CHAPTER ONE

ENGINEERING WORKSHOP AND SAFETY

1.0 WORKSHOP

A workshop is a building or an area where engineering works are been carried out. A workshop must meet certain standard for approval before it can function as an engineering workshop.

1.1 WORKSHOP LAYOUT

In a workshop the following standard practice and procedure should be strictly maintained.

(i) Uncongested working area
(ii) Adequate ventilation and lightning
(iii) Safe storage for tools and stacking of materials
(iv) A clear and free gangway
(v) Available emergency exit
(vi) Adequate safety gadgets and equipment
(vii) Provision of toilets, dressing room and bathroom

1.2 ACCIDENT

Accident can be defined as an unplanned, unexpected, undesigned sudden hazardous occurrence that may lead to bodily injury, death or damage to a machine.

1.2.1 CAUSES OF ACCIDENT IN THE WORKSHOP

(i) Lack of provision of safety devices/gadgets
(ii) Failure to use Personal Protective Equipment (PPE) like overall, safety boots, helmet, etc.
(iii) Use of damaged tools or faulty machines
(iv) Carelessness in the workshop
(v) Loss of concentration due to tiredness
(vi) Over congestion of working area
(vii) Inadequate lighting and ventilation
(viii) Poor workshop and plant layout

1.2.2 TYPES OF ACCIDENT IN THE WORKSHOP

Some of the possible accident type in the workshop are listed below

1.2.2.1 Gas Leakage

Inhaling of leaking gas like carbon monoxide fumes or any carbon compound can kill. Such leaked gases can also cause explosion that can lead to a wild fire that can cause a lot of damage to lives and properties.

1.2.2.2 Injury from cut

Injury can result when sharp edged tools are badly positioned when working or due to unguarded sharp edges of machines, tools or workpiece.

1.2.2.3 Slips, Trips and Falls

The types of injuries incurred from slips, trips and falls include head and back injuries, broken bones, cuts and lacerations, sprains and pulled muscles. The most common reasons for falls in the workshop are wet or oily floor, occasioned spills, weather hazards, poor lighting, obstructed view, wrong tool storage, congested gangways etc.

1.2.2.4 Being Caught in or struck by moving Machinery

When body parts get caught in or struck by exposed moving parts or flying objects (like metal chips) from machines without protective guards, the results are often disastrous.

1.2.2.5 Overexertion and Repetitive Stress Injuries

Overexertion injuries are related to pulling, lifting, pushing, holding, carrying and throwing. They account for nearly 33% of occupational injuries and contribute to loss of productivity.

1.2.3 ACCIDENT PREVENTION TECHNIQUES

(a) Always work under the supervision of an instructor
(b) Observe all safety rules
(c) Always use necessary safety devices
(d) Sand buckets and fire extinguishers must be placed in position to arrest any fire outbreak
(e) Workshop floor must always be kept clean and dry at all times
(f) Always think SAFETY FIRST and SAFETY ALWAYS

1.3 FIRE

Fire is a form of a chemical reaction that involves the rapid oxidation of combustible fuel (material) with the subsequent liberation of heat and light.

1.3.1 FIRE TRIANGLE

There are three (3) basic elements needed to produce a fire and they are:

a. HEAT
b. FUEL
c. OXYGEN

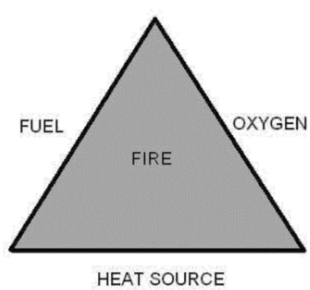


Fig 1.1 Fire Triangle

If one of these elements is not present, fire will not be created.

1.3.2 FIRE TETRAHEDRON

Beside the 3 basic elements there is the fourth element which is essential for the continuation of fire once it is ignited, this is known as the **CHAIN REACTION**. Once fire occurs, the burnt substance produce lots of heat which tends to burn the remaining fuel substance. This reaction occurs again and again, which in termed the “chain reaction”.

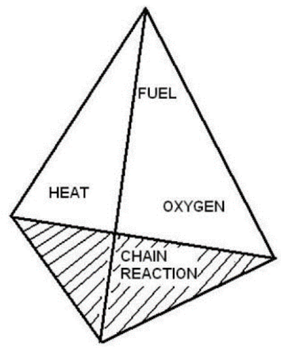


Fig. 1.2 Fire Tetrahedron

1.3.3 CLASSES OF FIRE

I. **Class ‘A’ Fire**: Fire involving solid fuel, e.g. wood, paper, cotton, etc.

II. **Class ‘B’ Fire:** Fire involving Liquid fuel, e.g. petrol, diesel, kerosene, etc.

III. **Class ‘C’ Fire:** Fire involving Gas fuel, e.g. Liquefied Petroleum Gas (LPG), compressed natural gas (CNG), etc.

IV. **Class ‘D’ Fire:** Fire involving combustible metals, e.g. sodium, phosphorus, magnesium, etc.

V. **Class ‘E’ Fire:** Fire involving energized electrical equipment, e.g. switch boards, transformers, etc.

VI. **Class ‘K’ Fire:** Fire involving kitchen oil, e.g. Liquefied Petroleum Gas, Kerosene, etc.

1.3.4 TYPES OF FIRE EXTINGUISHER

(a) Portable fire extinguishers for small fire
(b) Water type extinguisher for Class A fire
(c) Foam extinguisher for Class B fire
(d) Dry Chemical Powder (DCP) for all classes of fire except Class D
(e) Halon extinguishers for Class K, B and C fires
(f) Carbon dioxide extinguisher for Class B and C fire

1.3.5 FIRE TEMPERATURE

1.3.5.1 <u>Flash Point</u>: It is the minimum temperature at which the rate of vaporization of fuel is sufficient to produce a momentary flash upon the application of source of ignition.

1.3.5.2 <u>Fire Point</u>: Is the minimum temperature at which the burning vapour is capable to enable combustion to continue.

1.3.5.3 <u>Ignition Temperature</u>: Is the minimum temperature at which fuel will ignite with help of ignition source. It is also called "auto ignition temperature"

1.3.6 FIRE EXTINGUISHING METHODS

(a) Cooling: Removal of HEAT by water (generally for Class A fire)
(b) Starvation: Removal of FUEL by cutting fuel supply
(c) Smothering: Removal of Oxygen by using CO_2 or DCP (Dry Chemical Powder)
(d) Chain Break Mechanism: Breaking the Chain Reaction by DCP

1.3.7 FIRE FIGHTING MEDIAS

(a) Water
(b) Foam; which can be either Chemical Foam or Mechanical Foam
(c) Carbon dioxide
(d) Halogenated Hydrocarbons
(e) Dry Chemical Powder (DCP) such as sodium bicarbonate, potassium sulphate, etc.
(f) Combustible metal extinguishing agents like inert gas, G-I powder, etc.

1.4 SAFETY

Safety is defined as a condition which gives freedom from hazard, risk or accident that may cause injury, damage and loss to man, materials or machine and even death. It can also be said to be the method of working without harm, danger or injury. The removal of hazards to both man and machines.

1.4.1 SAFETY DEVICES

All safety devices are generally referred to as 'Personal Protective Equipment' (PPE). These PPEs include the following:

a. Safety Googles: These equipment protect the eyes during welding and grinding operations

b. Overall and Safety Boots: The overall is a type of garment worn that serves as a protective clothing while working at the workshop. The boot protects against any sharp object on the floor

c. Helmet: This device is needed where machines or equipment are suspended or in areas where construction is still ongoing, and it serves as protection for the head. Helmet is a must in all construction sites.

d. Nose caps and Earmuffs: The nose cap gives protection agaimst dust and fumes in the workshop while the ear protector guards the ear against very decibels of noise from machines that could damage the ear drum.

e. Sand Buckets and Fire Extinguisher: These are very necessary to handle fire outbreak which may result from electrical faults, combustible materials, gas leakages, explosions, etc.

f. First aid box: In the workshop, a first aid box must be available. In an event that an accident does occurs, it will be used to handle minor injuries and stabilize the affected person before onward transmission of such to the hospital for further treatment.

g. Safety Signs and Posters: Safety signs are legible pictorial cautions and warnings hung on the walls of the workshop with necessary safety instructions to be obeyed so as to guard against hazard and accident.

1.4.2 GENERAL SAFETY RULES AND REGULATIONS

Among the numerous safety instructions to be adhered to in the workshop, here are some of the general and very vital ones

1. Machines must not be operated without permission and formal instruction.
2. The operator of a machine should know the quickest way of stopping the machine in case of an accident
3. Ensure that the working environment is well lighted and properly ventilated.
4. Always switch off machines after use and remove them from the electric socket.
5. The floor of the workshop should not be littered with dangerous objects.
6. In operating any machine, over-confidence must be guided against
7. Jobs must not be held by hand for drilling or machining, the job must be clamped down properly to the machine table vice to avoid any form of accident
8. Always ensure that you put on appropriate Personal Protective Equipment when in the workshop
9. Use the right tool for the right job and ensure to use tools with good handle e.g. file
10. While working on the machine, do not leave the chuck key in the machine chuck. This may fly out when the machine is set in motion and can cause accident or damage.
11. Do not wear overflowing garments, bangles, neck ties and chains in the workshop.
12. Do not allow yourself to be distracted while operating a machine
13. Long hairs must be properly and decently packed while working in the workshop
14. There should be no horse play in the workshop
15. Eating, drinking and smoking is highly prohibited in the working area

16. Machine gangways should be free from all forms of congestions for easy passage and escape if needs be
17. Emergency escape route must be available for easy escape and should be made easily accessible
18. All safety signs MUST be obeyed always
19. Always make sure that belts and pulleys including all moving parts are provided with safe guards
20. NOTE: Accident can be prevented by obeying safety rules. Therefore, safety must be regarded as an integral part of your job, because safe method is also a more productive method. Remember SAFETY FIRST, SAFETY ALWAYS. Always be safety conscious.

CHAPTER TWO

FITTING

2.0 INTRODUCTION

These days small, medium and heavy industries are using automatic machines. But bench and fitting work also plays a significant role for completing and finishing a job to the desired accuracy. Most of semi-finished works can be accomplished with fairly good degree of accuracy in a reasonable time through various kinds of quick machining operations. They still require some minor operations to be performed to finish the job by hand.

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

2.1 TOOLS USED IN FITTING SHOP

Tools used in bench and fitting shop are classified as under.

1. Measuring and Marking tools
2. Cutting tools
3. Holding tools
4. Striking tools
5. Supporting tools, and
6. Miscellaneous tools

2.2 MARKING OUT AND MEASURING TOOLS

In engineering measurement, the size of the part being checked is compared with a known standard of some kind e.g. using a rule to measure the length and width of a box. The tools and techniques used to check the features of a component are described below;

2.2.1 STEEL RULE

It is the simplest measuring tool just like a scale used in fitting shop. The steel rule is a graduated strip of metal used to determine any required dimension within the scope of the graduation. Steel rules are obtainable in various lengths and widths and graduated in centimeters and millimeters. Also, there is a steel tape rule (which is a long narrow folding steel rule) graduated and used in the same manner as steel rule, but for measuring long dimensions.

Fig 2.1 Steel Rule

2.2.2 CALIPERS

They are indirect measuring tools used to measure or transfer linear dimensions. These are used with the help of a steel Rule to check inside and outside measurements. These are made of Case hardened mild steel or hardened and tempered low carbon steel. While using, but the legs of the caliper are set against the surface of the work, whether inside or outside and the distance between the legs is measured with the help of a scale and the same can be transferred to another desired place. These are specified by the length of the leg. In the case of outside caliper, the legs are bent inwards and in the case of inside caliper, the legs bent outwards.

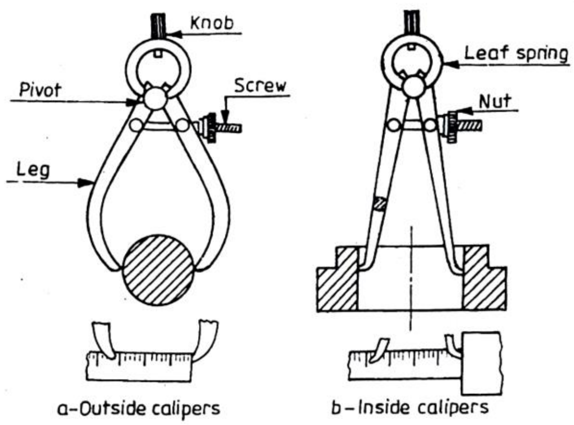


Fig 2.2 Calipers

2.2.3 TRAMMEL

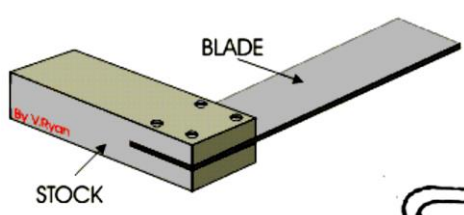
Trammel is used for marking and drawing large circles or arcs, which are beyond the scope of dividers.

2.2.4 TRY SQUARE

It is measuring and marking tool for 90^0 angle. In practice, it is used for checking the squareness of many types of small works when extreme accuracy is not required .The blade of the Try square is made of hardened steel and the stock of cast Iron or steel. The size of the Try square is specified by the length of the blade.

2.2.5 SCRIBER

A Scriber is a slender steel tool, used to scribe or mark lines on metal work pieces. It is made of hardened and tempered High Carbon Steel. The Tip of the scriber is generally ground at 12^0 to 15^0. It is generally available in lengths, ranging from 125mm to 250mm. It has two pointed ends the bent end is used for marking lines where the straight end cannot reach.



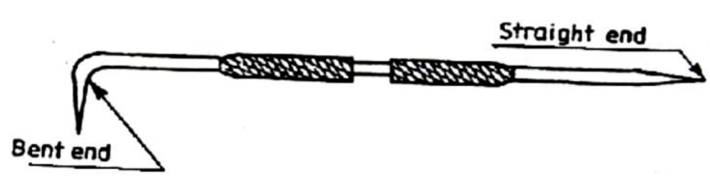


Fig 2.3 Try Square **Fig 2.4 Scriber**

2.2.6 ODD LEG CALIPER

This is also called 'Jenny Caliper' or Hermaphrodite. This is used for marking parallel liners from a finished edge and also for locating the center of round bars; it has one leg pointed like a divider and the other leg bent like a caliper. Its size is specified by the length of the leg up to the hinge point.

2.2.7 DIVIDER

It is basically similar to the calipers except that its legs are kept straight and pointed at the measuring edge. This is used for marking circles, arcs laying, marking out perpendicular lines or by setting lines. It is made of case hardened mild steel or hardened and tempered low carbon steel. Its size is specified by the length of the leg.

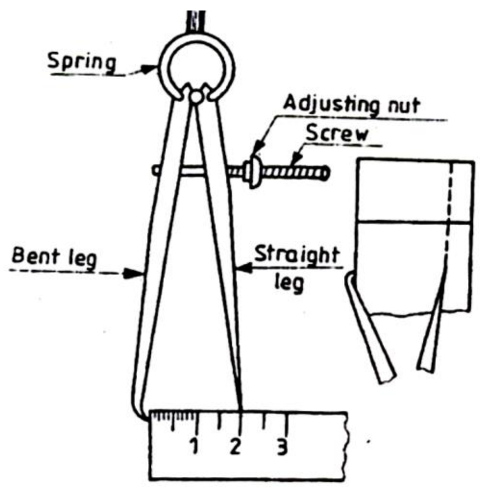


Fig 2.5 Odd leg Caliper

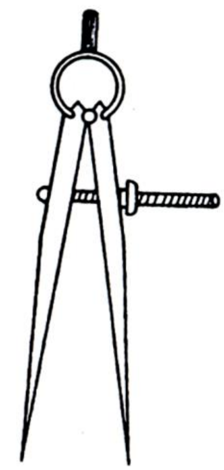


Fig 2.6 Divider

2.2.8 SURFACE PLATE

The surface plate is machined to fine limits and is used for testing the flatness of the work piece. It is also used for marking out small box and is more precious than the marking table. The degree of the finish depends upon whether it is designed for bench work in a fitting shop or for use in an inspection room; the surface plate is made of Cast Iron, hardened Steel or Granite stone. It is specified by length, width, height and grade. Handles are provided on two opposite sides, to carry it while shifting from one place to another.

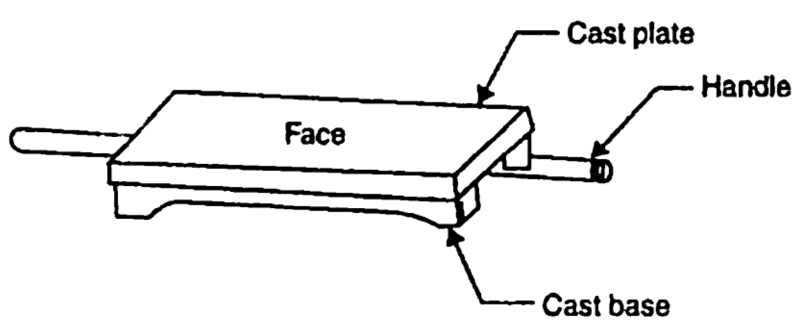


Fig 2.7 Surface Plate

2.2.9 PUNCHES

These are used for making indentations on the scribed lines, to make them visible clearly. These are made of high carbon steel. A punch is specified by its length and diameter (say as 150' 12.5mm). It consists of a cylindrical knurled body, which is plain for some length at the top of it. At the other end, it is ground to a point. The tapered point of the punch is hardened over a length of 20 to 30mm.

Fig 2.8 Dot Punch

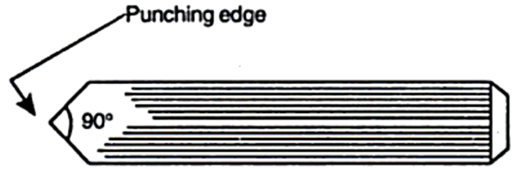


Fig 2.9 Center Punch

(a) Dot punch:is used to lightly indent along the layout lines, to locate center of holes and to provide a small center mark for divider point, etc. for this purpose, the punch is ground to a conical point having 60° included angle.

(b) Center punch: is similar to the dot punch, except that it is ground to a conical point having 90° included angle. It is used to mark the location of the holes to be drilled.

2.2.10 COMBINATION SET

This comprises a rule, a protractor for checking angular surfaces, a square for checking the squareness of right angle faces and a center head for locating the center of a round bar.

2.2.11 MARKING OUT TABLE

All marking out processes are done on this table. It is made of cast iron. The purpose of marking out is to provide a visual guide in the form of a scribe lines, so that the component can be made to the sizes required.

2.2.12 VERNIER CALIPER

These are used for measuring outside as well as inside dimensions accurately. It may also be used as a depth gauge. It has two jaws. One jaw is formed at one end of its main scale and the other jaw is made part of a vernier scale.

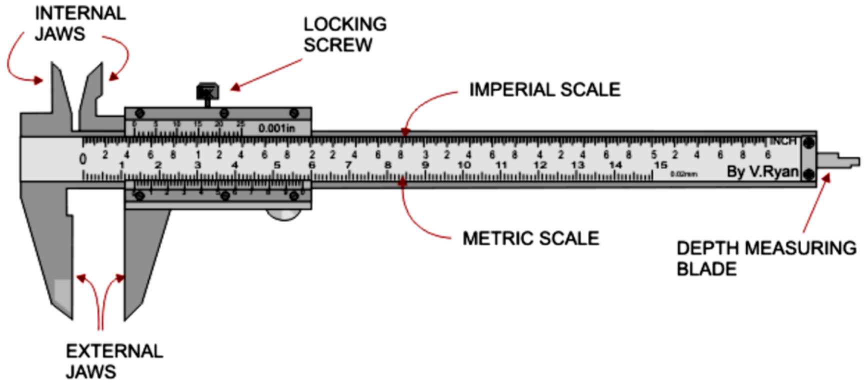


Fig 2.10 Vernier Caliper

2.2.13 VERNIER HEIGHT GUAGE

The Vernier Height gauge clamped with a scriber. It is used for Lay out work and offset scriber is used when it is required to take measurement from the surface, on which the gauge is standing. The accuracy and working principle of this gauge are the same as those of the vernier calipers. Its size is specified by the maximum height that can be measured by it. It is made of Nickel-Chromium Steel.

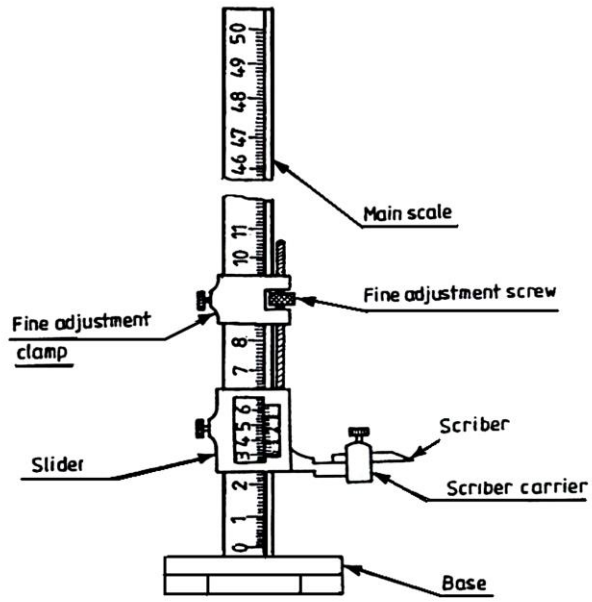


Fig 2.11 Vernier Height Guage

2.2.14 SCREW MICROMETERS

These are precision measuring tools and they are available in many forms, e.g.
(a) Outside micrometer for measuring outside diameter
(b) Inside micrometer for measuring the diameter of holes
(c) Micrometer depth guage for accurate measurement of depth of holes and slots

2.3 CUTTING TOOLS

Cutting tools are the tools that are used for material removal by means of shear deformation. These involve various types of files, scrapers, chisels, drills, reamers, taps, snip or shear and hacksaws.

2.3.1 HACKSAW

The Hack Saw is used for cutting metal by hand. It consists of a frame, which holds a thin blade, firmly in position. Hacksaw blade is specified by the number of teeth for centimeter. Hacksaw blades have a number of teeth ranging from 5 to 15 per centimeter (cm). Blades having lesser number of teeth per cm are used for cutting soft materials like aluminum, brass and bronze. Blades having larger number of teeth per centimeter are used for cutting hard materials like steel and cast Iron.

Hacksaw blades are classified as (i) All hard and (ii) flexible type. The all hard blades are made of H.S.S, hardened and tempered throughout to retain their cutting edges longer.

These are used to cut hard metals. These blades are hard and brittle and can break easily by twisting and forcing them into the work while sawing. Flexible blades are made of H.S.S or low alloy steel but only the teeth are hardened and the rest of the blade is soft and flexible. These are suitable for use by un-skilled or semi-skilled persons.

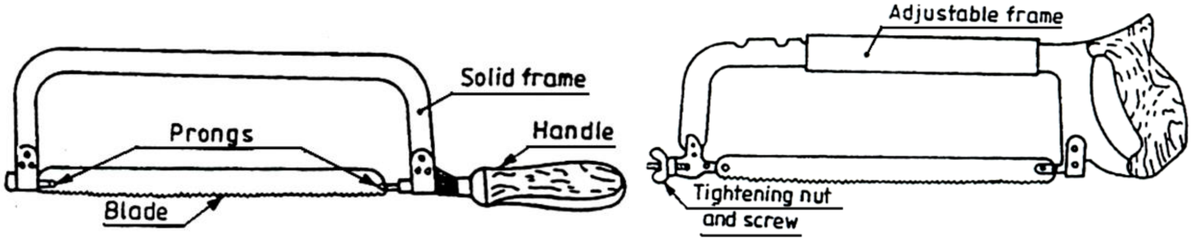


Fig 2.12 Hacksaw with Fixed and Adjustable Frame

2.3.2 TWIST DRILL

Twist drills are used for making holes. These are made of High speed steel. Both straight and taper shank twist drills are used. The parallel shank twist drill can be held in an ordinary self – centering drill check. The tapper shank twist drill fits into a corresponding tapered bore provided in the drilling machine spindle.

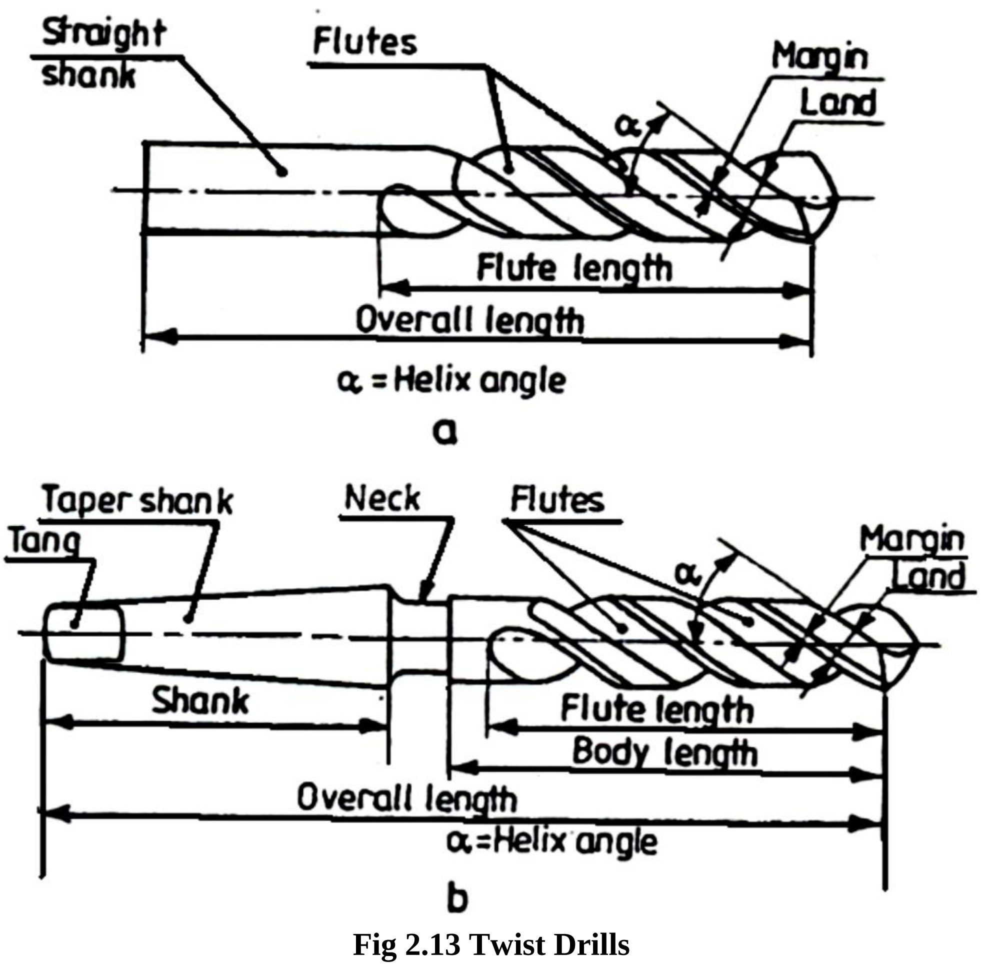


Fig 2.13 Twist Drills

2.3.3 CHISEL

Chisels are used for removing surplus metal or for cutting thin sheets. These tools are made from 0.9% to 1.0% carbon steel of octagonal or hexagonal section. Chisels are annealed, hardened and tempered to produce a tough shank and hard cutting edge. Annealing relieves the internal stresses in a metal. The cutting angle of the chisel for general purpose is about 60°.

Commonly used forms of chisels are flat, cross cut, half round and diamond point chisels. Flat chisel is used for chipping a large surface and cutting off bolts and rivets. Cross cut chisel is used for cutting slots and key ways. Half round chisel is used to cut oil grooves in bearing. Diamond chisel is used for cutting or forming vee grooves and also chipping plates.

Fig 2.14 Flat Chisel

2.3.4 TAPS AND TAP WRENCHES

A tap is a hardened and steel tool, used for cutting internal thread in a drill hole. Hand Taps are usually supplied in sets of three in each diameter and thread size. Each set consists of a tapper tap, intermediate tap and plug or bottoming tap. Taps are made of high carbon steel or high speed steel.

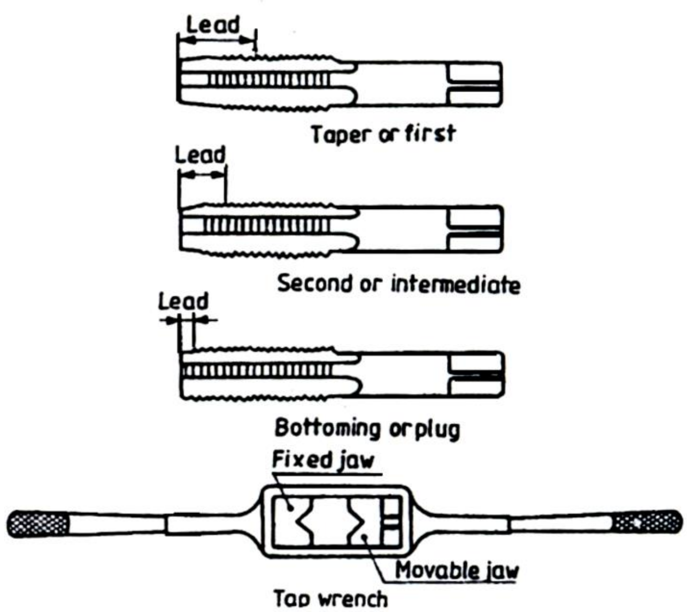


Fig 2.15 Tap and Tap Wrench

2.3.5 DIES AND DIE HOLDER

Dies are the cutting tools used for making external thread. Dies are made either solid or split type. They are fixed in a die stock for holding and adjusting the die gap. They are made of Steel or High Carbon Steel.

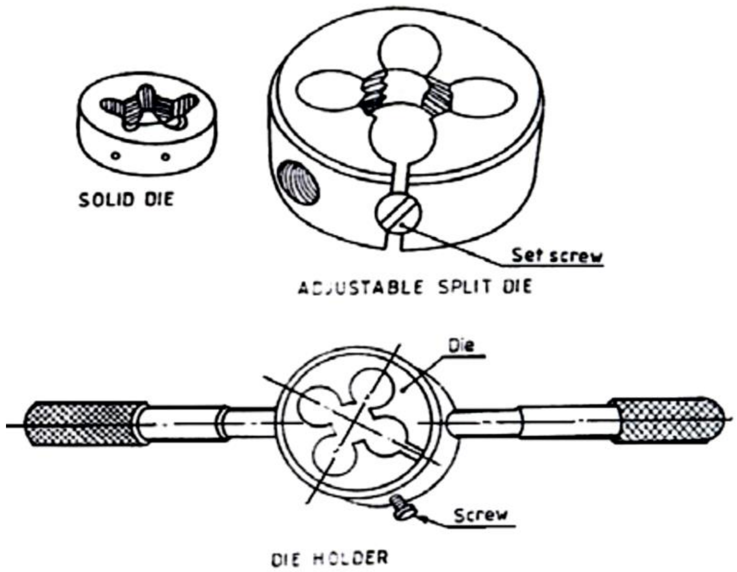


Fig 2.16 Dies and Die Holder

2.3.5 BENCH DRILLING MACHINE

Holes are drilled for fastening parts with rivets, bolts or for producing internal thread. Bench drilling machine is the most versatile machine used in a fitting shop for the purpose. Twist drills, made of tool steel or high speed steel are used with the drilling machine for drilling holes.

The following are the stages in drilling work:

1. Select the correct size drills, put it into the check and lock it firmly
2. Adjust the speed of the machine to suit the work by changing the belt on the pulleys. Use high speed for small diameter drills and soft materials and low speed for large diameter drills and hard materials.
3. Layout of the location of the pole and mark it with a center punch.
4. Hold the work firmly in the vice on the machine table and clamp it directly on to the machine table.
5. Put on the power, locate the punch mark and apply slight pressure with the Feed Handle.
6. Once Drilling is commenced at the correct location, apply enough pressure and continue drilling. When drilling steel apply cutting oil at the drilling point.
7. Release the pressure slightly, when the drill point pierces the lower surface of the metal. This prevents the drill catching and damaging the work or drill.
8. On completion of drilling retrace the drill out of the work and put-off the power supply.

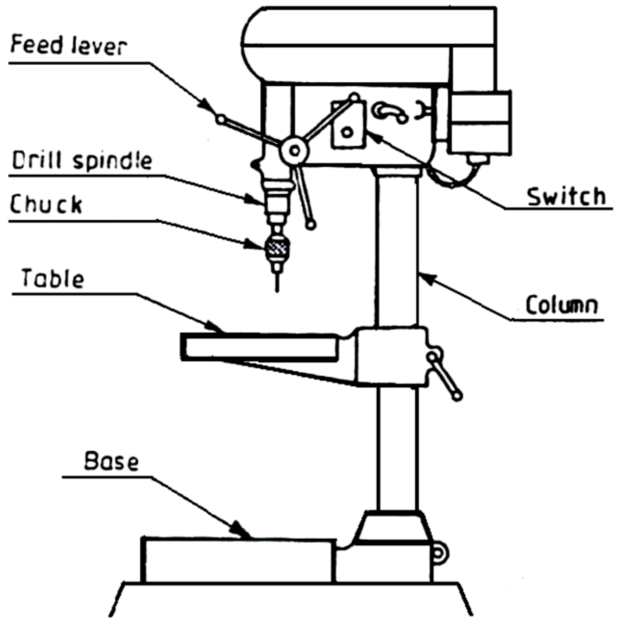


Fig 2.17 Bench Drill

2.4 HOLDING TOOLS

Also known as Clamping tools are used for securing job or workpiece firmly before carrying out operations on them.

2.4.1 BENCH VICE

The bench vice is a work holding device. It is the most commonly used vice in a fitting shop. It is fixed to the bench with bolts and nuts. The vice body consists of two main parts, fixed jaw and movable jaw. When the vice handle is turned in a clockwise direction, the sliding jaw forces the work against the fixed jaw. Jaw plates are made of hardened steel. Serrations on the jaws ensure a good grip. Jaw caps made of soft material are used to protect finished surfaces, gripped in the vice. The size of the vice is specified by the length of the jaws. The vice body is made of cast Iron which is strong in compression, weak in tension and so fractures under shocks and therefore should never be hammered.

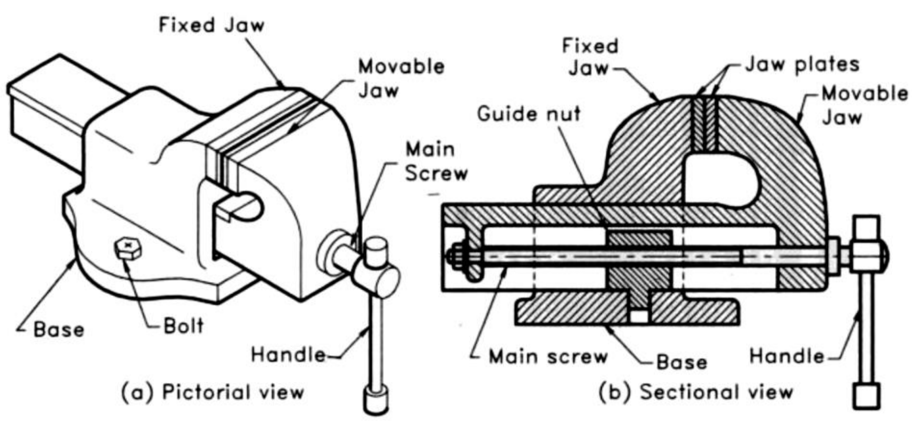


Fig 2.18 Bench Vice

2.4.2 V-BLOCK

V-block is rectangular or square block with a V-groove on one or both sides opposite to each other. The angle of the 'V' is usually 90^0. V-block with a clamp is used to hold cylindrical work securely during layout of measurement for measuring operations or for drilling. The bar is faced longitudinally in the V-Groove and the screw of the C-clamp is tightened. This grip the rod firm with its axis parallel to the axis of the v-groove.

2.4.3 C-CLAMP

This is used to hold work against an angle plate or v-block or any other surface when gripping is required. Its fixed jaw is shaped like English alphabet 'C' and the movable jaw is round in shape and directly fitted to the threaded screw at the end .The working principle of this clamp is the same as that of the bench vice.

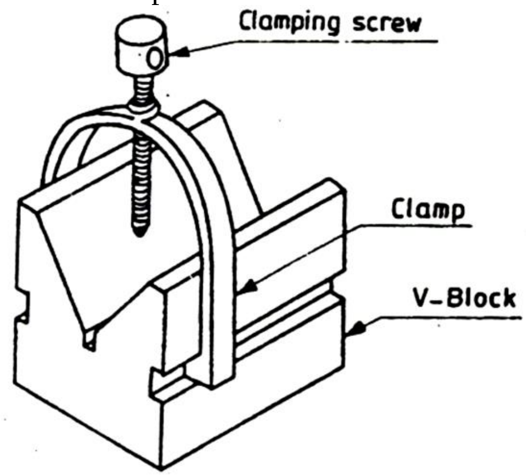


Fig 2.19 V-Block

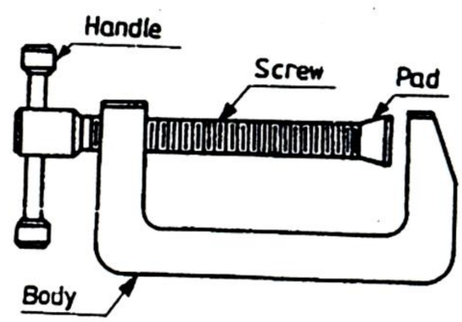


Fig 2.20 C-Clamp

2.5 FINISHING TOOLS

2.5.1 SCRAPERS

These are specially designed to remove only very small amount of metal in order to bring the surface of a component to a high degree of flatness or roundness. i.e. it is used for removing high spots on metal surfaces.

There are three types of scraper namely: Flat scraper, half round scraper and triangular scraper.

(a) Flat scraper is used for removing or scrapping errors in flatness of surfaces.
(b) Half round scraper is used for scrapping internal cylindrical surfaces and bearing
(c) Triangular scraper is used for removing burrs or sharp edges from internal surfaces of brush

2.5.2 FILES

A file is hardened steel, having small parallel rows of cutting edges or teeth on its surfaces. Filing is one of the methods of removing small amounts of material from the surface of a metal part. On the faces, the teeth are usually diagonal to the edge. One end of the file is shaped to fit into a wooden handle. The hand file is parallel in width and tapering slightly in thickness, towards the tip. It is provided with double cut teeth. On the faces, single cut on one edge and no teeth on the other edge, which is known as a safe edge.

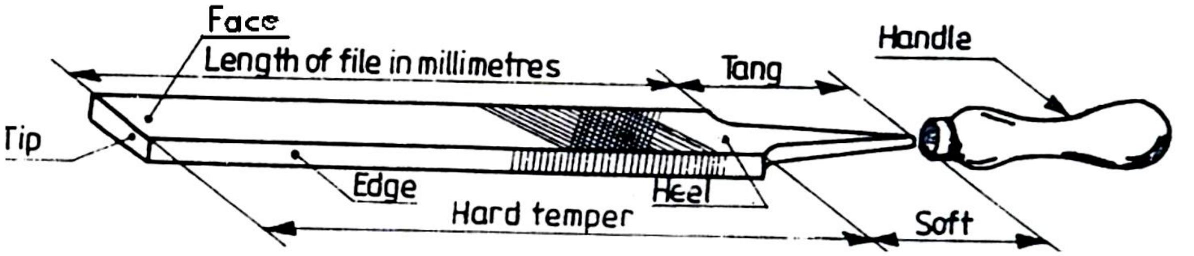


Fig 2.21 Parts of a Hand File

2.5.2.1 FILES CLASSIFICATION

Files are classified according to their Size, Shape, cutting teeth and pitch or grade of the teeth.

(a) Size: The length of file is measured from the tip to the heel and varies from 4 to 14 inch.
(b) Shape: This is the shape of its cross section and the ones available are flat, square, round, half-round, triangular etc.
(c) Cutting Teeth: This means the pattern of the cutting teeth of a file, it may be single cut, double cut or Rasp. Single cut is used for filing non-ferrous metals while double cut files are used for filing iron and steel. Rasp files are used for filing woods and non-metallic materials.
(d) Grade of Cut: This is the fineness or coarseness of cutting teeth of a file and is determined by the number of cutting teeth per inch or centimeter e.g.
    (i) Rough File – 20 teeth per inch
    (ii) Bastard File – 30 teeth per inch
    (iii) Second cut – 40 teeth per inch
    (iv) Smooth File – 50-60 teeth per inch
    (v) Dead Smooth File – 100 teeth per inch

Rough and Bastard files are used for rough cutting while Smooth and dead smooth files are used for finishing work.

2.5.2.2 FILING METHODS

The accuracy of filing depends mainly on the skill of the filer. Files should be used in perfect horizontal position. The production of a flat and square surfaces by filing must be leant first from a skilled Craftsman. There are three common methods of filing: cross-filing, draw filing and profile filing.

2.5.2.3 PINNING

Pinning of files is the clogging of the file teeth with the metal particles being filed, which usually occur when filing soft and ductile metals. If these pins or metal particles are not removed, the cutting efficiency of the file will be reduced and the work surface will be scratched. Pinning can be removed by cleaning the file teeth with a file card (wire brush).

Also, pinning may be minimized or somehow avoided by coating the file teeth with chalk or turpentine before using it to file ductile metals.

2.6 STRIKING TOOLS

Hammers are the most common tools used for striking in the fitting shop. Various types of hammers (such as ball peen hammer, straight peen hammer, cross-peen hammer, double face hammer and soft face hammer) are acting as striking tools.

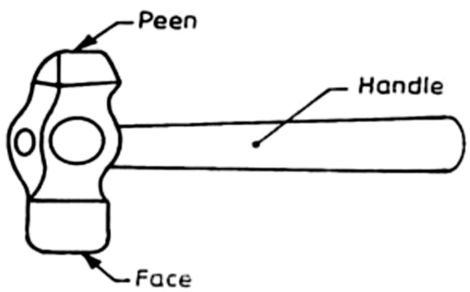


Fig 2.22 Straight Pein Hammer

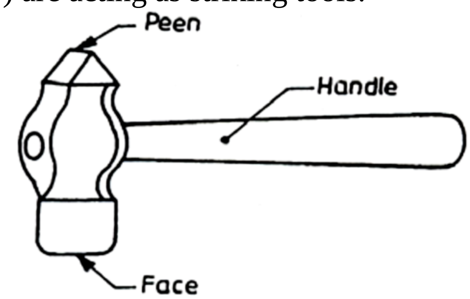


Fig 2.23 Cross Pein Hammer

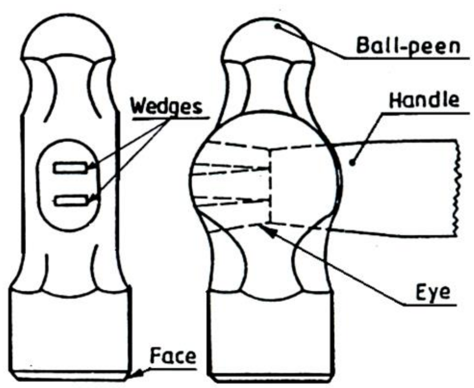


Fig 2.24 Ball Pein Hammer

2.7 MISCELLANEOUS TOOLS

2.7.1 File card

It is a metal brush, used for cleaning the files, to free them from filings, clogged in-between the teeth.

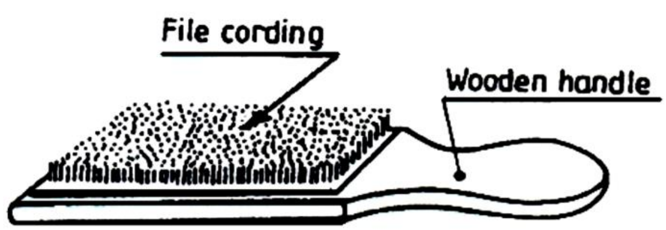


Fig 2.25 File Card

2.7.2 Spirit level

It is used to check the leveling of machines.

2.7.3 Screw Driver

A screw driver is designed to turn screws. The blade is made of steel and is available in different lengths and diameters. The grinding of the tip to the correct shape is very important. A star screw driver is specially designed to fit the head of star screws. The end of the blade is fluted instead of flattened. The screw driver is specified by the length of the metal part from handle to the tip.

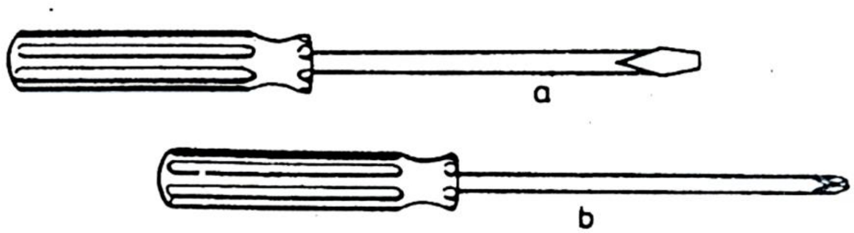


Fig 2.26 Screw Drivers - *(a) Flat (b) Star*

2.7.4 Spanner

A spanner or wrench is a tool for turning nuts and bolts. It is usually made of forged steel. There are many kinds of spanners. They are named according to their application. The size of the spanner denotes the size of the bolt on which it can work.

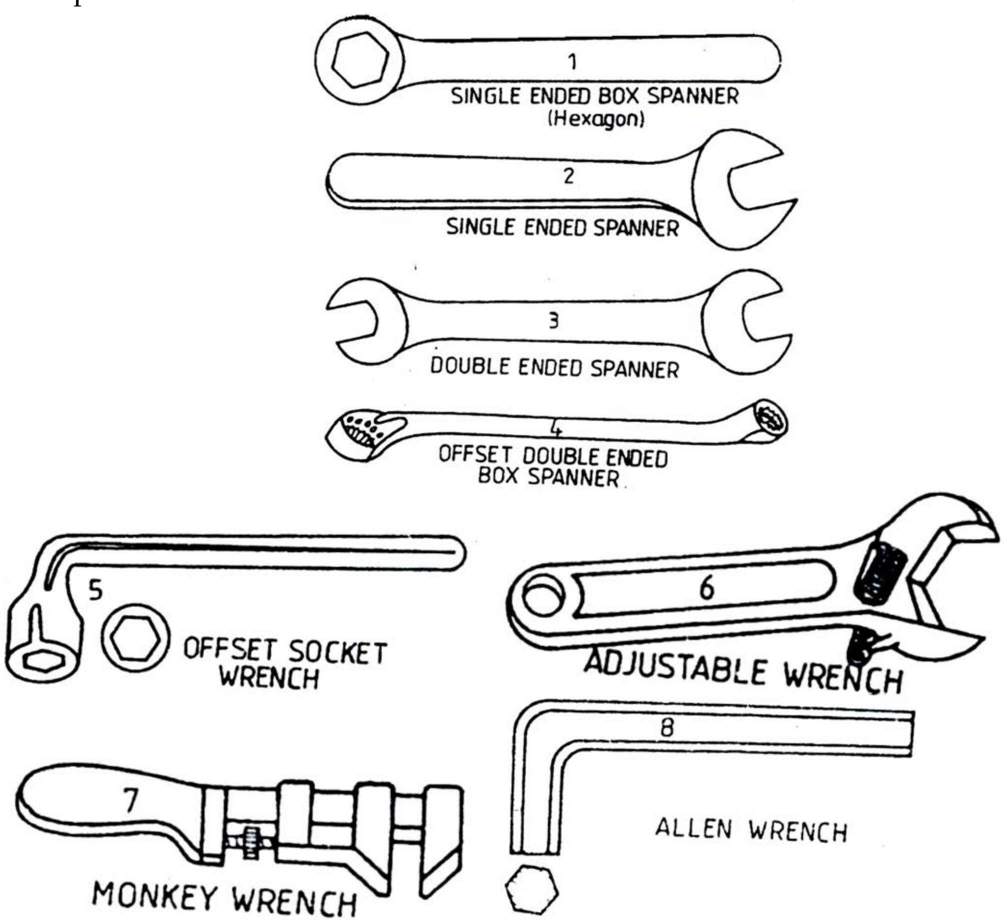


Fig 2.27 Spanners

2.8 SAFETY PRACTICES FOR FITTING WORKSHOP

The following are some of the safe and correct work practices in bench work and fitting shop, with respect to the tools used

1. Keep hands and tools wiped clean and free of dirt, oil and grease. Dry tools are safer to use than slippery tools.
2. Do not carry sharp tools in pockets.
3. Wear leather shoes and not sandals.
4. Do not wear loose clothes.
5. Do no keep working tools at the edge of the table.
6. Position the work piece such that the cut to be made is close to the vice. This practice prevents springing, saw breakage and personal injury.
7. Apply force only on the forward (cutting) stroke and relieve the force on the return stroke while sawing and filing.
8. Do not hold the work piece in hand while cutting.
9. Use the file with a properly fitted tight handle.
10. After filing, remove the burrs from the edges of the work, to prevent cuts to the fingers.
11. Do not use vice as an anvil.
12. While sawing, keep the blade straight; otherwise it will break
13. Do not use a file without handle.
14. Clean the vice after use.

2.9 MODELS FOR PRACTICE

Prepare the models, as per the dimensions and fits shown in below.

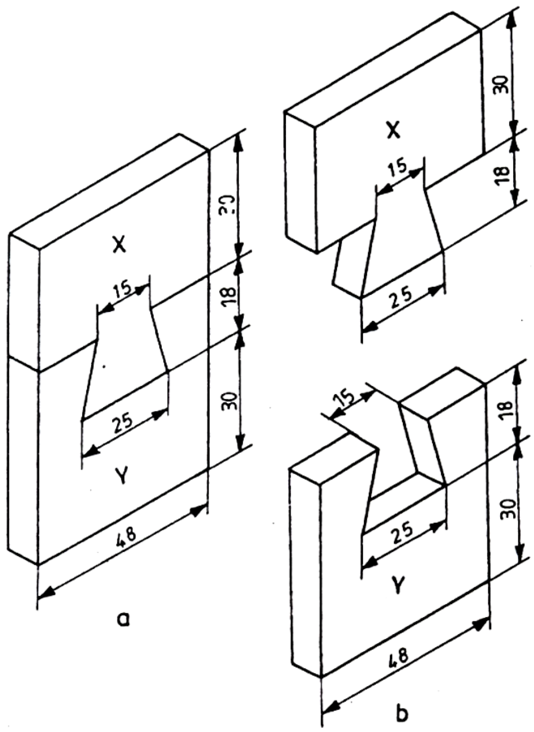


Fig 2.28 Dovetail Fitting

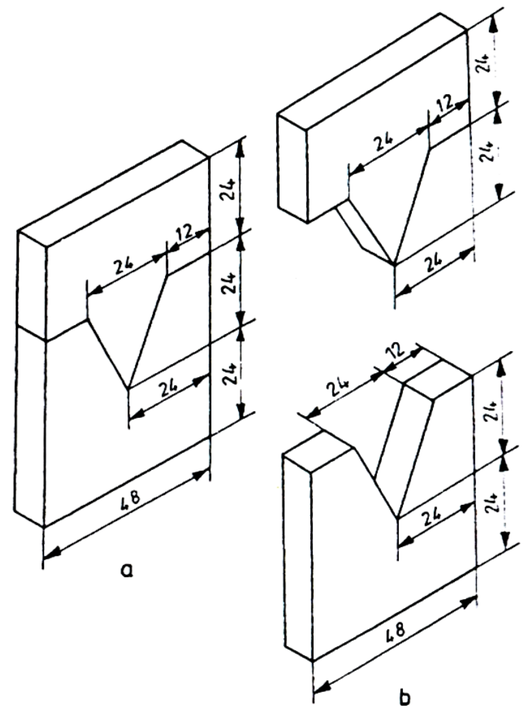


Fig 2.29 V-Fitting

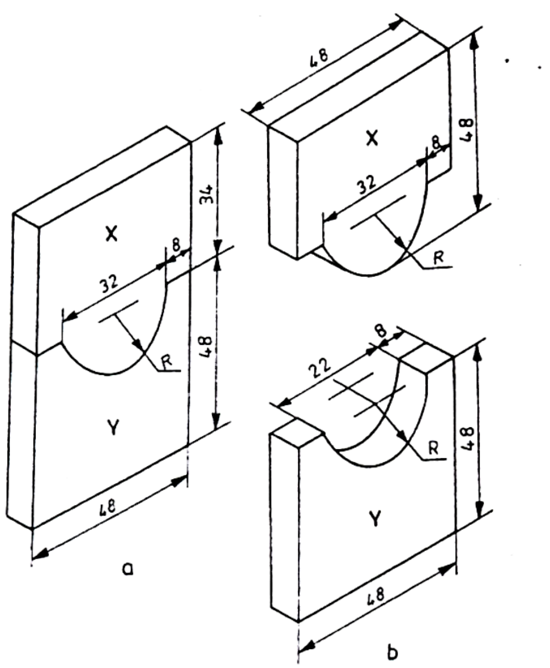


Fig 2.30 Half Round Fitting

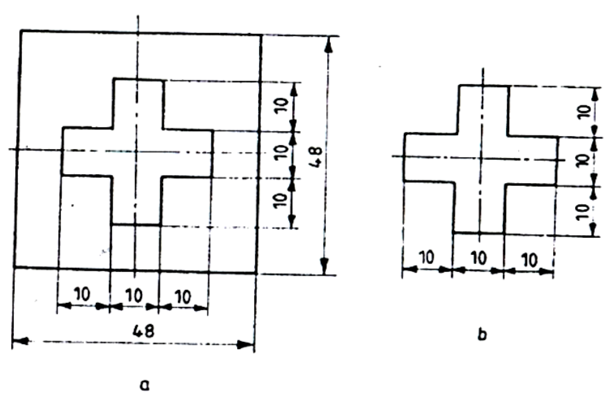


Fig 2.31 Cross Fitting

Exercise 1

Square Filing

Aim: To file the given two Mild Steel pieces in to a square shape of 48 mm side as shown in the Figure below

Tools required

Bench vice, set of Files, Steel rule, Try-square, Vernier caliper, Vernier height gauge, Ball-peen hammer, Scriber, Dot punch, Surface plate, Angle plate and Anvil.

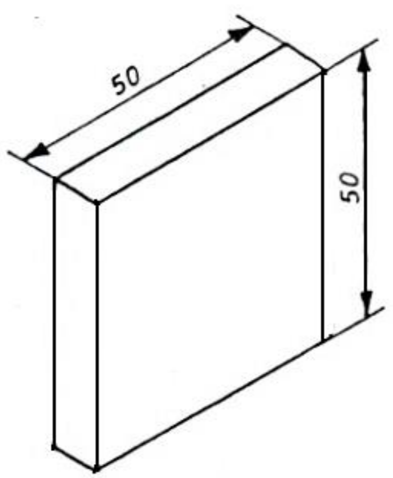
Sequence of operations

1. The dimensions of the given piece are checked with the steel rule.
2. The job is fixed rigidly in a bench vice and the two adjacent sides are filed, using the rough flat file first and then the smooth flat file such that, the two sides are at right angle.
3. The right angle of the two adjacent sides is checked with the try-square.
4. Chalk is then applied on the surface of the work piece.
5. The given dimensions are marked by scribing two lines, with reference to the above two datum sides by using Vernier height gauge, Angle plate and Surface plate.
6. Using the dot punch, dots are punched along the above scribed lines.
7. The two sides are then filed, by fitting the job in the bench vice; followed by checking the flatness of the surfaces.

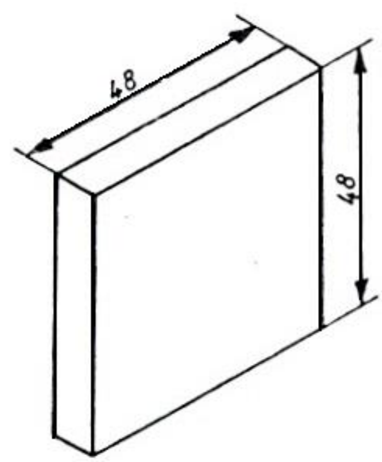
As the material removal through filing is relatively less, filing is done instead of sawing.

Result

The square pieces of 48 mm side is thus obtained by filing, as discussed above.



a. Raw material



b. Finished job

Exercise 2

V-Fitting

Aim: To make V- fit from the given two MS plates and drilling and Tapping as shown in the Figure below

Tools required

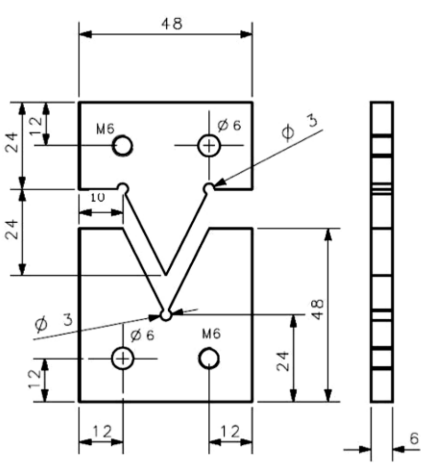
Bench vice, set of Files, Try-square, Scriber, Steel rule, Ball-peen hammer, Dot punch, Hacksaw, Vernier caliper, Surface plate, Angle plate, Vernier height gauge, 5mm drill bit, 3mm drill bit, M6 tap set with wrench, Anvil and Drilling machine.

Sequence of operations

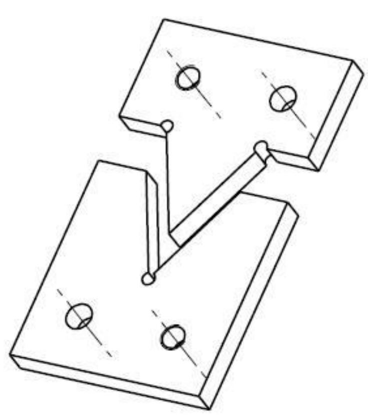
1. The burrs in the pieces are removed and the dimensions are checked with steel rule.
2. Make both pieces surface levels and right angles by fixing in the Vice, use Files for removing material to get level.
3. With the help of Try square check the right angles and surface levels.
4. Using Surface plate and Angle plate mark the given two metal pieces as per drawing with Vernier height gauge.
5. Punch the scribed lines with dot punch and hammer keeping on the Anvil. Punch to punch give 5mm gap.
6. Cut excess material wherever necessary with Hacksaw frame with blade, Drill bits and Taps.
7. The corners and flat surfaces are filed by using square/flat and triangular file to get the sharp corners.
8. Dimensions are checked by vernier caliper and match the two pieces. Any defect noticed, are rectified by filing with a smooth file.
9. Care is taken to see that the punched dots are not crossed, which is indicated by the half of the punch dots left on the pieces.

Result

The required V- fitting is thus obtained, by following the stages, as described above.



(a)



(b)

CHAPTER THREE

CARPENTRY

3.0 INTRODUCTION

Carpentry is the process of shaping Timber using hand tools. The products produced are used in building constructions, such as doors and windows, furniture manufacturing, patterns for moulding in foundries, etc. Carpentry work mainly involves the joining together of wooden pieces and finishing the surfaces after shaping them. Hence, the term joining is also used commonly for carpentry. A student studying the fundamentals of wood working has to know about timber and other carpentry materials, wood working tools, carpentry operations and the method of making common types of joints.

3.1 MATERIALS USED IN CARPENTRY

Basic materials used in carpentry shop are timber and plywood. Auxiliary materials used are nails, screws, adhesives, paints, varnishes, etc.

3.2 TIMBER

Timber is the name given to wood obtained from exogenous (outward growing) trees. In these trees, the growth is outward from the center by the addition of almost concentric layers of fresh wood every year known as annual rings. After the full growth, these trees are cut and sawed for conversion into rectangular sections of various sizes for engineering purposes. Timber is available in market in various shapes and size. The common shapes and sizes are given below:

a. **Log:** This is the trunk of the tree which is free from branches.
b. **Balk:** This is the log sawn to have rough square cross section.
c. **Deal:** This is the log formed after sawing into rectangular cross section of width about 225 mm and thickness up to 100 mm.
d. **Plank:** This is the timber piece having width more than 275 mm and thickness of between 50 to 150 mm.
e. **Board:** This is the timber piece below 50 mm in thickness and above 125 mm in width.
f. **Batten:** This is the timber piece below 175 mm in width and thickness between 30 mm to 50 mm in thickness.
g. **Scantlings:** These are timber pieces of various assorted and nonstandard sizes other than the types given above.

3.3 CLASSIFICATION OF WOOD

The timber used for commercial purposes can be divided into two classes as soft wood and hard wood

3.3.1 Soft Wood

A soft wood is light in weight and light colored. They may have distinct annual rings but the medullar rays (radial lines) are not visible and the color of the *sap wood* (outer layers) is not distinctive from the heart wood (inner layers). These woods cannot resist stresses developed across their fibers; hence, not suitable for wood working.

3.3.2 Hard wood

In this type of wood the annual rings are compact and thin and the medullar rays (radial lines} are Visible in most cases. Hard woods are nearly equally strong both along and across the fibers. Hard wood is the material used for wood working.

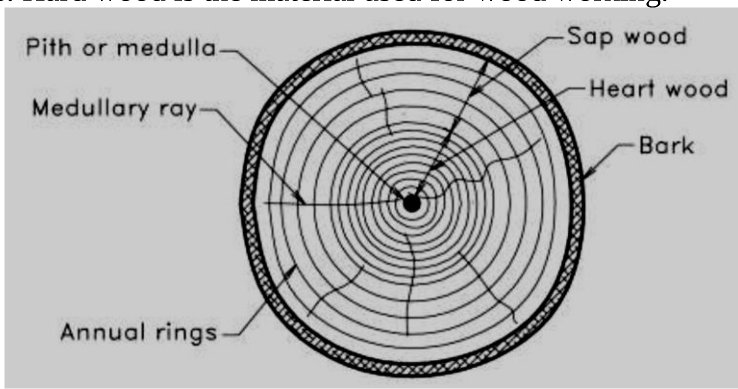


Fig 3.1 Parts of a Wood

3.4 CLASSIFICATION OF TIMBER

According to the manner of growth of trees, timber can be classified as:
(i) Exogenous or out ward growing
(ii) Endogenous or in ward growing

3.4.1 Exogenous or out ward growing

In exogenous trees the growth take place from the center by the addition of concentric layers of fresh wood every year, known as annual rings. These varieties of trees are suitable for building and other engineering purposes. The exogenous trees are again classified as:
a) Conifers or ever green trees
b) Deciduous or broad leaf trees

The conifer give soft woods and the deciduous gives hard wood. Common example of hard wood are Sal, teak, rose wood, sandal, shisham (indian rosewood), oak beach, ash ebony, mango, neem, babool, etc., soft wood include kail pine, deodar, chir, walnut, seemal etc.

3.4.2 Endogenous or in ward growing timber

These trees grow in wards i.e. every fresh layer of sap wood is added inside instead of outside. Examples are cane, bamboo, coconut tree etc.

3.5 CHARACTERISTICS OF GOOD TIMBER

A good timber must possess the following characteristics:
a. It should have minimum moisture content, i.e., the timber should be well seasoned.
b. The grains of wood should be straight and long.
c. It must retain its straightness after seasoning.
d. It should produce near metallic sound on hammering.
e. It should be free from knots or cracks.
f. It should be of uniform color, throughout the part of the wood.
g. It should respond well to the finishing and polishing operations.
h. During driving the nails and screw, it should not split easily.

3.6 SEASONING

A newly felled tree contains considerable moisture content. If this is not removed, the timber is likely to wrap, shrink, crack or decay. Seasoning is the art of extracting the moisture content under controlled conditions, at a uniform rate, from all the parts of the timber. Only seasoned wood should be used for all carpentry works. Seasoning makes the wood resilient and lighter. Further, it ensures that the wood will not distort after it is made into an object.

3.6.1 Different methods of seasoning

(a) Air seasoning or Natural seasoning
(b) Water seasoning
(c) Electrical seasoning
(d) Kiln seasoning

3.7 PLY WOOD

Thick sheet formed by pasting veneers of wood is called ply. Three or more ply joined by glues is called plywood. The grains of adjacent layers are kept at right angle to each other in order to get better strength in both directions. Good hard wood are used for the outer layer and they are called facing ply while the inner ones are called core ply and low quality wood is used for this. The ply wood is made by either cold pressing or hot pressing.

3.8 WOOD JOINTS

There are many kinds of joints used to connect wood stock. Each joint has a definite use and requires lay in-out, cutting them together. The strength of the joint depends upon amount of contact area. If a particular joint does not have much contact area, then it must be reinforced with nails, screws or dowels. The figure below shows some commonly used wood joints.

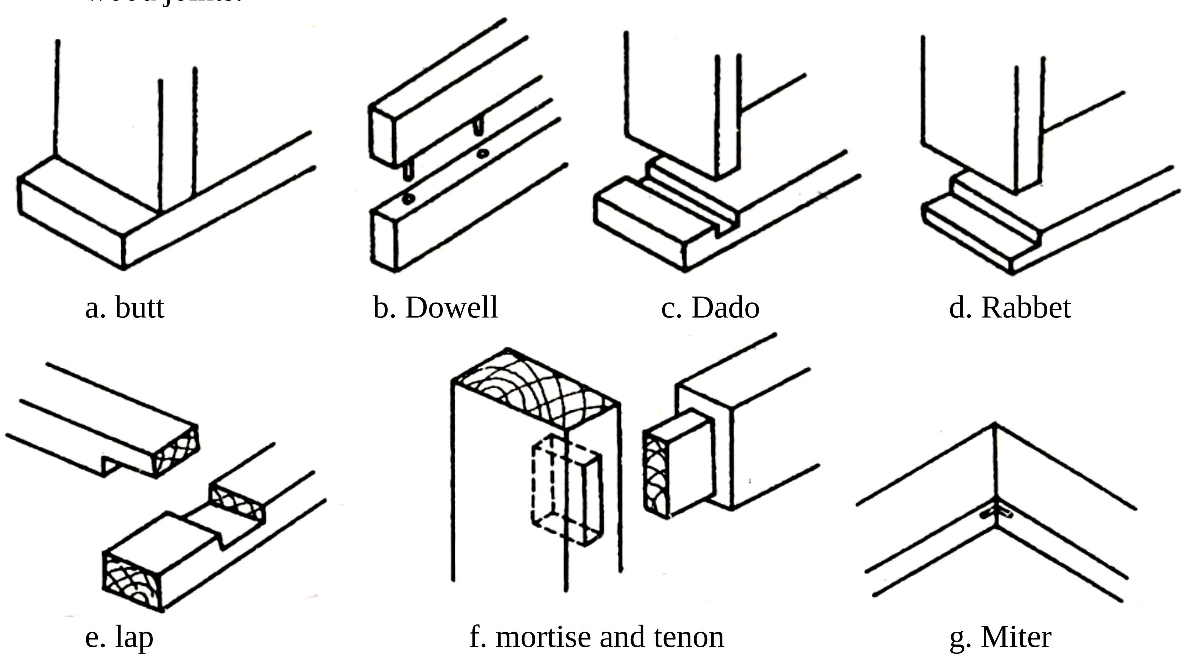


Fig 3.2 Common Wood Joint

3.8.1 Lap Joint

In lap joints, an equal amount of wood is removed from each piece, as shown in the figure below. Lap joints are easy to layout, using a try-square and a marking gauge. The procedure suggested for sawing and removing the waste stock is to be followed. If the joint is found to be too tight, it is better to reduce the width of the mating piece, instead of trimming the shoulder of the joint. This type of joint is used for small boxes to large pieces of furniture.

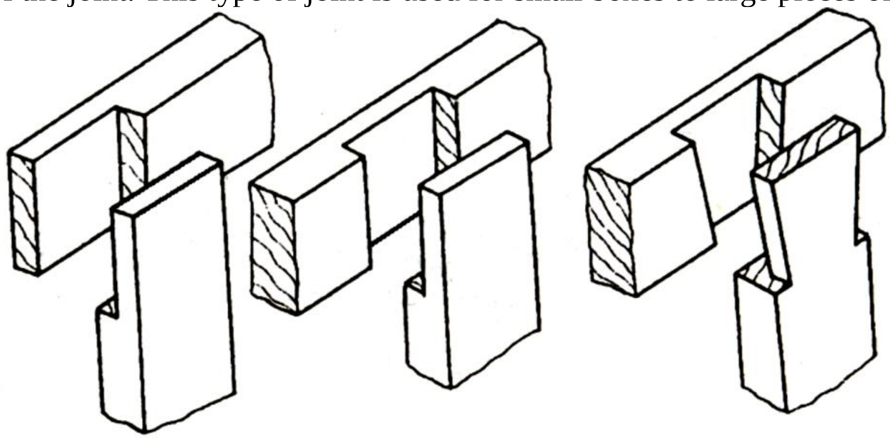


Fig 3.3 Lap Joints

3.8.2 Mortise and Tenon Joint

It is used in the construction of quality furniture. It results in a strong joint and requires considerable skill to make it. The following are the stages involved in the work.

- **a.** Mark the mortise and tenon layouts.
- **b.** Cut the mortise first by drilling series of holes within the layout line, chiseling out the waste stock and trimming the corners and sides.
- **c.** Prepare the tenon by cutting and chiseling.
- **d.** Check the tenon size against the mortise that has been prepared and adjust it if necessary.

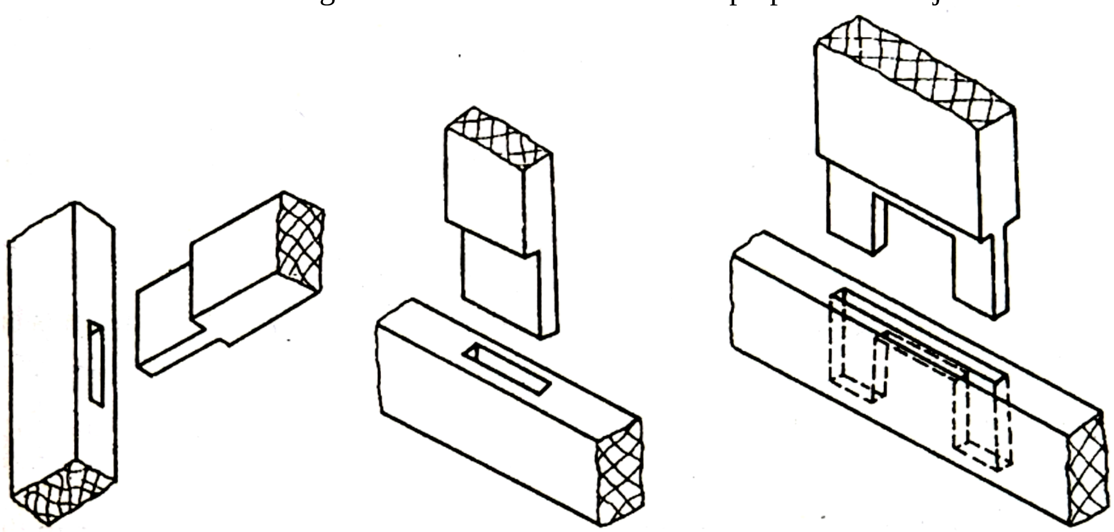


Fig 3.4 Mortise and Tenon Joint

3.8.3 Bridle Joint

This is the reverse of mortise and tenon joint in form. The marking-out of the joint is the same as for mortise and tenon joint. This joint is used where the members are of square or near square section and unsuitable for mortise and tenon joint.

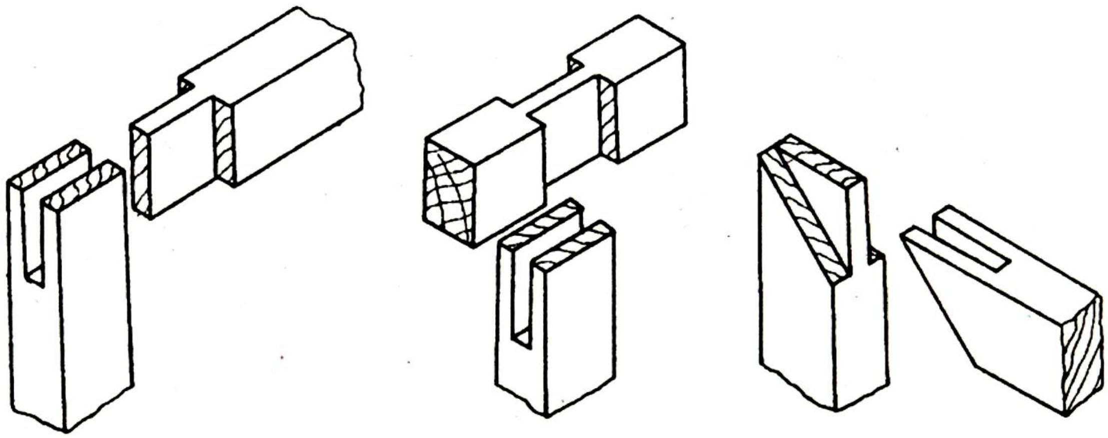


Fig 3.5 Bridle Joint

3.9 TOOLS FOR WOOD WORKING

The principal hand tools used in a carpentry workshop can be classified into:

(a) Marking and measuring tool
(b) Cutting tool
(c) Planning tool
(d) Boring tool
(e) Striking tool
(f) Holding tool

3.9.1 MARKING AND MEASURING TOOL

Accurate marking and measurement is very essential in carpentry work, to produce parts to exact size. To transfer dimensions onto the work; the following are the marking and measuring tools that are required in a carpentry shop.

(a) Steel rule and Steel tape

Steel rule is a simple measuring instrument consisting of a long, thin metal strip with a marked scale of unit divisions. It is an important tool for linear measurement. *Steel tape* is used for large measurements, such as marking on boards and checking the overall dimensions of the work.

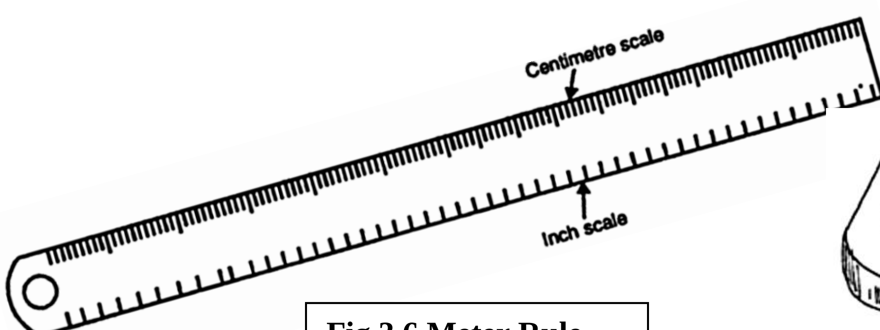


Fig 3.6 Meter Rule

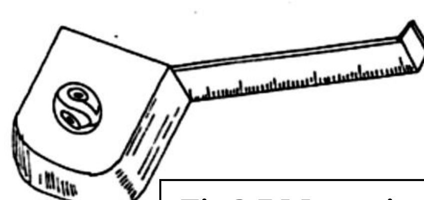


Fig 3.7 Measuring tape

(b) Marking gauge

It is a tool used to mark lines parallel to the edge of a wooden piece. It consists of a square wooden stem with a sliding wooden stock (head) on it. On the stem is fitted a marking pin, made of steel. The stock is set at any desired distance from the marking point and fixed in position by a screw. It must be ensured that the marking pin projects through the stem, about 3mm and the end are sharp enough to make a very fine line. A *mortise gauge* consists of two pins. In this, it is possible to adjust the distance between the pins, to draw two parallel lines on the stock.

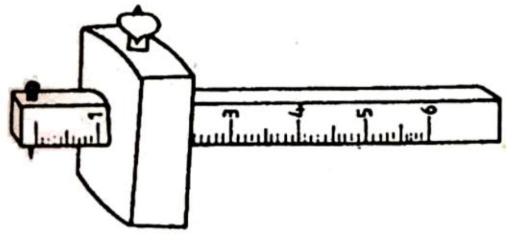


Fig 3.8 Marking Gauge

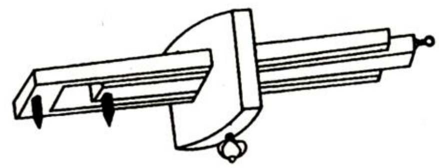


Fig 3.9 Mortise Gauge

(c) Try-square

It is used for marking and testing the squareness and straightness of planed surfaces. It consists of a steel blade, fitted in a cast iron stock. It is also used for checking the planed surfaces for flatness. Its size varies from 150 to 300mm, according to the length of the blade. It is less accurate when compared to the try-square used in the fitting shop.

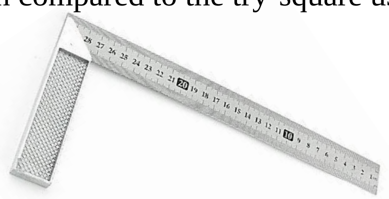


Fig 3.10 Try Square

(d) Compass and divider

Compass and divider, are used for marking arcs and circles on the planed surfaces of the wood.

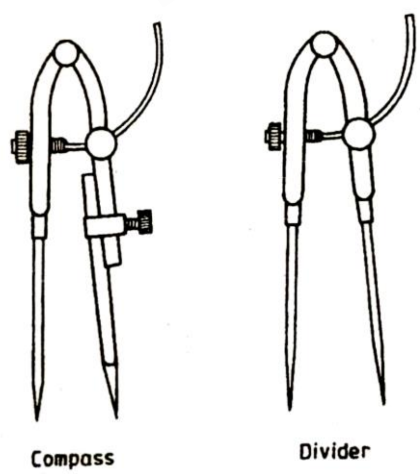


Fig 3.11 Compass and Divider

(e) Scriber or marking knife

It is used for marking on timber. It is made of steel having one end pointed and the other end formed into a sharp cutting edge.

(f) Bevel

It is used for laying-out and checking angles. The blade of the bevel is adjustable and may be held in place by a thumb screw. After it is set to the desired angle, it can be used in much the same way as a try-square. A good way to set it to the required angle is to mark the angle on a surface and then adjust the blade to fit the angle.

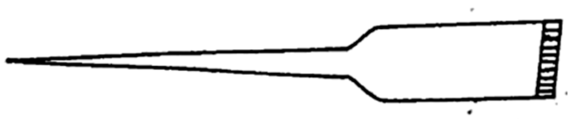


Fig 3.12 Marking Knife

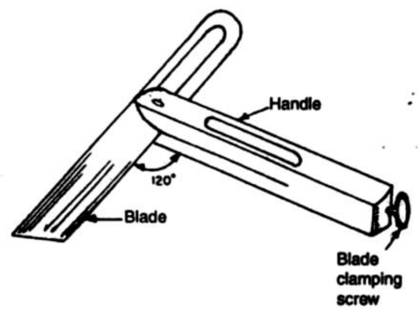


Fig 3.13 Bevel Square

3.9.2 HOLDING TOOLS

(a) Work Bench

This is a table having size and raised construction made of hard wood. The size ranges from 50- 80 cm in length and about 90cm in width. Two or four carpenters can work at a time on the work bench.

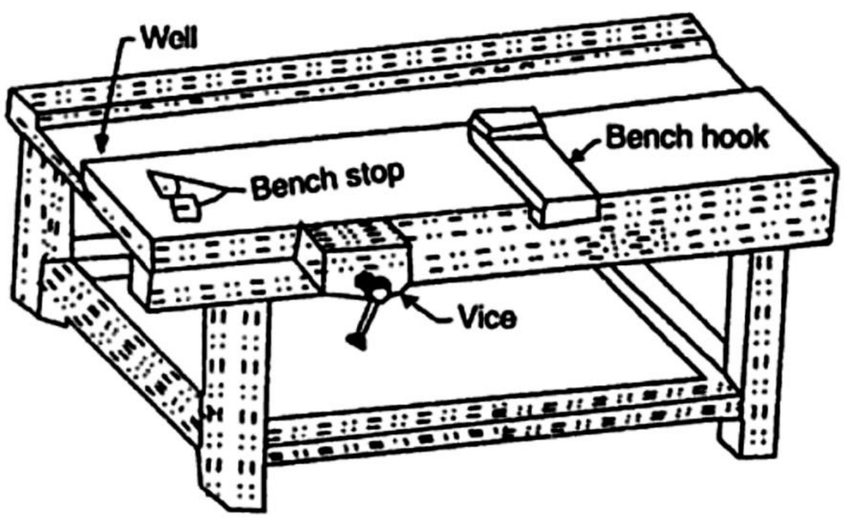


Fig. 3.14 Work Bench

(b) Carpenter's Vice

It consists of jaw fixed on the table side and movable jaw kept in position by means of screw and handle. The body of vice is made of cast iron or steel. The jaws are lined with hard wood which can be removed when it is damaged.

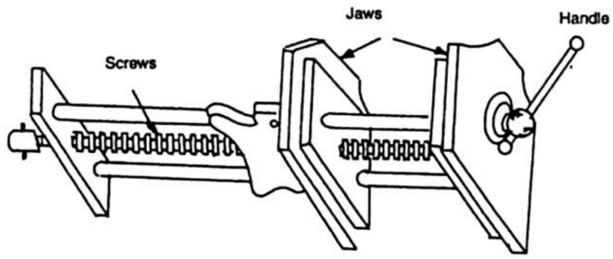


Fig 3.15 Carpenter's Vice

(c) **C-clamp**

Figure 3.12 shows a C-clamp, which is used for holding small works.

(d) **Bar clamp**

Figure 3.13 shows a bar clamp. It is made of steel bar of T-section, with malleable iron fittings and a steel screw. It is used for holding wide works such as frames or tops.

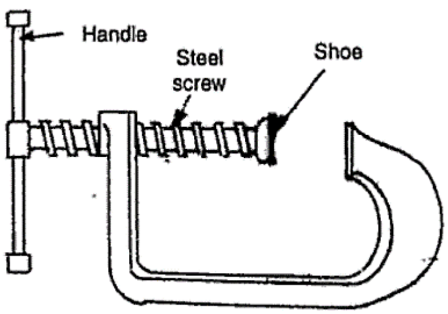


Fig. 3.16 C-Clamp

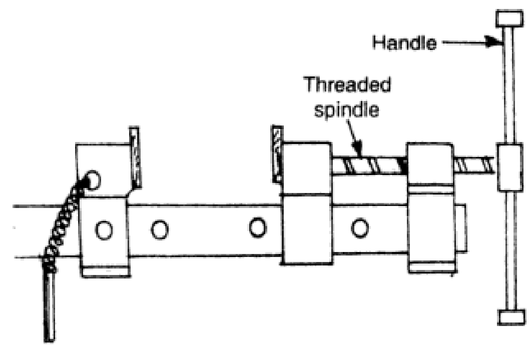


Fig 3.17 Bar or T Clamp

3.9.3 CUTTING TOOLS

3.9.3.1 Saws

A saw is a tool used to cut wood into desired shapes and sizes through reciprocating motions of its edge relative to the work to be cut. There are different types of saws, designed to suit different purposes. A saw is specified by the length of its tooled edge. The following saws are used in Carpentry.

(a) Rip Saw: The blade of rip saw is either straight or skew-backed. The teeth are so set that the cutting edge of this saw makes a steeper angle about 60^0.
(b) Tenon or backsaw: A tenon saw is used for fine and accurate work. It consists of a very fine blade, which is reinforced with a rigid steel back. The teeth are shaped like those of cross cut saw.
(c) Compass Saw: It is a type of saw used for making curved cuts known as compasses, particularly in confined spaces where a larger saw would not fit.

(d) Key hole Saw: This is a fine-toothed handsaw, with a long, narrow, tapered blade. Keyhole saws also called jab saws are used mostly for cutting curves

(e) Cross Cut Saw: This is similar in shape to a rip saw. It is used to cut across the grain of the stock. The correct angle for cross cutting is 45^0. The teeth are so set that the saw kerf is wider than the blade thickness. This allows the blade to move freely in the cut without sticking.

(f) Bow Saw: It is a much smaller type of saw with a bow shape for a single person use, ideal for cutting logs for a wood stove or open fireplace.

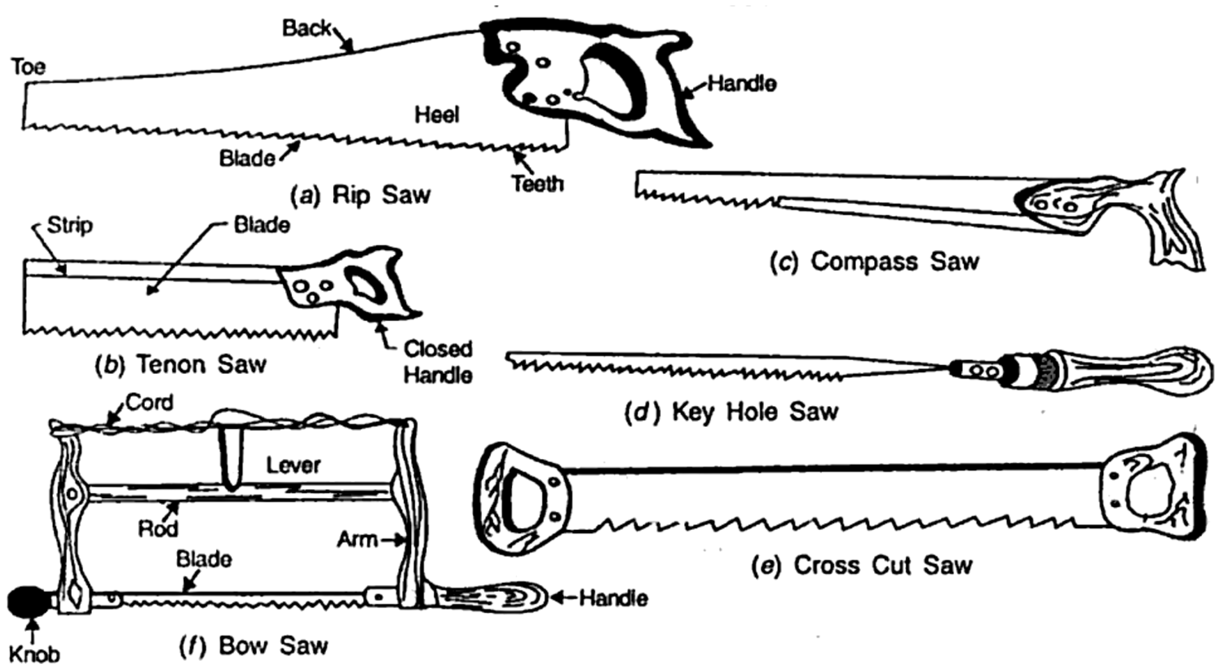


Fig 3.18 Types of Saws

3.9.3.2 Chisels

Chisels are used for cutting and shaping wood accurately. Wood chisels are made of various blade widths, ranging from 3 to 50mm. Most of the wood chisels are made into tang type having a steel shank which fits inside the handle.

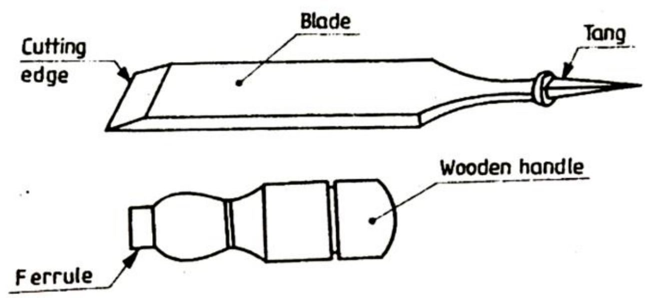


Fig. 3.19 Parts of a Chisel

The following are some of the common types of chisels.

(a) Firmer Chisels- They are the most common and general purpose chisel used by carpenter. They have flat blade of 15-50mm width and 125mm length.
(b) Dove Tail Chisel (beveled edge firmer chisel) - These chisels are used for fine and delicate works as well as for cutting corners.
(c) Mortise chisel – These chisels are used for heavy and deep cut to remove large quantity of wood. These chisels have width of about 15mm but the blade thickness may range from 6-15mm.

3.9.4 PLANNING TOOLS

Planning tool is used to smoothen the wooden surfaces.

(a) Wooden jack plane

This is the most commonly used plane in carpentry shop. The main part of a wooden jack plane is a wooden block called sole, in which steel blade having knife edge is fixed at an angle with the help of wooden edge. The angle of the blade is kept about 45 ° to bottom surface of the blade.

(b) Metal Jack Plane

It serves the same purpose as the wooden jack plane but facilitates a smoother operations and better finish. The body of a metal jack plane is made from a grey iron casting with the side and sole machined and ground to better finish.

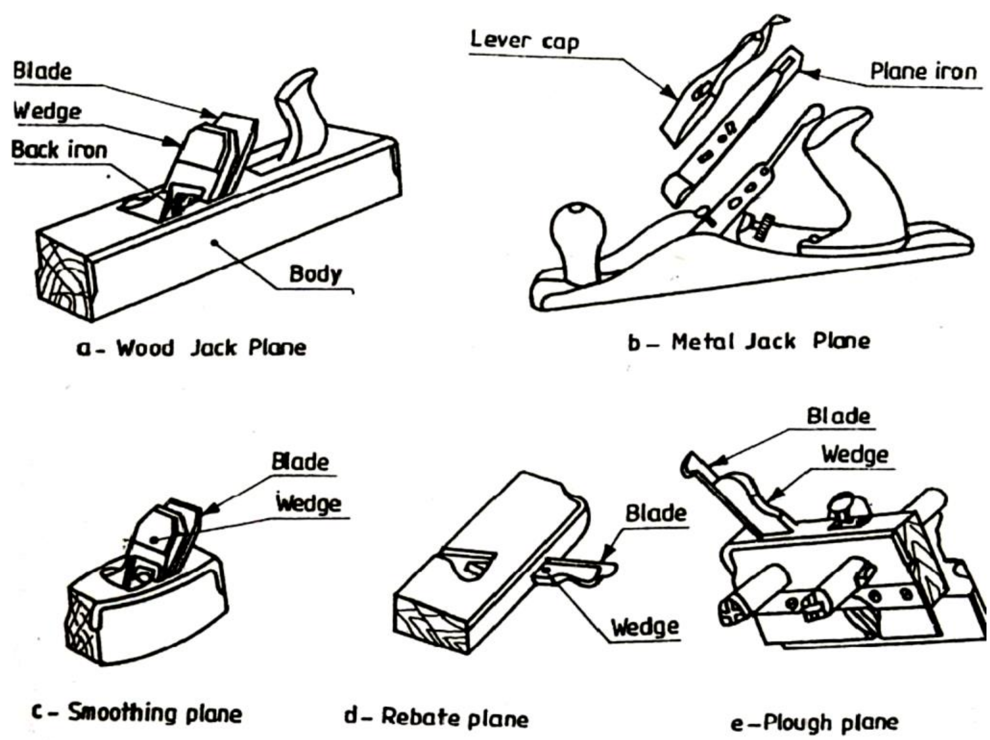


Fig 3.20 Types of Planes

3.9.5 DRILLING AND BORING TOOLS

(a) Bradawl:
It is a hand operated tool, used to bore small holes for starting a screw or large nail.

(b) Carpenters brace
It is used for rotating auger bits, twist drills, etc., to produce holes in wood. In some designs, braces are made with ratchet device.

(c) Auger bit
It is the most common tool used for making holes in wood. During drilling, the lead screw of the bit guides it into the wood, necessitating only moderate pressure on the brace. The helical flutes on the surface carry the chips to the outer surface.

(d) Hand drill
Carpenter’s brace is used to make relatively large size holes; whereas hand drill is used for drilling small holes. A straight shank drill is used with this tool. It is small, light in weight and may be conveniently used than the brace. The drill bit is clamped in the chuck at its end and is rotated by a handle attached to gear and pinion arrangement.

(e) **Gimlet**
It has cutting edges like a twist drill. It is used for drilling large diameter holes with the hand’s pressure.

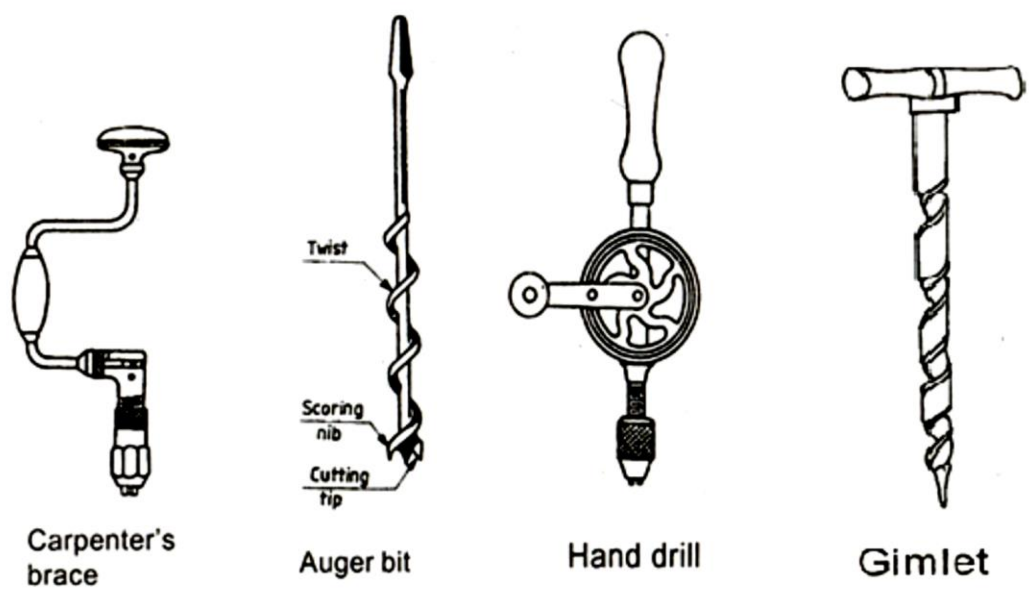


Fig 3.21 Drilling Tools

3.9.6 MISCELLANEOUS TOOLS

(a) Mallet

This is wooden headed hammer of round or rectangular cross section. The striking face is made flat. Mallet is used for striking the cutting tools and has wooden handle.

(b) Claw Hammer

This is a hammer having steel head and wooden handle. The flat face of the head is used to drive nails and the claw portion for extracting nails out of the wood.

(c) Pincer

It is made of two forged steel arms with a hinged joint and is used for pulling-out small nails from wood. The inner faces of the pincer jaws are bevelled and the outer faces are plain. The end of one arm has a ball and the other has a claw. The bevelled jaws and the claw are used for pulling out small nails, pins and screws from the wood.

(d) **Screw Driver:**

It is used for driving wood screws into wood or unscrewing them. The length of a screw driver is determined by the length of the blade. As the length of the blade increases, the width and thickness of the tip also increase.

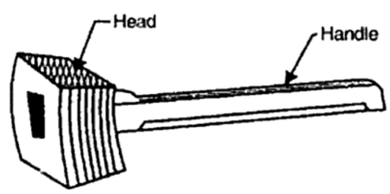


Fig 3.22 Mallet

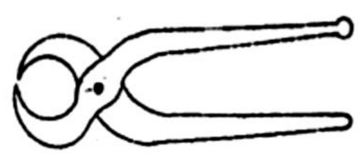


Fig 3.23 Pincer

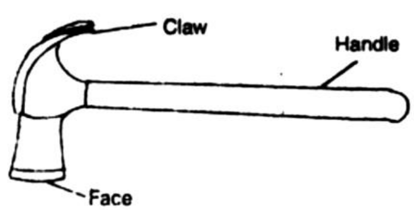


Fig 3.24 Claw Hammer

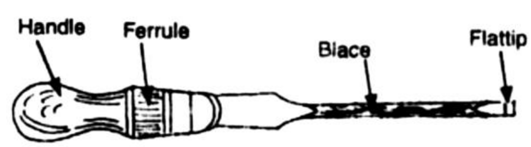


Fig. 3.25 Screw Driver

3.10 SAFETY PRACTICES FOR CARPENTRY WORKSHOP

The following are some of the safe and correct work practices in carpentry shop, with respect to the tools used

1. Tools that are not being used should always be kept at their proper places.
2. Make sure that your hands are not in front of sharp edged tools while you are using them.
3. Use only sharp tools. A dull tool requires excessive pressure, causing the tool to slip.
4. Wooden pieces with nails, should never be allowed to remain on the floor.
5. Be careful when you are using your thumb as a guide in cross-cutting and ripping.
6. Test the sharpness of the cutting edge of chisel on wood or paper, but not on your hand.
7. Never chisel towards any part of the body.
8. Do not use chisels where nails are present. Do not use chisel as a screwdriver.
9. Do not use a saw with a loose handle.
10. Always use triangular file for sharpening the teeth.
11. Do not use a saw on metallic substances.
12. Do not use mallet to strike nails.
13. Do not use plane at the places, where a nail is driven in the wood.

Exercise 1

T-Lap joint

Aim: To make a T-lap joint as shown in Figure 2.19, from the given reaper of size 50 x 35 x 250 mm.

Tools required: Carpenter's vice, steel rule, jack plane, try-square, marking gauge, 25 mm firmer chisel, cross-cut saw, tenon saw, scriber and mallet.

Sequence of operations

1. The given reaper is checked to ensure its correct size.
2. The reaper is firmly clamped in the carpenter's vice and any two adjacent faces are planed by the jack plane and the two faces are checked for squareness with the try square.
3. Marking gauge is set and lines are drawn at 30 and 45 mm, to mark the thickness and width of the model respectively.
4. The excess material is first chiseled out with firmer chisel and then planed to correct size.
5. The mating dimensions of the parts X and Yare then marked using scale and marking gauge
6. Using the cross-cut saw, the portions to be removed are cut in both the pieces, followed by chiseling and also the parts X and Y are separated by cross-cutting, using the tenon saw
7. The ends of both the parts are chiseled to the exact lengths.
8. A fine finishing is given to the parts, if required so that, proper fitting is obtained.
9. The parts are fitted to obtain a slightly tight joint.

Result The T-Lap joint is thus made by following the above sequence of operations.

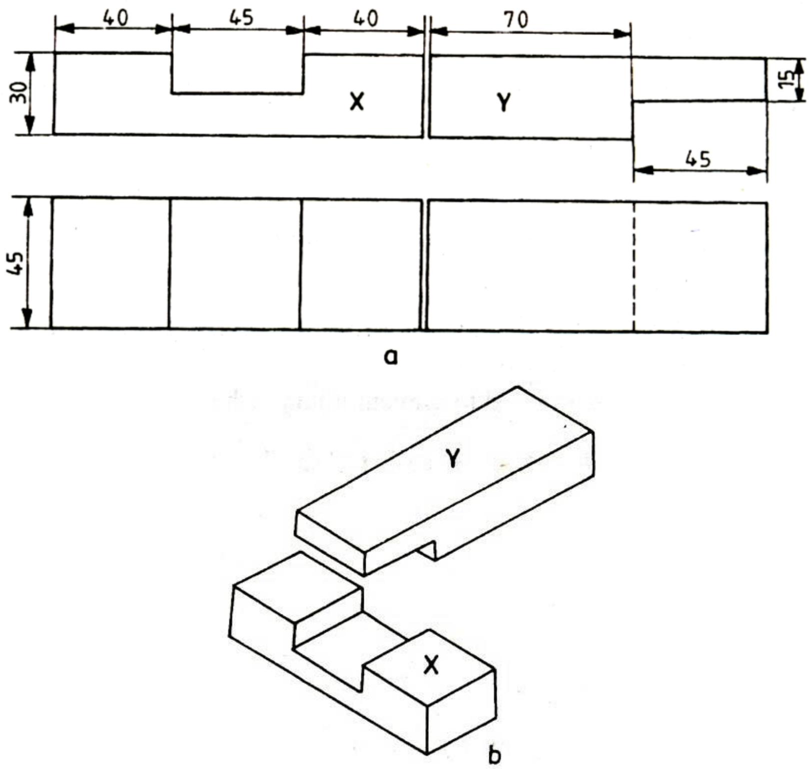


Figure E1: T-Lap Joint

Exercise 2

Dovetail lap joint

Aim: To make a dovetail lap joint that is as shown in the Figure below, from the given reaper of size 50 x 35 x 250 mm.

Tools required: Carpenter's vice, steel rule, jack plane, try-square, marking gauge, 25 mm firmer chisel, cross-cut saw, tenon saw, scriber and mallet.

Sequence of operations

1. The given reaper is checked to ensure its correct size.
2. The reaper is firmly clamped in the carpenter's vice and any two adjacent faces are planed by the jack plane and the two faces are checked for squareness with the try square.
3. Marking gauge is set and lines are drawn at 30 anc145 mm, to mark the thickness and width of the model respectively.
4. The excess material is first chiseled out with firmer chisel and then planed to correct size.
5. The mating dimensions of the parts X and Yare then marked using scale and marking gauge.
6. Using the cross-cut saw, the portions to be removed are cut in both the pieces, followed by chiseling and also the parts X and Yare separated by cross cutting, using the tenon saw.
7. The ends of both the parts are chiseled to exact lengths.
8. A fine finishing is given to the parts, if required so that, proper fitting is obtained.
9. The parts are fitted to obtain a slightly tight joint.

Result The dovetail lap joint is thus made by following the above sequence of operations.

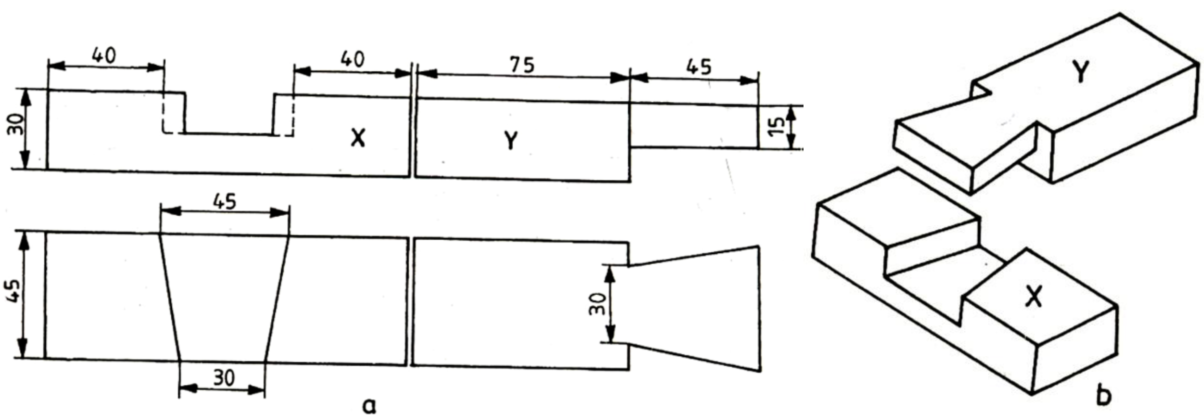


Fig E2: Dovetail Lap Joint

Exercise 3

Mortise and Tenon joint

Aim: To make a mortise and tenon joint as shown the figure below, from the given reaper of size 50 x 35 x 250mm.

Tools required: Carpenter's vice, steel rule, jack plane, try-square, marking gauge, 25mm firmer chisel, 6 mm mortise chisel, cross-cut saw, tenon saw, scriber and mallet.

Sequence of operations

1. The given reaper is checked to ensure its correct size.
2. The reaper is firmly clamped in the carpenter's vice and one of its faces are planed by the jack plane and checked for straightness.
3. The adjacent face is then planed and the faces are checked for squareness with the try-square.
4. Marking gauge is set and lines are drawn at 30 and 45 mm, to mark the thickness and width of the model respectively.
5. The excess material is first chiseled out with the firmer chisel and then planed to correct size.
6. The mating dimensions of the parts X and Yare then marked using the scale and marking gauge.
7. Using the cross-cut saw, the portions to be removed in part Y (tenon) is cut, followed by chiseling.
8. The material to be removed in part X (mortise) is carried out by using the mortise and firmer chisels.
9. The parts X and Yare separated by cross-cutting with the tenon saw
10. The ends of both the parts are chiseled to exact lengths.
11. Finish chiseling is done wherever needed so that, the parts can be fitted to obtain a near tight joint.

Result The mortise and tenon joint is thus made by following the above sequence of operations.

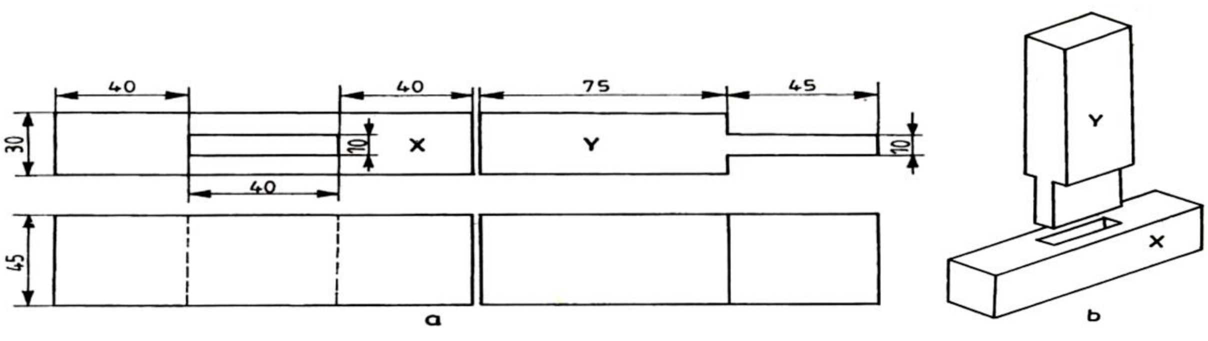


Fig E3: Mortise and Tenon Joint

CHAPTER FOUR

SHEET METAL WORK

4.0 INTRODUCTION

Sheet metal work has its own significance in the engineering work. Many products, which fulfill the household needs, decoration work and various engineering articles, are produced from sheet metals. Common examples of sheet metal work are hoopers, canisters, guards, covers, pipes, hoods, funnels, bends, boxes etc. Such articles are found less expensive, lighter in weight and in some cases sheet metal products replace the use of castings or forgings.

4.1 METALS USED IN SHEET METAL WORK

A metal plate of thickness less than 4 mm is considered as sheet. The size of the sheet is specified by its length, width and thickness in mm. In British system, the thickness of sheet is specified by a number called Standard Wire Gauge (SWG). The commonly used gauge numbers and the equivalent thickness in mm are given in table 4.1 below.

Table 4.1

SWG (No.)	16	17	18	19	20	22	24	27	30
Thickness (mm)	1.62	1.42	1.22	1.02	0.91	0.71	0.56	0.42	0.37

The following metals are generally used in sheet metal work:

i. **Black Iron Sheet:**
It is the cheapest among all. It has a bluish-black appearance and is uncoated sheet. Being uncoated, it corrodes rapidly. It is prepared by rolling to the desired thickness, then annealed by heating in a furnace and then set aside to cool gradually. The use of this metal is limited to articles that are to be painted or enameled such as stovepipes, tanks, pans etc.

ii. **Galvanized Iron:**
It is a soft steel coated with molten zinc. This coating resist rust, improves appearances, improves solderability, and improves water resistance. It is popularly known as G.I. sheets. Articles such as pans, buckets, furnaces, cabinet etc. are made from G.I sheets.

iii. **Stainless Steel:**
It is an alloy of steel with nickel, chromium and traces of other metals. It has good corrosive resistance. The cost of stainless steel is very high but tougher than G.I sheets. It is used in kitchenware, food handling equipment, chemical plants etc.

iv. **Copper:**
It is a reddish colored metal and is extremely malleable and ductile. Copper sheets have good corrosion resistance as well as good appearances but costs are high as compared to G.I and stainless steel. Because of high thermal conductivity, it is used for the radiator of automobiles, domestic heating appliances etc.

v. Aluminum

Aluminum cannot be used in its pure form, but is used in its alloy form. Common additions are copper, silicon, manganese and iron. It has many qualities like high ratio of strength to weight, corrosion resistant qualities, and ease in fabrication and whitish in color. It is used in manufacturing of a number of products such as refrigerator trays, household appliances, lighting fixtures, window work, construction of airplanes and in many electrical and transportation industries.

vi. Tin Plates

It is an iron sheet coated with the tin to protect it against rust. This metal has a very bright silvery appearance and is used principally in making food containers, cans and pans.

vii. Lead

It is a very soft, malleable, low melting point metal and possesses high resistance to acid corrosion. It is having low mechanical strength so it is used to provide lining to the highly corrosive acid tanks. It is also used in radiation shielding.

4.2 HAND TOOLS USED IN SHEET METAL WORK

Ranging from measuring to marking to cutting and forming, various types of hand tools are used in sheet metal work. A list of them is given below:

a) Measuring tools
b) Marking tools
c) Cutting tools
d) Forming tools
e) Joining tools

4.2.1 MEASURING TOOLS

The following types of tools are commonly used in sheet metal shops to measure the dimensions of work pieces:

a) Steel rule
b) Vernier caliper
c) Micrometer
d) Sheet Metal gauge

Some of the tools above have been discussed already in Chapter two.

4.2.1.1 Sheet Metal Gauge

It is a disc shaped piece of metal, having a number of slots on the outside edge as shown in figure below. The slots are of various widths and each corresponds to a certain standard wire gauge (SWG) number. The gauge is placed over the edge of the sheet to be measured and a slot is found that will slip over the metal with a light fit pressure. Standard tables are referred to for conversion of SWG numbers to mm sizes.

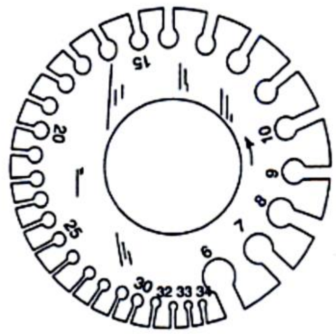


Fig 4.1 Sheet Metal Gauge

4.2.2 MARKING TOOLS:

a. **Scriber:** It is used to scribe or mark line on a metal surface for a variety of purposes. It is a metalworker's pencil

b. **Trammel:** These are used for drawing large circles and arcs that are beyond the limit of dividers. It has two straight, removable legs tapered to a needle point mounted on separate holders which slide on steel (or wooden) bar and held in position by thumb screws.

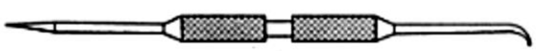


Fig 4.2. Scriber

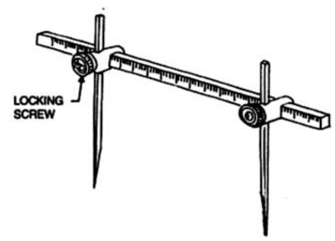


Fig 4.3. Trammel

c. **Punches:** It is used in sheet metal work for marking on sheet, locating centers. There are two types of punches. a) Dot punch and b) Prick punch.

4.2.3 CUTTING TOOLS

To cut the sheet metal as per the pattern drawn and to make holes for rivets etc., the following types of tools are used.

1. **Snip:** A snip is a hand shear used to cut thin sheets of gauge size number 20 or above. It works like ordinary scissors. There are several types and sizes of snips available to cut along straight lines or curved lines. Figure 4.4(a) shows a straight snip having straight blades to cut along straight lines. Figure 4.4(b) shows a bent snip having curved blades to cut along curved lines. These snips are used for cutting thin sheets. The heavier types are known as bench shear and block shear.

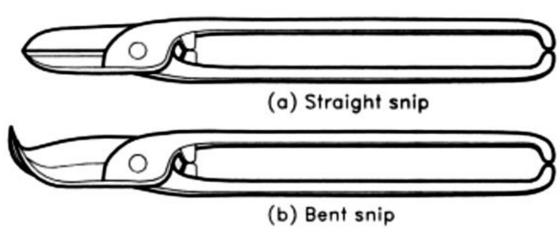


Fig 4.4. Snips

4.2.4 FORMING TOOLS

Shaping of the sheet metal such as folding, bending, curling, etc., are done by using the following types of forming tools.

1. **Stakes:** Stakes are the sheet metal anvils used for bending, seaming and forming by using a hammer or mallet. They work as the supporting tool as well as the forming tools. They are made in different sizes and shapes depending upon the job requirement. Commonly used stakes are

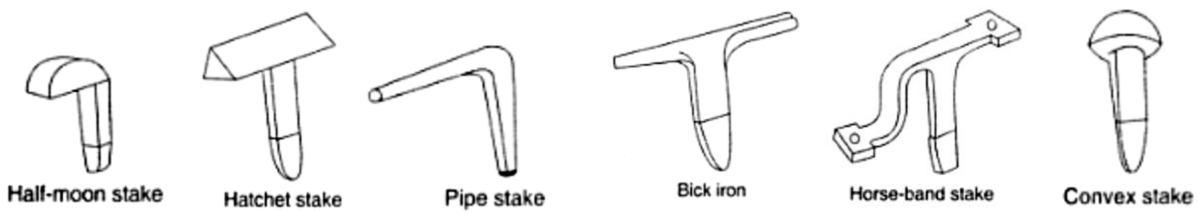


Fig 4.5. Stakes

2. **Stake Holder:** The stake holder used in sheet metal shop is a rectangular bench plate as shown in figure below

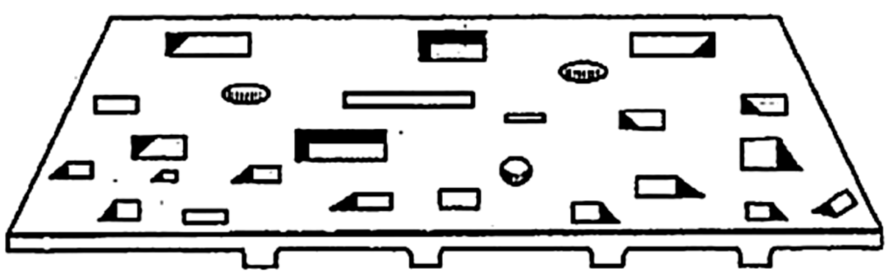


Fig 4.6. Stake Holder

3. **Hammers:** The sheet metal is shaped by hammering or striking with mallet, after keeping the work on suitable form of stake. The hammers used for sheet metal work are (a) *Setting hammer*, for setting down the edge while making double seam, (b) *Raising hammer* for forming curved or hollow shape from flat piece, and (c) *Riveting hammer* for riveting purpose. *Mallets* are soft hammers used to give soft blows which will not damage the sheet and at the same time will shape them. The commonly used types of hammers and mallets are shown in Figure.

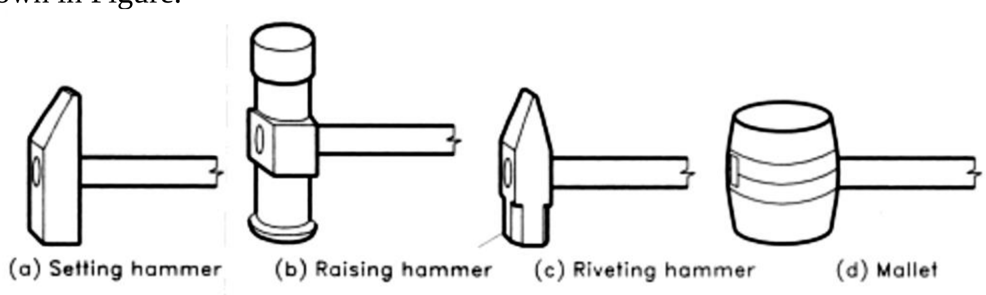


Fig 4.7. Hammers and Mallet

4.2.5 JOINING TOOLS:

The tools exclusively used for making and finishing joints are:

a) Hand grooves b) Rivet set c) Soldering irons

(a) Hand Groovers

Hand groovers are used to flatten and shape joints made in sheet metals. The tool has a groove of required width and depth like a die. This groover is placed over the joint (double hem or lock seam) and hammered from the top of it, to shape the joint to that of the groove.

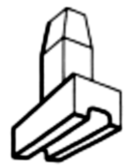


Fig 4.8. Hand Groove

(b) Rivet Set

Rivet get is made of tool steel. At the bottom of the rivet set there is a deep hole and a cup-shaped hole. The deep hole is used to draw a rivet through sheet metal and the cup shaped hole is used to form the finished head of the rivet. Another hole on the side of the set is to release the burrs that are punched. Dollies are used to backup rivets, when it is not possible to support the job on a bench.

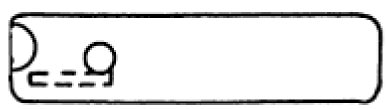


Fig 4.9. Rivet Set

(c) Soldering Iron

A soldering iron consists of a copper block, fixed on an iron rod with a wooden handle. It is made in various shapes and sizes to suit the use as shown in the figure below. The purpose of the copper block is to act as a heat source for melting and spreading the solder (filler metal) at the joining area. The soldering iron (copper) is heated using furnace, blower or by electrical resistance.

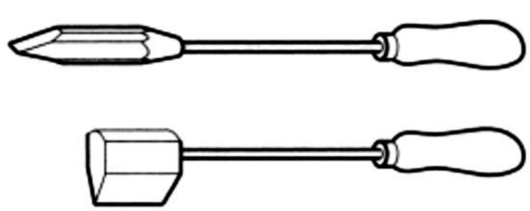


Fig. 4.10. Soldering Iron

4.3 SHEET METAL JOINTS

The line of joint on a sheet metal pieces is called seam. The most common types of seams are as follows:

1. **Lap seam:** This is the simplest seam used in sheet metal work Fig 4.11(a). This consists of one edge lapping over the other and the joint is made by soldering or riveting.
2. **Grooved seam:** A grooved seam is made by hooking two-folded edges together and then off setting them as shown in Fig 4.11(b). This joint is self-locking and stronger to some extent than lap seam.
3. **Single seam:** This seam is used to join a bottom portion to a vertical body as shown in Fig 4.11(c). The bottom edge is hooked over the bent edge of the vertical body. This method of joint can be used for square, rectangular or round containers.
4. **Double seam:** This seam is similar lo single seam with the difference that the formed edge is bent upwards against the body as shown in Fig 4.11(d).
5. **Dove-tail seam:** This seam is used to connect a cylindrical piece to a flat piece as shown in Fig 4.11(e). The edge of the cylindrical part to be joined is slit at short distance and is bent so that alternate pieces come inside and outside of the joint. Permanent joint is obtained by soldering or riveting.
6. **Flanged (burred) bottom seam:** This seam is used to fasten the bottom of a container to its body. The flange of a cylindrical job is often called a burr. The joint consists of a narrow flange which may be joined to inside or outside of the vessel as shown in Fig 4.11(f).

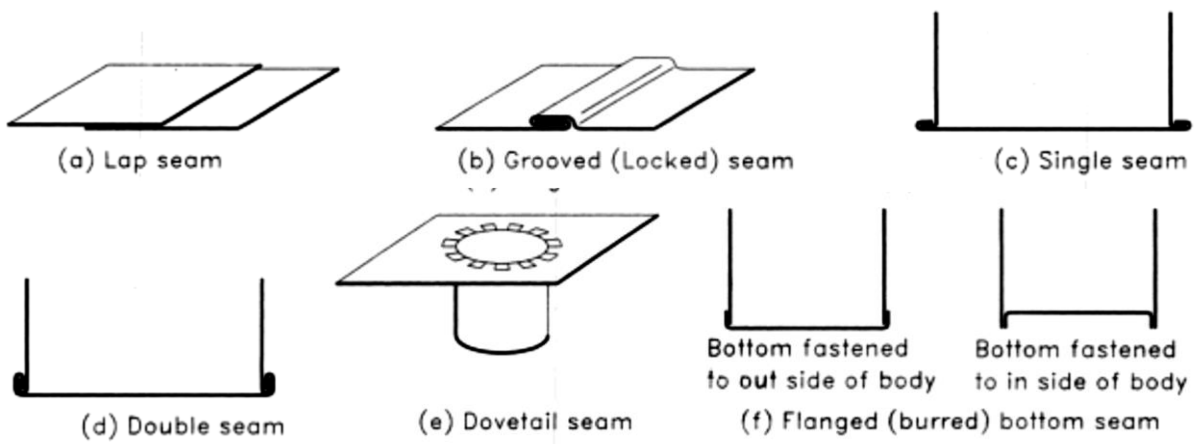


Fig 4.11. Types of Seam

4.4 EDGE FORMING

For sheet metal objects strength is given to the edge and the sharpness is eliminated by folding the edge. The common types of folding used in sheet metal work are as shown in the figure below:

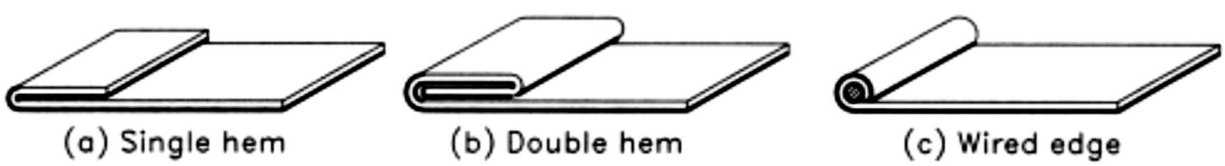


Fig 4.12. Types of Edge Folding

4.5 SHEET METAL OPERATIONS

The major operations carried out in sheet metal work are as follows

a. Cleaning	b. Measuring	c. Marking
d. Hand Cutting	e. Hand Shearing	f. Hand Forming
g. Edge Forming	h. Wiring	i. Joint Making
j. Bending	k. Drawing	l. Soldering
m. Circle cutting	n. Machine Shearing	o. Nibbling
p. Piercing	q. Blanking	

4.6 MACHINES USED IN SHEET METAL SHOP

The various machines which are in use to perform different operations on metal sheet are:

a. Shearing Machine	b. Bending Machine	c. Folding Machine
d. Grooving Machine	e. Peining Machine	f. Beading Machine
g. Swaging Machine	h. Burring Machine	i. Double seaming Machine

CHAPTER FIVE

METAL JOINING PROCESSES

5.0 INTRODUCTION

Metal Joining is the connection of two metal parts together either temporarily or permanently with or without the application of heat or pressure. Joining of elements into a single body is known as Fabrication. The process includes cutting, bending and assembling. Metal joining process are broadly classified into Joining by application of heat which are Welding, Soldering and Brazing, and Joining using Fasteners which are Bolting, Screwing and Riveting. Another joining process is joining using adhesive bonding

5.1 WELDING

Welding is a process for joining two similar or dissimilar metals by fusion. It joins different metals/alloys, with or without the application of pressure and with or without the use of filler metal. The fusion of metal takes place by means of heat. The heat may be generated either from combustion of gases, electric arc, electric resistance or by chemical reaction.

Welding provides a permanent joint but it normally affects the metallurgy of the components. It is therefore usually accompanied by post weld heat treatment for most of the critical components. The welding is widely used as a fabrication and repairing process in industries. Some of the typical applications of welding include the fabrication of ships, pressure vessels, automobile bodies, off-shore platform, bridges, welded pipes, sealing of nuclear fuel and explosives, etc.

5.2 ADVANTAGES AND DISADVANTAGES OF WELDING

5.2.1 Advantages of Welding

1. Welding is more economical and is much faster process as compared to other processes (riveting, bolting, casting etc.)
2. Welding, if properly controlled results in permanent joints having strength equal or sometimes more than base metal.
3. Large number of metals and alloys both similar and dissimilar can be joined by welding.
4. General welding equipment is not very costly.
5. Portable welding equipment can be easily made available.
6. Welding permits considerable freedom in design.
7. Welding can join welding jobs through spots, as continuous pressure tight seams, end-to-end and in a number of other configurations.
8. Welding can also be mechanized.

5.2.2 Disadvantages of Welding

1. It results in residual stresses and distortion of the work pieces.
2. Welded joint needs stress relieving and heat treatment.
3. Welding gives out harmful radiations (light), fumes and spatter.
4. Jigs, and fixtures may also be needed to hold and position the parts to be welded

5. Edges preparation of the welding jobs are required before welding
6. Skilled welder is required for production of good welding
7. Heat during welding produces metallurgical changes as the structure of the welded joint is not same as that of the parent metal.

5.3 WELDING JOINTS

Welding joints are of generally two major kinds namely lap joint and butt joint. The main types are described as under.

5.3.1 Lap Weld Joint

a. **Single-Lap Joint**

This joint, made by overlapping the edges of the plate, is not recommended for most work. The single lap has very little resistance to bending. It can be used satisfactorily for joining two cylinders that fit inside one another.

b. **Double-Lap Joint**

This is stronger than the single-lap joint but has the disadvantage that it requires twice as much welding.

c. **Tee Fillet Weld**

This type of joint, although widely used, should not be employed if an alternative design is possible.

5.3.2 Butt Weld Joint

a. **Single-Vee Butt Weld**

It is used for plates up to 15.8 mm thick. The angle of the vee depends upon the technique being used, the plates being spaced approximately 3.2 mm.

b. **Double-Vee Butt Weld**

It is used for plates over 13 mm thick when the welding can be performed on both sides of the plate. The top vee angle is either 60° or 80°, while the bottom angle is 80°, depending on the technique being used.

5.4 WELDING TERMINOLOGIES

Most of the metals and alloys can be welded by one type of welding process or the other. However, some are easier to weld than others. To compare this ease in welding term ‘weldability’ is often used. **Weldability** may be defined as property of a metal which indicates the ease with which it can be welded with other similar or dissimilar metals. Elements of welding process used with common welding joints such as base metal, fusion zone, weld face, root face, root opening toe and root are depicted in the figure below.

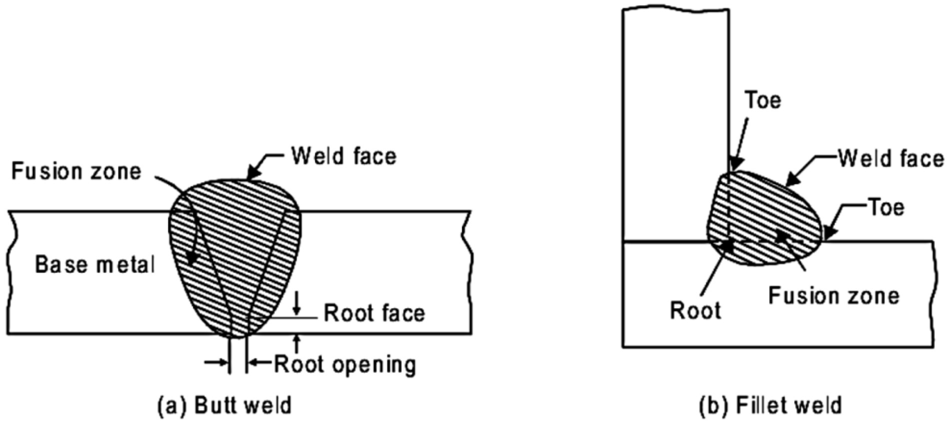


Fig 5.2. Welding Terminologies

5.5 WELDING POSITIONS

There are four types of welding positions, which are given as:

a. **Flat or Down-hand Welding Position**
The flat position or down hand position is one in which the welding is performed from the upper side of the joint and the face of the weld is approximately horizontal.

b. **Horizontal Welding Position**
In horizontal position, the plane of the work piece is vertical and the deposited weld head is horizontal. This position of welding is most commonly used in welding vessels and reservoirs.

c. **Vertical Welding Position**
In vertical position, the plane of the work-piece is vertical and the weld is deposited upon a vertical surface. It is difficult to produce satisfactory welds in this position due to the effect of the force of gravity on the molten metal.

d. **Overhead Welding Position**
The overhead position is probably even more difficult to weld than the vertical position. Here the pull of gravity against the molten metal is much greater.

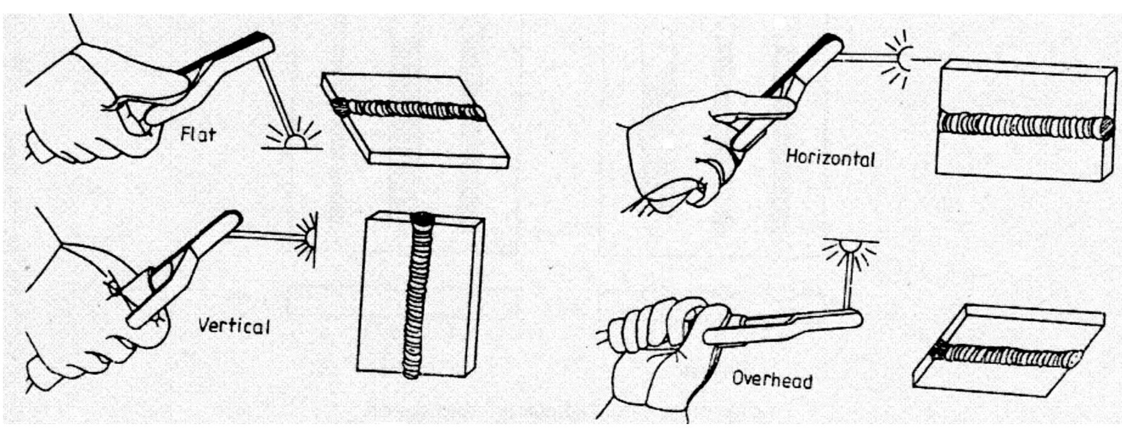


Fig 5.3 Welding Positions

5.6 ELECTRIC ARC WELDING

Electric Arc welding is the welding process, in which heat is generated by an electric arc struck between an electrode and the work piece or between two electrodes to weld base metal. Electric arc is luminous electrical discharge between two electrodes through ionized gas.

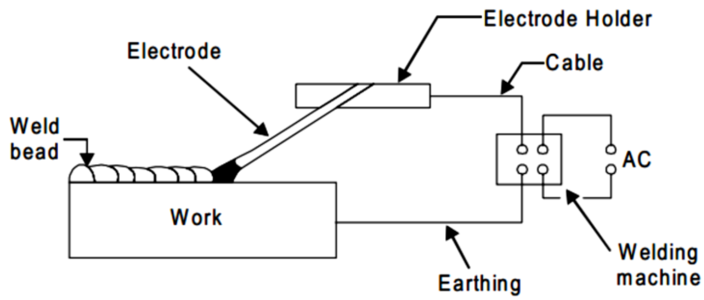


Fig 5.4 Principles of Arc Welding

5.6.1 ARC WELDING EQUIPMENT

1. Arc welding power source

Both direct current (DC) and alternating current (AC) are used for electric arc welding, each having its particular applications. DC welding supply is usually obtained from generators driven by electric motor or if no electricity is available by internal combustion engines. For AC welding supply, transformers are predominantly used for almost all Arc-welding where mains electricity supply is available. They have to step down the usual supply voltage (200-400 volts) to the normal open circuit welding voltage (50-90 volts).

The following factors influence the selection of a power source:

a. Type of electrodes to be used and metals to be welded
b. Available power source (AC or DC)
c. Required output
d. Duty cycle
e. Efficiency
f. Initial costs and running costs
g. Available floor space
h. Versatility of equipment

2. Welding Cables

Welding cables are required for conduction of current from the power source through the electrode holder, the arc, the work piece and back to the welding power source. These are insulated copper or aluminum cables.

3. Electrode Holder

Electrode holder is used for holding the electrode manually and conducting current to it. These are usually matched to the size of the lead, which in turn matched to the amperage output of the arc welder. Electrode holders are available in sizes that range from 150 to 500 Amps.

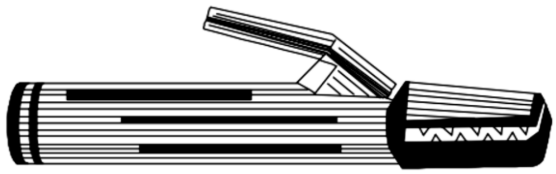


Fig. 5.5 Electrode Holder

4. **Welding Electrodes**
   Filler rods are used in arc welding are called electrodes. These are made of metallic wire called core wire, having approximately the same composition as the metal to be welded. These are coated uniformly with a protective coating called flux. Welding electrodes are classified into following types:-

a. **Consumable electrode**
   It is made of different metals and their alloys. The end of this electrode starts melting when arc is struck between the electrode and workpiece. Thus consumable electrode itself acts as a filler metal. There are two types of consumable electrodes which are Bare electrodes and coated electrodes. Bare electrodes consist of a metal or alloy wire without any flux coating on them. Coated electrodes have flux coating which starts melting as soon as an electric arc is struck. This coating on melting performs many functions like prevention of joint from atmospheric contamination, arc stabilizers etc.

b. **Non-consumable electrodes**
   They are made up of high melting point materials like carbon, pure tungsten or alloy tungsten etc. These electrodes do not melt away during welding. But practically, the electrode length goes on decreasing with the passage of time, because of oxidation and vaporization of the electrode material during welding. The materials of non-consumable electrodes are usually copper coated carbon or graphite, pure tungsten, thoriated or zirconiated tungsten.

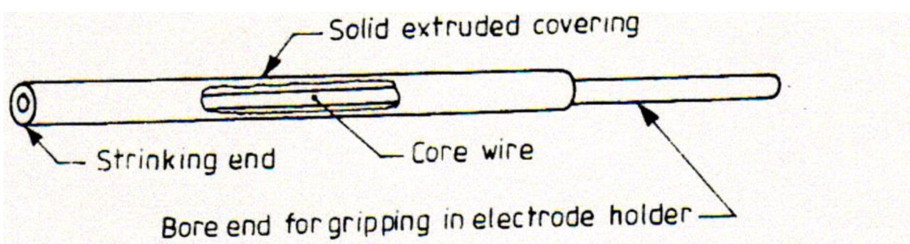


Fig 5.6 Parts of an Electrode

5. **Hand Screen**
   Hand screen is used for protection of eyes and supervision of weld bead.

6. **Chipping hammer**
   A chipping hammer is used for removing slag formation on welds. One end of the head is sharpened like a cold chisel and the other, to a blunt, round point. It is generally made of tool steel. Removing the spatter and slag formed on and around the welding beads on the metal surface is known as chipping.

7. **Wire brush**
   Wire brush is used to clean the surface to be weld.

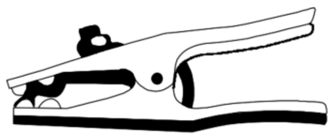


Fig 5.7 Earth Clamp

Fig 5.8 Chipping Hammer

Fig 5.9 Wire Brush

8. **Face shield**
   A face shield is used to protect the eyes and face from the rays of the arc and from spatter or flying particles of hot metal. It is available either in hand or helmet type. The hand type is convenient to use wherever the work can be done with one hand. The helmet type though not comfortable to wear, leaves both hands free for the work. Shields are made of light weight non-reflecting fiber and fitted with dark glasses to filter out the harmful rays of the arc. In some designs, a cover glass is fitted in front of the dark lens to protect it from spatter.

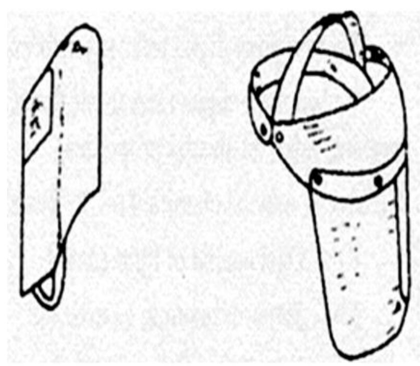


Fig. 5.10 Face Shield

9. **Ground clamp**
   It is connected to the end of the ground cable and is clamped to the work or welding table to complete the electric circuit. It should be strong and durable and give a low resistance connection.

Fig. 5.11 Ground Clamp

5.7 TECHNIQUES OF WELDING

5.7.1 Preparation of work

Before welding, the work pieces must be thoroughly cleaned of rust, scale and other foreign material. The piece for metal generally welded without beveling the edges, however, thick work piece should be beveled or veed out to ensure adequate penetration and fusion of all parts of the weld. But, in either case, the parts to be welded must be separated slightly to allow better penetration of the weld.

Before commencing the welding process, the following must be considered

a. Ensure that the welding cables are connected to proper power source.
b. Set the electrode, as per the thickness of the plate to be welded.
c. Set the welding current, as per the size of the electrode to be used.

NOTE: While making butt welds in thin metal, it is a better practice to tack-weld the pieces intervals to hold them properly while welding.

5.7.2 Striking an arc

The following are the stages and methods of striking an arc and running a bead

a. Select an electrode of suitable kind and size for the work and set the welding current at a proper value.
b. Fasten the ground clamp to either the work or welding table.
c. Start or strike the arc by either of the following methods

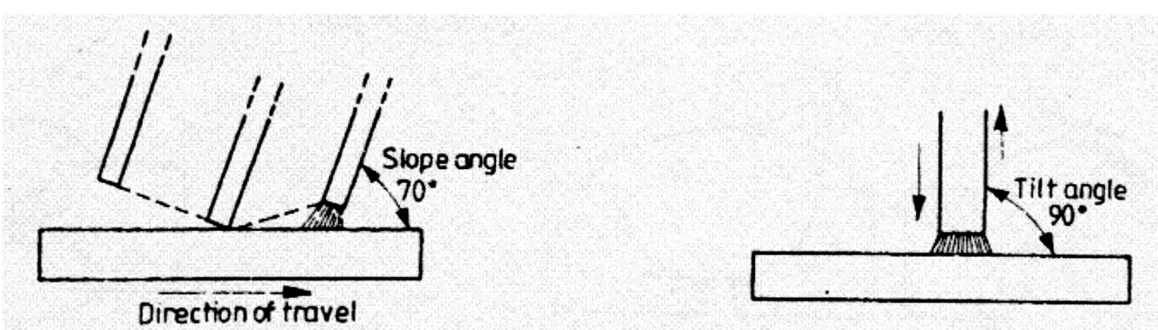
   i. Strike and withdraw

   In this method the arc is started by moving the end of the electrode onto the work with a slow sweeping motion, similar to striking a match.

   ii. Touch and with draw

   In this method, the arc is started by keeping the electrode perpendicular to the work and touching or bouncing it lightly on the work. This method is preferred as it facilitates restarting the momentarily broken arc quickly. If the electrode sticks to the work, quickly bend it back and forth, pulling at the same time. Make sure to keep the shield in front of the face, when the electrode is freed from sticking.

d. As soon as the arc is struck, move the electrode along, slowly from left to right, keeping at 15º to 25º from vertical and in the direction of welding.



Strike and withdraw   Touch and withdraw

Fig 5.12 Striking an Arc

5.7.3 Weaving

A steady, uniform motion of the electrode produces a satisfactory bead. However, a slight weaving or oscillating motion is preferred, as this keeps the metal molten a little longer and allows the gas to escape, bringing the slag to the surface. Weaving also produces a wider bead with better penetration.

5.8 ADVANTAGES & DISADVANTAGES OF ARC WELDING

5.8.1 Advantages of Arc Welding

- **a.** Welding process is simple.
- **b.** Equipment is portable and the cost is fairly low.
- **c.** All the engineering metals can be welded because of the availability of a wide variety of electrodes.

5.8.2 Disadvantages of Arc Welding

1. Mechanized welding is not possible because of limited length of the electrode.
2. Number of electrodes may have to be used while welding long joints.
3. A defect (slag inclusion or insufficient penetration) may occur at the place where welding is restarted with a fresh electrode

5.9 GAS WELDING

This is a fusion process in which the edges of the parent metal are melted and fused together with the addition of filler metal of similar composition called welding rod. The heat is provided by oxy-acetylene flame and the equipment used comprises of two cylinders of compressed gas. One cylinder painted maroon contains acetylene gas and the other cylinder painted black contains oxygen gas. The supply of gas flows from the cylinders to the blowpipe in rubber canvas hose and is controlled by the pressure regulators. The temperature of the oxyacetylene flame is about 3200^{o}C. While the gas working pressure is 34KPa (5psi)

5.9.1 TYPES OF GAS WELDING FLAMES

There are three types of gas welding flame which are: Oxidizing flame, Neutral flame and Carburizing flame.

a. Oxidizing Flame

This is usually achieved by reducing the flow of acetylene and increasing oxygen flow. It is used for welding brasses and bronzes.

b. Neutral Flame

This is achieved by adjusting the control valves of both oxygen and acetylene regulators to give equal volumes of oxygen and acetylene. It is used for welding steel, stainless steel, cast-iron, copper and aluminum.

c. Carburizing Flame

This is achieved by increasing the flow of acetylene to produce a feather of acetylene at the end of the center white cone. It is used for hard facing work. A carburizing flame gives up carbon when it is applied to heated steel.

5.9.2 SYSTEMS OF GAS WELDING

Two Systems of Gas welding are in general use:

a. Low-pressure system

In low-pressure system, acetylene is supplied at low pressure through the action of water on calcium carbide (commonly used by panel beaters). This is mixed with oxygen to form welding flame. The type of blowpipe used for this low pressure system is called injector type.

c. High-pressure system

In high pressure system, both the oxygen and the acetylene are supplied from seamless cylinders. The type of blowpipe used for high pressure system is called balanced type.

5.9.2.1 Advantages of High-Pressure over the Low-Pressure System

- **a.** It is very easy to operate
- **b.** Accurate regulation of both oxygen and acetylene cylinder is possible
- **c.** Safety against any explosion is high
- **d.** Higher working efficiency can be attained

5.9.3 HOW TO IGNITE FLAME IN GAS WELDING

- **a.** The first thing is to open the blow-pipe acetylene control valve to about ½ of a turn.
- **b.** Hold the spark lighter about 20mm away from the end of the nozzle
- **c.** Ignite the acetylene.
- **d.** Adjust the control valve until a clean flame free from smoke is obtained
- **e.** Then gradually open the oxygen control valve until the desired type of flame is obtained

5.9.4 WELDING METHODS

There are two types of welding methods used in gas welding; they are leftward and rightward method

a. Leftward Method

In this method, welding is performed from right to left, while the welding rod is held steady and the flame being oscillated slightly. This method is used mostly for welding non-ferrous metals and steel plates up to about 6mm thickness.

b. Rightward Method

In this method, welding is performed from left to right, while the flame is kept steady and the end of the welding rod is given a circular motion. It is used for welding steel work of over 6mm thickness. The rightward method has the following advantages on thicker metal plates.

- i. It is quicker than leftward method
- ii. It consumes less gas and welding rod
- iii. Less distortion is experienced

5.10 SPECIAL ARC-WELDING PROCESS

Special arc-welding process are the developments of electric arc welding method. Special arc welding methods are developed to widen the scope and efficiency of welding and to overcome the difficulties associated with certain metals while using electric arc welding method, which is usually controlled by hand. Special arc -welding process includes; Tungsten inert gas welding, metal inert gas welding, submerged arc welding and carbon arc welding. All these processes are done at a fast rate than ordinary metal arc welding.

5.10.1 Tungsten Inert Gas Welding (TIG)

In some places, this is referred to as Argon-arc welding. The modern equipment for TIG welding may be AC or DC square wave welding machines e. g DTB 275 or DTB 375 with integral water cooling unit. In this process, a tungsten electrode is being held in a torch, through which the inert gas argon is passed at a low speed (about 0.2 0.7 bar pressure). When the tungsten electrode is made to contact with the work, an arc is then struck and welding commences.

The tungsten electrode has a melting point of 3350°C. The shield of argon gas acts as a flux and thereby protects the weld from any atmospheric action. Both manual and automatic welding can be carried out. The process is widely used for welding sheet steel, aluminium, magnesium and deoxidized copper. The process has advantage of not using flux.

5.10.2 Metal Inert Gas Welding (MIG)

In the MIG welding process, an arc is struck between the work piece and a continuous wire electrode fed through the welding hose to the torch. A shielding gas which may be argon or carbon dioxide contained in a standard cylinder with a regulator is made to flow through the torch and forms a shield over the weld and thereby protect it from atmospheric contamination. MIG welding machines of constant potential type are available in the following capacities; ESAB--LAG 200/315/400 or SMR350.

The MIG welding machine comprises a transformer/rectifier as power sources, an electric motor powered feed unit that pushes the wire electrode to the torch, the torch which is connected to the welding current, wire electrode and the shielding gas contained in a cylinder with regulator.

The advantage of MIG welding is that, it produces high quality welds at high welding speeds; without the need of a flux or the necessity for any slag removal.

The process can as well be used for welding most metals such as carbon steels, alloy steels, aluminium, nickel, copper, magnesium and titanium. Both, semi-automatic and fully automatic welding can be performed.

5.10.3 Submerged -Arc Welding

In this process an arc is struck between lightly coated electrode (inform of copper plated steel wire) and the work. The equipment used generally for submerged arc welding is A. C transformer having welding currents up to 3500 amperes.

It may be operated automatically by a traveling welding head on long flat runs or with a fixed head and travelling work. The welding electrode is carried on a drum and fed through rollers, while the flux is fed from a tube attached to the welding head and travels in front of the electrode wire. The flux is made of granulated powder form of calcium/magnesium silicate, which fuses at a temperature below that of weld. This results in. the weld being submerged in a bath of molten slag, which cracks off on cooling. This process produces high quality welds at Very high speeds. Heavy welding currents are possible and a thickness of 50mm work can be welded in one pass. Flash, spatter, smoke or noise associated with some Welding methods are totally eradicated in submerged arc welding. The process is used mostly for welding carbon steel and alloy-steels.

5.10.4 Carbon Arc Welding

The most commonly used equipment for carbon arc welding is D.C welding generator. In this process, an arc is struck between a carbon electrode and the work. The heat generated melts the joint area of the parent metals and where necessary a metal filler rod and thereby produces a welded joint. The gas from the burning carbon serves as a flux to some extent, but it is usual to employ real flux to guide against carbon "pick up" from the electrode. Both manual and automatic set up are used in this welding process. Automatic carbon arc welding is capable of high-speed working. Used for welding steels, galvanized steels, low alloy steels, copper, brass, bronze and aluminium.

5.11 ELECTRIC RESISTANCE WELDING

This is a pressure welding process, where the work is usually placed between two electrodes and a low voltage heavy current is passed through it. The work has a much higher electrical resistance than the remaining parts of the circuit and the area between the electrodes is heated to a welding temperature. Mechanically pressure is then applied and the weld is complete. There are three common types of resistance welding; spot welding, butt welding and seam welding.

a. Spot welding

This is used to join two metal plates together at their joint surface. The plates are pressed firmly together by the electrode pressure. When the spot in the middle reaches welding temperature, a weld is then made at this spot and the current is switched off. Cooling water is circulated through the core of each electrode to prevent heating of the electrode tips. Spot welding is a suitable substitute for riveting on light plates; because there is no hole to drill or rivet to fit.

b. Butt welding

This is used for joining the ends of metal rod, bar, tube and similar sections. The machine has two clamps for gripping the parts to be joined. One clamp is fixed and connected to negative part of the transformer, while the other is movable and connected to positive pole. When the ends of the bar are brought in contact with each other, the current is switched on and an arc is then struck between the parts; the intense heat develop rapidly at the joint and the two ends are forge-welded together.

c. Seam Welding

This is similar in principle to that of spot welding; but the plain electrodes are replaced by rollers. The plates to be joined are passed between these rollers at a fixed speed and the line cycle of current. Heat and weld pressure goes on automatically producing a line of spot welds as long as the plate is fed along, the spacing of which is determined by the speed of the movement and the current timing. This process is used when a continuous joint is required.

5.12 SOLDERING

Soldering is a method of joining similar or dissimilar metals by heating them to a suitable temperature and by means of a filler metal, called solder, having liquidus temperature not exceeding 450°C and below the solidus of the base material. Though soldering obtains a good joint between the two plates, the strength of the joint is limited by the strength of the filler metal used. Solders are essentially alloys of lead and tin. To improve the mechanical properties and temperature resistance, solders are added to other alloying elements such as zinc, cadmium and silver in various proportions.

The most commonly used soldering methods include soldering iron (flame or electrically heated), dip soldering, and wave soldering.

5.12.1 Basic Operations in Soldering

For making soldered joints, the following operations are required to be performed sequentially

a. Shaping and fixing of metal parts together
b. Cleaning of surfaces
c. Flux application
d. Application of heat and solder

5.12.2 Solders

Solders are alloys of lead and tin. Solder may also contain certain other elements like cadmium, and antimony in small quantities. The percentage composition of tin and lead determines the physical and mechanical properties of the solder and the joint made. Most solder is available in many forms-bar, stick, fill, wire, strip, and so on. It can be obtained in circular or semi-circular rings or any other desired shape. Sometimes the flux is included with the solder. For example, a cored solder wire is a tube of solder filled with flux.

5.12.3 Solder Fluxes

The flux does not constitute a part of the soldered joint. Zinc chloride, ammonium chloride, and hydrochloric acid are the examples of fluxes commonly used in soldering. The function of fluxes in soldering is to remove oxides and other surface compounds from the surfaces to be soldered by displacing or dissolving them. Soldering fluxes may be classified into four groups-

(1) Inorganic fluxes (most active)
(2) Organic fluxes (moderately active)
(3) Rosin fluxes (least active), and
(4) Special fluxes for specific applications

5.13 BRAZING

Like soldering, brazing is a process of joining metals without melting the base metal. Filler material used for brazing has liquidus temperature above 450°C and below the solidus temperature of the base metal. The filler metal is drawn into the joint by means of capillary action (entering of fluid into tightly fitted surfaces). Brazing is a much widely used joining process in various industries because of its many advantages. Due to the higher melting point of the filler material, the joint strength is more than in soldering. Almost all metals can be joined by brazing except aluminum and magnesium which cannot easily be joined by brazing.

During brazing, the base metal of the two pieces to be joined is not melted. An important requirement is that the filler metal must wet the base metal surfaces to which it is applied. The surfaces to be joined must be chemically clean before brazing. However, fluxes are applied to remove oxides from the surfaces. Borax is the most widely used flux during the process of brazing. It will dissolve the oxides of most of the common metals.

5.14 Methods of Brazing

The following as discussed below are the brazing methods that there are:

a. Torch Brazing

It is the most widely used brazing method. Heat is produced, generally, by burning a mixture of oxy-acetylene gas, as in the gas welding. A carbonizing flame is suitable for this purpose as it produces sufficiently high temperature needed for brazing.

b. Furnace Brazing

It is suitable for brazing large number of small or medium parts. Usually brazing filler metal in the granular or powder form or as strips is placed at the joint, and then the assembly is placed in the furnace and heated. Large number of small parts can be accommodated in a furnace and simultaneously brazed.

5.15 SAFE PRACTICE IN WELDING

a. Always weld in a well-ventilated place. Fumes given off from welding are unpleasant and in some cases may be injurious, particularly from galvanized or zinc coated parts.
b. Do not weld around combustible or inflammable materials, where sparks may cause a fire.
c. Never weld containers, which have been used for storing gasoline, oil or similar materials, without first having them thoroughly cleaned.
d. Check the welding machine to make sure that it is properly grounded and that all leads properly insulated.
e. Never look at the arc with the naked eye. The arc can burn your eyes severely. Always use a face shield while welding.
f. Prevent welding cables from coming in contact with hot metal, water, oil, or grease. Avoid dragging the cables around sharp corners.
g. Ensure proper insulation of the cables and check for openings.
h. Always wear the safety hand gloves, apron and leather shoes.
i. Always turn off the machine when leaving the work.
j. Apply eye drops after welding is over for the day, to relieve the strain on the eyes.
k. While welding, stand on dry footing and keep the body insulated from the electrode, any other parts of the electrode holder and the work.

Exercise 1

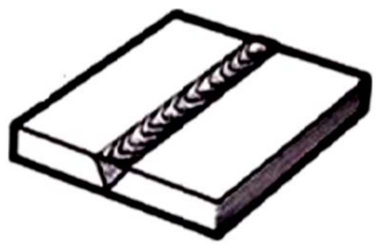
Single V - Butt joint

Aim: To make a single v-butt joint, using the given mild steel pieces of and by arc welding.

Material used: Two mild steel pieces of 100X40X6 mm.

Tools and equipment used

Arc welding machine, Mild steel electrodes, Electrode holder, Ground clamp, flat nose Tong, Face shield, Apron, Hand gloves, Metallic work Table, Bench vice, Rough flat file, Try square, Steel rule, Wire brush, Ball peen hammer, Chipping hammer, Chisel and Grinding machine.



Single V-Butt Joint

Operations to be carried out

1. Cleaning the work pieces
2. Tack welding
3. Full welding
4. Cooling
5. Chipping
6. Finishing

Procedure

1. Take the two mild steel pieces of given dimensions and clean the surfaces thoroughly from rust, dust particles, oil and grease.
2. Remove the sharp corners and burrs by filing or grinding.
3. One edge of each piece is beveled, to an angle 30°.
4. The two pieces are positioned on the welding table such that, they are separated slightly for better penetration of the weld.
5. The electrode is fitted in to the electrode holder and the welding current is set to a proper value.
6. The ground clamp is fastened to the welding table. The machine is switched ON
7. Wearing the apron, hand gloves, using the face shield, the arc is struck and the work pieces are tack welded at the ends and holding the two pieces together; first run of the weld is done to fill the root gap.
8. Second run of the welding is done with proper weaving and with uniform movement. During the process of welding, the electrode is kept at angle of 15° to 25° from vertical and in the direction of welding.
9. The slag formation on the weld is removed by chipping hammer.
10. Filing is done to remove spatters around the weld.

Result The single v-butt joint is thus made, using the tools and equipment as mentioned above.

Exercise 2

Double -Lap joint

Aim: To make a double lap joint, using the given mild steel pieces and by arc welding.

Material used: Two **mild steel** pieces of 100X40X6 mm.

Tools and equipment used

Arc welding machine, Mild steel electrodes, Electrode holder, Ground clamp, flat nose Tong, Face shield, Apron, Hand gloves, Metallic work Table, Bench vice, Rough flat file, Try square, Steel rule, Wire brush, Ball peen hammer, Chipping hammer, Chisel and Grinding machine.

Double Lap Joint

Operations to be carried out

1. Cleaning the work pieces
2. Tack welding
3. Full welding
4. Cooling
5. Chipping
6. Finishing

Procedure

1. Take the two mild steel pieces of given dimensions and clean the surfaces thoroughly from rust, dust particles, oil and grease.
2. Remove the sharp corners and burrs by filing or grinding and prepare the work pieces.
3. The work pieces are positioned on the welding table, to form a lap joint with the required over lapping.
4. The electrode is fitted in to the electrode holder and the welding current is set to a proper value.
5. The ground clamp is fastened to the welding table.
6. Wearing the apron, hand gloves, using the face shield and holding the over lapped pieces the arc is struck and the work pieces are tack-welded at the ends of both the sides
7. The alignment of the lap joint is checked and the tack-welded pieces are reset, if required.
8. Welding is then carried out throughout the length of the lap joint, on both the sides.
9. Remove the slag, spatters and clean the joint.

Result The double lap joint is thus made, using the tools and equipment as mentioned above.

Exercise 3

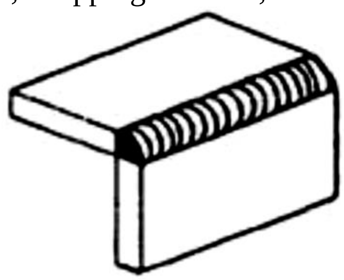
Corner joint

Aim: To make a corner joint, using the given mild steel pieces and by arc welding.

Material used: Two **mild steel** pieces of 100X40X6 mm.

Tools and equipment used

Arc welding machine, Mild steel electrodes, Electrode holder, Ground clamp, flat nose Tong, Face shield, Apron, Hand gloves, Metallic work Table, Bench vice, Rough flat file, Try square, Steel rule, Wire brush, Ball peen hammer, Chipping hammer, Chisel and Grinding machine.



Operations to be carried out

1. Cleaning the work pieces
2. Tack welding
3. Full welding
4. Cooling
5. Chipping
6. Finishing

Procedure

1. Take the two mild steel pieces of given dimensions and clean the surfaces thoroughly from rust, dust particles, oil and grease.
2. Remove the sharp corners and burrs by filing or grinding and prepare the work pieces.
3. The work pieces are positioned on the welding table such that, the L shape is formed.
4. The electrode is fitted in to the electrode holder and the welding current is set to a proper value.
5. The ground clamp is fastened to the welding table.
6. Wearing the apron, hand gloves, using the face shield and holding the pieces the arc is struck and the work pieces are tack-welded at both the ends.
7. The alignment of the corner joint is checked and the tack-welded pieces are reset, if required.
8. Welding is then carried out throughout the length.
9. Remove the slag, spatters and clean the joint.

Result The Corner joint is thus made, using the tools and equipment as mentioned above.

CHAPTER SIX

MACHINING

6.1 INTRODUCTION

In a machine shop, metals are cut to shape on different machine tools. A lathe is used to cut and shape the metal by revolving the work against a cutting tool. The work is clamped either in a chuck, fitted on to the lathe spindle or in-between the centers. The cutting tool is fixed in a tool post, mounted on a movable carriage that is positioned on the lathe bed. The cutting tool can be fed on to the work, either lengthwise or cross-wise. While turning, the chuck rotates in counter-clockwise direction, when viewed from the tail stock end.

6.2 PRINCIPAL PARTS OF A LATHE

Figure 6.1 shows a center lathe, indicating the main parts. The name is due to the fact that work pieces are held by the centers.

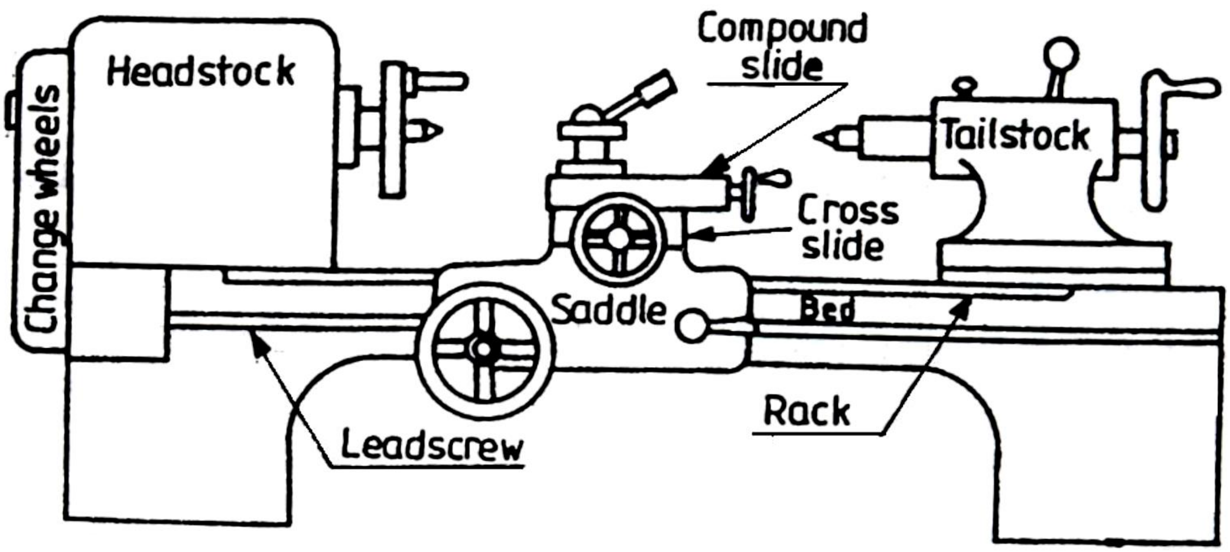


Fig 6.1 Parts of a Centre Lathe

6.2.1 Bed

It is an essential part of a lathe, which must be strong and rigid. It carries all parts of the machine and resists the cutting forces. The carriage and the tail stock move along the guide ways provided on the bed. It is usually made of cast iron.

6.2.2 Head stock

It contains either a cone pulley or gearings to provide the necessary range of speeds and feeds. It contains the main spindle, to which the work is held and rotated.

6.2.3 Tail stock

It is used to support the right hand end of a long work piece. It may be clamped in any position along the lathe bed. The tail stock spindle has an internal Morse taper to receive the dead center that supports the work. Drills, reamers, taps may also be fitted into the spindle, for performing operations such as drilling, reaming and tapping.

6.2.4 Carriage or Saddle

It is used to control the movement of the cutting tool. The carriage assembly consists of the longitudinal slide, cross slide and the compound slide and apron. The cross slide moves across the length of the bed and perpendicular to the axis of the spindle. This movement is used for facing and to provide the necessary depth of cut while turning. The apron, which is bolted to the saddle, is on the front of the lathe and contains the longitudinal and cross slide controls.

6.2.5 Compound Rest

It supports the tool post. By swiveling the compound rest on the cross slide, short tapers may be turned to any desired angles.

6.2.6 Tool Post

The tool post, holds the tool holder or the tool, which may be adjusted to any working position.

6.2.7 Lead Screw

It is a long threaded shaft, located in front of the carriage, running from the head-stock to the tail stock. It is geared to the spindle and controls the movement of the tool, either for automatic feeding or for cutting threads.

6.2.8 Centers

There are two centers known as dead center and live center. The dead center is positioned in the tail stock spindle and the live center, in the head-stock spindle. While turning between centers, the dead center does not revolve with the work while the live center revolves with the work.

6.3 WORK-HOLDING DEVICES

6.3.1 Three jaw chuck

It is a work holding device having three jaws (self-centering) which will close or open with respect to the chuck center or the spindle center, as shown in the figure below. It is used for holding regular objects like round bars, hexagonal rods, etc.

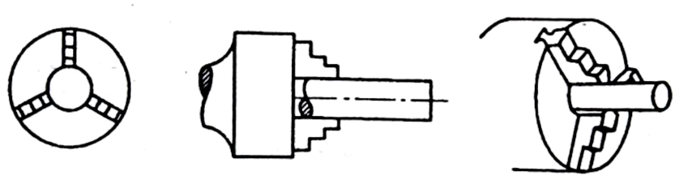


Fig 6.2 Three Jaw Chuck

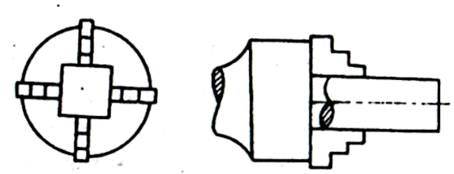


Fig 6.3 Four Jaw Chuck

6.3.2 Face plate

It is a plate of large diameter, used for turning operations. Certain types of work that cannot be held in chucks are held on the face plate with the help of various accessories.

6.3.3 Lathe dogs and driving plate

These are used to drive a work piece that is held between centers. These are provided with an opening to receive and clamp the work piece and dog tail, the tail of the dog is carried by the pin provided in the driving plate for driving the work piece.

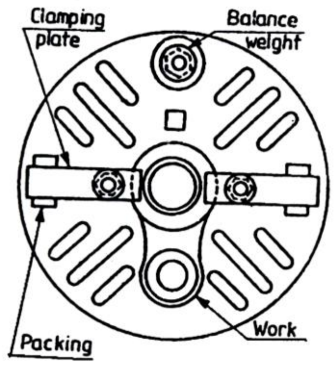


Fig 6.4 Face Plate

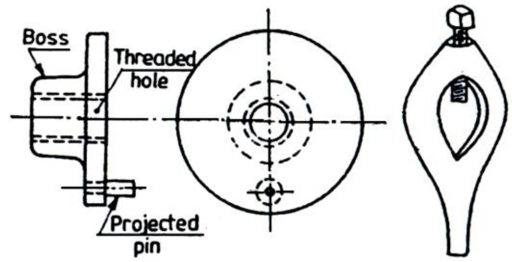


Fig 6.5 Lathe dog and driving plate

6.4 MEASURING INSTRUMENTS

6.4.1 Outside and Inside Calipers

Firm joint or spring calipers are used for transfer of dimensions with the help of a steel rule.

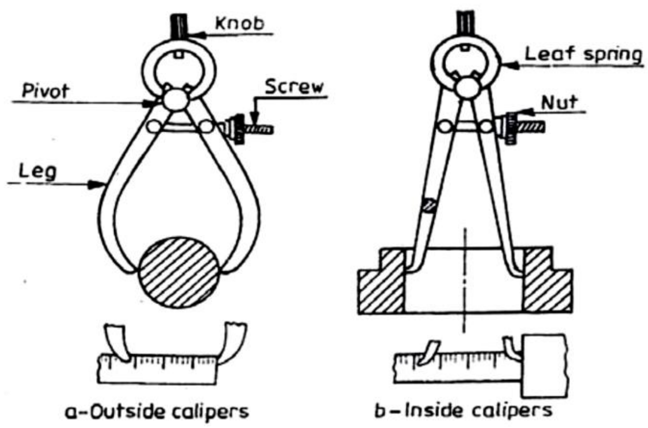


Fig 6.5 Calipers

6.4.2 Micrometers

Outside and inside micrometers are used for measuring components where greater accuracy is required.

6.4.3 Vernier Calipers

Vernier caliper is a versatile instrument with which both outside and inside measurements may be made accurately. These instruments may have provision for depth measurement also.

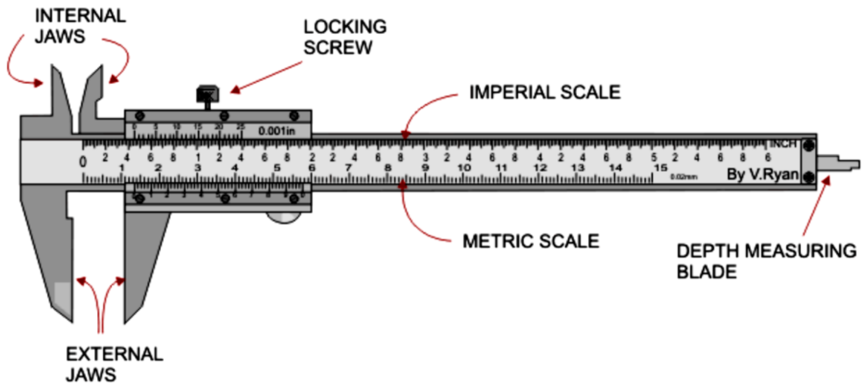


Fig 6.6 Vernier Caliper

6.5 CUTTING PARAMETERS

6.5.1 Cutting speed

It is defined as the speed at which the material is removed and is specified in meters per minute. It depends upon the work piece material, feed, depth of cut, type of operation and so many other cutting conditions. It is calculated from the relation,

Spindle speed (RPM) = cutting speed x 1000 / (πD)
Where D is the work piece diameter in mm.

6.5.2 Feed

It is the distance traversed by the tool along the bed, during one revolution of the work. Its value depends upon the depth of cut and surface finish of the work desired.

6.5.3 Depth of Cut

It is the movement of the tip of the cutting tool, from the surface of the work piece and perpendicular to the lathe axis. Its value depends upon the nature of operation like rough turning or finish turning.

6.6 TOOL MATERIALS

General purpose hand cutting tools are usually made from carbon steel or tool steel. The single point lathe cutting tools are made of high speed steel (HSS).the main alloying elements in 18-4-1 HSS tools are 18 percent tungsten, 4 percent chromium and 1 percent vanadium.5 to 10 percent cobalt is also added to improve the heat resisting properties of the tool. Carbide tipped tools fixed in tool holders, are mostly used in production shops.

6.7 TOOL GEOMETRY

A single point cutting tool used on lathe may be considered as a simple wedge. Figure 4.8 shows the common turning tools used for different operations. Figure 6.9 shows the basic angles of a simple turning tool.

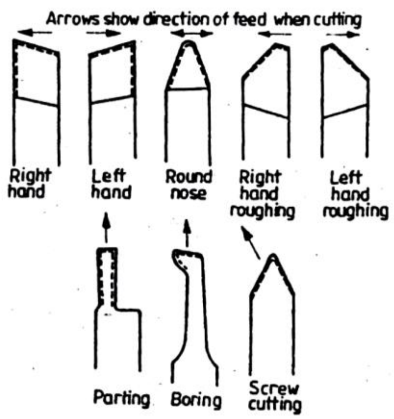


Fig 6.7 Common Turning Tool

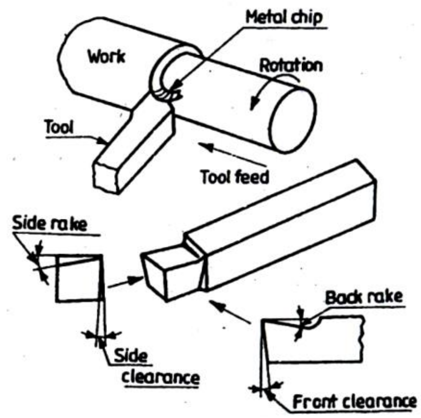


Fig 6.8 Tool Geometry

6.8 LATHE OPERATIONS

6.8.1 Turning

Cylindrical shapes, both external and internal, are produced by turning operation. Turning is the process in which the material is removed by a traversing cutting tool, from the surface of a rotating work piece. The operation used for machining internal surfaces is often called the boring operation in which a hole previously drilled is enlarged.

For turning long work, first it should be faced and center drilled at one end and then supported by means of the tail-stock centre.

6.8.2 Boring

Boring is enlarging a hole and is used when correct size drill is not available. However, it should be noted that boring cannot make a hole.

6.8.3 Facing

Facing is a machining operation, performed to make the end surface of the work piece, flat and perpendicular to the axis of rotation. For this, the work piece may be held in a chuck and rotated about the lathe axis. A facing tool is fed perpendicular to the axis of the lathe. The tool is slightly inclined towards the end of the work piece.

6.8.4 Taper Turning

A taper is defined as the uniform change in the diameter of a work piece, measured along its length. It is expressed as a ratio of the difference in diameters to the length. It is also expressed in degrees of half the included (taper) angle. Taper turning refers to the production of a conical surface, on the work piece on a lathe. Short steep tapers may be cut on a lathe by swiveling the *compound rest* to the required angle. Here, the cutting tool is fed by means of the compound slide feed handle. The work piece is rotated in a chuck or face plate or between centers.

6.8.5 Drilling

Holes that are axially located in cylindrical parts are produced by drilling operation, using a twist drill. For this, the work piece is rotated in a chuck or face plate. The tail stock spindle has a standard taper. The drill bit is fitted into the tail stock spindle directly or through drill chuck. The tail stock is then moved over the bed and clamped on it near the work. When the job rotates, the drill bit is fed into the work by turning the tail stock hand wheel.

6.8.6 Knurling

It is the process of embossing a diamond shaped regular pattern on the surface of a work piece using a special knurling tool. This tool consists of a set of hardened steel rollers in a holder with the teeth cut on their surface in a definite pattern. The tool is held rigidly on the tool post and the rollers are pressed against the revolving work piece to squeeze the metal against the multiple cutting edges. The purpose of knurling is to provide an effective gripping surface on a work piece to prevent it from slipping when operated by hand.

6.8.7 Chamfering

It is the operation of beveling the extreme end of a work piece. Chamfer is provided for better look, to enable nut to pass freely on threaded work piece, to remove burrs and protect the end of the work piece from being damaged.

6.8.8 Threading

Threading is nothing but cutting helical groove on a work piece. Threads may be cut either on the internal or external cylindrical surfaces. A specially shaped cutting tool, known as thread cutting tool, is used for this purpose. Thread cutting in a lathe is performed by traversing the cutting tool at a definite rate, in proportion to the rate at which the work revolves.

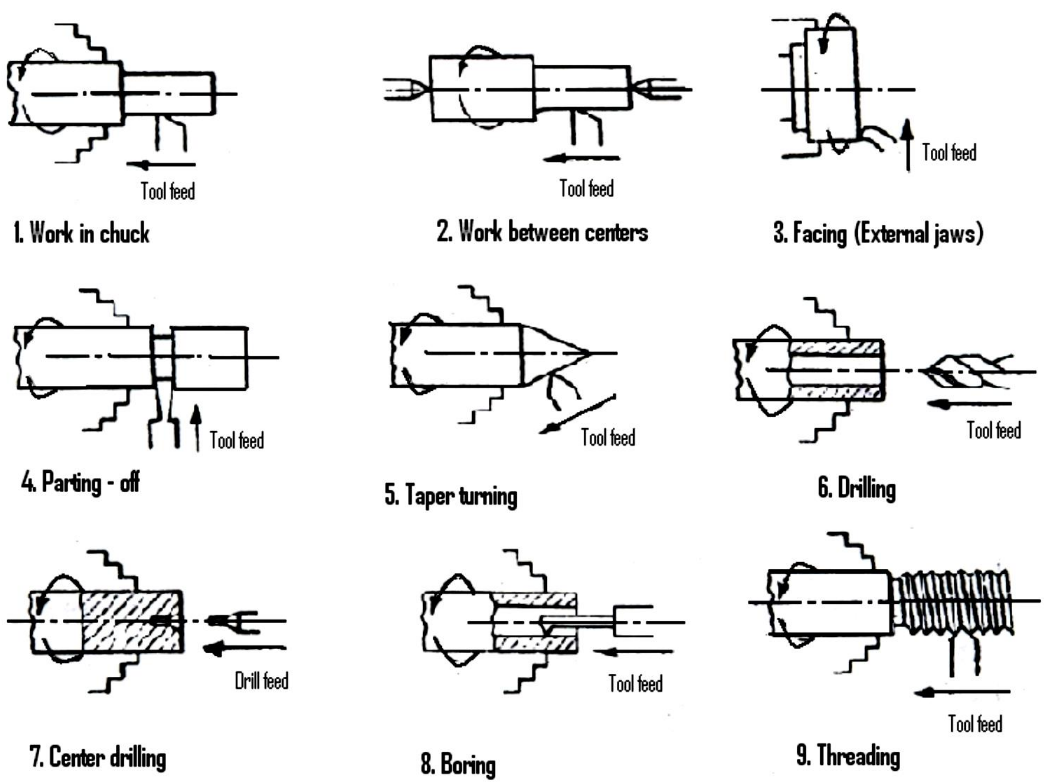


Fig 6.9 Operations on Lathe

6.9 SAFETY PRECAUTIONS

a. Always wear eye protection - preferably industrial quality safety glasses with side-shields. The lathe can throw off sharp, hot metal chips at considerable speed as well as spin off spirals of metal that can be quite hazardous. Don't take chances with your eyes.
b. Wear short sleeve shirts, loose sleeves can catch on rotating work and quickly pull your hand or arm into harm's way.
c. Wear shoes - preferably leather work shoes - to protect your feet from sharp metal chips on the shop floor and from tools and chunks of metal that may get dropped.
d. Remove wrist watches, necklaces, chains and other jewelry. Tie back long hair so it can't get caught in the rotating work. Think about what happens to your face if your hair gets entangled.
e. Always double check to make sure your work is securely clamped in the chuck or between centers before starting the lathe. Start the lathe at low speed and increase the speed gradually.
f. Get in the habit of removing the chuck key immediately after use. Some users recommend never removing your hand from the chuck key when it is in the chuck. The chuck key can be a lethal projectile if the lathe is started with the chuck key in the chuck.
g. Keep your fingers clear of the rotating work and cutting tools. This sounds obvious, but I am often tempted to break away metal spirals as they form at the cutting tool.
h. Avoid reaching over the spinning chuck. For filing operations, hold the tang end of the file in your left hand so that your hand and arm are not above the spinning chuck.
i. Never use a file with a bare tang - the tang could be forced back into your wrist or palm.

Exercise 1

Facing and plain turning

Aim

To obtain required diameter of a cylindrical work piece with the given length

Tools & Equipment

Lathe machine. Mild steel bar, right hand cutting tool, box key or tool post key, chuck key, steel rule, outside calipers or vernier calipers.

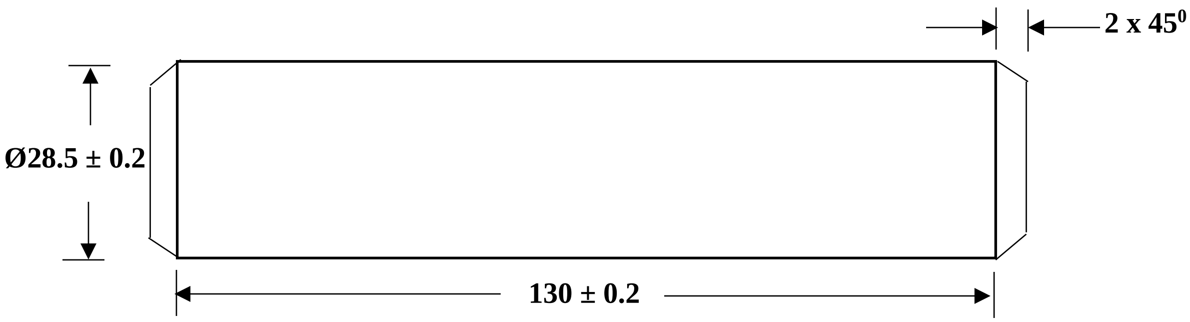


Figure MS-E1: Plain Turning

Theory

Facing is the operations of finishing the ends of work to make ends flat, smooth and to required length. Rough turning operation is used where excessive stock is to be removed and surface finish is not critical. For such an operation deep cuts with coarse feed are used. During rough machining, maximum metal is removed and very little oversize dimension is left for finishing operation.

Procedure

1. The given work piece is held in the 3-jawchuck of the lathe machine and tightened firmly with chuck key.
2. Right hand single point cutting tool is taken tightened firmly with the help of box key in the tool post.
3. Machine is switched on and the tool post is swiveled and the cutting point is adjusted such that it positioned approximately for facing operation then the tool is fed into the work piece and the tool post is given the transverse movement by rotating the hand wheel of the cross slide.
4. With this facing is completed and the tool post is swiveled and cutting point is made parallel to the axis of work piece.
5. Depth of cut is given by cross slide to the tool post and the side hand wheel is rotated to give the longitudinal movement for the tool post and job is turned to the required length and diameter.
6. After completion of the job it is inspected for the dimensions obtained with the help of steel rule and outside caliper or vernier caliper.

Precautions

1. Work piece should be held firmly.
2. In rough turning operation do not over feed the tool, as it may damage the cutting point of the tool.
3. Exercise over hung of tool should be avoided as it results in chatter and causes rough machined surface.
4. It is important to ensure that during facing operation the cutting is performed from center point to the outer diameter of the work piece.

Result The job is thus made according to the given dimensions.

Exercise 2

Step turning

Aim

To obtain required diameters (steps) on a cylindrical work piece with the given lengths.

Tools & Equipment

Lathe machine. Mild steel bar, right hand cutting tool, box key or tool post key, chuck key, steel rule, outside calipers or vernier calipers.

Theory

Step turning is the operation of creating various cylindrical cross sections on a metal blank. Rough turning operation is used where excessive stock is to be removed and surface finish is not critical. For such a operation deep cuts with coarse feed are used. During rough machining maximum metal is removed and very little oversize dimension is left for finishing operation.

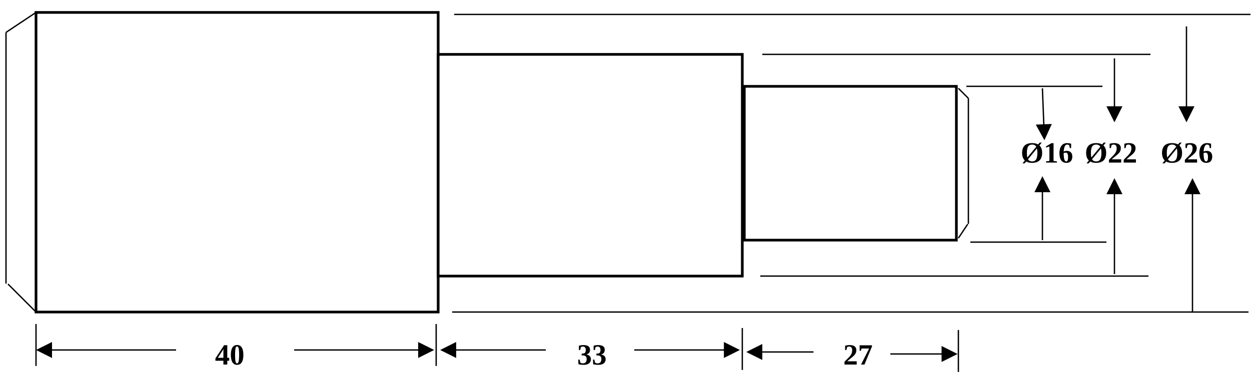


Figure MS-E2: Step Turning

Procedure

1. The given work piece is held in the 3-jawchuck of the lathe machine and tightened firmly with chuck key.
2. Right hand single point cutting tool is taken tightened firmly with the help of box key in the tool post.
3. Machine is switched on and the tool post is swiveled and the cutting point is adjusted such that it positioned approximately for facing operation then the tool is fed into the work piece and the tool post is given the transverse movement by rotating the hand wheel of the cross slide.
4. With this facing is completed and the tool post is swiveled and cutting point is made parallel to the axis of work piece.
5. Depth of cut is given by cross slide to the tool post and the side hand wheel is rotated to give the longitudinal movement for the tool post and job is turned to the required length and diameters according to the sketch shown in figure.
6. After completion of the job it is inspected for the dimensions obtained with the help of steel rule and outside caliper or vernier caliper.

Precautions

1. Work piece should be held firmly.
2. In rough turning operation do not over feed the tool, as it may damage the cutting point of the tool.
3. Exercise over hung of tool should be avoided as it results in chatter and causes rough machined surface.
4. It is important to ensure that during facing operation the cutting is performed from center point to the outer diameter of the work piece.

Result The job is thus made according to the given dimensions.

Exercise 3

Shoulder turning

Aim

To obtain required diameters on a cylindrical work piece with the given dimensions.

Tools & Equipment

Lathe machine, Mild steel bar, right hand cutting tool, box key or tool post key, chuck key, steel rule, calipers or vernier calipers.

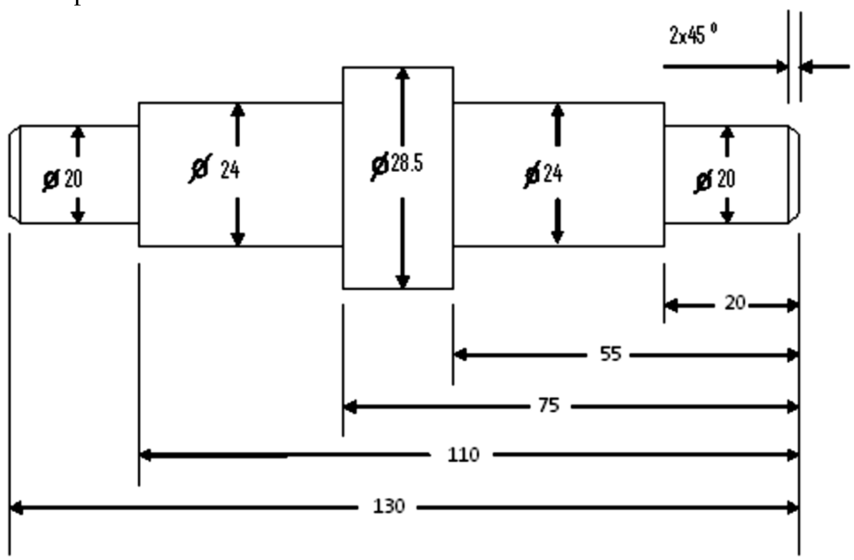


Figure MS-E3: Shoulder Turning

Procedure

1. The given work piece is held in the 3-jawchuck of the lathe machine and tightened firmly with chuck key.
2. Right hand single point cutting tool is tightened firmly with the help of box key in the tool post.
3. Machine is switched on and the tool post is swiveled and the cutting point is adjusted such that it positioned approximately for facing operation then the tool is fed into the work piece and the tool post is given the transverse movement by rotating the hand wheel of the cross slide.
4. With this facing is completed and the tool post is swiveled and cutting point is made parallel to the axis of work piece.
5. Depth of cut is given by cross slide to the tool post and the side hand wheel is rotated to give the longitudinal movement for the tool post and job is turned to the required length and diameters.
6. After completion of the job it is inspected for the dimensions obtained with the help of steel rule and outside caliper or vernier caliper.

Precautions

1. Work piece should be held firmly.
2. In rough turning operation do not over feed the tool, as it may damage the cutting point of the tool.
3. Exercise over hung of tool should be avoided as it results in chatter and causes rough machined surface.
4. It is important to ensure that during facing operation the cutting is performed from center point to the outer diameter of the work piece.

Result: The job is thus made according to the given dimensions.

CHAPTER EIGHT
FORGING

8.0 INTRODUCTION

Forging or Blacksmithy is the oldest shaping process used for the producing small articles for which accuracy in size is not so important. The parts are shaped by heating them in an open fire or hearth by the blacksmith and shaping them through applying compressive forces using hammer.

Forging is the process of shaping hot metal by means of hammering, squeezing, bending etc. When a steel is heated to forging temperature its tensile strength, hardness and toughness are reduced while its ductility, malleability and plasticity increases. This enables the steel to be forged easily. Forging can be divided into three methods namely; hand forging, drop forging and machine forging.

8.1 APPLICATIONS OF FORGING

Almost all metals and alloys can be forged. The low and medium carbon steels are readily hot forged without difficulty, but the high-carbon and alloy steels are more difficult to forge and require greater care. Forging is generally carried out on carbon alloy steels, wrought iron, copper-base alloys, aluminum alloys, and magnesium alloys. Stainless steels, nickel-based super alloys, and titanium are forged especially for aerospace uses.

8.2 FORGEABILITY

The ease with which forging is done is called forgeability. The forgeability of a material can also be defined as the capacity of a material to undergo deformation under compression without rupture. Forgeability increases with temperature up to a point at which a second phase, e.g., from ferrite to austenite in steel, appears or if grain growth becomes excessive.

8.3 HAND FORGING

In this process, the shaping of the hot metal is carried out under the hand control (using hand tools) and accuracy depends upon the skill of the smith. Also, hand-forging covers the manufacture of small and medium size components required in small quantities.

8.4 COMMON HAND FORGING TOOLS

For carrying out forging operations manually, certain common hand forging tools are employed. These are also called blacksmith’s tools, for a blacksmith is one who works on the forging of metals in their hot state. The main hand forging tools are as under.

8.4.1 Tongs

The tongs are generally used for holding work while doing a forging operation. Various kinds of tongs are shown in the figure below.

a. Straight-lip fluted tongs are commonly used for holding square, circular and hexagonal bar stock.
b. Rivet or ring tongs are widely used for holding bolts, rivets and other work of circular section.
c. Flat tongs are used for mainly for holding work of rectangular section.
d. Gad tongs are used for holding general pick-up work, either straight or tapered.

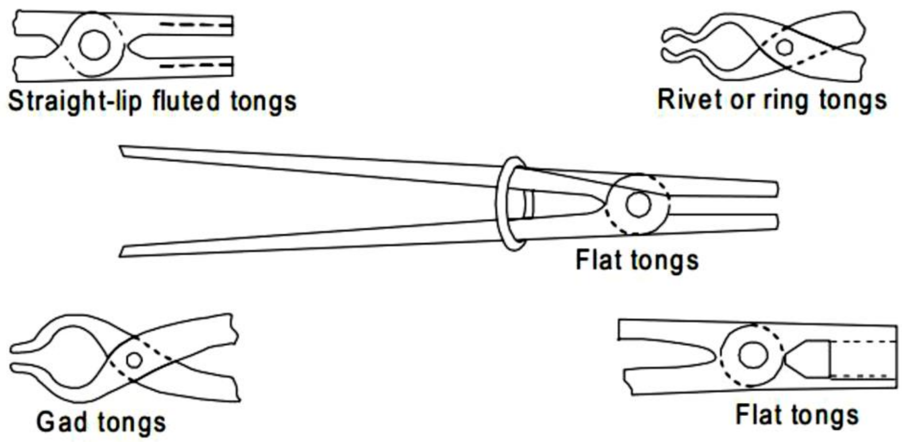


Fig 8.1 Tongs

8.4.2 Flatter

Flatter is shown in **Fig. 8.2**. It is commonly used in forging shop to give smoothness and accuracy to articles which have already been shaped by fullers and swages.

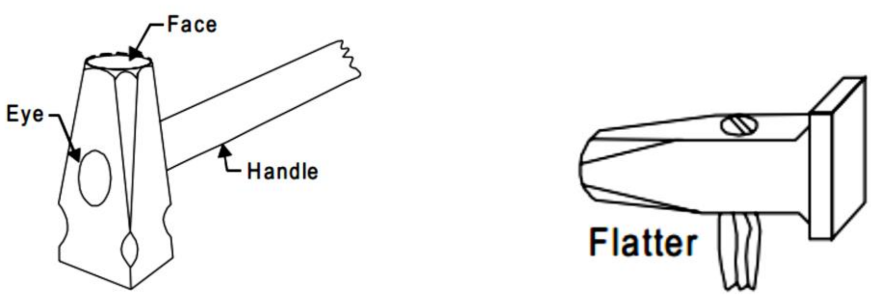


Fig 8.2 Flatter

8.4.3 Fuller

Fullers are in pairs and are used for forming grooves and for crimping the metal when drawing down. The top fuller is provided with a handle and the bottom fuller fits into the hardie hole in the anvil.

8.4.4 Punch

Punch is used in forging shop for making holes in metal part when it is at forging heat.

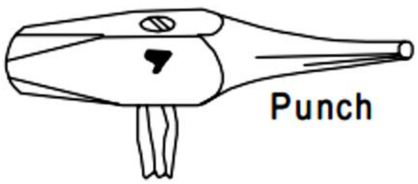


Fig 8.3 Punch

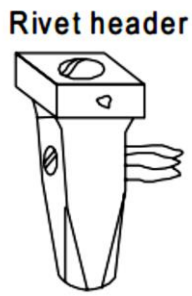


Fig 8.4 Rivet Header

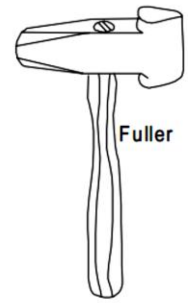


Fig 8.5 Fuller

8.4.5 Rivet header

Rivet header is used in forging shop for producing rivets heads on parts.

8.4.6 Chisels

Chisels are used for cutting metals and for nicking prior to breaking. They may be hot or cold depending on whether the metal to be cut is hot or cold. A hot chisel generally used in forging shop is shown in the figure below. The main difference between the two is in the edge. The edge of a cold chisel is hardened and tempered with an angle of about 60°, whilst the edge of a hot chisel is 30° and the hardening is not necessary. The edge is made slightly rounded for better cutting action.

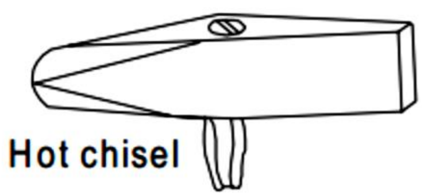


Fig 8.6 Hot Chisel

8.4.7 Hand hammers

There are two major kinds of hammers are used in hand forging:

a. The hand hammer used by the smith himself and

b. The sledge hammer used by the striker.

Hand hammers may further be classified as

a. ball peen hammer
b. straight peen hammer, and
c. cross peen hammer.

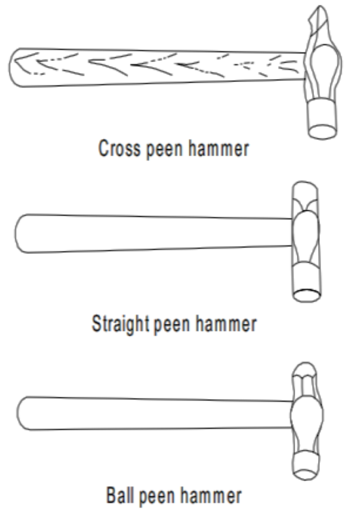


Fig 8.7 Hand Hammers

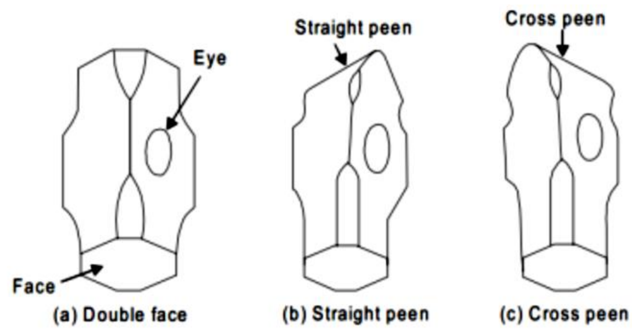


Fig 8.8 Sledge Hammers

Sledge hammers may further be classified as

a. Double face hammer,
b. straight peen hammer, and
c. cross peen hammer.

Hammer heads are made of cast steel and, their ends are hardened and tempered. The striking face is made slightly convex. The weight of a hand hammer varies from about 0.5 to 2 kg whereas the weight of a sledge hammer varies from 4 to 10 kg

8.4.8 Swage block

This is a heavy rectangular piece of cast iron having a series of various shaped grooves around its periphery and round, square and rectangular holes are provided in it. It is mainly used for heading, bending, squaring, sizing, and forming operations on forging jobs. It is 0.25m or even more wide. It may be used either flat or edgewise in its stand.

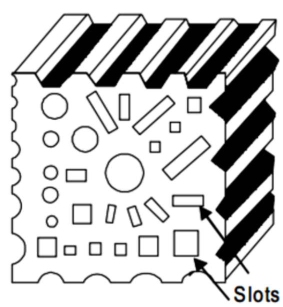


Fig 8.9 Swage Block

8.4.9 Anvil

An anvil is one of the most commonly used tool in forging shop. It acts as a support for blacksmith’s work during hammering. The body of the anvil is made of mild steel with a tool steel face welded on the body, but the beak or horn used for bending curves is not steel faced. The round hole in the anvil called pritchel hole is generally used for bending rods of small diameter, and as a die for hot punching operations. The square or hardie hole is used for holding square shanks of various fittings. Anvils in forging shop may vary up to about 100 to 150 kg and they should always stand with the top face about 0.75m from the floor. This height may be attained by resting the anvil on a wooden or cast iron base in the forging shop.

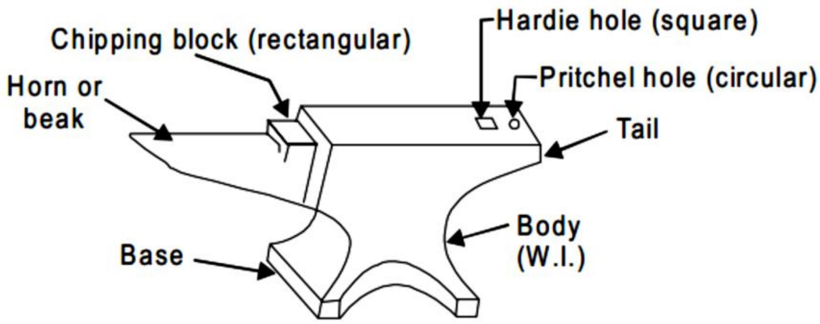


Fig 8.8 Anvil

8.5 FORGING OPERATIONS:

The following are the basic operations that may be performed by hand forging:

1. **Drawing-down**

   Drawing is the process of reducing the thickness of a bar by increasing its length. Forging the tapered end of a cold chisel is an example of drawing operation. A pair of fullers can be used for this operation.

2. **Upsetting**

   It is a process of increasing the area of cross-section of a metal piece locally, with a corresponding reduction in length. In this, only the portion to be upset is heated to forging temperature and the work is then struck at the end with a hammer. Hammering is done by the smith himself, if the job is small, or by his helper, in case of big jobs, when heavy blows are required with a sledge hammer.

3. **Flattening**

   This is another process which gives a reduction in thickness and an increase in length. This process involves the use of flatter to produce a finished flat surface. Flatters are the tools that are made with a perfectly flat face of about 7.5 cm square.

4. **Swaging**

   This is a process of finishing the cross section of the work to size and shape. Top and bottom swages are usually used for this operation. For larger work, swage block can be used.

5. **Bending**

   Bending is the process of forming a metal bar into an angle or a curve or a circle. Hand forging involves various types of bending operation. Bend may have a sharp angle or a slow curve. Sharp bend may be made on the anvil or in a vice, while accurate and uniform types of bends may be performed with the aid of a bending fixtures. A fixture is a device used for holding components in position for workshop operation.

6. **Twisting**

   This is an operation of forming a strip of metal bar into spiral shape, by holding a hot or ductile metal bar at one end in a vice or fixture and turning the other end in order to have its shape curled like spiral.

7. **Cutting (Hot and Cold Chisels)**

   Chisels are used to cut metals, either in hot or cold state. The cold chisel is similar to fitter's chisel, except that it is longer and has a handle. A hot chisel is used for cutting hot metal and its cutting edge is long and slender when compared to cold chisel. These chisels are made of tool steel, hardened and tempered.

8. **Forge Welding**

   This is the process where two separate piece of metals are united by heating them to a plastic condition and then hammering them together, a flux is applied to the joint surface to prevent oxide forming on them. Sand may be used as a flux for welding wrought iron and a mixture of sand and borax is suitable for mild steel. The temperatures at which these metals may be successfully welded are:

   a. Wrought Iron – 1300^0C (White Heat)
   b. Mild Steel – 1150^0C (Yellow Heat)

8.6 DROP FORGING

This is a kind of power operated forging process that uses a pair of dies to produce large numbers of similar parts. A pair of dies with shaped impressions are fitted to the tup and the anvil. The hot blank to be forged is often pre-formed to a suitable size and shape before it is placed in the lower die. The top die attached to the tup then drops from a height of about three metres on to the hot blank, and the energy or its drop squeezes the metal until it fills the impression of the dies. it is from this working principle that the name drop forging is derived. Any excess formed as a flash will be cut off later. The dies for drop forging are made from medium carbon steel. Typical applications of drop forging are production of spanners hammer heads and connecting-rods.

8.6.1 ADVANTAGES OF DROP FORGING

a. It produces large numbers of identical parts.
b. It is suitable for mass production of works
c. Its production rater is high
d. The cost of production is relatively low
e. it produces more accurate forgings
f. It is used for certain tool-steels that are not easy to machine

8.6.2 LIMITATIONS OF DROP FORGING

a. Dies are rather too expensive
b. Very complex shapes cannot be produced as they could not be removed from the dies easily

8.7 MACHINE FORGING

This is a kind of power operated forging process that uses power hammers for forgings that are too big or large for a sledge-hammer. The upright designed type of power hammer is the most commonly used.

A power hammer consists an anvil block for supporting the work, the tup that carries the hammer for striking the work, the frame and the operating mechanism. Power hammer can be operated mechanically (using a crank and spring device) or pneumatically using compressed air or hydraulically - using fluid pressure and even steam pressure can be used as a source of drive for the tup. The size of any power hammer is governed by the weight of the tup, piston and piston-rod.

There is also a forging press that works with continuous and steady pressure on metal to be forged. It does not use striking force like machine forging. But force is applied more gradually to the workpiece.

8.8 SAFETY WHEN FORGlNG

a. Always wear a good leather apron
b. Use correct tongs at all time
c. Don‘t leave hot metal where it could he accidentally handled
d. Avoid the use of loose hammer-head

NOTE: Overheating above the forging temperature will result to weak and brittle metal while heating below forging temperature may lead to distortion or cracking due to internal stresses that might have set-up.