Workshop Practice

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WORKSHOP PRACTICE

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Lesson-1

Introduction to workshop practice, safety, care and precaution in workshop

1.0. Introduction

Workshop practice is a very vast one and it is very difficult for anyone to claim a mastery over it. It provides the basic working knowledge of the production and properties of different materials used in the industry. It also explains the use of different tools, equipments, machinery and techniques of manufacturing, which ultimately facilitate shaping of these materials into various usable forms. In general, various mechanical workshops know by long training how to use workshop tools, machine tools and equipment. Trained and competent persons should be admitted to this type of mechanical works and permitted to operate equipment.

Ores (raw material for industry)

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To suitable reducing or refining processes convert the metal into molten form

↓

This molten metal poured into mould to give commercial castings called ingots.

↓

From suitable process- to obtain usable metal products of different shapes and sizes

Processes:

1. Primary shaping processes

2. Machining processes

3. Joining processes

4. Surface finishing processes

5. Processes effecting change in properties.

1.1.1. Primary shaping processes

Some of these finish the product to its usable form whereas others do not and it requires further working to finish the component to the desired shape and size.

Wire drawing lead to the directly usable articles, which do not need further processing before use.

Casting,forging, bending, rolling, drawing, power metal forging, etc

1.1.2.Machining processes

Large number of components need further processing after primary processes known as secondary operation to obtain desired shape and dimensional accuracy. These operations require the use of one or more machine tools, various types of cutting tools and cutters, job holding devices, marking and measuring instruments, testing devices and gauges etc.

Common machining operations are:

Turning,Threading. Drilling, Boring, Planning, Shaping, Sawing, Milling, Grinding,Slotting, etc.

1.1.3. Joining processes

These processes are used for joining metal parts and in general fabrication work. Such requirement usually occur when larger lengths of standard sections are required or several pieces are to be joined together to fabricate a desired structure.

Common processes are Welding, Soldering, Brazing, Riveting, Screwing, Pressing, etc.

1.1.4.Surface Finishing Processes

These processes should not be misunderstood as metal removing processes in any case as they are primarily intended to provide a good surface finish or a decorative and/or protective coating on to the metal surface, although a very negligible amount of metal removal or addition may take place. Thus, any appreciable variation in dimensions will not be effected by these processes. The common processes employed for obtaining desired surface finish are the following:

1. Buffing 2. Polishing

3. Lapping 4. Belt grinding

5. Metal spraying 6. Painting

1.1.5. Processes Effecting Change in Properties

These processes are employed to impart certain specific properties to the metal parts so as to make them suitable for particular operations. Most physical properties like hardening, softening and grain refinement etc., call for particular heat treatment. Heat treatments not only effect the physical properties, but in most cases also make a marked change in the internal structure of the metal. So is the case with cold and hot working of metals.

1. Heat treatment 2. Cold working

3. Hot working

Workshop safety

The safety in Workshops has been written not only to provide appropriate safety procedures but also to assist trained workshop personnel with the provision of a reference document outlining the general principles of safe working practices relevant to the mechanical engineering aspects. It relates to specific are as where definite safety measures are required for workshop operations

Factories Act and Accident

Various acts relating to accidents are spelt out in workmen's compensation Act-1923, The factories act-1948 and Fatal Accidents Act-1855. These acts describe the regulations for fencing and guarding the dangerous machinery, items and employer's liabilities.

1.1.6. Concept of Accident

It is very difficult to give a definition of the word'Accident'. However, a generally accepted conception that an accident is a mishap, a disaster that results in some sort of injury, to men, machines or tools and equipments and in general loss to the organization.

The said injury or loss may be of minor or major nature and the accident is termed as non-reportable or reportable. For example, a small cut on the body will be reportable accident in a training workshop. It can be treated by first aid and does not involve any appreciable loss of time, and will not be considered a reportable accident in a production unit.

1.1.7. Causes of Accidents

The 98% accidents could be easily avoided provided due precautions are taken well in time. A very familiar slogan goes on to say that accidents do not just happen but are caused due to the failure of one element or the other, and the most unfortunate factor is that the human element is the most pronounced of all which fail.

The common causes which lead to accidents are the following:

1. Unsafe working position.

2. Improper or defective tools or their improper use.

3. Improper acts- which result in violation of safety rules and non-observance of safety precautions.

1.1.8. Common Sources of Accidents

The large number of machines in use and an even larger number of parts. This can be regarded as sources of danger and require guarding for protection against accidents.

Some common sources of accident are listed below :

Projecting nips between sets of revolving parts, viz., gears, rolls and friction wheels, etc.

1. Projecting fasteners on revolving parts.

2. Revolving cutting tools, circular saw blades.

3. Revolving drums, crushers, spiked cylinder and armed mixers, etc.

4. Revolving shafts, spindles, bars and tools like drills,reamers, boring bars and chucks, etc.

5. Projecting sharp edges or nips of belt and chain drives viz., belt, pulleys, chains, sprockets and belt fasteners.

6. Reciprocating tools and dies of power presses, drop hammers, and revolving presses, etc.

7. Grinding wheels and stones.

8. Reciprocating knives and saw blades such as cutting and trimming machines and power hack-saws, etc.

9. Revolving drums and cylinders without casing, such as concrete and other mixers.

10. Intermittent feed mechanisms.

11. Projecting nips between various links and mechanisms, like cranks connecting rods, piston rods, rotating wheels and discs, etc.

1.2. Common Methods of Protection

The common methods of protection against accidents are the following:

1. Safety by position.

2. Safety by construction.

3. Safety by using interlock guards.

4. Safety by using fixed guards.

5. Safety by using automatic guards.

6. Safety by using distance guards.

1.2.1. Safety by construction

When a new machine is designed, it should be ensured that all its dangerous parts are either enclosed in suitable housings or provided with suitable safety guards. For example, the belt drive and motor in a lathe or milling machine are enclosed, the back gears in a lathe are either enclosed or provided with cast iron guards or covers. Lubricating points are provided on the outer surfaces so that the interior parts are not required to be opened every time.

1.2.2. Safety by Position

The machine design is in such a way that the dangerous parts are located such that they are always beyond the reach of the operator. The dangerous parts of all the machines should invariably be guarded and undertaking should be made to make them enclosed in the body or housing of the machines.

1.2.3. Safety by using interlock guards

It is a very efficient and sound method of guarding in that the guard cannot be removed and dangerous parts exposed until and unless the machine is totally stopped. Similarly, the machine cannot be started to work unless the guard returns in position and protects the dangerous parts.

An interlocking guard may be mechanical,electrical or some sort of a combination of these. It is essential that it should:

1. Prevent the starting and operation of the machine in case the interlocking device fails.

2. Always acquire its position to guard the dangerous part before the machine can be started.

3. Remain closed in position until the dangerous part is completely at rest.

1.2.4. Safety by using fixed guards

These guards either for man integral part of the machine or are tightly secured to them. They should be made to have rigid construction and should be so placed that any access to the dangerous parts of the machine is totally prevented in the running condition of the machines.

Steel sheets can be advantageously used and they facilitate an easy fabrication of guards and are lighter in weight.

In some cases the fixed guards are made adjustable in order to accommodate different kinds of works or sets of tools. In some cases the fixed guards are provided at a distance from the danger point.

1.2.5. Safety by using distance guards

The principle of a distance guards is that a fencing, enough high, is made of bars,at a suitable distance from the machine such that even if the operative, by chance, extends his hands over it, his fingers, clothes or any part of the body does not reach within the area of dangerous parts. An additional measure of safety, some sort of tripping device is also usually incorporated to stop the machine quickly in case of an accident.

1.2.6. Safety by using automatic guards

The principle of an automatic guard is that its operation is actuated by some moving part of the machine.

It may linked that the part will automatically bring the guard in protecting position before the operation of the machine starts. The design of the guard is such that it automatically forces the operative away from the dangerous area of work before the operation starts and does not permit his access to the area again until and unless the machine stops. It may be noted that due to enough time being required for their operation, this type of guards are not suitable for quick-acting and fast-running machines. Their use is largely favoured for heavy and slow acting machines like heavy power presses.

Lesson-2

The Bench Work Tools and its Uses

Introduction

Bench work has its own essential position in all engineering works. In the mechanized workshops, where most of the work is carried out on an automatic machine, while bench work has its own importance. The jobs can be finished to a fairly good degree of accuracy through machining operation; they often require the hand operations to be done on them to finish to the desired accuracy. A fitter’s work is unavoidable when different parts are to be assembled in position after they have been finished. Alignment of machine parts, bearings, engine slide valves and similar other works call for a fitter’s work. Reconditioning and refitting of machines and machine parts cannot be done without a skilled fitter. All the above types of works require the use of a large number of hand tools and a fitter must have good working knowledge of all these tools and instruments.

2.1. Filter’s vices

Vices are the most suitable and widely used tools for gripping different jobs in position during various operations carried out in a fitting shop.

There are a fairly good number of different types of vices such as parallel jaw vice, machine vice, hand vice and pipe vice.

From these, the parallel jaw vice is the most commonly used in general fitting work. These vices are available in different trade sizes and the selection of a suitable size will depend upon the maximum size of the work. The width of the jaws determines the size of the vice.

In fixing it on the fitter’s bench it is held with the help of bolts passing through the planks of the bench. The bolts are tightened by means of nuts and the vice is held firmly on the bench. The jaws of the vice are usually kept overhanging the edge of the bench.

Bench vice

It is the most commonly used vice sometimes also known as parallel jaw vice. It essentially consists of a cast steel body, a movable jaw, a fixed jaw, both made of cast steel, a handle, a square threaded screw and a nut all made of mild steel. A separate cast steel plates known as jaw plates with teeth are fixed to the jaws by means of set screws and they can be replaced when worn. The movement of the vice is caused by the screw which passes through the nut fixed under the movable jaw. The screw is provided with a collar inside to prevent it from coming out and handle at the outer end. The width of the jaws suitable for common work varies from 80 to 140 mm and the maximum opening being 95 to 180 mm.

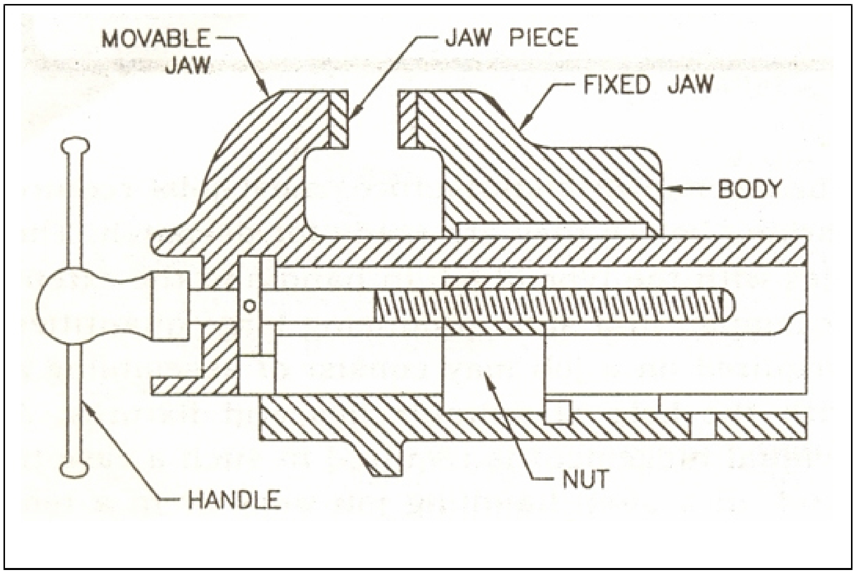


Fig.2.1 Bench vice

2.2. Surface Plate

Its specific use is in testing the trueness of a finished surface, testing a try square, providing adequate bearing surface for V-block and angle plates, etc., in scribing work.

It is a cast iron plate having a square or rectangular top perfectly planed true and square with adjacent machined faces. The top is finished true by means of grinding and scrapping. This plate carries a cast iron base under it and the bottom surface of the base is also machined true to keep the top surface of the plate in a perfect horizontal plane.

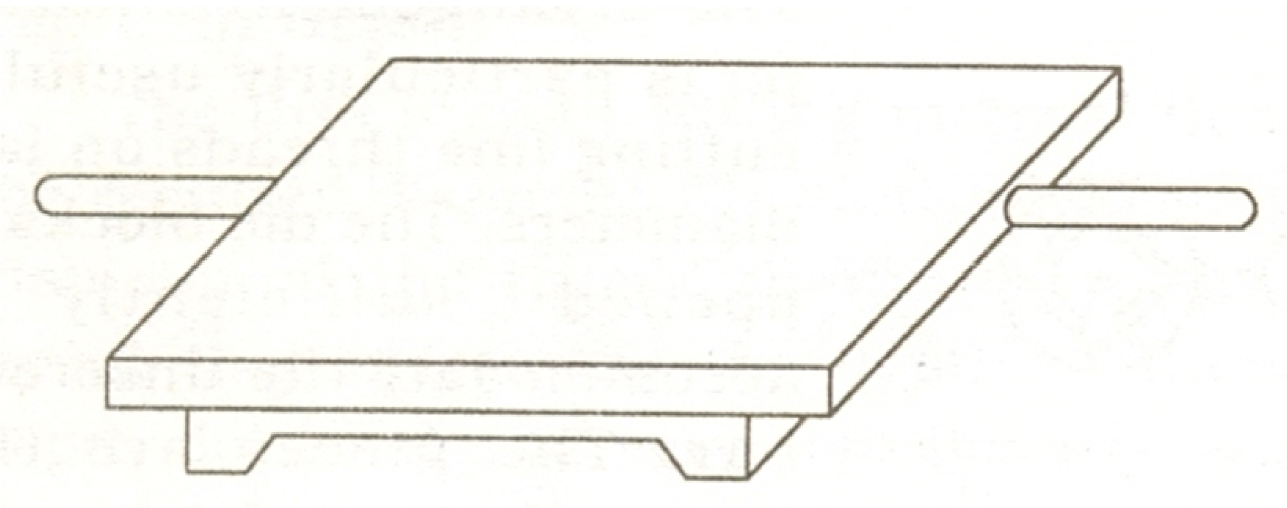
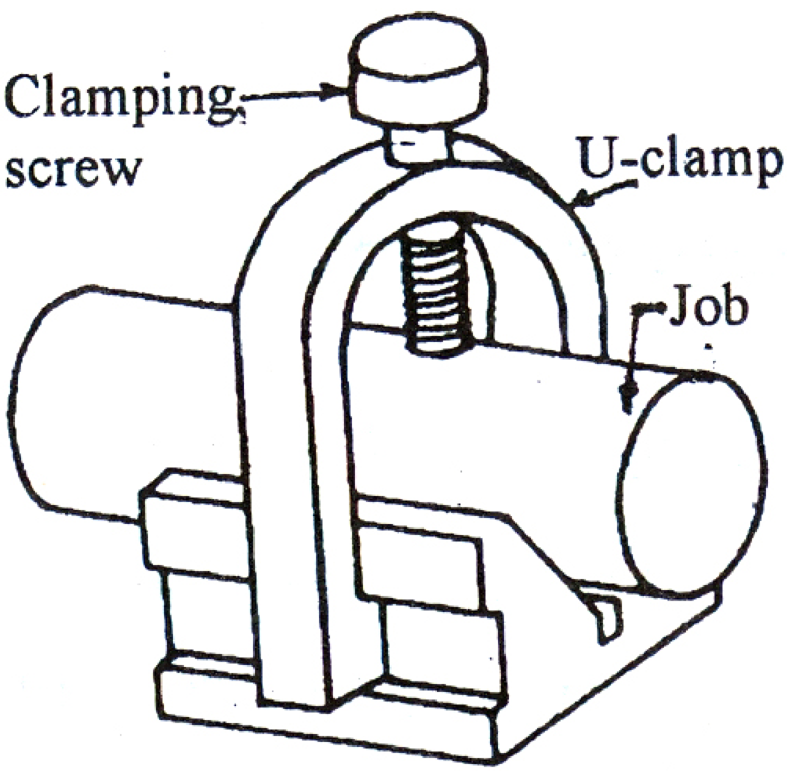


Fig.2.2 Surface plate

2.3. 'V' –Block

A 'V" block serves as a very useful support to the work in marking. It usually works in conjunction with a U-clamp.

Round bar is placed longitudinally in the block and the screw in the clamp tightened. Its specific use is in holding the round bars during marking and center drilling their end faces, which are to be held between centers on the lathe. Also it is very suitable for holding round bars in drilling operations when the axis of the drill is to be kept normal to the axis of the bar.



V - Block

2.4. Simple Scribing block

It is principal marking tool in a fitting shop and is made in various forms and sizes. It consists of a cast iron sliding base fitted with a vertical steel rod. The marker is fitted into an adjustable device carrying a knurled nut at one end. By means of the nut the marker can be loosened or tightened to set it at any desired inclination, moved to and fro inside the hole accommodating it or adjust its height along the vertical pillar. Normally it is used in conjunction with either a surface plate or marking table. Its specific use is in locating centers of round rods held in V-block, describing straight lines on work held firmly in its position by means of a suitable device like angle plate and also in drawing a number of lines parallel to a true surface.

2.5. Universal Surface Gauge

It consists of a cast base, perfectly planed at the top, bottom and all sides. Two guide pins are provided at the rear end of the base which can be pressed down to project below the base. These pins can be used against the edge of the surface plate or any other finished surface for guiding the instrument during scribing.

A swivel bolt is provided at the top of the base in which the spindle is fitted. This spindle can be swung and locked in any desired position by means of the adjusting screw. The scriber is fitted in an adjustable screw on the spindle and is capable of being adjusted at any inclination and height along the spindle. A rocker is provided at the top of the base and it carries an adjusting screw at its rear end.

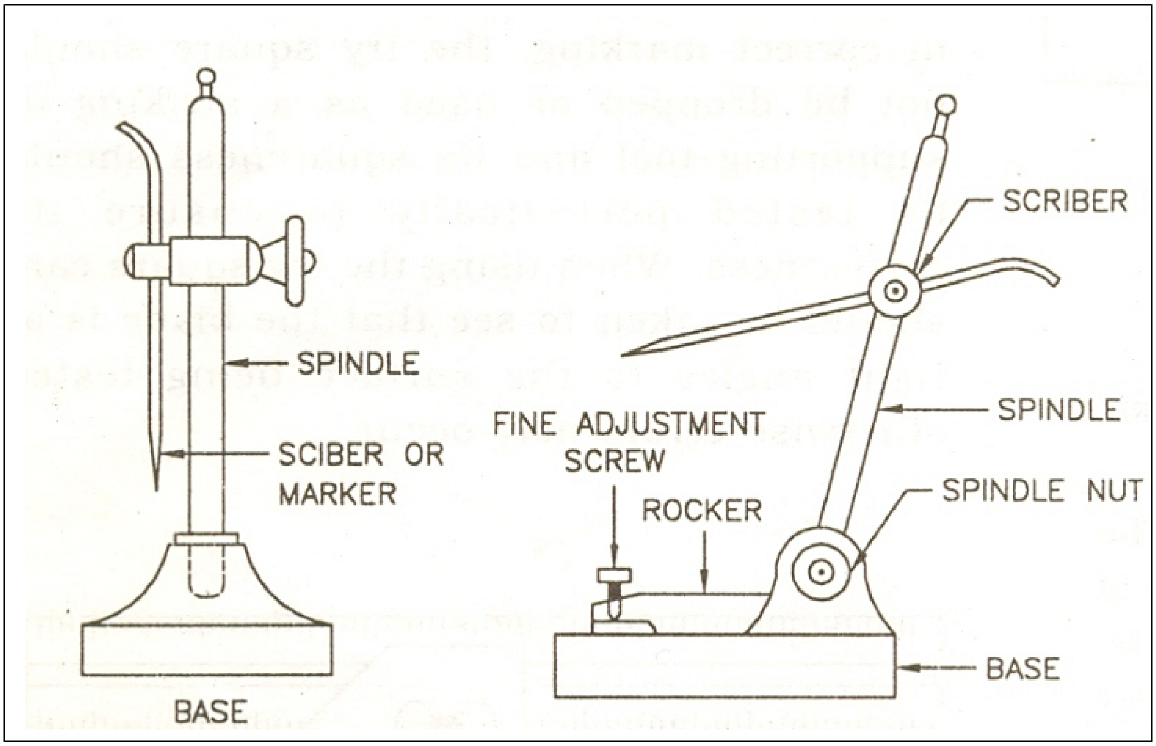


Fig.2.4 Simple scribing block and Universal Surface Gauge

2.6. Try Square

It is better known as engineer's try square and is a very common tool used for scribing straight lines at right angles to a true surface or testing the trueness of mutually normal surfaces. They are made in different sizes from the steel pieces.

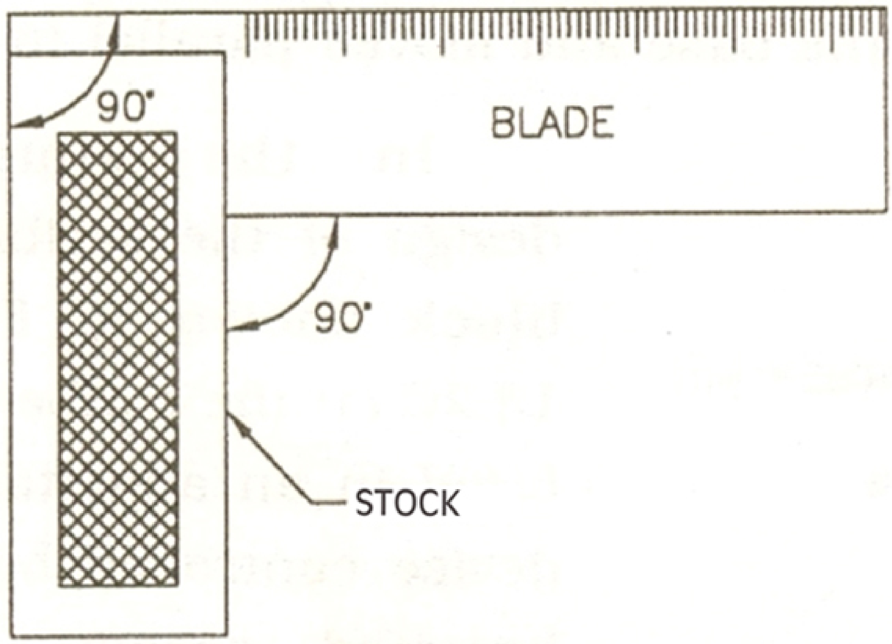


Fig.2.5 Try square

It consists of a steel blade fitted into a steel stock of rectangular cross-section. They are well hardened and tempered to suit the need. Both inner and outer surface of the blade are kept truly at right angles to the corresponding surfaces of the stock.

2.7. Bevel gauge

Whenever angles other than right angles are required to be tested or set and marked sliding bevel square or bevel gauge is used.

It consists of a steel stock of rectangular cross-section carrying a slotted steel blade at its end. This blade can be made to slide, set at any desired angle and secured in that position by means of a screw.

2.8. Files

Files of different types are the principal hand tools used by a fitter. All the files, irrespective of their shape, size and grade, essentially consist of two main parts, viz., a toothed blade and a pointed tang, which is fitted in a handle. Files are generally forged out of high carbon steel, followed by cutting of teeth, hardening and tempering etc. Common shapes of the files available are flat, hand, square, pillar, round, half round, triangular, knife edge, etc.

These files are manufactured in different varieties and their classification is governed by the following factors: effective length-i.e. excluding the length of tang, shape or form of the cross-section, depth, spacing and cut of teeth

Length of the files varies according to the need but the most commonly used lengths range from 10 cm to 30 cm and they cover almost all sorts of filing work done by hand.

Length between 10 cm and 15 cm are generally used for fine work, between 15 cm and 25 cm for medium sized work and above 25 cm for all general and large sized jobs.

Square file which carried double cut teeth on all the four faces and is normally made tapered for about one-third of its length near the end opposite to the tang.

Triangular file which normally carries single cut teeth on all the faces and is made tapered towards the end for about two-third of its length near the tip. The cross-section is an equilateral triangle.

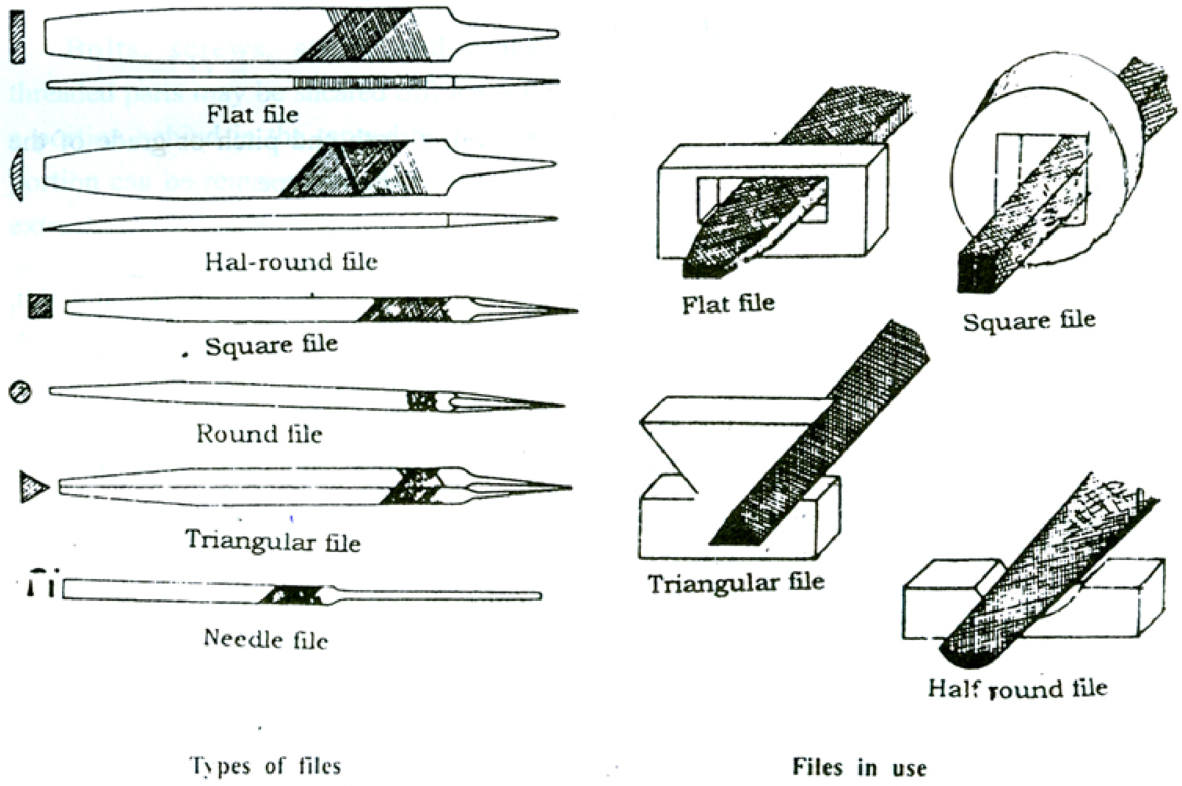


Fig.2.6 Types of Files

Teeth of the files may single cut or double cut. Single teeth are parallel and at angle of 60ºto the center line of the file. Double cut files have two sets of teeth, the overcut teeth are cut at angle of 60º and the uppercut at 75º to 80º to the centre line. Files are also further classified according to the coarseness or spacing between the rows of teeth.

1. Rough (R) with 10 to 4.5 cuts per 10 mm length
2. Bastard (B) with 18 to 6 cuts per 10 mm length
3. Second cut (SC) with 21 to 11 cuts per 10 mm length
4. Smooth (S) with 30 to 15 cuts per 10 mm length
5. Dead smooth (DS) with 35 to 28 cuts per 10 mm length
6. Super smooth (SS) with 63 to 40 cuts per 10 mm length

2.9. Scrapers

Scraping is a very important hand operation in bench work employed for obtaining a fine surface finish on the work, particularly for removing convex spots from machined surfaces, and the tools used for doing this operation are known as scrapers.

They vary in shape and size, depending upon the specific work for which they are employed.

They are usually made from rejected old files. Such files are heated and bent to the desired shape. They are fitted with a wooden handle.

2.10. Chisels

There are many verities of chisels used for chipping work by a fitter. Some very commonly used forms are Flat, Cross-cut, Round nose and Diamond point.

All the chisels are forged from bar stock of carbon steel, to the desired shape and the cutting edge ground to the correct angle.

The forging operation is followed by annealing, hardening and tempering to make chisel body tough and obtain a sharp cutting edge.

Full length of the chisel is never hardened, only a small length about the cutting edge (say about 20 to 30 mm) is hardened.

The included angle at the cutting edge varies between 40 and 70, depending upon the material on which it is to be used. Approximate values of cutting angles for common materials are as follows:

Brass and copper 40

Wrought iron 50

Cast iron and general cutting work 60

Steel (cast) 70

A flat chisel is a general purpose chisel which is most widely used in cutting work, chipping large surface, cutting metal sheets, rods, bar stocks and similar other purposes. Since it cuts the metal in cold state it is also frequently known as cold chisel.

A round nose chisel is used for drawing the eccentric hold back to correct centre which has run off-centre during drilling operation. Another specific use of this type of chisel is in cutting oil grooves and channels in bearings and pulley bushes and cleaning small round corners.

A cross cut is a comparatively narrow chisel having its cutting edge slightly broader than the blade. It is made to keep the blade free when the chisel is used to cut deep groove into the metal. Normal widths of the cutting edge vary from 3 mm to 12 mm. This chisel is used to cut parallel grooves on large surfaces, before chipping by means of a flat chisel, cutting key ways, etc.

A diamond point chisel is a special purpose chisel used for chipping rough plates and cutting cast iron pipes, cutting 'V' grooves, chipping sharp corners, squaring up corners of previously cut slots and cleaning angles.

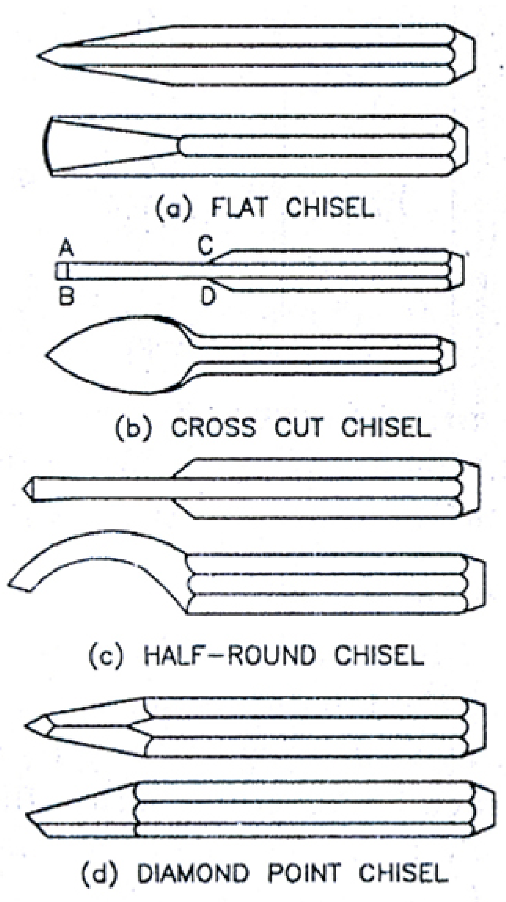


Fig.2.7 Types of chisel

2.11. Hammers

The hammer is one of the most widely used fitter's tools. It is used for striking chisels in chipping and cutting and the punch in marking.

All the hammers used in a fitting shop are similar in construction to the smith's hand hammers, such as ball peen, cross peen, straight peen, etc. The only difference lies in weight. Hammers used in fitting work are comparatively lighter in weight than the smith's hand hammers. They normally weigh from 0.45 kg to 0.7 kg.

Ball peen hammer is the most commonly used hammer. The peen is ball shaped. It is used for riveting, chipping, drawing and laying out. The weight of the hammer varies from 0.11 to 0.91 kg (as per IS standards)..

Fig.2.8 Hammers

Cross peen hammer resembles the ball peen hammer in shape except that its peen is in wedge shape and at right angles to the eye. This hammer is used for bending and hammering in the corners.

Straight peen hammer has a peen in line with the handle and is used for peening or stretching the metal.

2.12. Hack-saw

Desired lengths of bar stocks, rods, tubes, iron flats and metal sheets, etc. are always required to be cut in fitting shop. Hack-saw is a common tool used for this purpose. It consists of a metal frame, fitted with a wooden handle, carrying metal clips with wing-nut at its end to hold. The clip carrying the wing nut is threaded so as to stretch the blade to the desired extent. The frame can be either of fixed type, which can accommodate the same length of blades or adjustable type which is capable of accommodating different lengths of blades.

Hack saw blades are made of high carbon steel or low alloy steel. Hack saw blade is the main part. Push type blades, those which cut in forward stroke only, are generally used. In these, the teeth always point away from the operator. The blades in common use are generally 0.7 mm thick, 12.7 mm wide and 20 cm to 30 long. About 5 to 7 teeth per cm length of blade from the course group and 8 to 12 teeth per cm from the fine group of teeth.

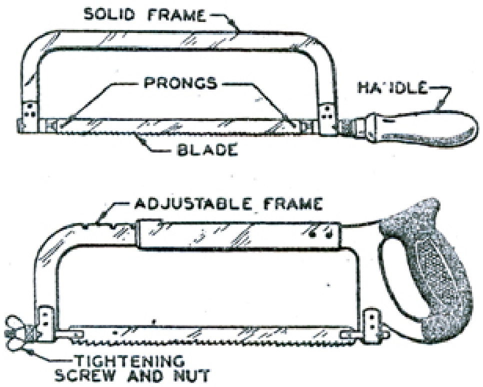


Figure 2.8 Different parts of a hack saw

Lesson-3

The bench work tools, its uses and processes

3.1. Miscellaneous tools

1. Punch

A punch made from a steel rod with a length of 90 to 150 mm and a diameter of 8 to 13 mm is used in bench work for marking purpose and locating centres in more permanent manner. The punch with a tapered point angle of 40^0 is called a princk punch and that of600 point angle is called a centre punch.

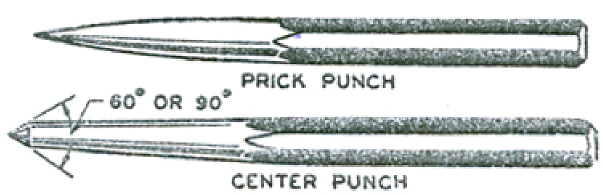


Fig.3.1 Punch

2. Calipers

Calipers are the devices used for measuring and transferring the inside or outside dimensions of components. Although gradually they are being replaced by the more accurate and precision instruments and gauges, like micrometers in modern workshops, still they stand as the in general work on account of their cheapness and ease in handling.

3. Screw Drivers

It is a very useful hand tool for rotating the screws. It consists of wooden or a plastic handle and steel blade, shaped at the end. The flat end of the tool is inserted into the slot provided on the head of the screw for rotating it. Screw drivers are made in various sizes to suit the corresponding sizes of the slots on the screw heads. Sometimes star headed screw driver is used for star headed screws.

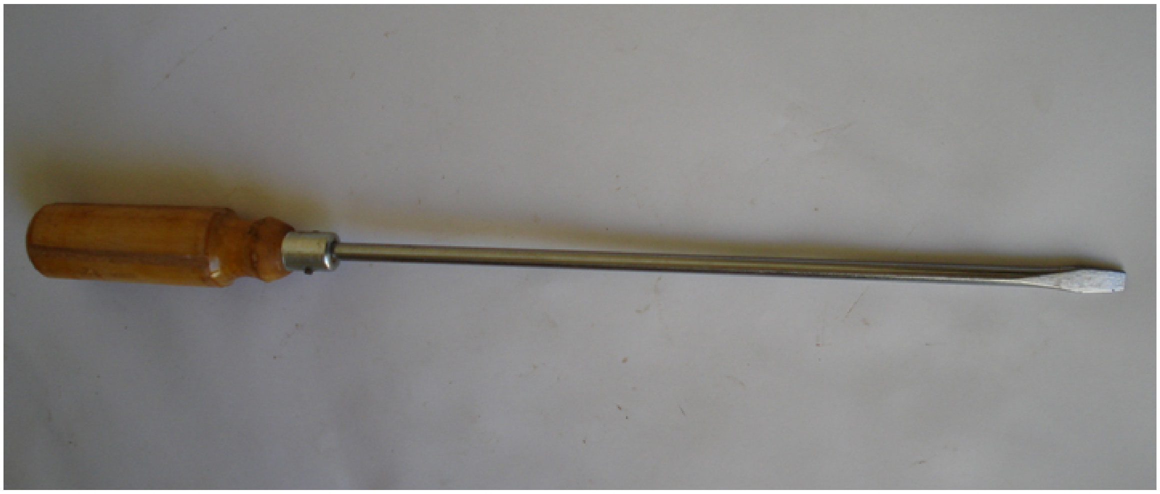


Fig.3.2 Screw driver

4. Drills

Drilling is an important operation carried out in a fitting shop for producing different types and sizes of holes in various materials. There are many forms of drills used for this purpose.

The simplest form is a flat drill which is used for wood work. The other important and most widely used is a fluted twist drill. It has a cylindrical body carrying the spiral flutes cut on its surface. Twist drills are usually made of high-speed steel, some cheaper varieties are made of high carbon steel. They are made in different forms to suit the work but the most commonly used types are (i) those having parallel shank and (ii) those having tapered shank,Parallel shank is provided on small sized drills (say up to 12.7 mm) only and those above this size are usually provided with a tapered shank.

The twist drill essentially consists of two main parts, a shank which is gripped in the chuck of the drilling machine and the body forms the main cutting unit. Main advantages of using twist drills are:

1. The chips of the metal are automatically driven out of the hole through the spiral flutes.

2. Cutting edges are retained in good condition for a fairly long period.

3. Heavier feeds and speeds can be quite safely employed.

4. For the same size and depth of hole they need less power as compared to other forms of drills.

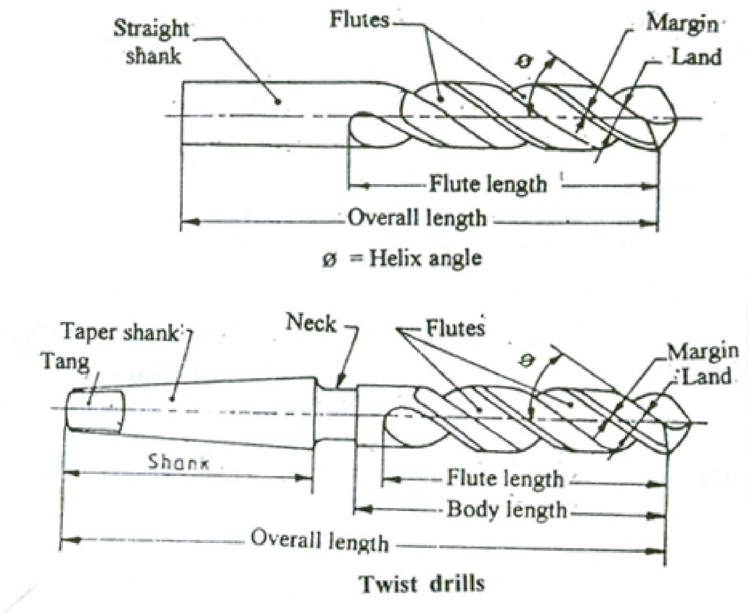


Fig.3.3 Twist drill

5. Taps

The hand operated taps used in fitting shops are employed for cutting internal threads in cylindrical holes or for cleaning damaged threads in similar parts. A tap consists of a toothed body having flutes (usually 4) cut on its surface, a round shank and a square formation at the end of the shank. The flutes are provided for the same purpose as in case of a twist drill and square formation at the top enables to grip by the tapping handle.

All the hand taps of different sizes are usually available in a set of three taps of each size known as taper or rough, second and finish or plug respectively. The main difference between the three taps is the chamfer angle. In the threading operations they are used in the same order as taper, second and plug.

When starting tapping care should be taken to start the thread in alignment with the hole. Also the tap should be occasionally rotated back about a turn to break the chips and facilitate their removal.

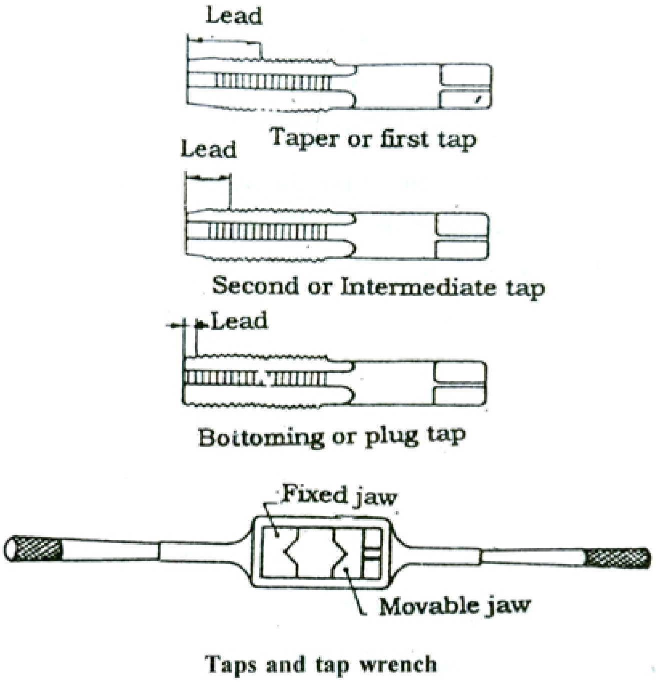


Fig. 3.4 Taps and tap wrench

6. Dies and stocks

Dies are used to cut threads on a round bar of a metal, such as the threads on a bolt. It is a round or square block of hardened steel with a hole containing threads and flutes which form cutting edges. Die may be a solid or adjustable type. Solid die has fixed dimensions. An adjustable die may be split type with a split through one side or two piece rectangular type. These types of dies are fitted into special stocks and closed by means of adjusting screws.The size of a die is specified by the outside diameter of the thread to be cut and pitch of the thread.

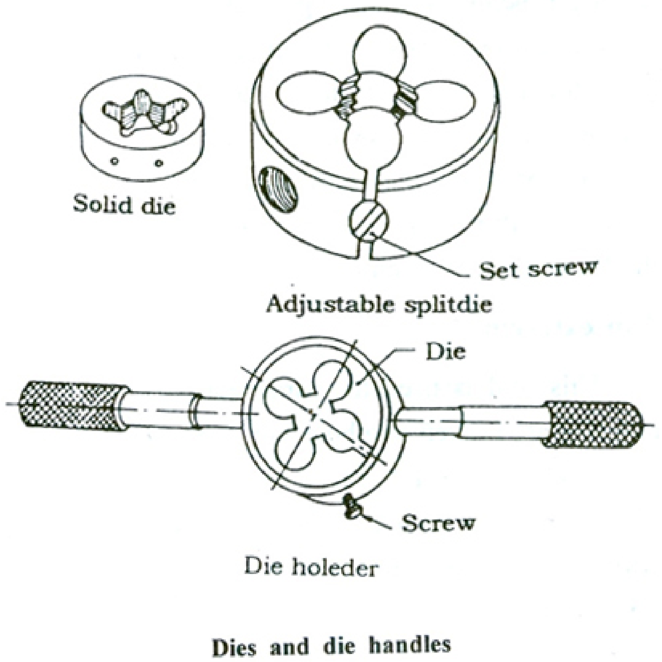


Fig.3.5 Die and die handles

3.7. Bench work processes:

Bench work involves following hand operations to finish the work to desired shape and size with required accuracy.

1. Marking

2.Chipping

3.Sawing

4. Filing

5. Draw filing

6.Threading

7. Grinding

Some common bench work processes are described here

1. Marking

- It is the basic and one of the most important operations in bench work.
- It should be remembered that how accurately and carefully one tries to perform other operations it will be of no help until and unless the piece has been properly and accurately marked.
- Sufficient care should be exercised in performing this operation to obtain a desired fitting of the components.
- Marking on the work can be done by setting out dimensions with the help of a working drawing.
- The surface to be marked is coated with either the paste of red lead or chalk and allowed to dry.
- After that, the work is held in a clamp, if it is round. If the work is too thin, it is normally supported against an angle plate keeping the surface to be marked in a vertical plane. Lines in horizontal direction are scribed by means of a scribing gauge.
- Lines at right angles to this can be drawn easily by first turning the work through 90 and then using the scriber.
- Lines can easily be marked with the help of a try square. Circles and arcs on flat surfaces are inscribed by means of dividers.

- After the scribing work is over, indentations on the surface are made, by using the center punch and hammer along the scribed lines and arcs.
- The punch marks serve as the guide during further operations like filing, chipping and drilling. etc.

2. Chipping

- It is the operation employed for removing the excess metal by means of cold chisels.
- To have a properly chipped surface it is essential that the same cutting angle should be maintained throughout the operation.
- In case the surface is too large it is advisable to cut grooves along the whole surface by means of a cross cut chisel and then chip off the remaining metal.
- The cutting angles of the chisels differ for different metals.
- Frequent lubrication and cooling of the cutting edge, while taking heavy cuts for removing large amount of metal, it helps considerably in chipping the metal easily and more effectively.
- To the correct cutting angle of the chisel, proper gripping of the chisel and the hammer and correct standing position of the operator play a significant part.
- The chisel should be firmly gripped in one hand leaving about 3 to 5 cm length above the thumb of the hand, and hammer should be held near the end of the handle to ensure more power in the blows.
- The operator should stand erect with his two feet sufficiently apart to balance his own weight equally on both the feet.
- The operator should always see the cutting edge of the chisel and not the top of the same.

3. Sawing

- This operation is performed in fitting shop for cutting different metal pieces to the desired size and shape, usually prior to other operations such as filing, drilling, scraping, etc.
- It is also employed for cutting metal pieces of required length out of the bar stock.
- For sawing, the saw blade should be properly fitted, and stretched to have the proper tension, in such a way that the cutting teeth always point away from the operator so as to cut the metal in forward stroke.
- Sawing should be done steadily and slowly.
- An average speed of about 50 strokes per minute is a good practice.
- Sufficient pressure should be exerted in the forward stroke and this be relieved during the backward stroke.
- It is advisable to use a coolant throughout the operation. A new blade should not be directly used on a hard metal.

4. Filing

- Similar to the saw blades, most of the files have their teeth pointing away from the operator such that they cut during the forward stroke.
- The pressure of the hand in filing should also be applied only during the forward stroke and relieved during the return stroke.
- Beginners particularly should be careful enough to practice correct movement of file.
- It should always be more in a perfect horizontal plane for obtaining a truly plane and smooth surface.
- As far as possible, try to use full length of the file during the operation.
- Moving the file diagonally on a flat surface always yields best results. A coarse pitched file should be employed when enough metal is to be removed, followed by finishing with a smooth file.

5. Draw filing

- When the surface is to be finally finished by filing only and no other operation, like scraping, is to follow the filing operation, a special method of filing, called Draw filing, is employed for finishing the surface.
- A flat file of fine cut is used for this operation.
- It should be ensured before use that the file teeth are free from metal particles,
- Other wise a numbers of scratches will be produced on the surface. It is usual to employ a file card quite frequently for cleaning the file teeth both before use as well as during use.
- For draw filing operation the file is held flat on the surface between the two hands.
- The file must move forward and backward. Flatness and evenness of the surface should be checked quite frequently during the operation.

For final finishing, it is a common practice to rub a chalk piece over the entire surface of the file. This helps in producing a finely finished surface.

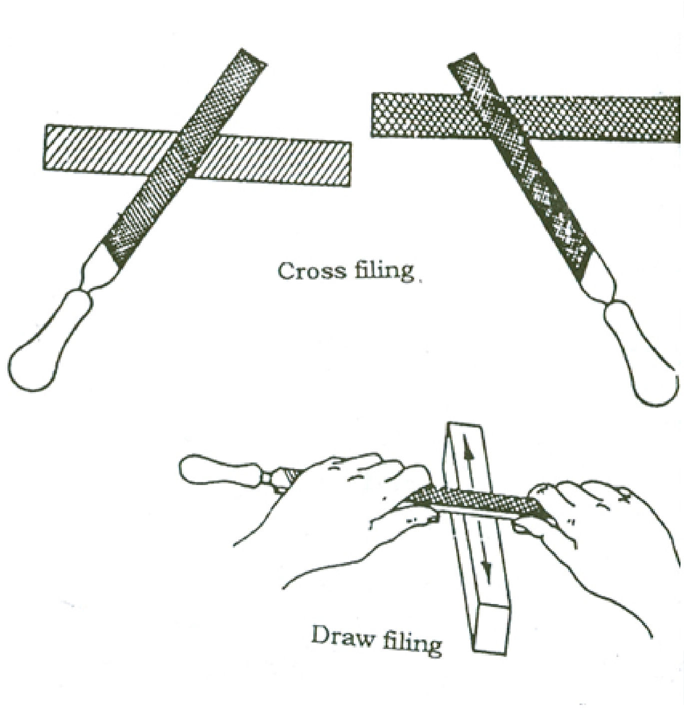


Fig.3.6 Cross and draw filing

Lesson-4
Smithy and forging tools and equipment

4.1. Introduction

- A smithy's work involves heating of a metal stock to a desired temperature, enable it to obtain sufficient plasticity, followed by the operations like hammering, bending, pressing etc., to give it the desired shape. This is known as forging.
- The above operations can either be carried out by hand hammering, by power hammers, or by forging machines.
- Hand forging is the term used for the process when it is done by hand tools. Similarly, forging done with the help of power hammers is known as power forging, when carried out by means of drop hammers as drop forging, and when by forging machines as machine forging.
- Applying pressure for shaping the metal, the primary requirement always is to heat the metal to a definite temperature to bring in into the plastic state.
- This may be done either in an open hearth, known as smith's forge, or in closed furnace. Small jobs are normally heated in the Smith's forge and larger jobs in closed furnaces.
- The Hand forging process is employed for relatively small components, machine forging for medium sized and large articles requiring very heavy blows and drop forging for mass production of identical parts.

4.2. Principal tools and other equipments used in hand forging

4.2.1. Smith's forge or hearth.

- It has a robust cast iron or steel structure consisting of 4 leg supports, an iron bottom known as hearth, a hood at the top and tuyere opening into the hearth either from the rear or from the bottom.
- The hearth carries the coal and provided with fire bricks lining to withstand the extensive heat produced due to the combustion of coal. In the absence of this lining the heat produced, as started above, will directly effect the metal structure of the hearth, so that the body, particularly the bottom and the surrounding walls, may even melt.
- With the result, the entire structure will collapse and the hearth will no more be useful.
- Air, under pressure is supplied by the blower, suitably placed somewhere near the forge, through the tuyere opening in the hearth.
- This blower can either be hand operated or power driven. The latter is preferable, but in the absence of availability of power supply choice of the former has no alternative.
- If hand blowers are to be used, they are usually mounted at the rear of the forge itself. In case the power driven units are to be employed the blower is suitably placed in one corner of the shop and all the forges are connected with it by means of a well-laid pipe running underground all around the hearths.
- At suitable points auxiliary pipes are used to connect the tuyere with the main pipe line.
- A valve is incorporated in the auxiliary pipe, just before the place where it is connected with the tuyere, to control the supply of air to the furnace.
- The chimney provided at the top enables as easy escape of smoke and gases produced due to the burning of coal.
- A water tank is provided, in front of the forge, which carries water for the purpose of quenching.
- These hearths can also be made to have masonry construction provided with all the attachments like chimney, tuyere, blower, water tank, etc.

4.2.2. Anvil

- To carry out the forging operations successfully, a proper supporting device is needed which should be capable of withstanding heavy blows rendered to the job.

- An anvil stands as the most appropriate choice for this purpose.
- Its body is generally made of cast steel, wrought iron or mild steel provided with a hardened top, about 20 to 25 mm thick.
- This hardened plate is welded to the body on the top.
- The horn or beak is used in bending the metal or forming curved shapes. The flat step provided, between the top and the horn, is used to support jobs during cutting and is known as chipping block.
- The flat projecting piece at the back of the anvil is known as tail.
- It carries a square hole to accommodate the square shank of the bottom part of various hand tools like swages, fuller. It is called a hardie hole.
- The circular hole provided near the hardie hole is known as pritchel hole.
- The commonly used size of an anvil weighs approximately 50-150 kg although it is manufactured in various sizes.
- The top face of the anvil should stand at about 0.75 m from the floor.

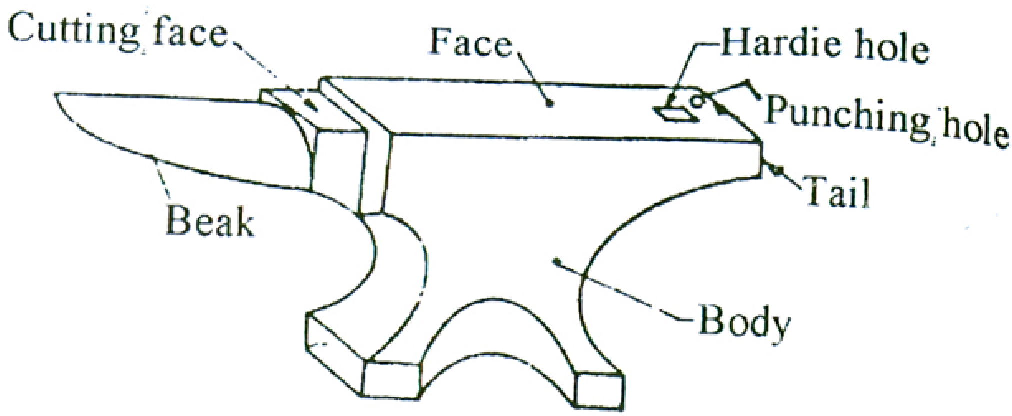


Fig.4.1 Anvil

4.2.3. Hammer

- The classification of hammers is largely according to the size and weight of the hammers used in forging.
- A smith's hand hammer is a small sized hammer used by the smith himself and the sledge hammer is comparatively larger in size, heavier in weight and is used by the smith's helper, known as hammer man.
- The smith's hand hammer is normally a small sized ball peen hammer.

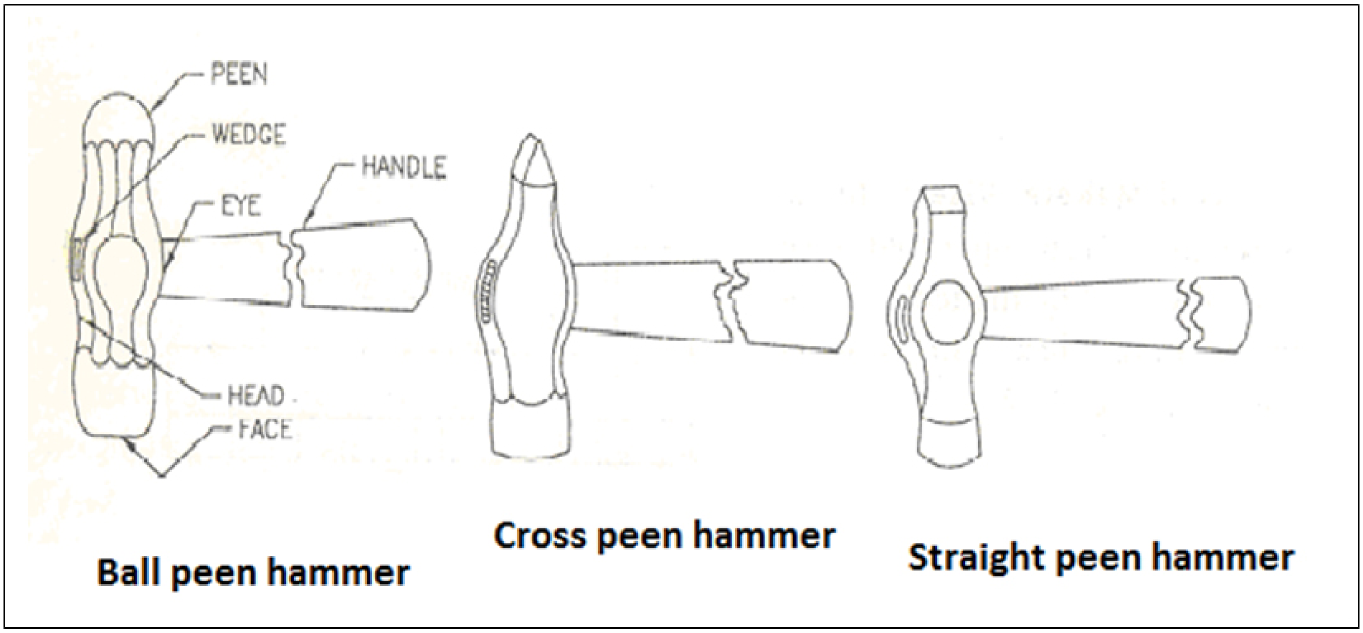


Fig.4.2 Smithy hammers

All the hammers are mainly divided into 4 parts; namely peen, eye, cheeks and face. The peen is the top part made slightly tapered from the cheeks and rounded at the top. It gets a particular form known a ball peen hammer.

The face is hardened and polished well and is given slight rounding along the circular edges so that the metal surface is not spoiled by the sharp edges when the former is struck by the hammer.

The eye is normally made oval or elliptical in shape and accommodates the handle or shaft. For small sized hammers these handles are made of shisham wood or bamboo, but in case of sledge hammers the handles made of solid bamboos. A steel wedge is always forced into the handle after it is fitted into the hammer so as to prevent the slipping of the hammer off the handle during striking.

A smith's hammer is usually a ball peen hammer or a straight peen sledge type hammer of relatively small size. Its weight normally varies between 1.0 kg and1.8 kg. A ball peen hammer is used for all general work and its peen is employed when light blows at a faster speed are needed, such as in fullering a rivet head in a countersunk hole.

Sledge hammers are comparatively 3to 4 times heavier than the hand hammers. They are available in varying sizes and weights from 3 kg to 8 kg. They are employed when heavy blows are needed in forging and other operations done on heavy jobs.

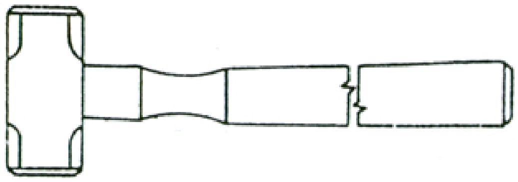


Fig.4.3 Sledge hammer

4.2.4. Swage Block

It is usually a block of cast steel or cast iron carrying a number of slots of different shapes and sizes along its four side faces and through holes from its top face to bottom face.

This is used as a support in punching holes and forming different shapes. The job to be given a desired shape is kept on a similar shaped slot, which acts as a bottom swage, and then the top swage is applied on the other side of the job.

The holes in the top and bottom face are used in punching. Their use prevents the punch from spoiling by striking against a hard surface after the hole has been punched.

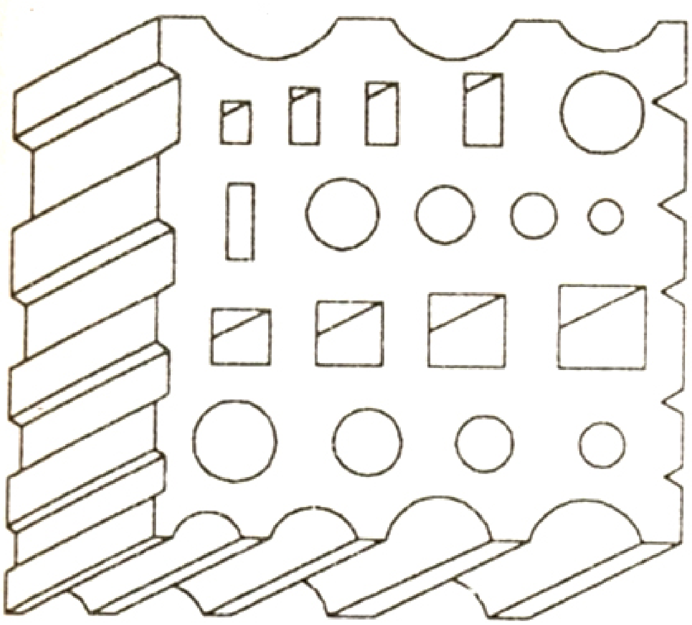


Fig.4.4 swage block

4.2.5. Tongs

- They are used to hold the jobs in position and turning over during forging operation. They are made of mild steel.

- Tongs are usually made in two pieces, riveted together to form a hinge. Smaller length on one side of the hinge carries the holding jaws, which are made in different shapes and sizes to suit the corresponding shapes and sizes of the jobs, and the longer portions on the other side of the hinge form the arms which are held in hand by the smith.

Overall sizes of the tongs vary according to the size and shape of the job to be held, but the commonly used lengths of the tongs in hand forging vary from 400 mm to 600 mm with the jaws' opening ranging from 6mm to 55 mm.

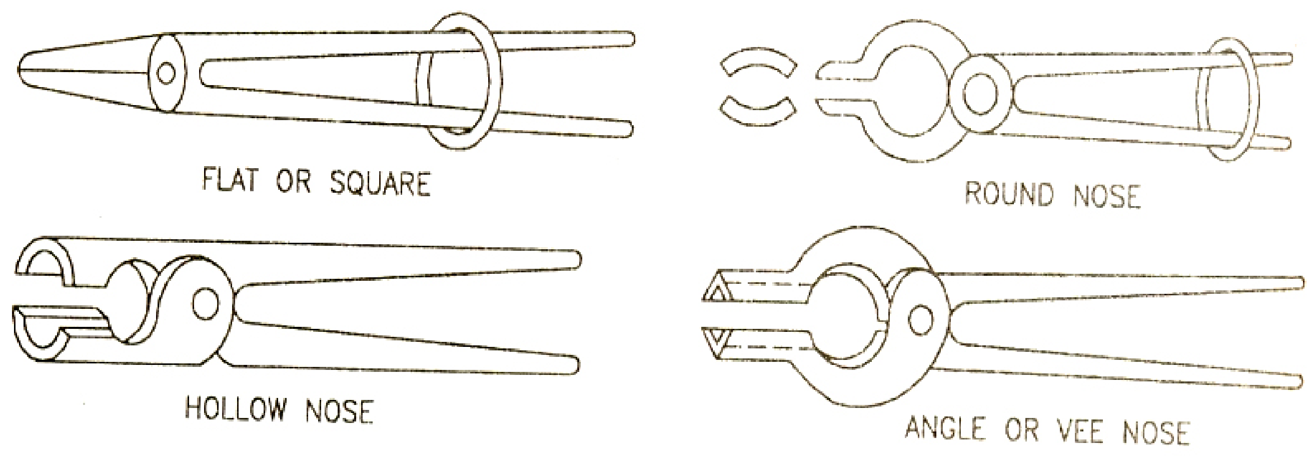


Fig.4.5 Tongs

- Tongs are usually named after the inside shapes of the jaws.
- Flat tongs are used for gripping thin section and small flat pieces.
- Round hollow tongs, with curved surface inside, are used for holding round work.
- Hollow tongs with square jaws are used to hold square or hexagonal work. Pick up tongs have their jaws so shaped that even small sections can be easily picked up. They are not used for holding the work.

4.2.6. Chisels

- Chisels are used to cut metals in hot or cold state.
- Those which are used for cutting the metal in hot state are termed as hot chisels and the others used for cutting in cold state are known as cold chisels.
- The main difference between these chisels is in the included angle at the cutting edge.
- A cold chisel carries an included angle of 60^0 at the cutting edge and the latter is well hardened and tempered. It is made of high carbon steel.
- A hot chisel can be made of medium carbon steel as there is no need of hardening. It is used to cut the metal in plastic state. The included angle of its cutting edge is 30^0.

4.2.7. Punches

Punches are tapered tools made in various shapes and sizes. They are used for producing holes in red hot jobs. A larger tapered punch is called a drift.

The job is placed on the anvil and the punch is hammered through it up to about half its depth. In is then turned over and the punch made to pass through it.Completion of this operation in two stages prevents the job from splitting and full to bursting.

4.2.8.Flatters

These are also known as smoothers.They are made of high carbon steel and consist of a square body, fitted with a handle, and a flat square bottom. They are used for leveling and finishing a flat surface after drawing out or any other forging operation.

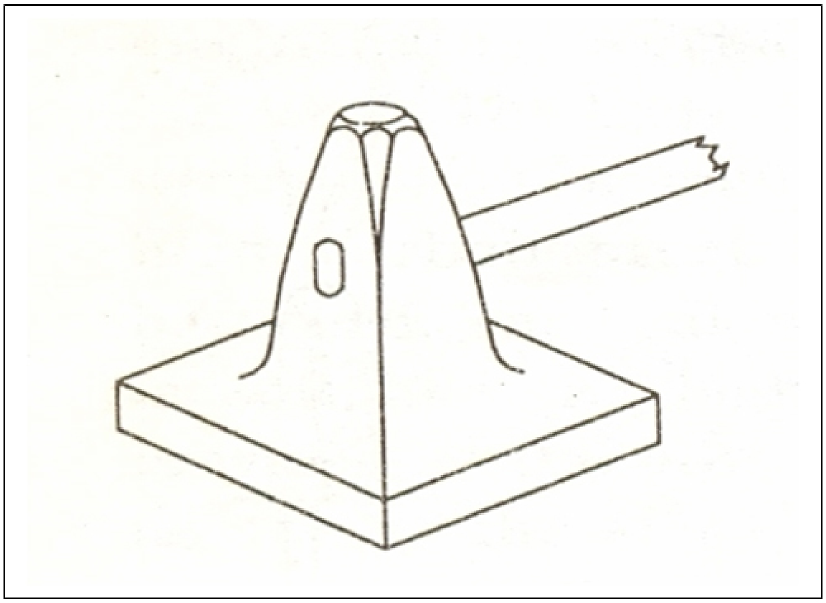


Fig.4.6 Flatter

4.2.9. Set Hammer

It is made of tool steel and hardened. It is not used for striking purpose. Its construction is also similar to that of a flatter but is smaller in size and it does not carry an enlarged bottom face. It is used for finishing corners, formed by two adjacent surfaces at right angles. The job is supported on the anvil and the tool is hammered from the top.

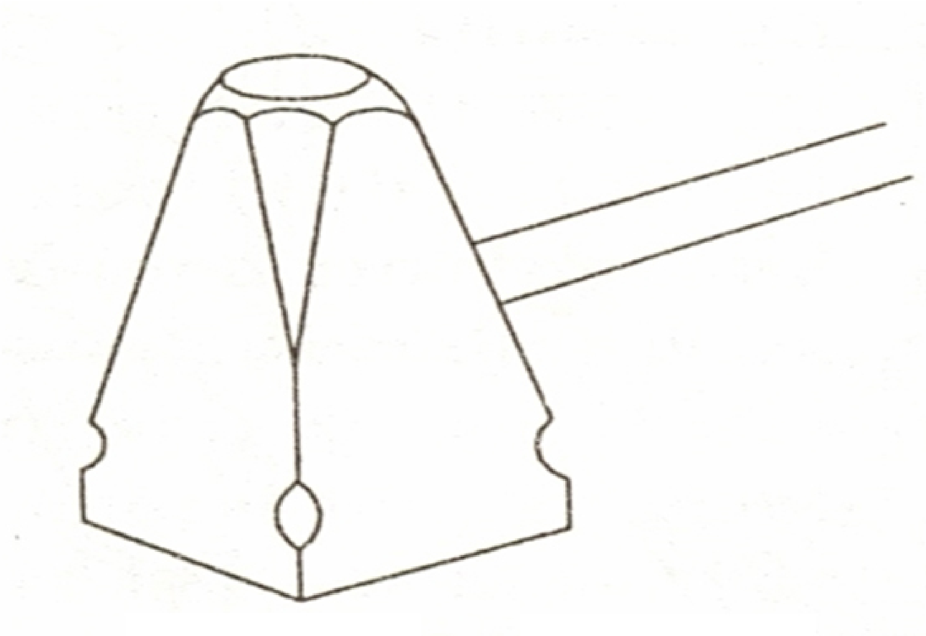


Fig.4.7 Set hammer

4.2.11. Fullers

These tools are made of high carbon steel in different sizes to suit the various types of jobs. They are usually used in pairs, consisting of a top and a bottom filler. Their working edges are normally rounded. They, are employed for making necks by reducing the cross-section of a job and also in drawing out.

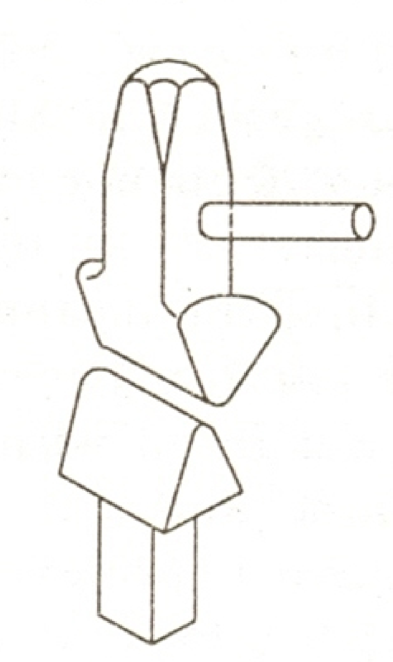


Fig.4.8 Fullers

4.2.12**. Swages**

- Like fullers, they are also made of high carbon steel in two parts called the top and bottom swages.
- Their working faces carry circular grooves to suit the size of the work. They are available in various sizes.
- The top swage carries is a handle and the bottom swage a square shank to fit the hardie hole of the anvil during the operation.

They are used for increasing the length of a circularrod or for finishing the circular surface of a job after forging.

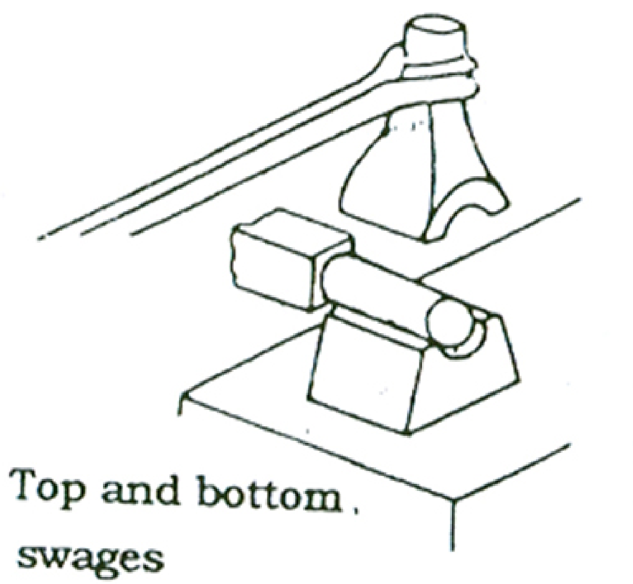


Fig.4.9 Swages

Lesson 5.

Smithy and forging operation

5.1. Fuels Used in Furnaces

Many types of fuels are used in the furnace employed in forging work. All these fuels can be broadly classified into three groups, as follows:

1. Solid fuels – such as coal, coke, charcoal etc.

2. Liquid fuel – they include different types of fuel oils.

3. Gaseous fuels – natural gas and producer gas.

5.2. Forging Materials

The materials possessing the ability to sustain substantial plastic deformation without fracture even in presence often sile stresses can be forged easily. Wrougt iron, low and medium carbon steels, low alloy steels, aluminium, magnesium and copper alloys are common forgeable materials. Austenite and marten site stainless steels, nickel alloys can be forged with some difficulty.

5.3. Forging Temperatures

Forging materials must be heated to a temperature at which it will possess high plastic properties both at the beginning and at the end of the forging process. If the forging operation is finished at lower temperature, this leads to cold hardening and cracks. With excessive heating, the forgings suffer oxidization and much metal is wasted. Approximate temperatures for forging the following common metals at the beginning and at the end of forging process are as under:

Metals	Temp. in °C at the beginning	Temp in °C at the end
1. Wrought iron	Just below 1300	800
2. Low carbon steels	1250-1300	800-850
3. Hard, high carbon and alloy steels	1100-1150	825-875
4. Brass, bronze	950	600
5. Aluminium and magnesium alloys	500	350

The temperature of heating steel for hand forging can be estimated by the heat colour of the heated steel are given in the following table :

Colour	Approx. temperature in °C
Faint red	500
Blood red	650
Cherry red	750
Bright red	850
Salmon	900
Orange	950
Yellow	1050
white	1200

5.4. Forging Operations:

For giving desired shapes to the products the following operations are used in a smithy shop.

1. Upsetting

2. Drawing out or drawing down.

3. Cutting

4. Bending.

5. Punching and drifting.

6. Setting down and finishing.

5.4.1. Upsetting or Jumping

- Upsetting is the process through which the cross-section of a metal piece is increased with a corresponding reduction in its length.
- When a metal is sufficiently heated, so that it acquires the plastic stage, it becomes soft.
- If some pressure is applied to it the metal tends to increase in its dimensions at right angles to the direction of application of force with a corresponding reduction in its dimensions parallel to the line of action of the said force.
- The particular part in the bar shape, where said increase in the cross-section is desired, is heated till it acquires a fully plastic state.

The hot portion of the bar is then kept on the anvil face and the bar hammered at the top.

Couldn't load plugin.

Hammering in this operation is done either by the smith himself, if the job is small, by means of a hand hammer or by his helper in case of big jobs, when heavy blows are needed, by means of a sledge hammer.

5.4.2.Drawing Out

This process is also known as drawing down. It is exactly a reverse process to that of upsetting in the sense, it is employed when a reduction in thickness, width or both of a bar is desired with a corresponding increase in its length. The desired effect is possible to be obtained by the use of either the peen of a cross peen hammer, a set of fullers or a pair of swages (for round bars only).

The process of heating and cooling the length, not required to be drawn, is the same as in case of upsetting, but the selection of the above tools is governed by the shape of the cross-section of the stock, the amount by which the increase in length is desired and also the required finished shape of the job.

5.4.3.Cutting

- Cutting of metals in hot or cold state is done by means of hot or cold chisels respectively.
- This operation is required in removing extra metal from the job before finishing it, cutting required lengths of pieces from a stock, splitting a metal piece into two at a desired location and similar other requirements.
- Enough care should be taken while cutting cold steel, since there is every likelihood of the chips flying off in different directions and cause injuries.
- Also, more power and time is taken in cold cutting as compared to hot chiseling.
- If very thick section is being cut, even cracks may sometimes occur. Cold cutting is, therefore, preferred for the thin sections only, such as rods of thin sections and sheets, etc., (usually below 20 mm thickness).
- Especially alloy steels should never be cut cold.

- For hot cutting of steel, it should be heated to red heat in the furnace and then cut. The usual temperature for hot cutting is 850 ^{0}C to 950 ^{0}C.

5.4.4.Bending

Bending of bars, flats and other similar stock material is usually done in a smithy shop. This can be done to produce different types of bent shapes such as angles, ovals and circles, etc.

Any desired angle can be made through this operation. For making a right angle bend that particular portion of the stock, which is to be subjected to bending, is heated and jumped on the outer surface.

This operation is carried out on the edge of the anvil or on the perfectly square edge of a rectangular block. After bending, the outside bulging is finished by means of a flatter and the inside one by means of a set hammer.

Curved shapes of bends are formed on the horn of the anvil. For mass production of articles made through bending, particularly when dimensional accuracy is a must, jigs and fixtures are designed to help in performing this operation quickly and efficiently. This results in a considerable saving of time and labour.

5.4.5.Punching and drifting

Punching and drifting are used for producing and finishing holes and preparatory for producing other shapes.Punching should be done in two stages. In the first stage the work piece is kept flat on the anvil and holes performed half way through. Then job is turned upside down. The application of punching, producing the slot a number of holes are punched and the remaining excess material is cut out using a chisel. The slot may then be finished hot drifting or may be finished by filing when cold.

5.4.6 Setting down

It is a localized drawing down or swaging operation. Usually the work is fullered at the place where the setting down is effected by the set hammer.

5.5 Forging processes

The processes of reducing a metal billet between flat dies or in closed impression dies to obtain a part of predetermine size and shape are smith forging and impression die forging respectively.Depending on the equipments utilized they are further sub-divided as under.

5.5.1 Smith die forging

It is also known as flat die or open die forging. It is simple,relatively inexpensive and allows the production of large verities of shapes.The final shape of the forging depends largely on the skill of the smith.

A. Hand forging: Hand forging is employed only to shape a small number of light forgings mainly in repair shops. This is done by hammering the piece of metal, when it is heated to proper temperature, on an anvil. A hand hammer or a sledge hammer is used for striking.

B. Power forging: Large machine parts which cannot be forged by hand forging, use of power hammers and presses is employed to do the job.

i. Hammer forging: machines which work on forging by blow are called hammers. The heavy falling part of the hammer is called the ram and the rigid support is in the form of anvil block. The power hammer may be a gravity fall type or a higher striking velocity type such as mechanical hammer,air and steam hammer etc. these hammers are available with different ram weight and different blows rate per minute.

Press forging: Forging presses for smithy work are usually of the hydraulic type. In press forging, pressure or squeeze is applied to the raw material and intensity of this pressure increase as the plastic metal resists deformation. As the pressure applied squeezes the metal slowly compared to blow hammer, more time is available for the flow of metal being forged.

5.5.2. Impression die forging:

It is employed for more complex shapes of greater accuracy, large quantities of identical forgings as well as for special items with quality and economy reasons.

a) Drop forging: Three types of drop hammers are used in making drop forgings. They are board or gravity type, air lift hammer and power drop hammer also, called steam hammer.

b) Press forging: It is done in presses rather than with hammers. The action is relatively slow squeezing instead of delivering heavy blows. This allows the gases to escape from the forging.

Machine or upset forging: Forging of the ring or rod types with all kinds of heads and shoulder, such as bolts, nuts, washers, collers, pinions gear, blanks etc can be conveniently produced in forging machines. Large number of small identical items can be machine forged.

Lesson-6

Heat treatment process:Hardening, tempering, annealing and normalizing

6.1. Introduction

Steel and other alloys have a large number of applications in engineering practice under varying conditions, requiring different properties in them. At one place they may be subjected to bending while at the other to twisting. They may be required to withstand various types of stresses and as tool materials to have hardness, specially red hardness, combined with toughness along with anon-brittle cutting edge. They may be required to bear static or dynamic loads,revolve at extremely high speeds, operate in highly corrosive media, carry an extremely hard skin with a tough core, subjected to fatigue and creep, etc.Such varying condition of their applications require these materials to possess specific properties of the required order to successfully serve under these conditions. But, a material may lack in some or all of these properties either fully or partially. These deficiencies are fulfilled through the process of heat treatment. Generally all steels can be heat treated as per need. Aluminium is the only non-ferrous metal which can be effectively heat treated.

The process of heat treatment involves heating of solid metals to specified (recrystalisation)temperatures holding them at that temperature and then cooling them at suitable rates in order to enable the metals to acquire the desired properties to the required extents. All this take place because of the changes in size, form,nature and the distribution of different constituents in the micro-structure of these metals. All heat treatment processes, therefore, comprise the following three stages of components:

1. Heating the metal to a predefined temperature.

2. Holding it at that temperature for sufficient time so that the structure of the metal becomes uniform throughout.

3. Cooling the metal at a predetermined rate in a suitable media so as to force the metal to acquire a desired internal structure and thus, obtain the desired properties to the required extent. All this takes place because of the changes in size,form, nature and the distribution of different constituents in the micro-structure of these metals.

6.2. Purpose of Heat Treatment

Metals and alloys are heat treated in order to achieve one or more of the following objectives:

1. To relieve internal stresses set up during other operations like casting, welding, hot and cold working, etc.

2. To improve mechanical properties like hardness,toughness, strength, ductility, etc.

3. To improve machinability

4. To change the internal structure to improve their resistance to heat, wear and corrosion.

5. To effect a change in their grain size.

6. To soften them to make suitable for operations like cold rolling and wire drawing.

7. To improve their electrical and magnetic properties.

8. To make their structure homogenous so as to remove coring and segregation.

9. To drive out trapped gases.

In order to understand the complete mechanism of heat treatment it is essential to know the internal structure, phase transformation, etc. fully. However, a brief review is given:

6.3. Classification of heat treatment processes

Various heat treatment processes can be classified as follows:

1. Annealing.

2. Normalizing.

3. Hardening.

4. Tempering.

5. Case hardening.

6. Surface hardening.

7. Diffusion coating.

6.3.1. Annealing

Annealing is indeed one of the most important heat treatment processes. The internal structure of the metal gets stabilized through this process. This heat treatment is given to the metal so as to achieve one on more of the following objectives:

1. To refine the grains and provide homogenous structure.

2. To relieve internal stresses set up during earlier operations.

3. To soften the metal and, thus, improve its machinability.

4. To effect changes in some mechanical,electrical and magnetic properties.

5. To prepare steel for further treatment or processing.

6. To drive out gases trapped during casting.

7. To produce desired macro structure.

Different type of annealing processes can be classified as follows:

1. Full annealing.

2. Process annealing.

3. Spheroidise annealing.

4. Diffusion annealing.

5. Isothermal annealing.

6.3.2. Full annealing

The main objectives of this type of annealing are to soften the metal, relieve its stresses and refine its grain structure. It is also known as high temperature annealing. In this process complete phase recrystallisation takes place and,therefore, all imperfections of the previous structure are wiped out. This involves heating of steel to a temperature about 30^{o} to 50^{o}above the higher critical point for hypoeutectoid steels, and by the same amount above the lower critical point for hyperuectoid steels, holding it at that temperature for sufficient time to allow the internal changes to take place and then cooling slowly. The steel gets softened by this process,together with an appreciable amount of increase in its ductility and toughness.

Table: Annealing temperatures for carbon steels

Table 6.1: Annealing temperatures for carbon steels

Material	Annealing temp. ° C
Dead mild steel (< 0.15%)-	870-930
Mild steel (0.15 to 0.3%)-	840-870
Medium carbon steel (0.3 to 0.8%C)	780-840
High carbon steel (0.8 to 1.5%C)	760-780

Cooling is done by allowing approximately 3 to 4 minutes time at elevated temperatures per mm thickness of the largest section. High temperature cooling is usually done in the furnace itself by lowering of temperature at the rate of 10 to 30^{o} C below the lower critical temperature. The specimen is then air cooled down to the room temperature. This process makes a course pear litic structure which is quite soft and ductile. An alternate method of cooling after soaking is to embed the metal in a non-conducting material like sand, lime, mica, ash, etc.

2. Process annealing

The purpose of process annealing is to remove the ill effects of cold working and often the metal so that its ductility is restored and it can be again plastically deformed or put to service without any danger of its failure due to fracture. It is also known a slow temperature annealing or sub-critical annealing or commercial annealing.The process is extremely useful for mild steels and low carbon steels and is cheaper and quicker than full annealing. Also, less scale is produced during this process. The main out put of this process is increased ductility and plasticity, improved shock resistance, reduced hardness, improved machinability and removal of internal stresses. During cold working operations like cold-rolling, wire drawing, a metal gets severely strain-hardened . Due to this, the metal is heated to a temperature, generally in the range of 550^{o}C to 650^{o}C, held there for enough time to allow recrystallisation of cold worked metal and,thus, softening to take place and then cooled at a slower rate (normally in air).

3. Spheroidise annealing

The main purpose of spheroidise annealing is to produce a structure of steel which consists of globules or well dispersed spheroids of cementite in ferrite matrix. Following are the main methods through which the above objective can be obtained:

1. High carbon steels: Heating the steel to a temperature slightly above the lower critical point (say between 730^{o}C to 770^{o}C,depending upon the carbon percentage), holding it at that temperature for sufficient time and than cooling it in the furnace to a temperature 600^{o}Cto 550^{o}C, followed by slowly cooling it down to room temperature instill air.

2. Tool steels and high-alloy steels: Heating to a temperature of 750^{o}C to 800^{o}C, or even higher, holding at that temperature for several hours and then cooling slowly.

4. Diffusion annealing

The purpose of diffusion annealing is to remove the heterogeneity in the chemical composition of steel ingots and heavy castings This process is mainly used before applying full annealing to steel castings. In this process , the metal is heated to a temperature between 1100^{o}C to 1200^{o}C,where diffusion occurs and grains are homogenized. The metal piece being treated is held at the diffusion temperature for a short time to allow complete diffusion and than cooled down to between 800^{o}C to 850^{o}C by keeping it inside the shut off furnace for a period of about 6 to 8 hours. Then it is removed from the furnace and cooled in air down to the room temperature. Then full annealing is performed.

5. Isothermal annealing

The isothermal annealing consists of heating steel to austenite state and then cooling it down to a temperature of about 630^{o}C to 680^{o}Cat a relatively faster rate. It is followed by holding it at this constant temperature (i.e isothermal) for some time and then cooling it down to the room temperature at a rapid rate. During the isothermal holding full decomposition to pearlite structure takes place and that is why the process is known as isothermal annealing. Because of the two rapid coolings the total annealing time is considerably reduced.

Normalizing:

The normalizing process is similar to annealing in sequence but vary in the heating temperature range, holding time and the rate of cooling. Heating temperature of steel is 40^{o}C to 50^{o}Cabove the higher critical point, held at that temperature for a relatively very short period of time (about 15 min.) and then cooled down to room temperature in still air. This heat treatment is commonly used as the final heat treatment for such articles which are supposed to be subjected to higher stress during operation. Due to this treatment internal stress caused during previous operations are removed, internal structure is refined to fine grains and mechanical properties of steel are improved. This process also improves the impact strength, yield point and ultimate tensile strength of steels. As compared to the annealed steels of the same composition the normalized steels will be less ductile but stronger and harder. For improvement of the mechanical properties normalizing process should be preferred and to attain better machinability, softening and greater removal of internal stress annealing process should be employed.

Hardening:

This process is widely applied to all cutting tools, all machine parts made from alloy steels, dies and some selected machine parts subjected to heavy duty work. In hardening process steel is heated to a temperature within the hardening range, which is 30^{o}C to 50^{o}C above the higher critical point for hypoeutectoid steels and by the same amount above the lower critical point for hypoeutectoid steels, holding it at that temperature for sufficient time to allow it to attain austenitic structure and cooled rapidly by quenching in a suitable medium like water, oil or salt both.

In the process of hardening the steel is developed in such controlled conditions,by rapid quenching, that the transformation is disallowed at the lower critical point and by doing so we force the change to take place at a much lower temperature. By rapid cooling the time allowed to the metal is too short and hence transformation is not able to occur at the lower critical temperature.

Tempering:

A hardened steel piece, due to martensitic structure, is extremely hard and brittle, due to which it is found unsuitable for most practical purposes. So a subsequent treatment is required to obtain a desired degree of toughness at the cost of some strength and hardness to make it suitable for use. It is especially true in case of the tools. This is exactly what is mainly aimed at through tempering of steel. This process enables transformation of some martensite into ferrite and cementite. The exact amount of martensite transformed into ferrite plus cementite will depend upon the temperature to which the metal is reheated and the time allowed for the transformation.

The process involves reheating the hardened steel to a temperature below the lower critical temperature, holding it at that temperature for sufficient time and then cooling it slowly down to the room temperature.

When the hardened steel is reheated to a temperature between 100^{o}C to 200^{o}Csome of the interstitial carbon is precipitated out from martensite to form acarbide called epsilon carbide. This leads to the restoration of BCC structure in the matrix. Further heating to between 200^{o}C 400^{o}Cenables the structure to transform to ferrite plus cementite. Further heating to between 400^{o}C and 550^{o}C leads to the nucleation and growth of a new ferrite structure, rendering the metal weaker but more ductile.If steel is heated above 550^{o}C the cementite becomes spheroidised,and if heating is continued even beyond the structure will revert back to the stable martensite. As such, if a good impact strength is desired reheating should not extend beyond 300^{o} to 350^{o}C. The section thickness of the components being treated also have a decisive effect on the results. Heavy components and thicker sections required longer tempering times then the lighter and thinner ones.

Types of tempering:

On the basis of the ranges of temperatures to which the components are reheated for tempering, the tempering procedures are classified as follows:

1. Low temperature tempering . This treatment results in reduction of internal stresses and improvement in toughness and ductility without any appreciable loss in hardness. The heating range for this type of tempering is from 150^{o}C to 250^{o}C. The different colours appearing on the surface of the metal are indicative of the approximate temperature attained by it. Carbon tool steels, low alloy tool steels, case carburized and surface hardened parts, measuring tools, etc are tempered by this method. Approximate temperatures, corresponding colours and the tools for whose tempering they are used are given in following table.

Approximate tempering temperatures and temper colours for tools :

Table -6.2: Approximate tempering temperatures and temper colours for tools

Color	Temperature in °C	Use
Light yellow	220-225	Surgical instruments and turning tools for brass, Hacksaw blades
Patel straw	225-230	Turning, planning and shaping tools, hammer faces and screw cutting dies for non-ferrous alloys
Dark straw	230-240	Milling cutters, blades for iron jack planes, wood working tools, drills.
Brown	240-250	Shear blades, thread chasers, taps and dies for steel, reamers, boring tools.
Brownish purple	250-260	Brace bits for wood, gauges, punches, snaps for river heads.
Purple	260-270	Axes, twist drills, punches and dies for power press work, scissors for sheet metal work.
Dark purple	270-280	Cold sets for steel, chisels for chipping work, smith's tools.
Light blue	280-290	Screw drivers, cold chisels for wrought iron
Dark blue	290-300	Springs, blades for wood cutting saws.

2. Medium temperature tempering . This process involves reheating the component to a temperature range between 350^{o}Cto 450^{o}C, holding at that temperature for sufficient time and then cooling it to room temperature. This method of tempering is used to increase the toughness of steel but reduces the hardness. It also increases the ductility and decresess the strength. It is mainly used for articles where a high yield strength, coupled with toughness, is a major requirement and subjected to impact loading, like coils and springs, hammers, chisels, etc.

3. High temperature tempering . The process involves reheating the hardened steel to a temperature between 500^{o}C to 650 ^{o}, holding it there for a certain time and then cooling it down to the room temperature.This process enables the steel attaining high ductility while retaining enough hardness. This provides a micro-structure which carries a useful combination of good strength and toughness with complete elimination of internal stresses .E.g.Crankshafts, connecting rods and gears

Tempering baths:

Mainly following three types of tempering baths are used for tempering of steel parts and cutting tools:

Lead bath : Lead or lead alloy bath may be used for tempering steel parts. The parts are preheated and then immersed in the bath, which is already heated to the tempering temperature. Once the parts reach the tempesing temperature they are taken out and cooled to attain the required temper.

Oil bath: Oil baths can be employed for various temperature ranges. Mineral oils are commonly used for these baths. Light oil baths are used for temperatures upto 230 ^{o}C only. Heavy oil baths can be used for heating range from343 ^{o}C to 370 ^{o}C. For oil heating the bath temperature is first raised to the required tempering range and then partially heated component is immersed in it. If the temperature of the bath falls below the required level both the bath and the immersed component can be heated together to the tempering temperature. After the component has reached the required temperature it is removed and immersed in a tank of caustic soda, followed by quenching in a hot water bath.

Salt bath : Salt baths, carrying liquid nitrates or nitrates plus nitrites, are used for higher temperatures. The salts used for these baths are generally chlorides and fluorides. These baths are very widely used for tempering of high speed steels.They can be used for temperature range upto 540 ^{o}C to 600 ^{o}C. From efficiency and economy points of view salt bath can not be used below 173^{o}.

Lesson-7

Metal cutting

7.1. Introduction

All metal cutting operations basically involve forcing a cutting tool with one or more cutting edges progressively through the excess material on the work piece. The work piece and the tool are securely held in a machine tool and its accessories while power is supplied to provide relative motion between the tool and the work piece. This results in removal of any excess material interfering with the relative motion in the form of chips. Metals are cut primarily to produce surfaces of desired shape, accuracy or surface finish depending upon their use. Since all machining involves considerable amount of labour, cost and loss of material as chips, machining should never be overdone to the extent of producing surfaces which are more accurate or better finished than those required for proper functioning of the product.

7.2. The Machine Tool

Machining is done with the help of power driven non-portable machines known as machine tools in order to perform its function. The machine tool must incorporate means for holding the workpiece and the tools and for providing relative motion between the tool and the workpiece. The form of surface produced in a particular machine tool depends upon the shape of the cutting tool, the path of the tool as it traverses through the material or both. If the tool moves past the workpiece in a linear path as in shaping or vice versa as in planning a straight cut plane surface is produced. On the other hand, if either the tool (boring) or workpiece (turning) is rotating and the other unit is travelling in a definite path relative to the axis, a surface of revolution is generated. Machining operations are named and classified according to the shape of the cutter, nature of relative movement, shape of the generated surface and the type of finish.

Performance wise a machine tool is expected to satisfy the following requirements:

1. It must have a high efficiency.

2. It must be possible to produce the specified dimensional accuracy, surface finish and form consistently and preferable independent of operator’s skill.

3. It should have a high enough production rate corresponding to latest development in technology.

7.2.1. Types of Machine Tools

Machine tools of different types and sizes have been developed because of variation in shape of the surface to be machined, size of the workpiece, surface accuracy desired and quantity required to be produced.

Broadly speaking machine tools may be classified into three major categories:

1. General purpose machine tools.

2. Production machine tools.

3. Special purpose machine tools.

1. General purpose machine tools

General purpose machine tools are machine tools like lathe, drilling machine and milling machine that are designed to deal with a variety of work and can perform a reasonably large number of operations within their range. A lathe, for example, can be used to do turning, knurling, threading or tapering on a job held between centres, turning, drilling, boring or facing on a job held in a chuck, turning, boring or facing on a job held on the face plate or boring in work held on the carriage using a boring bar held in the spindle. It can also be used for milling, grinding ore relieving with suitable attachments. Similarly a milling machine can be used for plain milling, slotting, angular cutting, indexing or helical milling operations. General purpose machine tools are useful in smaller machine shops and repair shops or for small quantity production.

2. Production Machine Tools

Production machine tools are designed to increase the rate of production and to reduce the manufacturing costs. Features like multiple spindle heads, multi-tool turrets and specially designed fixtures are incorporated in these machine tools to reduce the non-productive time or to combine more than one operation. Typical examples of this category are capstan and turret lathes, automatic screw machines, multi-spindle drilling machines and production milling machines. They are used for medium size production and batch work.

3. Special Purpose Machine Tools

Special purpose machine tools are machines which have been designed for some specific purpose and perform only one or a limited number of operations. Machines of this category include cam shaft grinders, gear generators and piston turning lathes. Special purpose machines, in most cases, perform operations that may be done on basic machines but for larger quantities they are much more economical than standard machine tools.

7.3. Cutting Tools

Metal cutting tools may be classified as single-point, double-point or multi-point tools depending upon the number of active cutting edges on the tool. Tools used on lathe, shaper or planer have a single cutting edge and are called single-point tools. Drilling tools have two cutting edges while milling cutters, in general, have more than two cutting edges. Grinding is a more general form of multi-point cutting in that the abrasive grains taking part in cutting do not have any fixed geometry or orientation. As far as their metal cutting action is concerned a double or multi-point tool behaves just the same way as a combination of so many single-point tools. The properties of cutting tools are thus discussed with reference to single point tools of the type used on lathe for turning.

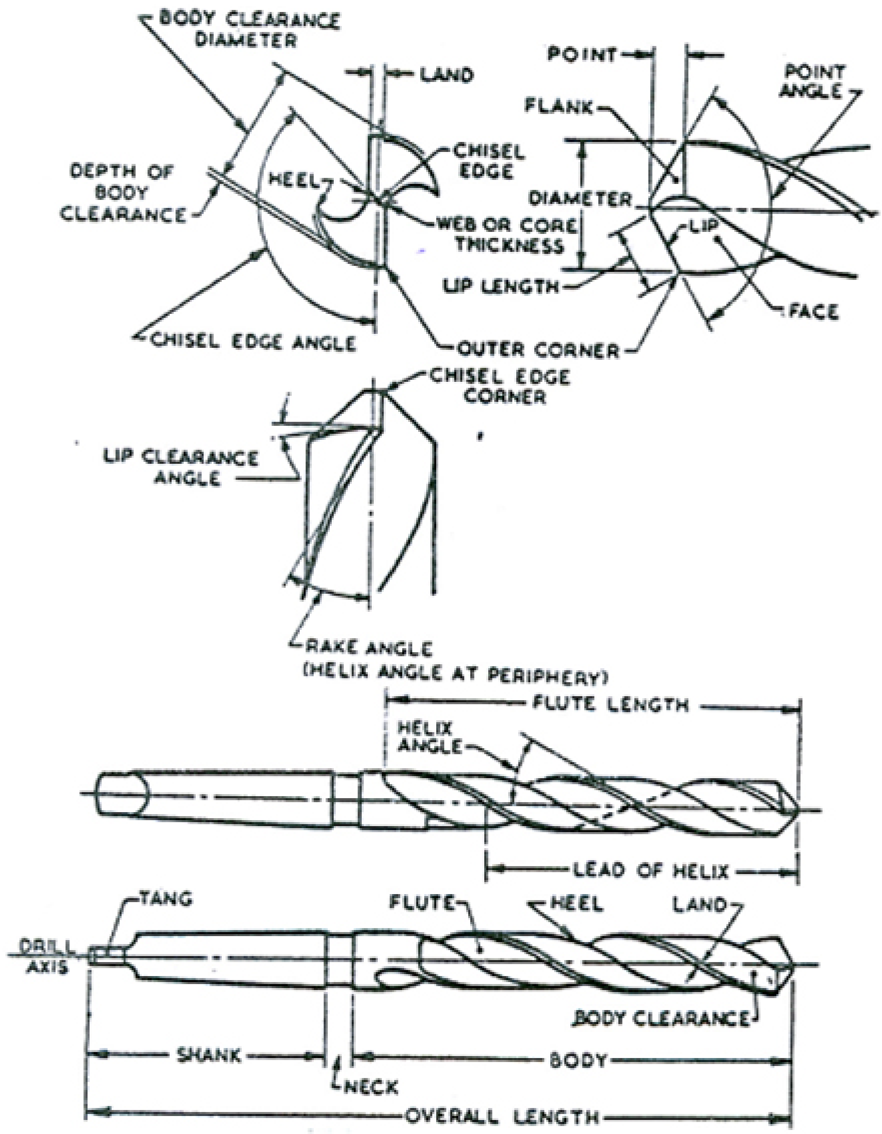


Figure 7.1 Twist drill nomenclature

7.4. Tool Materials

In order for a machining operation to proceed at a fast rate with minimum tool and machining cost the cutting tool material must satisfy certain basic requirements. The more important of these requirements are given below:

7.4.1. **Hot Hardness**: This represents the capacity of the tool to retain its cutting ability and hardness at the high temperatures developed at the chip-tool interface. To be effective the tool material must remain harder than the work material at all temperatures. Hot hardness of the tool material becomes more significant as the cutting speed is increased or the hardness of the metal to be machined becomes higher.

7.4.2. **Wear Resistance**: The life of a tool is determined by the wear developed on its cutting face due to motion of the chip and on its flanks due to contact with the machined surface. In order for the tool to continue to perform its duties satisfactorily it is important that the wear characteristics of its material relative to that of the work piece are such that excessive tool wear does not occur during the machining process.

7.4.3. **Toughness:** Toughness is necessary to enable the tool to withstand cutting forces, to absorb shock and to prevent the chipping of the cutting edge. The tool must not become so hard that it becomes brittle. Toughness is particularly important for tools like milling cutters which are subjected to impact loading due to interrupted cutting.

7.4.5. **Low Friction:** The co-efficient of friction between the tool material and the chip should be low. This is important for reducing tool forces, keeping chip-tool interface temperature low, increasing tool life and improving surface finish.

7.4.6. **Thermal Conductivity:** A material with a high thermal conductivity can conduct heat away from the chip tool interface faster. This results in a lower chip-tool interface temperatures, less interface welding and longer tool life.

7.4.7. **Cost:** This includes the cost of material, cost of grinding and the cost of replacement when the tool is worn out. A cheap material that requires frequent stopping of the machine for tool changing may prove much costlier in the long run compared to the one which has a higher initial cost but can be operated for a longer time at a higher speed.

The properties of the tool material as outlines above are often contradictory and inter-dependent. For example, a material that has a good wear resistance will not generally have high toughness. There is no single tool material that satisfies all the requirements specified above.

7.5. Commonly available tool materials and their characteristics are discussed below:

7.5..1 **Carbon Tool Steels:** Carbon tool steels contain carbon in amount ranging from 0.90 to 1.20 percent. These steels are relatively cheap and the tools are relatively easy to make and harden. With proper heat treatment these steels can attain hardness as much as any of the high speed alloys but they begin to lose their hardness at around 300^{o}C. Cutting tools of carbon steels are limited to show speeds and light duty work. Carbon steels are used for machining soft materials like wood and for hand tools like files and chisels.

7.5.2. **High Speed Steels:** High speed steels were so named because they could cut at speeds higher than those of carbon steels. The name is misleading because the speeds at which these materials cut are actually much lower than those used for many other materials like carbides and stellites that are now available.

High speed steels have excellent hardenability and can retain their hardness up to 650^{o}C. They are relatively tough and moderately priced. They can be shaped easily. As such high speed steels are commonly used for drills, reamers; counter bores, milling cutters and single point tools. One of the oldest and the most common variety of high speed steels is 18-4-1. It contains 18 percent tungsten, 4 percent chromium, 1 percent vanadium and about 0.5 to 0.75 percent carbon. It is considered to be one of the best all purpose tool steels. Many high speed steels use molybdenum to replace tungsten partially or completely because one part of molybdenum can replace two parts of tungsten. Molybdenum high speed steels such as 6-6-4-2 containing 6 percent tungsten, 6 percent molybdenum, 4 percent chromium and 2 percent vanadium with about 0.6 percent carbon have excellent toughness and cutting ability.

Cobalt is sometimes added to high speed steels to improve their red-hardness. These super high speed steels are used for heavy cutting operations involving higher cutting pressures and temperatures on the tool but are too costly for general purpose work. One composition of these super high speed steel alloys contains 20 percent tungsten, 4 percent chromium, 2 percent vanadium, and 12 percent cobalt.

High speed steels have one major disadvantage in that they require lot of care in heat treatment. Rather complex heat treatment cycles are used to develop the most favourable properties.

7.5.3. **Cast Non-Ferrous Alloys:** These are alloys containing principally chromium cobalt and tungsten with smaller percentages of one or more carbide forming elements like tantalum, molybdenum and boron but no iron. They also contain 1 to 4 percent carbon. A typical alloy of this type known as stellite contains 30 to 35 percent chromium, 43 to 48 percent cobalt, 17 to 19 percent tungsten and about 2 percent carbon.

Cast non-ferrous alloys are able to maintain good cutting edges up to 900^{o}C. Compared with high speed steels they can be used at twice the cutting speeds. They have a good resistance to cratering. They can take a good polish which helps metal from sticking on the tool face and forming the built-up-edge. They are also corrosion resistant. But they are brittle, can be machined only by grinding and do not respond to heat treatment. Intricate tools can only be made by casting and grinding.

7.5.4. **Carbides:** Carbide cutting tool inserts principally consist of tungsten carbide particles held together by cobalt or nickel as binder. Straight tungsten carbide tools containing about 94 percent tungsten carbide and 6 percent cobalt are used for machining cast iron and most other materials.

They cannot be used for machining steel because the chips tend to stick to the tool. Tantalum, Titanium carbides are added in steel cutting tungsten carbide grades in addition to increasing their cobalt content to overcome this difficulty. A typical analysis of a steel cutting grade may contain 82 percent tungsten carbide, 10 percent titanium carbide and 8 percent cobalt. Such a carbide has very low coefficient of friction and thus has less tendency for sticking.

Carbide tools are made by powder metallurgy techniques. They have a high initial cost but can be used at speeds which are two-to-three times those for cast nonferrous alloys. They can retain their cutting edges up to 1200 ^{o}C. They are very hard and have a high compressive strength but they are brittle and cannot withstand impact loading. Grinding is difficult and can only be done with silicon carbide or diamond wheels. Because of these reasons carbide tools are generally used as brazed or throw-away inserts. Even they have to be rigidly clamped. The need to provide high rotational speeds and yet assure extreme rigidity has led to considerable improvement in the design of machine tools used with these inserts.

7.5.6. **Ceramics:** Ceramics, sintered oxides, or cemented oxides are essentially aluminum oxide powder along with additives of titanium, magnesium or chromium oxide with a binder processed by powder metallurgy in the form of tool inserts. These inserts are either clamped into a tool holder or bonded to it. Ceramics are harder than other materials discussed so far and retain their hardness up to 1100 ^{o}C. They have a low coefficient of friction and a good resistance to cratering. The surface finish produced by ceramics is comparable with that produced by carbides but ceramics consume about 20 percent lesser power. The use of ceramic tools is limited only by their brittleness and the lack of rigidity and speed range on the conventional machine tools.

7.5.7. **Diamond:** Diamond is the hardest known material and can be used for machining at very high cutting speeds up to 25 m/s. Because of its high cost diamond is justified only when machining hard materials which are difficult to cut with other tool materials or for applications where very high accuracy and surface finish are desired. Diamond is also brittle, does not conduct heat well and can take only light cuts. Typical applications are precision boring of holes and machining of highly abrasive materials like fiber glass. Diamonds are also used for dressing grinding wheels and in finishing operations like lapping, honing and super finishing. When uses as cutting tools diamonds must be held very rigidly to avoid shock loading.

7.6. Cutting Parameters:

Cutting speed, Feed and depth of cut:

Cutting speed, feed and depth of cut are the parameters which determined the relative motion of the tool and work piece in a cutting operation and represent the rate at which excess material is removed per unit time. A proper selection of these parameters is essential for efficient machining.

7.6.1. Cutting speed

The cutting speed is defined as the surface rate of travel of the cutting edge relative to the work piece. It is expressed in meters per second. The amount of heat generated at the chip tool interface during a machining operation and the life of the tool are directly influenced by the cutting speed.

The speed selected for any operation depends on the work material, cutting tool material, cutting fluid used and the type of cut. Lower speeds are used for harder materials and for heavier roughing cuts while finishing cuts in softer materials can be taken at much higher speeds.

7.6.2. Feed

Feed is defined as the rate at which the cutting tool advances along or into the surface of the work piece. For machines in which either the job or the tool rotates, feed is expressed in millimeters per revolution of the rotating member. For machines in which the work piece or tool reciprocates feed is expressed as millimeters per stroke. Other methods of expressing feed include feed in millimeters per second or millimeters per tooth of the cutter.

Feed has an important influence on the tool forces and surface finish. Lower feed values have to be used when machining with higher speeds, harder work pieces, less rigid machine tools, lesser supply of cutting fluid or a blunt tool.

7.6.3. Depth of cut

Depth of cut is the normal distance from the original surface to the surface being exposed by the tool. It is measured in millimeters. Either tool or work piece may be moved to give depth of cut depending upon the machine.

It must be pointed out that the direction of feed and depth of cut must be established carefully with reference to the type of operation. On a lathe for example, the longitudinal movement of the tool along the length of the bed constitutes feed motion in plain turning but a depth motion in facing. Similarly the motion at right angles to the bed axis with the help of cross slide constitutes a depth motion for turning but a feed motion for facing.

7.7. Cutting Fluids

7.7.1. Functions of the cutting fluid

Cutting fluids are used in metal cutting primarily for two reasons:

1. To reduce friction at the tool work and tool chip contact zones lubricating action.

2. To dissipate the heat generated during the cutting process – cooling action.

In addition, cutting fluids also help in washing away the chips from the cutting zone and in lubricating some of the moving parts of the machine.

The lubricating action of the cutting fluids reduces forces, increase tool life, reduces the tendency to form built-up-edge and improves surface finish. Since in metal cutting the ratio of real area of contact to the apparent area of contact is very close to unity and contact pressures are very higher, there is no possibility of fluid film existing between the surfaces in contact. The lubricating action of the cutting fluid is primarily due to the formation of a low shear strength film in the metal surface which can be easily sheared. The formation of such films takes time. Therefore, lubricating action of cutting fluids is not very predominant for high speed machining operations such as grinding. Again, the chemical properties of the cutting fluid are more important than its physical properties. Additives are often added to the fluids to improve their lubricating properties.

The cooling action of the cutting fluid helps carry away the heat generated during cutting and hence helps in retaining the strength of the tool. Cooling the work piece also helps in maintaining the dimensional accuracy by reducing the distortion caused due to heat. It also makes work handling easier. Amongst all the fluids, water based fluids are the most efficient for cooling because of their high specific heat and thermal conductivity. Compared to oils, water based fluids are two to three times faster. But water is likely to cause corrosion of machine parts. Anti-corrosive additives are mixed with water based coolants to control this corrosive action.

7.6.3. Types of cutting fluids

The cutting fluids commonly used may be divided into : (i) neat oils (ii) water soluble oils (iii) synthetic coolants and (iv) gaseous fluids.

(i) Neat oils: Neat oils or straight cutting oils are mineral oils, vegetable oils or combination of these two. Neat oils can be further divided into straight mineral oils, compounded oils for E.P. oils. Straight minerals oils without any additives are suitable only for light loads and hence are used for machining nonferrous metals like aluminum and magnesium.

(ii) **Water soluble oils:** Water soluble oils are blends of mineral oils, emulsifying agents, and coupling agents. For use these oils are mixed with water to form a water emulsion. Water provides the cooling effect and the oil is used for its lubricating properties.

(iii) **Synthetic coolants:** Synthetic coolants are non-petroleum products which are blended with water in the ratio of 50 to 250 parts of water for each part of the chemical. They have cooling properties better than soluble oils and are used chiefly for grinding.

(iv) **Gaseous fluids:** One of the major problems in cutting fluid application is the difficulty for the cutting fluid to actually reach the cutting zone during machining. The effectiveness of the cutting fluid can be considerably increased by supplying the cutting fluid in the form of a gas. Mist is the most commonly used gaseous fluid. In a mist cooling system, compressed air is used to atomize the coolant.

7.6.4. Selection of cutting fluids for different operations

The type of cutting fluid to be used depends upon the work material and the characteristics of the machining process. No single cutting fluid can be specified as the best of meet all requirements. The following general guide lines may be used.

a) Effect of work piece material

Cast Iron: Cast iron is generally cut without any cutting fluid. The graphite flakes in the structure of cast iron help in its easy machining. Sometimes cast iron is also cut with water soluble oils or using compressed air. The use of compressed air necessitates and exhaust system to remove the dust caused by blowing of fine iron particles.

Wrought iron: lard oil or water soluble oil

Steel: 1. Low and medium carbon steels: Water soluble oil

2.High carbon and nickel chromium alloy steel: Heavy duty soluble oils

Stainless steel: Heavy duty soluble oil or neat oil, with chlorine

Aluminium: Soluble oil or kerosene.

Brass, Bronze: Worked dry or with paraffin or lard oil.

Magnesium alloys: Low viscosity inactive fatty mineral oils.

Lesson-8

Electric arc welding

8.1. INTRODUCTION

Welding is process of joining similar metals by application of heat with or without application of pressure and addition of filler material. Such a welded joint has continuous homogeneous material of the similar composition and properties of the parts being joined together. All the engineering branches and metal industries extensively make use of welding processes in one or other form.

Types of welding:

Welding methods may be broadly classified in two general groups.

I. Plastic welding: It is also known as pressure welding. Metal pieces to be joined are heated to a plastic state and then forged together by external pressure generally without addition of filter material.

a) Forge welding : heating by a forge

b) Resistance welding : heating by electrical resistance

c) Thermit welding : heating by chemical reaction (without filler metal)

II. Fusion welding : It is also known as non-pressure welding. Material at the joint along with the filler metal, is heated to a molten state and allowed to solidified. Filler metal is used.

a) Arc welding : Heating by electrical arc.

b) Gas welding : Heating by gases.

c) Thermit welding : Heating by chemical reaction & with filer metal.

Apart from the above processes,solid state welding, newer welding etc are also the newly developed welding processes.

Electric Arc welding:

An electric arc is produced when two current carrying conductors are brought together and then separated by small distance provided there is sufficient voltage available to force a flow of current through the air gap. The arc produced is associated with a bright glow and intense heat throughout its length and may have a temperature of the order of about 5000^{o}C to 5500^{o}C. An arc is produced between a work piece and a carbon electrode at a voltage of about 35 to 40 volts and that between a work piece and a metal electrode at about 15 to 40 volts. Since most of the commercial circuits, normally operate at much higher voltages it is necessary to use specially designed equipment for producing arc for welding.

An arc suitable for welding may be struck in any one of the following ways.

1. Between consumable metal electrode and the work piece.
2. Between a non-consumable electrode and the work piece.
3. Between two non-consumable electrodes.
4. Between two work pieces.

An arc between a consumable filler metal electrode and the workpiece is extensively used in many of the welding processes today. When the arc is of the intense heat produced, quickly melts the work piece metal under the arc and produces a molten metal. Simultaneously the end of the electrode melts and the molten metal is carried by the arc into the metal pool on the workpiece to provide a filler to the joint. A proper arc length is important for sustaining the arc and producing a good weld. The processes which use an arc produced between a consumable electrode and the work piece include metal arc welding.

Gas Metal Arc (GMA), earlier known as Metal Inert Gas (MIG) welding and Tungsten Inert Gas (TIG) welding using inert gases for the shielding are also widely used.

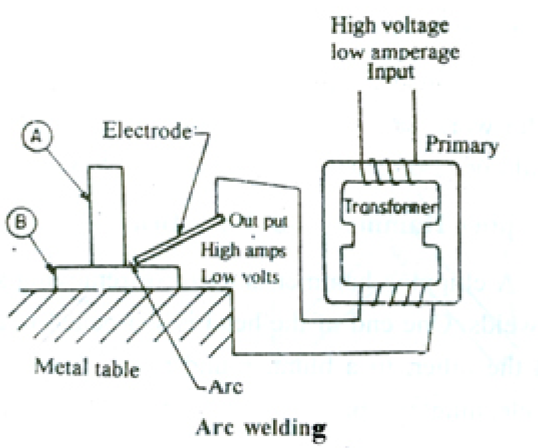


Fig. 8.1 Electric arc welding

8.2. Arc welding equipment:

Arc welding equipment:

1. AC or DC machine 2. Electrode

3. Electrode holder 4. Cables, cable connections

5. Chipping hammer 6. Earthing clamps

7. Wire brush 8. Helmet

9. Safety goggles 10. Hand gloves

8.3. AC or DC machine

An arc suitable for welding can be either with AC or DC source. The voltage ranges from 15 to 45 volts depending on the welding process. The current for welding may range from 30 to 600 amperes depending on the process and the thickness of material to be welded.

Ordinary electrical loads like heaters and motors work with, steady voltage and current but the welding arc is highly unsteady in both these parameters. The nature of the welding process itself results in frequent short circuits.

ADC arc is more stable because of the unidirectional flow of current and finds specific applications in cast iron and non ferrous welding. AC welding has the obvious advantage of lower power cost, low equipment cost and easy maintenance due to the absence of moving parts. AC welding is becoming more and more common.

Table- 8.1: Comparison between AC and DC arc welding

A.C. arc welding	D.C. Welding
The A.C. Welding transformer has no moving parts and is simpler.	The D.C welding generator has rotating parts and is more complicated
The transformer costs less and its maintenance cost is low.	The generator costs more and its maintenance cost is high.
Since the distribution of heat is equal, therefore there is no need for changing the polarity. Hence only ferrous metals are usually welded by A.C.	.Heat distribution is different in two poles, i.e., two-third in positive and one-third in negative. By changing the polarity, all types of metals can be welded by D.C.
All types of electrodes can not be used in A.C. arc welding because the current constantly reverses with every cycle. Only coated electrodes can be used.	All types of electrodes, bare or coated can be used in D.C. arc welding because the polarity can be changed to suit the electrode.
The problem of 'arc blow' does not arise, as it is very easy to control.	In D.C. the 'arc blow' is severe and cannot be controlled easily.
It can be used only when A.C. supply from the mains is available.	In the absence of A.C. main supply, an engine driven D.C. generator set can be used.
A.C. is more dangerous	D.C. is comparatively less dangerous

8.4. Electrode

It is filler metal in the form of a wire or rod used as a terminal in an electric current for the purpose of producing an electric arc. The electrodes are classified as consumable electrode and non-consumable electrode.A consumable electrode is similar in composition to the metal being welded and it melts to become a part of weld.

Anon-consumable electrode may be made of carbon, graphite or tungsten, which do not consume during the welding operation. When the core of the bare metallic wire is provided with a covering or coating of some fluxing materials it is known as coated electrode. The slag forming constituents are silicate;manganese oxide and iron oxide are used for coating. The advantages are to facilitate the establishment and maintenance of arc, to protect the molten metal from the oxygen and nitrogen of the air by producing a shield of gas around the arc and welding pool, to provide the formation of a slag so as to protect the welding seam from rapid cooling and to provide a means of introducing alloying elements. The coated electrode may be light coated or heavy coated. **Both bare and coated electrods for hand arc welding are made up to 12mm in diameter and 450mm long.**

8.5. Chipping Hammer

A chipping hammer is used for removing slag and spatter. It is advisable to wear chipping goggles while using chipping hammer so that particles of slag may not strike the eyes .

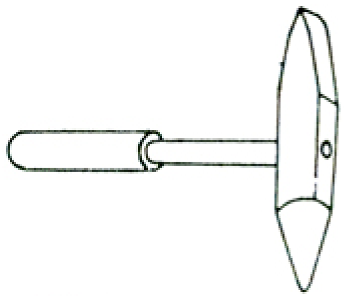


Fig. 8.2 Chipping hammer

8.6. Wire Brush

Wire brush is a cleaning tool. It is used for removing loose slag,spatter and oxides.

8.7. Helmet

A helmet is used by the welder for protection of his eyes, face and the throat from harmful rays of electric arc and from the hot flying particles or spatter.

8.8. Hand Gloves

For protection of wrist and hands, gloves are worn by the welders.They are made of leather or asbestos. They should be as flexible as possible.Gloves provide protection against.

8.9. Types of Welded Joints

The common joints used in forge welding may be lap joint, butt joint, T joint and V joint. The relative positions of the two pieces being joined determine the type of joint.The following are the five basic types of joints commonly used in fusion welding.

8.9.1. Lap joint - This is used to joint two overlapping plates so that the edge of each plate is welded in the other. The lap joint is obtained by over lapping the plates and then welding the edges of the plates. These joints are employed on plates having thickness less than 3 mm.

8.9.2. Corner joint - It is used to joint two edges of two plates whose surfaces are at right angles to each other. The corner joint is obtained by joining the edges of two plates whose surfaces are at an angle of approximately 90 ° to each other. It is used for both light and heavy gauge sheet metal.In some cases corner joint can be welded, without any filler metal, by melting off the edges of the parent metal.

8.9.3. Butt joint : The butt joint is obtained by welding the ends or edges of the two plates, which are approximately in the same plane with each other. In butt welds, the plate edges do not require beveling if the thickness of plate is less than 5 mm. On the other hand, if the plate thickness is 5 mm to 12.5 mm,the edges should be beveled to V or U-groove and plates having thickness above12.5 mm should have a V or U-groove on both sides

8.9.4. T-joint - The T-joint is obtained by joining two plates whose surfaces are approximately at right angles to each other. It is widely used to weld stiffeners in aircraft and other thin walled structures. These joints are suitable up to 3 mm thickness.

8.9.5. Edge joint - It consists of joining the edge of parallel plate by means of weld. The edge joint is obtained by joining two parallel plates. It is economical for plates having thickness less than 6 mm. This joint is unsuitable for members subjected to direct tension or bending.

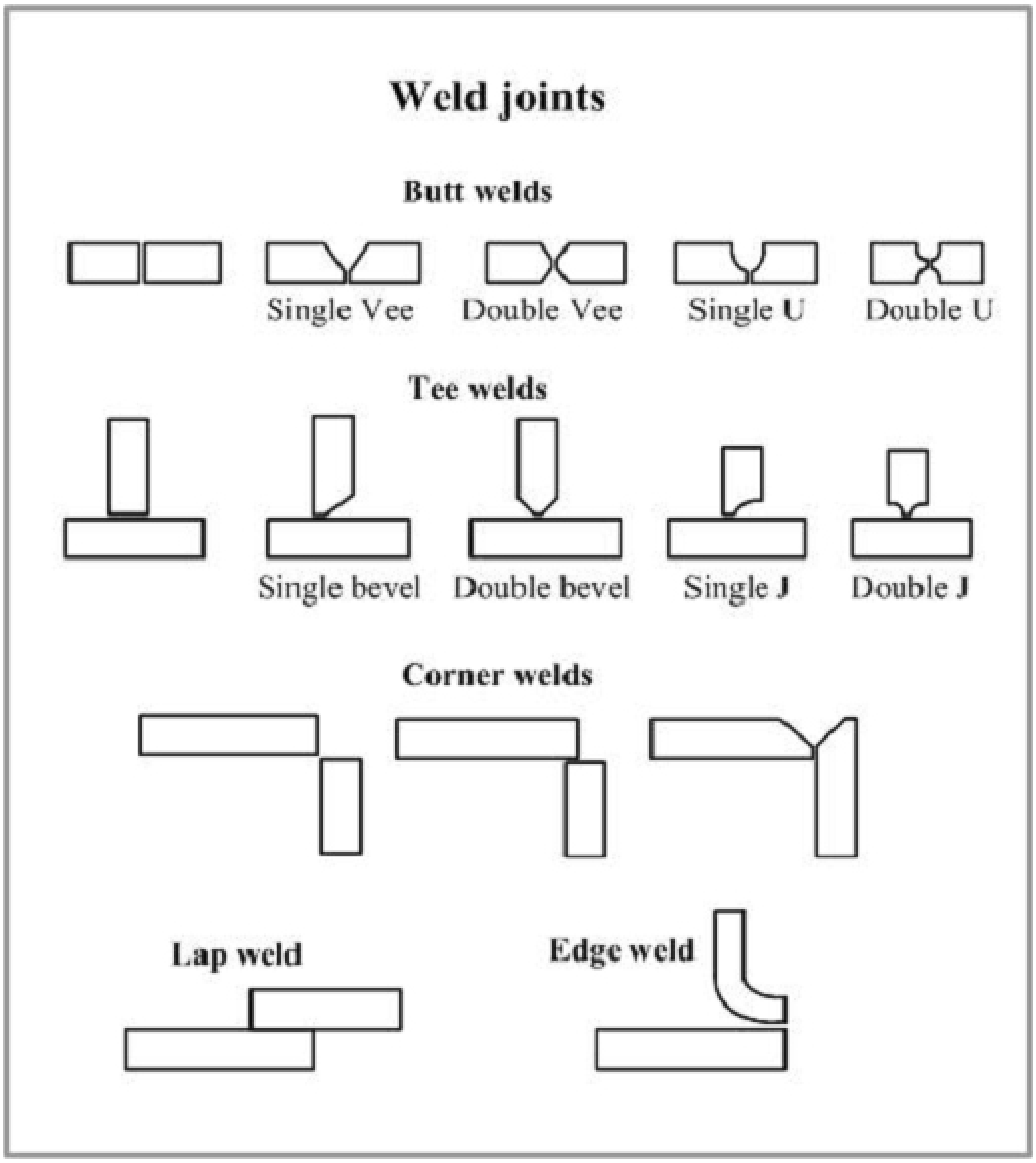


Fig.8.3 Types of welded joint

8.10. Welding Positions - The welding positions are classified as follows:

8.11. Flat position (F). - In this position, the filler metal is deposited from the upper side of the joint with the face of the weld horizontal.

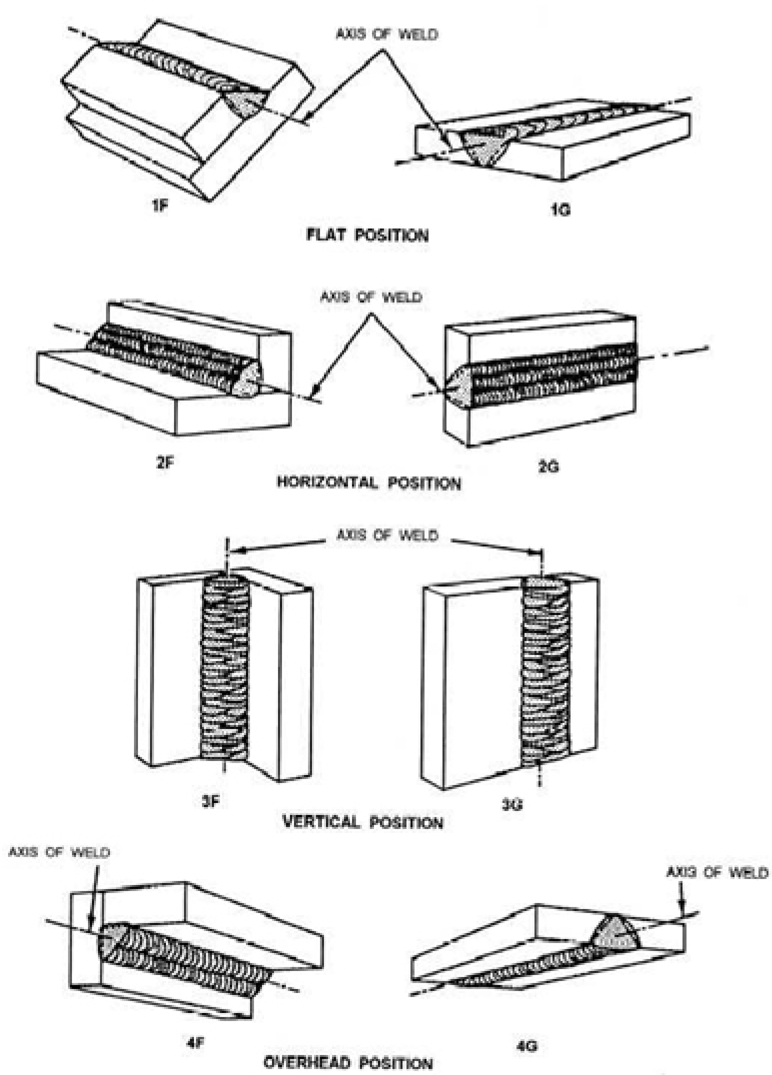


Fig.8.4 Welding position

8.11. Horizontal position(H). In this position, the weld is deposited upon the side of a horizontal and against a vertical surface.

8.12. Vertical position(V). In this position, the line of welding is in a vertical plane and the weld is deposited upon a vertical surface.

8.13. Overhead position(O) - In this position, the weld is deposited from the under side of the joint and the face of the weld is horizontal. It is the reverse of flat welding.

Resistance welding

In resistance welding the metal parts to be joined are heated to a plastic state over a limited area by their resistance to the flow of an electric current and mechanical pressure is used to complete the weld. Here two copper electrodes are incorporated in a circuit of low resistance and the metals to be welded are pressed between the electrodes. The circuit is thus completed and electricalresistance at the joint of metal is so high in comparison with the rest of thecircuit and if the current is heavy enough the highest temperature will beproduced directly at the joint.

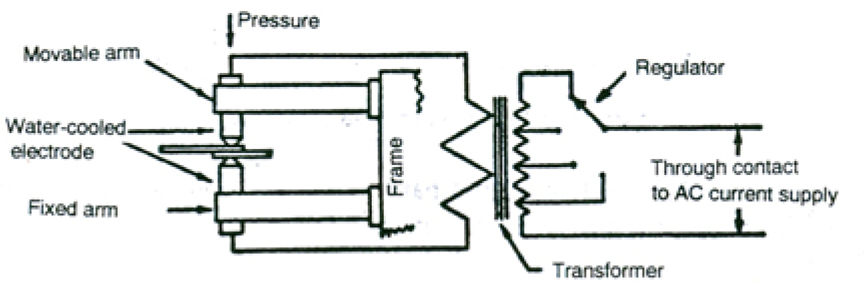


Figure 8.5 The electrical circuit of a resistance welder

Resistancewelding which is used with sheet metal from 0.5 to 3.2mm thick and with steelpipe tubing is employed mainly for mass production. Metals of medium and highresistance such as steel, stainless steel, monel metal, silicon bronze etc areeasy to weld. The resistance welding can be subdivided in number of processesbut the important are :

1) Butt

2) Spot

3) Seam

4) Projection

5) Percussion welding

Lesson-9
Gas welding

9.1. INTRODUCTION

In gas welding the heat required for heating and melting the parent and filler metals is obtained by the combustion of a fuel gas with oxygen. Fuel gases used in commercial gas welding practice are acetylene, hydrogen and natural gas.
Acetylene is the most widely used because the temperatures obtained by combustion of acetylene are much higher than those obtained by combustion of hydrogen or natural gas. Oxy-hydrogen flame may be used for welding thin sheets of steel and low temperature melting materials and alloys.

9.2. Supply of oxygen and Acetylene

Oxygen is industrially produced by electrolysis of water or by liquidation of air and separating oxygen. The gas produced is compressed and charged into cylinder with 40 liter capacity to a pressure of about 15.4MPa at 21ºC temperature.
Commercial acetylene is produced by the action of water on calcium carbide. High pressure storing and distribution of acetylene in cylinder is done by dissolving the gas in acetone. The steel cylinder used for storing acetylene is first packed with 80% porous material such as asbestos, or charcoal. Acetylene cylinders contain 1.7 to 9 cubic metres of free acetylene at a pressure of 1.7 MPa and a temperature of 20^{o}C.

9.3. Oxyacetylene flame

The oxyacetylene flame, like all other flames, is produced when the two gases meet and undergo combustion with the evolution of heat and light. With commercially pure oxygen and acetylene the hottest known flame is produced with an estimated temperature around 3500^{o}C.
The flame temperature obtained depends on the relative proportion of the fuel gas and oxygen drawn in the pure form. Since temperature is not the only requirement in commercial application of the oxyacetylene flame varying ratios of oxygen and acetylene have been found suitable for different applications.
Types of flames:
Flames can be classified into three categories:
1. Balanced or neutral flame.
2. Reducing or carburizing flame.
3. Oxidising flame.

Balanced or neutral flame: The balanced or neutral flame is produced by burning a one-to-one mixture of oxygen and acetylene at the tip of the torch nozzle. This flame is characterized by a well defined luminous cone gradually rounding off towards the tip.

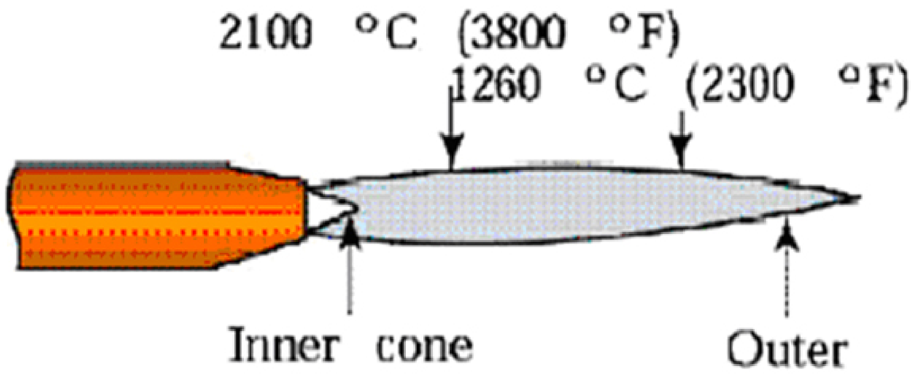


Fig. 9.1 Neutral flame

The intermediate zone is slightly reducing in nature and cannot be distinguished from the inner cone and the outside envelope. Welding is done using the flame in this zone. The envelope is neutral in nature and provides a protective atmosphere around the weld. The neutral flame is the most generally used flame for all heating and welding applications.

Oxidizing flame: The oxidizing flame is produced by burning acetylene with excess oxygen. The inner cone becomes short and pointed. The envelope also is shortened due to intense oxidation. The envelope is blue and the inner cone has reduced.

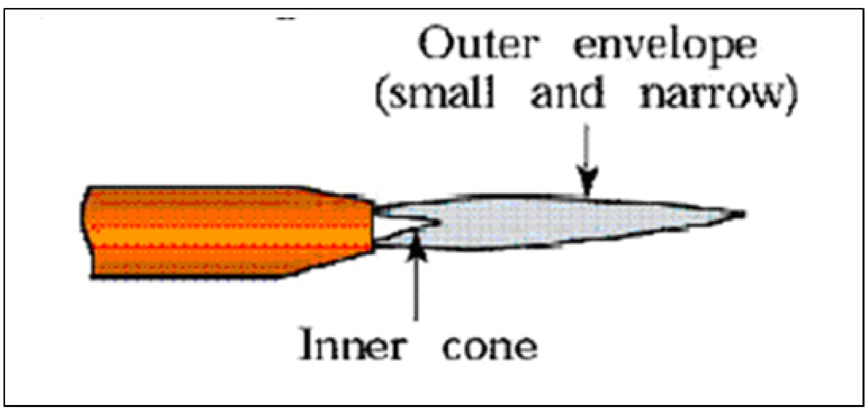


Fig. 9.2 Reducing or carburising flame:

The intermediate zone contains some free oxygen from the torch. It may also contain some carbon dioxide and is oxidizing in nature. This flame being the hottest of the oxyacetylene flames is used where the maximum flame temperature is desired. The oxidizing flame is used as a preheating flame in many oxyacetylene cutting operations. It is also used in the fusion welding of nonferrous metals, particularly, brass and bronze. The intense heat of the flame also takes care of the greater loss of heat associated with high thermal conductivity of non ferrous metals.

Reducing or carburising flame: This type of flame is obtained by burning an excess amount of acetylene. It is characterized by a secondary luminous intermediate zone surrounding the inner cone. The luminous cone is not so well defined as in the balanced flame. The intermediate or excess acetylene zone is not clearly demarcated from the outside envelope. The envelope takes on a reddish tinge and may carry some soot.

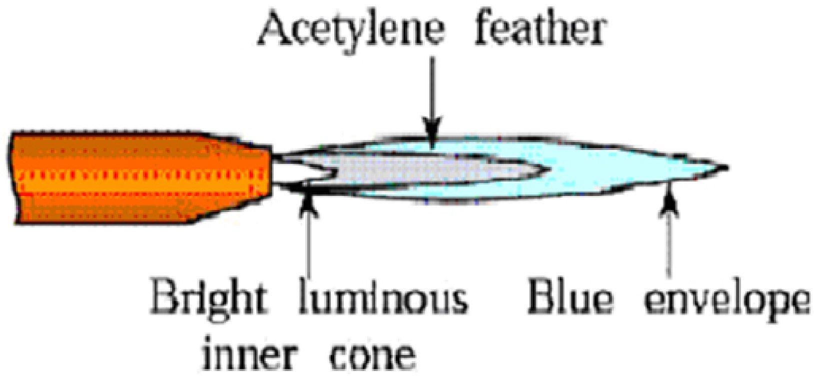


Fig. 9.3 Reducing or carburising flame:

The intermediate zone contains free carbon along with carbon monoxide and hydrogen.
It is reducing as well as carburizing in nature. If too much of acetylene in proportion to oxygen is supplied by the torch the envelope may also carry some carbon. The reducing flame finds applications where the highly reducing nature of the flame is conductive to welding as well as in cases where the carburizing nature offers an advantage.
It is used in the welding of metals like nickel, alloy steels and many of the non-ferrous hard surface materials. The carburizing nature of the flame is taken advantage of in the welding of low carbon steels to increase the rate of welding.

9.3. Flame Temperature

Temperature is one of the important characteristics of the flame. Higher the temperature more efficient is the heating and melting of the metal. The temperature of the flame is not constant. It varies along and across the flame and depends on the composition of the flame.
Welding is done using the flame in this zone. It decides the nature of the flame-reducing, carburizing or oxidizing. The flame temperature depends on the oxygen to acetylene ratio and increases with increase in this ratio upto a certain point. The limiting values are 1.2 to 1.9 with corresponding temperatures of 3300 to 3500^0C. The maximum temperature obtained in a reducing flame is about 2900^0C, that in a neutral flame about 3250^0C and for an oxidizing flame about 3500^0C.

9.4. Oxy-acetylene welding equipment

Majority of the oxy-acetylene welding is done manually. The commonly used oxy-acetylene welding set up consists of a welding torch with a set of tips, hoses, pressure regulators, cylinders containing oxygen and acetylene under pressure and accessories such as goggles, friction lighter and gloves. The basic set up is mounted on a trolley making it portable so that it can be readily taken to the job site.

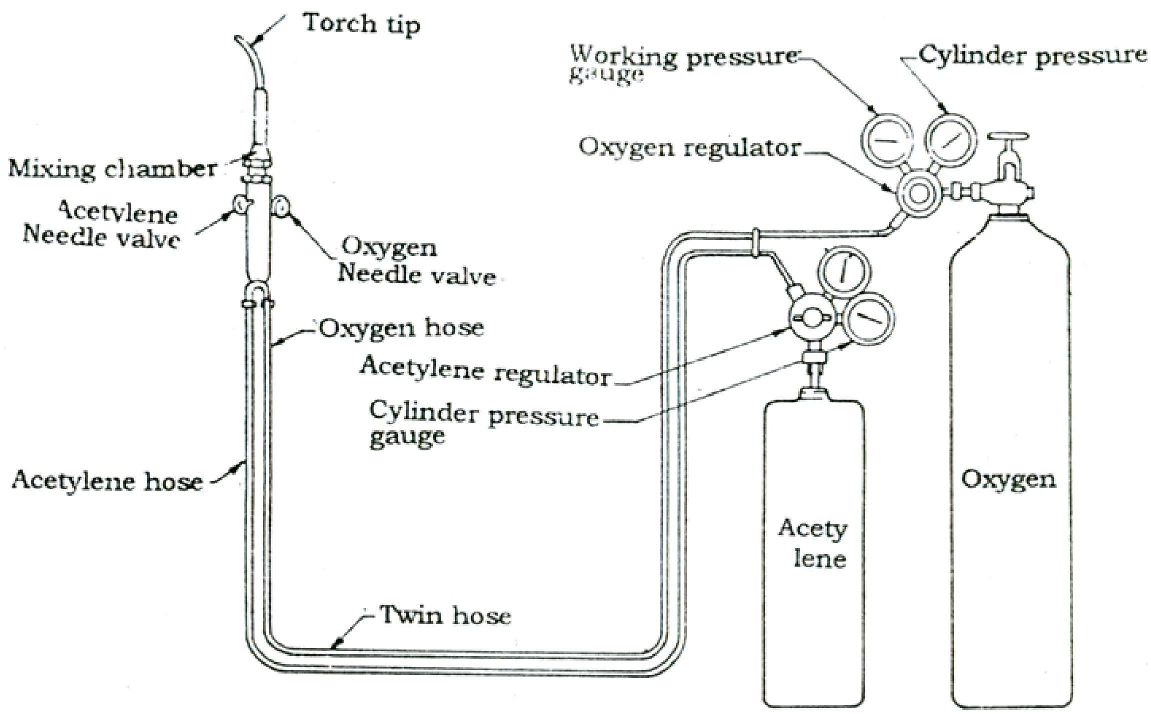


Fig. 9.4 Oxy-acetylene welding set

9.5. Welding Torch

The oxyacetylene welding torch is a device used for mixing the two gases in proportions, burning the mixture at the end of the tip and moving and directing the flame. The torch has a handle at one end of which are the inlet connections for the gases and valves for controlling the quantity of the gases. At the other end of the handle are the mixing chamber followed by the tip. The oxyacetylene flame is produced by lighting the mixture at torch tip.
Welding torch tips are made of a nonferrous metal such as copper because of its high thermal conductivity. High thermal conductivity of the tip material permits the tips to run cool and reduces the danger of their burning at high temperatures. Larger tip sizes, which release more gas mixture and produce more heat are used for welding thicker pieces of metal.

9.6. Pressure Regulators

The functions of pressure regulators are to reduce the high cylinder pressure to the desired working pressure, and to maintain a constant working pressure and volumetric rate of gas flow regardless of the gas source pressure variations.
Two pressure gauges are provided on the regulator, one to read the cylinder pressure and the other to read the pressure at which the gas is delivered to the torch. The desired working pressure is adjusted by a hand screw. When this screw is turned counter clock-wise till it runs free the valve in the regulator is closed and no gas can pass through. When the hand screw is turned clockwise the valve in the regulator opens and the gas passes through to the torch. The desired pressure is set by turning the screw handle till the pressure gauge reads this pressure.

9.7. Hoses

Hoses used for gas welding torches should be strong, non-porous, flexible and light. Reinforced rubber hoses specially made for the purpose are employed. Care should be taken to see that the hoses are not interchanged.
Colour code and safety.

Green or black colour is used for oxygen cylinders, hose and knobs on torches and maroon or red for acetylene cylinder, hoses, and knobs. All oxygen connections have right hand threads and acetylene connections left hand threads. This is done for proper identification and to avoid possible mistake in connections which may lead to dangerous consequences.

9.8. Welding rods

The properties and composition of a weld should match those of the base metal closely. For this reason different types of welding rods have been developed for welding of various ferrous and non ferrous metals.

The molten filler metal must flow smoothly and freely and unite with the base metal to produce sound, clean welds. Welding rods for ferrous metals are designed for producing welds of high tensile strength and ductility. Some of the rods are alloyed with silicon, manganese, nickel, chromium, vanadium, molybdenum and other metals to suit different welding requirements. Stainless steel is welded with rods containing chromium, nickel and titanium, molybdenum or niobium.

Welding rods are produced in a variety of diameter sizes ranging from 1.5.mm to 10 mm and in standard length of about 1 meter.

9.9. Oxyacetylene welding techniques

In oxyacetylene welding, the weld is started by preheating the base metal and producing a small puddle of molten metal.

In forehand welding the rod leads the torch in the direction of welding and the flame is directed forward in the direction in which weld is progressing. This technique produces good looking neat welds and is used for welding thin metal sheets up to 4 mm thick. Forehand welding as defined for a right hander with torch in right hand and filler rod in the left hand is leftwards and is also called leftward or forward welding.

In the backhand welding the torch leads the rod in the direction of travel and the flame is directed back at the molten metal puddle and the completed weld. This is a great help while welding in position like vertical or overhead where the molten metal otherwise may easily flow out of the weld. More heat is concentrated at the weld zone making the process suitable for welding of thicker work pieces. For a right hander backhand welding proceeds rightwards and hence is also called rightward or backward welding. Backward welding is used in pipe and plate welding.

Related Process

9.10. Oxygen cutting

Oxygen cutting is a process of controlled oxidation of ferrous metal. It is used extensively for cutting large metal pieces in the fabrication industry. For plain carbon steels the kindling or ignition temperature ranges from 750 to 850^{0}C. This corresponds to a bright red colour in day light. If a starting spot, normally at the edge of the piece, is heated to the kindling temperature and a jet of commercially pure oxygen is directed at the spot a very active chemical reaction results leading to oxidization or burning of steel. The iron oxide formed is very brittle and a narrow slot with uniformly smooth parallel walls is formed along the path of the jet. With skilled workmanship and mechanically guided cutting torches deep cuts with close tolerances and alignment can be made.

9.11. Gas cutting equipment

Gas cutting equipment is similar to the gas welding equipment except for the torch and the specially designed cutting oxygen regulator. The cutting torch heats the steel to kindling temperature with a number of small preheating oxyacetylene flames. These surround the central hole for the stream of oxygen which will do the cutting. Cutting oxygen pressure regulators are specially designed to deliver oxygen in large volumes and at higher pressure. They are fitted with working pressure gauges with a range up to 300 KPa. Cutting torches may be operated by hand or by machine. Machine operated oxygen cutting torches are manipulated mechanically, but the basic elements remain unchanged.

9.12. Soldering

Soldering is a process in which two or more metal items are joined together by melting and flowing a filler metal into the joint, the filler metal having a relatively low melting point than the melting point of metals to be joined.

a) Soft soldering is characterized by the melting point of the filler metal, which is below 400 °C. The filler metal used in the process is called solder , is an alloy of tin and lead. It is used extensively in sheet metal work for joining parts that not exposed

to the action of high temperatures and are not subjected to excessive loads and forces. A suitable flux to prevent oxidation of the surfaces to be soldered is used. Zinc chloride is the most common soldering flux.
b) Hard soldering employs solders which melts at high temperatures and are stinger than the soft soldering. The temperature of various hard solders vary f rom 600 to 900°C. When silver alloyed with tin is used as solder to join the parts, it is known hard soldering.
A soldering iron is a device for applying heat to melt solder for attaching two metal parts. A soldering iron is composed of a heated metal tip and an insulated handle. Heating is often achieved electrically, by passing a current, supplied through an electrical cord or a battery, through a heating element. Another heating method includes combustion of a suitable gas, which can either be delivered through a tank mounted on the iron (flameless), or through an external flame.

Advantages of soldering
· Low power is required;
· Low process temperature;
· No thermal distortions and residual stresses in the joint parts;
· Microstructure is not affected by heat;
· Easily automated process;
· Dissimilar materials may be joined;
· High variety of materials may be joined;
· Thin wall parts may be joined;
· Moderate skill of the operator is required.
c) Brazing:
The joining of two metal pieces by means of heat and a special filler metal having a melting point above 400ºC but lower than the melting point of the parts of be joined, is called brazing. The copper base and silver alloys are commonly used as filler metals for brazing. In brazing, the two metal pieces to be joined are, first of all, cleaned to remove all grease and oxide. The parts are fitted together along the line of joint and held in that position by some clamp. Borax is widely used flux. Many other proprietary brands are also available. The filler metal used for brazing is known as spelter. The actual heating may be done in different ways and accordingly the brazing methods are classified as torch brazing, furnace brazing, resistance brazing, immersion brazing etc.

Lesson-10

Introduction to lathe machine

Introduction

The main function of a lathe is to remove metal from a piece of work to give it the required shape and size.This is accomplished by holding the work securely and rigidly on the machine and then turning it against a cutting tool which will remove metal from the work in the form of chips.

10.1 Types of lathes:

1. Speed lathe 5. Tool room lathe

2. Engine lathe 6. Special purpose lathe

3. Bench lathe 7. NC and CNC lathe

4. Production lathe (Automatic lathe, capstan and turret lathe)

10.1.1. Speed lathe

A speed lathe derives its name from the fact that very high spindle speeds are used in this machine. This is the simplest of all lathes.

It consists of a bed supported on legs, a head stock, a tail stock and an adjustable slide for supporting the tool. There is no feed box, carriage or lead screw.

The workplace is held between centres or attached to the face plate.It may be driven from a variable speed motor. The tool is fed and controlled by hand while being supported on the tool slide.

The speed lathe is used principally for turning of wood for small cabinet work.

10.1.2. Engine lathe

Engine lathe is the most important member of the lathe family and the most commonly used. This lathe differs from a speed lathe in that a much larger number of speed steps are available on this machine.

The power to the engine lathe spindle may be given with the help of a belt drive from an overhead line shaft but most modern machines have a captive motor with either a cone pulley drive or an all geared head stock arrangement. The work piece may be supported between centres. The tools are held generally in the tool post on the carriage but sometimes in the tail stock.

10.1.3. Bench lathe

It is a small lathe that is mounted on a work bench. It is used for small work pieces having a maximum swing of 250 mm at the face plate. Lathes of this type are used for precision work on small parts for instrument making.

10.1.4. Production Lathe

Production lathes are machines designed to produce large number of duplicate parts faster and with less skill and labour. They employ faster work holding devices and may have two or more tools operating simultaneously. The supervision is simplified and much less skill is needed except for setting the machine. These machines may also be made partially or fully automatic with the operator being needed only for loading the bar stock and removing the finished workpieces. Depending upon the complexity, production lathes may be divided into automatic lathes, capstan and turret lathes.

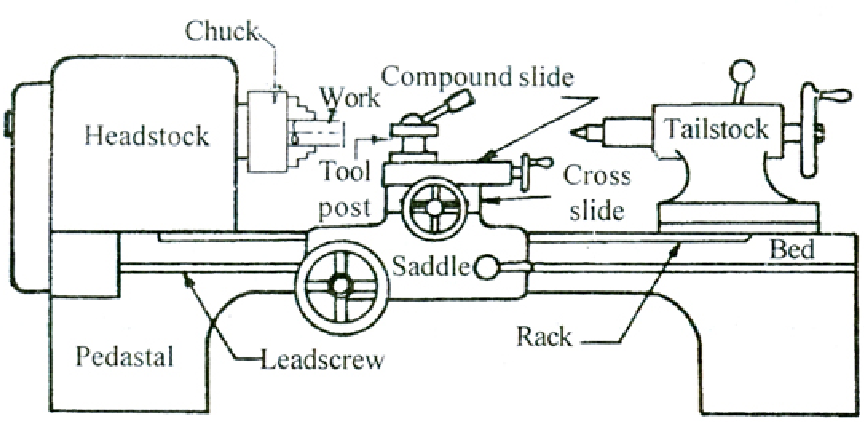
10.2. Lathe construction

The machine essentially consists of the following major units:

1. Bed
2. Head stock
3. Tall stock
4. Carriage assembly

10.6.4. Carriage Assembly:

The carriage assembly of the lathe comprises of a number of components which support, move and control the tool. The carriage assembly consists of a saddle, cross slide, compound rest, top slide, tool post and apron. Movement of the entire carriage assembly along the bed provides feed for the tool parallel to the lathe axis: movement of the cross slide along its guides on the saddle provides feed of the tool across the lathe axis and the movement of the top slide along its guide over the compound rest provides motion to the tool along a direction set by the compound rest. The movement of the carriage and cross slide may be by hand or by power but the movement of top slide is only by hand.



Parts of a lathe

Figure 10.1 A geared-head lathe

10.2.1. Bed

The bed of the lathe forms the base of the machine. It is supported on two legs at a convenient height. It carries the head stock and the tail stock for supporting the work and provides a base for the movement of the carriage assembly which carries the tool.

To ensure accurate machining work it is necessary that the bed has enough rigidly and torsional stiffness to withstand the action of cutting forces.

The bed of the lathe is sometimes made with a small gap in front of the head stock to accommodate short jobs which need a swing larger than that available on the rest of the bed.

10.2.2. Head stock

The head stock houses the spindle and the means for supporting and rotating the spindle. It is rigidly fixed on the bed. The spindle which is made of steel is made hollow so that long bars which are being machined at the end may pass through it. The right hand end of the spindle which projects out of the head stock body has a threaded outside and a tapered bore. For turning between centres a carrier plate may be mounted on the threaded end. In larger lathes instead of the threaded end, a flange is provided over which the dog plate, chuck or face plate as the case may be, are located and bolted. The tapered end and the hollow spindle also permit mounting of a draw-in collect chuck when designed.

10.2.3. Tail stock

The tail stock is for the purpose of primarily giving an outer bearing, support for work being turned on centres. It can be adjusted for alignment or non-alignment with respect to the spindle centre and carries a centre called dead centre for supporting one end of the work. Both live and dead centres have 60 conical points to fit centre holes in the work, the other end tapering to allow for good fitting into the spindles. Now-a-days, the dead centre is mounted in ball bearing so that it rotates with the job avoiding friction of the job with dead centre. This is specially necessary with heavy jobs.

10.2.4. Carriage Assembly

The carriage assembly of the lathe comprises of a number of components which support, move and control the tool. The carriage assembly consists of a saddle, cross slide, compound rest, top slide, tool post and apron. Movement of the entire carriage assembly along the bed provides feed for the tool parallel to the lathe axis: movement of the cross slide along its guides on the saddle provides feed of the tool across the lathe axis and the movement of the top slide along its guide over the compound rest provides motion to the tool along a direction set by the compound rest. The movement of the carriage and cross slide may be by hand or by power but the movement of top slide is only by hand.

Fig. 10.2 Carriage assembly

10.2.5. Lathe accessories

Lathe accessories include centres, catch plates and carriers, chucks, face plates, angle plates,mandrels, and rests. They are used either for holding and supporting the work or for holding the tool.

Lathe centres: The most common method of holding the work in a lathe is between the two centres –live centre and dead centre. They are made of very hard materials to resist deflection and wear.

Carriers and catch plates: Carriers and catch plates are used to drive a work piece when it is held between two centres.

Chucks: A chuck is one of the most important devices for holding and rotating a piece of work in a lathe. Work pieces of short length, and large diameter or of irregular shape which cannot be conveniently mounted between centres are held quickly and rigidly in a chuck.

The different types of chucks are :

(1) Four jaw independent chuck 4. Magnetic chuck

(2) Three jaw universal chuck 5 Drill chuck

(3) Combination chuck

10.3. Lathe operations

With suitable attachments and modifications a lathe can be made to perform any machining operation done on a number of general purpose machines. Operations commonly performed on a lathe include turning, facing, form turning, grooving, drilling,boring, knurling, taper turning and thread cutting.

10.3.1 **Turning**

Turning is the operation in which a cylindrical surface is produced. The work piece is supported between centres or in any other work holding device, and rotated at the desired speed. The tool is first given a depth of cut by using the cross slide motion of the carriage and then given an axial feed by hand or power. Which can be made to overlap to produce a cylindrical surface on the work piece by adjusting the feed and having a large nose radius. Repeated cuts may be necessary to obtain a desired reduction of size. A final finishing cut may be given to the work piece with low depth of cut and feed but high speed to attain the desired degree of surface finish.

10.3.2. Facing

Facing is an operation used to produce a flat surface at right angles to the rotational axis of the job. In this case tool is fed at right angles to the job while the depth of cut is provided by the axial motion of the carriage. The job may be held in a chuck or between centres. In this centre about half of the front cone is removed to give access to the tool.

10.3.3 Drilling

The work piece is held in a chuck or on a face plate and the drill is held in the tail stock quill or in a drill chuck held in the quill. The taper in the quill ensures that the axis of the drill is concentric with the rotational axis of the spindle. Feeding is done by movement of the tail stock quill. Reamers, counter bores and other cutting tools may also be used similarly in place of drill.

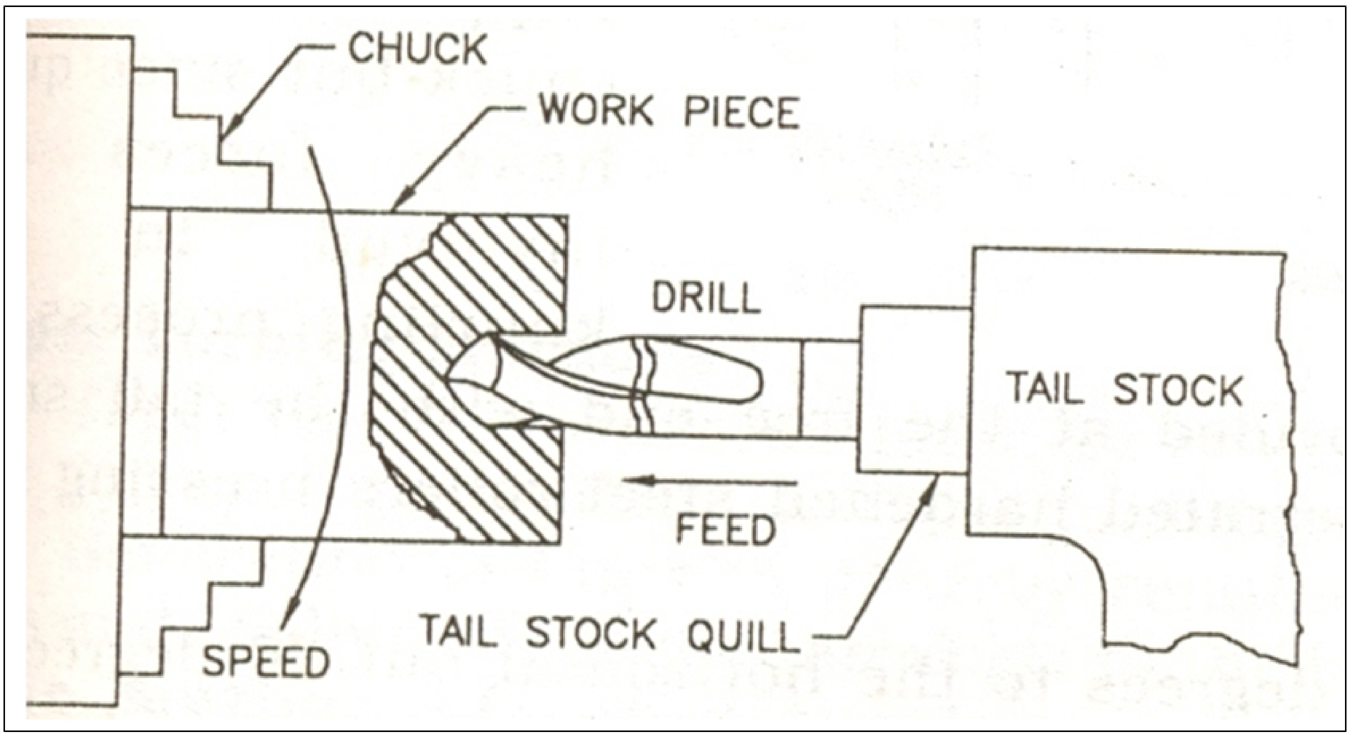


Fig. 10.3 Drilling operation

10.3.4. Boring

Boring is the process of enlarging a hole produced by drilling, casting, punching or forging with the help of a single point tool. Boring cannot originate a hole.In boring the job is held in a chuck or face plate and a boring tool held on the tool post are fed into it. The operation is similar to external turning in that the feed and depth of cut are given by the longitudinal and cross motions of the tool respectively. Since the enlarged hole is being generated with a motion of the work piece about an axial motion of the tool.

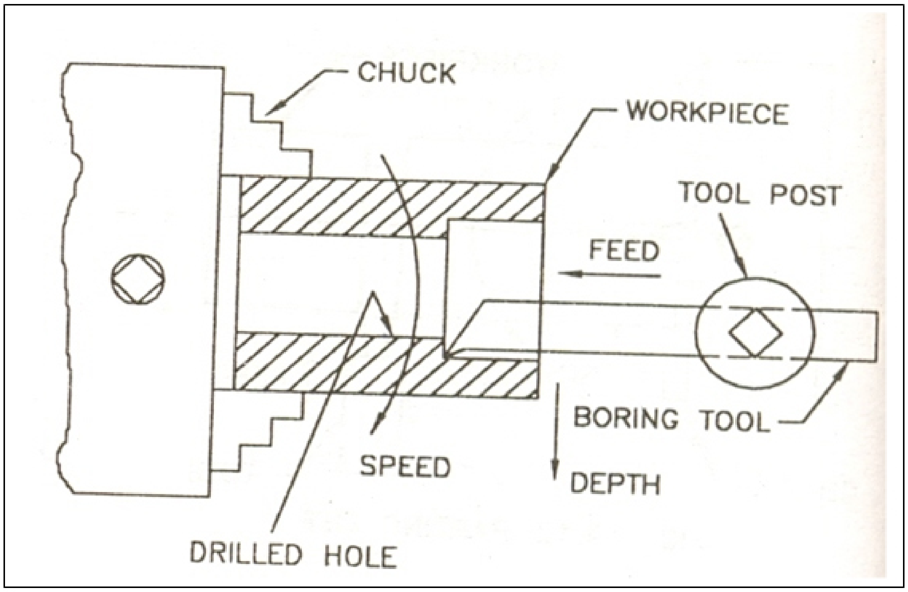


Fig. 10.4 Boring operation

10.3.5 Knurling

Knurling is the process of embossing a diamond shaped pattern on the cylindrical surface of a work piece. Knurling is done on the work piece so that it does not slip when held and operated by hand. The work piece is supported in the chuck but since quite heavy forces are involved in the knurling process an additional support is generally provided at the free end with the tail stock centre. Knurling is done with two serrated hardened steel rollers pressing into the work piece.

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Fig. 10.5 Knurling operation

The roller serrations are at 45 degrees to the horizontal but 90degrees to each other so that a diamond shaped pattern is produced by amechanical working process. No cutting is involved in the knurling process. Acomplete knurling tool head consists of three pairs of knurling rollers withdifferent depth and spacing of serrations to give fine, medium and coarseknurling.

10.3.6 Taper Turning :

Taper turning isthe process of producing external and internal conical surfaces by combiningthe rotation of the job and the relative angular feed of the tool. Tapers areused on many tools and machine components for alignment and for easy holding. Suchas the shank of twist drills, end mills and reamers, spindles of lathe anddrilling machine.

Thread cutting

Difficult forms ofthreads can be cut on a lathe by making certain adjustments and/or proving someattachments for the purpose.

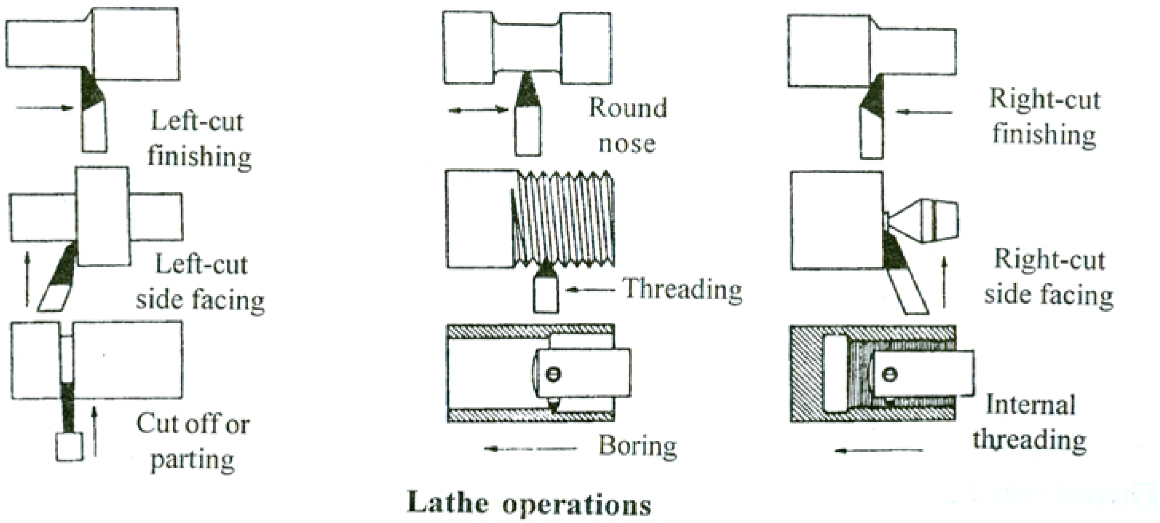

Fig. 10.6 Lathe operation

Lesson-11

Introduction to drilling machine

Introduction

The drilling machine is one of the most important machine tools in a workshop. As regards its importance, it is second only to the lathe. In a drilling machine holes can be drilled quickly and at low cost. The hole is generated by the rotating edges of a cutting tool known as the drill which exerts large force on the work clamped on the table. As the machine tool exerts a vertical pressure to originate a hole it is loosely called a drill press. Drilling machines are made in many types and sizes, each is designed to handle a class of work or specific jobs to the best advantage.

Types of drilling machines :

1. Portable drilling machine
2. Sensitive drilling machine
3. Upright drilling machine
4. Radial drilling machine
5. Gang drilling machine
6. Multiple spindle drilling machine
7. Automatic drilling machine
8. Deep hole drilling machine

11.1 Sensitive drilling machine

It is a small machine designed for drilling small holes at high speeds in light jobs. It may be bench or floor mounted. It consists of a base, a vertical column, horizontal table, a head supporting the motor and driving mechanism and a vertical spindle for driving and rotating the drill.Total drilling operation is manually controlled. The machine is capable of drilling holes from 1.5 to 15mm diameter.

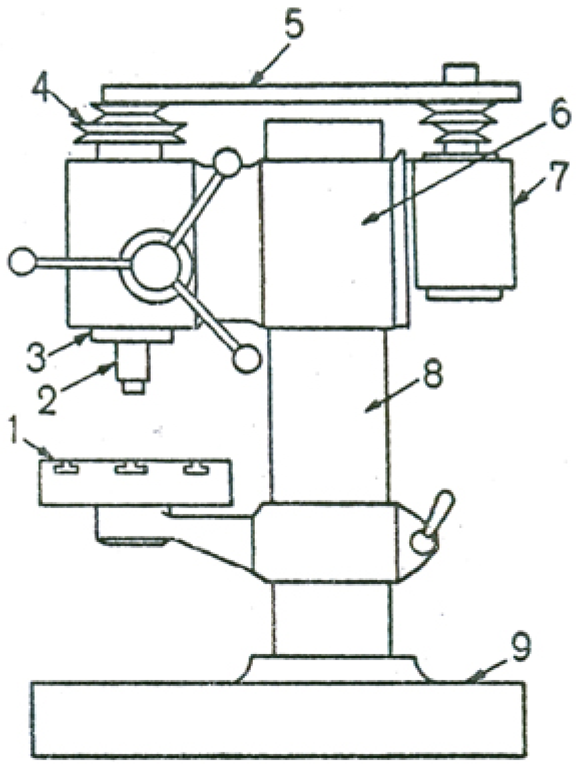

Figure 11.2 Sensitive drilling machine
1. Table, 2. Vertieal drill spindle, 3. Sleeve, 4. Cone pulley, 5. V-belt, 6. Head, 7. Driving motor, 8: Vertical column, 9. Base.

11.2. Upright drilling machine

The upright drilling machine is designed for handling medium sized workpieces. In an upright drilling machine a large number of spindle speeds and feeds may be available for drilling different types of work. The table of machine also has different types of adjustments. There are two general classes of upright drilling machine:

(1) Round column section or pillar drilling machine

(2) Box column section

11.2.1 Round column section or pillar drilling machine

The round column section upright drilling machine or pillar drilling machine consists of a round column that rises from the base which rests on the floor,an arm and a round table assembly, and a drill head assembly.

The arm and the table have three adjustments for locating work pieces under the spindle. The arm and the table may be moved up and down on the column for accommodating work pieces of different heights. The table and the arm may be moved in an arc up to 180^0around the column and may be champed at any position. This permits setting of the work below the spindle.

This is particularly intended for lighter work. The maximum size of hole that the machine can drill is not more than 50 mm.

11.2.2. Box column section upright drilling machine:

The upright drilling machine with box column section has the square table fitted on the slides at the front face of the machine column. Heavy box column gives the machine strength and rigidity. The table is raised or lowered by an elevating screw that gives additional support to the table. These special features permit the machine to work with heavier work pieces, and holes more than 50 mm in diameter can be drilled through this machine.

11.3. Radial drilling machine

The radial drilling machine is intended for drilling medium to large and heavy workpieces. The machine consists of a heavy, round, vertical column mounted on a large base. The column supports a radial arm which can be raised and lowered to accommodate work pieces of different heights.

The arm may be swung around to any position over the work bed. The drill head containing mechanism for rotating and feeding the drill is mounted in a radial arm and can be moved horizontally on the guide-ways and clamped at any desired position.

These three movements in a radial drilling machine when combined together permit the drill to be located at any desired point on a large work piece for drilling the hole.

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Fig. 11.2 Radial drilling machine

11.3.1. Plain radial drilling machine:

Ina plain radial drilling machine provisions are made for vertical adjustment of the arm, horizontal movement of the drill head along the arm, and circular movement of the arm in horizontal plane about the vertical column.

11.3.2. Semi universal machine

Ina semi universal machine, in addition to the above three movements, the drill head can be swung about a horizontal axis perpendicular to the arm. This fourth movement of the drill head permits drilling hole at an angle to the horizontal plane other than the normal position.

11.3.3. Universal machine

Ina universal machine, in addition to the above four movements, the arm holding the drill head may be rotated on a horizontal axis. All these five movements in a universal machine enable it to drill on a work piece at any angle.

11.4. Gang drilling machine

When a number of single spindle drilling machine columns are placed side by side on a common base and have a common work-table, the machine is known as the gang drilling machine.

In this machine four to six spindles may be mounted side by side. This type of machine is specially adapted for production work. A series of operations may be performed on the work by simply shifting the work from one position to the other on the work-table. Each spindle may be set up properly with different tools for different operations.

11.5. Multiple – spindle drilling machine

The function of a multiple-spindle drilling machine is to drill a number of holes in a piece of work simultaneously and to reproduce the same pattern of holes in a number of identical pieces in a mass production work. Such machines have several spindles driven by a single motor and all the spindles holding drill are fed into the work simultaneously. Feeding motion is usually obtained by raising the work-table.

11.6. Drilling operations

The operations that are commonly performed on drilling machines are 1. Drilling,

1. Reaming ,

2. Boring,

3. Counter-boring,

4. Counter-sinking,

5. Spot-facing

1. Drilling: This is the operation of making a circular hole by removing a volume of metal from the work piece by a cutting tool called drill.
2. Reaming: This is the operation of sizing and finishing a hole already made by a drill. Reaming is performed by means of a cutting tool called reamer having several cutting edges. Reaming serves to make the hole smoother, straighter and more accurate in diameter. Reamer may be classified as solid reamer and adjustable reamer.
3. Boring: This is the operation of enlarging a hole by means of adjustable cutting tools with only one cutting edge. A boring tool is employed for this purpose.

4. Counter-boring : This is the operation of enlarging the end of a hole, as for the recess for a counter-sunk rivet. The tool used is known as counter-bore.
5. Counter-sinking : This is the operation of making a cone-shaped enlargement of the end of a hole, as for the recess for a flat head screw.

Spot – facing: This is the operation of removing enough material to provide a flat surface around a hole to accommodate the head of a bolt or a nut. A spot-facing tool is very nearly similar to the counter-bore.

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Fig. 11.3 Drilling operations

Boring machine

The boring machine is one of the most versatile machine tools used to bore holes in large and heavy parts such as engine frames, steam engine cylinders, machine housing etc. which are practically impossible to hold and rotate in as engine lathe or a drilling machine.

Lesson-12

Introduction to milling and grinding machine

Milling

12.1. Introduction

Milling may be defined as a machining operation for removing excess material from a work piece with a multi-tooth rotating cutter.

Flat or curved surfaces of many shapes can be machined by milling with good finish and accuracy.

A milling machine may also be used for drilling, slotting, making a circular profile, gear cutting or helical milling with suitable attachments.

Generally the work piece is fed past the rotating cutter but sometimes feed may also be given to the cutter. The teeth of the cutter act as individual cutting edges each producing a small chip of its own.

12.2. Milling machines

Milling machines are made in a variety of designs and sizes. They may vary in terms of the drive mechanism, method of feeding, table movements' available number of cutters operating simultaneously etc.

12.3. Milling machines

Knee and column type milling machines are the general purpose machines most widely used in industry. They are capable of producing flat or formed surfaces and may also be used for gear or spine cutting, helical milling,drilling, boring and slotting when provided with suitable attachments. These machines are available with vertical or horizontal spindles and may be of plain or universal type.

12.3.1Plain Horizontal Knee-and-Column Type Milling Machine: A plain horizontal milling machine has a rigidly supported horizontal arbor on which the cutters are mounted. The spindle of the machine is hollow, with an internal taper at the end to accurately locate the arbor or the shank of a milling cutter. Arbors are held in place by a long bolt, called draw bar. This screws into the tapered end and is fastened at the back of the machine. The knee of the machine is mounted on the column and can be adjusted or fed lengthwise on top of the saddle in the third coordinate direction. Feed may be given by hand or power. The over arm extending from the top of the column carries a support for the outer end of the arbor. Braces are available to tie the arbor support and over arm to the knee for added support. Work pieces, various attachments and milling fixtures are fixed on the table making use of the T-slots provided on the table for this purpose.

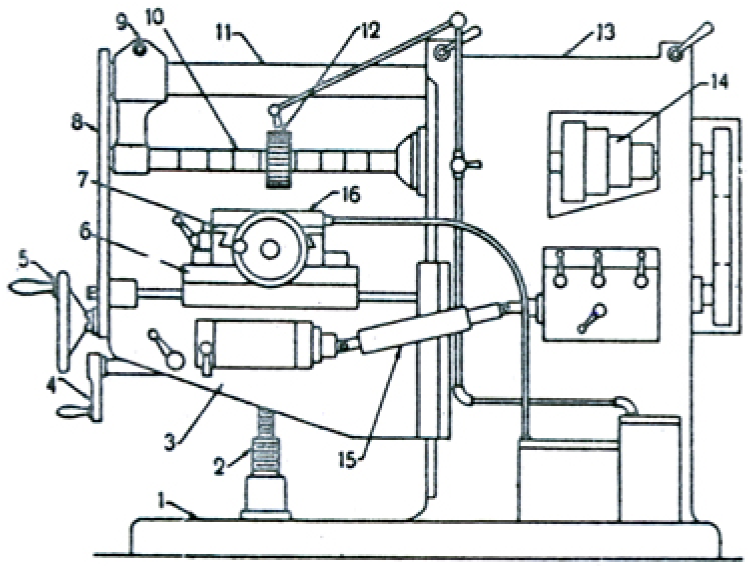


Fig. 12.1 Column and knee type milling machine
1. Base, 2. Elevating screw, 3. Knee, 4. Knee elevating handle, 5. Crossfeed handle, 6. Saddle, 7. Table, 8. Front base, 9. Arbor support, 10. Arbor, 11. Overhanging arm, 12. Cutter, 13. Column, 14. Conepulley, 15. Telescopic feed shaft.

12.4. Types of the cutters:

This classification of cutters is based on the general shape of the cutters or the type of work they will do.

12.4.1. Plain milling cutters: These are disc shaped cutters with teeth only on their circumference and no teeth on the sides. The teeth may be straight or helical if width exceeds 16 mm. These cutters are used for machining flat surfaces and may be called slab mills when used for slabbing work. Notches may be provided in the teeth of wide helical cutters used for heavy slabbing work to break the chips and help in their removal.

12.4.2. Side and face cutters: These cutters are similar to plain cutters except that they have teeth on one or both sides as well as on their periphery.They may have straight helical or staggered teeth.

These cutters are used for machining slots with smoother or more accurate sides than those machined with plain milling cutters.

12.4.3. Sitting saws: These are thin arbor mounting cutters with a thickness of 5 mm or less. They resemble plain milling cutters with cutting edges only on the outer surface. They are used for producing narrow slots or for parting-off operations. The sides of these cutters are relieved by grinding so that the sides do not rub during use.

12.4.4. Angle milling cutters: The teeth on these cutters are cut on conical surfaces. Both single and double conical surface cutters are available. Angle cutters are used for machining dove-tails, ratchet wheels, flutes on reamers etc.

12.4.5. Form milling cutters: Cutters of this type include concave and convex cutters, gear cutters, fluting cutters and many other cutters with special contours. These cutters produce an inverse replica of the shapes of their cutting edges on the work piece. Some of these cutters like gear-tooth space cutters and flute cutters are available in standard sizes, others must be made specially for the job. It is necessary to ensure that the contour of the cutting edges of a form milling cutter is not changed when re-sharpening the cutter.

12.4.6. End mills: These are shank mounting cutters with teeth at the end as well as on the periphery. They have either straight or helical flutes. They are used for cutting slots, producing recesses, squaring ends or surfacing.

12.4.7. T-slot cutters: Cutters of this type are used for cutting T-slots. They resemble small plain milling cutters with straight or tapered shanks for holding in the spindle.

12.5 Grinding

Introduction

Grinding is a metal cutting operation performed by means of a rotating abrasive wheel that acts as a tool.This is generally used to finish work pieces which must show a high surface quality, accuracy of shape and dimensions. Mostly grinding is the finishing operation because it removes comparatively little metal about 0.25 to 0.50 mm in most operations and the accuracy in the dimensions is in the order of 0.000025 mm. grinding may be of two types: 1. Rough or non-precision grinding where the work is held in operator’s hand. The work is pressed hard against the wheel or vice-versa. The accuracy and surface finish obtained are of secondary importance and considerable amount of metal is removed.

2. Precision grinding which is concerned with producing good surface finish and high degree of accuracy. The wheel or work or both are guided in precise path.

Grinding Machine

Grinding machines are of rough type or precision type. Rough grinder may be floor stand and bench grinder, portable and flexible shaft grinder, swing frame grinder or abrasive belt grinder type. Precision grinders may be cylindrical grinder, internal grinder, surface grinder, tool and cutter grinder or special grinder type.

The simplest type of grinder is the floor stand grinder with a horizontal spindle with wheels usually at both ends and is mounted on a base or pedestal. There is a provision for driving the wheel spindle by belt from motor at the rear at floor level. Frequently the wheels are mounted directly on the motor shaft extensions, where the motor is on the stand. The small size machine mounted on a bench is called bench grinder. All the grinding machines operate on the same principle but the different work holding and wheel driving mechanisms and attachments are provided to achieve desired grinding.

Grinding wheels

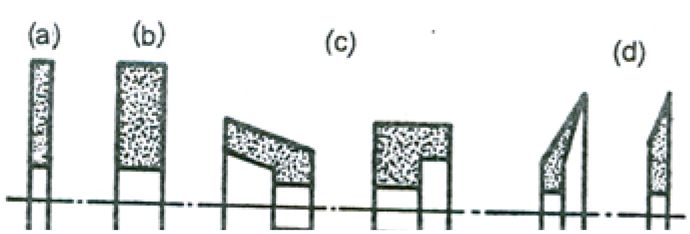
Grinding wheel is a multi-tooth cutter made up of many hard particles which do the cutting. Abrasive grains are mixed with suitable bond which acts as a matrix or holder when the wheel is in use. The abrasive wheel is usually mounted on some form of machine adopted to a particular type of work. It must be hard and tough and the wheel surface must be capable of gradually breaking down to expose new sharp cutting edges to the material being ground. The material components of a grinding wheel are the abrasive grain and the bond; however there are other physical characteristics such as grain size, structure and wheel shape must be considered in grinding wheel manufacturing and selection.

Abrasives:

1. Natural : sand stones, silicon quartz, emery corundum and diamond.
2. Artificial or manufactured : Aluminium oxid (Al_2O_3) known as alundum and aloxide, silicon carbide known as carborundum and crystolon.

Abrasive grains are bonded together in the form of grinding wheel generally by bonds like vitrified, resinoid, rubber, shellar, silicate and oxy-chloride,vitrified, resinoid and rubber bonds are the most common.

Grinding wheels are made indifferent shapes and sizes to adopt them for use in different types of grinding machines and on different classes of work. The shapes of the wheels may straight, cylindrical, cup, dish, segmented etc as shown below.



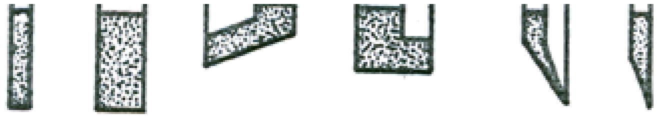


Fig. 12.2 Principal shapes of grinding wheels
a-disc, b-straight, c-cup, and d-dish.

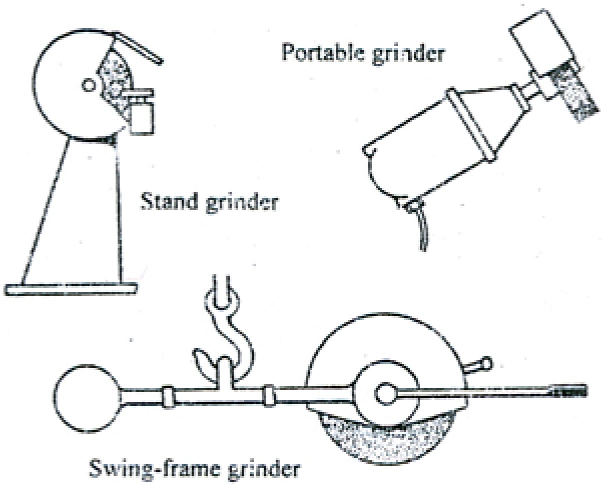


Figure 12.3 Rough grinding machines
1. Stand grinder, 2. Portable grinder,
3. Swing frame grinder.

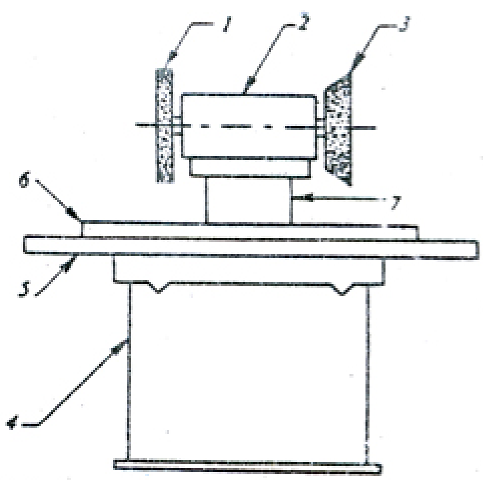


Figure 12.4 Block diagram of a tool and cutter grinder
1. & 3. Wheel 2. Wheelhead, 4. Base, 5. Saddle, 6. Table, 7. Column.

Lesson-13

Introduction to shaper and planer machine, CNC machines

13.1. INTRODUCTION

A shaper is a machine tool that uses reciprocating straight line motion of the tool and a perpendicular feed of the job or the tool. By moving the work piece across the path of the reciprocating tool a flat surface is generated regardless of the shape of the tool. With special tools, attachments and devices for holding the work, a shaper can also be used to cut external and internal key ways, gears, racks, dovetails, T-slots and other miscellaneous shapes.

Shaping is essentially an inefficient method of metal removal but the simplicity of the process coupled with short set up time and cheap tooling makes it extremely useful for single job.

The most common type of horizontal shapers is the production push cut shaper. This type of shaper consists of a frame or column supported on abase, a reciprocating ram and a work table. The frame houses the drive mechanism of the shaper. The top of the frame provides guide ways for the ram.The front of the frame provides guide ways for a cross rail which can be moved up and down. Sliding along the cross rail, perpendicular to the line of motion of the ram is a saddle which carries the work table. On the front end of the ram is fitted a tool head which holds the tool and is provided with means for feeding the tool into the work.

The reciprocating motion of the ram provides the straight line motion to the tool which is the speed for cutting. The vertical movement of the cross rail permits jobs of different heights to be accommodated below the tool and is a machine setting. Motion of the table along the cross rail provides the feed motion for horizontal shaping. The motion of the tool slide on the tool head in conjunction with the swivel base provides feed motion for vertical and angular cuts. The motion of the table along the cross rail for feeding is powered by a paul and ratchet arrangement and timed by actuating the paul by the shaper ram drive the feed is provided at the end of return stroke.

The tool slide swivel base is held on the circular seat on the ram and is graduated to indicate the angle of swivel. The apron consisting of the clapper box, the clapper block and the tool post is clamped on the vertical slide by a screw. It can be swivelled about the apron swivelp in by releasing the clamping screw. The clapper block which carries the tool post is connected to the clapper box by means of a hinge pin. The clapper box-blocks assembly provides a rigid support to the tool in the forward or cutting stroke but on the return stroke the clapper block is lifted out of the clapper box to clear the tool from the work piece. This prevents scratching of the work piece and wear of the tool due to tool dragging.

Shaper mechanism

In a shaper rotary movement of the drive is converted into reciprocating movement by the mechanism contained within the column or frame of the machine. The ram holding the tool gets the reciprocating movement. In a standard shaper metal is removed in the forward cutting stroke, while the return stroke goes idle and no metal is removed during this period. This mechanism is known as quick return mechanism. The reciprocating movement of the ram and quick return mechanism of the machine usually obtained by any one of the following methods:

1. Crank and slotted link mechanism
2. Whitworth quick return mechanism
3. Hydraulic shaper mechanism

The principle of quick return motion is illustrated in fig. 13.1. when the link is in the position PM, the ram will be at the extreme backward position of its stroke, and when it is at PN, the extreme forward position of the ram will have been reached. PM and PN are shown tangent to the crank pin circle stroke, therefore, takes place when the crank rotates through the angle C_1KC_2 and the return stroke takes place when the crank rotates through the angle C_2LC_1. It is evident that the angle C_1KC_2 made by the forward or cutting stroke is greater than the angle C_2LC_1 described by there turn stroke.

The angular velocity of the crank pin being constant the return stroke is, therefore, completed within a shorter time for which it is known as quick return motion.

Cutting time to return time ration usually varies between 2:1 and the practical limit is 2:2.

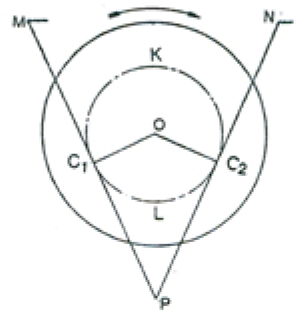


Fig. 13.1 Principle of quick return

Figure 13.1 Principle of quick return

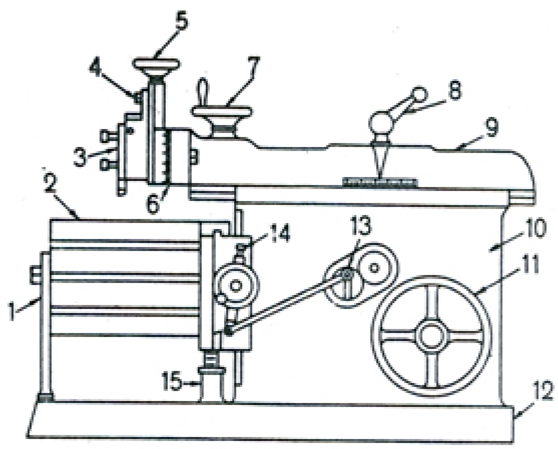


Fig. 13.2 Parts of a standard shaper

1. Table support, 2. Table, 3. Clapper box, 4. Apron clamping bolts, 5. Downfeed hand wheel, 6. Swivel base degree graduations, 7. Position of stroke adjustment handwheel, 8. Ram block locking handle, 9. Ram, 10. Column, 11. Driving pulley, 12. Base, 13. Feed disc, 14. Pawl mechanism, 15. Elevating screw.

Figure 13.2 Parts of a standard shaper

Planer

The planer is almost exactly similar to a shaper, and is primarily intended to produce plane and flat surfaces by a single point cutting tool. The fundamental difference between a shaper and planer is that the table reciprocates past the stationary cutting tool and feed is supplied by the lateral movement of the tool, where as in a shaper the tool reciprocates and the feed is given by the crosswise movement of the table.

Longer stroke of practically unlimited length can be obtained by having the work piece attached to a long, horizontal, reciprocating bed while the tool is attached to a massive column or arch or, rather, a cross-rail with a lead screw that generates the feed movement.

Most planer cut in one; some, in both directions. The slots and holes are provided for bolts,keys, pins for holding and locating work pieces on the finished table top.

The large work that is not expected to be machines on other machines, such as shapers is conveniently machined on planners.

Slotter

The slotter machine operates almost on the same principle as that of a shaper. The major difference between a slotter and shaper is that in a slotter the ram holding the tool reciprocates in a vertical axis, whereas in a shaper the ram holding the tool reciprocates in a horizontal axis. A slotter is therefore, considered a vertical shaper, and they are almost similar to each other as regards their construction, operation, and use.

The slotter is used for cutting grooves, key ways, and slots of various shapes, for making both internal and external regular and irregular surfaces.

NC-CNC machine tools

Numerical control or computerised numerical control is a technique of automatically operating a productive facility based on code of letters, numbers and special characters. The complete set of coded instructions; responsible for executing an operation is called part programme. In computer-aided part programming, much of the tedious computational work needed in manual programming is performed by the computer microprocessor. This programme is translated into electrical signals to drive various motors to operate the machine to carry out the required operations. Avoidance of human intervention, omission of conventional tooling and fixturing and quick change capability of NC system are the primary factors considered to decide the level of acceptance of machine tools for a particular job. All NC/CNC machine tools are provided with drive motors and other accessories to do auxiliary functions of the machine along with the work table, spindle and other hardware of the traditional machine tools.

Lesson-14

Wood working tools and their use

14.1. Marking and Measuring Tools:

Carpenters' folding rule: This is a wooden scale used for measuring and setting out dimensions. It consists of four pieces each 15 cm long hinged at the ends to make folding. When opened out its total length is 60 cm.

Straight Edge: The straight edge is a machined flat piece of wood or metal used for testing the trueness of surfaces.

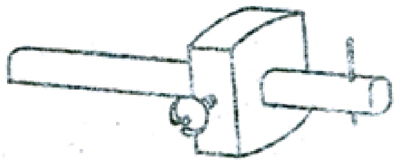
14.2. Try square: Try squares are used for a variety of purposes like measuring and setting out dimensions, testing flatness, drawing parallel lines at right angles to a plane surface and checking square ness of two adjacent surfaces. A try square consists of a steel blade with a wooden or cast iron stock. Sizes vary from 150 to 300 mm according to the length of the blade. The blade is graduated to serve as a scale.

14.3. Gauges: Gauges are very important carpentry tools used for marking and for cutting. A gauge essentially consists of a small square or rectangular wooden stem sliding in a wooden stock. The stem carries one or more steel marking points or a cutting knife. The gauge is then held firmly against a planed surface and pushed along to get the required markings.

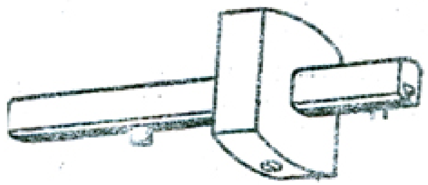
The three commonly used gauges are marking gauge, mortise gauge and cutting gauge.

The marking gauge has one marking point. It gives an accurate cut line parallel to a true edge, usually along the grain. The mortise gauge has two marking points one fixed near the end of the stem and the other attached to a sliding bar. The two teeth cut two parallel lines, called mortise lines needed for joints etc.

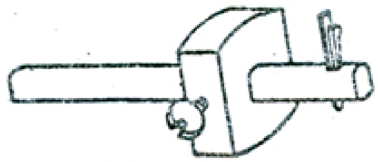
The cutting gauge is similar to a marking gauge but instead of a marking pin it consists of a steel cutting knife held in position by a wedge. The wedge enables the depth of cut to be varied. This gauge is used for cutting parallel strips of thin sheets of wood up to 3 mm thick, for gauging fine deep lines and cutting small rebates.



(a) Marking gauge



(b) Mortise gauge



(c) Cutting gauge

Figure 14.1 Gauges

14.4. Cutting Tools

Saws:

All the saws used in wood working essentially consist of two main parts-the blade and the handle. The blade carries the cutting teeth and is made of steel. The handle is made of wood and is used for holding the blade and applying pressure. The teeth of the saw are given a set to prevent the saw from binding during the sawing operation.

The saws are classified as push cut saws or pull cut saws depending upon whether they cut in the forward stroke or in the return stroke. Push cut saws are in more common use than pull cut saws.

Saws are generally specified by the length of the blade measured along the toothed edge and pitch of teeth expressed in millimeters.

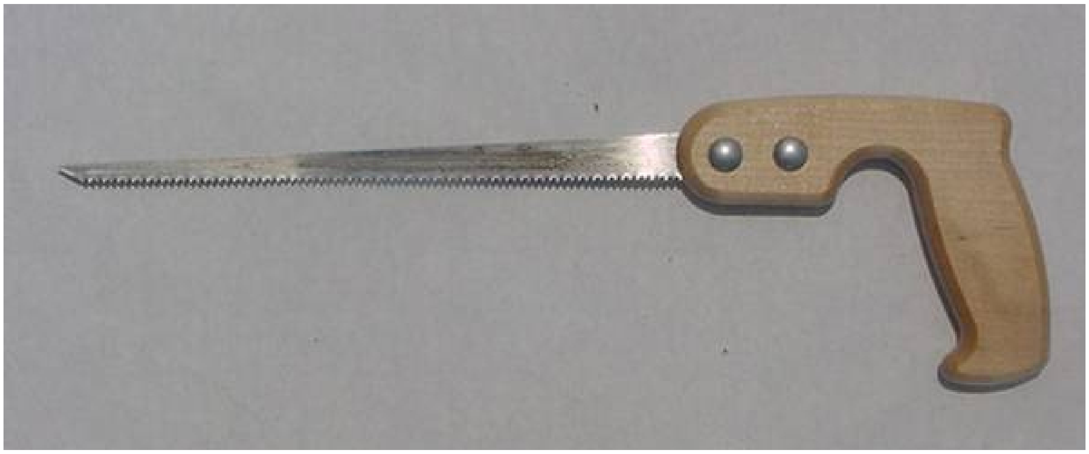
The common types of saws used in wood working are the following:

1. Rip Saw: Rip saws are used for cutting along the grains in thick wood. The blade is about 120 to 200 mm wide near the handle and about 60 to 100 mm near the tip. The cutting action starts from near the tip and gradually the whole length is involved. The length of the blade is about 700 mm and the tooth pitch 5 to 8 mm.

Hand Saw: The cross cut or hand saw is designed primarily for cutting across the grains but is used as a general purpose saw in wood working. Its blade is 500 to 700 mm long. A blade with finer pitch is preferred for hard wood and that having coarse pitch for soft wood. This saw can be used for cutting along the grains but is slow compared to rip saw.


Fig 14.2 Cross cut saw

1. Compass Saw: This saw has a narrow tapering blade about 250 to 400 mm long fixed to an open wooden handle. It is used for cutting curves in confined spaces. The blade is quite flexible and can thus be easily used for taking straight or curved cuts on the inside or outside surfaces of the work piece. Compass saws are commercially available in two designs one with a fixed blade and the other in which three interchangeable blades of different widths can be fitted.



1. Tennon or back : More commonly used for cross-cutting when a finer and more accurate finish is required. Blade being very thin, is rain forced with a rigid steel back. Blades are of 250 to 400 mm long with 13 teeth per 25mm.

14.5. Chisels

A large variety of chisels is used in carpentry work for removing wood varying from very fine shavings removed by hand pressure to thick sections removed with the help of a mallet.

Chisels have forged steel blades fitted into wooden handles and are specified by the shape and width of the blade.

The four common types of chisels are following

1. **Firmer Chisel**: This chisel has a flat blade about 100 to 150 mm long and 3 to 5 mm thick. It is the most general purpose chisel. It is used by hand pressure or mallet depending on the amount of material to be removed. Width varies from 3 to 50 mm.

2. **Bevelled Edge Firmer Chisel**: Also known as dovetail chisel this type of chisel has beveled edges as shown. The beveling of the edges reduces the thickness of the chisel at the sides enabling it to enter sharp corners and finish them. This chisel is used for fine and delicate work

3. **Paring Chisel**: Firmer and beveled edge firmer chisels when made with long thin blade are known as paring chisels. Such chisels are generally manipulated by hand and are 5 to 50 mm wide and 225 to500 mm long.

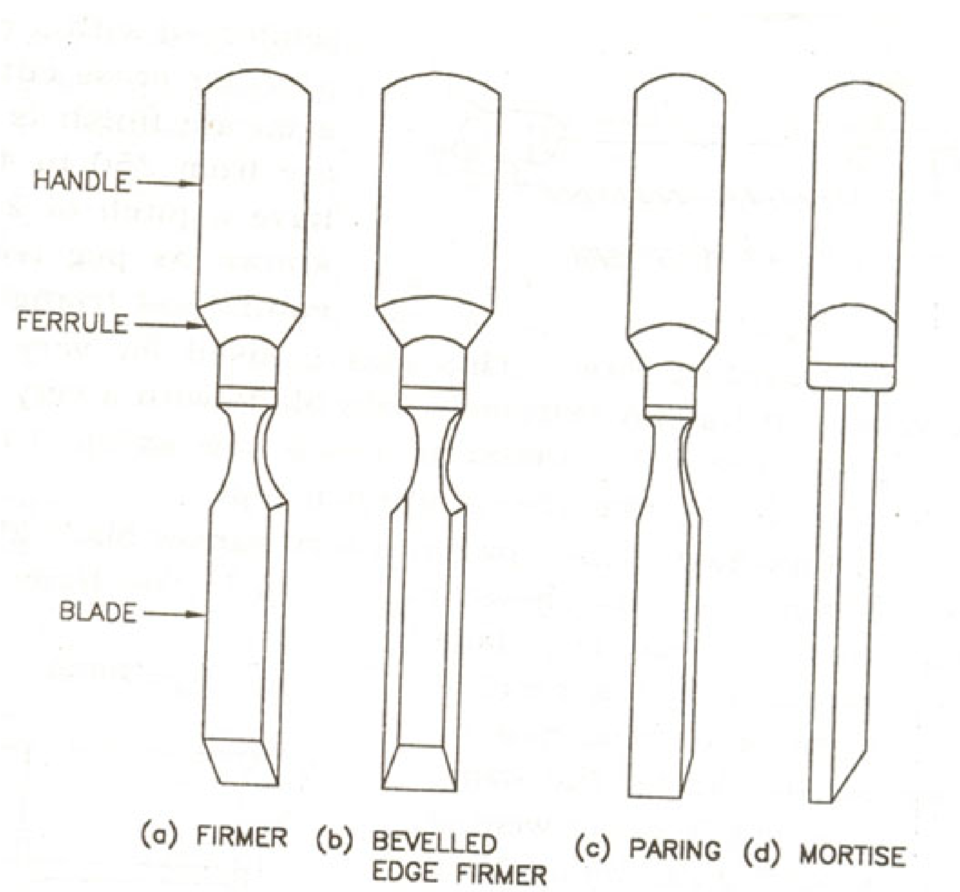


Fig. 14.4 Types of chisels

4. **Mortise Chisel**: This type of chisel is used for taking heavy and deep cuts resulting in more stock removal as in making mortises. It is made with a heavy blade with generous shoulder or collar to withstand the larger force of the mallet blows. Blades vary in width from 3to 16 mm. The blade thickness is form 6 to 15 mm.

Axe:

The axe consists of a steel head and a wooden handle. It is used for removing the back etc. from the wood and for splitting the logs.

14.6. Planning Tools

In the past all planes were made out of high quality wood but metal planes have now replaced wooden planes. As compared to wooden planes metal planes are more efficient, can be used with greater control, can be easily adjusted and give better finish. The planes more commonly used include the following:

14.7. Wooden Jack Plane: A jack plane is the first plane used on timber for trueing it. It consists of a block of wood or stock into which the blade is fixed with a wooden wedge. The bottom face of the stock called sole is made perfectly smooth and level. The blade made of high carbon steel is fixed at 45 degrees to the sole and is held in position by atapered wooden wedge. Another blade is fixed on the cutting block between the blade and the wedge. This does not do any cutting but only supports the cutting blade and prevents shattering. It also helps in breaking the shavings as they are produced by making them curl. Jack planes are 350 to 425 mm long with blades 50 to 75 mm wide.

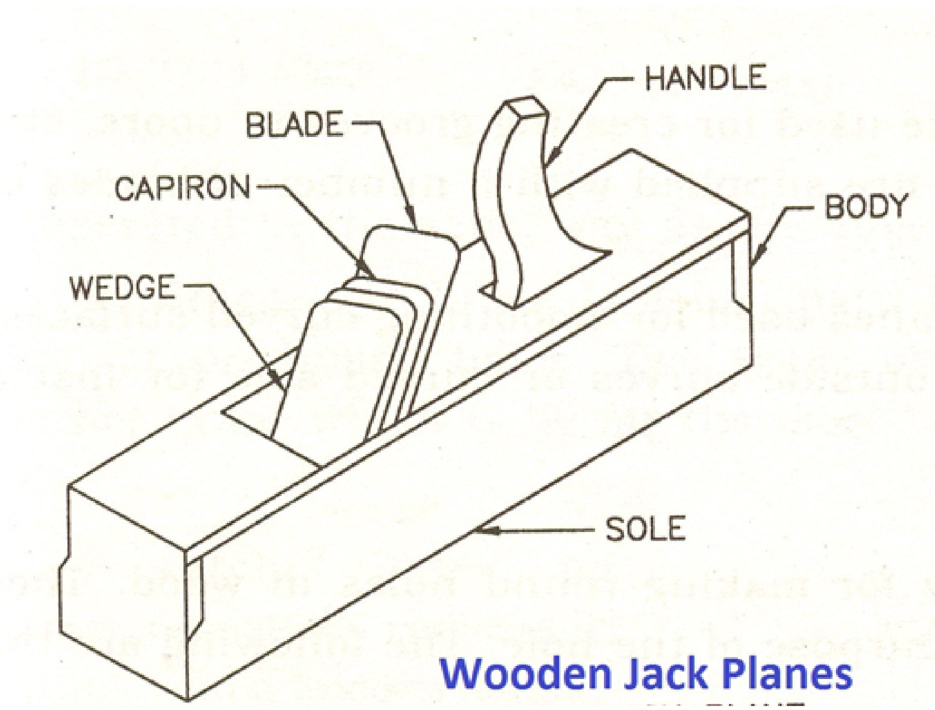


Fig. 14.5 Wooden jack planes

14.8. Metal jack plane: Metal jack planes serve the same purpose as wooden jack planes but facilitate a smoother operation and better finish. The body of a metal plane is made from a gray iron casting with the sides and sole machines and ground to a bright finish. The thickness of the shaving removed is governed by a fine screw adjustment and a lateral adjustment lever is used for adjusting the blade at right angles.

Other planes:

1. Trying plane : For finidhing plane with very fine cut.
2. Smoothing plane : Small in size and used for smoothing and finishing.
3. Rebate plane : For making recess along the edge of the wood piece.
4. Plough plane : For making small grooves where panel fitting is required.

14.9. Boring Tools

Boring tools are needed frequently for making round holes in wood. They are selected according to the type and purpose of the hole.

Spring bit: Spring bit is used for drilling holes not larger than 5 mm in diameter. It maybe driven in by a hammer or with an oscillatory motion of the hand. It is chiefly used for making lead-holes for large nails or screws.

Brace : Used for holding and turning bit for boring holes. It may be a ratchet or wheel brace type.

Auger: Auger is a long steel bar with a fluted body for half of its length and an eye at the top through which a handle can be fitted for turning the auger. A small screw is provided at the bottom of the auger to serve as a pilot in starting a hole. The anger is operated by holding the handle in both hands and rotating while simultaneously pressing downwards. Augers are chiefly used for rough structural work and are available in various sizes up to 25 mm diameter. Small auger bits are also available for use with braces.

Gimlet: A gimlet is a smaller form of auger and is used for producing small holes. It is operated in the same way as the auger.

Auger Bit: An auger bit as mentioned earlier is a small auger. It has a screw point and a helical or twisted stem. This bit produces long, clean and accurate holes from 6 to 35 mm diameter a longor across the grains. Since the whole body of the bit is fluted, removal of shavings is easier and as such this bit is extremely useful for drilling deep holes.

Counter sink Bit: This bit is used for making conical depressions to receive screws etc. This bit is also known as arose bit.

14.10. Striking Tools

Striking or impelling tools are used for driving chisels and nails into the wood and for assembly work. The two types of striking tools used for wood-working are (i) mallet and (ii) hammer.

Mallet: A mallet is a small wooden hammer of round or rectangular cross section. It is made of hard wood. A mallet is used to give light blows to the cutting tools with wooden heads such as chisels and gouges.

Figure 14.6 Mallet

Hammers: Twotypes of hammers are normally used in wood working: cross peen hammer and theclaw hammer. The cross peen hammer is used for light bench work. It has caststeel head with the face and peen being tempered. The handle is made of eitherwood or bamboo. These hammers are specified by size number and range from 200gm. to 550 gm.

The claw hammer in addition tobeing used as a hammer, can also be usedfor pulling out bent nails and for this reason it is preferred by the woodworkers. These hammers are available in four sizes weighing 375, 450, 550 and675 gm.

Figure 14.7 Claw Hammer

Holding andSupporting Tools:

Thiscategory of tools is used for holding and/or supporting the job duringoperation. For accurate work the job must be properly held and supportedagainst the forces being applied to cut or shape it. The commonly used tools inthis category include the following:

14.11.WorkBench: The work bench is a heavy rigid table made of hard wood. It isusually 3 to 3.65 metres long. 0.7 m wide and 0.7 m high. A double bench is3.75 to 4.3 m long 0.9 m wide and 0.7 m high. Two or four carpenter’s vises arefitted on opposite sides of the bench to hold jobs. Racks may be provided inthe table for storing tools, finished jobs and other equipment.

14.12. BenchVice: The bench vise most commonly used for woodworking has one jaw fixedto the side of the table while the other can be moved by means of a screw. Thescrew works inside a fixed half nut and is operated with a handle. The insidesurfaces of the jaws are fitted with wooden liners to prevent scratching of thework piece surfaces when they are clamped.

Bench Stop: The bench stop is simplya block of wood projecting above the top surface of the bench. This is used toprevent the wood from sliding forward during planning.

Bar Cramp: The bar or sash cramp ismade up of a steel bar of rectangular or T-section which carries a screwinside. The screw is provided with a handle at one end while the other end isattached to a jaw as shown in Fig. 14.23. Another jaw is mounted on the bodyand can be fixed anywhere on the bar with the help of a retaining pin. The barcramp is used for holding wide work pieces such as door frames.

Cramps and Screws: Cramps and screws of various types andsizes are commonly used by woodworkers for holding odd shape work pieces. Twoof the most common ones are the C-Clamp and hand screw.

Miscellaneous tools:

Rasps and files : there are used for cleaning by some curvedsurface.

Pincelr: It is making used for pulling out nails, tacks etc.

Screw drivers : They are used for screwing or unscrewing screw used inwood. Screw drivers used for carpentry work are available with long handles andstrong nose

Lesson-15

Carpentry and pattern making, mould material and their application

15.1.INTRODUCTION

A Pattern making may be defined as replica model of the desired casting which, when packed in a suitable moulding material, produces a cavity called mould. This cavity when filled with molten metal, produces the desired casting after solidification of the poured metal.

The ways in which a pattern differs from an actual component are

1. It carries additional allowance over those portions which are to be machined. (Machining allowance)

2. When a pattern is withdrawn from a mould it may injure the edges. To avoid this danger the pattern is made with slight tapes inward on the vertical surfaces. (Draft allowance)

3. It carries an additional allowance to compensate for metal shrinkage. (Shrinkage allowance)

4. It carries the necessary draft to enable its easy removal from the sand mass (shake or rapping allowance)

5. Some castings tend to warp or distort on cooling. To compensate the pattern is made with certain distortion allowances.(Distortion or camber allowance)

6. It carries additional projections called core prints, to produce seats for cores.

The important considerations which a pattern maker is to make in order to plan the successfully to yield desired results are the following

1. Number of casting to be made from the same pattern

2. The appearance and surface finish of the casting to be produced

3. Facility and ease in moulding

4. Method of withdrawal of the pattern from the mould

15.2.PATTERN MATERIALS

15.2.1. Wood

It is the common material used for pattern making because the following advantages

1. It is cheap and available in abundance.

2. It can be easily shaped into different forms and intricate designs.

3. Its manipulation is easy because of lightness in weight.

4. It can be preserved for a fairly long time by applying proper preservatives like varnish.

5. Good surface finish can be easily obtained by only planing and sanding.

Disadvantage of wood

1. It wears out quickly due to its low resistance to sand abrasion

2. It is very susceptible to moisture, which may lead to its warping or splitting.This needs its careful storing in a dry place and the application of preservatives

3. Its life is short as compared to other pattern materials. This confines its use to such cases only when a small number of castings are required.

The wood selected for pattern making should be straight grained, free from knots and other natural defects. It should be properly seasoned before use. Common woods used are Deodar, Teak, shisham and Mahogany.

15.2.2.Metals

Metals have a much longer life than wooden patterns.

They carry the following disadvantage

1. They are costlier than wood, and cannot be used with smaller number of casting are to be made

2. Metals are very heavy and in case of large casting the weight of the pattern always may be a problem.

3. Forgiving different shapes and fine surface finish they need machining operation.

Metals used in pattern making are the following

(A) Brass:Commonly used metal for small patterns particularly in bench and machine moulding. It has a high strength, high resistance to corrosion, sand abrasion,takes a good surface finish and can be cast into any shape.

(B) Cast iron: It is cheap and can be casted into any shape. It has a good machinability, high resistance to sand abrasion, good strength. Its excessive weight is a great drawback with it.

(C) Aluminium and its alloy: Larger patterns of metal are usually made from aluminium or its alloys because of their light weight and low cost. They can be cast into any shape and machined to give a good surface finish. They have a high resistance to corrosion.

15.2.3

Plastics and gypsum cement known as plaster of paris are also used for making patterns and core boxes because of their light weight, high strength resistance to wear and corrosion, moisture,surface finish and reasonable cost.

15.3.FACTORS EFFECTING THE SELECTION OF PATTERN MATERIAL

The selection of a material for making the pattern is depend on the following factor

1. Number of casting to be made

2. Method of moulding to be used. It may be hand or machine.

3. Type of casting method to be used

4. Degree of accuracy in dimension and quality of surface finish required on the casting

5. Design of casting.

15.6.1.Types of patterns : The type of pattern to be used for a particular casting depends upon many factors like the bulk of casting, type of moulding process, number of castings required and the anticipated difficulty of moulding of the typical shape. The following types of patterns are commonly used

1. Single piece pattern

2. Two piece pattern or split pattern

3. Multi piece pattern

4. Match plate patterns

5. Sweep pattern

6. Pattern with loose pieces

7. Follow board pattern

8. Gated patterns

9. Cope and drag patterns

10. Skeleton patterns

1. **Single piece pattern** :This pattern is made in one piece and carries no joint, partition of loose pieces. It is simplest pattern. Depending upon the shape, it can be moulded in one or two boxes. This pattern is the cheapest but its use can be limited extent of production only. Because its involve large numbers of manual operation.

2. **Two piece pattern or split pattern** :When pattern making is difficult by single pattern. For such casting two piece pattern are employed. They are made in two part which are joined at the parting line. While moulding, one part of the pattern is contained by the drag and other by the cope.

3. **Multi piece pattern** :Casting having a more complicated design than above require the pattern in more than two parts in order to facilitate an easy moulding and withdrawal of pattern. These pattern may consist of three, four of more number of parts depending on their design.

4. **Match plate patterns** :This patterns are used where a rapid production of small and accurate casting is desired on a large scale. Their construction cost is quite high, but the same is easily compensated by a high rate of production, greater dimensional accuracy and minimum requirement for machining in the casting. These pattern are made in two pieces, one piece mounted on one side and the other on the other side of a plate. The plate may be of wood, steel or aluminium. Aluminium is preferred due to its lightness and cheapness.

5. **Sweep pattern** :Sweeps can be advantageously used for preparing moulds of large symmetrical casting, particularly of circular cross section. This effects a large saving in time, labour and material. The equipment consists of a base, suitably placed in the sand mass, a vertical spindle and a wooden template, called sweep. The sweep is rotated about the spindle to form the cavity. Then sweep and spindle are removed, leaving the base in the sand. Separately prepared core is placed in the mould, gates cut and the mould is ready for pouring.

6. **Pattern with loose pieces** :some pattern are made to have loose pieces in order to enable their easy withdrawal from the mould. These pieces form an integral part of the pattern during moulding. After mould is complete, the pattern is withdrawal leaving the pieces in the sand which are later withdrawal separately through the cavity formed by the pattern.

7. **Follow board pattern** :A follow board is a wooden board used to support a pattern during moulding.Such single piece patterns which have an odd shape or very thin wall require a follow board. The follow board carries a projection conforming to the inside shape of the thin walled pattern to support it during moulding. If such support is not provided the pattern may get broken due to less wall thickness during ramming.

8. **Gate Pattern** :Groups of patterns with gate formers attached to the pattern proper are called gated patterns; may be made of wood or metal and are used for mase production of small castings

9. **Cope and Drag Pattern** :For production large heavy castings, difficult to handle by single person.Separate cope and drag patterns are used to ease this difficulty. They are made in halves, split in convenient joint line.

10. **Skeleton Pattern** :Patterns for very large castings would require tremendons amount of timber fora full pattern. In such cases a frame work farming a skeleton pattern may be employed to give general contains and size of the desired castings.

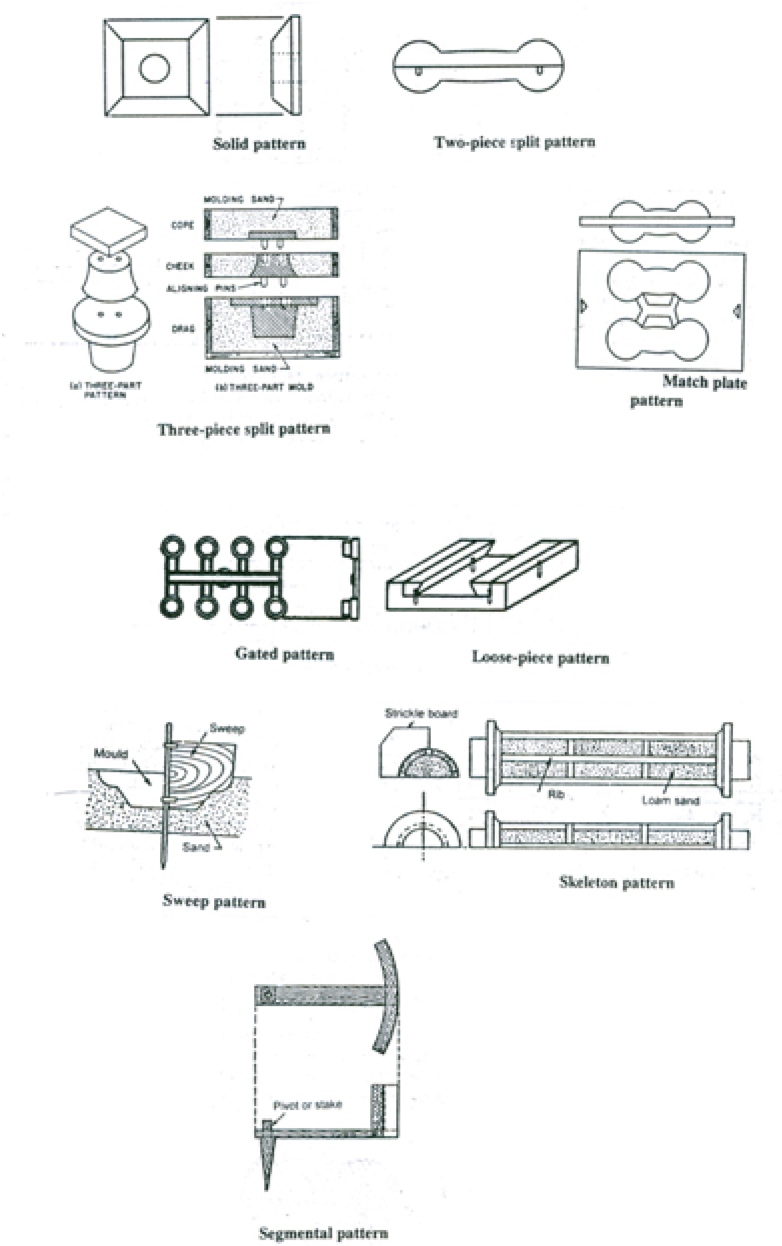


Fig 15.1 Various types of patterns

Moulding

Foundry or casting is a process of forming metallic products by melting the metal, pouring it into a cavity known as the mould and allowing it to solidify. Foundry engineering deals with the process of making casting in mould prepared by patterns. The principal material used in the foundry shop for moulding is the sand. For mould preparation special hand tools, mould boxes (flasks) and mechanical tools and equipments are used. Cores are separate shapes of sand that are generally required to form the hollow interiors of the casting or a hole through the casting. The care is left in the mould in casting and is removed after the casting moulding sands.

The main ingredients of moulding sands are (i) Silica sand grains (ii) Clay, (iii) Moisture and (iv)Miscellaneous materials like iron oxide, lime stone, soda and potash. Silicas and in the form of granular quartz is the main constituent, clay is of very small particles under 20 microns sand and may be up to 5 to 20 percent in the moulding sand. The moisture water should be of 2 to 8 percent. In general moulding sand must have good properties like porosity, flowability,collapsibility, adhesiveness, cohesiveness or strength and refractoriness, generally natural sands are mixed with clay, line, magnesia, potash, soda,horse manure, saw dust, cow dung, coal dust in small quantities to get the desired properties.

Moulding Process and Classification

(I) Moulding processes are commonly classified according to the different forms.

(i) Hand moulding : Employed for unit or small lot productions.

(ii) Machine Moulding : For large lot and mass production.

(II) Classification according to the type of materials used.

(I) Green sand Moulds

(II) Dry sand Moulds

(III) Skin Dried Moulds

(IV) Loam Moulds

(III) Classification according to the methods used. Which are based on the place / particular applications in the foundry.

(I) Bench Moudling

(II) Floor Moudling

(III) Pit Moudling

(IV) Plate Moudling

(V) Sweep Moudling

Green Sand would.

It is the most common process used for general purpose. Green sand moulds are prepared with natural moulding sands or with the mixture of silicon sand, clayand water. The moulding sand with moisture is called as green sand mould. The surface of the mould which comes in contact with the molten metal forms the most important part in green sand moulds. To get a clean casting and to prevent the sand from burning a layer of facing sand is given surrounding to pattern. Some times bonding materials such as molasses, a gelatinized starch is added to the facing sand mixture or sprayed upon the surfaces of the finished moulds. It is a common practice to coat the surfaces of the sand mould with refractory materials such as the carbonaceous materials known as blackings or mineral coating to produce a smooth skin on the castings. The materials commonly usedare graphite, coke, charcoal, gas carbon, plumbag, block lead, silicon, mica,tale etc. Fig. 15.2 shows the process of making green sand mould.

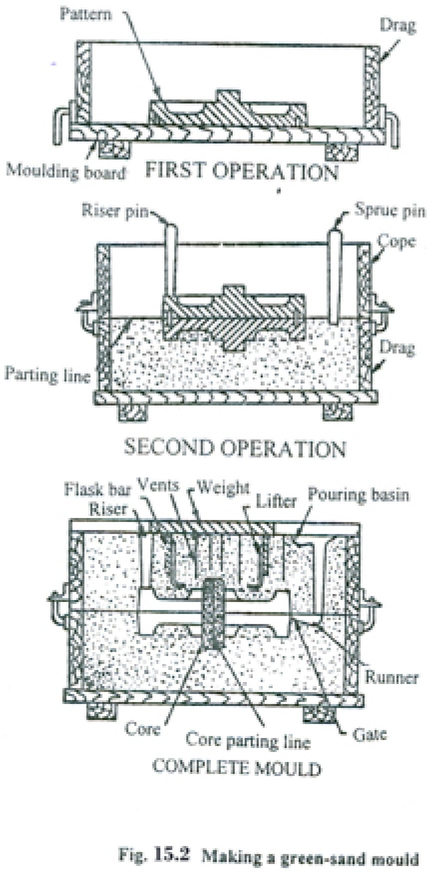


Figure 15.2 making a green-sand mould

Dry Sand Mould.

It is similar to green sand mould except a different sand mixture is used and all parts of the mould are dried in an oven before being reassembled for casting. Here the binding materials suchas flour, resin, molasses or clay are thoroughly mixed and tempered. Dry sand moulds are often used for large works.

Loam Mould

Loam is clay and sand mixed with water to form a thin plastic mixture from which moulds are made loam sand also contains fire clay or genistere. The loan must be sufficiently adhesive so that it can cling to the vertical surface.

Module 8. Jigs and fixtures

Lesson-16

Use of jigs and fixtures in production

16.1. Jigs and fixtures

l Jigs and Fixtures are Production-work holding devices used to manufacture duplicate parts accurately. A Jig is a special device that not only holds the work piece but also guides the cutting tool as the operation is performed**. It** is a special device that has built in features for automatically determining location dimensions for machining or assembly. A jig can assist in guiding tools and clamp the work piece.

Various types of jigs are: Plate, Diameter, Channel, Leaf, Ring, Box etc.

2. A Fixture is a production tool that locates , holds and supports the work securely so that the required machining operations can be performed. A device which clamps work during machining. Usually designed for a specific part or family of parts. The primary purpose of a fixture is to clamp the work piece.

The application of jigs and fixtures is an important aspect of workshop engineering, and their application is of some consideration on all but the simplest types of production, small orders and tool room work.

16.2. Elements of Jigs and Fixtures

1. Locating Elements: These position the work piece accurately with respect to the tool guiding or setting elements in the fixture.
2. Clamping Elements: These hold the work piece securely in the located position during operation.
3. Tool Guiding and Setting Elements: These aid guiding of the tool in the correct position with respect to work piece.

16.3. Advantages of Jigs and Fixtures

1. Productivity
2. Interchangeability
3. Skill Reduction
4. Cost Reduction

16.4. Jigs and Fixture Design Factor

1. Study of the component.

2. Study of the type of the capacity of the m/c.

3. Study of the locating elements.

4. Study of the clamping arrangement.

5. Study of clearance between jig and the component.

6. Study of the indexing devices.

7. Study of the fool-proofing arrangement.

8. Study of the ejecting devices.

9. Study of the swarf removal arrangement.

10. Study of rigidity and the vibration problems.

11. Study the safety devices.

12. Study the methods of manufacture of jigs and fixture.

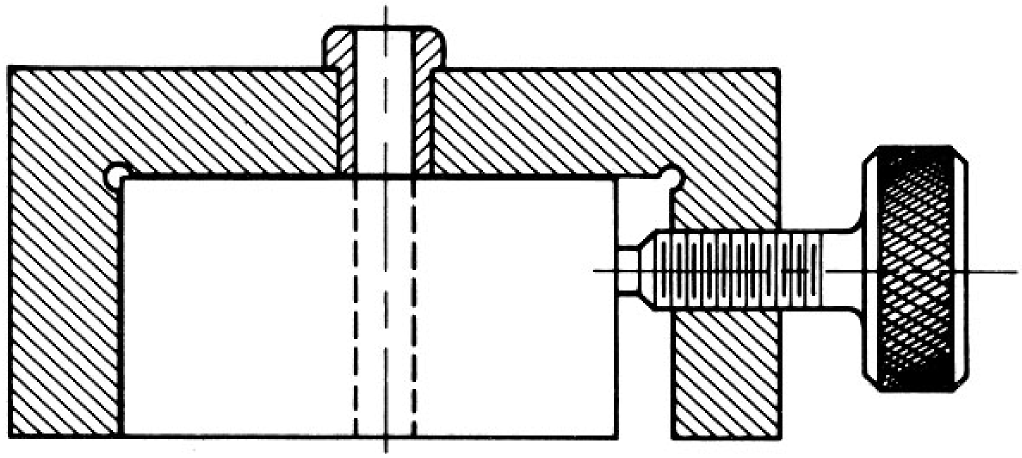
The primary object of their use might be

- to facilitate the holding and support of an awkward or frail article for some machining operation,
- to position a component and guide the cutters so that every component will be uniform,
- to accommodate several components at one setting to take advantage of multiple machining,
- to hold a component which could not be held conveniently without a fixture, and so on. Probably the use of a jig would achieve more than one of the above objects and others we have not mentioned but which will emerge in our subsequent discussion.

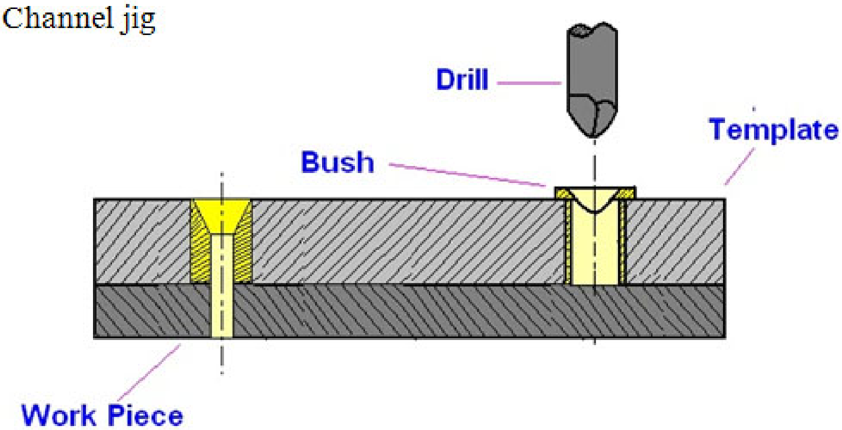
The difference between a jig and a fixture is not important, but it is generally recognized that, while in a jig there is some incorporation for actually guiding the tools or cutters which operate on the work, a fixture holds and locates the work without necessarily providing definite guidance for the tools. Fixtures are generally heavier in construction and bolted rigidly on the machine table whereas jigs are made lighter for quick handling and clamping with the table is often unnecessary. The fixtures are employed for holding the work in milling, grinding, planing or turning operations where as the jigs are used for holding the work and guiding the tool particularly in drilling, reaming and taping operations.

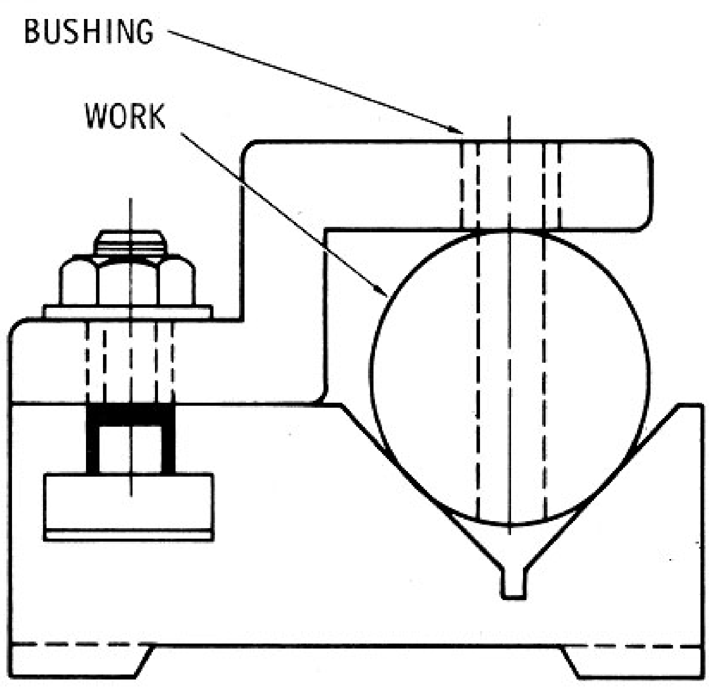
16.5. TYPES OF JIGS

The quality, type and complexity of jigs and fixtures used depend solely on the type of work to be machined and the scale of production required. A few simple type of drill jigs are shown below:

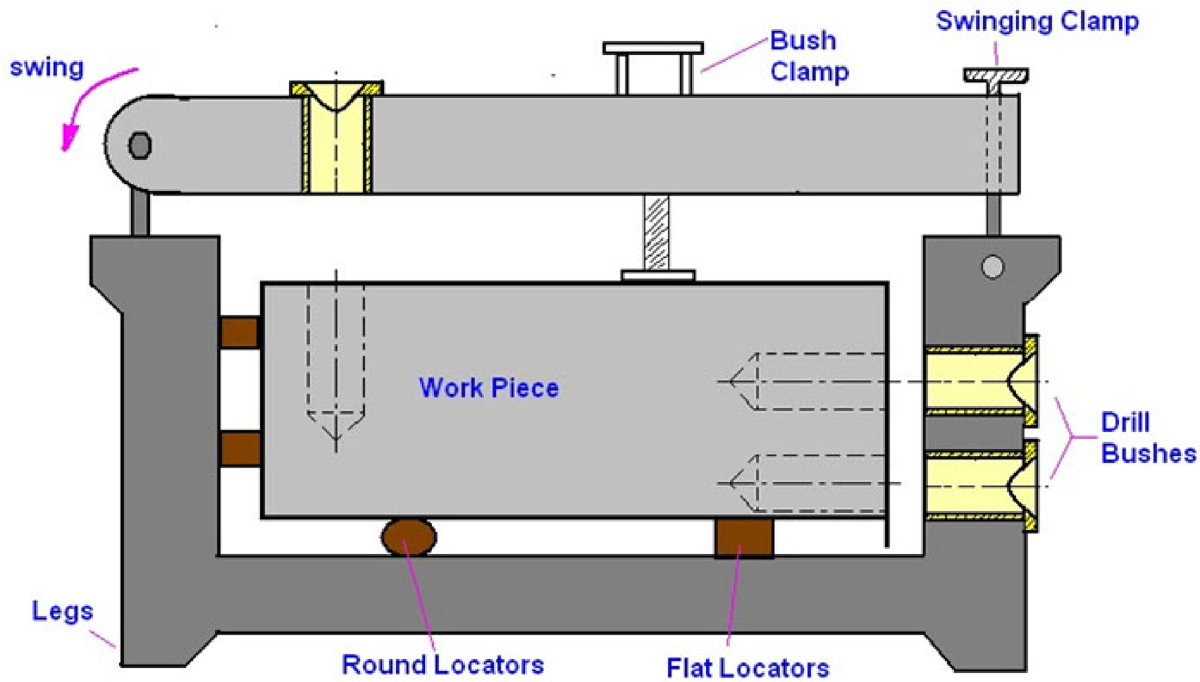


Channel jig

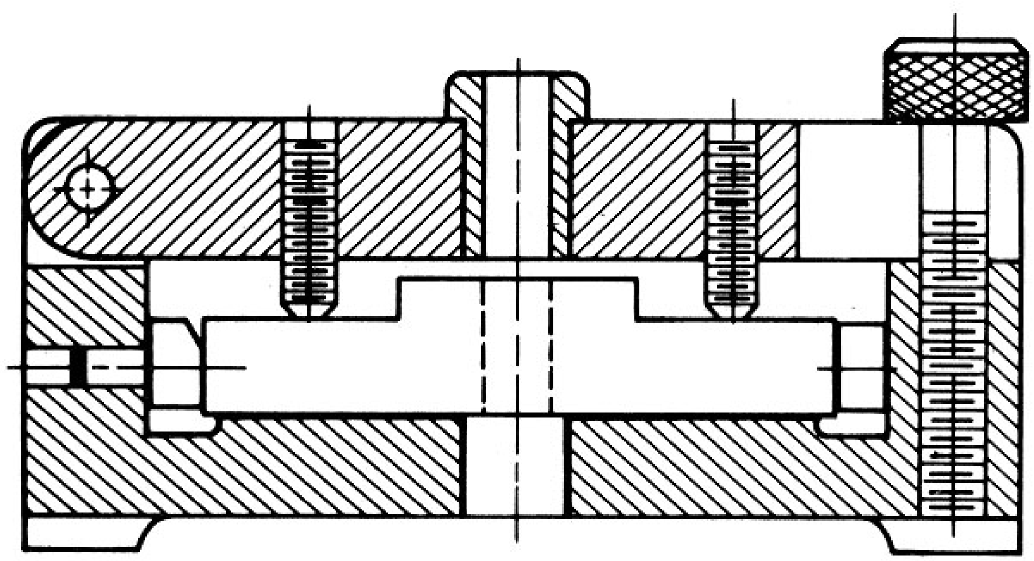




Diameter jig



Box jig



Leaf jig

16.6.1. Location

Correct location influences the accuracy of the finished result, and particularly its positional relationship with other surfaces on the component. An important aspect of design is concerned with the location of the component. Furthermore, unless location arrangements are reliable and consistent, the jig will not produce uniform components. Location arrangements are closely related to other aspects of jig application; for example, a perfectly satisfactory method of location might be spoiled by faulty methods of clamping causing the component to lift away from the locating face, or due to poor design a locating face might be clogged by swarf.

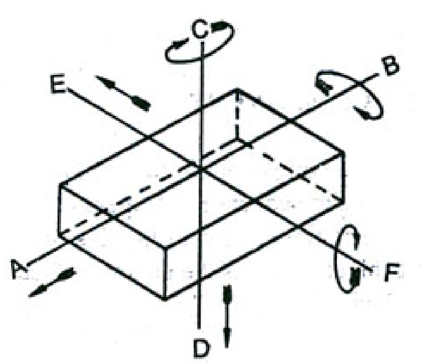
16.6.2. Methods of location

Locating plugs :

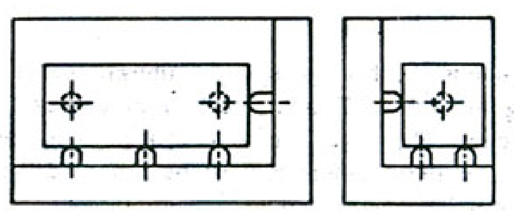
- According to the conditions of application, a plug may be fixed as a permanent part of the construction or it may be loose. Unless the job is of a very simple nature for use with only a few components, locating plugs should be hardened and ground, a case-hardening steel being suitable as the soft core lends toughness. When the plug is a permanent part of the jig, it may be a drive fit into a bored hole or it may be secured by a nut and washer.
- Locating plugs should not, in general, be screwed in to a jig, as it is impossible to guarantee the locational accuracy of a screwed connection. If such an arrangement is unavoidable, a plain pilot portion jig-bored to position will help to secure accuracy, but even this is far from ideal. When loose plugs fit into the jig, a hardened and ground bush should be provided as otherwise it will be necessary, sooner or later, to overcome the wear by reboring the hole and fitting a bush.
- When a component locates on two plugs, one provides all the location necessary except the angular radial position of the second hole. The important hole, therefore, should have a full plug, and the other plug may be cut away, to facilitate insertion of the component and compensate for small variations in centre distance of the holes.
- Detachable plugs should be as light as possible and provided with generous handles or permanent tommy bars if they are to escape mutilation by hammers or spanners. Lightness may be obtained by making plugs hollow. To facilitate their insertion, plugs should be provided with a gradual lead and a radius on the end .It should never be necessary to employ more than two plugs to locate a single, rigid component.

Principle of locations

As shown in Fig, a rectangular block is free to move along the axis AB, CD and EF. The body can also rotate about these axis, and thus the total degrees of freedom of a body along which it can move a jig, all these six movements must be restrained by arranging suitable locating points and then clamping the block in position. The principles of determining locating points are as under:



Six degree freedom of a rectangular block



Six point location of a rectangular block

Six point location of a rectangular block:

It is assumed the blocked shown in the figure is made to rest on several points on the jig body as shown. The bottom of the block is supported against three points, the rear face of the block bears against two points and the side of the block rests against a single point all projecting from the jig body. It will be now clear that the downward movement of the block along CD is restrained by three supporting points, which have the capability of supporting even a rough casting. The movement along EF and AB axis are restrained by the double and the single points respectively. The rotary movement of the block about AB, CD and EF are also restrained by the bottom, back and side pins. The six points thus serve to locate a block correctly while restraining all its movements. The locating points for an uneven object can be determined by different arrangements, but the guiding principle remains the same.

16.6.5. Clamping

In all forms of jigs and fixtures it is necessary to provide facilities for clamping the work, and there are several important aspects to this.

· Work should be held rigidly to the jig, and to locating faces, but should not be distorted in any way. This involves the use of efficient clamping methods, applied at points where they will act against solid metal, with the avoidance of forces directed where there is no support. Thin, fragile components require particular consideration if distortion is to be avoided.

· Clamping should be simple, quick and foolproof. Jigs are often used by unskilled operatives who do not possess the mechanical instincts necessary to tighten clamps intelligently. Generous allowance must be made for this in the design of clamping arrangements.

· The components of the clamping system must be robust, and as far as possible made non-detachable. The first point is obvious, but cases are often seen where clamps are too thin for the forces put on then and become bent in consequence. Detachable parts of jigs often get mislaid.

REFERENCES

Arora, R. P. Basic Mechanical Engineering. Charotar Publishing House Pvt. Ltd., Anand (Guj.).

Chapman, W.A.J. and Martin, S. J. 1998. Workshop Technology. Part-III. Viva Books Private Ltd, New Delhi.

Raghuvanshi, B. S. 2002. Workshop Technology. Vol. 2. Dhanpat Rai & Co. (P) Ltd, Delhi.