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PAPER I

WORK SHOP TECHNOLOGY

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Mechanical & Automobile Engineering
(M & AE)

PAPER I

WORK SHOP TECHNOLOGY

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UNIT: 1
Engineering Materials

STRUCTURE

- Introduction.
- Classification of Engineering Materials.
- Mechanical Properties of Metals.
- Ferrous Metal.
- Non – Ferrous Metal.
- Non –Metals.
- Importance of Safety Precautions in Workshop

INTRODUCTION:

Metals are used for various engineering purpose and requirements, such as structural members, pipes, tanks and building up of engineering machines. Out of all metals, Iron is the most popular metal in the field of engineering. All the metals have a crystalline structure.

CLASSIFICATION OF ENGINEERING MATERIALS:

Engineering materials are basically classified into two groups namely metals and non-metals, and their sub classification is given below.

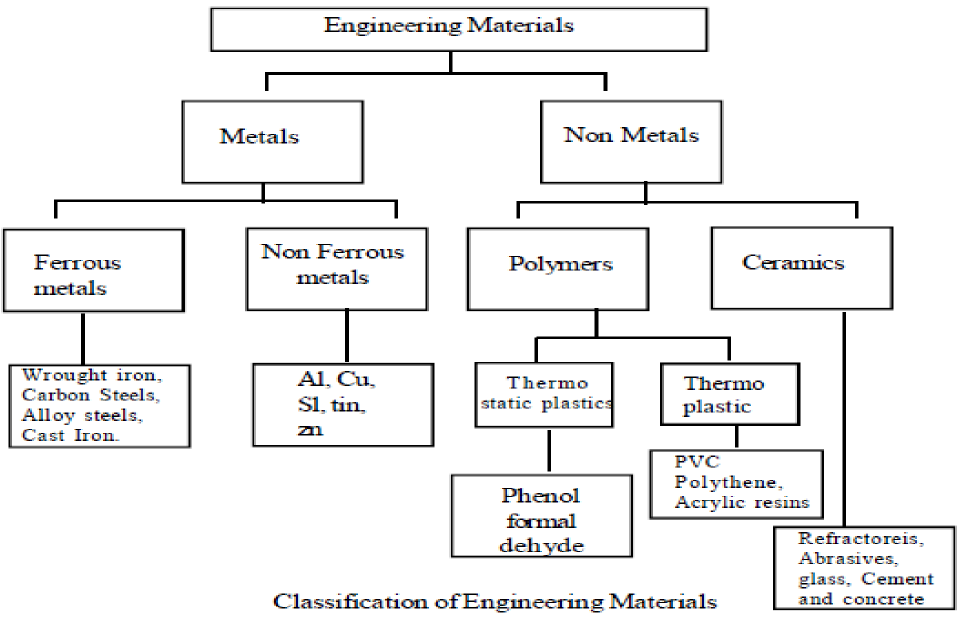


Fig 1.1 Classification of Engineering Materials

MECHANICAL PROPERTIES OF METALS:

The mechanical properties that determine the behavior of metals under applied forces. These properties are most important for the designing point of view.

1. **Strength:** Ability of a material to resist loads without failure.
2. **Tensile Strength:** Ability of a material in tension to withstand stress without failure.
3. **Shear Strength:** Ability of a material to withstand transverse loads without fracture.
4. **Elasticity:** Property of material which enables it to regain its original shape after deformation within the elastic limit.
5. **Stiffness:** Property of material which enables it to resist deformation.
6. **Plasticity:** Ability of material to be deformed permanently without fracture even after removal of force.
7. **Ductility:** Ability of a material to deform plastically without rupture under tensile load.
8. **Malleability:** Property which enables the metal to withstand deformation by a compressive load without fracture.
9. **Brittleness:** Property of the material of sudden fracture without any appreciable deformation.
10. **Hardness:** Property of the material which enables it to resist abrasion, indentation, machining and scratching.
11. **Toughness:** Ability of material to absorb maximum energy up to fracture takes place.
12. **Fatigue:** Failure of material under repeated loads or fluctuating loads.
13. **Weldability:** Ability of a material to be joined by welding
14. **Castability:** Property of a metal which indicates the ease with which it can be cast into different shapes and sizes from its liquid state.

FERROUS METALS:

The metals which contain iron as base metal are called ferrous metals. eg. Cast Iron, Alloy steels etc.

These are classified as

1) Pig iron	**2) Cast iron**	**3) Wrought iron**
4) Carbon Steel	**5) Alloy steel**	**6) Stainless steel**

Cast iron:

Pig iron re-melted and there by refined together with definite amount of lime stone, Steel Scrap and spoiled castings in cupola. It contains 2-4% Carbon, a small percentage of Silicon, Sulphur, Phosphorus and Manganese.

Properties of Cast Iron:

1. It has good fluidity.
2. It can be easily machined.
3. It is brittle in nature.
4. It is resistance to deformation.
5. It is wear resistant.

Uses of Cast Iron:

1. It is used in making pipes.
2. It is used for making machine bodies.
3. It is used in making automotive industry parts.

Wrought iron:

It is a almost pure iron. Its carbon content is 0.15%.

Properties of Wrought iron:

1. It is soft at white stage of heat. It can be easily forged and welded.
2. It is ductile, malleable and tough.
3. Its melting point is15000c.
4. It is resistant to corrosion.
5. Its specific gravity is7.8

Uses of Wrought iron:

Used for making rivets, railway couplings, chains bolts and nuts etc.

Carbon steels:

Steel is made as the iron alloy with carbon content up to 2%.Carbon steels are divided into two types. They are

1) Mild steel (or) Low carbon steel **2) High carbon steel**

1.3.3.a. Mild steel (or) Low carbon steel:

These are also called low carbon steels having carbon content of 0.15 – 0.3%.

Properties of mild steel:

1. It has low fluidity.
2. It has good tensile strength.
3. It is ductile.

4. It can be cold worked easily.

Uses of mild steel:

1. It is used for making structures.
2. It is used for making nuts and bolts.
3. It is used for making machine components.
4. It is used for making boiler plates.

High carbon steel:

High carbon steels have more than 0.60% carbon i.e.0.6–0.9% carbon. It is generally used for making parts requiring strength, hardness and wear resistance.

Properties of high carbon steels:

1. It has good strength.
2. It has high toughness.
3. It has increased wear resistance.

Uses of high carbon steels:

1. It is used for making Drop hammers.
2. It is used for making Screwdrivers.
3. It is used for making laminated springs.
4. It is used for making gears.
5. It is used for making piston rings.

Alloy Steel:

Steel is a metal alloy consisting mostly of iron, in addition to small amount of carbon, depending upon the grade and quality of the steel. Alloy steel is any type of steel to which one or more elements besides carbon have been added to produce desired physical properties. The most common alloying elements added to steel are Chromium, Nickel, manganese, silicon, Vanadium etc...

Properties of alloy steel:

1. High Strength.
2. High corrosion resistance.
3. High wear resistance.
4. Good toughness.

Uses of alloy steel:

1. It is used for making aero plane parts.
2. It is used for making auto mobile parts.
3. It is used for railway track work.
4. It is used for making locomotive parts.

Stainless steel:

It contains 18% chromium, 8%nickel, 0.06% to 0.12% carbon. They are called stainless because in the presence of oxygen, they develop a thin adherent film of chromium oxide that protects the metal from corrosion.

Properties of stainless steel:

1. It has high corrosion resistance.
2. It has high strength.
3. Good toughness.
4. It posses nonmagnetic properties.
5. It can be rolled.

Uses of stainless steel:

1. It is used for making surgical instruments.
2. It is used for making utensils.
3. It is used for making containers for pharmaceutical industries.
4. It is used for making springs.

NON – FERROUS METALS:

The metal which do not contain iron as base metal Eg: Al, cu, Lead, Zn and gold etc. All the nonferrous metals have common set of properties. The melting points of these metals are generally lower than ferrous metals.

Copper:

Copper is easily identified from all other metals due to reddish in colour and is extracted from copper pyrites.

Properties of copper:

1. It is relatively soft.
2. It is very malleable and ductile.
3. It is very good conductor of heat and electricity.
4. It is very flexible.

Uses of copper:

1. It is used for making electrical cables.
2. It is used for making kitchen vessels.
3. It is used for making pipes which are used in refrigerators.
4. It is used making for ornaments.

Brass:

It is basically refers to a yellowish alloy of copper and zinc and it comprises of 65% copper and 35% zinc. There are various classes of brass, depending on the proportion of copper and zinc are available for various uses. The melting point of brass ranges from 8000C-10000C.

Properties of Brass:

1. It is noncorrosive.
2. Air, water and some acids do not affect it.
3. It is poor conductor of electricity.

Uses of Brass:

1. It is used for making utensils.
2. It is used for manufacturing ornaments.
3. It is used in hydraulic fittings, pump lining, in making bearing and bushes.
4. It is used in making locks.

Bronze:

It is alloy of copper and tin. The composition range is 5-25% tin and 75 to 95% copper. The corrosion resistances of bronzes are superior than brasses.

Properties of Bronze:

1. It is comparatively hard.
2. It is resistance to surface wear.
3. It can be casted into wires and sheets.
4. It has high strength.

Uses of Bronze:

1. It is used in hydraulic fittings, pump linings.
2. It is used in making utensils, bearings, bushes, sheets, rods, wire etc.

Tin:

Although it is used in small amounts, tin is an important metal. Tin is used as protective layer on the sheet metal. It is obtained from tin stone.

Properties of Tin:

1. It is white soft metal.
2. Good resistance to acid corrosion.
3. Low strength.
4. It is malleable and ductile.
5. It does not corrode at both dry and wet climates.

Uses of Tin:

1. It is used as a coating on steel containers for preservation of food products
2. It is used in making thin foil sand as an alloying element in the manufacture of bearings.

Zinc:

It is fourth most utilized industrially after iron, Aluminium and copper. It is used for galvanizing the steel sheet or wire as it serves as an ode to protect from corrosion attack.

Properties of Zinc:

1. It is soluble in copper.
2. Low melting point and high fluidity.
3. High corrosionresistance.
4. It is ductile andmalleable.

Uses of Zinc:

1. It is used for die casting.
2. It is used for production of brass.
3. It is used in battery cells for making dry batteries.
4. It is used as protective coating in iron and steel against rusting.

Gun Metal:

Gun metal contains10% tin, 88% copper and 2% zinc. Zinc is added to clean the metal and increase fluidity. It is not suitable for being worked in the cold state.

Properties of Gun Metal:

1. It is highly anti corrosive.
2. It has goodmach inability.
3. It has good harden ability.

Uses of Gun Metal:

1. It is used for casting guns and cannons.
2. It is used for boiler fitting.
3. It is used for making bearings.
4. It is used for making glands in centrifugal pumps.

White Metal:

White metal contains copper-tin-antinomy and it contains 88% tin, 8% antimony and 4% copper.

Properties:

5. It is a soft metal with low coefficient of friction.
6. It has little strength.

Uses:

It is the most common bearing metal used into cast iron boxes when the bearings are subjected to high pressure and load.

Aluminium:

Aluminium is most abundant metal in the earth crust. It is silvery white in colour. It makes up about 8% by weight of the earth's solid surface Aluminium is remarkable for its low density and ability to resist corrosion

Properties of Aluminium:

1. It is a good conductor of heat and electricity.
2. It is very light in weight.
3. In pure state is very weak and soft.

Uses of Aluminium:

1. It is used for making automobile parts.
2. It is used for ornamental purpose.
3. It is used for making aircraft parts.
4. It is used for making bars, tubes &rivets.

NON –METALS:

1. **Wood**:

Another name given to wood is timber. It is obtained from trees after full growth and made suitable for engineering building process.

2. **Plastics**:

The word plastic is common term that is used for many materials of a synthetic or semi synthetic nature. Now plastic materials are most widely used for domestic as well as industrial purpose due to its low cost, light weight and it looks decorative.

3. **Rubber**:

Rubber is a polymer which is a word that is derived from the Greek meaning “many parts”. Natural rubber is formed in the latex which comes from the rubber trees. It is collected in a cup mounted on each tree. Rubber is used for making tyres, tubes, shock absorbers, rubber cushions, weather stripping around car’s wind shield and gaskets

IMPORTANCE OF SAFETY PRECAUTIONS IN WORKSHOP:

1. Never wear loose clothing, ties and shirts with long sleeves.
2. Keep the shop floor clean and free from oil and grease.
3. Don’t use blunt or dull tool, it slips and causes injury.
4. While using chisels, see that cutting is performed in the direction away from the body.
5. Keep hands away from moving parts.
6. There must be sufficient light and ventilation at work place.
7. Exhaust fans should be provided to remove smokes and fumes.
8. Use proper tools according to the nature of the job.
9. Use of shoes and apron is essential.
10. Never carry tools in pocket.
11. Observe all the safety codes while working in the workshop.

SHORT ANSWER QUESTIONS

1. Write the classification of Engineering Materials.
2. Write the properties of Wrought Iron.
3. Write the uses of Aluminum.
4. Explain the non-metal plastics.

LONG ANSWER QUESTIONS

1. Explain the mechanical properties of metals.
2. Explain the properties and uses of
   a) cast iron b) carbon steel c) stainless steel
3. Explain the properties and uses of non-ferrous metals
   a) copper b) Tin c) zinc

UNIT: 2

Carpentry

Structure

Introduction

Measuring Tools and Marking Tools

Cutting Tools

Boring Tools

Striking Tools

Holding Devices & Miscellaneous Tools

Carpentry Process

Carpentry Joints

Wood Working Machines

INTRODUCTION:

Carpentry deals with the all works such as roofs, floors, partitions, making of doors, windows, cupboards, dressers, stairs and all interior fitments for a building. Wood is the material used for any type of wood work.

Measuring tools:

1. **Steel rule:**

   It is direct measuring instrument. Various sizes and designs are available for measuring and setting out dimensions.

2. **Steel tape:**

   This is used for longer dimensions. They are available from lengths from0.6m to2.5m.

Marking tools:

1. **Straight Edge:**

   It is a machined flat piece having truly straight and parallel edges. It is used for testing trueness and straightness of edges.

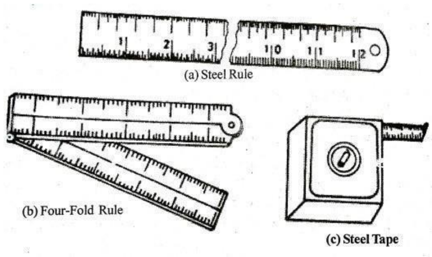


Fig 2.1 Marking tools

2. **Try Square:**

It is used for marking and testing angles at 90 . It consists steel blade riveted to a hard wood stock, which has protective brass plate on the working surface.

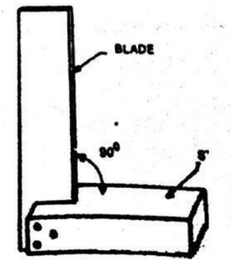


Fig 2.2 Try square

3. **Metre Square:**

It is used for marking and testing at 45. It has a steel blade fitted in a wooden or metal stock.

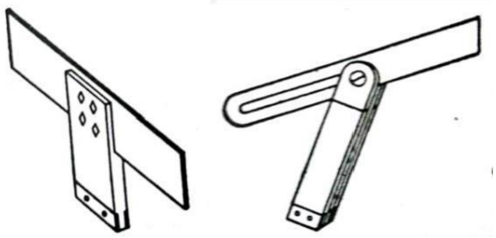


Fig 2.3 Metre Square

4. **Marking Knife:**

All the dimensional line marked with pencil are cut with marking knife. It has a chisel edge at one end and sharp point at other end.

Fig 2.4 Marking knife

5. **Marking Gauge:**

It has a stem with a sharp point pin at one end. It is used to cut line along the grains and parallel to an edge.

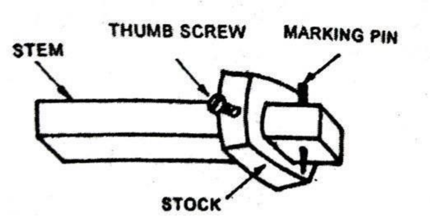


Fig 2.5 Marking Gauge

6. **Divider:**

   It has two pointed legs. It is used for transferring dimensions and scribing curves or circles.

Cutting tools:

1. **Saw:**

   The saw is commonly used cutting tool in wood working. The saw has a blade which carries cutting teeth and handle.

2. **Rip saw:**

   It used to cut the wood along the grains.

3. **Crosscut saw:**

   It is used for cutting the wood across the grains.

4. **Panel saw:**

   It has a fixed saw. It is used for fine work. It is used for ripping and crosscutting.

5. **Tenon saw:**

   It is used for cross cutting when a fine and accurate finishing is required.

6. **Dovetail saw:**

   It is used to get accuracy.

7. **Bow-saw:**

   This saw is used for cutting quick curves and the handle can revolve in their sockets. The blade can be adjusted to any desired positions.

8. **Key Hole Saw:**

It is smallest aw. It has a trapped blade fixed into the handle by crews. It is used for cutting key holes and is very useful for internal and intricate work.

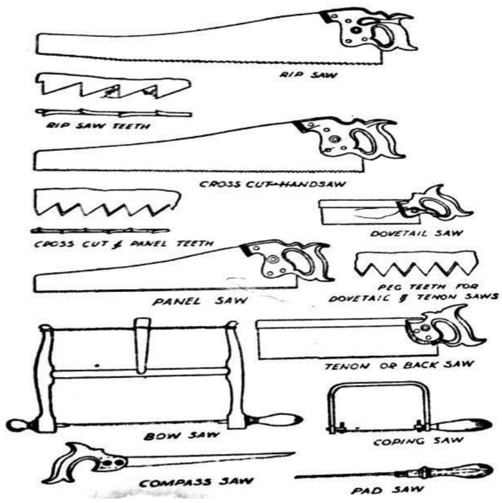


Fig 2. 6 Different types of saws

Chisels:

A fairy large number of chisels are used in wood work for cutting in different manners to produce desired shape and cavities. The chisel consists of these parts irrespective of their size and use. The common types of chisels are used in carpentry work are the following.

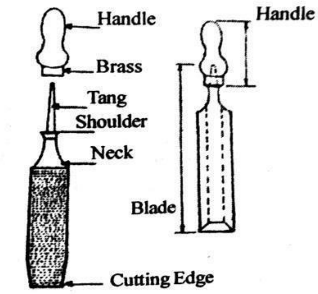


Fig 2.7 Chisels

1. **Firmer Chisel:**

This chisel is capable of doing heavy work and is used for joining and shaping the wood with or without mallet. The blade is made of rectangular sections with bevel edge.

2. **Paring Chisel:**

These chisels have a long blades used to cut the deep corners with hand pressure. They are mostly used for pattern making.

3. **Mortise Chisel:**

It is used for taking heavy and deep cuts resulting in more stock removal as in case of making mortises.

4. **Socket Chisel:**

It is provided with socket instead of tang. The wooden handle is inserted into this socket. This prevents splitting of handle while removing heavy stock.

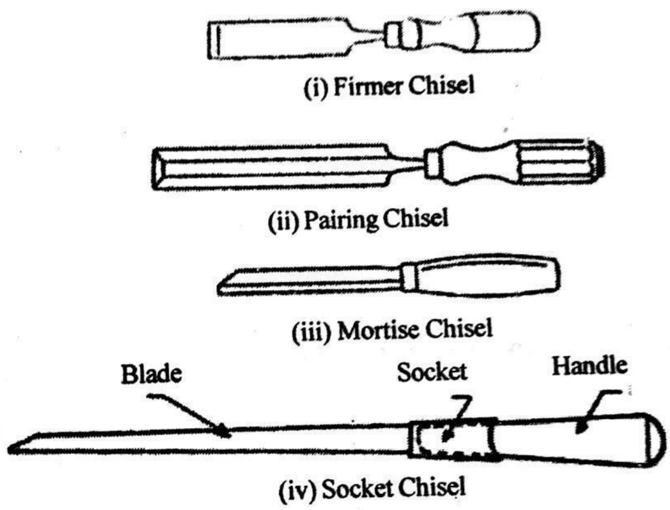


Fig 2.8 Different types of Chisels

Planes:

Planes are used in producing flat and smooth surfaces by cutting thin layers of wood. The plane consists of these parts – Body, cutting blade, handle, knob and other controls. The common types of planes used in carpentry are

1. **Jack Plane:**

It consists of a wooden body or stock in which blade or cutter is fastened at an angle of 45 degree to the sole. The plane iron and cap iron are assembled and inserted in a mouth of plane along with the wedge. The back iron supports the cutting edge and also breaks the shavings so that curl away from the blade. The blade can be set for taking deeper or shallower cuts.

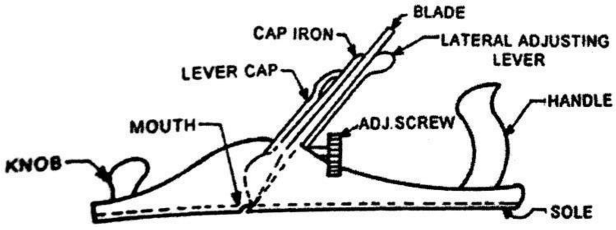


Fig 2.9 Jack Plane

2. Trying Plane:

These are used to make true flat surfaces which are formed by jack plane. It is longer than jackplane.

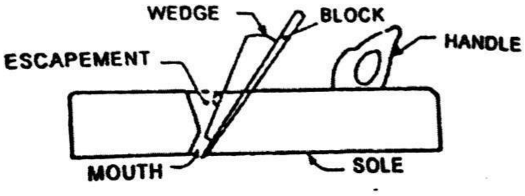


Fig 2.10 Trying Plane

3. Smoothing Plane:

It is nothing but a smaller wooden jack plane without handle. In operation its stock itself is held in both hands. It is used for better finish and smoothness to the surface already plane by ajackplane.

4. Rebate Plane:

It is small in size and is used to cut the recess along the edge of a work piece. In rebate plane the edges of cutting iron is in line with the side of plane.

5. Plough Plane:

It is used for making deep grooves of standard size. A deep gauge is fixed on the body, and is operated by thumb screw. It allows the plane to make a groove of constant depth.

6. Router Plane:

It is used for finishing the grooves to a constant depth which are formed by chisel or saw.

Boring Tools:

Boring tools are necessary to make holes in wood. The various types of boring tools are as follows:

1. Bradawl:

It is used for boring small holes for inserting the screws and mails. It has chisel like point and is operated by hand.

2. Gimlet:

It is hand operated tool used for making small holes for screws. It has a spiral flutes with screw like point.

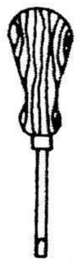


Fig 2.11 Bradawl **Fig 2.12 Gimlet**

3. Brace:

It is a boring tool used for making holes. It holds and rotates various types of bits for producing holes and is operate by hand. The most commonly used braces are ratchet brace and wheel brace. These are used for making larger holes of different sizes.

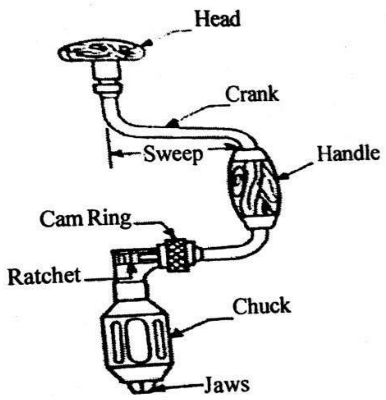


Fig 2.13 Brace

4. Auger bit:

It is used for producing long deep holes of diameter ranging from 6 to 40 m. It is steel bar. An eye at top to which the handle is fitted. The bottom end is provided with a screw point.

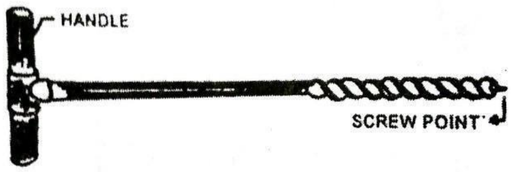


Fig 2.14 Auger bit

Striking Tools:

Striking tools are called Hammers used to drive in nails and to operate chisels. The most common striking tools used in carpentry are hammers and mallets.

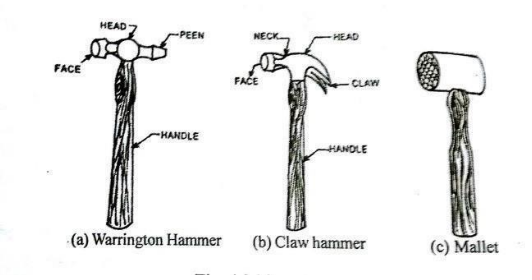


Fig 2.15 Different types of Striking Tools

1. Warrington Hammer:

It is used for bench work and light work. It is made of cast steel with tampered face and pen. The wooden handle fits in the eye and steel wedge s driven into form a rigid joint.

2. Claw Hammer:

It is dual purpose hammer and face is used to drive in nails, and claws at the other end for pulling out nails.

3. Mallet:

It is used for operating the chisel and gauges. It is made of hard wood and is provided with handle.

Holding Devices:

To enable the wood worker to cut the wood accurately, it must be held steady. There are number of devices to hold the job.

1. Bench vice:

It is made of steel. It has the jaws, one is fixed to the side of the table while the other is kept movable by means of a screw and handle. The job is held between two jaws. The faces of jaws are lined with hard wood to prevent damage of work surface.

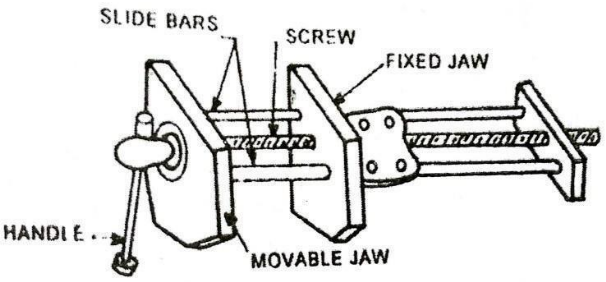


Fig 2.16 Bench vice

2. Bench Stop:

It is simply a block of wood projecting above the top surface of the bench. This is used to prevent the wood from moving forward when being planned.

3. Bench Hold Fast:

It consists of a cast iron pillar, steel arm and screw with a handle. It is used for securing the work to the bench. The pillar drops into a hole bored in the bench and the screw operates the arm to hold work on the table.

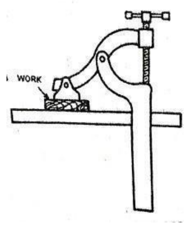


Fig 2.17 Bench hold Fast

4. Bench hook:

It is used to support work while planning or cutting. It is made of wood and can be placed conveniently on the worktable.

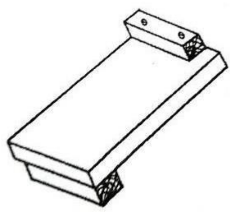


Fig 2.18 Bench hook

5. Sash cramp:

This is used for holding wide work such as frames or tops. It consists of a steel bar fitted with two jaws one of which is movable by a screw and other is fixed into one of the spaced holes by a fastening pin.

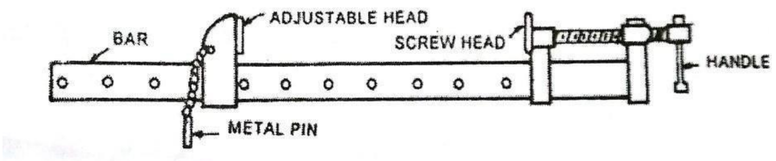


Fig 2.19 Sash Cramp

6. G-Clamp:

It is used to hold small works and it consists of frame with a fixed jaw at one end and movable jaw is operated by a screw and a thumb nut at the other end. It I also used to hold small parts for gluing.

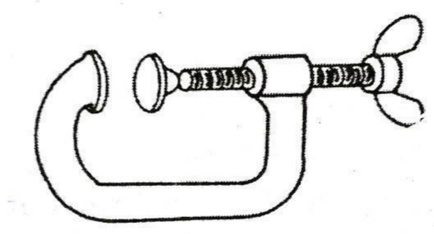


Fig 2.20 G-Clamp

Miscellaneous Tools:

1. Raspor File:

It is used for finishing the wood surface. It has sharp cutting teeth and it is used for finishing small curved surfaces.

2. Scraper:

It has fine edge which cuts fine shavings and remove plane marks.

3. Glass paper:

Where a surface is having very small imperfections that the no other cutting tool will do, then glass paper is used. It consists of small particles of glass struck to sheet of paper. Its sharp edges cut the wood.

4. Ratchet Screw Driver:

It is very useful for turning screws through a few degrees in.

5. Screw Driver:

These are used for screwing or unscrewing for the screws used in woodwork.

Carpentry Processes:

1. Marking:

The marking is the operation of setting out dimensions of a product on work surface. The success of completing a job depends on accurate and orderly marking .The dimensions and other internal details are marked with respect to the finished edge and face of a work piece.

2. Sawing:

It is the process of cutting wood by using saw. While sawing the work should be gripped perfectly in a vice. To start a saw cut hold the saw nearly horizontal. Support the blade with left thumb and draw the blade backward and push forward until it has started a cut.

3. Planning:

Planning is a process of smoothing the surface of wood by a planer. The work for planning is supported by the back bench stop or held firmly in the vice. The pressure is applied during the cutting stroke and relieved on the return stroke. It is important to move plane in a straight line to avoid rounding at the ends, and to obtain smooth surface planning is done along the grains.

4. Chiseling:

Chiseling is the process of cutting excess wood with chisel to obtain desired shape and required form of joint. In chiseling hand pressure is applied to remove thin layers. For quick removal of excess wood large cuts can be made using a mallet.

5. Boring:

It is the process of making holes in wood. The work is secured firmly in a vice or suitable cramp and the hole position is marked with punch. The hole is produced by turning and feeding the bit into work.

6. Rebating:

It is the process of cutting a recess along the edge of wood by a rebate plane. While rebating, the plane must be kept pressed into the side of the wood.

7. Grounding:

These operations are involved in joining of wood. Grooving is the process of cutting a channel in a wooden piece this is usually performed by plough plane.

8. Tongueing:

It is the process of making a projection corresponding to a groove in which it has to fit. This operation is usually performed by Moulding plane.

9. Moulding:

It is the process of making curved surface along the length of wood. This operation is performed with Moulding plane and is used for decoration work.

10. Polishing:

It is the process of producing a smooth reflecting surface with inly the minimum removal of material. To obtain such a finish it is necessary to incorporate suitable abrasive within the polishing composition.

Carpentry Joints:

1. Halving Joints:

Halving joints or half-lap joints are used in construction of frames. Marking and cutting of any joint must be accurate so that it can be glued together with the final external surface level.

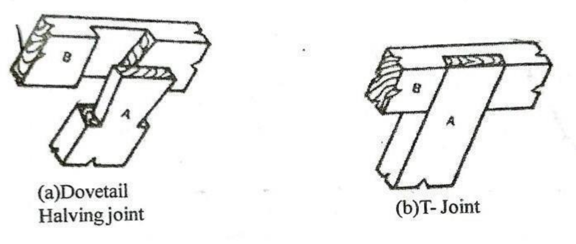


Fig 2.21 T Halving joints

2. Mortise and Tenon Joints:

It is strongest joint, and is used for the construction of doors, windows and frames.

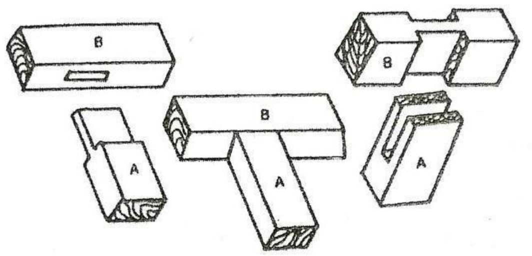


Fig 2.22 Mortise & Tenon Joint

3. MitreJoint:

It is formed by cutting the ends at an angle. The two ends are joined by nails or screws. This joint is used in photo-frame.

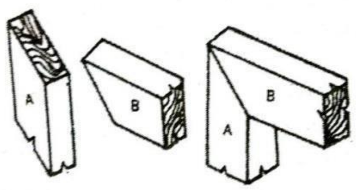


Fig 2.23 Mitre joint

4. Dovetail Joint:

This is the strongest corner joint and is used for construction of boxes and cupboards.

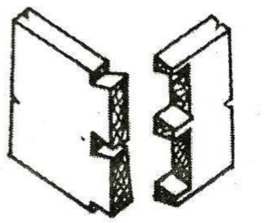


Fig 2.24 Dovetail joint

5. Butt or Rubbed Joint:

It is a widening joint, used to produce wide boards like drawing boards, table tops. To make the joint the edges are planed true with trying plane, butted and joined together with glue.

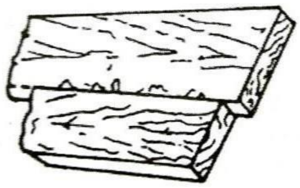


Fig 2.25 Butt joint

6. Tongue and grooved Joint:

It is a widening joint used for planks and boards. This joint is prepared by means of special plane. The tongue is fitted into the groove. Sometimes grooves are made on both the edges and a separate tongue is inserted in it. Such joint are called inserted tongue and groove joint.

7. Screw joint:

This joint is used for thick wooden pieces which do not glue readily. One piece carries the screw while the other piece has a hole for head of the screw and as lot for shank.

8. Corner joint:

Corner joint in which the butt end of one piece is joined against the other at right angles are called square corner joints.

Wood Working Machines:

1. Wood turning Lathe:

It is used for producing cylindrical, conical (tapered) and spherical components.

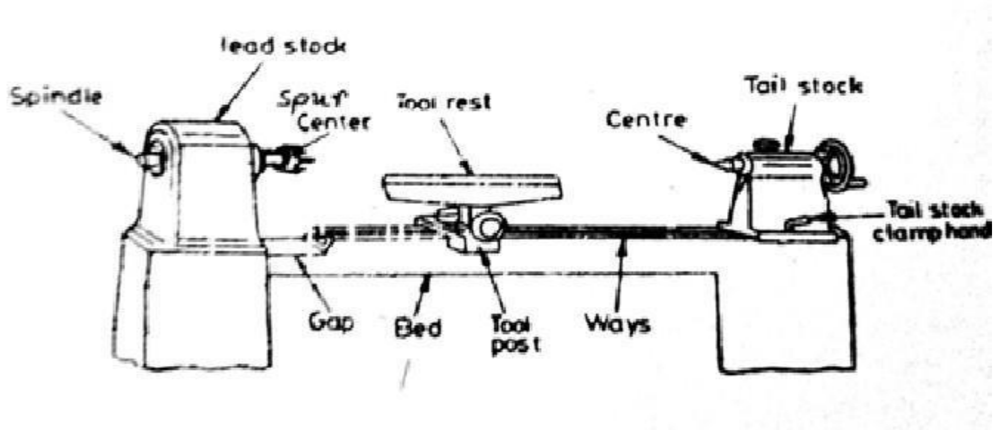


Fig 2.26 Wood Turning Lathe

A cast iron bed is fixed horizontally on the base. It supports head stock, tail stock and tool rest. Head stock is fixed permanently to the left hand end, and the head stock spindle is connected to the motor shaft by means of cone pulley drive. Tailstock is located to the right hand and can be secured rigidly at any desired position. Tool rest which supports the gauges during cutting (turning) may be fixed on the bed in the required position. The workpiece is rotated between the spur center and dead center and cutting tools supported on tool rest are manipulated by hand to obtain desired shape.

Wood Planner:

It is used for planning large work pieces and capable of producing true surface with enough accuracy at a faster rate. It consists of table over which the work is fed against a revolving cylindrical cutter head carrying 2-3 knives. The cutter is mounted on a over head raft and the table can be raised or lowered to attain desired thickness.

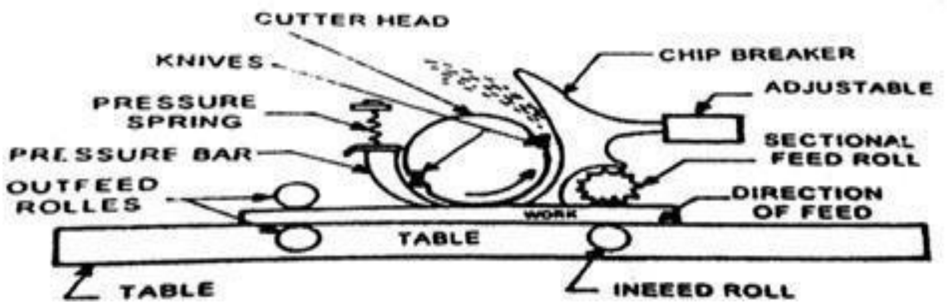


Fig 2.27 Principle of Wood Planer

SHORT ANSWER QUESTIONS

1. Draw the chisel and label the parts.
2. Explain the boring tool brace.
3. Explain the holding device bench vise.
4. Write the names of miscellaneous tools.

LONG ANSWER QUESTIONS

1. Explain carpentry processes.
2. Explain carpentry joints with sketches.
3. Explain wood working machines with sketches.

UNIT: 3

Sheet Metal work

STRUCTURE

Introduction

Metals used in Sheet Metal Work

Tools and Equipment

Sheet Metal Operations

INTRODUCTION:

The metal flank having less than 2mm thick is called sheet metal. Sheet metal work deals with the production of components in a wide variety of shapes and sizes from sheet metal with the aid of hand tools or machines.

METALS USED IN SHEET METAL WORK:

1. **Galvanized Iron:**

   It is a sheet of soft steel which is coated with zinc. Zinc resists corrosion and improves the appearance of metal. It is used for making pans, buckets, duct, gutters, tanks and boxes.

2. **Black Iron:**

   It is an uncoated sheet of metal. It corrodes easily. The parts which are made are coated with paint.

3. **Tin plate:**

   Tin plate is a iron or steel coated with pure tin. It is used for food containers, cans and pans.

4. **Stainless Steel:**

   It is an alloy steel which has corrosion resistance. This steel is commonly known as 18-8 stainless steel. It contains 18% chromium and 8% nickel. It is used for making food containers, dairy equipment, surgical instruments, chemical plants, kitchen wares etc.

5. **Copper:**

   It has reddish color and possesses good malleability ductility and resistant to atmospheric corrosion. It is used for making water pipes, roofing, cutters and other parts of building.

6. **Aluminum:**

Aluminum sheets are the alloy of copper, silicon, magnesium and iron. It has resistance to corrosion. It is used in construction of aero plane, refrigerators, light fixture, windows and ventilators.

Tools and Equipment:

Sheet metal hand tools:

1. **Steel rule:**

It is used for measuring and lay outing small works with accuracy up to 0.5mm.

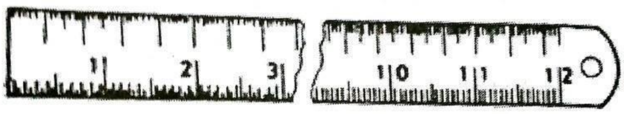


Fig. 3.1 Steel Rule

2. **Vernier caliper:**

It is used for measuring dimensions upto0.05mm.

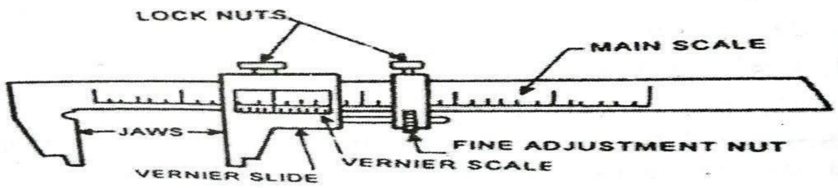


Fig. 3.2 Vernier Caliper

3. **Micrometer:**

It is used to measure the thickness of sheet upto 0.01mm.

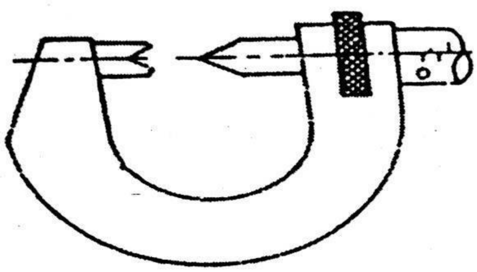


Fig. 3.3 Micrometer

4. **Sheet metal gauge:**

This is used to measure the thickness of sheet.

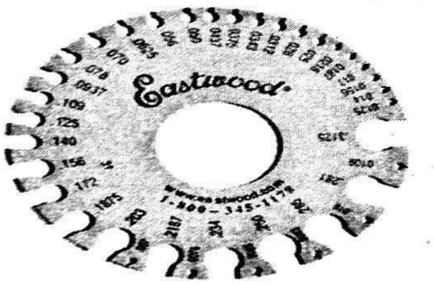


Fig. 3.4 Sheet metal gauge

5. **Straightedge:**

It is a steel bar has one long edge is beveled and comes in variety of lengths. It is used for drawing long straight lines.

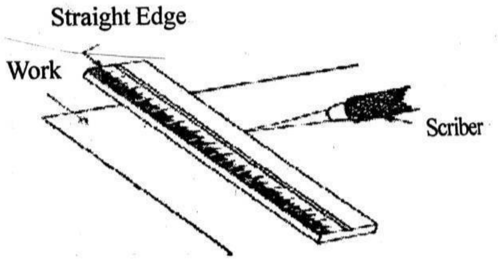


Fig. 3.5 Straight edge

6. **Scriber:**

It is a steel wire to mark layout lines on the sheet metal.

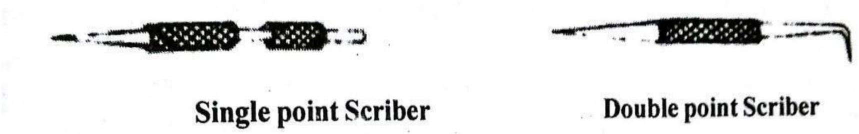


Fig. 3.6 Types of Scriber

7. **Divider:**

Dividers are used to draw circles or arcs on sheet metal and to divide the lines into two equal parts.

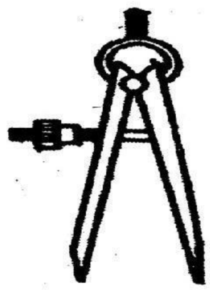


Fig 3.7 Divider

8. Trammel point:

It is used to draw large circles and arcs.

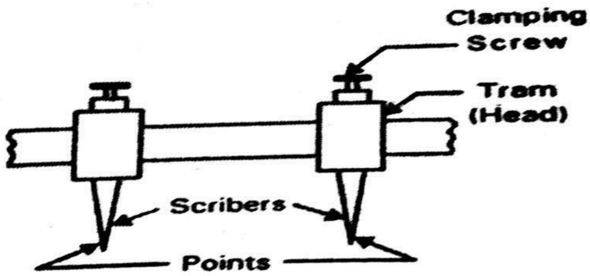


Fig 3.8 Trammel point

9. Chisel:

Chisel is used to cut sheets, rivets, bolts and for chipping operation.

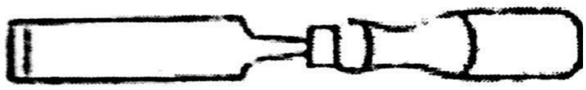


Fig 3.9 Chisel

10. Punches:

Punches are used for making small indentation on the work piece. Punch is of two types 1.Prick punch and 2.Center punch.

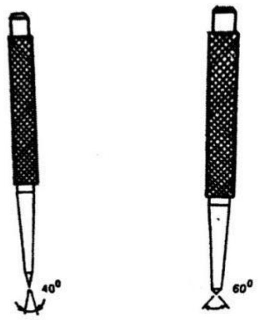


Fig 3.10 Punches

Hammers:

Hammers are used for forming shapes by hallowing, stretching or throwing off. The types of hammers are

- ❖ Ball pin Hammer: It is used for general purpose.
- ❖ Rivet Hammer: It is used for spreading rivets.
- ❖ Setting hammer: Flat facer is used for flattering seem without damage to the sheet metal.
- ❖ Rising Hammer: it is used for denting the metal down to shape.
- ❖ Mallets: Mallets are used for make light blows on the sheet. These are made with fiber, plastic, wood or rubber.

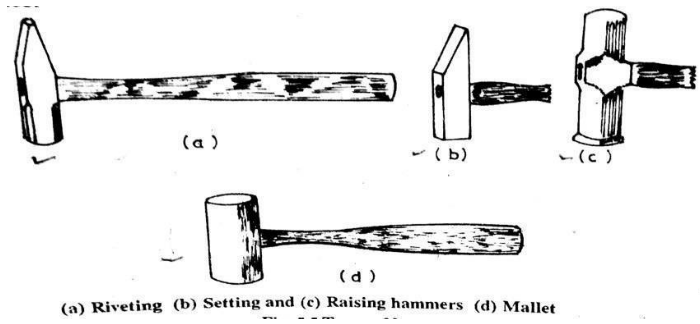


Fig 3.11 Types of Hammer

1. **Snips or shears:**

These are heavy scissors used for making straight or circular cuts. The common types of snips are straight snips which are used for straight cuts and bend snips are used for make a curved cuts.

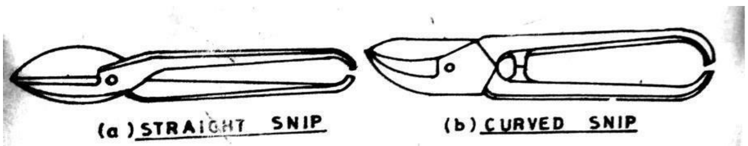


Fig 3.12 Types of snips

2. **Pliers:**

Pliers are used to forming and holding the work. Round nose pliers are used for holding and forming into various shapes.

3. **Stakes:**

These are used for bending, seeming, farming using hammer or a mallet. They are work supporting tools while working. The double seeming steamers are used to make a double seam. The brake horn stake is used for riveting and forming long surfaces, bending straight edges and making corners. The bevel edged stake is used for making straight and sharp bends.

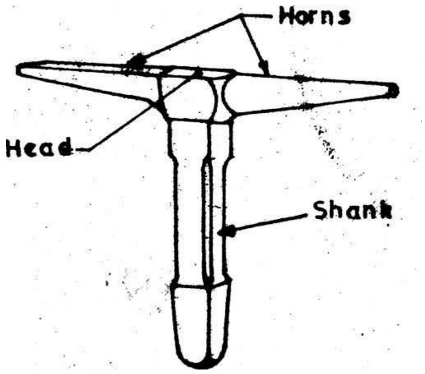


Fig 3.13 Stakes

4. **Groves:**

These are used for grooving and flattering a seam.

5. **Rivet set:**

Rivet set has a deep hole in the bottom to draw a rivet through metal and a cup shaped hole to form the finished head of a rivet.

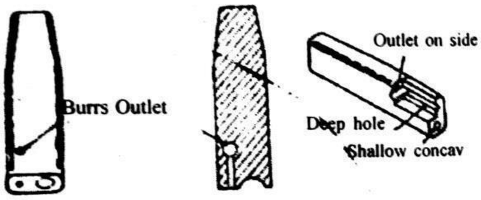


Fig 3.14 Rivet set

6. **Soldering Iron:**

It is used to join two pieces of metal by soft soldering by using an alloy of tin and lead. Soft solder is transferred to join by means of soldering iron.

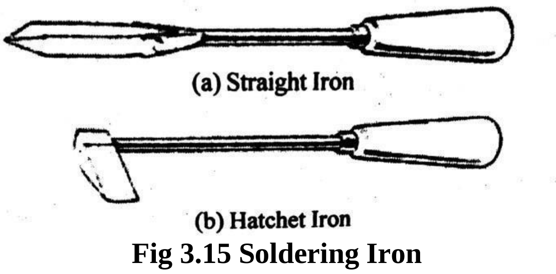


Fig 3.15 Soldering Iron

Sheet Metal Operations:

The various operations are required to produce an object from sheet metal.

These operations may be classified as:

1. **Shearing**
2. **Bending**
3. **Drawing and**
4. **Squeezing**

1. Shearing:

It is the process of cutting across a sheet or strip. The various shearing operations include.

- **a.** Cutting off: Process of severing a piece from a strip by cutting along a single line.
- **b.** Parting: Separating a piece from a strip by removing the scrap. The width of cut is equal to the thickness of crap removed.
- **c.** Blanking: Operation of cutting out desired shape from the strip by a single blow of the punch.
- **d.** Punching &piercing: Process of making a desired hole by using a punch and die. The term punching is restricted to circular holes.
- **e.** Notching: process of cutting out the edges of the strip to obtain the desired outer counter of the work piece. Various types of notches for folding a sheet metal are shown.
- **f.** Slitting: Process of cutting a strip in a line along its length.
- **g.** Lancing: Cutting operation in which hole in partly cut and bending down the cut portion.
- **h.** Nabbing: Process of cutting any counter from sheet metal; a small punch is used for generating the required profile. It involves removing the metal in small increments.
- **i.** Trimming: Process of finishing the edges of a part by removing the flash or excess metal around it.

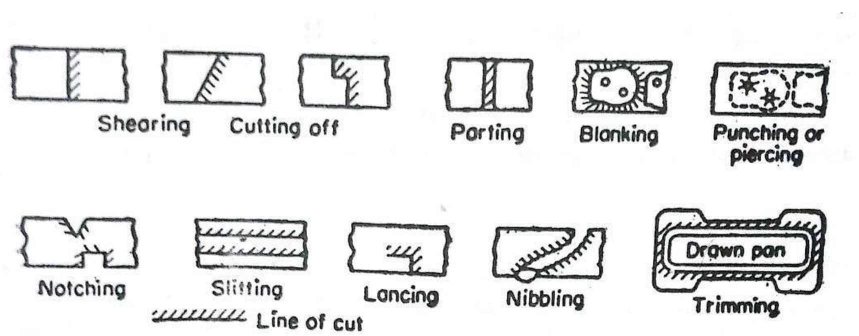


Fig 3.16 Types of shearing operations

2. Bending:

Bending is the folding operations by using suitable tools. The common forms of bending sheet metal are single bend, double bend, straight flange, embossing, bending and folding edges and seams. A number of methods can be used to bend or fold sheets.

a. Folding Edges:

The edges of the sheet metal objects must be formed. This ensures safe edge with finished appearance. In addition, it provides additional strength. The various forms of folding edges are shown:

Hem is a folding edge on the sheet metal. It is intended to increase the strength and to make a smooth finished edge. The double hem provides much greater strength than the single iron.

b. Wired Edge:

Provides a clean and safe edge. It has greater strength and double hem. The technique of forming wired edge is known as wiring and this consists of folding a piece of sheet metal around a wire of given diameter.

c. Seams:

Seaming is the process of joining the edges of sheet metal, and the sections where pieces of sheet metal joined is called a seam. The various types of seams are shown:

The lap seam is a simple type of seam and it consists of lapping the edge of one sheet over the other. The joint is made permanent either by soldering or riveting.

The Grooved seam is one of the most common types of seams used in sheet-metal work. It consists of hooking two folded edge sand locking them together with a hand Grover. A single seam and a double seam are used to join a bottom to a vertical boy such as containers. The folding of edges for single and double seams is shown:

Types of notches: Notching is the process of making a slit or penning at the edges of sheet-metal. This prevent over lapping of sheet where the corners come together. The size, location and type of notches depend on the shape of the object.

d. Flanging and Burring:

Flanging is the operation of producing edges having various widths and angles on flat or curved sheets. Flanging on cylindrical article is difficult than straight flanging.

The process of making a narrow flange is known as “Burring” and is performed on burring machine.

e. Rising:

Rising is the process of making depression on flat surface so as to form curved shapes. It is shaped by hammering on a suitable raising block.

f. Hallowing:

It is process of deformation of sheet-metal into a particular shape. It involves the stretching of the metal, and is usually done on a hollow wooden block.

g. Planishing:

It is a finishing process applied to sheet-metal. It is intended to bring the final shape with an improved surface, and imparts some degree of hardness to the metal.

3. Drawing:

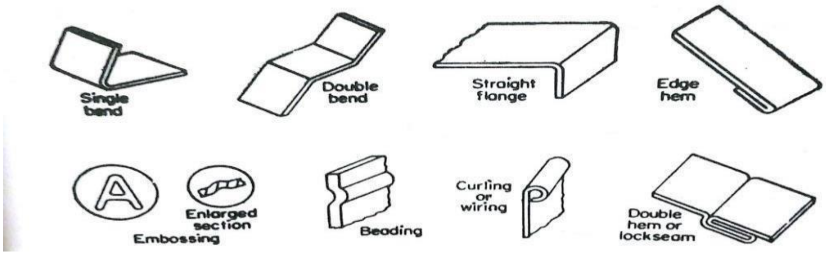


Fig 3.17 Different forms of Bending

Drawing the process of producing the hollow shapes such as cups and dishes from a flat sheet metal. Drawing processes can be classified into two types:

1. Deep drawing 2. Shallow or Box drawing.

In deep drawing the height of the component is greater than the diameter or width. In shallow or box drawing the height of the component is less than the diameter or width.

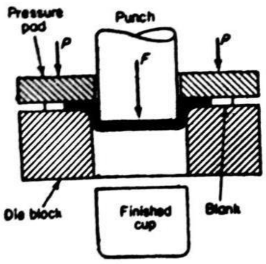


Fig 3.18 Drawing

4. Squeezing:

Squeezing operation involves the severe cold deformation. It requires a greater amount of pressure to deform metal, at cold state, within the confined space of die and punch to attain desired shape. Sizing, coining, hobbing, ironing, riveting etc. are examples of squeezing operations.

a. **Sizing**: It is a squeezing operation employed to attain close tolerances and smooth surface finish. In this operation the metal need not confined in the cavity, and only contact between work piece and the die occurs where the metal required to flow.

b. **Coining:** Coining is squeezing operation in which the metal flows into the cavity between the punch and i.e. It is employed for making coins, medals and similar articles.

c. **Hobbing:** It is a process of producing cavities of desired form in a blank of soft material. The process consists of forcing hardened steel hub into the soft metal. During the process the blank is confined in a steel retainer to prevent lateral flow of metal.

d. Ironing: It is a process of reducing the wall thickness of the cup by using punch and die.

e. Riveting: it is a process of cold heading both the ends of slug and is used to fasten two pieces together.

SHEET METAL JOINTS:

1. Hem and Seam Joints:

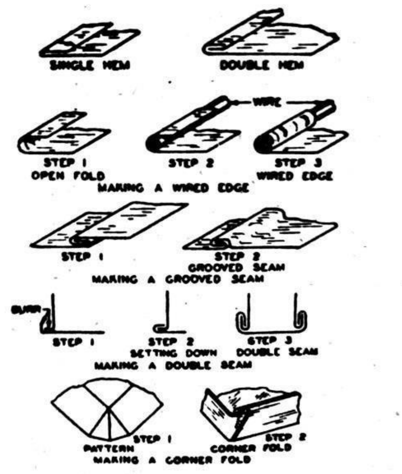


Fig 3.19 Hems and seams

a. Hem Joint: Hem is an edge or boarder made by folding.

- Single Hem: it is made by single folding of the edge of sheet metal.
- Double Hem: it is made by folding the edge over twice to make it smooth.
- Wired edge hem: the holding of a piece of sheet metal around a wire of given diameter.

b. Seam joint: it is a joint formed by two edges of sheet metal.

- Lap seam: it is a simple type of seam which consists of lapping the edge of one sheet over the other and the joint is made by soldering or riveting.
- Grooved seam: it is made by hooking two single hems together.
- Single seam: it is used to join a bottom to vertical bodies of various shapes.
- Double seam: its formed edges bent upwards against the body.
- Flanged seam: it is used to join the bottom of a container to its body.
- Dovetail seam: it is used to join one pipe to another pipe or a sheet to pipe.

Fastening Methods:

The following fastening methods are widely adapted in sheet metal work.

A) Riveting:

It is permanent fastening method by using rivets. Each rivet consists of ahead, shank and tail and are made of wrought iron, mild steel, aluminum, copper and brass. It is customary to use rivets of the same metal as the parts that are being joined. Riveting with a hammer and rivet set is shown. The required holes must be either punched or drilled before riveting.

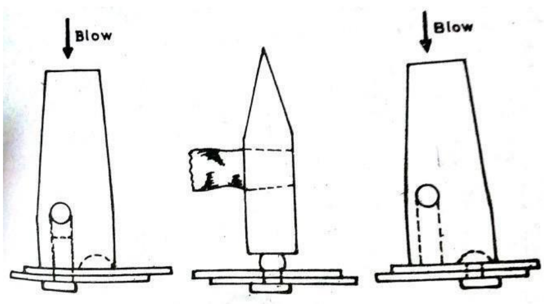


Fig 3.20 Types of Rivets

B) Soldering:

Soldering is the process of joining two or more pieces of metal by means of an alloy. This alloy is called solder and is composed of lead and tin. The melting point of solder is less than the metal being joined. For soldering the base metal is heated by soldering iron which also melts solder and flux. The flux is used to dissolve the oxide film on the surface, and also to prevent any further oxidation during soldering. The molten solder fills the space between mating surfaces, and as it solidifies forms a bond with the surfaces of the joint.

C) Brazing:

Brazing is similar to soldering, but it gives much stronger joint. In general, silver alloys are used as filler material for brazing. This filler material is called "spelter" and its melting point is higher than solder, but lower than the metals being joined.

In any brazing operation the two metal pieces to be joined must be cleaned and are properly fitted together with appropriate clearance for the filler material. Flux is applied on the joint and heated to a temperature just above the melting point of the spelter. The liquid spelter is disturbed between the surfaces by capillary action. After solidification it adheres to surfaces and forms a strong joining.

D) Spot Welding:

Welding is a process of joining metal pieces by application of heat with or without pressure. The spot welding is widely used for joining the sheet metals by application of heat and pressure.

In spot welding the sheets to be joined together are held between two electrodes. A low voltage current of high amperage is passed through electrodes causing local heating and at welding temperature the pressure between the electrodes squeezes the metal together to form a joint.

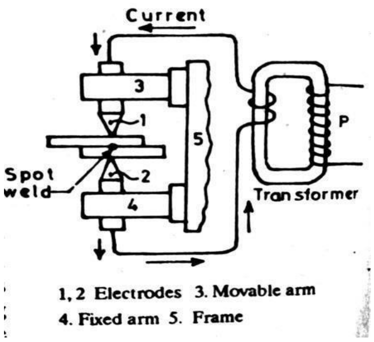


Fig 3.21 Spot Welding

SHORT ANSWER QUESTIONS

1. Write the names of sheet metal hand tools.
2. Write the use of Trammel point in sheet metal work.
3. Write the types of hammers used in sheet metal work.
4. Draw and explain the stake used in sheet metal work.
5. Write the types of Hem and seam joints in sheet metal work.

LONG ANSWER QUESTIONS

1. Write about any three sheet metal operations.
2. Explain metals used in sheet metal work.
3. Explain any three fastening methods used in sheet metalwork.

UNIT: 4
Fitting, Drilling and Grinding

STRUCTURE

Introduction

Marking Tools

Cutting Tools

Striking Tools

Holding Devices or Vice

Miscellaneous Tools

Checking and Measuring Instruments

Fitting Operations

Drilling Machines

Drilling Machine Operations

Grinding

FITTING

INTRODUCTION:

Fitting is a process of assembling of main machine parts. A bench work has its own importance, where parts often require a hand operation of it them to desired accuracy.

Fitting tools are

1. Marking tools
2. Cutting tools
3. Striking tools
4. Holding tools
5. Miscellaneous tools
6. Checking and measuring tools

MARKING TOOLS:

Marking out is the technique of reproducing the layout from the blue print by means of scribed lines, so that the job may be finished to the required specification. Marking tools are used in this process.

Following are the marking tools, commonly used in the fitting shop

V-block:

The V-block is made of cast iron and all the faces are machined true. The two opposite side faces have V-grooves and the two have slots. The round bars are held firmly by a U-clamp engaging in slots, which prevents the bar from rotating. The V-blocks are used for holding round bars during marking and centre drilling their end faces which are to be held between centers on lathe. It is also suitable for holding round bars while they are drill' at right angles to their axis. V-blocks are specified by length, width and height.

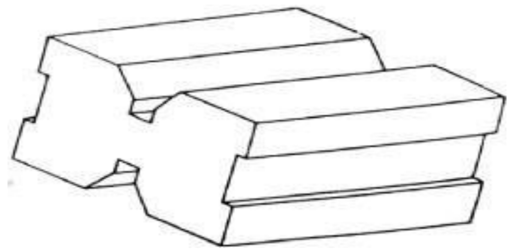


Fig 4.1 V - Block

Angle Plate:

The angle plate is made of grey cast iron and two plane surfaces at right angles to each other. It is used combination with the surface plate for supporting work in perpendicular position. It has various slots in it to enable the work to be held firmly by bolts and clamps.

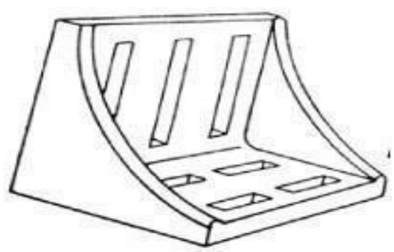


Fig 4.2 Angle Plate

Try Square:

It consists of a steel blade fitted into a steel stock of rectangular cross-section as shown in Fig. 4.3 It is used for testing the squareness of surfaces and to scribe lines at right angles to a given edge.

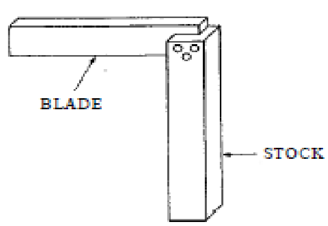


Fig 4.3 Try Square

Scriber:

The scriber as shown in Fig. 4.4, is a piece of hardened steel about 150 to 300 mm and 3 to 5 mm in diameter, pointed at one or both ends like a needle. It is held like a pencil to scribe lines on metal. The bent end is used to scribe lines in places where the straight end cannot reach. The ends are sharpened on an oilstone when necessary.

Fig 4.4 Scriber

Scribing Block or Surface Gauge:

Scribing block is an instrument used for scribing lines on vertical surfaces or transferring height from one job to another, using a scriber.

These scribing blocks can be available in two types

1. Simple scribing block
2. Universal surface gauge

Simple Scribing Block:

It consists of a cast iron sliding base, on the centre of which a steel rod (spindle) is fixed vertically as shown in fig. A steel scriber held in the holder, scriber is slide, tilt and rotate on the rod after clamping it with a set screw. It is normally used in combination with surface plate. Its specific use is in locating centers of round rods held in V-block describing straight lines on work, held firmly in its position by means of angle plate and also in drawing a number of lines parallel to a true surface.

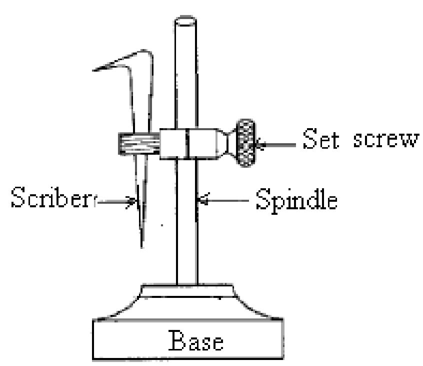


Fig 4.5 Simple Sliding Block

Universal Surface Gauge:

It consists of a cast iron base perfectly machined and planed at the top, bottom and all sides as shown in Fig 3.1.5.b. It carries a spindle, which may be set at any angle. A scriber, which may also be set at any angle or at any height is clamped to the spindle. A fine adjustment is provided by a screw (height adjustment screw) and movement of this screw swings the scriber through a small arc and so varies the height. It carries a V-shaped slot in the base, which helps to rest it on a round bar, so that the dimensions may be set off from the bar to some other part of the work.

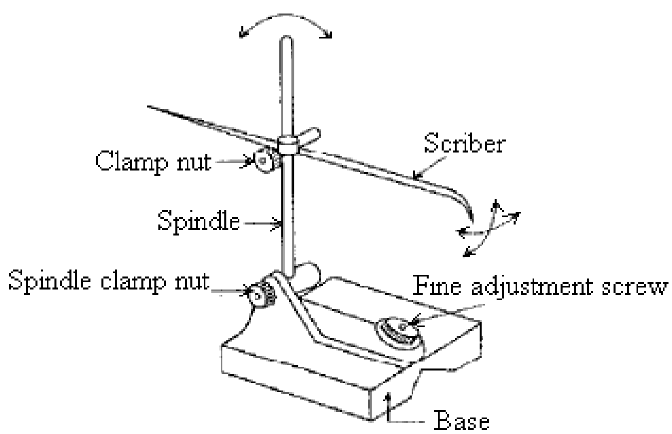


Fig 4.6 Universal Surface Gauge

It is used:

- For marking on vertical, as well as on horizontal surfaces.
- To find out the centre of around work, to align work in centre.
- To layout marking on a work of any shape.

Punches:

A punch is a primary marking tool used in bench work. It is made of cast steel. It has a serrated or knurled body to enable a firm grip by hand. One end (top called head) of it is slightly chamfered and flat, to prevent from burring while hammering and the other end carries a point ground to some included angle.

Various Types of Punches are:

Prick punch, centre punch, number punch and letter punch

Prick punch:

It has a sharper point with an included angle of 30°. It is used for marking position of lines and centers of circles to be drawn with the dividers.

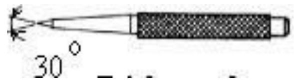


Fig 4.7 Prick punch

Centre punch:

It has a point ground to an included angle of 60° or 90°. It is used for marking the ends of work to be centered for turning in lathe, for all centers of holes, for drilling, for marking in sawing, chipping, etc.

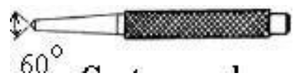


Fig 4.8 Centre punch

Number Punch:

It is used to mark numbers from '0' to '9' on work surfaces.

Letter Punch:

It is used to mark letters from 'A' to 'Z' on work surfaces.

Cutting tools:

Cutting tools plays a most important role in removing excess metal from the job to obtain desired finished part. The various cutting tools used in fitting are:

1. Chisels.
2. Hacksaws.
3. Files.
4. Scrapers.
5. Drill bits.
6. Reamers.
7. Taps.
8. Dies and stock.

Chisels:

Cold chisels are used for cutting thin sheets and to remove excess material from large surfaces. In this case the surface finish and accuracy are usually poor.

Parts of chisel: It consists of following parts

1. Head

2. Body or shank

3. Point or cutting edge

Head:

The head is tapered towards top and made tough to with stand hammer blows

Body or Shank:

The cross section of the shank is made hexagonal or octagonal to have grip while working.

Point or Cutting Edge:

The cutting edge is hardened and tempered and made to specified angle. The hardening followed by tempering makes the chisel to maintain its sharp edge.

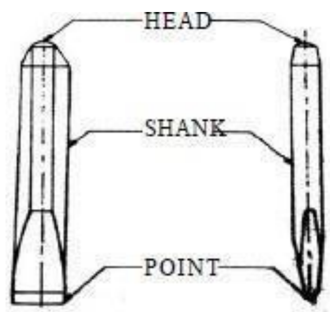


Fig 4.9 Parts of Chisel

The shape of cutting edge is required to specify the chisel. The five most important types of chisels are:

1. Flat chisel
2. Cross cut chisel
3. Half round chisel
4. Diamond point chisel
5. Side chisel

Flat Chisel:

It is most common chisel used for chipping large surface sand cutting the sheets. It is also used to part off metal after chain drilling. The length of a flat chisel varies from 100mm to 400mm and the width from 16mm to32mm.

Fig 4.10 Flat Chisel

Cross Cut Chisel:

The crosscut chisel or cape chisel is used for cutting grooves and channels and keys ways in shafts and pulleys. Its cutting edge is wider than the supporting metal to provide clearance. The length of chisel varies from 100mm to 400mm and width varies from 4mm to 12mm.

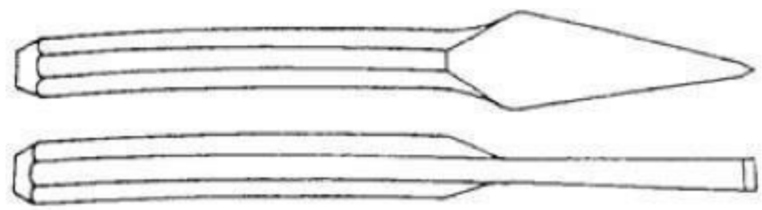


Fig 4.11 Cross Cut Chisel

Half Round Chisel:

It is particularly useful for cutting oil ways, cutting curved grooves in bearings, bosses and pulleys. They are also used for setting over pilot holes. When a hole is to be drilled a pilot hole is drilled first.

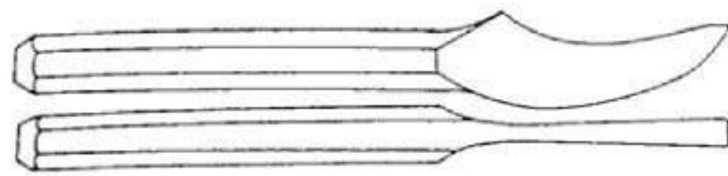
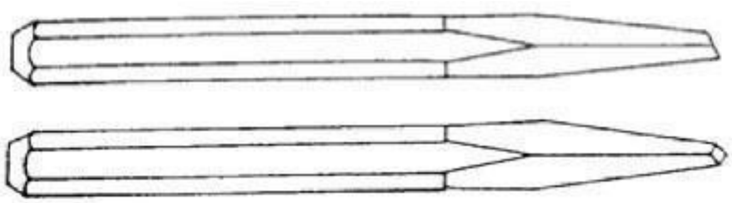


Fig 4.12 Half Round Chisel

Diamond Point Chisel:



Its edge is in the form of diamond used for cutting V- grooves, cleaning corners and squaring small holes.

Fig 4.13 Diamond Point Chisel

Side Chisel:

This is used for chipping and removing the surplus metal in rectangular slots. The shank of the chisel is bent out a little side way and vertically down again.

Fig 4.14 Side Chisel

Hacksaw:

It is a basic hand cutting tool used for cutting unwanted material. It is used for cutting metals and making recesses prepare to filing or chipping. It is also used for cutting slots and contours.

Parts of Hack saw:

It consists of the following parts.

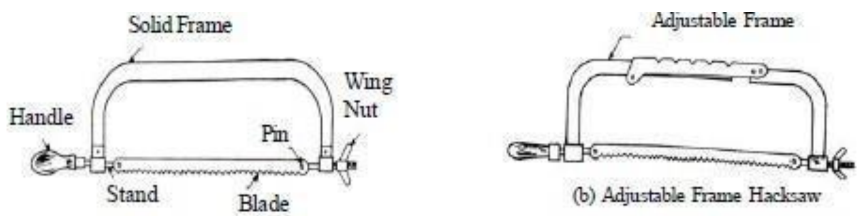
1. Metal frame   2. Blade   3. Handle

4. Wing nut   5. Screw

The frame is made to hold the blade tightly. They are made in two types.

a) The solid frame hack saw in which the length cannot be changed.

b) The adjustable frame in which the frame can be adjusted to hold the blades of different lengths.

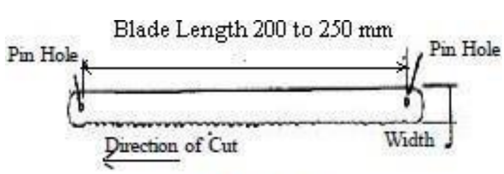


(a) Solid Frame Hacksaw   **(b) Adjustable Frame Hacksaw**

Fig 4.15 Types of Frames

Hacksaw Blade:

It is thin, narrow steel strip made of high carbon steel or low alloy steel or high speed steel. The blade has two pin holes at the ends which fits over two pins which project from the stand that slides in and out of the frame end. Tightening the wing nut at the frontend tensions the blade sufficiently to prevent it from flexing when cutting. The blade must be fitted such that teeth points away from the handle so that cut takes on the forward stroke.



Hack Saw Blade

Fig 4.16 Hacksaw blade

Files:

File is a cutting tool with multiple teeth like cutting edges used for producing smooth surface. The accuracy that can be achieved from 0.2 to 0.05 mm.

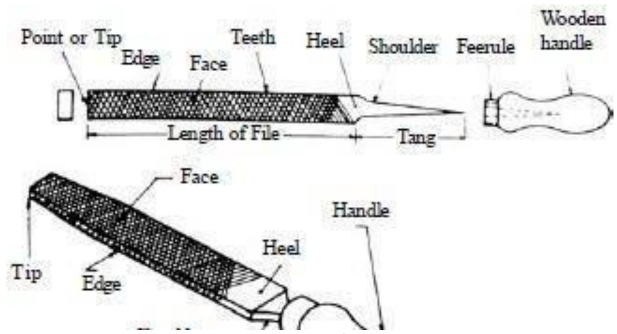


Fig 4.17 Parts of a File

Parts of the file:

1. **Tang:** It is the pointed part which fits into the wooden handle.
2. **Tip or point:** It is the opposite end of the tang.
3. **Face or side:** This is the broad part of a file with teeth cut on it.
4. **Edge:** It is the safe edge of file which has no teeth.
5. **Heel:** The heel is next to handle of the file with or without teeth.
6. **Shoulder:** The curved part of the file separating the tang from the body.
7. **Handle:** The part which is fitted to the handle made of wood.

The files of different cross section or types are needed to suit the various job operations. The most commonly used files are

1. Flat file	2.Hand File	3.Square file	4.Round file
5. Half round file	6.Triangular file	7.Knife edge file	8.Pillar file

Flat file:

This is tapered in both width and thickness used for heavy filing. This file is parallel to about two third of length, then tapers in both width and thickness.

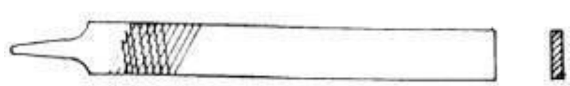


Fig 4.18 Flat File

Hand file:

This is used where flat file is not suitable for filing flat surfaces and has rectangular cross section with parallel edges throughout but thickness is tapered towards point.

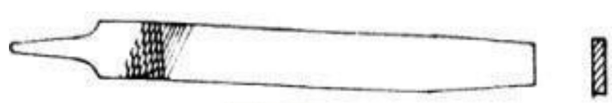


Fig 4.19 Hand File

Square file:

This is in square cross section used for filing square and rectangular holes and for finishing the bottom narrow slots.

Fig 4.20 Square file

Round file:

They are round in cross-section and usually tapered. They are used for filing circular holes, curved surfaces and finishing fillets.

Fig 4.21 Round File

Half round file:

This file is tapered double-cut and its cross-section is not a half circle but only one third of a circle. This file is used for round cuts and filing curved surfaces.

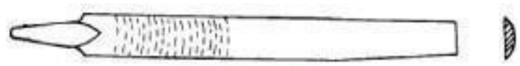


Fig 4.22 Half Round File

Triangular file:

The cross section of file is like equilateral triangle used for filing grooves, slots, holes and sharp corners.

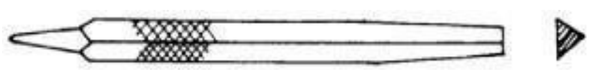


Fig 4.23 Triangular file

Knife edged file:

Its shape is like a knife used to file narrow slots, grooves and sharp corners. Its width and thickness are tapered towards point in the form of knife.

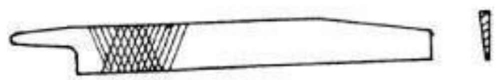


Fig 4.24 Knife edged file

Pillar file:

A pillar file is similar to hand file, it has rectangular cross section but is narrower and thicker than hand file. It has one or both uncut edges (i.e, safe edges) and is used for narrow work, such as keyways, slots and grooves.

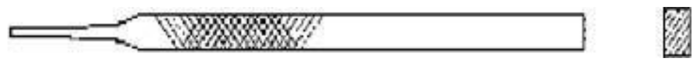


Fig 4.25 Pillar file

Needle File:

The needle files are made in sizes from 100 to 200 mm, various shapes and cuts. They are extremely delicate and are used for fine work such as pierced designs in thin metal. They are very easily broken, so care should be taken when using them.

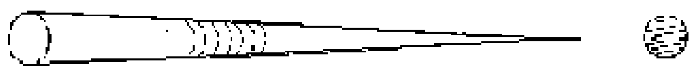


Fig 4.26 Needle File

Scrapers:

These are used to shaving off thin slices of metal to make a fine and smooth surface which is not possible with a file or chisel. This is made of good quality forged steel and its cutting edge is usually made thin, made from old files.

Parts of Scrapers

1. Cutting edge with rounded corners
2. Blade
3. Tang
4. Wooden handle.

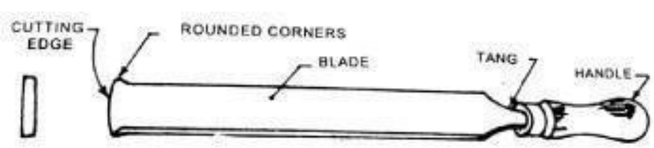


Fig 4.27 Scrapper

1. **Cutting edge with rounded corners:** The cutting edge is hardened without tempered to make hard.
2. **Blade :** The broad part of a scraper
3. **Tang:** The narrow part which fits into wooden handle.
4. **Wooden handle :** That fits into tang to have grip while scrapping

According cross section, the scrapers are classified into three types. They are

1. Flat scraper 2.Triangular scraper 3. Half round scraper.

Flat Scraper:

This type of scraper is used for scrapping plane surfaces or slots and the cutting edge at the ends of the blade is curved. The corners are rounded to prevent deep scratches on finished surface. It also helps to scrap the metal exactly at the desired spot.

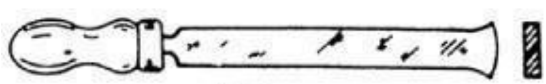


Fig 4.28 Flat Scraper

Triangular Scraper:

It has three cutting edges and is made from old triangular files used to scrap round or curved surfaces and to remove sharp corners.

Fig 4.29 Triangular Scraper

Half round Scraper:

It is used for finishing curved surfaces and chamfering holes and removing burrs.

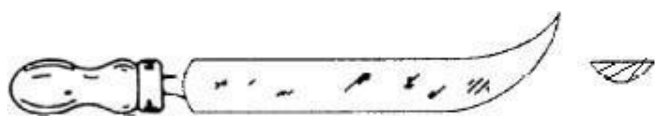


Fig 4.30 Half round Scraper

Dies and diestock:

It is a circular disc of hardened tool steel used to make external threads on a round rod or bolts with a die and stock. Die has a hole containing threads and flutes which form cutting edges.

These are mainly two types

1. **Solid Die**
2. **Adjustable Die**

Solid Die:

It is one which has fixed dimension and cannot be adjusted for smaller or large diameter. It is used for re-cutting damaged threads and may be driven by suitable wrench.

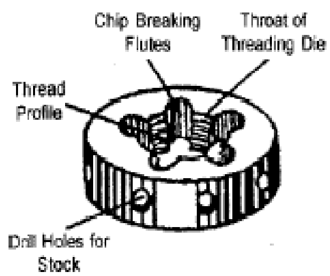


Fig 4.31 Solid Die

Adjustable Die:

It can be set to cut larger and smaller diameters. It has a split through one side and a slight adjustment is possible with the help of setscrew.

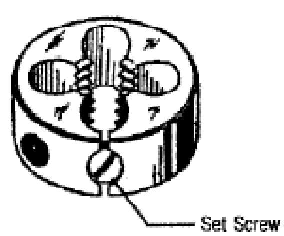


Fig 4.32 Adjustable Die

Die stock:

The tool for holding and turning the threading die is called a die-stock. It is often just called a stock. Die stocks are provided with threaded pins. When the die has been inserted into the stock the thread pins are tightened so that they engage in the drill holes of the die to hold it.

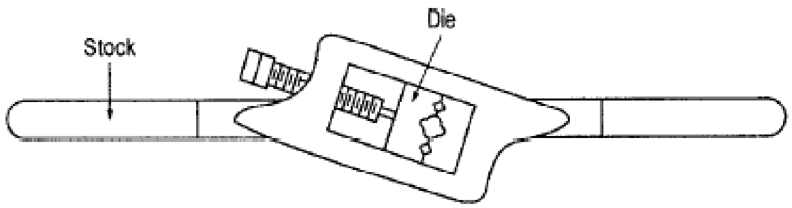


Fig 4.33 Die stock

Striking Tools:

Hand hammers are also called striking tools used to strike the job. They are made of forged steel of various sizes and shapers to suit various purposes like punching, chipping, marking, bending and riveting.

Parts of Hammer

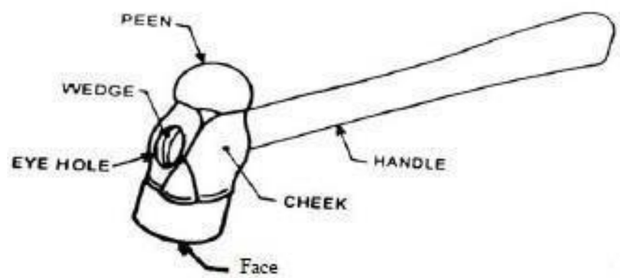


Fig 4.34 Parts of Hand Hammer

A hammer consists of four parts namely

1. Face **2.Peen** **3. Cheek** **4. Eye-hole.**

Face: It is the striking portion polished well and is given slight convexity to avoid spoilage of the surface of the metal to be hammered.

Peen: It is the other end of the head and is made into different shapes to suit various operations.

Cheek: Middle portion of the hammer head.

Eye-Hole: It is made oval or elliptical in shape to accommodate the handle.

Depending upon the shape of the peen, hand hammers are classified as

1. Ball Peen Hammer **2. Cross PeenHammer**

3. Straight Peen Hammer **4. Soft PeenHammer**

Ball Peen Hammer:

It has a flat striking face and ball shaped peen which is hardened and polished.

This hammer is chiefly used for chipping and riveting.

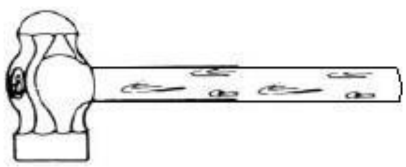


Fig 4.35 Ball peen hammer

Cross Peen hammer:

It has wedged shape peen across the eye. It is used for bending, stretching, hammering into shoulders.

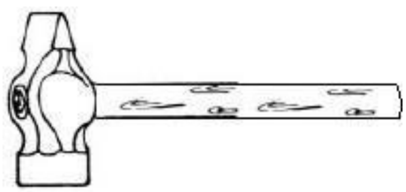


Fig 4.36 Cross peen hammer

Straight peen hammer:

This is similar to cross peen hammer except that the peen in this case is parallel to eye. It is used for stretching and peening the metal.

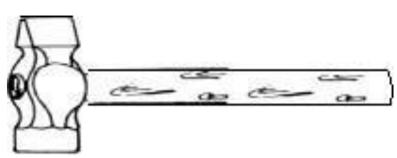


Fig 4.37 Straight peen hammer

4.3.4. Soft hammer or Mallet:

These are soft hammers used give light blows where the work surface must not be amaged. They are made of either rubber, plastic or wood.

Fig 4.38 Soft hammer or Mallet

Holding Devices or Vice:

In most of the metal cutting operations quite a large number of forces will be involved. So it is necessary that the work must be secured highly so that it does not move when subjected to the cutting forces. Therefore, holding the job is an important aspect of all metal cutting operations. A vice is a work holding device used to grip the job tightly. Different types of vices are used for various purposes. They include

1. Bench vice **2.Pipe vice** **3.Hand vice**

4. Pin vice **5.Tool maker's vice**

Bench Vice:

This is most commonly used tool for holding the work. It has two jaws one of which is fixed to the bench and other slides with the aid of square screw and a box nut arrangement. The outer end of screw carries a handle, and a collar prevents the screw from coming out of the unit while rotating. The sliding jaw moves close to the fixed jaw to hold the work and the tightening force is exerted by further rotation of handle. The working faces of jaws are serrated to give additional grip.

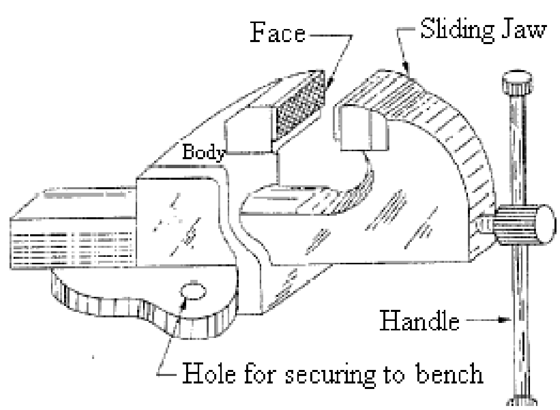


Fig 4.39 Bench Vice

Pipe Vice:

It is generally used for holding round sections, tubes and pipes etc. It has two serrated jaws, one is fixed and that is moved by rotation of handle. It is used in plumbing work and it grips the circular objects at four points on its surfaces.

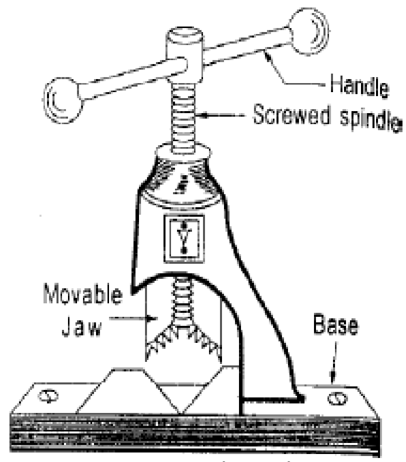


Fig 4.40 Pipe vice

Hand Vice:

It is used for gripping small objects like screw, rivets and keys when they are inconvenient to hold by the bench vice. It has two legs made of Mild steel which holds two jaws at the top and are hinged together at the bottom .A spring is provided between these legs to keep them away. The work is held between the serrated jaws by means of a wing nut and screw.

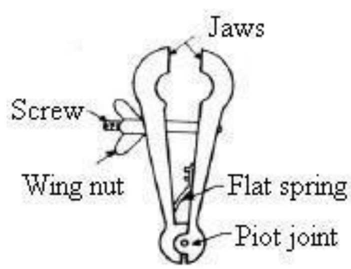


Fig 4.41 Hand vice

Pin Vice:

It is used for holding small parts such as wires, nails and pins. It consists of three jaw self centering chuck which is operated by turning the handle to hold work.

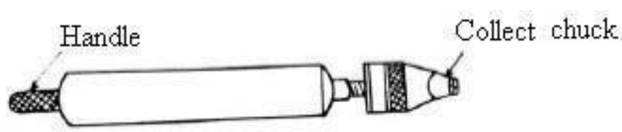


Fig4.42 Pin vice

Tool Maker's Vice:

It is a small vice made of mild steel used for holding small jobs which requires fitting or drilling. It is used by tool and die makers and silver smiths to hold small jobs.

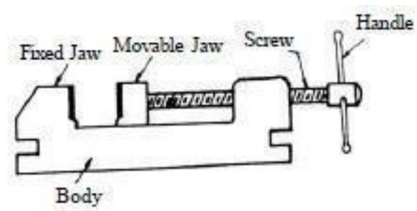


Fig 4.43 Tool maker's vice

Miscellaneous Tools:

In addition to the above tools, the following tools are widely used in fitting.

1. File Card **2. Screw driver**
3. Spanner **4. Pliers**

File Card

It is the short wire brush used to remove small chips called pins, and to clean the file. While filing these chips are deposited between the teeth of file which reduces cutting Ability and causing scratches on work piece.

Fig 4.44 File Card

Screwdriver

Screw driver is used for tightening and loosening the screws. It is made in variety of shapes to suit various job operations.

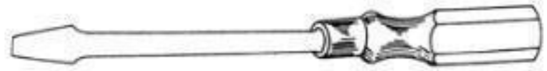


Fig 4.45 Screwdriver

Spanner

These are also called wrenches, are used for tightening or loosening nuts and bolts. The following types of spanners are widely used in fitting.

1. **Single end spanner** 2. **Double end spanner**
2. **Adjustable spanner** 4. **Box type spanner**

Single ended spanner:

It is provided with holding mouth at one end only and is capable of fitting to only one size of nut or bolt.

Fig 4.46 Single ended spanner

Double ended spanner:

Its openings are provided on both ends and both the openings are different sizes. Thus they are capable of fitting to two different sizes of bolts and nuts.

Fig 4.47 Double ended spanner

Adjustable spanner:

It has one fixed jaw and one movable jaw which make it adjustable to various sizes of nuts. When using this tool, the jaws should be pointed in the direction of force, which will prevent the spanner from slipping off aunt.

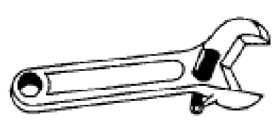


Fig 4.48 Adjustable spanner

Box type spanner:

It has closed end jaws. This voids the danger of slipping the spanner off the nut. They can be single ended as well as double ended.

Fig 4.49 Single ended Box type spanner

Pliers:

These are used for holding small jobs which are difficult to held by hand. They are used for bending and cutting the wires. The following types of pliers are most common.

1. **Cutting pliers** **2. Nose Pliers**

Cutting Plier:

A simple form of cutting plier is having two jaws at one end with serrations provided on the underside of them, which provides a firm grip of the article and further these jaws form the cutter blades near the joint used for cutting wires.

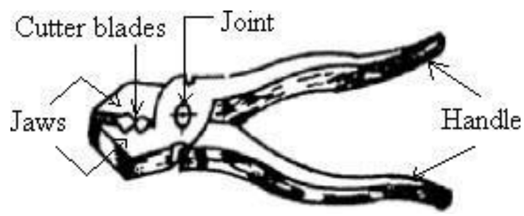


Fig 4.50 Cutting Plier

Needle Nose Plier:

This plier has thin pointed jaws. Its specific use in holding very small and intricate parts and transferring them to or from very narrow and deep places, such as in watch, electrical and radio repair work.

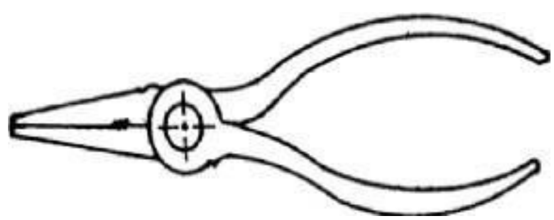


Fig 4.51 Needle Nose Plier

Checking and Measuring Instruments:

Number of checking and measuring tools are used for inspecting and measuring the dimensions of the components during their manufacture to have accurate size and shape. They are

1. Steelrule **2. Calipers** **3. Dividers**

4.Combination set **5. Bevel protractor**

Steel Rule:

It is a stiff, straight steel strip having all the faces machined true. On one of the flat faces graduations are marked in centimeters and inches. Steel rules are made 150, 300, 500 and 1000 mm long. They are used to set out dimensions.

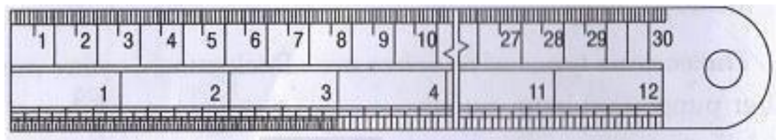


Fig 4.52 Steel Rule

Calipers:

A calipers is used to transfer and compare a dimension from one object to another or from a part to a scale or micrometer where the measurement cannot be made directly. Four types of calipers are generally used. They are

1. **Outside calipers**
2. **Inside calipers**
3. **Hermaphrodite caliper**
4. **Transfer caliper**

Outside Calipers:

An outside caliper is a two legged steel instrument with its legs bent inwards. It is used for measuring or comparing thickness, diameters and other outside dimensions. A steel rule must be used in conjunction with them if a direct reading is desired.

The outside calipers are of two types i.e., firm joint and spring type.

The firm joint calipers have two legs hinged between washers for movement.

The spring calipers have a flat curved spring instead of hinge and the legs are kept in position by an adjusting screw and nut.

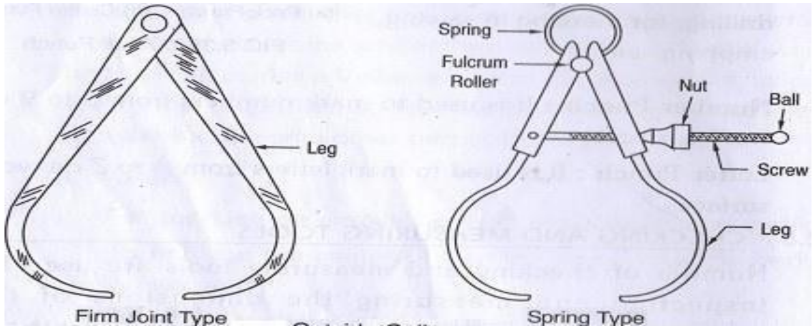


Fig 4.53 Outside Calipers

Inside Calipers:

An inside caliper is exactly similar to an outside calipers in appearance with its legs bent outwards. This is used for comparing or measuring whole diameters, distances between shoulders, or other parallel surfaces of any inside dimension. To obtain a specific reading steel rule must be used, as with the outside calipers. The inside calipers are also two types, firm joint and spring type.

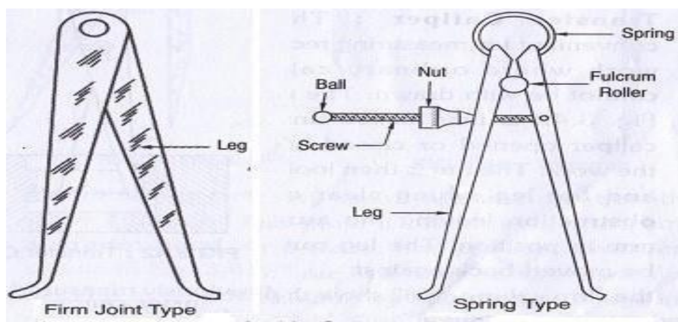


Fig 4.54 Inside Callipers

Hermaphrodite caliper:

This is sometimes called as odd leg caliper. It is made of steel tapered strip which is hinged between washers at one end. It has one pointed leg like a divider and the tip of the other leg is bent inwardly. It is used to find out of the center of a cylindrical work and for scribing lines parallel to the edge of the work.

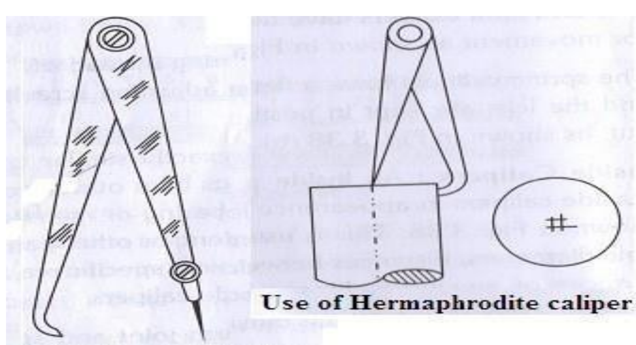


Fig 4.55 Hermaphrodite caliper

Transfer caliper:

This is convenient for measuring recessed work where ordinary calipers cannot be withdrawn. The nut is first locked and the caliper opened or closed against the work. The nut is then loosened and the leg swung clear of the obstruction leaving the auxiliary arm in position. The leg can now be moved back against the stop, where it will show the size previously measured. There may be both outside and inside calipers.

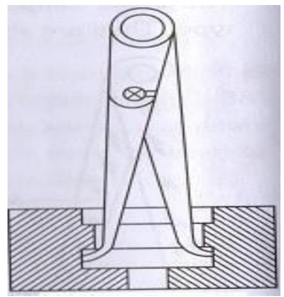


Fig 4.56 Transfer caliper

Divider:

A divider is similar in construction to a caliper excel that both legs are straight with sharp hardened points at the end. The most common type of the divider used in fitting has spring attachment. The dividers are used for measuring the distance between two points, dividing a given length in a definite ratio, drawing circles and arcs and transferring dimensions from scales to objects. Its size is measured by the greatest distance it can be opened between the legs.

A large circle or an arc having a large radius may be drawn with a tool called trammel or beam compass.

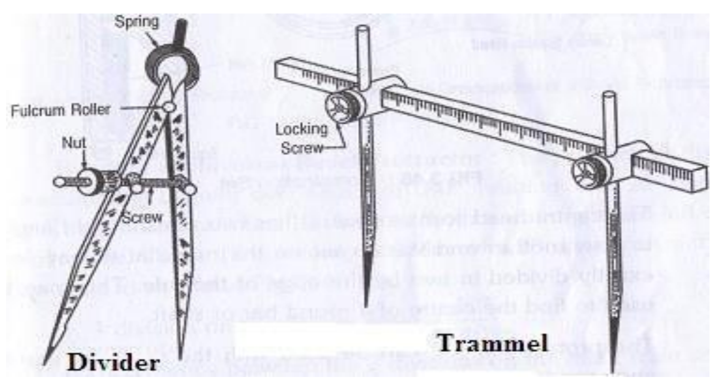


Fig 4.57 Divider and Trammel

Combination set:

It is very useful instrument frequently used in the fitting and machine shop. It combines in one instrument a square head, a centre head, and a bevel protractor. The three heads are used separately being held in, at any desired position by nuts which engage in a slot machined on the whole length of the beam at its back.

The beam (rule) of the instrument is marked either in inches or centimeters or in both for measuring the length and height where as required. Length of the rule varies from 200 to 6000mm.

The square head has one edge square to the rule, giving a right angle (90°), while the other edge form a mitre (45°). It is also provided with a spirit level. Both 90° and 45° can be tested by this head, along with the rule both ways. The vernier scale is fitted with the disc to take reading during measurement.

The centre head (centre square) has two arms at right angle to one another and it is set on the rule that this angle is exactly divided in two by the edge of the rule. This may be used to find the centre of around bar or shaft.

The protractor head can be used with the rule to measure angles or to measure the slope of a surface. It is also fitted with a spirit level to help in leveling the work of setting it an angle.

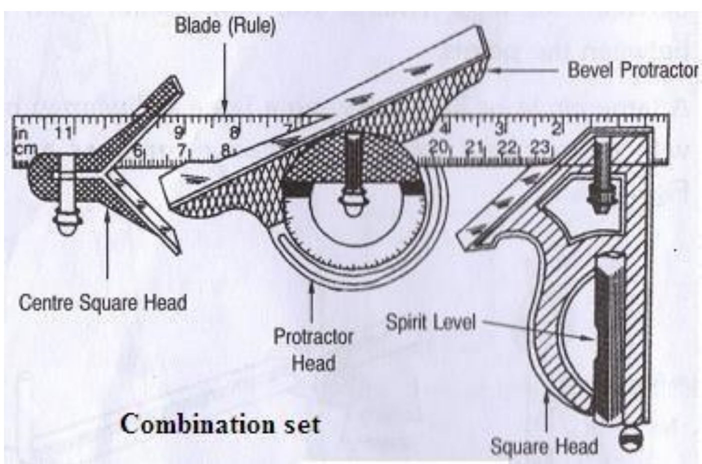


Fig 4.58 Combination Set

Bevel Protractor:

The bevel protractor, known as universal bevel protractor or vernier protractor is widely Used for measuring and testing angles, with measuring accuracy up to 5min (i.e $\frac{1}{12}$of a degree). The universal bevel protractor, consists of a base, sliding blade graduated disc (or the main scale) and vernier scale. The protractor's disc is free to rotate at the pivot and can be clamped with a nut in the base assembly. The blade can slide both ways. The vernier scale is fitted with the disc to take reading during measurement.

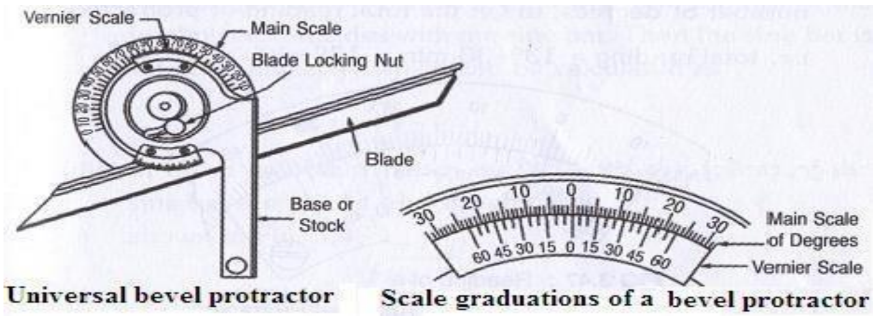


Fig 4.59 Bevel Protractor

How to take reading with the Universal Bevel Protractor:

The protractor's disc is graduated in degrees over an arc of 180°, reading 0 to 90° each way. The vernier scale has 12 divisions both to the right and left of the zero line. These 12 divisions coincides with 23 divisions on the main scale.

$$\therefore \quad \text{1 division on the vernier scale} = \frac{23^\circ}{12}$$

Difference between the 2 divisions on the main scale and one division on the vernier scale

$$= 2 - \frac{23^\circ}{12}$$

$$= \frac{1^\circ}{12}$$

$$= 5 \text{ minutes}$$

In order to take a reading from the universal bevel protractor.

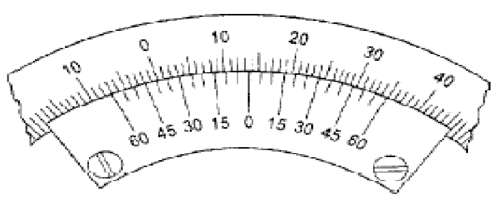


Fig 4.60 Reading in Universal Bevel Protractor

1. First, read off directly from the main scale the number of whole degrees between 0 and 0 of the vernier scale. From fig. we see the whole degrees are equal to13°.
2. Now count the number of divisions, in the same direction from zero on the vernier scale to the line which coincide with the line on the main scale, from Fig. it is 6thdivision.
3. Multiply this number by 5, i.e, 6 x 5 = 30, and this product will be the number of minutes, it should be added to the whole number of degrees, to get the total reading of protractor

   i.e. Total reading = 13°+30 min = 13°+ 30' = 13°30'

Fitting Operations:

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

The main operations are as follows:

1. Chipping	**2.Filing**	**3.Scraping**	**4.Grinding**
5. Sawing	**6.Marking**	**7.Drilling**	**8.Reaming**
9. Tapping	**10. Dieing**		

Chipping:

Chipping is the process of removing thick layers of metal by cold chisels. In chipping work, the job is firmly held in a vice and the metal is removed by striking the chisel on to the job by a hammer. Chipping operation is shown in Fig.

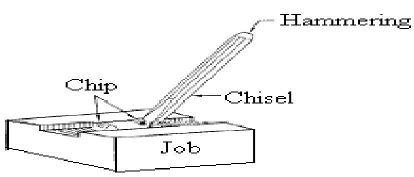


Fig 4.61 Chipping with a chisel

Filing:

Filing is usually done after chipping. It serves to remove the burr from the cuts and clean the face of the cuts and to finish the final shape of a work piece. Filing allows work to be made accurate eto0.05 mm in some cases to 0.02 mm and even to 0.01 mm.

Generally two methods are commonly used for filing:

1. Cross filing **2. Draw filing**

Cross filing:

The cross-filing is used for efficient removal of maximum amount of metal in the shortest possible time. During this operation the following steps may be noted:

1. The work should be held firmly in a vice with a minimum projection of the surface to be filed truly horizontal.
2. The file handle is grasped in the right hand, as shown in Fig. the end of the file handle pressing against the palm of the hand. The pressure on the work is applied by holding the end of the blade with the left hand.
3. The file must remain horizontal throughout the stroke (which should be long, slow and steady) with pressure applied only in the forward motion.
4. The file in the return stroke remains in contact with the work but the pressure is relieved from it.

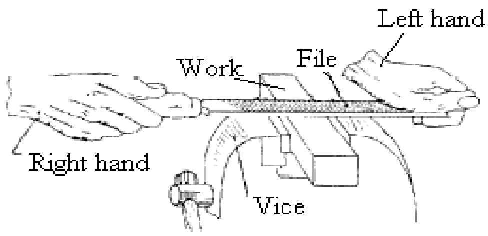


Fig 4.62 Cross Filing

Draw Filing:

The draw filing is used to remove file marks and for finishing operation. During this operation, the file is placed at right angles across the work and the file is gripped as close to the work as

Possible between two hands, especially the thumbs gripping the file, as shown in Fig. for fine cut with a flat face file should be used. It is moved lightly over the work for this purpose.

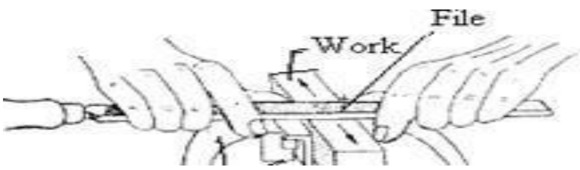


Fig 4.63 Draw Filing

Scraping:

Scraping means shaving or paring off thin slices or flakes of metal to make a fine, smooth surface. It is used for producing a truer flat surface than can be produced by machining or filing. So scraping often follows filing. During scraping, the handle of the scraper is held in the right hand with thumb and first finger pointing in the direction of cutting edge and the blade should be held in left hand, close to the cutting edge and the scraper should be held at some inclination (approximately 30°) to the work piece.

The usual procedure of scraping is to coat the top surface of a surface plate with Prussian blue or red lead. The surface to be scraped is rubbed against the surface plate. Thus the high spots on the work will be marked with the coated material. These spots are scraped, with moving the scraper in circular direction. The operation is repeated till all the high spots are removed at the entire surface becomes a perfectly smooth surface.

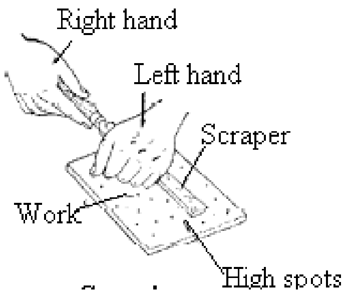


Fig 4.64 Scraping

DRILLING

Drills:

A drill is a cutting tool for making through hole in a metal piece and usually it has two cutting edges set an angle with axis. It does not produce accurate hole.

There are three types of drills.

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

Flat drill:

It is a simple drill used for producing holes in softer materials like wood and plastic. This is made of high carbon steel and has two cutting edges.

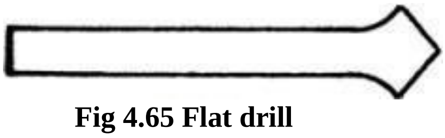


Fig 4.65 Flat drill

Straight fluted drill:

It has two cutting edges and two straight flutes used for drilling brass and non-ferrous metals.

Fig 4.66 Straight fluted drill

Twist drill:

This is most commonly used cutting tool in workshop. It has two cutting edges and two helical grooves which admits coolant and allows the chips to escape during the drilling. These are made of high speed steel.

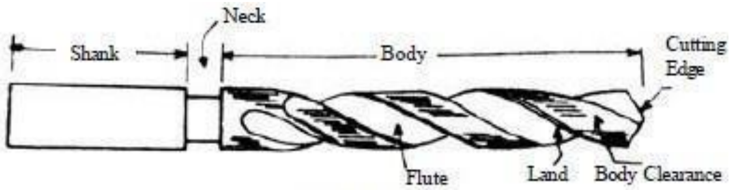


Fig 4.67 Twist drill

Reamers:

A drill does not produce accurate hole and it must be finished by finishing tool called reamer. When accurate holes with a smoother finish a required a reamer is used. Hence the reamer can only follow the drilled hole and removes very small amount of metal to make it smooth

There are two types of reamers

1. Hand Reamers **2. Machine Reamers**

Hand Reamer:

This reamer is turned by hand called hand reamer. The shank has a square tang so that a tap wrench can be used to turn the reamer in to work. These are available with straight or helical flutes.

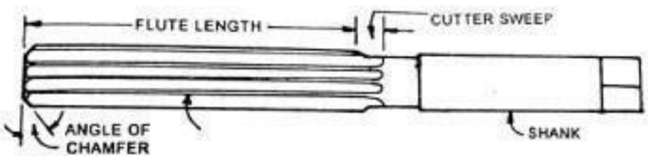


Fig 4.68 Hand reamer

Machine Reamers:

These are used to turn by the machine called machine reamers. Its shank is tapered which fits directly in the internal taper of the machine spindle. These are also available with straight shanks which are held and driven by drill chuck.

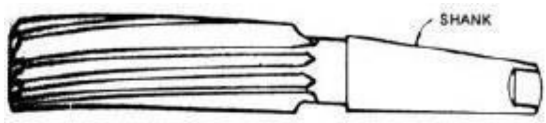


Fig 4.69 Machine Reamers

Taps and tap wrench:

A tap is a screw like tool which has threads like a bolt and three or four flutes cut across the threads which are used to produce internal threads. The edge of the thread formed by the flutes is the cutting edges. The lower part of the tap is somewhat tapered so that it can well attack the walls of the drill hole.

Hand taps are usually made in sets of three

1. Taper tap **2.Second tap** **3. Bottom tap**

Taper Tap:

In this tap about six threads are tapered and is used to start the thread, so that the threads are formed gradually as the tap is turned into the hole.

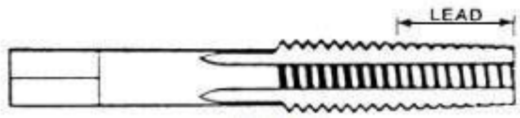


Fig 4.70 Taper Tap

Second tap:

It is tapered back from the edge about three or four threads used after taper tap. It has been used to cut the threads as far as possible

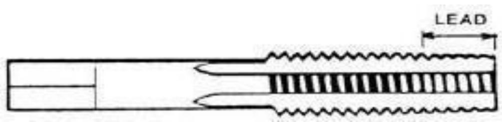


Fig 4.71 Second tap

Bottom tap:

It has full threads for the whole of its length. This is used to finish the Work prepared by the other two taps.

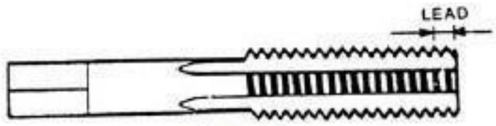


Fig 4.72 Bottom tap

Tap wrench:

The upper part of a tap consists of a shank end in a square for holding the tap by a tap wrench. This has two handles and it may be either fixed or adjustable. The adjustable wrenches may be used for taps of various sizes

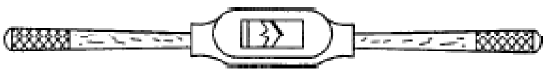


Fig 4.73 Tap wrench

Drilling Machines:

Drilling is a process of making holes in a work piece and is carried out by driving a rotating tool called "drill" into a rigidly held work piece. To accomplish the drilling two things are required i.e. drilling machine and drilling tools. A drilling machine is used for drilling holes. However it can perform operations other than drilling such as reaming, boring, lapping etc.

Types of drilling machine

1. Portable drilling machine or Electrical hand drilling machine
2. Sensitive drilling machine
3. Radial drilling machine
4. Upright drilling machine
5. Gang drilling machine

Portable drilling machine or Electrical hand drilling machine:

Portable drilling machine or Electrical hand drilling machine is a small light weight, compact ad self-contained unit that can drill holes up to 12.5 rnrn diameter.

The machine is driven by a small electric motor operating at high speed. The machine is capable of drilling holes in the work pieces in any position. The machine has only a hand feed mechanism for feeding the tool into the work piece. This enables the operator to feel how the drill is cutting and accordingly he can control the down feed pressure.

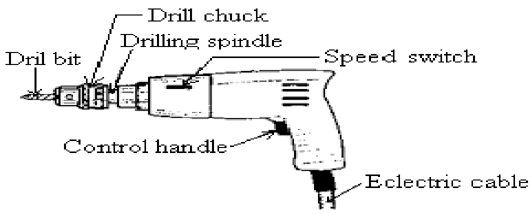


Fig 4.74 Portable drilling machine or Electrical hand drilling machine

Sensitive drilling machine:

It is a small drilling machine is mounted on a bench in which feed is hand operated and the cutting force applied is determined by sense of feel of the operator. The parts of sensitive drilling machine as shown below. It consists of a vertical column, a work table, head supporting the motor and driving mechanism, a vertical spindle for driving and rotating the drill.

The work is mounted on the work table which may be raised or lowered by the clamp to accommodate work pieces of different sizes. The driving mechanism consists of V-belt drive from machine spindle to drill spindle. Three or four speed stepped cone pulley is provided to give various speed ranges. The spindle is designed and mounted in a sleeve such that the spindle rotates and simultaneously moves up and down to provide feed for drill. This is achieved by a rack and pinion mechanism.

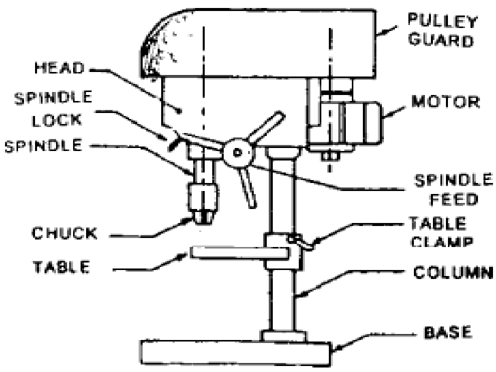


Fig 4.75 Sensitive Drilling Machine

Radial Drilling Machine:

Radial drilling machines are used for drilling heavy work pieces, where it is easier to move the drill rather than work and especially for the jobs where high degree of accuracy is required. It consists of base, column, radial arm, drill head and driving mechanism. The arm of radial drilling machine can be swing around the column to any position and angle. A wide range of spindle speeds, together with automatic feed of the spindle, makes the radial drilling machine suitable for drilling large castings. For lowering or raising the radial arm, a separate motor is provided. The work can be firmly champed on the table having T-slots. The table is fixed to the base. The radial arm and the spindle can be adjusted without disturbing the work setting.

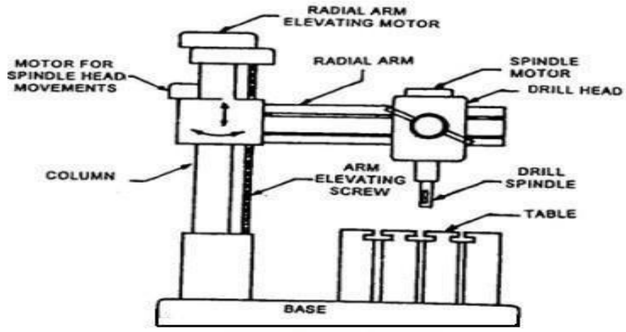


Fig 4.76 Radial Drilling Machine

Drill fittings: The following devices are used for holding the drills.

1. Drill Chuck **2. Drilling Machine Spindle**

3. Sleeves **4.Scokets**

1. **Drill Chuck:**

It is designed to hold straight shank drills of different sizes. The jaws of the chuck are tightened around the drill by means of drill chuck key. These drill chucks have standard taper shanks.

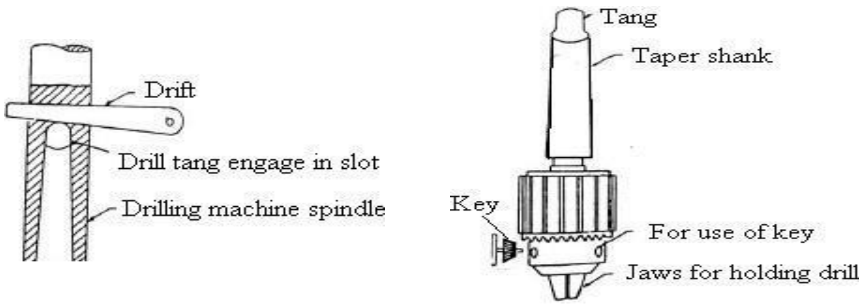


Fig 4.77 Drill Chuck

2. **Drilling machine spindle:**

These have the spindle bored out to a standard Morse taper to receive he taper shank of the tool. While fitting the tool, the shank is forced into the tapered hole and the tool is gripped by friction. Standard taper drills are directly fitted in the spindle. The drill may be removed by driving thedrift.

3. **Sleeve:**

The drill spindle is suitable for holding only one size of shank. If the taper shank of tool is smaller than the taper in spindle hole, a taper sleeve is used.

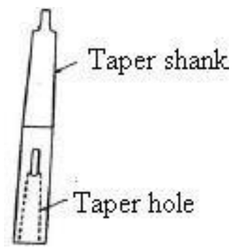


Fig 4.78 Sleeve

4. Socket:

It is used for the drilling whose taper is larger than spindle hole taper. It is much longer than sleeve. Its taper shank confirms to the spindle hole taper and fits in to it.

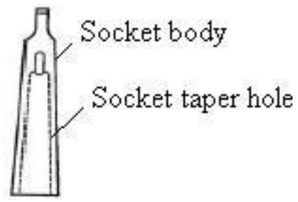


Fig 4.79 Drill Socket

Drilling Machine Operations:

The different operations that can be performed in a drilling machine are:

1. Drilling
2. Reaming
3. Boring
4. Counter boring
5. Counter sinking
6. Spot facing
7. Trepanning

Drilling:

Drilling is the operation of producing a cylindrical hole by removing metal by the rotating edge of a cutting tool called the drill. The drilling is one of the simplest methods of producing a hole. Before drilling the centre of the hole is located on the work piece by drawing two lines at right angles to each other and then a centre punch is used to produce an indentation at the centre. The drill point is pressed at this centre point to produce the required hole.

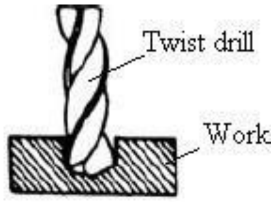


Fig 4.80 Drilling

Reaming:

Reaming is an accurate way of sizing and finishing a hole which has been previously drilled. In order to finish a hole and to bring it to the accurate size, the hole is drilled slightly undersize. The tool used for reaming is known as the reamer, which has multiple cutting edges. Reamer cannot ‘originate a hole. It simply follows the path which has been previously drilled and removes very small amount of metal.

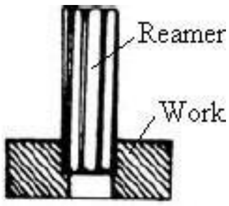


Fig 4.81 Reaming

Boring:

Boring is performed in a drilling machine for the following purposes.

- To enlarge a hole by means of an adjustable cutting tool with only one cutting edge. This is necessary where suitable sized drill is not available or where hole diameter is no large that it cannot be ordinarily drilled.
- To finish a hole accurately and to bring it to the required size.
- To machine the internal surface of a hole already produced in casting.
- To correct out of roundness of the hole.
- To correct the location of the hole as the boring tool follows an independent path with respect to the hole.

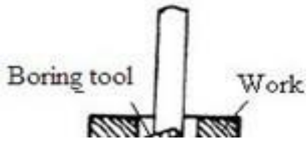


Fig 4.82 Boring

Counter Boring:

Counter boring is the operation of enlarging, the end of a hole cylindrically. The enlarged hole forms a square holder with the original hole. This is necessary in some cases to accommodate the heads of bolts, studs and pins. The tool used for counter boring is called a counter bore. The cutting edges of counter bore may have straight or spiral teeth.

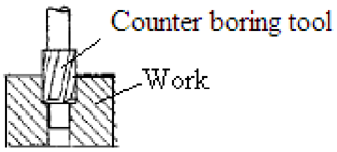


Fig 4.83 Counter Boring

Counter Sinking:

Countersinking is the operation of making a cone shaped enlargement of the end of a hole to provide a recess for a flat head screw or countersunk rivet fitted into the hole. The tool used for counter sinking is called a countersink. Standard counter sinks have 60°, 82° or 90° included angle and the cutting edges of the tool are formed at the conical surface.

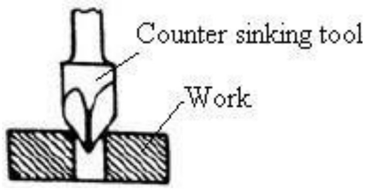


Fig 4.84 Counter Sinking

Spot Facing:

Spot facing is the operation of smoothing and squaring the surface around a hole for the seat for a nut or the head of a screw. A counter bore or a special spot facing tool may be employed for this purpose.

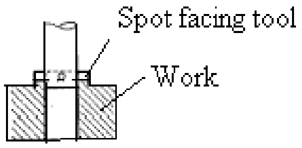


Fig 4.85 Spot Facing

Trepanning:

Trepanning is the operation of producing a hole by removing metal along the circumference of a hollow cutting tool. Trepanning operation is performed for producing large holes. Fewer chips are removed and much of the material is saved while the hole in produced.

Grinding:

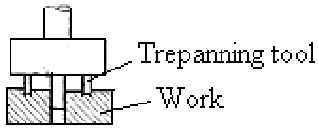


Fig 4.86 Trepanning

Grinding is a metal cutting operation performed by means of abrasive particles rigidly mounted on a rotating wheel. Each of the abrasive particles act as a single point cutting tool and grinding wheel acts as a multipoint cutting tool. The grinding operation is used to finish the work pieces with extremely high quality of surface finish and accuracy of shape and dimension. Grinding is one of the widely accepted finishing operations because it removes material in very small size of chips to 0.50 mm. It provides accuracy of the order of 0.000025 mm. Grinding of very hard material is also possible.

TYPES OF GRINDING:

There can be different criteria to classify grinding into different categories. On the basis of quality of grinding, it is classified as rough grinding and precision grinding.

Rough Grinding:

It involves removal of stock without any reference to the accuracy of results. Generally, rough grinding is followed by precision grinding.

Precision Grinding:

Precision grinding removes negligible amount of metal. It is used to produce finished parts and accurate dimensions.

Depending on the geometry of workpiece and the position at which workpiece is to be grind, it can be categorize as external grinding, internal grinding, surface grinding, form grinding and centreless grinding. Each of above categories can be further classified which will be explained below.

On the basis of position of mounting of a grinder it can be categorized as floor stand grinder (which can be installed on the ground); bench grinder, hand grinder, etc.

On the basis of position of spindle, it can be categorized as horizontal spindle environment in which the operation of grinding is done the grinding operation is classified as dry grinding and wet grinding. When cutting fluid is spread over the workpiece, wheel face and sides, it is named as wet grinding. The commonly used cutting fluid is soda water. Temperature of grinding zone reaches up to 2000^0 C in case of grinding of hard materials. Use of cutting fluid lowers down the temperature and so promotes wheel life. However, in case of dry grinding no coolant is used. It is generally used when workpiece material is not very hard and grinding time is also small.

Normally dry grinding produces two undesirable effects discalouration and burring which are eliminated in case of wet grinding some of the grinding machines are identified on the basis of their specific uses. Such grinders are called special purpose grinders like crank shaft grinders; piston grinder; roll grinders; cam grinders; thread grinders; way grinders and tool post grinders. These are nomenclature on the basis of their specific uses.

SHAPES AND SIZE OF A GRINDING WHEEL:

Grinding wheels are made in different shapes and sizes to adapt them for use in different types of Grinding machines and on different classes of work. These are classified in some groups on the basis of shapes and sizes. The shapes of Grinding wheels are standardized so that those commonly used in production and tool room grinding may be designated by a number or name or both. Some of the standard grinding wheels are shown below.

Straight Wheel:

Some straight wheels are shown in Figure 4.87 Types 1, 2 and 3. These are generally used for cylindrical, internal, centreless and surface grinding operations. These wheels vary in size, diameter and width of the face. All the parameters depend on the clays of work for which the wheel is used, size and power of grinding machine using the wheel.

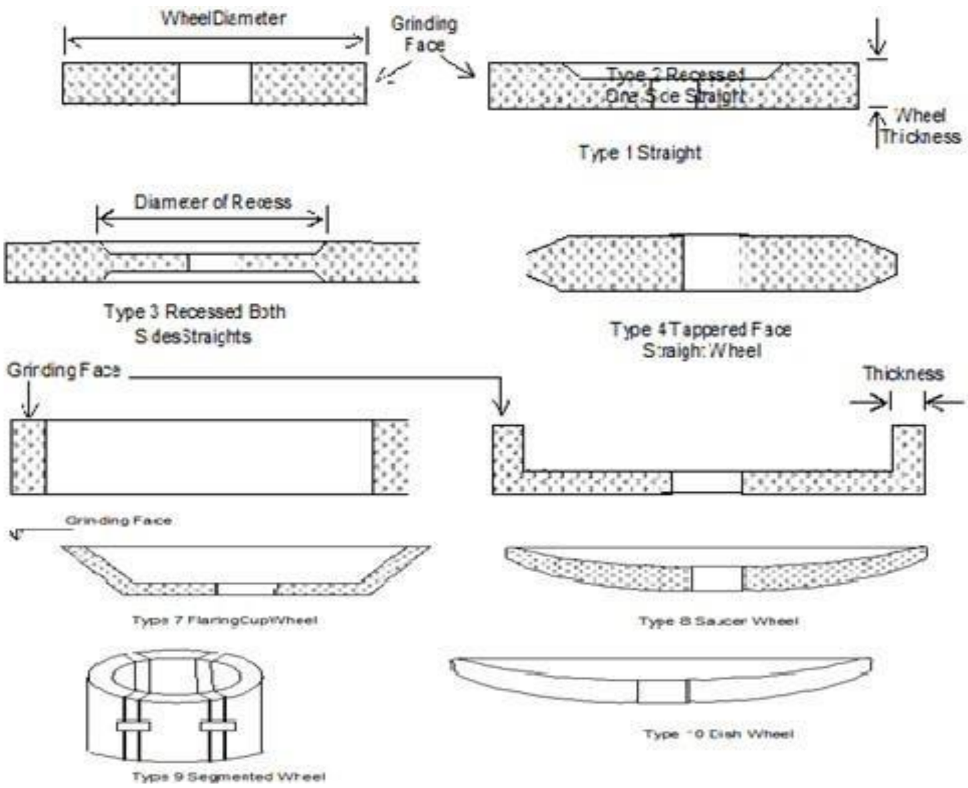


Figure 4.87 Different Types of Grinding Wheels

Tapered Face Straight Wheels:

This is Type 4 in Figure 4.87. It is also a straight wheel but its free is slightly tapered to facilitate the grinding of threads an gear teeth.

Cylindrical Wheel Ring:

Cylindrical Grinding wheel is shown in Figure 4.87 Type 5. It is used for surface Grinding, i.e. production of flat surfaces. Grinding takes place with the help of face of the wheel.

Cup Wheel:

Cup wheel shown in Figure 4.87 Type 6. It is used for grinding flat surfaces with the help of face of Grinding wheel.

Flaring Cup Wheel:

One modified Grinding wheel named as flaring cup wheel is Type 7 in Figure 4.87. It is used in grinding of tools in tool room.

Grinding Machines:

Grinding Machines are also regarded as machine tools. A distinguishing feature of grinding machines is the rotating abrasive tool. Grinding machine is employed to obtain high accuracy along with very high class of surface finish on the workpiece. However, advent of new generation of grinding wheels and grinding machines, characterised by their rigidity, power and speed enables one to go for high efficiency deep grinding (often called as abrasive milling) of not only hardened material but also ductile materials.

Conventional Grinding machines can be broadly classified as:

1. Surface Grinding Machine
2. Cylindrical Grinding Machine
3. Internal Grinding Machine
4. Tool and Cutter Grinding Machine

Surface Grinding Machine:

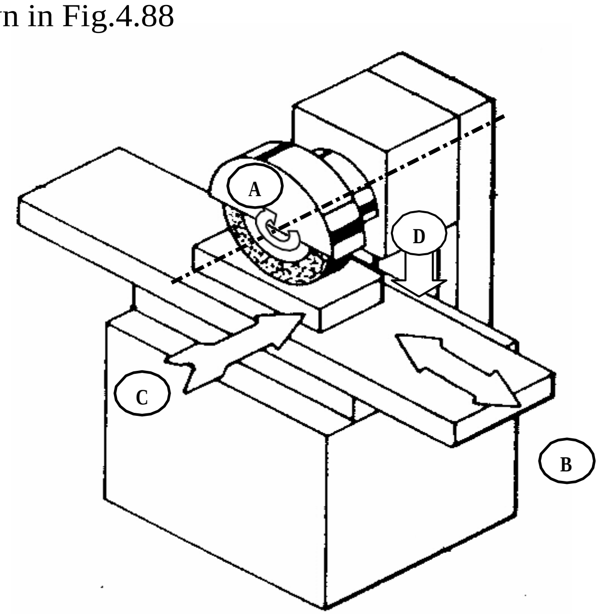
This machine may be similar to a milling machine used mainly to grind flat surface. However, some types of surface grinders are also capable of producing contour surface with formed Grinding wheel.

Basically there are four different types of surface Grinding machines characterised by the movement of their tables and the orientation of Grinding wheel spindles as follows:

- Horizontal spindle and reciprocating table
- Vertical spindle and reciprocating table
- Horizontal spindle and rotary table
- Vertical spindle and rotary table

Horizontal spindle reciprocating table grinder:

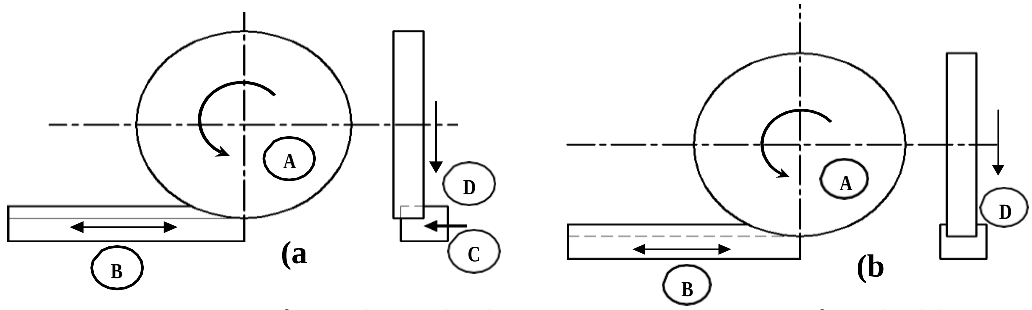
Figure 4.87 illustrates this machine with various motions required for grinding action. A disc type grinding wheel performs the grinding action with its peripheral surface. Both traverse and plunge grinding can be carried out in this machine as shown in Fig.4.88



A: Rotation of Grinding wheel B: Reciprocation of worktable

C: Transverse feed D: Down feed

Fig.4.88 Horizontal spindle reciprocating table surface grinder



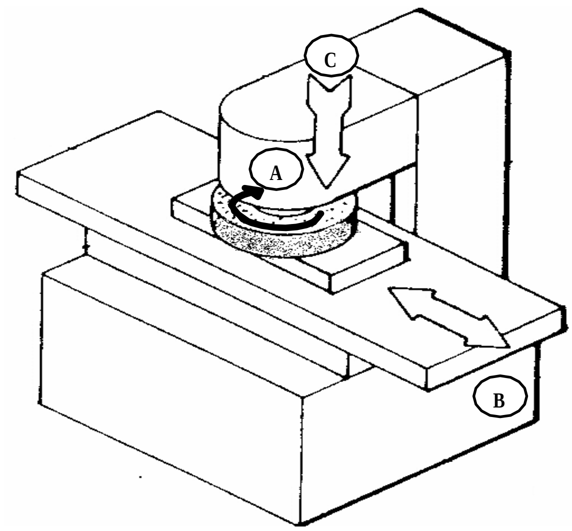
A: Rotation of Grinding wheel B: Reciprocation of worktable

C:Transversefeed D: Down feed

Fig. 4.89 Surface Grinding (a) Traverse Grinding (b) Plunge Grinding

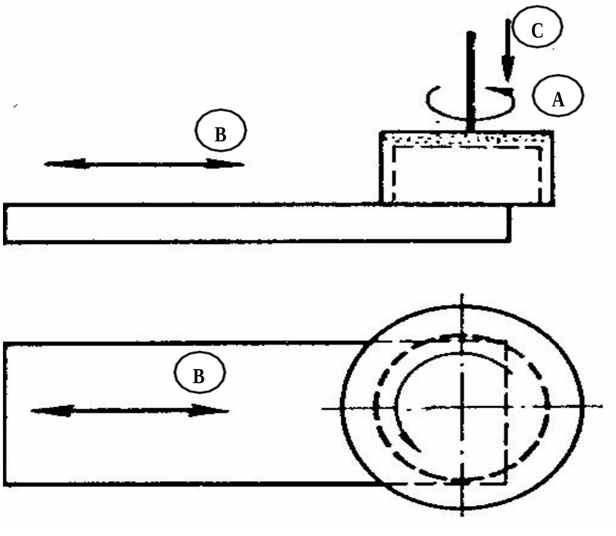
Vertical spindle reciprocating table grinder:

This Grinding machine with all working motions is shown in Fig. 4.90. The Grinding operation is similar to that of face milling on a vertical milling machine. In this machine a cup shaped wheel grinds the workpiece over its full width using end face of the wheel as shown in Fig. 4.91. This brings more grits in action at the same time and consequently a higher material removal rate may be attained than for grinding with a peripheral wheel.



A: Rotation of Grinding wheel
B: Reciprocation of worktable
C: Down feed of Grinding wheel

Fig. 4.90 Vertical spindle reciprocating table surface grinder

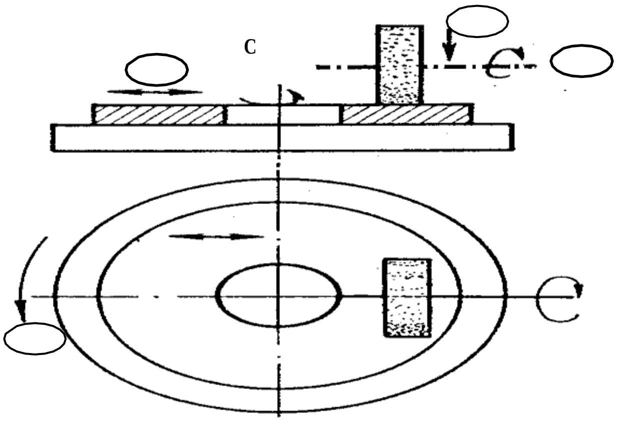


A: Rotation of Grinding wheel
B: Reciprocation of worktable
C: Down feed of Grinding wheel

Fig. 4.91 Surface Grinding in Vertical spindle reciprocating table surface grinder

Horizontal spindle rotary table grinder:

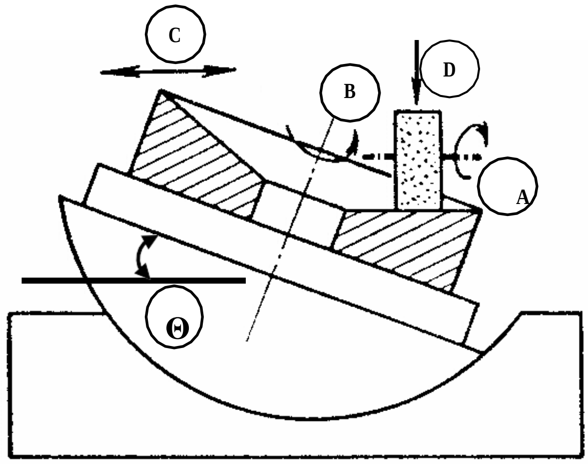
Surface Grinding in this machine is shown in Fig.4.92. In principle the operation is same as that for facing on the lathe. This machine has a limitation in accommodation of workpiece and therefore does not have wide spread use. However, by swivelling the worktable, concave or convex or tapered surface can be produced on individual part as illustrated in Fig. 4.93



A: Rotation of Grinding wheel B: Table rotation C: Table reciprocation

D: Down feed of Grinding wheel

Fig. 4.92 Surface Grinding in Horizontal spindle rotary table surface grinder

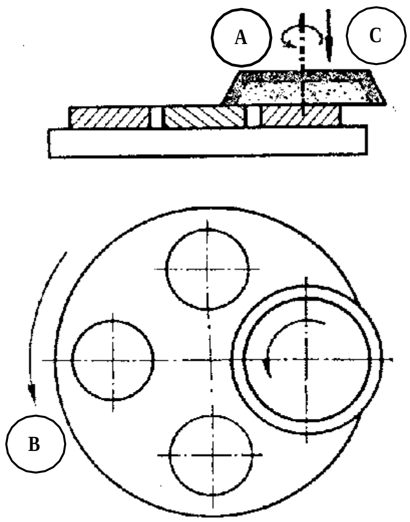


A: Rotation of Grinding wheel
B: Table rotation
C: Table reciprocation
D: Down feed of Grinding wheel
Θ: Swivel angle

Fig. 4.93 Grinding of a tapered surface in horizontal spindle rotary table surface grinder

Vertical spindle rotary table grinder:

The principle of Grinding in this machine is shown in Fig. 4.94. The machine is mostly suitable for small workpieces in large quantities. This primarily production type machine often uses two or more grinding heads thus enabling both roughing and finishing in one rotation of the work table.



A: Rotation of Grinding wheel
B: Work table rotation
C: Down feed of Grinding wheel

Fig. 4.94 Surface Grinding in vertical spindle rotary table surface grinder

Creep feed Grinding Machine:

This machine enables single pass grinding of a surface with a larger down feed but slower table speed than that adopted for multi-pass conventional surface grinding. This machine is characterised by high stiffness, high spindle power, recirculating ball screw drive for table movement and adequate supply of grinding fluid. A further development in this field is the creep feed grinding centre which carries more than one wheel with provision of automatic wheel changing. A number of operations can be performed on the workpiece. It is implied that such machines, in the view of their size and complexity, are automated through CNC.

Cylindrical Grinding machine:

This machine is used to produce external cylindrical surface. The surfaces may be straight, tapered, steps or profiled. Broadly there are three different types of cylindrical grinding machine as follows:

1. Plain centre type cylindrical Grinder
2. Universal cylindrical surface Grinder
3. Centreless cylindrical surface Grinder

Plain Centre type Cylindrical Grinder:

Figure 4.95 illustrates schematically this machine and various motions required for grinding action. The machine is similar to a centre lathe in many respects. The workpiece is held between head stock and tailstock centres. A disc type grinding wheel performs the grinding action with its peripheral surface. Both traverse and plunge grinding can be carried out in this machine as shown in Fig.4.96.

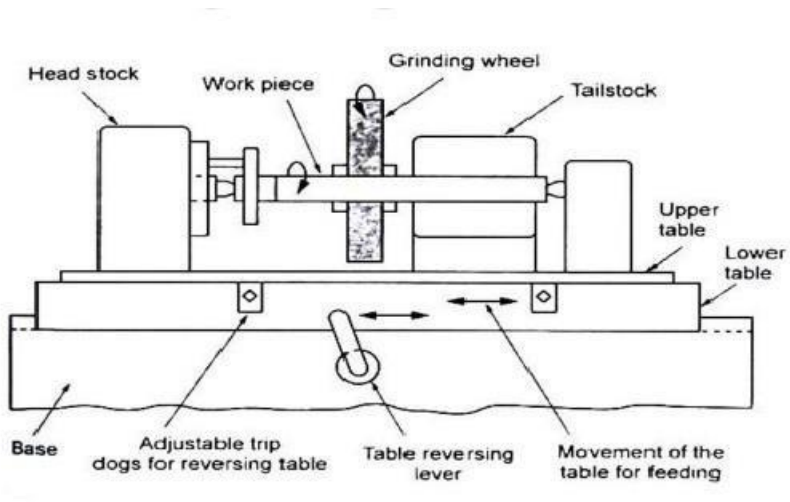
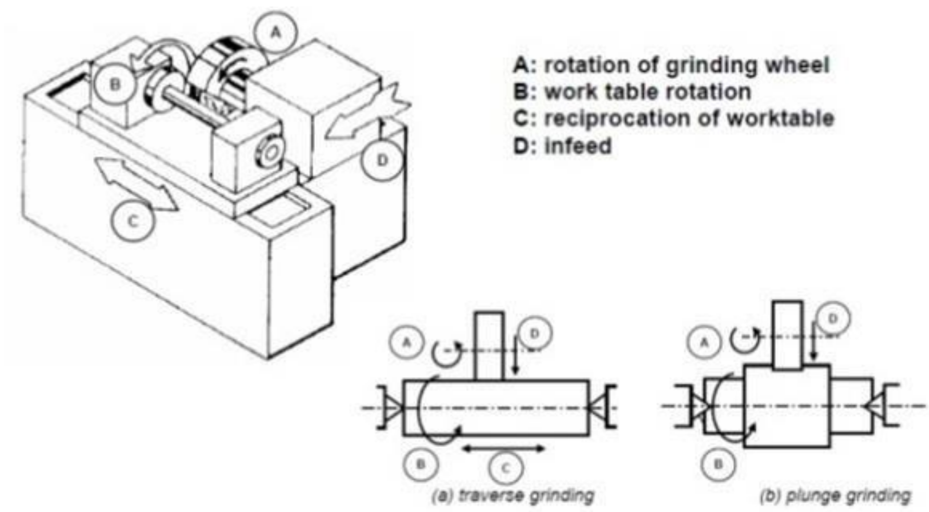


Fig. 4.95 Plain Centre Type Cylindrical Grinder

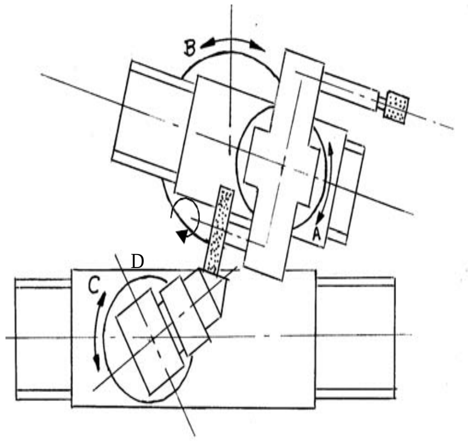


A: Rotation of Grinding wheel B: Work piece rotation
C: Reciprocation of worktable D: Infeed

Fig. 4.96 Cylindrical (a) Traverse Grinding and (b) Plunge Grinding

Universal Cylindrical Surface Grinder:

Universal cylindrical grinder is similar to a plain cylindrical one except that it is more versatile. In addition to small worktable swivel, this machine provides large swivel of head stock, wheel head slide and wheel head mount on the wheel head slide.



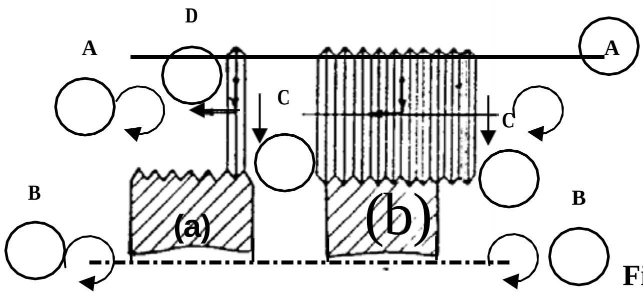
A: swiveling wheel head
B: swiveling wheel head slide
C: swiveling headstock
D: rotation of Grinding wheel

Fig. 4.97 Important features of Universal Cylindrical Grinding Machine

This allows grinding of any taper on the workpiece. Universal Grinder is also equipped with an additional head for internal grinding. Schematic illustration of important features of this machine is shown inFig.4.97.

Special application of Cylindrical Grinder:

Principle of cylindrical grinding is being used for thread grinding with specially formed wheel that matches the thread profile. A single ribbed wheel or a multi ribbed wheel can be used as shown in Fig. 4.98.

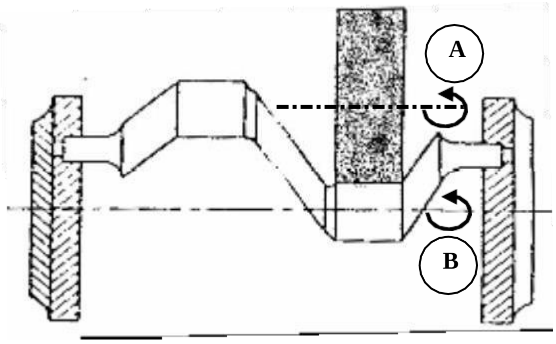


A: Rotation of Grinding Wheel
B: Rotation of Work Piece
C: Down Feed
D: Longitudinal Feed of Wheel

Fig. 4.98 Thread Grinding with (a) Single Rib (b) Multi - Ribbed Wheel

Roll grinding is a specific case of cylindrical grinding wherein large work pieces such as shafts, spindles and rolls are ground.

Crankshaft or crank pin grinders also resemble cylindrical grinder but are engaged to grind crank pins which are eccentric from the centre line of the shaft as shown in Fig.4.99. The eccentricity is obtained by the use of special chuck.



A: Rotation of wheel
B: Rotation of crank pin

Fig. 4.99 Grinding of Crank Pin

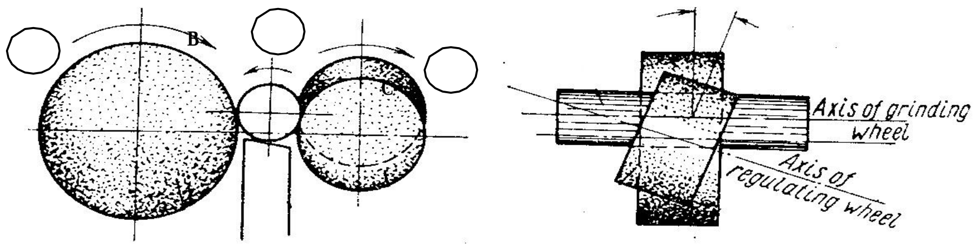
Cam and camshaft grinders are essentially subsets of cylindrical grinding machine dedicated to finish various profiles on disc cams and cam shafts. The desired contour on the work piece is generated by varying the distance between wheel and work piece axes. The cradle carrying the head stock and tail stock is provided with rocking motion derived from the rotation of a master cam that rotates in synchronization with the work piece. Newer machines however, use CNC in place of master cam to generate cam on the workpiece.

External Centreless Grinder:

This grinding machine is a production machine in which outside diameter of the workpiece is ground. The work piece is not held between centres but by a work support blade. It is rotated by means of a regulating wheel and ground by the grinding wheel.

In through-feed centreless grinding, the regulating wheel revolving at a much lower surface speed than grinding wheel controls the rotation and longitudinal motion of the work piece. The regulating wheel is kept slightly inclined to the axis of the grinding wheel and the workpiece is fed longitudinally as shown in Fig.4.100.

A

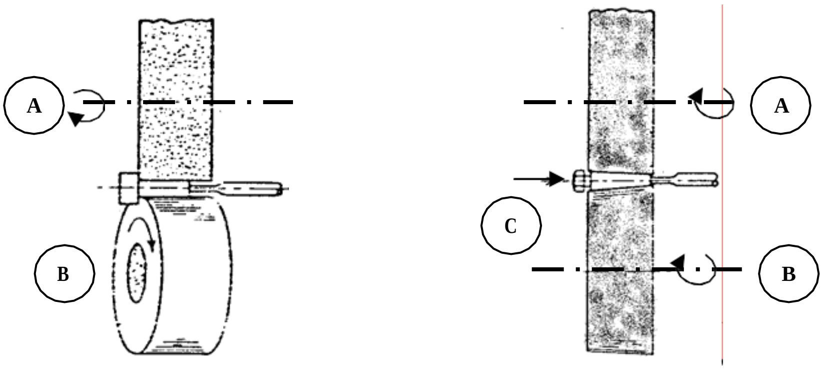


A: Rotation of Grinding wheel B: Work piece rotation
C: Reciprocation of worktable

Fig.4.100 Centreless through feed Grinding

Parts with variable diameter can be ground by Centreless infeed grinding as shown in Fig. 4.101(a). The operation is similar to plunge grinding with cylindrical grinder.

End feed Grinding shown in Fig. 4.101(b) is used for workpiece with tapered surface.



A: rotation of Grinding wheel B: rotation of regulating wheel C: feed on workpiece

Fig. 4.101 Centreless (a) In Feed and (b) End Feed Grinding

The Grinding wheel or the regulating wheel or both require to be correctly profiled to get the required taper on the workpiece.

Tool post Grinder:

A self powered grinding wheel is mounted on the tool post or compound rest to provide the grinding action in a lathe. Rotation to the workpiece is provided by the lathe spindle. The lathe carriage is used toreciprocate the wheel head.

Internal Grinding machine:

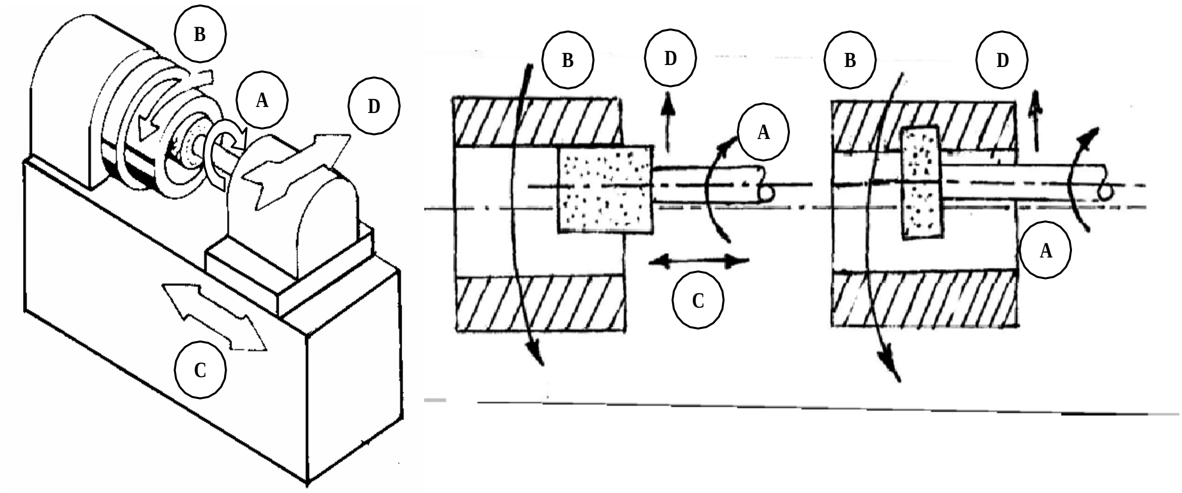
This machine is used to produce internal cylindrical surface. The surface may be straight, tapered, grooved or profiled.

Broadly there are three different types of internal grinding machine as follows:

1. Chucking type internal Grinder
2. Planetary internal Grinder
3. Centreless internal Grinder

Chucking type Internal Grinder:

Figure 4.102 illustrates schematically this machine and various motions required for grinding action. The workpiece is usually mounted in a chuck. A magnetic face plate can also be used. A small grinding wheel performs the necessary grinding with its peripheral surface. Both transverse and plunge grinding can be carried out in this machine as shown in Fig. 4.103.

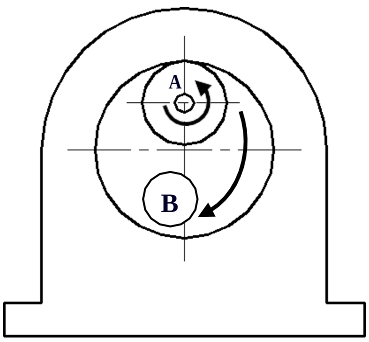


A: Rotation of Grinding wheel B: Work piece rotation
C: Reciprocation of worktable D: Infeed

Fig. 4.102 Internal Centreless Grinder Fig. 4.103 Internal (a) Traverse Grinding and (b) Plunge Grinding

Planetary Internal Grinder:

Planetary internal grinder is used where the workpiece is of irregular shape and cannot be rotated conveniently as shown in Fig. 4.104. In this machine the work piece does not rotate. Instead, the grinding wheel orbits the axis of the hole in the workpiece.



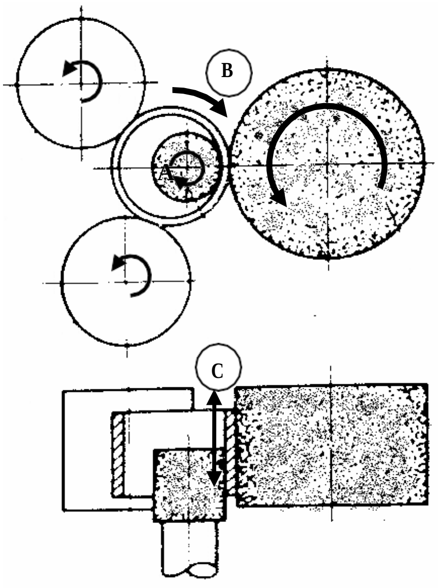
A: rotation of Grinding wheel

B: orbiting motion of Grinding

Fig. 4.104 Internal Grinding in Planetary Grinder

Centreless Internal Grinder:

This machine is used for Grinding cylindrical and tapered holes in cylindrical parts (e.g. cylindrical liners, various bushings etc). The workpiece is rotated between supporting roll, pressure roll and regulating wheel and is ground by the grinding wheel as illustrated in Fig.4.105



A: Grinding wheel rotation B: work piece rotation
C: wheel reciprocation

Fig. 4.105 Internal Centreless Grinding

Tool and Cutter Grinder Machine:

Tool Grinding may be divided into two subgroups: tool manufacturing and tool resharpening. There are many types of tool and cutter grinding machine to meet these requirements. Simple single point tools are occasionally sharpened by hand on bench or pedestal grinder. However, tools and cutters with complex geometry like milling cutter, drills, reamers and hobs require sophisticated grinding machine commonly known as universal tool and cutter grinder. Present trend is to use tool and cutter grinder equipped with CNC to grind tool angles, concentricity, cutting edges and dimensional size with high precision.

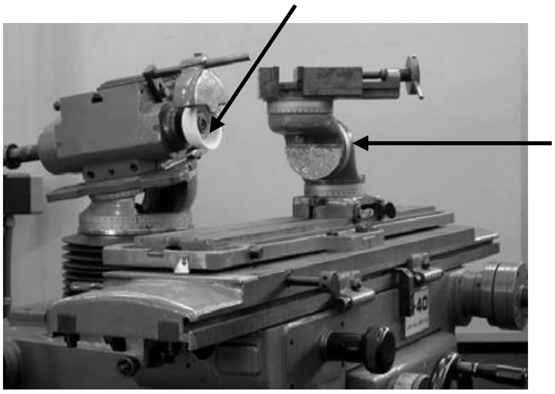


Fig. 4.106 Pictorial view of a tool and cutter Grinder

Abrasives:

Generally abrasive properties like hardness, toughness and resistance to fracture uniformly abrasives are classified into two principal groups :

1. **Natural Abrasives**
2. **Artificial Abrasives**

Natural Abrasives:

There are a few examples of natural abrasives which include sand stone (solid quartz); emery; corundum and diamond. Diamond is not recommended to use as abrasive due to its cost in effectiveness. However, diamond dust which is the waste of diamond dressing operation can be used as abrasives. Natural abrasive are being described below.

Sand stone is one of the natural abrasive used to make grinding stones. These are relatively soft. These cannot be used for grinding of hard material and at faster speed. Emery is a natural aluminium oxide containing 55 to 65% alumina, rest are iron oxide and impurities. If percentage of aluminium oxide is more, ranging from 75 to 95% then it is called corundum. It consists impurities as remaining amount. Both emery and corundum are harder than quartz and can have better abrasive action. Normally natural abrasives are not preferred due to presence of larger impurities and lack of uniformly in constituents. As both of these things influence the performance of grinding wheel adversely.

Artificial Abrasives:

Main artificial abrasive are silicon carbide and Aluminium Oxide. Artificial abrasive are preferred in manufacturing of grinding wheels because of their uniformity and purity. Artificial abrasives are described below. Silicon Carbide

It is also called carborundum. It is manufactured from 56 parts of silica sand, 34 parts of powdered cake, 2 pats of salt, 12 parts of saw dust in a long rectangular electric furnace of resistance type. Sand furnishes silicon, cake furnishes carbon, saw dust makes the charge porous, salt helps in fusing it. There are two types of silicon carbide abrasive, green grit with approximately 97% silicon carbide and black grit with approximately 95% silicon carbide. It is less harder than diamond and less tough than Aluminium Oxide. It is used for grinding of material of low tensile strength like cemented carbide, stone and ceramic, gray cast iron, brass, bronze, Aluminium vulcanized rubber, etc.

SHORT ANSWER QUESTIONS

1. Write the names of tools used in fitting shop.
2. Explain about universal surface gauge.
3. Draw the file and label the parts.
4. Write the types of drilling machines.
5. Write the devices used for holding the drills in drilling machines.
6. Write the names of different types of grinding wheels.
7. Write the types of conventional grinding machines.

LONG ANSWER QUESTIONS

1. Explain the tools
   a) V-Block b) Try- square c) Chisels d) Hack-saw e) Solid-die f) Tool-Makers vice.
2. Explain the various fitting operations.
3. Draw and explain the radial drilling machine.
4. Explain the various drilling operations.
5. Explain various drills and reamers used in drilling.
6. Explain any two surface grinding machines.
7. Explain any two cylindrical grinding machines.

UNIT: 5

Mechanical Working of Metals, Surface Heat Treatment and Finishing Operations

STRUCTURE

Introduction.

Hot Working Processes.

Advantages and Disadvantages of Hot Working.

Cold Working Processes.

Advantages and Disadvantages of Cold Working.

Surface Heat Treatment processes.

Finishing operations.

Introduction:

The shaping of metals by applying pressures either cold or hot condition is called mechanical working of metals.

Ex: Forging, bending, drawing, squeezing, spinning, shearing etc.

Hot Working Process:

Hot Working:

The plastic deformation of metal above re-crystallization temperature is called hot working. In this new grains are formed.

1. **Rolling:**

The plastic deformation of metal takes place as it passes through a pair of rolls rotating in opposite direction. This is due to squeezing action of rolls. In this reducing the cross- sectional area takes place. The hot rolling is used to produce bars, plates, sheets, rails and girders.

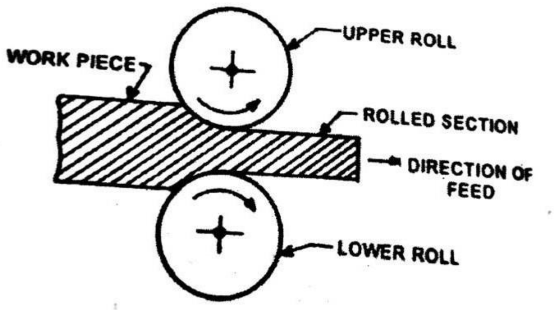


Fig 5.1 Rolling

2. Piercing:

Hot piercing is used to produce seamless tubes. A small hole is made at the end of the heated billet. It is feed between two piercing rolls rotating in the same direction. As a result seamless tube is produced.

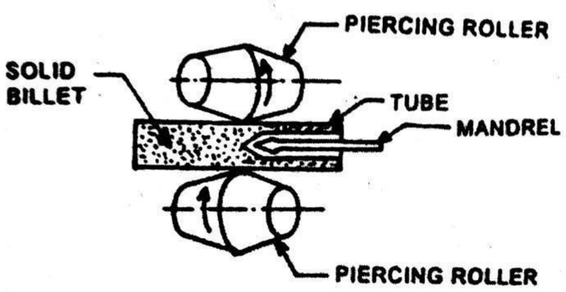


Fig 5.2 Piercing

3. Drawing or Cupping:

Drawing is the process of making cup shaped parts from sheet metal blanks. The blank is first heated then placed in position over the die or cavity. The punch descends through the die to form a cup.

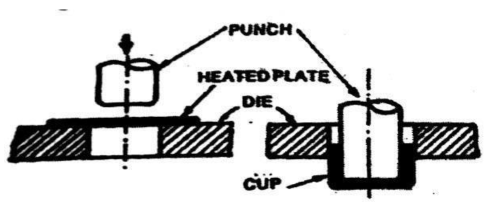


Fig 5.3 Drawing

4. Spinning:

It is the process of shaping thin sheets of metal by pressing against a rotating former. The blank is held between the former and adopter. The blank rotates with the former. A specially shaped tool is pressed against the blank and slowly moved to cover the former.

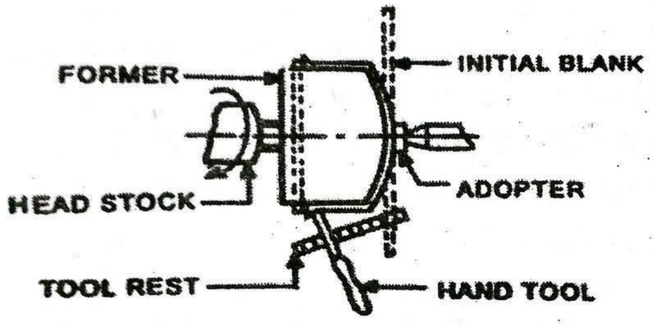


Fig 5.4 Spinning

5. Extrusion:

In this the metal billet is heated to plastic state and placed in a container. The billet is forced through a die by the pressure applied from the ram. The billet moves relative to the container.

Ex: Tubes, cables, air craft parts etc.

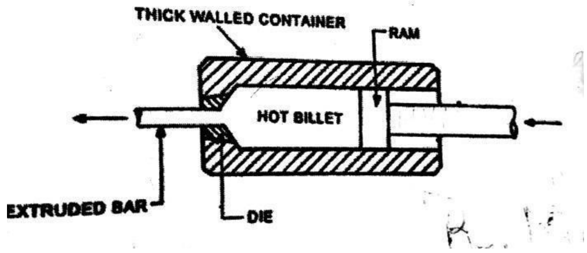


Fig 5.5 Extrusion

Advantages of Hot Working Process:

- The grain structure is refined.
- Less force is enough to shape the metal into desired shape.
- Strength and hardness of metal decreases.
- Porosity of metal eliminated.
- Ductility and toughness increases.
- Energy consumption is less.
- Uni-directional fiber structure is obtained.
- This process is easy and economical.
- Larger deformation is possible with less force.

Disadvantages:

- At high temperature scales are formed, so poor surface finish.
- Close tolerance cannot be maintained.
- Tooling and handling costs are high.
- Tool life is less due to work at high temperature.
- The steel work piece loose carbon, so crakes are developed on the surface of the work piece.

Cold Working Process:

Cold Working:

The plastic deformation of metal below re-crystallization temperature is called cold working.

1. **Rolling:**

In this process the metal is passed through the number of rollers till the required thickness is obtained. For this sheet, bars, rods are used.

Ex: Wrought Iron products.

2. **Bending:**

In this process the metal bars are bending into required shape. For this three rollers are used. Two rollers are in fixed position and other is adjustable. The long metal is passed through them. The rollers bend the metal.

3. **Drawing:**

It is the process to reduce the large diameter of metal into required low diameter. In this die is used. The metal is passed through the die, by applying force the metal comes out from die.

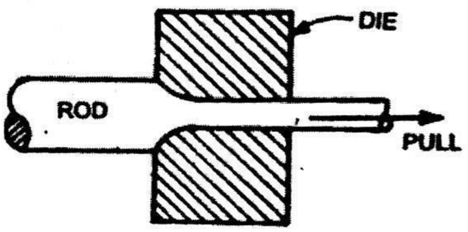


Fig 5.6 Drawing

4. **Spinning:**

It is the process of shaping thin sheet metal by pressing against the form which is rotation. This process is suitable for soft metals.

5. **Extrusion:**

It is the process of pushing the billet of metal through an orifice in the die.

The punch is passed on metal. Then the metal extruded into die shape.

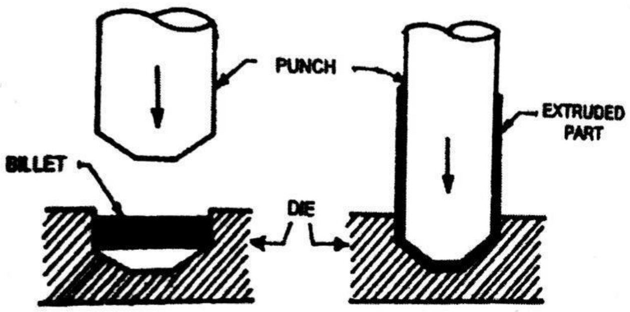


Fig 5.7 Extrusion

6. Squeezing:

It requires large amount of pressure to get required shape. For this a cavity of die and punch are required. Ex: bolts, screws, rivets.

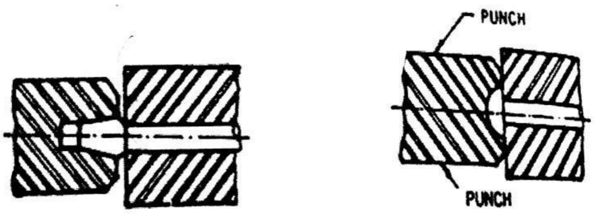


Fig 5.8 Squeezing

7. Reeding:

It is the process of intending large quantities of steel shots into the surface of metal. This is done by air blast. By this indentation compressive stresses are developed at outer layer. Due to this the metal surface is slightly hardened.

Advantages and Disadvantages of Cold Working:

Advantages:

- It improves surface finish.
- It gives scale free and bright surface.
- Strength and hardness are increased.
- They do not require any other finishing operations.
- Physical properties are increases.

Disadvantages:

- A high pressure and heavy equipment are required.
- Only small sized parts are worked. It is limited to ductile materials only.
- It increases the brittleness of the metal.

Surface Heat Treatment Processes:

Heat treatment is the process of heating and cooling metals, using specific predetermined methods to obtain desired properties. Both ferrous as well as non-ferrous metals undergo heat treatment before putting them to use.

Types of Heat Treatment:

There are four basic types of heat treatment in use today: annealing, normalizing, hardening, and tempering.

The following sections describe the techniques used in each process and show how they relate to Steelworkers.

1. Annealing:

The objective of annealing is the opposite of hardening. You anneal metals to relieve internal stresses, soften them, make them more ductile, and refine their grain structures. The process includes all three stages of heat treatment already covered (heat the metal to a specific temperature, hold it at a temperature for a set length of time, cool it to room temperature), but the cooling method will depend on the metal and the properties desired.

You may need to furnace-cool some metals or bury others in ashes, lime, or other insulating materials to achieve the appropriate characteristics.

Under certain job conditions, or without proper preheating, welding can produce areas of molten metal adjacent to other areas at room temperature. Given specific conditions, welding can actually weaken a metal, for as a weld cools, internal stresses occur along with hard spots and brittleness.

Annealing is just one method for correcting these problems and relieving the stresses.

2. Normalizing:

The intent of normalizing is to remove internal stresses that may have been induced by heat treating, welding, casting, forging, forming, or machining. Uncontrolled stress leads to metal failure; therefore, you should normalize steel before hardening it to ensure maximum results.

Normalizing applies to ferrous metals only, and it differs from annealing; the metal is heated to a higher temperature, but then it is removed from the furnace for air cooling.

Low-carbon steels do not usually require normalizing, but if they are normalized, no harmful effects result.

Castings are usually annealed rather than normalized; however, some castings require the normalizing heat treatment.

Normalized steel has a higher strength than annealed steel; it has a relatively high strength and ductility, much tougher than in any other structural condition. Metal parts that will be subjected to impact and those requiring maximum toughness with resistance to external stress are usually normalized.

In normalizing, since the metal is air cooled, the mass of a metal has a significant influence on the cooling rate and hence on the resulting piece's hardness. With normalizing, thin pieces cool faster in the air and are harder than thick ones, whereas with annealing and its associated furnace cooling, the hardness of the thin and thick pieces is about the same.

3. Hardening:

The purpose of hardening is not only to harden steel as the name implies, but also to increase its strength. However, there is a trade off; while a hardening heat treatment does increase the hardness and strength of the steel, it also makes it less ductile, and brittleness increases as hardness increases. To remove some of the brittleness, you should temper the steel after hardening.

Many nonferrous metals can also be hardened and their strength increased by controlled heating and rapid cooling, but for nonferrous metals, the same process is called heat treatment rather than hardening.

For most steels, hardening consists of employing the typical first two stages of heat treatment (slowly heat to temperature and soak to time and temperature), but the third stage is dissimilar. With hardening, you rapidly cool the metal by plunging it into oil, water, or brine. (Note: Most steels require rapid cooling [quenching] for hardening, but a few can be air cooled with the same results.)

4. Case Hardening:

The object of case hardening is to produce a hard, wear-resistant surface (case) over a strong, tough Core. In case hardening, the surface of the metal is chemically changed by the introduction of a high carbide or nitride content, but the Core remains chemically unaffected. When the metal is heat treated, the high-carbon surface responds to hardening and the Core toughens.

Case hardening applies only to ferrous metals. It is ideal for parts that must have a wear-resistant surface yet be internally tough enough to withstand heavy loading. Low- carbon and low-alloy series steels are best suited for case hardening. When high- carbon steels are case hardened, the hardness penetrates beyond the surface resulting in brittleness.

There are three principal processes for case hardening: carburizing, cyaniding, and nit riding.

5. Carburizing:

Carburizing — a case hardening process by which carbon is added to the surface of low-carbon steel.

When the carburized steel is heat treated, the case becomes hardened and the Core remains soft and tough--in other words, it has a high-carbon surface and a low- carbon interior.

There are two methods for carburizing steel:

- Heat the steel in a furnace containing a carbon monoxide atmosphere.
- Place the steel in a container packed with charcoal (or some other carbon- rich material) and heat in a furnace.

The parts can be left in the container and furnace to cool, or they can be removed and air-cooled. In either case, the parts become annealed during the slow cooling. The depth of the carbon penetration depends on the length of the soaking period during heat treatment. Modern methods dictate that carburizing is almost exclusively done by gas atmospheres.

6. Cyaniding:

Cyaniding — a case hardening process by which preheated steel is dipped into a heated cyanide bath and allowed to soak.

The part is then removed, quenched, and rinsed to remove any residual cyanide.

This process is fast and efficient. It produces a thin, hard shell, harder than the shell produced by carburizing, and can be completed in 20 to 30 minutes vice several hours. The major drawback is the use of cyanide; cyanide salts are a deadly poison.

7. Nitriding:

Nitriding – a case hardening process by which individual parts have been heat treated and tempered before being heated in a furnace that has an ammonia gas atmosphere.

This case hardening method produces the hardest surface of any of the hardening processes, and it differs from the other methods in that no quenching is required so there is no worry about warping or other types of distortion.

The nitriding process is used to case harden items such as gears, cylinder sleeves, camshafts, and other engine parts that need to be wear-resistant and operate in high- heat areas.

8. Flame Hardening:

Flame hardening is another process available for hardening the surface of metal parts. In flame hardening, you use an oxyacetylene flame to heat a thin layer of the surface to its critical temperature and then immediately quench it with a water spray. In this case, the cold base metal assists in the quenching since it is not preheated.

Similar to case hardening, this process produces a thin, hardened surface while the internal parts retain their original properties.

The process can be manual or mechanical, but in either case, you must maintain a close watch since an oxyacetylene flame can heat the metal rapidly and temperatures in this method are usually determined visually.

9. Tempering:

After hardening by either case or flame, steel is often harder than needed and too brittle for most practical uses, containing severe internal stresses that were set during the rapid cooling of the process. Following hardening, you need to temper the steel to relieve the internal stresses and reduce brittleness.

Tempering consists of:

- Heating the steel to a specific temperature (below its hardening temperature)
- Holding it at that temperature for the required length of time
- Cooling it, usually in still air.

The annealing, normalizing, and hardening processes all include steps at temperatures above the metal's upper critical point. Tempering is always conducted at temperatures below the metal's low-critical point.

Super Finishing Operations:

1. Honing:

Honing is a final finishing operation conducted on a surface, typically of an inside cylinder, such as of an automotive engine block. Abrasive stones are used to remove minute amounts of material in order to tighten the tolerance on cylindricity. Either type applies a slight, uniform pressure to a light abrasive that wipes over the entire surface. Honing is an abrading process for removing stock from metallic and non metallic surface. It is used to correct local irregularities such as ovality waviness of axis or non parallelism of cylindrical features and to develop a particular texture. Honing is the application of bonded abrasive stones (called hones) to a surface. The abrasive particles ($Al2O_3$ or SiC) are held by proper bond in the form of sticks. Honing is employed for grinding internal or external surface.

Mostly honing is done on internal surface or holes such as automobile cylinders. However it cannot correct hole location or perpendicularity. Surface finishes of 0.05 m Ra can be achieved. The hone rotates at 0.5-2.5 m/sec and reciprocates at 0.2-0.5 m/sec. The hole to be honed is flooded with a lubricant like paraffin while the honing sticks are removing metal. A honing machine rotates and reciprocates the hone inside holes being finished.

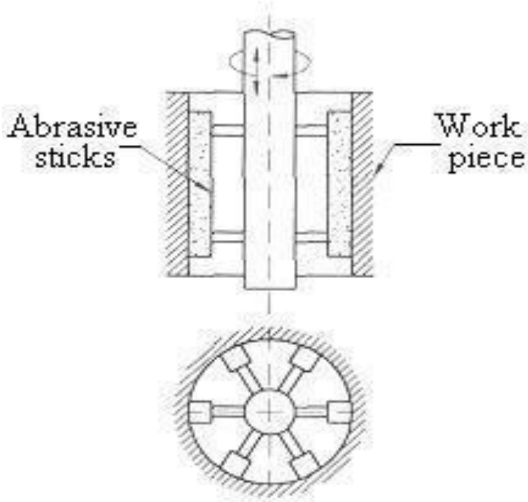


Fig. 5.9 Honing process

2. Lapping:

Lapping is a machining operation, in which two surfaces are rubbed together with an abrasive between them, by hand movement or by way of a machine. A paste of abrasive is rubbed against the surface of the component with certain pressure and with a relative motion. This can take two forms: The first type of lapping (traditionally called grinding), typically involves rubbing a brittle material such as glass against a surface such as iron or glass itself (also known as the "lap" or grinding tool) with an abrasive such as aluminum oxide, emery, silicon carbide, diamond, etc., in between them. This produces microscopically similar fractures as the abrasive rolls between the two surfaces and removes material from both. The other form of lapping involves a softer material for the lap, which is charged with the abrasive. The lap is then used to cut a harder material, which in most cases the work piece. The abrasive embeds within the softer material which holds it and permits it to score across and cut the harder material. Taken to the finer limit, this will produce a polished surface such as with a polishing cloth on an automobile, or a polishing cloth or polishing pitch upon glass or steel. With the aid of accurate interferometry and specialized polishing machines or skilled hand polishing can produce surfaces that are flat to better than 30 nanometers.

3. Buffing

Metal polishing, also termed buffing, it is the smoothing and brightening process of a surface by the rubbing action of fine abrasive in a lubricating binder applied intermittently to a moving wheel of wood cotton fabric felt or a cloth or a felt belt. Buffing is used to give a much more lustrous reflective finish that cannot be obtained by polishing. This gives a smooth finish by forming very thin lines that are not visible to the naked eye.

Buffing wheels are made of felt, pressed and glued layers of duck, or some select cloth and also of leather. The abrasive is mixed with a binder and is applied on either the buffing wheel or on the work. The buffing wheel rotates with a high peripheral speed up to 40 m/sec.

The abrasive may consist of iron oxide, chromium oxide etc. The binder is a paste consisting of wax mixed with grease, paraffin and kerosene or turpentine and other liquids. The stone is given as oscillating motion in the axial direction and simultaneously the job is given a rotary motion about the axis.

Buffing is commonly used in metal polishing of pressure cookers, cookware, and kitchenware. Pipes which are used in pharmaceutical, dairy and water industries are buffed to maintain hygienic conditions and prevent corrosion.

Super Finishing

Super finishing is a type of grinding also known as Micro finishing. An abrasive stick of very fine girt size (400-600 mesh) is retained in a suitable holder and held against the workplace surface under a high spring pressure. The stick is given a feeding and oscillatory motion. The work piece is rotated or reciprocated accordingly to the requirements of the shape being super finished. A lubricant is also fed into the contact surface. An extremely high quality surface with almost no defects is obtained. Holes can also be super-finished.

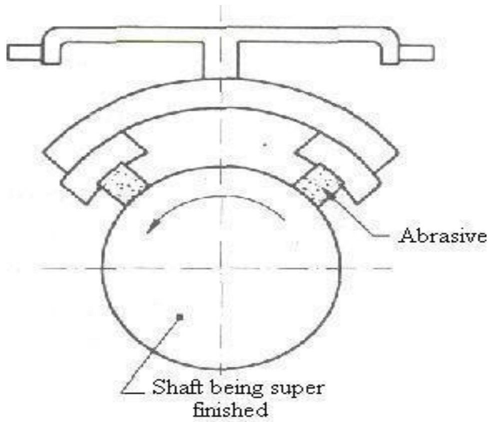


Fig. 5.10 Super Finishing of a shaft

Grinding

Grinding is a finishing process used to improve surface finish, abrade hard materials, and tighten the tolerance on flat and cylindrical surfaces by removing a small amount of material. In grinding, an abrasive material rubs against the metal part and removes tiny pieces of material. The abrasive material is typically on the surface of a wheel or belt and abrades material in a way similar to sanding (or sand grinding). On a microscopic scale, the chip formation in grinding is the same as that found in other machining processes. The abrasive action of grinding generates excessive heat so that flooding of the cutting area with fluid is necessary.

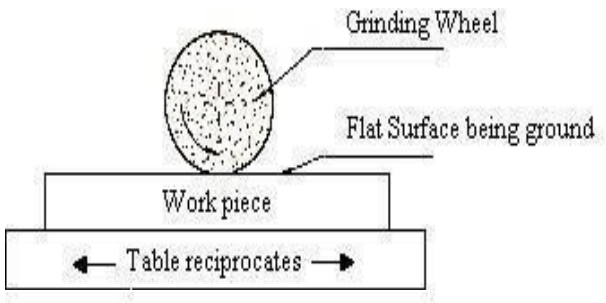


Fig. 5.11 Surface Grinding

Most of the processes, described in the present section involve removal of material with or without introducing or altering the surface stress/strain distribution and they also involve high costs. The only other technique which not only reduces surface roughness, but also introduces beneficial compressive residual stresses is BURNISHING, which process is described in detail in the next section.

Burnishing

Burnishing is considered as a cold-working finishing process, differing from other cold-working, surface treatment processes such as shot peening and sand blasting, etc. In that it produces a good surface finish and also induces residual compressive stresses at the metallic surface layers. Accordingly, burnishing distinguishes itself from chip- forming finishing processes such as grinding, honing, lapping and super-finishing which induce residual tensile stresses at the machined surface layers. Also, burnishing is economically desirable, because it is a simple and economical process, requiring less time and skill to obtain a high-quality surface finish.

The burnishing process can be achieved by applying a highly polished and hard ball or roller onto a metallic surface under pressure. This will cause the peaks of the metallic surface to spread out permanently, when the applied burnishing pressure exceeds the yield strength of the metallic material, to fill the valleys.

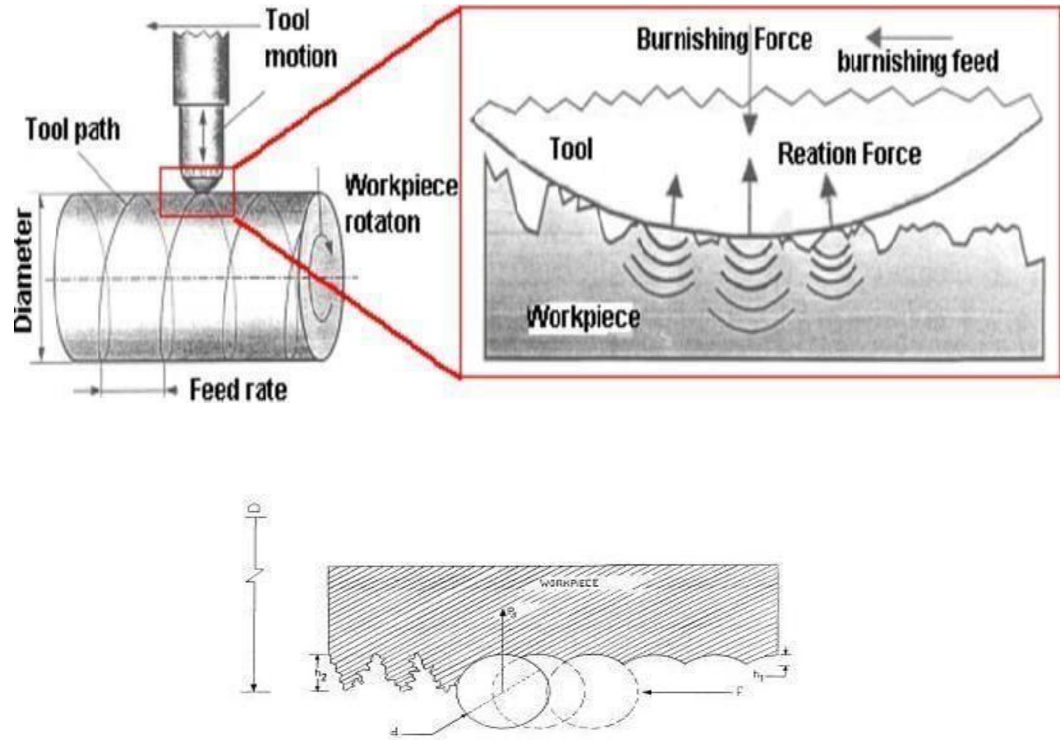


Fig. 5.12 Burnishing Process

The surface of the metallic material will be smoothed out and because of the plastic deformation the surface becomes work hardened, the material being left with a residual stress distribution that is compressive on the surface. The changes in surface characteristics due to burnishing will cause improvements in surface hardness, wear resistance, fatigue resistance, yield and tensile strength and corrosion resistance. It can be seen from this figure that the ball or roller rotates by the effect of frictional engagement between the surface of the ball or roller and the surface of the work piece. This process flattens the roughness peaks by causing plastic flow of the metal. It not only improves surface finish but also imposes favorable compressive residual stresses and raises hardness in functional surfaces, which can lead to long fatigue life and high load bearing capacity, surface finish, hardness, wear-resistance, and corrosion resistance.

The present work is an attempt to study the effects of roller burnishing on the surface roughness and hardness of Ferrous and Non-ferrous materials. The variable burnishing parameters selected for the experimental work were burnishing force, number of burnishing tool passes and other burnishing parameters such as feed- rate, speed, depth of cut etc.

SHORT ANSWER QUESTIONS

1. What is mechanical working of metals and give examples.
2. What is Hot working.
3. What is Cold working.
4. Write advantages and disadvantages of Cold working.

LONG ANSWER QUESTIONS

1. Explain Hot working processes.
2. Explain Heat treatment processes.
3. Explain super finishing operations.
4. Explain Burnishing processes.

UNIT: 6

Foundry

STRUCTURE

INTRODUCTION:

Manufacturing is the art of transforming raw materials into finished products. Foundry work deals with manufacture of products from molten metal and the products obtained are called castings. Castings are produced when the molten metal is poured into mould cavity and left to solidify. Casting or founding is one of the cheapest methods of producing parts to a given shape.

ADVANTAGES AND DISADVANTAGES OF CASTING

Advantages:

- Size of the casting is not a limitation. Castings may weight as much as200 tons or be as small as a wire of 0.5 mm diameter. In fact, casting is the only method available for producing massive objects in one single piece.
- The most simple or complex curved surfaces, inside or outside, and complicated shapes, which would otherwise be very difficult or impossible to machine forge, or fabricate, can usually be cast.
- As the metal can be placed exactly where it is required, large saving in weight is achieved.
- The casting process is ideally suited to the production of models or prototypes required for creating new designs.
- Castings offer the most complete range of mechanical and physical properties available in metals.
- Casting is usually found to be the cheapest method of metal shaping.
- Castings can be made to fairly close dimensional tolerances by choosing the proper type of moulding and casting process.

- Casting is adaptable to all types of production, i.e job, batch or mass production.

Disadvantages:

- The strength and toughness of casting is usually inferior to forgings.
- The process is not suitable for the metals having high melting point and low fluidity.
- A large number of defects occur in sand castings produced through various methods.
- Uneconomical for producing castings is small quantities and not expecting repeat orders.

FOUNDRY EQUIPMENT AND HAND MOULDING TOOLS:

Foundry tools and equipment may be classified into three groups namely hand tools, flasks and mechanical tools.

Hand Tools in Moulding:

1. Moulding Board:

It is a smooth wooden board, made slightly bigger size than moulding box. Pattern is placed on a moulding board and Moulding box placed found it, at the starting of mould. It also supports foe mould until the casting is solidified.

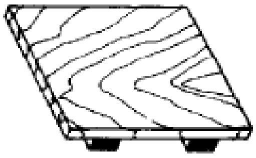


Fig 6.1 Moulding Board

2. Shovel:

It is used for mixing and tempering the moulding sand and loading the sand into flask.

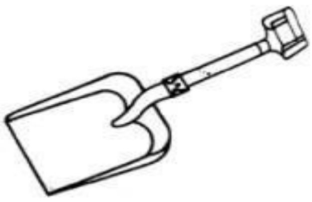


Fig 6.2 Shovel

3. Riddle:

It is a wire mesh fitted in to a wooden frame used for screening the sand and to scatter the fine moulding sand over pattern.

Fig 6.3 Riddle

4. Rammer:

These are used for packing the sand around the pattern in a flask. This is made of hard wood with one end flat and other wedge.

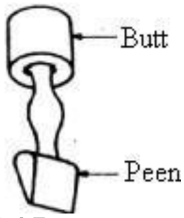


Fig 6.4 Rammer

5. Trowels:

These are used for cleaning, smoothing and patching the flat surface of the mould.

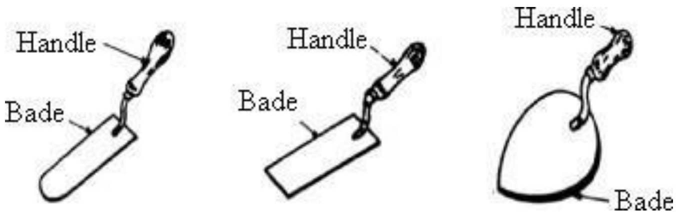


Fig 6.5 Types of Trowels

6. Slick:

It has a flat on one end and spoon on the other end. It is used for patching and smoothing the mould after the pattern has been drawn.

Fig 6.6 Slick

7. Lifter:

It is used for removing the sand particles from the mould.

Fig 6.7 Lifter

8. Strike of bar:

This is used to cutting off extra sand after ramming and bringing it to level with the surface.

Fig 6.8 Strike of bar

9. Bellow:

These are used to blow excess parting material form the pattern and also to blow loose sand particles from the mould.

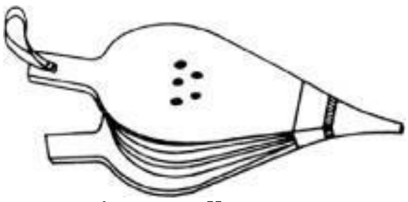


Fig 6.9 Bellow

10. Sprue Pin:

Pin used to make riser hole called riser pin.

Fig 6.10 Sprue Pin

11. Swab:

It is soft brush used for moistening the sand around the pattern.

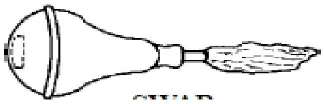


Fig 6.11 Swab

12. Gate Cutter:

It is a piece of steel sheet bent in the form used to cut gates.

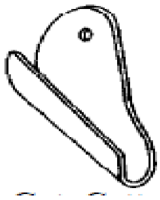


Fig 6.12 Gate Cutter

13. Mallet:

It is used to loosen the pattern to withdraw it from the mould and for stripping the core box from the cores.

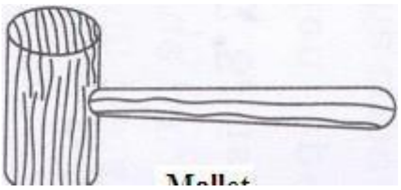


Fig 6.13 Mallet

14. Vent rod:

It is used to make series of small holes to permit gasses to escape while molten metal in being poured.

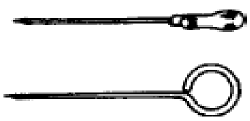


Fig 6.14 Vent Rod

15. Draw Spike:

It is used to rap and draw patterns from the sand.

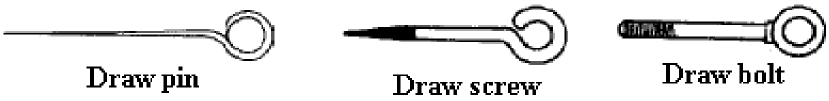


Fig 6.15 Types of Draw spike

16. Water Sprinkle:

It is a device used for wetting and tempering the mouldsand.

`

Fig 6.16 Water sprinkler

17. Spirit Level:

It is used for aligning flasks and adjusting the straight edges in pit moulding.

Fig 6.17 Spirit Level

18. Rapper:

Rapper is a fork-shaped rod used to drive the draw pattern, and then is used to rap the pattern from side-to-side, facilitate easy removal of pattern from mould.

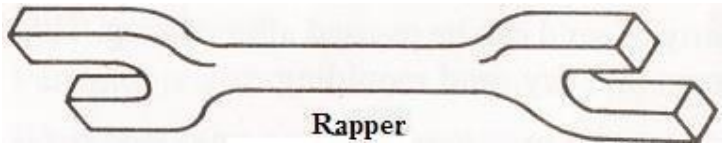


Fig 6.18 Rapper

19. Rapping plate or Lifting Plate :

Rapping or lifting plates are usually made of and used to facilitate the lifting the pattern from mould. It is fixed to large wooden pattern such that the top of plate is even with the parting line surface of the pattern.

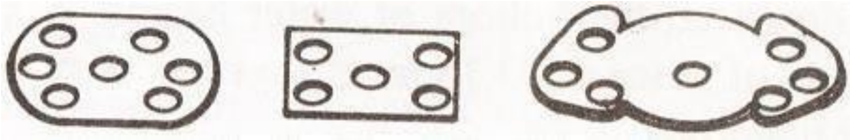


Fig 6.19 Rapping plate

20. Pouring weight:

It is a piece of metal placed on the mould to prevent the separation of the cope from the drag while the casting is being poured.

21. Gaggers:

These are iron or steel rods bent at ends, and are used to support the hanging masses of sand.

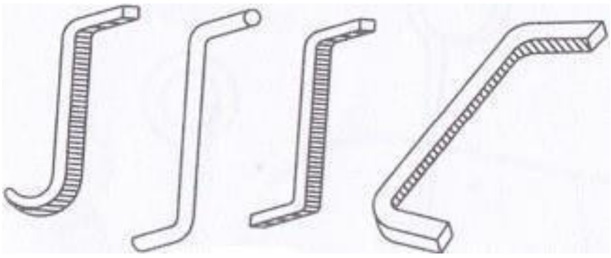


Fig 6.20 Gaggers

22. Clamps:

Clamps are locking devices used to hold the parts (i.e. cope and drag) of a completed mould together during the pouring.

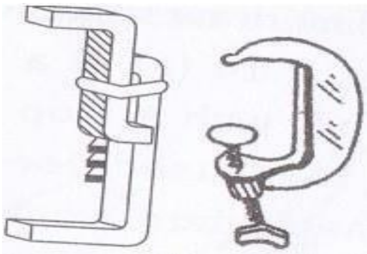


Fig 6.21 Clamp

23. Shake bag:

It is made from loosely woven cotton cloth and is used for dusting parting compound on the mould surfaces.

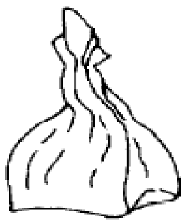


Fig 6.22 Shake bag

24. Flask

Sand moulds are prepared in specially constructed boxes called flasks. The purpose of flask is to impart the necessary strength to the sand in moulding. Moulding flask is generally made into two parts. The Cope (Top section) and the drag (bottom section). These two are held in position by pins. The common types of moulding boxes are snap flask, box flask and wooden moulding boxes.

25. Snap flask:

It is a small flask with open form. It is made with hinge on one corner and a lock on the opposite corner. It can be removed from the mould before it is poured.

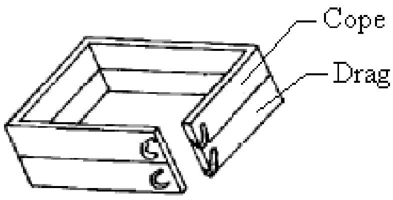


Fig 6.23 Snap Flask

26. Box Flask:

It is suitable for small and medium size castings, it is removed from the mould only after solidification of casting.

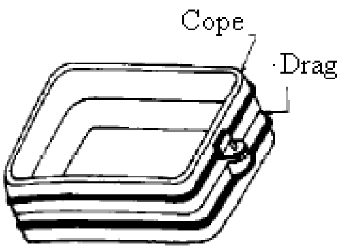


Fig 6.24 Box Flask

27. Wooden Moulding Boxes:

Wooden boxes are often used for making relatively large castings.

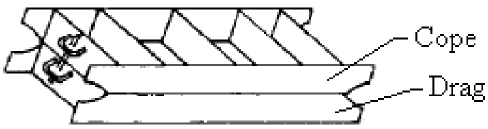


Fig 6.25 Wooden Moulding Flask

Mechanical Tools

These tools in the foundry include the many types of moulding machines that will ram the mould, roll it over and draw the pattern. Besides there are power operated riddles sand mixtures and sand conveyers etc.

TYPES OF MOULDING SAND AND PROPERTIES:

Probably the greatest advantage of sand as a moulding material is its versatility. A wide range of alloys can be cast into sand as it has a high tolerance for thermal shock. Thus relatively low melting point aluminum and magnesium alloys are sand cast as well as alloy steels. Furthermore, the mass of a casting is not a limiting factor. The majority of sand can be re- used after casting. This is particularly in the case of green and dry sand moulding.

Sand is formed by the disintegration of rocks under the action frost, wind and rain. In natural conditions, both large and small sand particles settle down on the bottom of water basins. Sand suitable for moulding consists of silica (SiO2) grains together with sufficient clay to act as binding materials.

Classifications of Moulding Sand

Moulding sand is classified as under:

1. According to the native of its origin.

1. Natural sand 2.Synthetic sand 3.Special sand

2. According to their initial condition (i.e. Green or dry) and use:

1. Greensand 2. Dry sand 3. Loam sand
4. Facing sand 5. Backing sand 6.System sand
7. Parting sand 8. Core sand

Natural Sand

Natural sand is collected like river beds or it dug from pits Natural proportion of clay (5-20%) is referred as TSS 3TS requires only to mix water with aggregate (sand- clay mixture).The clay develops the strength and plasticity for moulding. They are less refractory than synthetic sand. But, they have the advantage of maintaining moisture content for a long time and permitting easy patching and finishing of mould. This sand is used for non-ferrous castings and gray iron castings.

Synthetic Sand

Synthetic sand is essentially high silica grains containing no clay in natural form. They are mixed with clay (3 to 5% bentonite) and water (3 to 4%) to develop required moulding properties. It is used for steel castings.

Special Sand

Special sands are high refractory materials used for obtaining smoother surface of castings. They include Zirconium ($ZrSiO_4$), Olivine ($MgSiO_4$), Chromite ($FeO.Cr_2O_3$), Magnesite ($MgCO_3$) and Chromate ($3Al_2O_3SiO_2$).

Properties of Moulding Sand

Proper moulding sand must possess seven important properties.

1. Porosity:

The sand should have sufficiently porous to provide a passage for steam and gases otherwise the gases penetrate into metal which leads to the formation of gas cavities in casting.

2. Plasticity:

It is the ability of as and to acquire shape from the pattern that is moulded and retains it during casting.

3. Flowability:

It is the ability to flow under externally applied forces in to deeper sections of pattern and uniformly fill the flask.

4. Collapsibility:

It is the property of sand that permits it to collapse easily during its knockout from the casting.

5. Adhesiveness:

It is the ability of sand to stick to the surfaces of moulding boxes. This enables the mould to retain in a box during handling.

6. Cohesiveness:

It is the ability of sand particles to stick each other. It refers to the strength of moldings and to hold the grains together.

7. Refractoriness:

It is the ability of sand to with stand the heat of molten metal without fusion.

MOULDING SAND MIXTURES

Sand mixtures are those materials which are added to the moulding sand to improve upon some of its existing properties or to impart certain new properties to it. Some commonly used mixtures are coal dust, wood flour, silica flour and iron oxide.

Coal Dust or Sea Coal:

It is finely pulverized bituminous coal. It improves the surface finish, aids in cleaning of castings and prevents burning on sand.

Wood Flour:

It is a finely pulverized or ground soft wood. It improves finish, prevents burning on sand. It aids cleaning and improves collapsibility.

Silica Flour

It is finely ground silica sand of less than 54 microns. It fills interstices (voids) and thus reduces metal penetration.

Iron Oxide

Generally iron oxide is available in powder form. It is added to moulding sand to increase dry strength. It is also added to core sand to improve collapsibility.

PATTERN

Pattern is the replica or full size model of castings to be made. It gives its shape to the mould cavity where the molten metal solidifies to the desired for sand size. The design of casting should be as simple as possible to the pattern easy to draw from the sand and avoid more cores than necessary

These are made in two parts. One part is produced in drag and the other in cope. They are kept in position by dowel pins, and the split is usually arranged along the parting line.

Classification of Patterns

The type of pattern used depends upon the design of casting, complexity of shape, the number of castings required, moulding process, surface finish and accuracy. The following types of patterns are in common use.

1. Solid (single piece) pattern
2. Split pattern
3. Match plate pattern
4. Gated pattern
5. Sweep pattern
6. Cope and drag pattern
7. Skelton pattern
8. Loose piece pattern
9. Segmental pattern
10. Follow board pattern
11. Shell pattern

Solid Pattern

It is made in single piece and is best suited for limited production.

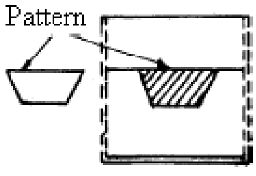


Fig 6.26 Solid Pattern

Split Pattern

It is used for intricate casting of unusual shapes. Split pattern may be two or three piece.

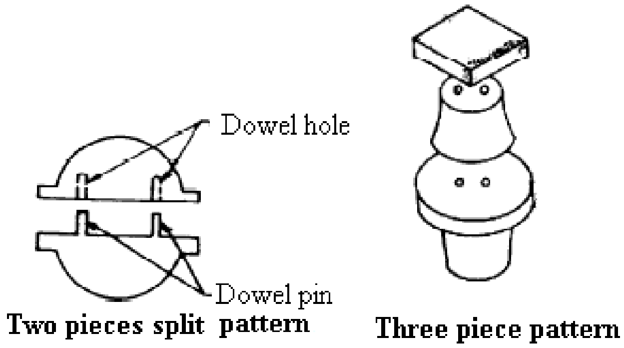


Fig 6.27 Split pattern

Match Plate Pattern

These patterns are mostly used in machine moulding as well as for producing large number of small castings by hand moulding.

Fig 6.28 Match plate pattern

Gated Pattern

These patterns include gates and risers for producing casting. The use of gated pattern eliminates the time required to cut the gating system by hand.

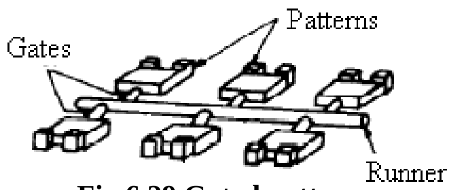


Fig 6.29 Gated pattern

Sweep Pattern

The template made of wood or metal revolving around a fixed axis in the mould shapes the sand to the desired contour. It is suitable for production of symmetrical castings.

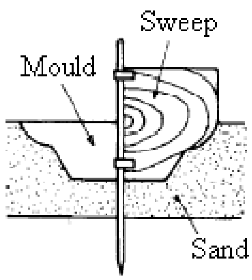


Fig 6.30 Sweep pattern

Cope and Drag Pattern

This pattern is made of two halves which are mounted on different plates. In this case, cope and drag parts of the mould are made separately.

Skelton Pattern

Skelton pattern is used for making large castings in small number. This consists of a simple wooden frame outlining the shape of casting. This frame work is filled with loam sand and rammed.

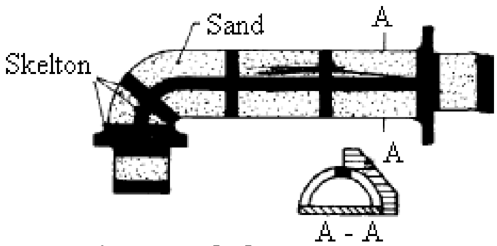


Fig 6.31 Skeleton pattern

Loose Piece Patterns

Loose piece pattern is used to produce the castings having projections in the sides. Such design makes impossible to draw the pattern from the mould. It is therefore necessary to make such projection in loose piece and fastened to main pattern by means of anchor. During the moulding the anchor pin is removed keeping loose piece in place. After completing mould, the main pattern is drawn, the loose piece remains in the mould but it is later removed with the help of pointed lifter.

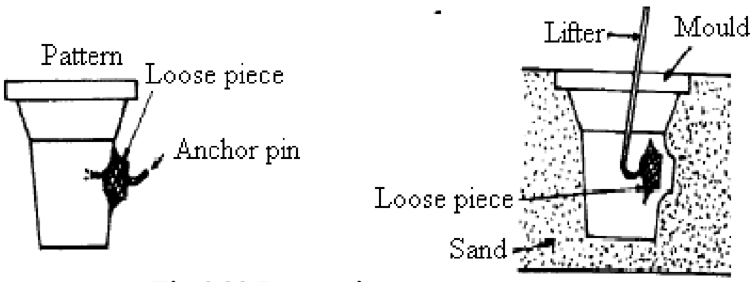


Fig 6.32 Loose piece pattern

Segmental Pattern

It is actually in the form of segment and used for moulding parts having circular sections such as rings, wheel rims and gears. This pattern revolves about centre and after ramming one section, it moves forward to another section to complete mould.

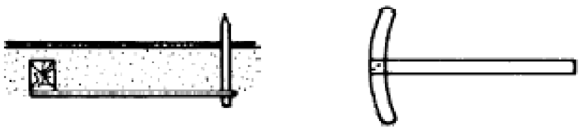


Fig 6.33 Segmental Pattern

Follow Board Pattern

It is used for making thin walled castings. Ramming of thin walled pattern may present problems such as sagging, breakage of pattern etc. It is therefore necessary to support pattern on block (follow board) that fit inside the pattern. Follow board is removed after ramming drag and the ramming of the cope then proceeds.

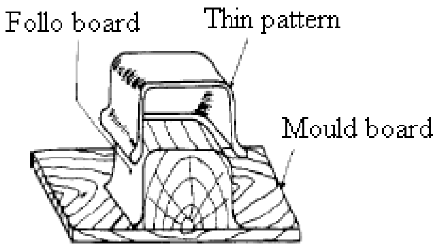


Fig 6.34 Follow Board Pattern

Shell Pattern

It is a hollow construction and its outside shape is used as pattern while in side is used as core box for making cores. The patterns are made in two halves and are accurately doweled together along parting line. It is mostly used for drainage fittings and pipe work.

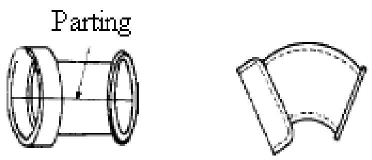


Fig 6.35 Shell Pattern

CORE AND TYPES OF CORE

Core is defined as bodies of sand, designed to form holes and cavities in castings. Cores are placed in the mould cavity before pouring to form the interior surface of the casting and are removed from finished part during shakeout and further processing.

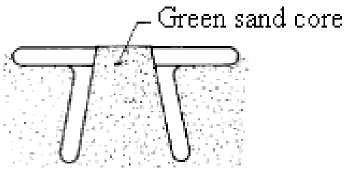
Types of Cores

Core may be classified as

1. **According to the Material used for Core.**
   a. Green-sand Core
   b. Dry-sand Core
2. **According to the position of Core.**
   a. Horizontal Core
   b. Vertical Core
   c. Balanced Core
   d. Cover and hanging Core
   e. Wing Core or Stop off Core
   f. Ram-up Core
   g. Kiss Core

Green sand Core

Green sand Core is formed by the pattern and made from the same sand as the rest of the mould. They require no Core prints. But green sand Cores have a relatively low strength. For more complex shapes, green sand Cores are not used,



because it is not possible to withdraw pattern from the mould.

Fig 6.36 Green sand Core

Dry sand Core

Dry sand Core is formed separately and inserted in the mould after pattern is withdrawn. These are held and positioned at a proper seat (formed by the Core prints) in the mould.

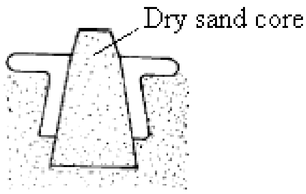


Fig 6.37 Dry sand Core

Horizontal Core

This Core is usually in cylindrical form. Horizontal Cores are laid down horizontally at the parting line of the mould.

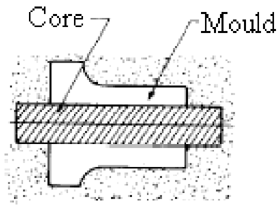


Fig 6.38 Horizontal Core

Vertical Core

Vertical Core is placed vertically in cope and drag of the mould. Taper is provided at top (i.e. at cope Core print) and bottom (i.e. at drag Core print). The amount of taper at the top is about 10 to 15° and at the bottom30.

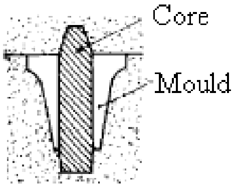


Fig 6.39 Vertical Core

Balanced Core

A balanced Core has a single Core print in the mould and is used to make a casting with blind hole (not through hole). To support long Cores in the mould cavity, chaplets are often used.

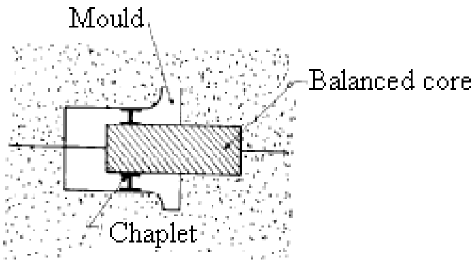


Fig 6.40 Balanced Core

Cover and hanging Cores

These are used when the pattern is rammed in the drag. A Core having its support at the drag is called cover Core and a Core hanging from the cope and does not have any support at the bottom (i.e. in the drag)is called hanging Core.

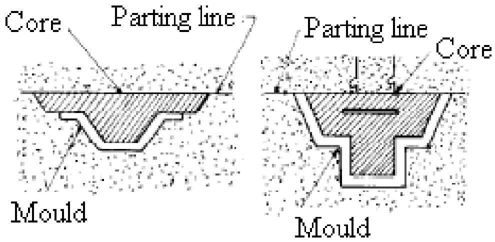


Fig 6.41Cover and hanging Core

Wing Core or Stop-off Core

It may be used when a hole is desired in the casting either above or below the parting line. A part of the Core that is placed in the seat becomes a stop-off (i.e. prevents the flow of metal into a cavity) and forms a surface of casting.

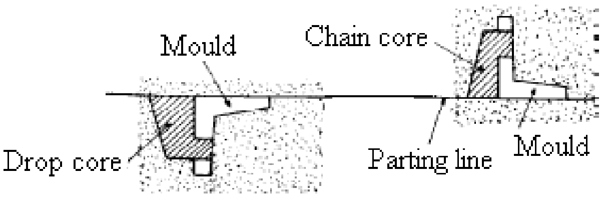


Fig 6.42 Wing Core

Ram-up Core

Ram-up Core is set in the mould along with pattern before ramming. It is used to make details in an in accessible position of casting.

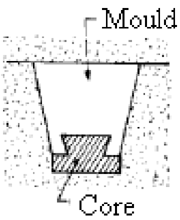


Fig 6.43 Ram-up Core

Kiss Core

When the pattern is not provided Core prints (i.e. no seat is available in the mould), the Core is held between cope and drag by the pressure of the cope. It is known as kiss Core and used to make holes in the casting in which the relative location of holes is not important.

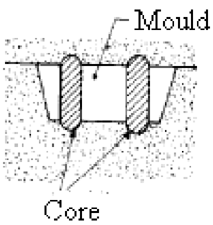


Fig 6.44 Kiss Core

MOULDING PROCESS

The Moulding processes may be classified as follows

1. According to the material used

a. Bench Moulding
b. Floor Moulding
c. Pit Moulding
d. Machine Moulding

2. According to the mould materials used

a. Green sand Moulding
b. Dry sand Moulding
c. Ceramic Moulding
d. Shell Moulding
e. Loam Moulding
f. Cement bonded Moulding
g. Skin-dried sand Moulding
h. CO_2 – process

3. Special casting methods

a. Die casting   b. Centrifugal casting   c. Investment casting

Bench Moulding

It is employed for small castings. In bench Moulding, Moulding flasks are kept on a bench of convenient height and mould is prepared as usual.

Floor Moulding

This method is adaptable to the production of large castings. In this case the mould is made on the foundry floor. It is simple and does not require equipment. However, it requires large manual work.

Pit Moulding

In this case mould is made in a pit, dug in a foundry floor. The pit acts as drag of Moulding box and a separate cope may be used. It is preferred for extremely large castings.

Machine Moulding

Machine Moulding is largely employed in batch and mass production. It enables higher output, accuracy of casting sand elimination of hard work of moulder. The Moulding machines perform the number of operations such as ramming of sand, removal of pattern and cutting the gates.

Green sand Moulding

This Moulding uses moist added to withstand the forces as the molten the mould. Green sand moulds are widely used metal is Poured medium castings. In this case no drying process of mould and the molten metal is poured as soon as the mould is prepared necessary is in the moist state at the time of metal pouring. The term green mould the moisture and not the colour of the sand.

Advantages:

- It is the least expensive method.
- It requires less time to prepare.
- It does not require any baking operation.
- Flasks are ready for reuse in minimum time.
- Less distortion of mould.
- Less danger of hot tearing of castings.
- Versatile-sand is reusable.

Disadvantages:

- Sand control is more critical.
- Moisture in the sand may causes defects like blowholes.
- Surface finish and dimensional accuracy of large castings.
- Mould lacks strength and erosion of mould is more common in the production of large casting.

Dry sand Moulding

Dry sand moulds are prepared in similar way green sand moulds except that the mould is dried before pouring molten metal. Drying (or baking) is usually carried in oven at about 240°C. The time of baking is depends on the binders used in the sand mixture and the amount of mould surface to be dried. The removal of moisture makes the mould stronger, improves erosion resistance and surface conditions.

Advantages:

- Stronger than green sand moulds, and less susceptible to damage in handling.
- Defects caused by the presence of moisture are avoided.
- Dimensional accuracy and surface finish are better than green sand mould.

Disadvantages:

- Cost of production is high.
- Production rate is slower.
- Mould distortion is greater.
- Castings are more susceptible to hot tears.
- It is not suitable for light and intricate castings.

Ceramic Moulding

Ceramic Moulding techniques employ a metal pattern and the pattern is kept in a flask. Thick slurry of refractory material (fine grained Zircon and alumina or silica) is applied to exposed pattern surfaces. The coating becomes tacky almost on contact and is ready to receive backing material. An in expensive, coarse backing slurry is poured rapidly over the facing coat until the flask is filled. It sets in about 3-5 minutes. The pattern is then withdrawn, and the ceramic mass removed from the flask is treated with catalyst (hardening fluid) to stabilize it chemically. The mould is then heated at about 980°C in a furnace to expel the liquid binder completely. The molten metal is then poured and the moulds are allowed to cool down slowly.

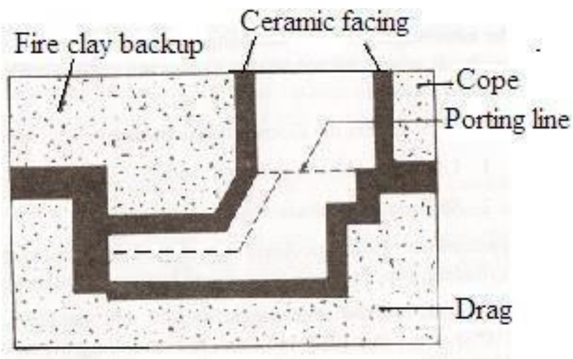


Fig 6.45 Ceramic Moulding

Advantages:

- Produce castings of highest precision and extremely high surface finish.
- A casting produced does not require machining.
- Process is suitable for all types of cast metals including highly reactive metals, such as titanium and uranium.
- Intricate castings with thin section can be produced.

Disadvantages:

- The process is expensive, because mould materials are costly and not reusable.
- Likely to produce parting line defects.

Shell Moulding

It is basically a sand Moulding in which the clay is replaced by resin bonding agent. It consists of the following steps.

Preparation of thin shell:

Fine silica sand (free from clay) is thoroughly mixed with about 5% thermosetting resin binder such as phenol-formaldehyde and placed into a container (dump box). The metal pattern plate is heated to about 250° C in an oven and is clamped to the top of the dump box as in Fig. (a). The metal patterns incorporates ejector pins to facilitate stripping of the completed mould. The dump box is inverted so that the sand resin mixture covers the pattern. After about 30 seconds, the resin cures causing the bonding of sand grains to form a shell around a pattern.

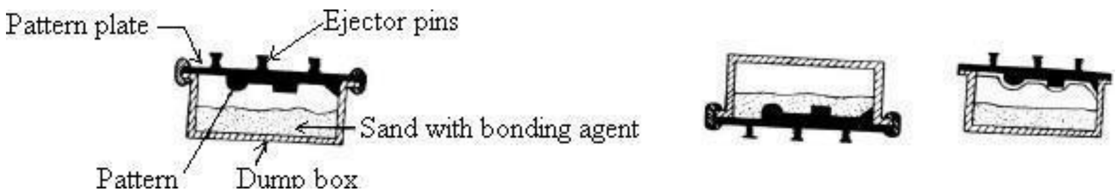


Fig 6.46 Partition of shell

Separating the shell from pattern:

The dump plate is returned to its original position and the surplus sand mixture falls back into the box. The pattern plate is removed and the shell is released by the ejector pins. The shells are light and thin, usually 5-10 mm thick.

Fig 6.47 Separation of shell

Mould formation:

The shell is further hardened by final curing for a few minutes at about 320°C. The two halves of shell are joined together by adhesive to form the mould. It is placed in suitable box and is supported by coarse sand or steel shots held in a box. The mould is ready. The molten metal is poured into the completed mould. After solidification the castings are removed from the sand.

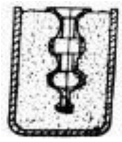


Fig 6.48 Clamping of shell to mould

Advantages:

- Produce accurate castings with very good surface finish.
- In most cases, machining operation is not required. Because sizes are very close enough to acceptable.
- Thin wall sections can be produced.
- Small Core holes can be produced.
- Shells can be stored for long time and can be reused.

Disadvantages:

- Cost of metal patterns is high.
- Cost of resin is high.
- Many equipment and control facilities are needed.
- Casting size and weight are limited.

Die casting or Injection Moulding

It involves the forcing of molten metal into die cavity under pressure and maintains this pressure until it solidifies.

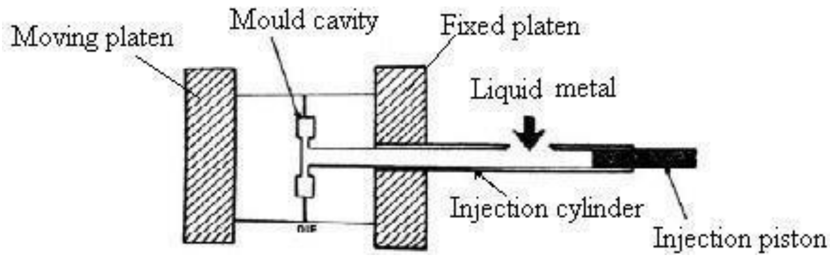


Fig 6.49 Die casting or Injection casting

Centrifugal casting

It is the variety method of producing castings in a rotating mould. The molten metal is poured in to the mould which is rotating at a speed of 1500 rpm and the centrifugal force spreads the molten metal uniformly along the entire length of the mould and holds it there until solidification is completed.

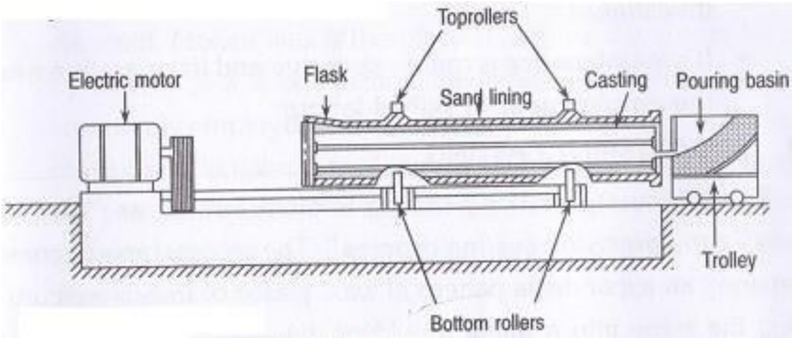


Fig 6.50 Centrifugal casting

Investment casting

This process of making casting is often termed as "lost wax process and precision casting process". The process broadly consists of preparing an expandable pattern of wax plastic or frozen mercury by pouring the same into a metal mould or die. This pattern is used for making the mould of investment material, which consists a refractory material and a liquid binder.

DEFECTS IN CASTING

Various defects in casting results due to improper sand preparation and process techniques the defects that commonly occur in castings are explained below.

Blow holes

Blow holes are spherical voids having a clean and smooth surface. They appear near to the surface. These defects are due to poor venting and lack of permeability in a Moulding sand. Proper venting, not too hard ramming and adjusting the moisture content in the sand may eliminate these defects.

Cold shuts and misruns

Cold shut and misruns are discontinuities in the casting as a result of poor fluidity of the molten metal. Misruns are formed when the entire section is not filled during pouring before solidification. Cold shuts formed when two streams of metal do not fuse together. These defects can be minimized by proper gating system and increasing in-pouring Temperature and increasing the fluidity of metal).

Hot tears

Hot tears are 'cracks' in the casting as a result of contraction stresses after solidification. An improvement in the casting design, proper ramming and increasing the collapsibility in the Core and mould may help elimination of hot tears.

Mismatch

Mismatch is a shift of the individual parts of a casting with respect to each other. The defect results from mismatching of cope and drag. To eliminate the defects, the flask should be properly closed and secured.

Shrinkage cavities

Shrinkage cavities are voids in the casting. They appear as a result of insufficient feeding, poor casting design, incorrect arrangement of gates and risers and high temperature of pouring metal. The defect can be eliminated by locating the riser at correct place and promoting the directional solidification by using chills (pieces of metals kept in mould to extract heat in certain location).

Fins or flash

Fins or flash are thin projections of metal, not intended as a part of the casting. They commonly appear along the mould joint because of much wear of flask halves or improper clamping of flasks.

Slag inclusions or slag holes

Slag inclusions or slag holes are cavities filled with slag, and produced when the slag gets into the casting when pouring metal into the mould. These defects are due to a poor skimming of metal in the ladle and in correct gating system.

Swell

Swell is an expansion of the mould cavity by metal pressure. It is thus, insufficient ramming and too rapid pouring of molten metal.

Scabs

Scabs are lumps of excess metal (i.e. irregular projections containing embedded sand) on the casting as a result of erosion of mould &y the stream of molten metal. The defect can be eliminated by proper ramming, using fine facing sand and controlling the flow of metal.

SHORT ANSWER QUESTIONS

1. Write the advantages of Casting.
2. Write the names of hand tools used in moulding.
3. Write the classification of moulding sand.
4. Write the commonly used mixtures in moulding sand mixtures.
5. Write the advantages of green sand moulding.
6. Write the disadvantages of dry sand moulding.

LONG ANSWER QUESTIONS

1. Write the properties of moulding sand.
2. Explain the types of patterns.
3. Write the types of cores and explain any three of them..
4. Explain the moulding process.
5. Explain ceramic moulding and write its advantages and disadvantages.
6. Explain defects in casting.

UNIT: 7
FORGING AND WELDING

STRUCTURE

Introduction

Supporting Tools

Hand Forging Equipment

Forging Operations

Machine Forging

Welding: Arc Welding & Gas Welding

INTRODUCTION

Forging is defined as the shaping of a headed metal by hammering and pressing. The components produced in this way are called forgings. This process is carried at the above re-crystallization temperature.

SUPPORTING TOOLS USED IN FORGING

1. **Anvil:**

   Anvil is used for supporting the work while hammering. It has a round hole (pritchel hole) for bending rods, a square hole (hardie hole) for holding Square shanks of various tools such as swages, fullers, hardie chisels etc. The body is made with mild steel and a grip of high carbon steel about 20 mm thick is welded on top to provide hard face. To attain proper height, it is placed on wooden block.

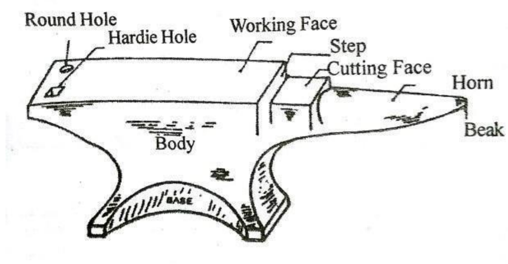


Fig. 7.1 Anvil

2. **Swage block:**

   The swage block is made with cast iron and is placed at a suitable height on wooden stand. It has grooves on face sand holes in the body. It is used for holding bars while bending and knocking up heads. It can also use for finishing round, square and hexagonal forms.

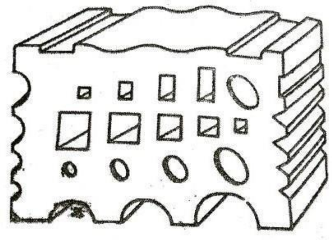


Fig. 7.2 Swage block

3. Tongs:

Tongs are used for holding the job in hand forging operations. They are made with mild steel. The jaws of the togs are used to hold the parts while hammered on the anvil. The various types of tongs are

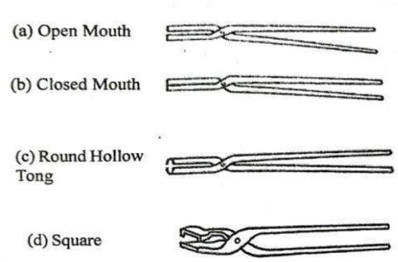


Fig. 7.3 Types of tongs

1. **Flat tong**: It is used for holding flat jobs along its length.
2. **Hollow bit tongs**: These are used for hold the roundbars.
3. **V- mouth & square mouth tongs**: They are used for to grip square bars.
4. **Pick up tongs**: they are used for picking up hot workpieces.
5. **Ring tong**: It is used for hold small circular works such as rivets, bolts etc.

4. Hammers:

Hammers are used to deform the workpiece into required shape. Two types of hammers are used. 1). Hand hammer 2). Sledgehammer.

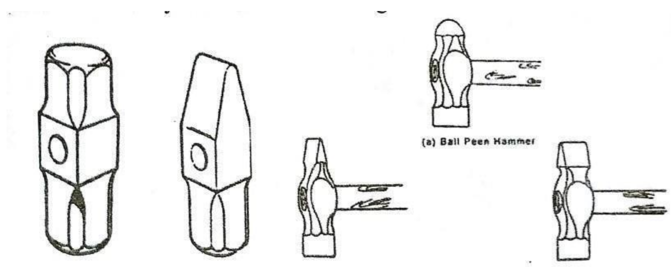


Fig. 7.4 Types of Hammers

5. Chisel:

Chisels are used for cutting metal and for nicking prior to breaking .They are hot chisel and cold chisel. Hot chisel is used for cutting the when hot. Cold chisel is used for cutting cold material.

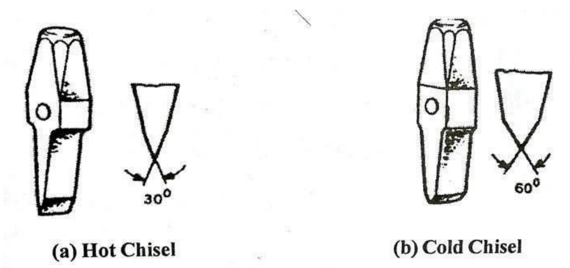


Fig. 7.5 Types of Chisels

6. Hardie tool:

It is a cutting tool with square shank to fit in the square hole of the anvil. It is used in combinations with hot or cold chisel.

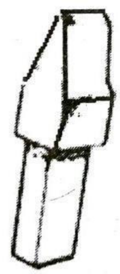


Fig. 7.6 Harddie tool

7. Swages:

Swages are used for reducing and finishing the round, square and hexagonal shapes.

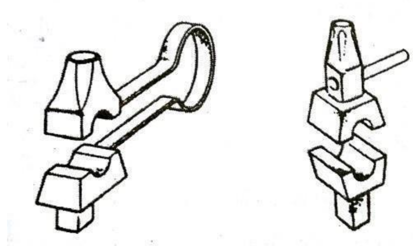


Fig. 7.7 Types of swages

8. Fullers:

Fullers are used for necking or grooving operations. These are made in various shapes and sizes. The bottom fuller has square shank to fit in the hardie hole and top one is provided with handle.

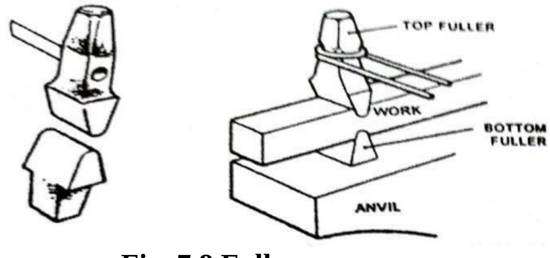


Fig. 7.8 Fullers

9. **Flatters and Set hammers:**

Flatters are used to obtain smooth and finished flat surface. Set hammers are used to finish corner and confined space.

10. **Punches:**

Punches are used for making holes in a metal. They are made in various shapes for punching holes of round, square and oval shapes.

11. **Drift:**

Drift is a tool used for enlarging the holes made bypunch.

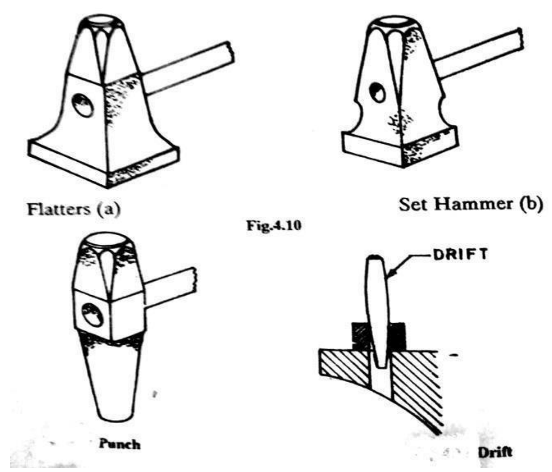


Fig. 7.9 (a) Flatter (b) Set hammer (c) Punch (d) Drift

HAND FORGING EQUIPMENT:

HEATING DEVICES:

The stocks are heated to the correct forging temperature in a smith hearth or in a furnace. Open or closed hearths are used. Gas and oils are used as fuels. The hearth is made of thick steel sheets. It is lined with fire bricks. It holds the coke and provides with tuyere and a tank containing water. Air is supplied through a fan or blower.

The air is admitted into the hearth may be regularized by valve arrangement. The hood at the top collects the fumes from the air.

Smoke and gas finally goes to the atmosphere. After firing the hearth the work piece is kept under the fire. When it becomes hot, it is removed from the hearth for shaping.

FORGING OPERATIONS:

Shapingtherawmaterialintodesiredshaperequiresdifferentoperations.The various operations are upsetting, drawing down, setting down, fullering, swaging, punching, drifting, bending, cutting and welding.

12. **Upsetting**:

It is the process of increasing cross sectional area at expense of its length. It is achieved by heating the bar at the middle and striking the end with hammer.

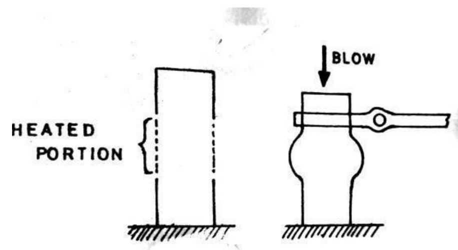


Fig. 7.10 Upsetting

13. **Drawing down:**

It is the process of decreasing the cross sectional area with corresponding increasing in length. It is carried out by using the edge, the horn of the anvil or fullers.

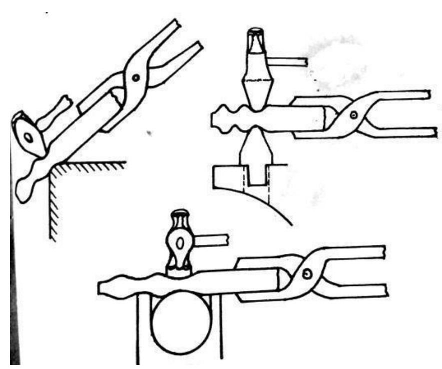


Fig. 7.11 Drawing down

14. **Setting down:**

It is the process of decreasing the thickness rather than general reduction of area. It is initiated with fullers and finished with flatters or set hammers.

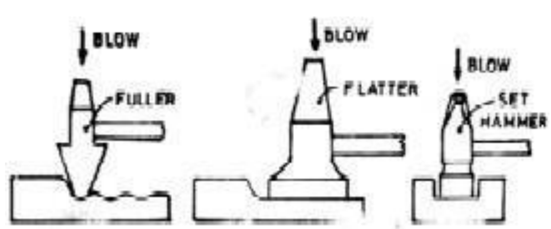


Fig. 7.12 Setting down

15. Fullering:

It is the process of increasing the length by necking the bars between the two fullers.

16. Swaging:

It is an operation by which a smooth and accurate shape by desired size is obtained. In this case the work is reduced between the swages.

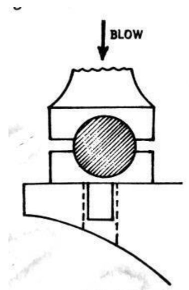


Fig. 7.13 Swaging

17. Punching:

It is the operation of obtaining through hole in the metal by using hot punch. It is carried on the pritchel hole of an anvil. It is carried in two steps. In the first step, the punch is driven half through one side of the metal, in the second step the work is turned over and the whole is completed.

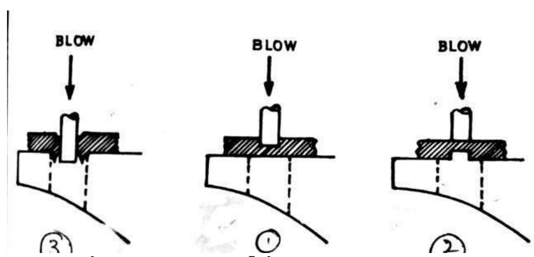


Fig. 7.14 Punching

18. Drifting:

It is the process of enlarging the punched hole.

19. Bending:

In this operation, the workpiece is bent in specified shape. It is carried on the horn of an anvil.

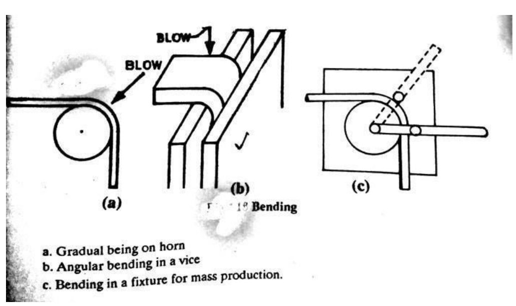


Fig. 7.15 Bending

20. Cutting:

It is the process of removing excess metal from the work piece with the chisel.

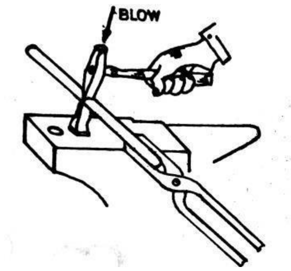


Fig. 7.16 Cutting

21. Welding:

It is the process of joining two pieces of metals. It is done by heating the work pieces to the plastic state and hammering them together. The two ends of the parts are shaped before welding.

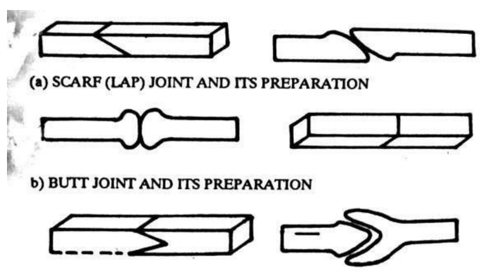


Fig. 7.17 Types of Forge Welds

MACHINE FORGING:

Heavy and medium forgings are made in machine forging. In this case power driven by forging hammer and forging press are used.

Forging hammer:

Forging hammers are used for upsetting and drawing down operations. Due to eccentricity at the driving end, spring oscillates. As the spring oscillates, the ram moves up and down to strike the work placed on the anvil. By adjusting the eccentricity, the required ram movement can be obtained. Forging hammers are

A. **Spring hammer**

B. **Pneumatic hammer**

C. **Air or steam hammer**

D. **Drop hammer.**

A) Spring Hammer:

It is adopted for upsetting and drawing out operations. Due to eccentricity at the driving and spring oscillates. As the spring oscillates the ram moves up and down in the guides to strike the work placed on the anvil. By adjusting the eccentricity the required ram movement can be obtained.

B) Pneumatic Hammer:

It is employed for forgings of small parts. It has two units. 1. Compressor cylinder and Ram cylinder. Air is compressed on both upward and downward strokes of the piston in compressor cylinder. This air enters into the ram cylinder through a controlled valve. Hammer falls due to its own weight and the pressure exerted above the piston. The upward stroke of hammer is obtained by exhausting the air above the piston and admitting it beneath the piston.

C) Steam or Air-Powered Hammers:

Steam or air-powered hammers are similar to air-lift hammers except that the hammer is raised either by steam or air, and is powered down onto the work piece by pressurized steam or air, adding controlled energy and speed beyond gravity. Striking force can be varied on each stroke over the entire range from a light tap to full power. The complete control of each work stroke places higher requirements on operator skills than for other types of hammer. In a growing number of cases, they are being controlled by programmable systems.

D) The drop forging hammer can be powered by gravity alone or additional sources of force can augment the hammer's power.

Forging Presses:

Forging presses are used for large variety of forged products. They employ a slow squeezing action. It results deeper penetration into metal. Forging presses are operated by mechanically or hydraulically.

A) Mechanical Presses:

These are widely used for manufacture of impression- die forgings from steel and non-ferrous alloys. In this type the ram is forced down by a crank and toggle joint mechanism, which is usually driven by electricmotor.

B) Hydraulic Press:

It is used for large steel forgings. The ram is moved by the pressure of the fluid (oil or water). Oil is mostly used in modern press. The pressure of oil is increased by pump and is transmitted to the cylinder in order to lift the ram or force it down.

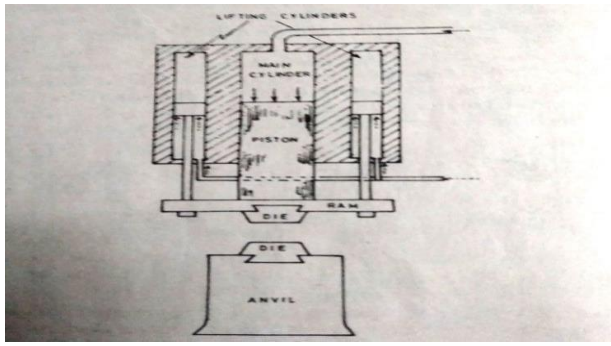


Fig. 7.18 Hydraulic Press

WELDING:

It is the process of making joint two metals by using heat with or without pressure.

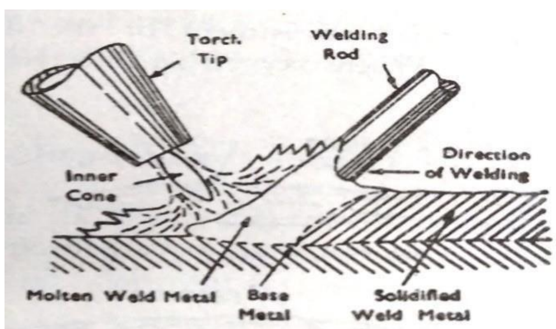


Fig. 7.19 Welding

Types of welding:

1. **Plastic or Pressure Welding:** It is the process of joining metals by heating in plastic state with applying the pressure.

2. **Fusion Welding:** It is the process of making joint by heating the metal and allow to solidify.

Arc Welding: Arc welding is most extensively employed method of joining metal plates. Here the source heat is an electric arc.

Arc Welding Equipment:

1. AC or DC welding machine
2. Electrode
3. Electrode holder
4. Cable, Cable connectors
5. Cable plug
6. Chipping hammer
7. Earth clamps
8. Wire brush
9. Helmet
10. Safety goggles
11. Hand gloves
12. Apron and sleeves.

Arc Welding Procedure:

Before starting the welding the joint should be prepared well and thoroughly cleaned to remove dirt, grease, oil etc. from the work surface. Edges of the thickened section should be beveled. The work piece should be firmly held. Make sure that the connections are given properly to main supply and electrode rod.

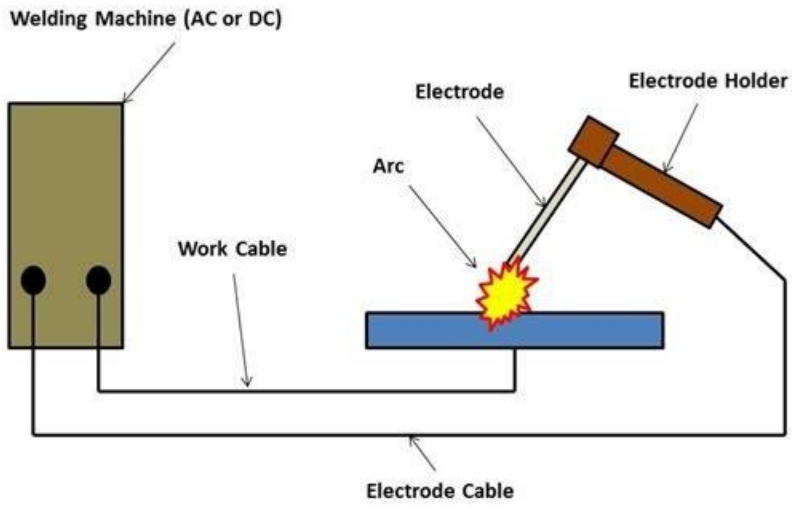


Fig. 7.20 Arc Welding

The arc column is generated between the anode and cathode. When these two conductors of an electric circuit are brought together and separated for a small distance i.e., 2-4 mm such that an electric arc is formed. Heat is generated as the ion strike the cathode. The heat of the arc raises the temperature of the parent metal which is melted forming a molten metal. The electrode rod is also melted and transferred between metal pieces to be welded. The welding may be proceeding by maintaining a gap2-4mm between the electrodes. After desired length has to been welded, the electrode holder should be lifted quickly to break the arc. Clean the welded joint with brush.

Gas Welding:

Gas welding is done by burning a combustible gas with air or oxygen in a concentrated flame of high temperature. The purpose of the flame is to heat and melt the parent metal and filler rod of a joint.

Gas Welding Equipment:

1. Welding torch
2. Pressure regulator
3. Welding tip
4. Hose and hose fitting
5. Goggles, gloves and spark lighter
6. Gas cylinders which are oxygen cylinder black in colour and Acetylene cylinder maroon red in colour.

Gas Welding Procedure:

- Arrange the work pieces and two cylinders in proper position.
- Blow out both cylinder valves before fitting the regulator so that all dirt may be cleaned.
- The regulator and valve fitting thoroughly checked that there is no oil grease.
- Fix the oxygen and acetylene regulator and pressure gauges to cylinders.
- Connect hose fittings of O_2 and C_2H_2.
- Open the cylinder valves slowly.
- Check for leaks at all joints before starting.
- To start the work turn on the acetylene first and allow it to pass through the nozzle.
- Then turn on oxygen slightly and allow the mixture to flow through hoses and blow pipes are full and cleared off air.
- Adjust the required pressure of two gases and light the mixture.
- Adjust the flames by regulating the supply of the gasses in correct proportions.
- After the work is completed the oxygen gas valve should be closed first and followed by the acetylene gas valve.
- Flux: Flux is a chemical component to prevent oxidation of molten weld material. The materials used in flux are zinc chloride and aluminum chloride.

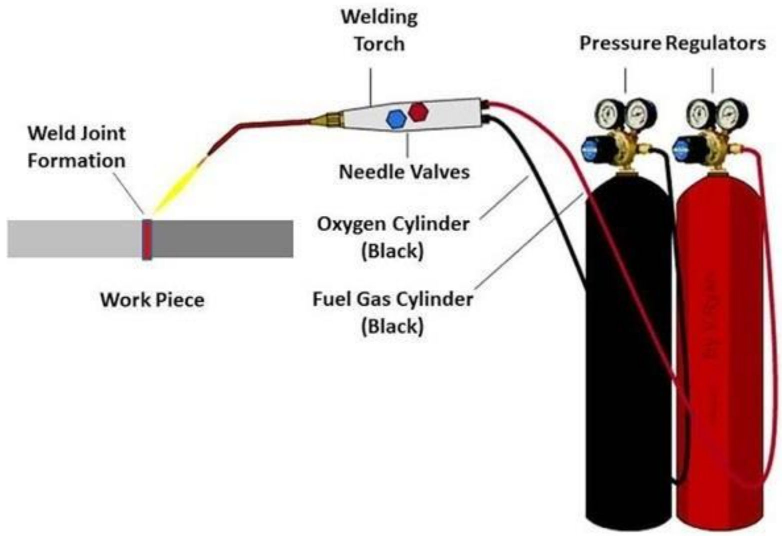


Fig. 7.21 Arc Welding

Submerged Arc Welding:

Submerged Arc Welding is used for the production of long continuous welding. In this case, a bare electrode (1.54 – 10mm) in the form of continuous wire is used and the arc is struck between electrode wire and work piece under the flux, consisting of lime, silica, magnesium oxide, calcium fluoride and other elements. The flux is fed as a powder in front of the electrode. The flux near the arc melts and forms a protective coating of slag, which is easily detached from finished weld. The rate of cooling of t he weld metal is slow and it is protected from atmosphere while cooling. The principle of submerged arc welding is shown in the fig. in this case, an automatic feeding device ensure that the gap between the electrode and the base metal is constant. Electric current usually range between 300A and 2000A. The power supply is from a standard single or three phase power lines with a primary rating upto 440V.

Developed in the 1940's submerged arc welding (SAW) process is best suited for the continuous welding of components having 12 to 50mm thickness. This process is used to weld a variety of carbon and alloy steel and stainless steel sheets. Typical applications are the welding of pressure vessels, boiler plates and pipes.

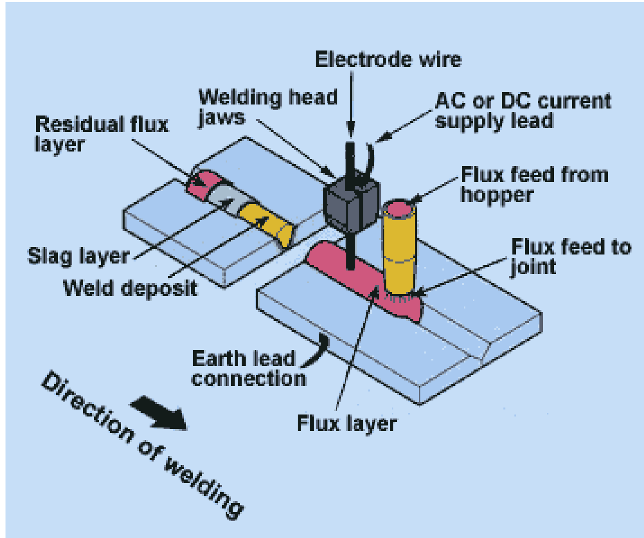


Fig. 7.22 Submerged Arc Welding

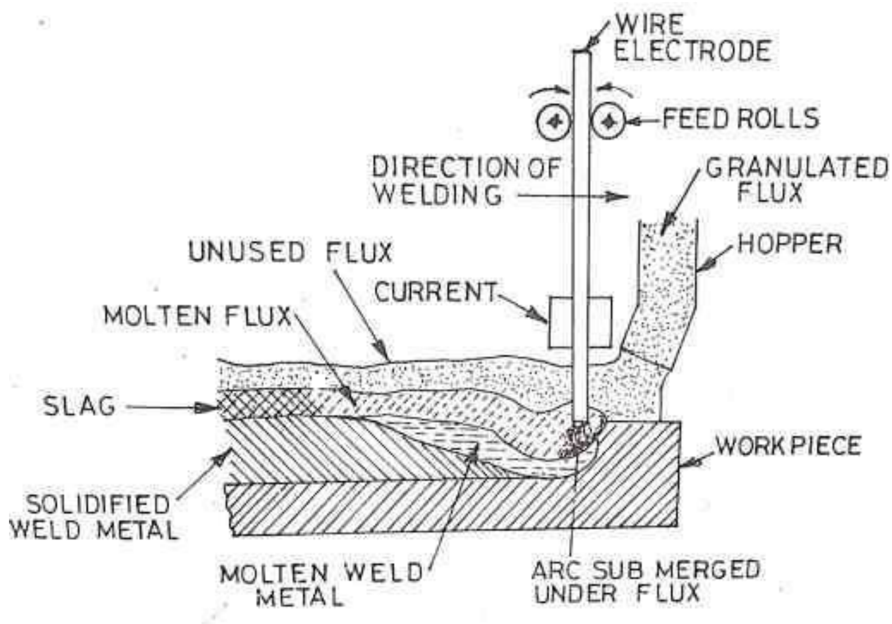


Fig. 7.23 Submerged Arc Welding

TIG Welding:

The tungsten inert gas (TIG) welding is an improvement of basic electric arc welding process. In TIG welding the intense arc is drawn between the work and non-consumable tungsten electrode. The arc and the welding zone are shielded by an inert gas (argon or helium) to avoid atmospheric contamination in the molten weld pool. Depending on weld materials, any standard AC or DC machines may be used to maintain electric arc.

TIG welding is used for welding all metals and alloys having various thickness. It is extensively used for welding aluminium, stainless and titanium. The process is employed for fabrication of missiles, air crafts and rockets. It is also used for fabrication of chemical plant and high pressure stem pipes.

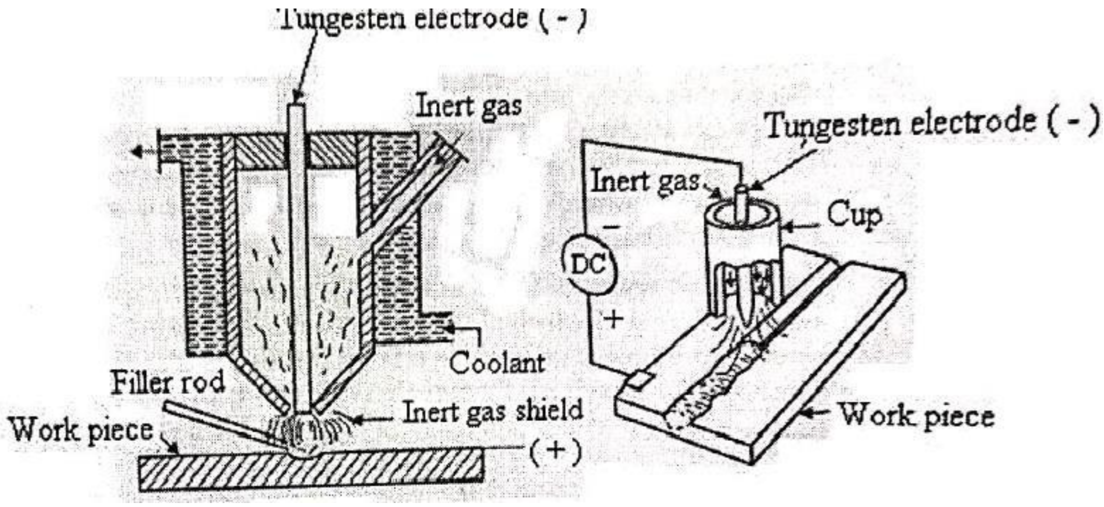


Fig. 7.24 TIG Welding

MIG Welding:

Metal Inert gas (MIG) welding is an arc welding process in which metal electrodes in the form of continuous wire is fed into the arc at the same rate at which it is being melted and deposited in the weld. The arc and the welding zone is shielded by inert gas to prevent atmospheric contaminations. T is also referred as gas metal arc welding (GMAW).

Direct current reverse polarity (DCRP) is generally used in MIG welding . Direct current straight polarity (DCSP) is sometimes used, but AC is not used in MIG due to unequal burn off rates of electrode wire.

MIG welding is used for welding carbon and low alloy steels, stainless steel, heat resistant alloys, magnesium alloys, copper and aluminium alloys. With special techniques (pre heating and post heating), the process can be employed for welding cast iron, titanium and other refractory materials. MIG welding is widely used in aircraft and automobile industries.

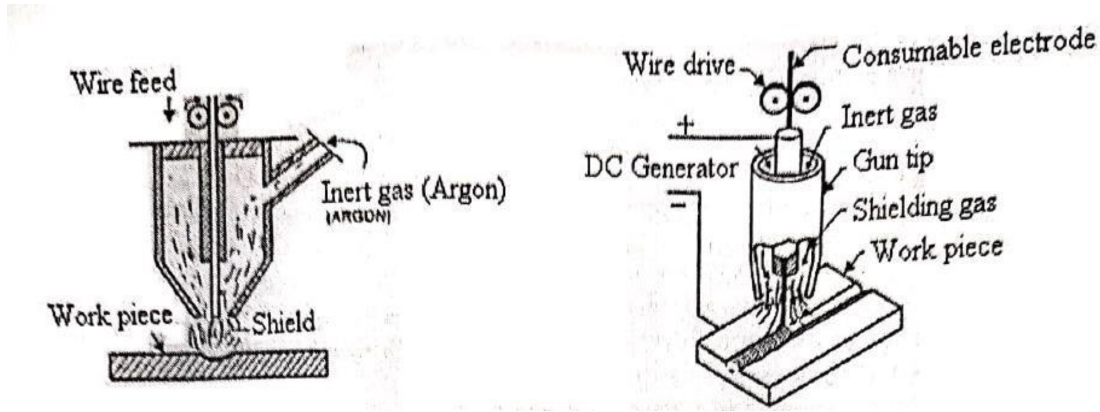


Fig. 7.25 MIG Welding

Thermit Welding:

Thermit welding is an exothermic chemical reaction for the purpose of developing a high temperature. It is a fusion process in which weld is effected by pouring super heated liquid thermit steel around the parts to be united. The heat of "thermit" reaction is utilised to bring the surfaces of metal to be welded into plastic state and mechanical pressure is then applied to complete the weld.

It is based on the chemical reaction between aluminium and iron oxide. The proportions are approximately three parts of iron oxide or magnetic iron scale and one part of aluminium. The reaction that takes place is represented by the following chemical equations.

$$8\ Al + 3\ Fe_3O_4 \rightarrow 9\ Fe + 4\ Al_2O_3 + \text{heat}$$

During the reaction, oxygen from iron oxide separates from it and combines with aluminium (which has strong affinity for it) to form aluminium oxide or slag or super heated thermit steel. During the reaction a very high temperature of the order of 2700^0C is developed. Thermit welding is applied for the repair of heavy parts such as tracks, spokes of driving wheels, broken motor casings, connecting rods and especially in the welding of pipes.

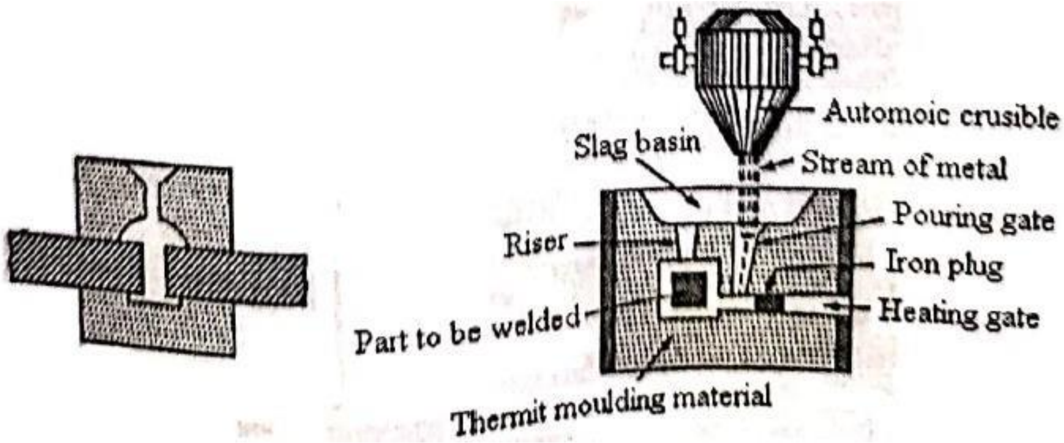


Fig. 7.26 Thermit Welding

Plasma Welding:

It is also called Plasma arc welding. Plasma is defined as a gas heated to at least practically ionized condition, enabling it to conduct an electric current. Plasma arc refers to a constricted electric arc which is achieved by passing the arc through a water cooled copper orifice. Its aim is to obtain high power density of the arc stream.

The plasma arc welding is similar to TIG with the exception that it employs a pilot arc starting circuit and constricting orifice. The arc is collimated and focused by the constricting nozzle made of copper block with cooling water duct and is less sensitive to variation of torch to work distance. The two important dimensions in the construction are orifice diameter and throat length.

Plasma arc welding is widely used for welding stainless steels, nickel alloys, refractory metals in aerospace industries. The plasma arc is not affected by magnetic field and its temperature is around 10,000-14,000^{0}K

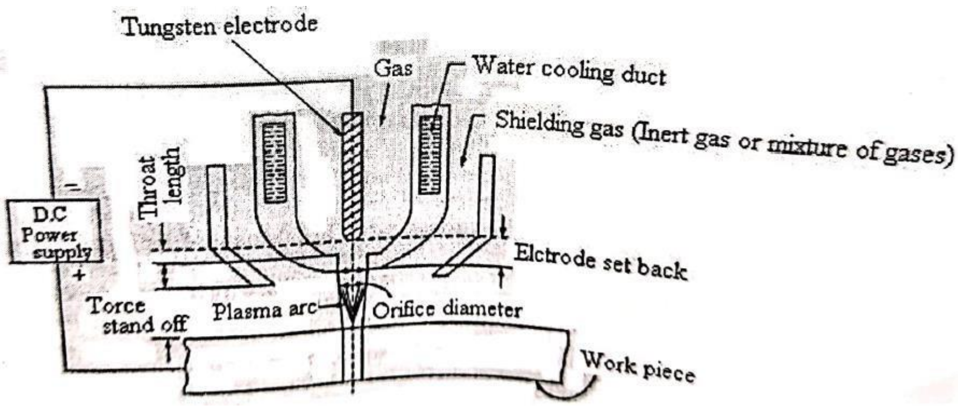


Fig. 7.27 Plasma Arc Welding

Safety Precautions in Welding Shop:

- Always wear a proper face shield.
- Always wear close-toed shoes.
- Always wear a long-sleeved, non-flammable shirt.
- Always wear proper welding gloves.
- Always wear ear protection (earplugs or muffs) to prevent sparks from entering your ear canal. An eardrum punctured by a spark will instantly cauterize and never heal.
- Never weld on or near anything that's been cleaned with a chlorinated hydrocarbon like brake-cleaner. When combined with UV light, chlorinated hydrocarbons can create phosgene gas, which can cause serious injury or death. Ventilation will not prevent poisoning.

SHORT ANSWER QUESTIONS

1. Write the tools used in Forging.
2. Write the forging operations.
3. Write the hammers used in Machine forging.
4. Write about forging presses.
5. Write about plastic and fusion weldings.
6. Where submerged arc welding is used.
7. Draw the Thermit welding and label the parts.
8. Draw Plasma welding and label the parts.

LONG ANSWER QUESTIONS

1. Write the working principle of Arc welding with sketch.
2. Explain the Gas welding principle with sketch.
3. Write the working principles of TIG and MIG welding with sketches.
4. Write the safety precautions required in welding shop.