlled. Outside calipers are used to measure outside dimensions of round bars, flats, grooves, and steps for measuring and comparing thickness. This is a very ideal tool for measuring diameter.





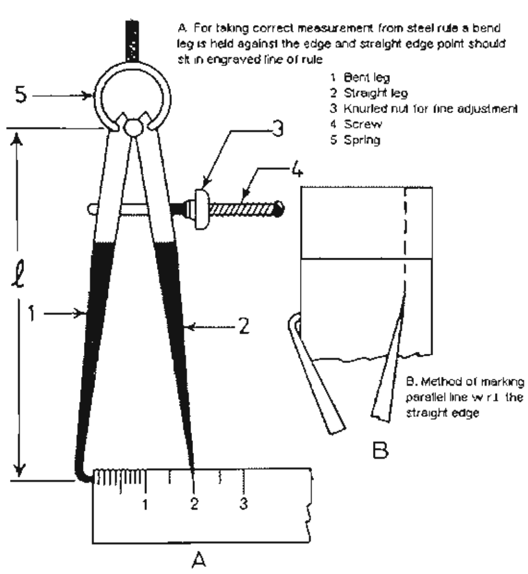
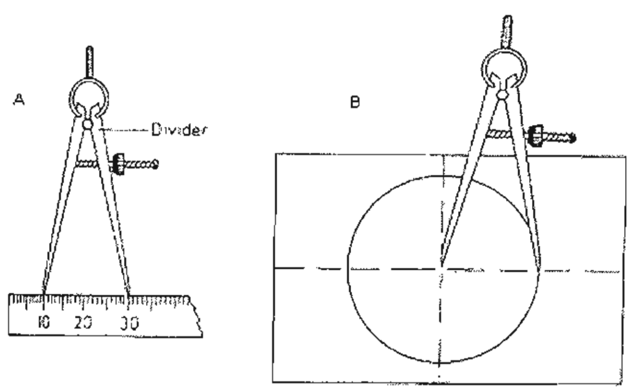


Fig 1.2 (a) Inside Caliper Fig 1.2 (b) Outside Caliper Fig 1.2 (c) Jenny Caliper

Jenny caliper

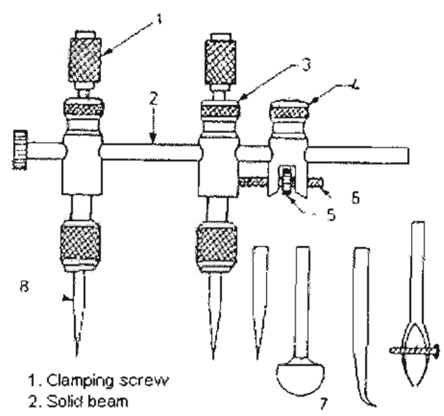
The Jenny caliper has *one leg bent inside and the other leg straight*. The caliper is used for marking parallel lines and for finding out the center of the round bars. For marking parallel lines, the bent leg is moved along the straight edge of the job and as the caliper is moved, the line parallel to the edge is drawn with the straight leg. This caliper is also named as ***Morphy caliper*** and ***Hermophrodite.***

All the above calipers are coupled with quick acting spring and knurled solid nut to set the dimensions by means of releasing the nut on a finely threaded adjusting screw. By adjusting the screw the movements of the legs are controlled. The size of the caliper is determined according to the length of the leg. This is made from hardened steel.



Method of using divider
A. While taking measurement from steel rule, keep the points on graduated lines; for correct setting.
B. Marking circle with a divider. A point should sit properly at the punch mark.

Fig 1.3 (a) Divider



1. Clamping screw
2. Solid beam
3. Sliding head
4. Carrier
5. Fine adjusting screw
6. Fine adjusting nut
7. Different types of legs

Fig 1.3 (b) Trammel

DIVIDERS

It is a very useful tool in layout work. They are used to mark out circles, arcs, perpendicular lines, bisecting lines and curvilinear lines and for plotting geometrical figures. They are also used to transfer dimensions from steel rule to work pieces. It is made from hardened steel, which keeps the points always sharp. It has two legs, which are firmly fixed by means of screw at the joints. Other type has a spring joint where legs are held by a spring. The length of leg determines the size. For longer sizes, the use of Trammel [fig.1.3(b)] is preferred as exact adjustments are difficult with dividers because of wide angle between the legs. Trammel is a tool used for laying large circles, arcs, radius, bisecting a line, marking a line etc., This tool is especially used for laying out material for boilers, tanks, bridges, towers etc. It consists of one solid beam and different types of legs, which can be slid and fixed at any place on the beam for doing a variety of markings.

SURFACE PLATES

Jobs are mounted on the surface plate for marking and measuring precision jobs, specially pre-machined jobs. The surface plate and marking plate have similar shapes. The difference lies in the accuracy of flat surface. The surface plates are more precision than marking plates. Also to maintain the accuracy of surface plates for long time, small surface plates are made of different materials such as hardened steel and granite stone, apart from very well seasoned cast iron. The cast iron plates are cheap because they are easily cast and machined.

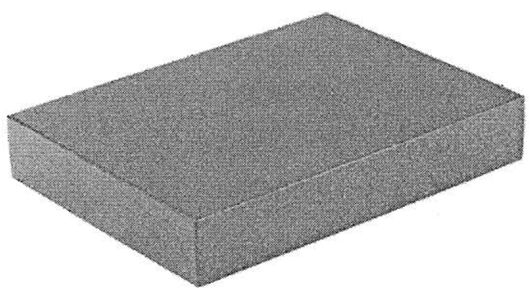


Fig 1.4 Surface Plate

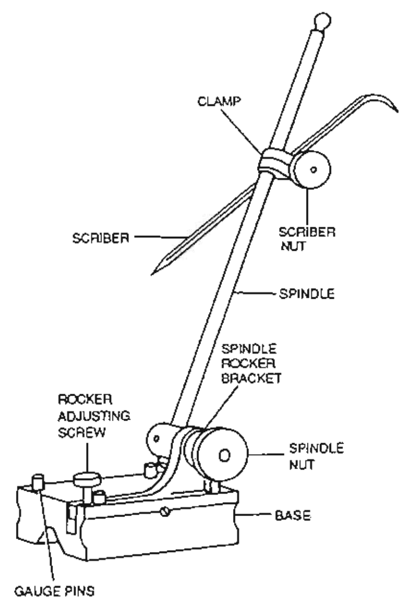


Fig 1.5 Surface gauge

SURFACE GAUGE

This is the main tool for three-dimensional layout. This is used along with the marking plate to scribe vertical, horizontal and parallel lines, to locate the centre of round bar, for setting of jobs on the tables for machining, checking of height and position of work pieces setup on surface plates

TRY SQUARE

It is a fine precision tool having true right angular edges. This tool is usually employed to check the flatness of a surface or squareness of adjacent edges. It is also often used for marking parallel lines, setting jobs etc. It consists of a Blade and Stock. The blade and stock may be, riveted together (or) detachable, or one solid integral part.

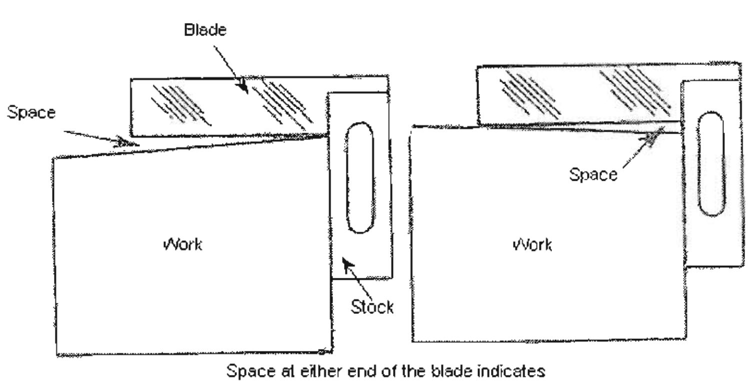


Fig 1.6 Try Square and its use

The Try squares are available in a wide range of sizes. Fig.1.6 shows the usage of Try square.

SCRIBER

Scribers look like pencil of 3 or 4 mm diameter and 200 mm long. These scribers are used for marking lines on work surfaces with reference to edge of any tool template, steel rules or squares. One end of the scriber is pointed to 15^0 and other end is bent. Scribers come in three main varieties such as single point, double point and removable point types.

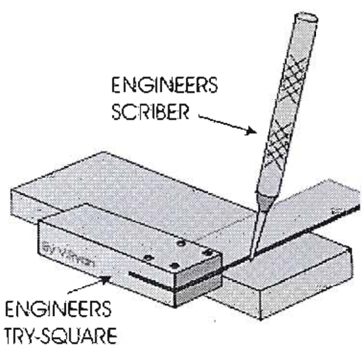


Fig 1.7 Scriber

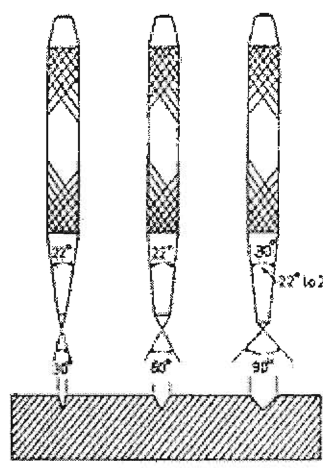
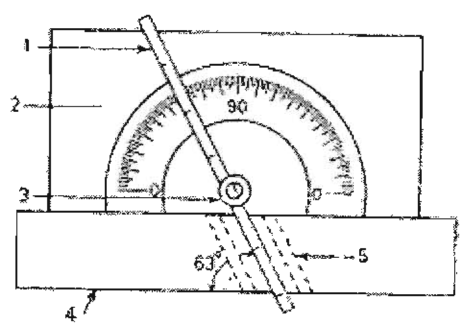


Fig 1.8 Punches



Protractor with rectangular head. It is set to layout an angle of 63 degree.
1. Graduated blade.
2. Rectangular head
3. Thumb nut. It locks the blade
4. Work
5. Line marked with protractor

Fig 1.9 Protractor

PUNCHES

These are sharply pointed tools used for marking indentations on the scribed lines in order to make them more clearly visible. Punches are made from tool steels (or) hardened steels. These punches are classified as Center punch and Dot punch. Both punches look the same except that they differ in their point angles. The dot punch point angle is generally between 30^o and 60^o but when ground to $30\,^o$, it is called as Prick punch. The dot punch is used to make small punch marks on layouts, lines to make them last longer. The centre punch is ground to 90^o to make the mouth of the punch mark wide enough to receive the drill point comfortably. Centre punch is used to widen the mark made by the dot punch.

PROTRACTOR

The Protractor shown in fig. 1.9 has a rectangular protractor head providing all four sides as working edges. The flat big surface on the back helps laying out the tool flat up on the paper or the work. The thumbnut locks the blade in the required position. The graduated blade is available to measure the depth of hole, groove and cavity.

VERNIER HEIGHT GAUGE

This gauge is designed to scribe vertical distances from plane surface like the ordinary height gauge. It is intended for accurate layout work. It consists of a base to which a graduated vertical beam is rigidly secured, a slide with Vernier and lock screw, a fine adjustment device, a scriber offset, and a scriber. The scriber is held with a holder on the jaw. The scriber can be sharpened several times and when worn out can be replaced.

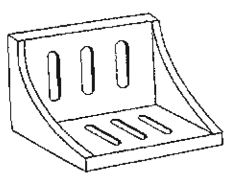


Fig 1.10. Angle Plate

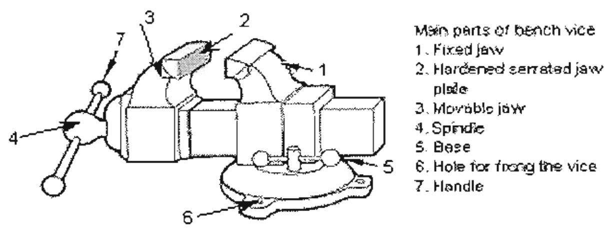


Fig 1.11. Bench Vice

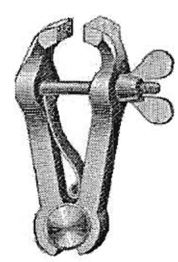


Fig 1.12 Hand Vice

HOLDING DEVICES

ANGLE PLATE

The angle plate has two plain surfaces at right angles to each other. The sides are machined at 90°. Holes, slots that enable to hold the work are made through the surfaces. It is made of cast iron. Angle plates are used to hold parts on either the vertical or horizontal surfaces.

VICES

These are the work-holding fixtures for clamping the work in the required position. Different types of vices are used in practice such as Leg vices, Parallel bench vices and Hand vices. Leg vices, which are simple and very strong, are used occasionally for crude and heavy jobs that involve chipping, riveting, bending, etc. Hand vice is used to grip small work pieces for drilling (or) filing when they are inconvenient/hazardous to hold by hand.

Hand operated plain parallel bench vices are most commonly used work-holding device for clamping work in the required position. This is mounted on a bench or on a machine bed. Bench vice is fixed to the bench with nut and bolt. The vice body consists of two main parts, fixed jaw and movable jaw, made of cast iron. The vice movement is caused by the movement of the screw through the nut fixed under movable jaw. This screw is provided with a collar inside to prevent it from coming out of the jaw, when rotated. Fig. 1.11 and 1.12 exhibits the details of a Bench vice and Hand vice.

STRIKING TOOLS

HAMMERS

Hammers are believed to be man's primitive tool. Hammers are made from structural and tool steels; the head is hardened and tempered. An eye is provided in the middle of the hammer for a handle. Hammers are available in many sizes and weighs from 100gm to 10kg and with many shapes of head.

Ball peen hammer

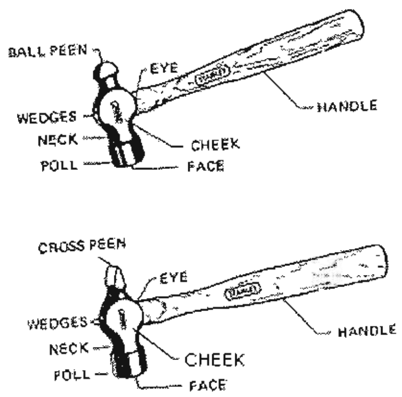
This is the most common type of hammer, which has a head with one end as ball shaped and the other end flat, This flat end is the striking face. It is used for all kinds of engineering work. The ball portion is used to straighten, soften and expand metal into the desired shape.

Cross peen hammer

These have blunt chisel shaped ends on the head opposite to the face. This is used for chipping, riveting and sheet metal shapes for bending, providing channels and collars, swaging etc.

Straight peen hammer

The Peen of this hammer is flat but straight to the handle. This is commonly used for bending channels, working on corners, etc.,



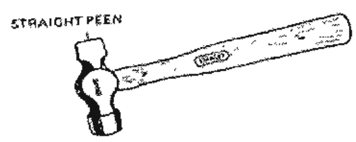


Fig 1.13. Ball and Cross peen hammers **Fig 1.14. Straight peen hammer**

CUTTING TOOLS/CHIPPING TOOLS

These tools are used for chipping, chiseling, sawing and scraping. Chisel is the simplest form of metal cutting tool in which the wedge shape is the most pronounced. Chisels used in the fitting shop for chipping and chiseling are called "**COLD CHIESELS**". They are made of cast steels (or) carbon tool steel and the cutting edge is hardened and tempered. They are classified according to their shape and cutting edge width.

Flat Chisel

The common form of chisel is flat or cold chisel. It is so called because it is used to cut cold metal. In this type, the cutting edge is convex to avoid the damage to the corners while in use. This radius reduces the possibility of the corners breaking off. The cutting edge is ground to an angle of approximately 60° and the edge width varies from 20 to 30mm. Only the cutting edge is hardened or tempered. The head of the chisel is left soft so that hammer faces are not damaged.

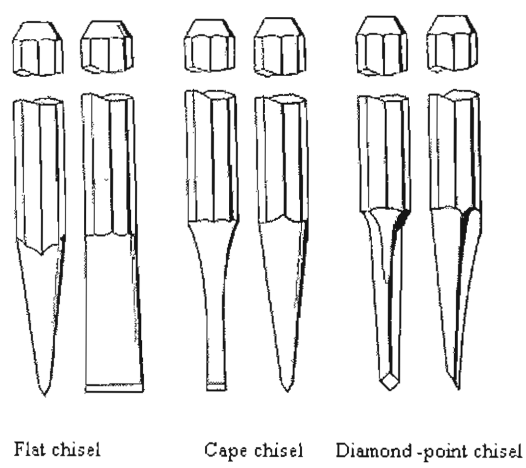


Fig 1.15. Types of Chisels

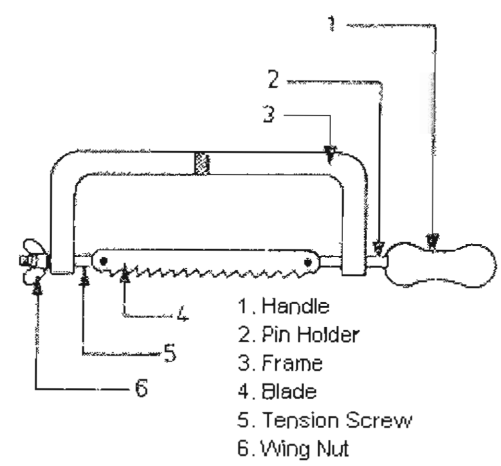


Fig 1.16. Hacksaw Frame with blade

Half-Round Chisel

A half round chisel is particularly useful for cutting oil ways, grooves in bearings, bosses and pulleys, forming flutes, bringing drill holes in the correct position when set out inaccurately. They are also used for setting over pilot holes. The shank is reduced to a half round taper, which is beveled at the end to give a circular edge

Diamond-Point Chisel

This type of chisel has cutting edge like a Diamond-point. It is used for cutting Vee-grooves, marking sharp corners, cleaning corners and squaring small holes. The chisel is drawn to a square section.

HACK SAW

Hack sawing is a process of removing small chips of materials by series of small teeth. The hacksaw is a tool designed for cutting thick metal sheets, round bar of bar stock of round and other sections and also to cut slots, contours etc. This is also used to draw vertical, horizontal and parallel lines.

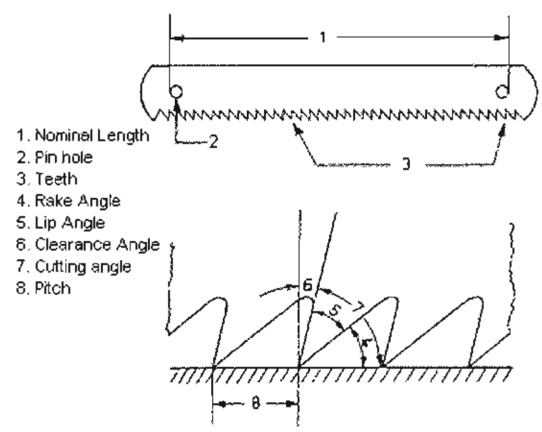


Fig 1.17. Typical View of the blade

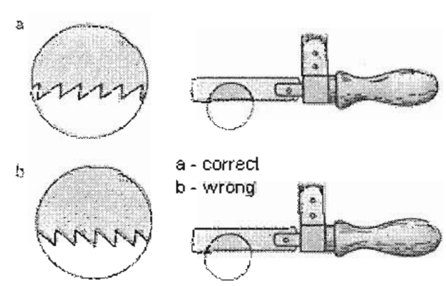


Fig 1.18. Mounting a hacksaw blade

A hand hacksaw has a frame and blade. At one end of the frame there is a fixed holder with handle and pin holders and at the other end, an adjustable holder with a blade tightening screw and wing nut. Both the holders have slits to accommodate the cutting blade secured in the pins. Hacksaw frames are made either fixed for a blade of a given length or adjustable, which allow blades of different length to be used.

Hack saw blades are commonly available with the following grades. **Coarse:** 14 teeth per 25mm (14TPI) for thick and soft metal

Medium: 22 teeth per 25 mm (22 TPI) for medium work: **Fine:** 32 teeth per 25 mm (32 TPI) for hard metal. The details of blade are given in the figure 1.17.

The blade is so placed into the holders that the teeth point away from the handle and not the other way round. One end of the blade is first inserted into the fixed holder and locked with a pin, and then the other end is inserted into the opposite holder and likewise fixed there. The correct and incorrect way of mounting the blade on the frame is shown in figure1.18.

FINISHING TOOLS

Files

Filing is a cutting operation on metals or other materials, which involves the removal of stock in small quantities by hand or by machines using a file. The file is a basic tool for giving the work the necessary shape and size, for fitting it to another part, for preparing its edges for welding, and for a variety of other manufacturing applications.

Files are used for working flat and curved surfaces, slots, grooves, holes of various shapes, angular surfaces, etc. Filing allowances are usually small, from 0.025 mm to 0.5 mm. Accuracies that can be achieved by filing range from 0.2 to 0.05 mm, and , in special cases, even to 0.001 mm.

Parts of a file

File is essentially a steel rod of a certain shape and length which has wedge-like teeth cut on its surfaces. Files are made from tool steels (or sometimes from chromium steels) and heat treated after teeth cutting.

A file consists of the following parts:

FACE: The surface of the file where teeth are cut is called the face. A file may have one or more than one face. A flat file has two faces.

EDGE: The side of the face is called the edge. If teeth are not cut on it, it is called a safe edge file, e.g. a hand or mill file. The edge is kept safe so that it does not cut the side of the job while filing. However, the teeth on the teething edge are always single-cut.

BELLY: Some files have one-third of their length tapered in width, and thickness. The tapered portion is called the belly.

TIP : The opposite side of the tang is called the tip which is near the belly. The stroke is always taken towards the tip in machinist files. It is also known as **POINT.**

HEEL: The uncut portion on the face near the shoulders is called the heel. Generally the grade and the manufacturer's name are stamped at this place.

SHOULDER: The tapered portion at the end of the edge and near the tang is called the shoulder.

TANG: The extreme narrow part opposite the point is named the tang. This portion is kept safe because it is thinner and the handle is fitted over here.

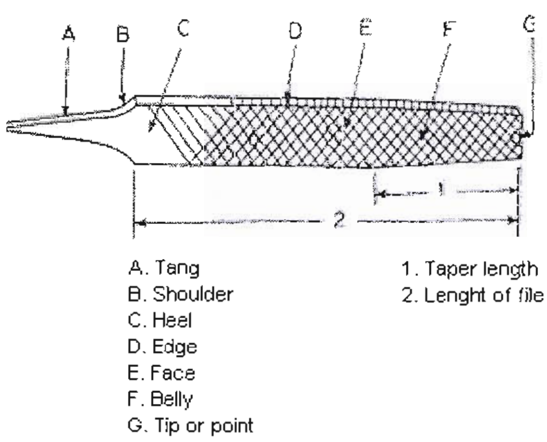


Fig 1.22. Parts of file

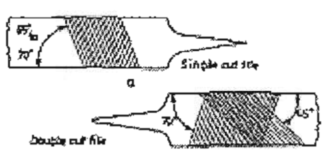
Fig. 1.19 Parts of File

Classification Of Files

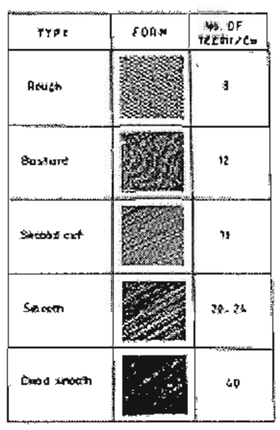
Files are manufactured in a variety of types and shapes, each for a specific purpose. They may be divided into Two classes namely Single cut and Double cut as shown in fig. 1.20(a).

Single cut files have single row of parallel teeth running diagonally across the face. They include *mill, long-angle lathe* and *saw files*. Single cut files are used when smooth finish is desired (or) when hard materials are to be finished. These files are used for metals like brass, Babbitt, lead, aluminium, bronze and copper with low resistance to cutting and also for non-metals. These types of files are also employed for sharpening saws, knives and for working in wood and cork.

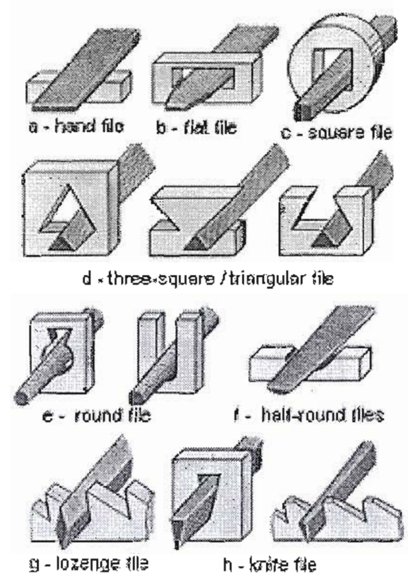
Double cut files have two intersecting rows of teeth. The first row is usually coarser and is called as the *overcut*. The other row is called as the *upcut*. These intersecting rows produces hundreds of cutting teeth which provide fast removal of metal and easy cleaning of chips. Both single and double cut files manufactured in various degrees of coarseness such as *rough, bastard, second cut, smooth* and *dead smooth* as shown in figure 1.20(b). The files most commonly used by the machinists are bastard, second cut and smooth files. By application files are classified into the following groups: general-purpose files, special-purpose files, needle files, and rasp files. Based on the cross section the general purpose files are further classified as *hand, flat, square, triangular, round, half round, lozenge* and *knife edge* as shown in figure 1.20(c).



1.20(a) Single and Double cut Files



1.20(b) Classification on the Basis of Coarseness



1.20(c) Classification on the Basis of Cross Section

A- hand and B – flat files are used for filing flat outside and inside surfaces, grooves and slots.
C - Square files are used for filing out square, rectangular, and polygonal holes, for filing narrow lands.

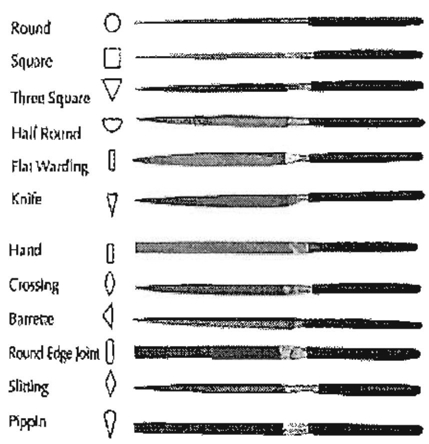
D – Triangular files are used for filing corners to angles of 60^0 and over in grooves, slots, holes, and for sharpening wood saws.

E – Round files used for filing out round, elliptical and curved openings, and concave surfaces with small radius.

F – Half round files used for concave surfaces with considerable radii and large holes (filing with the convex face) and for flats, convex surfaces and corners with angles of 30^0 and over (filing with the flat face);

G – lozenge files used for filing teeth in discs, gears, and sprockets, for deburring machined teeth in such parts, for filing slots and corners to angles of 15^0 and over;

H – knife files used for filing corners, grooves, narrow slots, and flat sides in triangular, square, and rectangular openings in various machine parts, and also in cutting tools, dies. Files of all these types excluding round ones are produced with chisel – cut and milled teeth.



1.21 Needle Files

1.22(a) Diamond Files

1.22(b) Rasp Files

Other grades are used for special jobs only. Special files are intended for specific applications, e.g. for filing non-ferrous alloys and non-metals, and for hardness testing.

Hardness – testing files are used where hardness cannot be checked by standard methods, i.e. at such hard-to-reach places as gear-tooth flanks, milling cutter blades, etc., or for checking hardness on the shop floor at heat-treatment installations. Such files are 'Calibrated' for specific hardness depending on the hardness of the work.

Needle files are small files as shown in figure 1.21 and used in tool and jewelry making, engraving, and finishing in various places, which are difficult to get at (holes, corners, lands, etc.)

Diamond files are employed in tool making for working and finishing cemented – carbide components of cutting tools and dies. A diamond file is basically a metal rod of the specified section whose face is covered with a thin diamond layer. The diamond-powder grain size varies according to application. [Fig.1.22]

Rasp files are employed for filing soft metals (lead, tin, copper, etc) and non-metals (leather, rubber, wood, plastics), when standard files rapidly clog and stop cutting. [Fig.1.22]

Methods of filing

There are four methods of filing a surface using a hand file.

Cross filing

This method is preferred for maximum removal of metal in minimum time. The strokes of file are run alternatively from right to left and then left to right. The idea of changing the direction from time to time is to keep the area of contact as large as possible during filing for maximum metal removal. The possibility of the surface becoming curved is quite small due to continuous changing of directions.

Straight filing

In this method, the file is pushed forward at right angles to the length of work and lifted clear off the work during the backward stroke. It is best suited for long and narrow jobs having lesser width

Diagonal Filing

To obtain a true and smooth surface the direction of file movement must be varied which is possible by diagonal filing. In this, first the file direction is from left to right at 30^0 to the vice axis and vice versa. Such sequence provides the required flatness and surface finish.

Draw filing

It is a simple method of filing to produce good finish on the edge of long and narrow work pieces. The file is held in both the hands across its body as close as possible. The file is placed at right angles to the work and pushed backward and forward, along the edge being filed. A fine cut file with a flat face should be used for draw filing.

DRILLING

Drilling is a process of making holes in a solid material using ***DRILL***. The machines intended for drilling is termed as ***Drilling machine***. Drilling is applied for holes of low grade accuracy and surface finish.

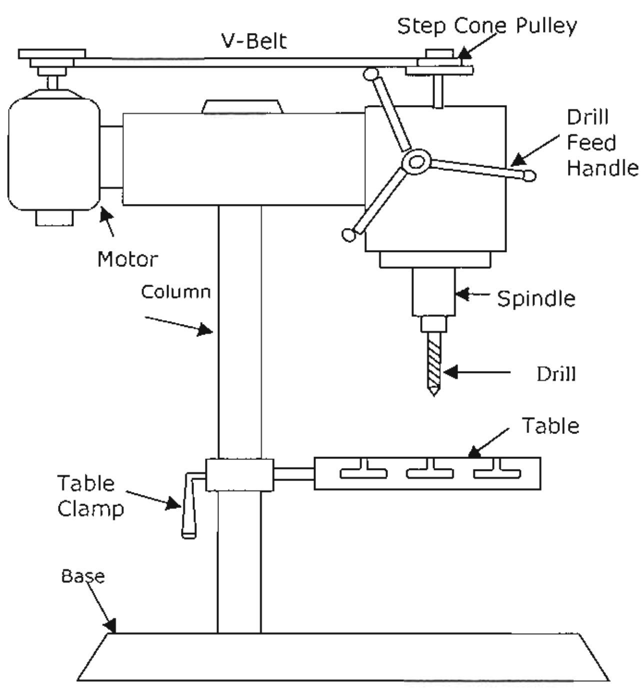


Fig.1.23 Sensitive Drilling Machine

Holes are drilled for fastening parts with rivets, bolts or for producing internal threads. Sensitive drilling machine is the most versatile machine used in a fitting shop for this purpose. Twist drills are made of tool steel or high-speed steel are used with the drilling machine for drilling holes. Following are the stages in drilling work.

1. Select the correct size drill, put it into the chuck and lock it firmly
2. Adjust the speed of the machine to suit the work by changing the belt on the pulleys. Use high speed for small drills and soft materials and low speed for large diameter drills and hard materials.
3. Layout the location of the hold and mark it with a centre punch.
4. Hold the work firmly in the vice on the machine table and clamp it directly onto the machine table.
5. Put-on the power, locate the punch mark and apply slight pressure with the feed handle.
6. Once drilling is commenced at the correct location, apply enough pressure and continue drilling. When drilling steel, apply cutting oil at the drilling point.

7. Release the pressure slightly, when the drill point pierces the lower surface of the metal. This prevents the drill catching and damaging the work or drill.
8. On completion of the drilling, retrace the drill out of the work and put-off the power supply.

Twist drill

The tool used for drilling is termed as drill. Twist drill is most commonly used tool for making holes. It is typically a two flute-cutting tool having two main parts namely the Body and the Shank. are used for making holes. These are made of high-speed steel. Both straight and taper shank twist drills are used.

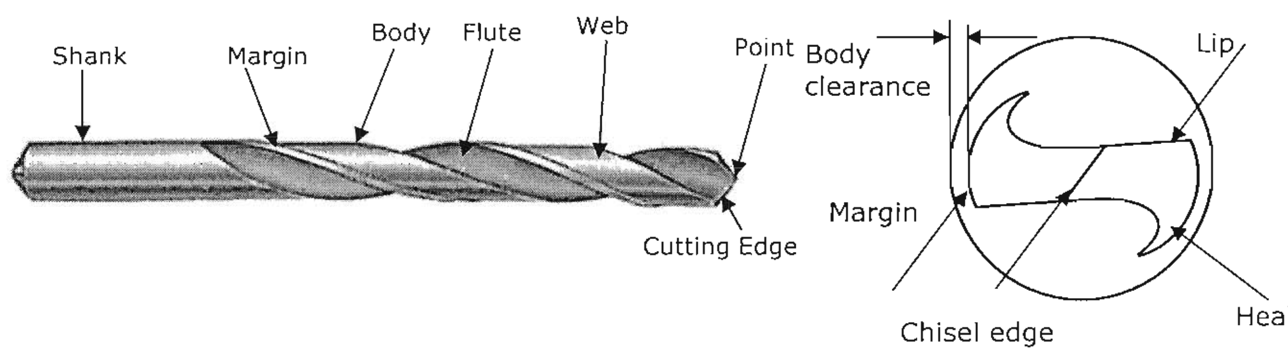


Fig.1.24 Nomenclature of twist drill

Designation of twist drills

Millimeters from 0.4mm onwards; Inches from 1/64" onwards; Letters drills A to Z Number drills 60 to 20: Taper shank drills 3 to 100mm

THREAD CUTTING TOOLS

Screw threads are produced by thread cutting, drilling, turning and by rolling. Threads may also be cut manually using ***Taps and Dies.***

TAPS AND TAP WRENCHES

A tap is a hardened steel tool, used for cutting internal threads in a drilled hold. Hand taps are usually supplied in sets of three for each diameter and thread size. Each set consists of a taper tap, intermediate tap and plug or bottoming tap.[figure1.25] In hand tapping, taps are driven with the aid of wrenches set on the blank square. The details of a bar type tap wrench is illustrated in figure1.26.

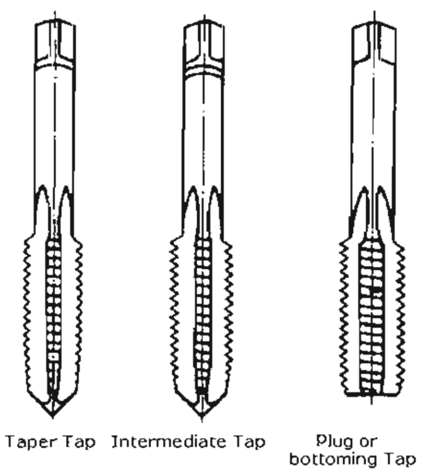


Fig.1.25 Set of tap

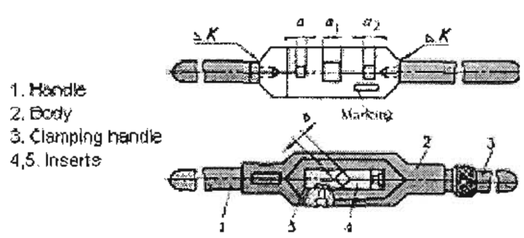


Fig. 1.26 Bar type tap wrenches

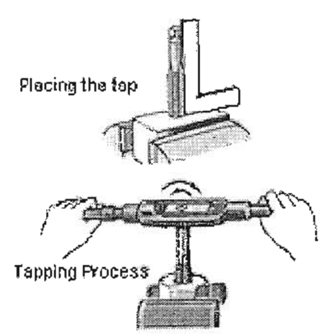


Fig. 1.27 Method of Tapping

The following are the stages involved in tapping operation.

1. Select the correct size tap, with the desired pitch.
2. Select the correct size tap drill, usually indicated on the tap.
3. Drill the hole.
4. Secure the tap in the tap wrench.
5. Insert the first or taper tap in the hole and start turning clockwise, by applying downward pressure.
6. Check the alignment of the tap with a try square and correct it if necessary, by applying sidewise pressure, while turning the tap.
7. Apply lubricant while taping in steel.
8. Turn the tap forward about half a turn and then back until chips break loose. Repeat the process until threading is completed with intermediate and bottoming taps.
9. Remove the tap carefully. If it gets stuck, work it back and forth gently to loosen.
   A bar type tapping is illustrated in figure1.27.

Note:

1. It is a good practice to drill a small countersink, about the depth of a one thread to ensure that a burr is not thrown up when tapping the hole.
2. While tapping in blind hole, remove the tap and clear the chips often so that the tap can reach the bottom of the hole.

CUTTING EXTERNAL THREADS

External threads are cut with round threading dies. These dies are of two types namely solid and split types as described in figure 1.29.

DIES AND DIE-HOLDERS

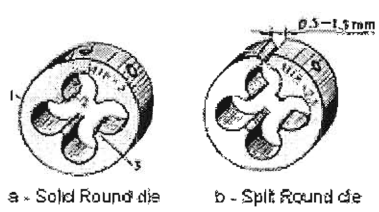


Fig. 1.28 Round threading dies

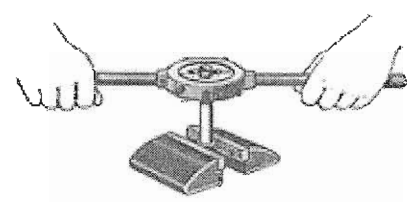


Fig. 1.29 Thread cutting with round threading die

Dies are the cutting tools used for making external threads. Dies are made either solid or split type. They are fixed in a die-holder for holding and adjusting the die gap. They are made of tool steel or high carbon steel. Cutting with a threading dies is illustrated in figure 1.30.

The following are the stages in producing external threads:

1. Prepare the work with a chamfer at its end.
2. Select the correct size die.
3. Position the die in the die-holder. Tighten the set-screws so that the dies is held firmly in its place. Incase of adjustable die, set the die to cut oversize threads first.
4. Fasten the work firmly in a vice.
5. Place the die over the chamfered end of the work and start cutting threads by turning it clockwise while applying downward pressure. Apply cutting fluid while threading in steel.
6. Turn back the die for the chips to break loose. Continue until threading is completed. Check the threaded work to see if it fits the tapped hold or nut. If the fit is too tight, adjust the die for a slight deeper cut and complete the threading again.