MECHANICAL WORKSHOP MANUAL

Government College of Engineering & Ceramic Technology

73, A.C. Banerjee Lane

Kolkata-700010

Govt. of West Bengal

Table of Content

MANUFACTURING METHODS

(Contact: 3L)

1.1. Introduction to Manufacturing

Since the beginning of civilization, man has been continuously engaged in converting the natural resources into useful products. The present day style of living and the products we use in our daily routine are solely based on manufacturing. If there is no manufacturing, there would be no aircraft, no ships, no cars, no scooters, no busses, no trains, no mobiles, no TVs, no rockets etc.; we would not even have houses to live in and nothing to wear. Without manufacturing, the lofty ideas of mankind can never become a reality and the society would go back to prehistoric times.

Manufacturing is process of conversion of a raw material of low utility and almost no value because of having no particular dimension, shape, size, characteristics into a product of high utility and value because of having appropriate size, shape, feature, dimensional accuracy and surface finish. So manufacturing is a value addition process.

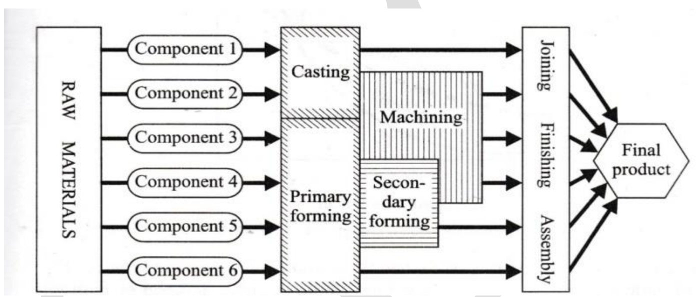


Fig.1.1. Manufacturing Processes

Changing a raw material into a final product generally involves various processes (Fig.1.1). The major manufacturing processes are:

(i) Casting
(ii) Forming
(iii) Machining
(iv) Joining

1.1.1. Casting

In this process, the material is first liquefied by heating in a suitable furnace. Then the liquid is poured into a previously prepared mould cavity where it is allowed to solidify. The solidified part is known as casting.

1.1.2. Forming Process

Forming can be defined as a process in which the desired size and shape are obtained through plastic deformation of a material. The stresses induced during the process are greater than the yield strength but less than the fracture strength of the material.

1.1.3. Machining Process

It is a manufacturing process in which energy is expanded to remove the excess material from a parent work-piece in the form of chips by a wedged shaped cutting tool to obtain desired shape, size, dimensional accuracy, surface finish and surface integrity etc.

1.1.4. Joining Process

Joining process is used to assemble different members to yield the desired complex configuration. The joining of different elements can be either temporary or permanent in nature. For example, Joining with screw elements is temporary whereas joining by welding is permanent in nature.

1.2. Advanced Manufacturing processes

With development of technologies more and more challenging problems are faced by the scientists and technologists in the field of manufacturing. So we will be learning about basic principles of some advanced manufacturing methods from the field of unconventional machining and additive manufacturing.

1.2.1. Abrasive jet machining (AJM)

In this process, the material removal takes place due to impingement of the fine abrasive particles. The particles move with a high speed air (or gas) stream. The stream is directed by means of a suitably designed nozzle on to the work surface to be machined. Material removal occurs due to erosion caused by the abrasive particles impacting the work surface at high speed.

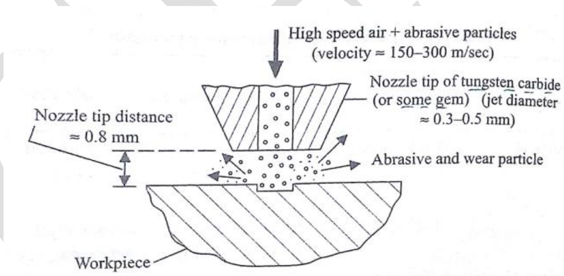


Fig. 1.2: Schematic diagram of AJM

1.2.2. Ultrasonic Machining (USM)

The basic USM process involves a tool (made of ductile an tough material) vibrating with a very high frequency and a continuous flow of an abrasive slurry in the small gap between the tool and the work piece (Fig. 1.3). The tool is gradually fed with a uniform force. The impact of the hard abrasive grains fractures the hard and brittle work surface, resulting in the removal of work material in the form of small wear particles which are carried away by the abrasive slurry.

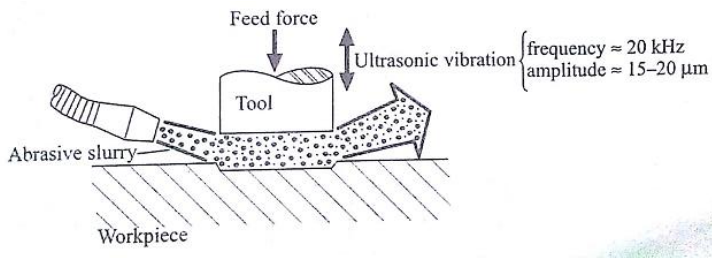


Fig.1.3: Schematic diagram of USM

1.2.3. Electrochemical Machining (ECM)

It is the reverse process of electroplating with some modifications. Te work-piece is connected to the positive and the tool is connected to the negative terminal (Fig.1.4). The gap between the tool and work-piece is filled with a suitable electrolyte. When the current is passed, the dissolution of the anode takes place.

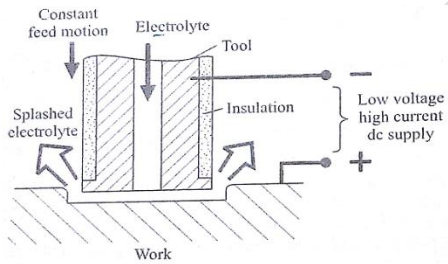


Fig. 1.4: Schematic diagram of ECM

1.2.4. Electric Discharge Machining (EDM)

The process of material removal by a controlled erosion through a series of electric sparks, commonly known as EDM. When discharge takes place between two points of the anode and the cathode, the intense heat is generated near the zone melts and evaporates the materials in the sparking zone.

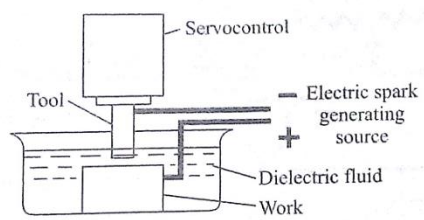


Fig.1.5: Schematic diagram of EDM

1.2.5. Additive Manufacturing

Towards the end of 20th century, the developments in both material science and computer technology reached the required levels for enabling man to imitate nature and develop shaping processes through gradual addition of material. Quite often such process is also known as rapid prototyping.

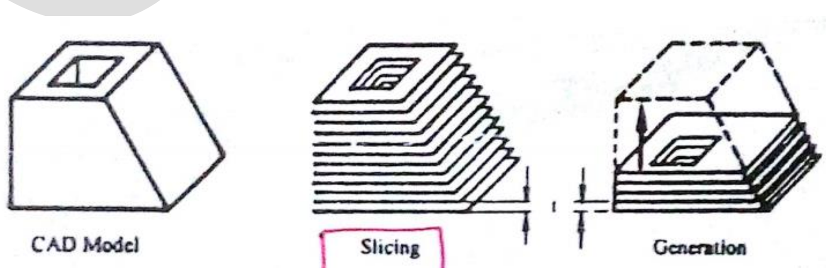


Fig.1.6: Basic principle of the additive manufacturing

CNC Machining and Additive Manufacturing

(Contact: 1L)

2.1. Concept of Numerical Control

Numerical control (NC) is a form of programmable automation in which the mechanical actions of a machine tool or other equipment are controlled by a program containing coded alphanumeric data. The alphanumerical data represent relative positions between a cutting tool and a work-piece. When the current job is completed, the program of instructions can be changed to process a new job. The capability to change the program makes NC suitable for low and medium production.

2.2. Basic Components of an NC System

An operational numerical control system consists of the following three basic components:

i) A part program of instructions
ii) Controller unit, also called machine control unit
iii) Machine tool or processing equipment

2.2.1. Program of Instructions

The part program is the set of detailed step by step commands that direct the actions of the processing equipment. It is coded on a suitable medium in numerical or symbolic that can be interpreted by the controller unit. The most common medium was the 1-inch-wide punched tape, using a standard format that could be interpreted by the machine control unit (MCU).

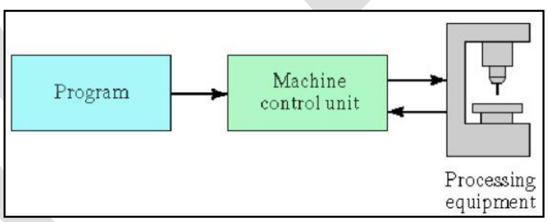


Fig.2.1. Components of NC system

2.2.2. Machine Control Unit (MCU)

The MCU consists or a microcomputer and related control hardware that stores the program of instructions and executes it by converting each command into mechanical actions of the processing equipment, one command at a time. Because the MCU is a computer, the term computer numerical control (CNC) is used to distinguish this type of NC from its technological predecessors that were based entirely on hard-wired electronics.

2.2.3. Machine Tool

The third basic component of an NC system is the processing equipment that performs useful work.

2.3. Example of NC Programming

The cylindrical work-piece clamped in the lathe chuck is to be machined to produce a stepped shaft. The following figure depicts the components of a NC system.

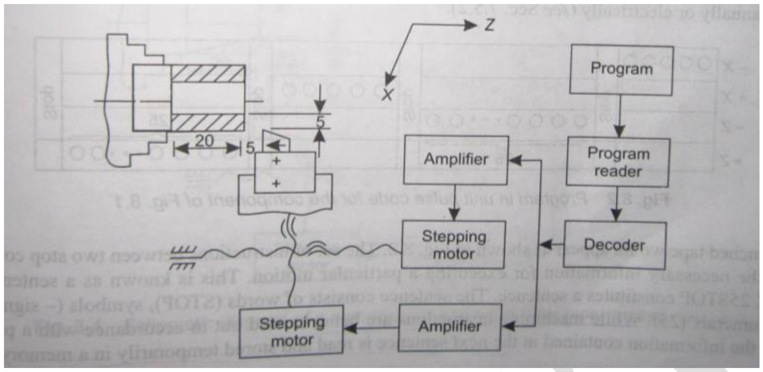


Fig.2.2. Schematic diagram of a NC system for simple turning operation

The steps of the tool post travel are as follows:

i) Travel the tool post in –X direction through 5 mm.
ii) Travel the tool post in –Z direction through 25 mm.
iii) Travel the tool post in +X direction through 5 mm.
iv) Travel the tool post in +Z direction through 25 mm.

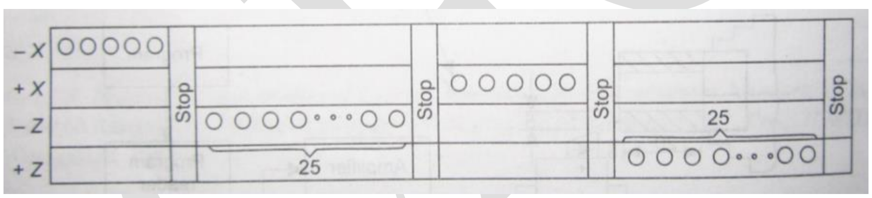


Fig.2.3. Program in unit pulse code for the component of Fig.2.2

2.4. Limitations of NC

i) NC requires training of personnel both for software as well as hardware.
ii) In preparing punched tape part programming mistakes are common. The mistakes can be corrected by replacing the tape again.
iii) Paper tapes are fragile and susceptible to tear.

2.5. Computer Numerical Control

Since the introduction of NC in 1952, there have been dramatic advances in digital computer technology. It was logical for the makers of NC equipment to incorporate these advances in computer technology into their products, starting first with large mainframe computers in the 1960s, followed by minicomputers in the 1970s, and microcomputers in the 1980s. Today, NC means computer numerical control.

Computer numerical control (CNC) is defined as an NC system whose MCU is based on a dedicated computer rather than on a hard-wired controller.

2.6. Advantages of CNC Machine Tools

i) Greater flexibility in terms of storage of programs and edit ability of the programs.
ii) Reduced data reading error.
iii) Conversion of units is possible within the computer memory.

2.7. Application of CNC

CNC is being used in following machines:

- Milling machine
- Turning machine
- Boring machine
- Drilling machine
- Grinding machine
- Welding and several other areas.

2.8. Additive Manufacturing

A fundamentally new concept in shaping of objects has emerged in the recent past. The final object is obtained by gradual addition of material (like construction of buildings). This process is known as generative manufacturing processes or additive manufacturing. The original state of the work material can also be liquid, powder or solid (in the form of foil or wire).

By rapid prototyping processes a solid object with prescribed shape, dimension and finish can be directly produced from the CAD based geometric model data stored in a computer without human interventions. The CAD model is split into layers as shown in Fig. 2.4. The slice thickness and slicing direction can be varied for convenience of generation. There after the object is fabricated through layer by layer.

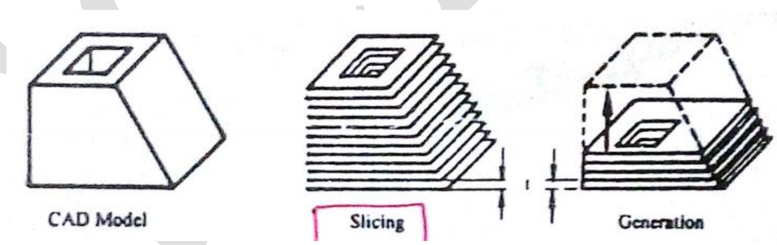


Fig.2.4: Basic Principle of additive manufacturing

Various rapid prototyping techniques are developed. They can be classified in three main categories, depending on the form of the starting material and the name of some techniques of each group is given below:

i) Liquid based: Stereo-lithography, solid ground curing, fused deposition modeling, beam interference solidification.
ii) Solid based: Laminated object manufacturing, solid foil polymerization.
iii) Powder based: Selective laser sintering, selective powder binding.

Fitting Operations and Power Tools

(Contact: 1L+3P)

3.1. Introduction

In engineering, particularly in heavy and medium engineering, even to-day, with the use of automatic machines, bench work and fitting have important roles to play to complete and finish a job to the desired accuracy. Although majority of the work can be finished to fairly good degree of accuracy in a reasonable time through various machining operations they still require some operations to be done on them to finish the job by hand. Much of the raw materials go into the machine shop and re-appear as a finished component ready for assembly; some parts need both machining and then a certain amount of work in fitting; other parts are entirely made and fitted on the bench.

The term “bench work” generally denotes the production of an article by hand on the bench. “Fitting” is the assembling together of parts and removing metals to secure the necessary fit, and may or may not be carried out at the bench. It is seen that there is no clear dividing line between these two terms, and in most cases they are both concerned, and the terms are used rather loosely.

However, all these two types of work require the use of a large number of tools and equipments and involve a number of operations to finish the work to the desired shape and size. The operations commonly used in bench and fitting work may be classified as:

i) Chipping
ii) Filing
iii) Scrapping
iv) Grinding
v) Sawing
vi) Marking
vii) Drilling
viii) Reaming
ix) Tapping
x) Dieing

3.2. Study of Different Tools

3.2.1. Bench Vice

The most commonly used is the engineer’s parallel-jaw bench vice, sometimes called fitter’s vice. It must be firmly fixed to the bench with coach screws, or with nuts and bolts. The vice essentially consists of cast iron body, a fixed jaw, a movable jaw—both made of cast steel, a handle, a square-threaded screw, and a nut—all made of mild steel. Separate cast steel plates known as jaw plates are fixed to the jaws by means of set screws and they can replaced when worn. The holding faces of the jaw plates have teeth for holding the work firmly but this has some disadvantage for soft metal which may be damaged when firmly held between the faces. The movement of the vice is caused by the movement of the screw through the nut fixed under the movable jaw and screw is provided with a collar inside to prevent it from coming out of the jaw when revolved. The size of a vice is known by the **width of the jaws**. The width suitable for common work varies from 80 to 140 mm, the **maximum opening** be 95 to 180 mm.

3.2.2. Hammer

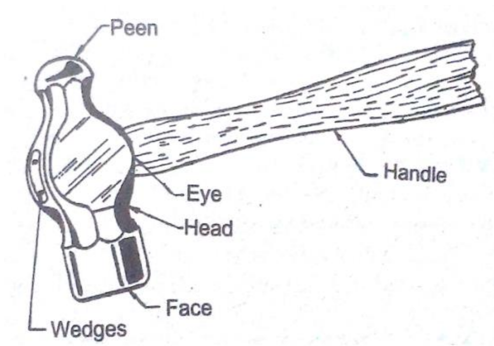


Fig.3.1: Ball peen hammer

Hammers are used to strike a job or a tool. They are made of forged steel of various sizes (weights) and shapes to suit various purposes. A suitable range would be from 0.11 to 0.33 kg for light work such as clinching small rivets and dot punching, 0.45kg for chiselling, 0.91 kg for heavier work such as chipping, the popular sizes for bench work being 0.33 and 0.45 kg.

A hammer consists of four parts namely peen, head, eye and face. The eye is normally made oval or elliptical in shape and it accommodates the handle or shaft. The end of the handle which fits into the eye is spread or split by forcing a metal wedge into it to prevent the hammer head from flying off the handle during striking. The handle is made of elastic wood or bamboo and is so shaped and sized that when gripped it gives an easy feel to the hand. This “feel” is known as “balance” of the hammer. A well balanced hammer “feels” just right when the handle is grasped at the correct point. The face is hardened and polished well, and is slightly convex, instead of flat to avoid spoilage of the surface of the metal to be hammered by the sharp edge of the flat surface. On an average, the hammer should be 250 to 325 mm long. The length of handles for light hammers is 200 to 260 mm, and that for heavy hammers is 380 to 450 mm.

Hammers are classified, according to the shape of the peen, as ball peen, cross peen and straight peen hammers.

3.2.2.1. Ball peen hammers

This is most common form of hammer and is sometimes called engineer’s hammer, or chipping hammer. The peen has a shape of a ball which is hardened and polished. This hammer is chiefly used for chipping and riveting. The size of this hammer varies from 0.11 to 0.91 kg.

3.2.2.2. Cross peen hammer

This is similar to ball peen hammer in shape and size except the peen which is across the shaft or eye. This is mainly used for bending, stretching, hammering into shoulders, inside curves, etc. The size varies from 0.22 to 0.91 kg.

3.2.2.3. Straight peen hammer

This hammer has a peen straight with the shaft, i.e., parallel to the axis of the shaft. This is used for stretching or peening the metal. The size varies from 0.11 to 0.91 kg.

3.2.3. Flat chisel

It is the most common of all the chisels used in engineering. It is the chisel which is used for most of the general chipping operations. It may be used for removing surplus metal from surfaces of jobs. The length of the flat chisel varies from 100 to 400 mm, while the width of the cutting edge varies from 16 to 32 mm.

3.2.4. Files

The most widely used hand tool to be found in an engineering workshop is the file. A file is a hardened piece of high grade steel with slanting rows of teeth. It is used to cut, smooth, or fit metal parts. It cuts all metals except hardened steel.

A file consists of tang, heel, face, edge and point as shown in figure below.

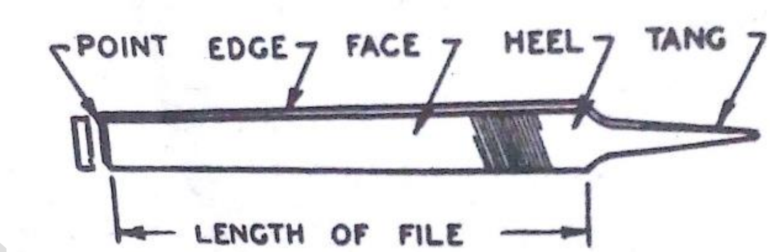


Fig.3.2: Different parts of a file

There are two categories of files depending on the cut of teeth.

Single-cut file: The teeth are cut parallel to other across the file at an angle of 60° to the centre line of the file.

Double cut file: They have two sets of teeth. One set is at 60° to the centre line whereas the up-cut teeth are at 80°.

The files are further divided according to the closeness or spacing between the rows of the teeth. In descending order the list is as follows:

i) Rough file
ii) Bastard file
iii) Second cut file

iv) Smooth file
v) Dead smooth file
vi) Super smooth file

Most commonly used files have following cross sectional shapes.

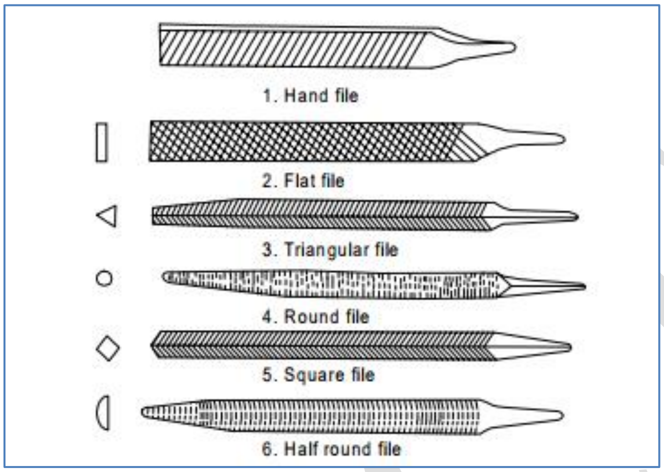


Fig.3.3: Classification of files according to cross section

3.2.4.1. Flat file

This is tapered in width and thickness, and one of the most commonly used files for general work. They are always double-cut on the faces and single-cut on the edges.

3.2.4.2. Hand file

This is parallel in its width, and tapered in thickness. A hand file is used for finishing flat surfaces. It has one edge (i.e., it is uncut) and therefore, is useful where the flat file cannot be used. They are always double-cut.

3.2.4.3. Square file

This is square in cross-section, double-cut and tapered towards the point. This is used for filing square corners, enlarging square or rectangular openings as splines and keyways.

3.2.4.4. Round file

They are round in cross-section and usually tapered, when they are termed rat-tailed. When parallel they are described as parallel round. Round files are used for filing curved surfaces and enlarging round holes and forming fillets. They may be single-cut or double-cut.

3.2.4.5. Triangular file

Three square or triangular file is tapered, double-cut, and the shape is that of an equilateral triangle. They are used for rectangular cuts and filing corners less than 90°.

3.2.4.6. Half round file

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

3.2.5. Methods of filing

Normally the work is held in a vice and the operator should place his/ her left foot in the direction of file stroke and his/ her right foot should be placed at angle of 90° in relation left foot. The two methods of filing are cross filing and draw filing. The aim of cross filing is always to move the whole of the file surface across the whole of the work surface in one stroke. In draw filing smoother cutting action is achieved.

3.2.6. Punch

A punch is used in a bench work for marking out work, locating centres, etc. in a more permanent manner. Two types of punches used are: prick punch, and centre punch. The prick punch is a sharply pointed tool. The tapered point of the punch has an angle of usually 40°. It is used to make small punch marks on layout lines in order to make them last longer.

The centre punch looks like a prick punch. Its point has an angle more obtuse than that of the prick punch point, this angle usually being 60°. The centre punch is used only to make the prick-punch marks larger at the centres of holes that are to be drilled, and hence the name centre punch. A strong blow of the hammer is needed to mark the point.

In its body portion, the punch is a steel rod 90 to 150 mm long and 8 to 13 mm in diameter.

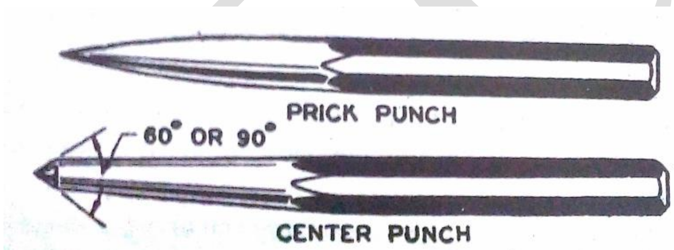


Fig. Punches

3.2.7. Callipers

A calliper is a device used to measure the distance between two opposite sides of an object. A calliper can be as simple as a compass with inward or outward-facing points. The tips of the calliper are adjusted to fit across the points to be measured, the calliper is then removed and the distance read by measuring between the tips with a measuring tool, such as a ruler.

Inside calipers: These are used to measure the internal size of an object.

Outside calipers: These are used to measure the external size of an object.

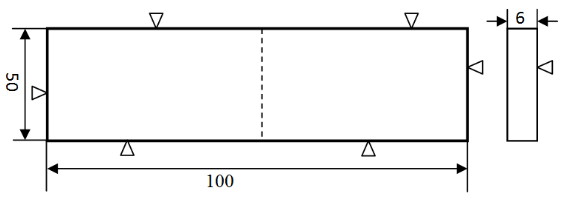
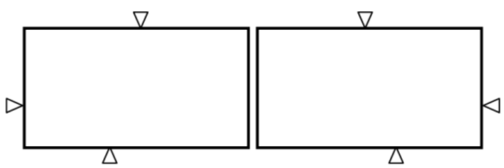
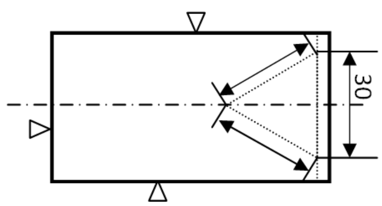
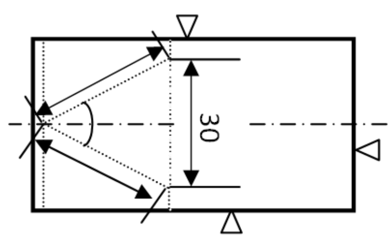
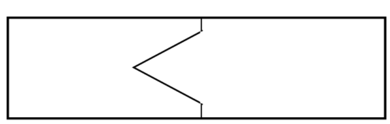
Divider calipers: The points are sharpened so that they act as scribers, one leg can then be placed in the dimple created by a centre or prick punch and the other leg pivoted so that it scribes a line on the work-piece's surface, thus forming an arc or circle. A divider calliper is also used to measure a distance between two points. The calliper's two ends are brought to the two points whose distance is being measured. The calliper's opening is then measured on a separate ruler.

Government College of Engineering & Ceramic Technology

Engineering Workshop

Job Name: Making of V-groove and V-notch

Material: Mild Steel plate of dimension 100 $mm \times 50$ $mm \times 6$ mm

Sketch of operation	Operation	Tools and Gauges
1. 	1. Filing 2. Checking of perpendicularity of surfaces 3. Marking	1. Files 2. Try square 3. Steel rule 4. Odd leg caliper 5. Punch 6. Hammer
2. 	4. Parting off into two halves	5. Hack saw
3. 	1. Marking for V-Groove 2. Punching 3. Sawing 4. Filing	1. Odd leg caliper 2. Divider 3. Steel rule 4. Punch 5. Hammer 6. Hack saw 7. Files
4. 	1. Marking for V-Notch 2. Punching 3. Sawing 4. Filing	1. Odd leg caliper 2. Divider 3. Steel rule 4. Punch 5. Hammer 6. Hack saw 7. Files
5. 	1. Final Checking	1. Try square 2. Standard Specimen

Name:…………………………………………………………………………………………

Roll No.:……………………………………………………Section:……………………………

Department:……………………………………………..Date:…………………………………

3.3. Assignment: Making of V-Groove and V-Notch

3.3.1. Aim
To make V-groove and V-notch

3.3.2. Tools Required
Files, Try square, Steel rule, Odd leg calliper, Punch, Hammer, Hack saw, Divider.

3.3.3. Procedure
i) File all surfaces to smoothen and clear them.
ii) The dimensions of the piece are checked with the steel rule.
iii) The piece is checked for flatness and perpendicularity of surfaces with the help of the try square.
iv) The piece is parted off into two equal halves.
v) Chalk is then applied on the surface of the two pieces.
vi) On one of the piece marking for V-groove is made while on the other marking for V-notch is made.
vii) Dots are punched along the lines scribed in previous step.
viii) Using the hacksaw, the unwanted portions are removed.
ix) Filing is done to smoothen the freshly cut surface.
x) The pieces are fitted together and are checked for the correctness of the fit. Any defects noticed are rectified by filing with a smooth file.

3.3.4. Conclusion
Bench Working is one of the most important processes in the workshop. I have acquired the knowledge of the technique of filing, measuring, chiseling, and all others tools I required to accomplish the task. Though the finished job was not of a professional level, it was still acceptable.

3.3.5. Precaution
i) Care should be taken while marking.
ii) Care should be taken while hack sawing.
iii) Use cleaning brush is required while removing chips.
iv) Safety practices of workshop are to be followed

3.3.6. Application
This particular job is designed for making us aware about major processes and uses of different tools of fitting section of workshop. The v notch weir is very good for measuring flow rate of open channel flow.

3.4. Power tools
Power tools use additional external power sources, other than human power, in order to enhance productivity. They are generally powered by an electric motor, a compressor, or by an internal

combustion engine. Power tools are classified as either stationary or portable, where portable means handheld.

They are used in industry, in construction, and around the house for cutting, shapping, drilling, painting, grinding, and polishing.

Stationary power tools for metalworking are usually called Machine tools. The lathe is the oldest known power tool. A table saw not only cuts faster than a hand saw, but the cuts are smoother, straighter and more square than manual job. An electric motor is the universal choice to power stationary tools. Portable electric tools may be either corded or battery-powered. Common power tools include the drill, various types of saws, the router, the electric sander etc. The term power tool is also used in a more general sense, meaning a technique for greatly simplifying a complex or difficult task.

CARPENTRY

(Contact: 1L+3P)

5.1. Introduction

Carpentry is a common term used with any class of work with wood. Timber is the basic material used for any class of woodworking. The term 'timber' is applied to the trees which provide us with wood. Wood is one of the most valuable bio-degradable raw materials of industry and daily uses. It is available in a wide choice of weights, strength, colours and textures. Wood is having good machining characteristics and can be sliced, bent, planed, sawed and sanded.

Indian timbers most commonly used for various wood works are babul, mahogany, mango, sal, sissu, teak etc.

5.2. Seasoning of Wood

The advantages of seasoning are that it makes the timber lighter in weight, more resilient, and less liable to twist, warp, and split. It is also in a better condition to retain its size and shape after being made into a piece of joinery. Wood increases in strength, hardness and stiffness as it dries. There are two methods of drying or seasoning.

5.2.1. Natural seasoning

This is also known as air drying. In this method the balks (roughly squared logs) are stacked under cover with spacers in between, so that a free circulation of air is provided all round them. This method is slow, but gives the best results. A further period of seasoning should also take place after the balks are cut by sawing and converted into planks or boards. This is to help dry out the interior of the timber which has been exposed by sawing.

5.2.2. Artificial seasoning

In the artificial seasoning method, the period of seasoning is very much reduced, a matter of two or three weeks being sufficient, according to the size of species of timber to be seasoned. The timber is stacked on a special truck and wheeled into a chamber which is then sealed. Hot air is circulated by fans, and a certain amount of steam is added in order to retain the correct humidity. Samples are tested at intervals to ascertain the percentage of moisture remaining in the timber. Seasoned timber still contains a proportion of moisture, which varies from 16 to 22% according to the seasoning conditions, and this need not be dried out any further is intended for use out-of-doors.

5.3. Carpentry Tools

In order to successfully work different forms to accurate shapes and dimensions, the wood-worker must know the use of a large number of tools. Some popular tools are described illustrated below:

i) Marking and measuring tools

ii) Cutting tools

iii) Planning tools

v) Striking tools

vi) Holding and miscellaneous tools

5.3.1. Making and Measuring Tools

5.3.1.1. Rules

Rules of various sizes and designs are used by wood-workers for measuring dimensions. They generally range from 0 to 60 cm. This is graduated on both side in millimeters and centimeters. For larger measurements carpenters use a flexible measuring rule of tape. Such rules are very useful for measuring curved and angular surfaces. When not in use, the blade is called into a small compact, watch-size case.

5.3.1.2. Try Square

Try squares are used for marking and testing angles of 90°. It consists of a steel blade, riveted into a stock. Sizes vary from 150 to 300 mm, according to the length of the blade.

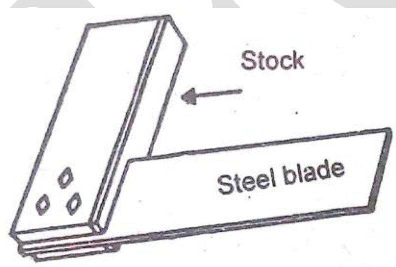


Fig.5.1: Try square

5.3.1.3. Marking Gauge

Gauges are used to mark lines parallel to the edge of a piece of wood. It consists of a small stem sliding in a stock. The stem carries one steel marking points or a cutting knife. The stock is set to the desired distance from the steel point and fixed by the thumb screw. The gauge is then held firmly against the edge of the wood and pushed along the sharp steel point marking the line.

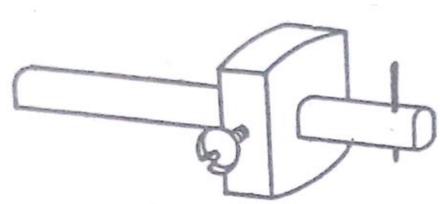


Fig.5.2: Marking gauge

5.3.2. Cutting Tools

5.3.2.1. Cross Cut Hand Saw

When cutting across the grain, a different action is required from the saw teeth than when ripping with the grain. Therefore, different types of saws are used, as one type cannot do both jobs successfully. A saw is generally specified by the length of its blade measured along the toothed edge, and pitch of teeth, expressed in millimeters. Cross-cut saws, or "hand saws" as they are sometimes called, are used for cutting across the grain in thick wood. They are 600 to 650 mm long with 8 to 10 teeth per 25 mm. The action of the teeth is that of a series of knives which sever the fibres and force out the waste wood in the form of saw dust. A saw should never be forced and it is kept moving steadily for nearly its full length. Its own weight plus the slightest pressure is all that is needed.

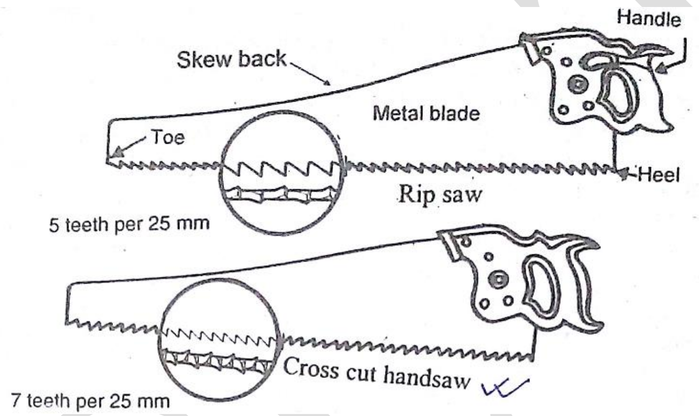


Fig.5.3: Cross cut handsaw

5.3.2.2. Chisels

Wood chisels most commonly in use include firmer chisel, either square of bevel edged and mortise chisels.

5.3.2.2.1. Firmer Chisel

The firmer chisel is the most useful for general purposes and may be used by hand pressure or mallet. It has a flat blade about 125 mm long. The width of the blade varies from 1.5-50 mm.

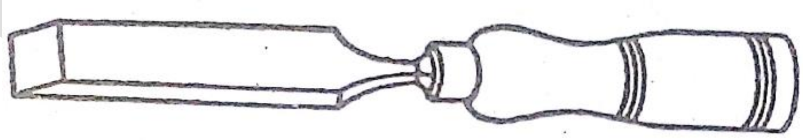


Fig.5.4: Firmer chisel

5.3.2.2.2. Mortise Chisel

The mortise chisel as its name indicates is used for chopping out mortises. These chisels are designed to withstand heavy work. They are made with a heavy deep (back to front) blade with a generous shoulder or collar to withstand the force of the mallet blows on the oval-sectioned handle. Many mortise chisels are fitted with a leather washer at the shoulder to absorb the hard shocks of the mallet blows. Blades very in width from 3-16 mm.

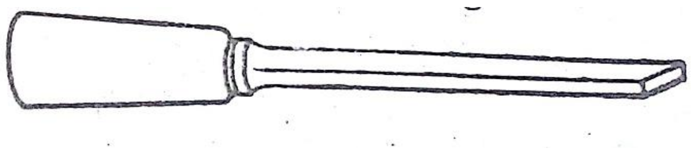


Fig.5.5: Mortise chisel

5.3.3. Planing Tools

5.3.3.1. Jack Plane

It consists of a block of wood or metal into which the blade is fixed by a wooden wedge. The blade is set at an angle of 45° to the sole. On the cutting blade another blade is fixed called cap iron or back iron. This does not cut, but stiffens the blade near its cutting edge to prevent chattering and partially breaks the shaving as it is made. It is the back iron which causes the shavings to be curled when they come out of the plane. Some types of planes do not have a cap iron. Jack planes are obtainable from 350 to 425 mm in length and with blades 50 to 75 mm wide.

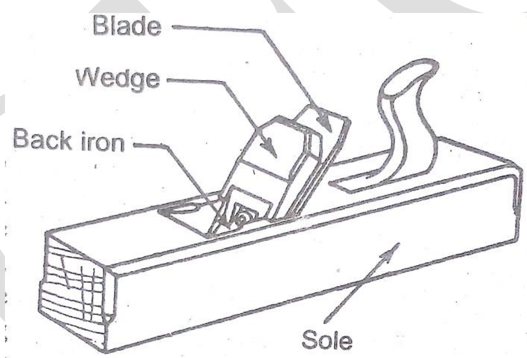


Fig.5.6: Jack plane

5.3.3.2. Trying Plane

The trying plane is a finishing plane, and is set with a very fine cut. It is used for producing as true surfaces or edge as possible, and is set to cut a shaving as thin as the smoothing plane. The length of the plane varies from 550 to 650 mm and the section of the body is 85 mm by 85 mm, with irons 60 mm wide.

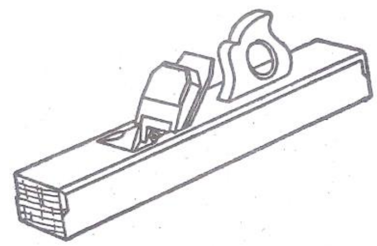


Fig.5.7: Trying plane

5.3.4. Striking tools

Striking tools include hammers and mallets.

5.3.4.1. Hammer

Engineers generally use ball peened hammer. Claw hammer is more favoured by the carpenters because it serves the dual purpose of a hammer and a pair of pincers. The claw is used for pulling out any nails accidently bent in driving. These hammers are made in numbers sizes from 1 to 4, weighing 375, 450, 550 and 675 gm.

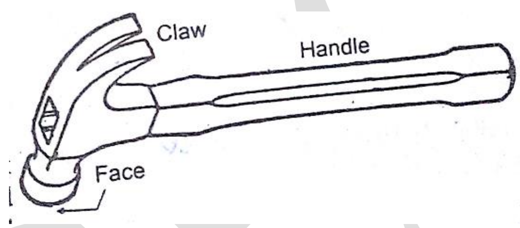


Fig.5.8: Claw Hammer

5.3.4.2. Mallet

The mallet is a wooden-headed hammer of round or rectangular cross-section. The striking face is made flat to the work. A mallet is used to give light blows to the cutting tools having wooden handle.

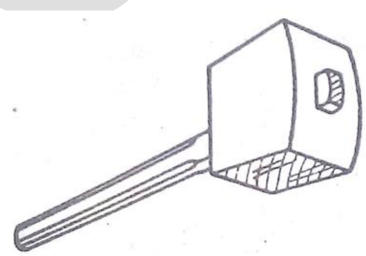


Fig.5.9: Mallet

5.3.5. Holding tools

To enable the woodworker to cut his wood accurately, it must be held steady. There are a number of tools and devices to hold wood having its own purpose according to the kind of cutting to be done.

5.3.5.1. Bench vice

The bench vice is the most commonly used. Its one jaw is fixed to the side of the table while the other is kept movable by means of a screw and a handle. The whole vice is made of iron and steel, the jaws being lined with hardwood face which do not mark and which can be renewed as required.

5.3.6. Miscellaneous tools

5.3.6.1. Rasps files

These are useful for cleaning up some curved surfaces. Scratches left by the file can be removed with the glass paper. A rasp is coarse form of file used for coarsely shaping wood. Typically a hand tool, it consists of a generally tapered rectangular, round, or half-round sectioned bar of case hardened steel with distinct, individually cut teeth. A narrow, pointed tang is common at one end, to which a handle may be fitted.

5.4. Carpentry Joints

Some popular woodworking joints are halving joints, mortise and tenon joints and dovetail joints.

5.4.1. Halving joint

The aim of this joint is to secure the corners and intersections of the framing, and at the time keep all the face flush, that is, in the same plane.

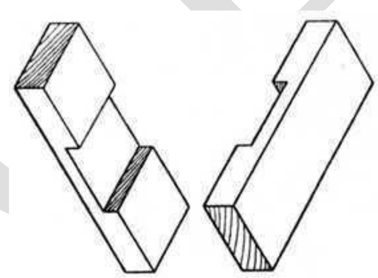


Fig. 5.10: Cross Halving Joint

5.4.2. Mortise and tenon joint

This family of joint is a large one and is probably the commonest used by the woodworker. Woodworkers around the world have used it for thousands of years to join pieces of wood, mainly a rectangular peg (tenon) fitting into a rectangular hole (mortise) at an angle of 90°.

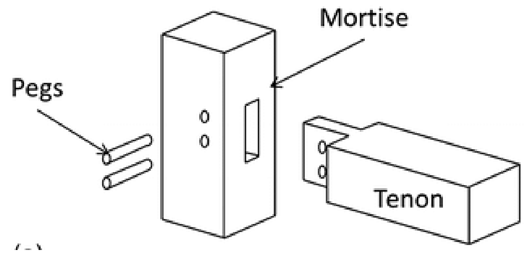


Fig.5.11: Mortise and tenon Joint

5.4.3. Dovetail joint

The dovetail joint is probably the strongest of all the corner joints. It was primarily a joint intended to take a strain in one direction, but it has several variations and many applications: from small boxes to large pieces of furniture.

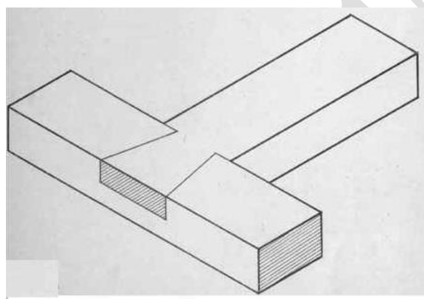


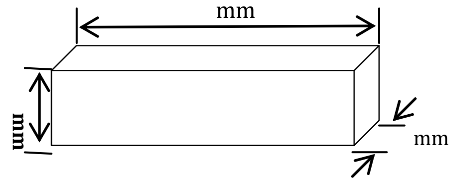
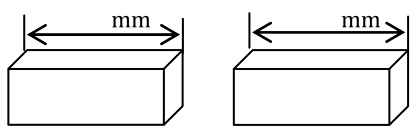
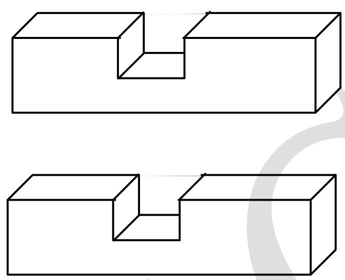
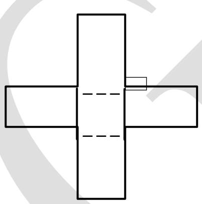
Fig.5.12: Dovetail Joint

Government College of Engineering & Ceramic Technology

Engineering Workshop

Job Name: Making wooden Halving Joint

Material: Teak Wood of dimension …...... $mm \times \ldots \ldots \ldots . mm \times \ldots \ldots . . mm$

Sketch of operation	Operation	Tools and Gauges
1. 	4. Planing and squareness checking 5. Marking	7. Jack Plane 8. Try square 9. Marking gauge 10. Steel rule
2. 	1. Parting off into two halves	1. Hand saw
3. 	5. Sawing 6. Chiseling	8. Hand saw 9. Firmer chisel 10. Mallet 11. Rasp file
4. 	6. Final check for the perpendicularity of the job	1. Try square

Name:……………………………………………………………………………………………

RollNo.:…………………………………………………………Section:……………………………

Department:……………………………………………..Date:…………………………………

5.5. Assignment: Making wooden Halving Joint

5.5.1. Aim

To make wooden halving joint

5.5.2. Tools required

Jack plane, try square, marking gauge, steel rule, hand saw, firmer chisel, mallet, and rasp file.

5.5.3. Procedure

I. Prepare material to size, as per given dimensions by planning.
II. Part off the wood into two equal halves.
III. Mark middle lines across each surface.
IV. On each piece, mark two lines which are going to be spaced out as far as the thickness of the other piece of timber.
V. Cut along the lines made in step (IV) with a hand saw. Make sure to cut only half the thickness of the timber.
VI. Now remove the excess timber with a mallet and a chisel which should leave a tight interlocking joint.
VII. Smooth the inner surface with a rasp file.
VIII. Finally check for the perpendicularity of the job by using a try square.

5.5.4. Conclusion

The job was done with utmost care and the final product is very near to perfection and can be used wherever required.

5.5.5. Precautions

I. Always wear safety equipment.
II. Wear appropriate clothing. Avoid loose-fitting clothing. Remove jewellery such as neck chains or bracelets.
III. Use sharp blades and bits.
IV. One should not use defective or damaged carpentry tools and machines while carrying out work in carpentry shop.
V. No carpentry tools should be thrown for saving time in handling.

5.5.6. Applications

I. Low cost frame type construction
II. Partitions in trays and drawers
III. Rails of table and chair

PLASTIC MOULDING AND GLASS CUTTING

(Contact: 1L+2P)

6.1. Introduction

Plastics are now inseparable from modern lifestyle. Plastics have successfully eliminated the use of metals and other natural products like wood and rubber. To enumerate a few types of products, we have plastic containers, polyester clothes, computer parts, automobile components, items of furniture, dolls, tool handles, plastics roofing sheets, site cabins, tents, waterproof sheets, kitchen wares, bags, etc.

6.2. Advantages of plastics

The main advantages in manufacturing in plastics are as follows:

i) Plastics are low temperature melting and setting materials and hence can be easily moulded in metal moulds.
ii) Cast plastic components generally don't need machining.
iii) Plastics are low density material and so components are lighter.
iv) Plastics can take a large number of colours so the components are good looking.
v) Plastics are not affected by acids and alkalis.

6.3. Types of plastics

Plastics materials are of two types:

i) Thermoplastics: These get soft on heating and can be easily moulded. Thermoplastics can be used again. Some examples of this class are: acrylic, nylon, polycarbonates, PVC etc.
ii) Thermosetting plastics: These materials are moulded only once. They cannot be remelted. On heating, they disintegrate and burn out. Some examples of this class are: Bakelite, epoxy resin, polyamides, polyester resin etc.

6.4. Manufacturing processes used for thermoplastics

The processes used for manufacturing thermoplastics are:

i) Vacuum forming of thermoplastics sheets
ii) Injection moulding
iii) Blow moulding

6.4.1. Vacuum forming of thermoplastics sheets

The process involves heating a plastic sheet until soft and then wraps it over a mould. A vacuum is applied sucking the sheet into the mould. The sheet is then ejected from the mould. In its advanced form, the vacuum forming process utilizes sophisticated pneumatic, hydraulic and heat controls thus enabling higher production speeds and more detailed vacuum formed applications.

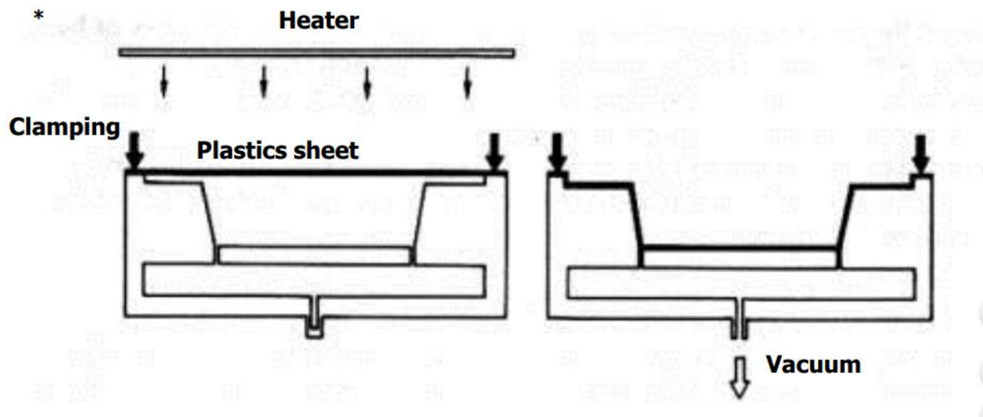


Fig.6.1: Vacuum forming machine

6.4.2. Injection moulding

The basic manufacturing process of injection molding comprises of melting of the plastic in the plastic injection moulding machine and then injection into a mold under high pressure. There, the material is cooled, solidified and afterwards released by opening the two halves of the mold. This technique results in a plastic product with a predetermined, fixed form.

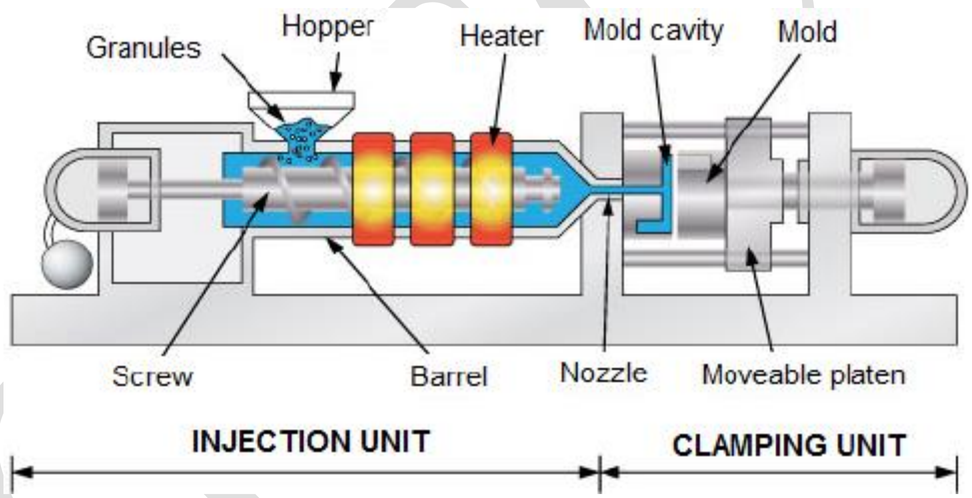


Fig.6.2: Injection moulding machine

6.4.3. Blow Moulding

It is used for producing hollow plastic components such as bottles, containers etc. A simple blow moulding process is illustrated in Fig.6. 3. The following sequence of operations is followed.

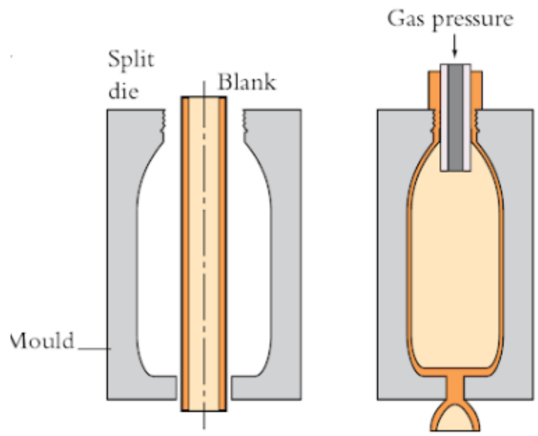


Fig.6.3: Schematic diagram of blow moulding operation

6.5. Manufacturing processes used for thermoset plastics

The thermoset plastic powder is heated to make it soft. It is then pressed into dies with a plunger and allowed to set at the desired temperature. The processes used for manufacturing thermoset plastics are:

i) Transfer moulding
ii) Compression moulding

6.5.1. Transfer moulding

Transfer molding process combines the principle of compression and transfer of the charge. In the transfer molding, the charge is transferred from the transfer pot to the mold. The mold is cooled and molded part is ejected. The schematic of transfer molding process is shown in Fig.6.4. In this process, the required amount of charge is weighted and inserted into the transfer pot before the molding process. The transfer pot is heated by the heating element above the melting temperature of the charge. The liquid charge is gravity filled through the sprue to the mold cavity. A "piston and cylinder" arrangement is built in the transfer pot so that the resin is squirted into the mold cavity through a sprue. The plunger is also preheated in the transfer pot. The plunger is used to push the liquid plastic charge from the transfer pot into the mold cavity under pressure. The mold cavity remains closed as the polymer charge is inserted. The mold cavity is held closed until the resin gets cured. The mold cavity is opened and the molded part can be removed once it has hardened with the help of ejector pin. The sprue and gate attached to the molded part have to be trimmed after the process has been completed.

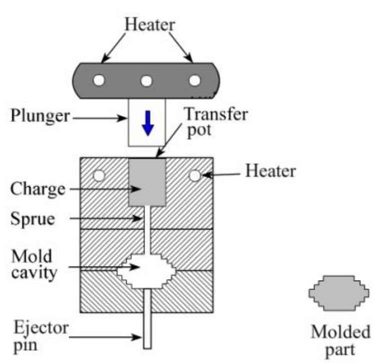


Fig.6.4: Transfer moulding process

6.5.2. Compression Molding

Compression molding process is one of the low cost molding methods as compared to injection molding and transfer molding. It is a high pressure forming process in which the molten plastic material is squeezed directly into a mould cavity by the application of heat and pressure to conform to the shape of the mold. The schematic of compression molding process is shown in Fig.6.5.

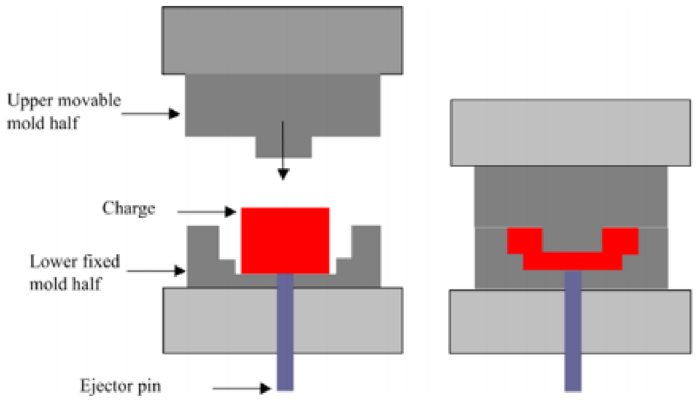


Fig.6.5: Compression Moulding

6.6. Working with Glasses

Glasses are widely used materials, from window panes as building material, to automobiles, aircraft, as TV and mobiles screens, light bulbs, kitchen wares, decoration articles, spectacles for eye sight, sun glasses, laboratory apparatus, etc., to glass fibers as reinforcing material for composites. Glasses are amorphous, non-crystalline solid material. Glass is generally transparent, hard, brittle, chemically iert, biologically inactive and an insulator towards electricity.

Glasses are mixtures of metallic silicates with no definite melting point, temperature range from 1000℃ to 2000℃. At high temperatures, it is highly viscous semi liquid which can be easily moulded into different shapes.

Some common types of glasses are:

- (i) General purpose glass
- (ii) Coloured glass
- (iii) Optical glass
- (iv) Pyrex glass
- (v) Photo-chromatic glass
- (vi) Crystal glass
- (vii) Laminated glass
- (viii) Safety glass
- (ix) Toughened glass

6.7. Cutting of glass sheet

The glass sheet can be cut by scoring the surface by a diamond point, hard conical wheel of tungsten carbide or hard steel. A diamond scoring tool is shown in Fig.6. 6. The glass sheet is laid on the table with a cloth pad underneath. A straight line is scored with the help of a steel rule. It is then gently tapped to separate the two pieces.

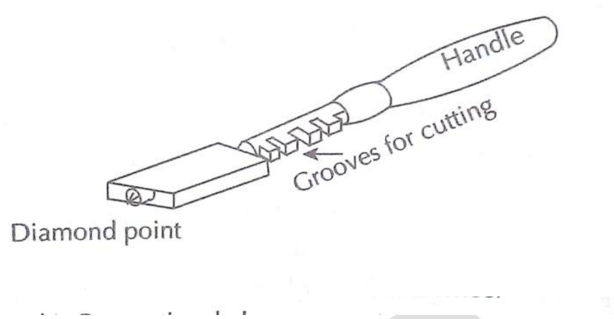


Fig. 6.6: Glass Cutters

METAL CASTING

(Contact: 1L+2P)

7.1 Introduction to Metal Casting

In this process, the material is first liquefied by properly heating in a suitable furnace. Then the liquid metal is poured into the mould cavity and allowed to solidify. Then the solidified part is known as casting.

7.2. Terminologies

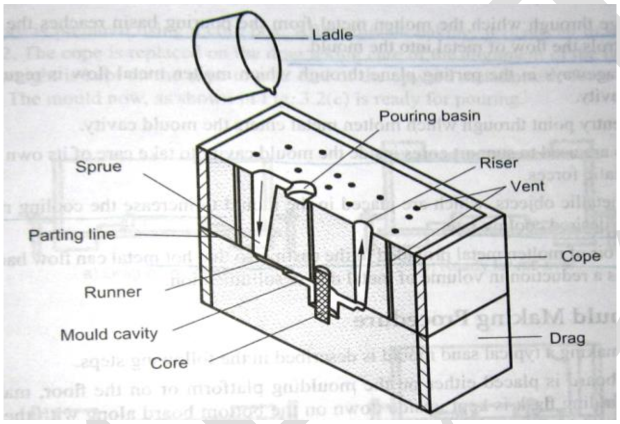


Fig. 7.1: Components of a sand casting set up

Cope: It is the top half of the moulding box.

Drag: The bottom part of the flask is called the drag.

Cheek: The middle part of the flask is called the cheek.

Riddle: It is a round sieve.

Trowel: a long flat metal plate fitted with an offset handle. It is used to flatten and smoothen the sand during moulding operation.

Lifter: It is used to scoop sand deep in the mould.

Slick: It is used to make or repair corners in a mould.

Core: A core is a specially designed shape of refractory to take the place of the metal in a mould and is used to make desired recess in casting.

Core print: provides an added projection on a pattern and forms a seat to support and locate the core in the mould.

Chaplet: Chaplets are metallic supports often kept inside the mould cavity to support cores and also to overcome the metallostatic forces. These are of the same composition as that of the pouring metal so that the molten metal would provide enough heat to completely melt them and thus fuse with it during solidification. An example of chaplet support is shown in figure below.

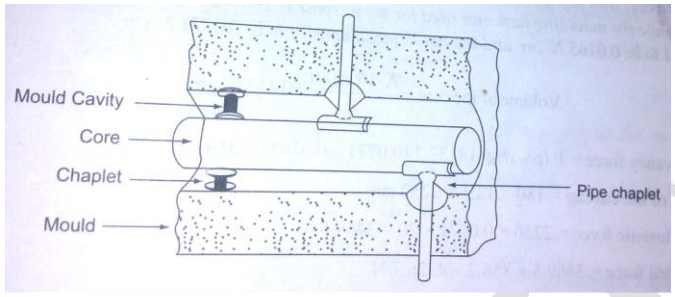


Fig. 7.2: Core supported by chaplets

Though chaplets are supposed to fuse with the parent metal but it is difficult to achieve and normally results in weak joint in casting. The other likely problem encountered in chaplets is the condensation of moisture, which finally ends up with blow holes. Generally chalets are thoroughly cleaned of any dirt, oil or grease before placing. Because of these problems associated with chaplets, it is highly desirable to redesign the casting as far as possible.

Sprue: It is the passage through which the molten metal from the pouring basin reaches the mould cavity. It is made tapered to avoid air inclusion.

Chill: Chills are metallic objects with high thermal conductivity, which are placed in the mould to increase the cooling rate of the castings to provide uniform cooling rate. Chills are provided in the mould so as to increase the heat extraction capability of the sand mould. A chill provides a steeper temperature gradient so that directional solidification as required in a casting can be obtained. Generally chills are metal inserts of steel that are placed at appropriate locations in the mould walls to help directional solidification.

Riser: It is the reservoir of molten metal provided in the casting so that hot metal can flow back into the mould cavity when there is reduction in volume of metal due to solidification.

Ingate: the actual entry point through which molten metal enters the mould cavity is called ingate.

Facing sand: Small amount of carbonaceous sand is sprinkled on the mould cavity to have better surface finish.

7.3. Steps of Sand Casting

Pattern making: This is the very first step of casting process. A pattern is the replica of the part to be cast and is required to make the mould cavity, although a pattern is always made larger than the final job to be produced. Normally patterns are made of wood having some allowances on it like shrinkage allowance, machining allowances. The mould is made by moulding sand around the pattern.

Mould and core making: Mould is made by hand if the number of mould to be prepared is small. If a large number of moulds are required, then moulding machines are used. Fine grain facing sand is used on the pattern surface to obtain a good surface on the casting. Green sand is a generally a mixture of sand (70-85%), clay (10-20%), water (3-6%), and some organic additives (1-6%). Clay together with water acts as a bonding agent and imparts tensile and shear strength to the moulding sand. Core is used only when hollow cavities are required with the casting. Thus with the help of pattern and core and obviously with moulding sand mould is prepared by ramming the sand around the pattern.

Melting: - Suitable metal is melted in suitable furnace for pouring. A proper care during melting is essential for a good defect free casting.

Pouring: - After melting, the metal is poured or injected into the mould cavity. A good gating design ensures distribution of metal in the mould cavity at a proper rate without excessive temperature loss. Pouring should be done with a particular time frame so that the molten metal can fill the cavity in due time.

Cleaning:- Generally a casting has riser, gating system alongwith its main part. So after completion of solidification the casting is taken out from the cope and drag box and the auxiliaries are need to be knocked off by cutting machine. Even in some cases to clean the sticky sands from the main casting part we may require sand blasting.

7.4. Patterns

Pattern is a replica of the final object to be made with some modifications. The mould cavity is made with the help of pattern.

7.4.1. Pattern allowances

A pattern is always made somewhat larger than the final job to be produced. This excess dimensions is referred as the pattern allowances. There are two main types of pattern allowances. First one is the shrinkage allowance and second one is machining allowance. The shrinkage allowance is provided to take care of the contractions of metal during casting process. Usually, a cast surface is too rough to be used as a final product as a result machining operation is required to produce finished surface. Some machining allowance is given for this reason.

- The following allowances are given to a pattern-

7.4.1.1. Shrinkage allowance

Shrinkage allowance is one of the major allowances to be considered. There are three types of shrinkages. But the last type is taken care by the pattern.

7.4.1.2. Liquid shrinkage

It refers to the reduction in volume when metal changes from liquid (from the pouring temperature) to saturated liquid point. This shrinkage is taken care of by the riser.

Transition shrinkage: It refers to the reduction in volume when metal changes from liquid (from the saturated liquid temperature) to saturated solid point. This shrinkage is also taken care of by the riser.

7.4.1.3. Solid shrinkage

It refers to the reduction in volume when metal changes from saturated solid temperature to room temperature. This shrinkage is taken care by pattern.

Grey cast iron has negative shrinkage allowance since there is graphite in it. Graphite has a tendency to expand on cooling.

7.4.1.4. Machining allowance

Usually, a cast surface is too rough to be used in the same way as the surface of final product. As a result machining operations are required to produce the finished surface.

Some more pattern allowances are as follows:

7.4.1.5. Draft allowance

At the time of withdrawing the pattern from the sand mould, the vertical faces of the pattern are in continual contact with the sand, which may damage the mould cavity. To reduce the chances of this happening, the vertical faces of the pattern are always tapered from the parting line. This provision is called draft allowance. Draft may be as much as 2 mm per 100 mm of vertical surface.

7.4.2. Pattern materials

The usual pattern materials are wood, plastic and metals. Disposable pattern materials are made of polystyrene.

7.5. Properties of moulding materials

The choice of moulding materials is based on their processing properties.

7.5.1. Green strength

The moulding sand that contains moisture is termed as green sand. The green sand particles must have the ability to cling to each other to impart sufficient strength to the mold. The green sand should have enough strength so that the constructed mould retains its shape.

7.5.2. Dry strength

When the moisture in the moulding sand is completely expelled, it is called dry sand. When molten metal is poured into a mould, the sand around the mould cavity is quickly converted into dry sand as the moisture in the sand immediately evaporates due to the heat in the molten metal. At this stage the molding sand must possess the sufficient strength to retain the exact shape of the mold cavity and at the same time it must be able to withstand the metallostatic pressure of the liquid material.

7.5.3. Hot strength

After all the moisture is eliminated, the sand would reach a high temperature as the metal in the mould is still in the liquid state. The strength of the sand that is required to hold the shape of the mould cavity then this is called hot strength.

7.5.4. Permeability

As the molten metal enters the mould cavity the heat from the metal dries the mould material in advance of the metal flow. The moisture is changed into steam as well large amount of gases, which are absorbed by the metal in the furnace, are to be expelled from the mould. If these gases are not allowed to escape, they would causes defects in the casting may even crumble or explode the mould. This gas evolution capability of the moulding sand is termed as permeability.

7.5.5. Refractoriness

This is the ability of sand to withstand high temperatures without fusing or breaking down.

A sand used for casting steel must be more refractory than one for brass or aluminium because of the greater pouring temperature involved. Also a sand used to cast heavy castings should be more refractory than one used for light thin castings of the same metal.

7.6. Casting inspection

Non-destructive inspection techniques are essential for creating a confidence when using a cast product. In this section, we shall briefly outline some of these techniques for testing various kinds of defects.

7.6.1. Visual Inspection

Common defects such as rough surfaces, obvious shifts, omission of cores and surface cracks can be detected by visual inspection of the casting. Cracks may be detected by hitting the casting with a mallet and listening to the quality of the tone.

7.6.2. Pressure test

The pressure test is conducted on a casting to be used as a pressure vessel. In this case, first of all the flanges and ports are blocked. Then the casting is filled with water or oil or compressed air. Thereafter casting is submerged in a soap solution when any leak will be evident by bubbles that come out.

7.6.3. Magnetic particle inspection

The magnetic particle test is conducted to check for very small voids and cracks at or just below the surface of the casting of a ferromagnetic material. The test involves inducing a magnetic field through the section under inspection. Then powdered ferromagnetic material is spread out on the surface. The presence of the voids or cracks in this section results in an abrupt change in the permeability of the surface; this in turn causes a leakage of the magnetic field. The powdered particles offer low resistance path to the leakage. Thus the particles accumulate on the disrupted magnetic field, outlining the boundary of a discontinuity.

7.6.4. Dye penetrant inspection

The dye penetrant method is used to detect invisible surface and sub-surface cracks in a non magnetic casting. The casting is brushed with, sprayed with, or dipped into a dye containing a fluorescent material. The surface to be inspected is then wiped, dried and viewed in darkness. The discontinuities in the surface will then be readily discernible.

7.6.5. Radiographic Examination

In this test both X-ray and $\gamma - ray$ can be used. With $\gamma - ray$, more than one film can be used exposed simultaneously; however X-ray pictures are more distinct. Defects like hot tears, cracks, porosity and void can be detected by this method. On the exposed films, the defects, being less dense, appear darker in contrast to the surrounding.

7.6.6. Ultrasonic inspection

For internal flaw detection normally ultrasonic inspection is used. In ultrasonic testing high frequency sound wave from 1-4 MHz are used. In this method a transducer is used to convert the electrical energy into sound energy and an ultrasonic wave is sent through the casting. Such a signal is readily transmitted through a homogeneous medium. If any flaw exists the signal gets reflected. The reflected ultrasonic impulse is converted into electrical pulses by the reverse piezo-electric effect. It is displayed on the visual screen. This method is not suitable for a material with high damping capacity (e.g. cast iron) because in such a case the signal gets considerably weakened over some distance.

WELDING AND BRAZING

(Contact: 1L+3P)

8.1. Introduction to welding

Welding is a process of joining in which a localized coalescence of metals or non-metals produced either by heating the materials to the welding temperature, with or without the application of pressure, or by the application of pressure alone, with or without the use of filler metal.

A fairly large number of industrial components are made by using welding. Common examples are aircraft and ship bodies, bridges, building trusses, welded machine frames, pipe lines, rail roads etc.

8.2. Advantages of welding

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

8.3. Welding joints

Different types of welding joints are classified as butt, lap, corner, tee and edge joints. These are shown in Fig. 8.1.

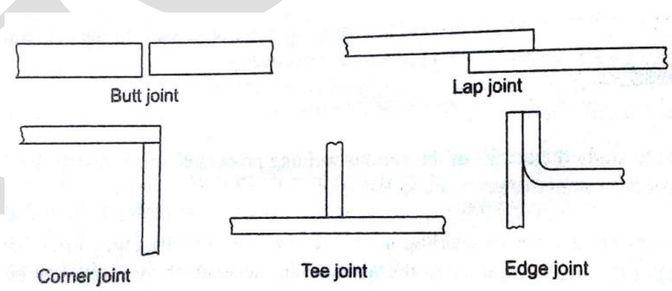


Fig.8.1: Types of welded joints

The edges of the joint in Fig.8.1 are used when the thickness of the two pieces to be joined is small, so that the heat of welding penetrates the full depth of the joint. However when thickness increases, it becomes necessary to prepare the edge in such a way that the heat is able to penetrate the entire depth. For very thick plates, the welding needs to be done from both sides. Some prepared butt joint edges are shown in Fig.8.2.

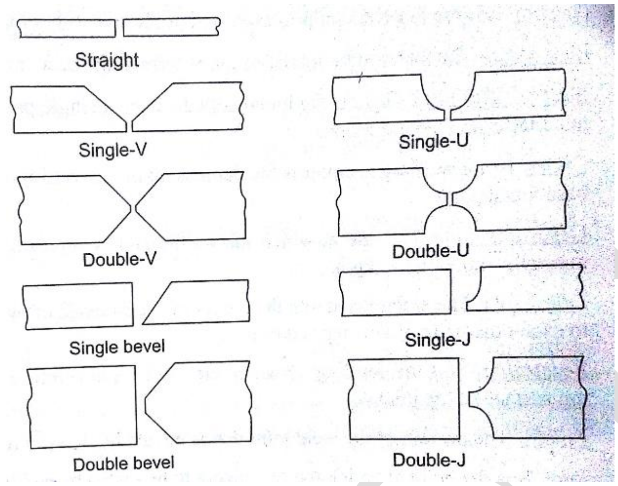


Fig.8.2. Butt joint edge preparation methods

8.4. Electric Arc Welding

In welding, generation of heat by an electric arc is one of the most efficient methods. This is one of the most widely used welding processes, mainly due to ease of use and high production rates that can be achieved economically.

8.4.1. Principle of arc

An arc is generated between two conductors of electricity, cathode and anode, when they are touched to establish the flow of current and then separated by a small distance. An arc is a sustained electric discharge through the ionized gas column, called plasma, between the two electrodes.

Electron releases from cathode and hits anode with very high velocity, as a result a large amount of heat is generated in the anode. About 70% of the total heat is liberated at the anode by the striking electrons. A temperature of the order of 6000℃ is generated at the anode.

If AC is used as a power source then the cathode and the anode would change simultaneously and as a result, both the workpiece and the electrode would be 50% heated.

For welding thin materials, work is made negative and the electrode is made positive. This type is termed as reverse polarity.

For welding heavy section, work is made positive and the electrode is made negative. This type is termed as straight polarity.

8.4.2. Why it is necessary to clean the surface to be welded?

First of all, we know that generally in welding an arc is generated between two conductors of electricity, cathode and anode, when they are touched to establish the flow of current and then separated by a small distance. Now if the stock is not with cleaned surface then there will be no induction between stock and electrode. Therefore there will be no arc. On the other hand, if any how the arc has been produced then also there will be a layer of impurities between the joined or welded parts.

8.4.3. Common arc welding equipments (including safety items)

Few of the important components of arc welding setup are described as under.

8.4.3.1. Arc welding power source

Both direct current (DC) and alternating current (AC) are used for electric arc welding. For AC welding supply, transformers are used for almost all arc welding. They have to step down the usual supply voltage (200- 400 volts) to the normal open circuit welding voltage (50-90 volts).

8.4.3.2. Welding cables

Welding cables are required for conduction of current from the power source through the electrode holder, the arc, the workpiece and back to the welding power source.

8.4.3.3. Electrode holder

Electrode holder is used for holding the electrode manually and conducting current to it.

8.4.3.4. Welding Electrodes

An electrode is a piece of wire or a rod of a metal or alloy, with or without coatings. An arc is set up between electrode and workpiece. Welding electrodes are classified into following types:

8.4.3.4.1. Consumable Electrodes

Consumable electrode is made of different metals and their alloys. The end of this electrode starts melting when arc is struck between the electrode and workpiece. Thus consumable electrode itself acts as a filler metal. Consumable electrodes are further classified into two types-

(*a*) Bare Electrodes: - Bare electrodes consist of a metal or alloy wire without any flux coating on them.

(*b*) Coated Electrodes: - Coated electrodes have flux coating which starts melting as soon as an electric arc is struck. This coating on melting performs many functions like (i) prevention of joint from atmospheric contamination, (ii) arc stabilizers, (iii) provide the slag to protect the weld from rapid cooling, (iv) remove oxidised impurities, (v) add alloying elements to the weld metal etc.

8.4.3.4.2. Non-consumable Electrodes

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

8.4.3.5. Hand Screen

Hand screen used for protection of eyes and supervision of weld bead.

8.4.3.6. Chipping hammer

Chipping Hammer is used to remove the slag by striking.

8.4.3.7. Wire brush

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

8.4.3.8. Protective clothing

Operator wears the protective clothing such as apron to keep away the exposure of direct heat to the body.

8.4.4. Arc Welding Processes

In this case, the arc is generated by the contact and separation of electrodes. Then the heat of arc raises the temperature of the parent material which is melted forming a weld pool. The welding rod is also melted and is transferred into the weld pool.

8.5. Gas welding

Gas welding is a fusion welding process. It joins metals using the heat of combustion of oxygen /air and fuel gas (i.e. acetylene, hydrogen) mixture is usually referred as gas welding. The intense heat (flame) thus produced melts and fuses together the edges of the parts to be welded, generally with the addition of a filler metal.

When acetylene is mixed with oxygen in correct proportions in the welding torch and ignited then the welding process is known as oxy-acetylene welding.

When hydrogen gas is mixed with oxygen in correct proportions in the welding torch and ignited then the welding process is known as oxy-hydrogen welding.

However it is possible to provide more or less oxygen than that theoretically required for complete combustion.

When excess of oxygen is provided over the fuel say acetylene then the flame is known as oxidizing flame. An oxidizing flame can be recognized by the small cone, which is shorter, much bluer in colour and more pointed than that of the neutral flame. The outer flame envelope is much shorter. Such a flame makes a loud roaring sound. It is the hottest flame and temperature is about 3330°C. A slightly oxidizing flame is helpful when welding Copper-base metals, Zinc-base metals and a few types of ferrous metals such as manganese steel and cast iron.

A neutral flame results when approximately equal volumes of oxygen and acetylene are mixed in the welding torch and burnt at the torch tip. The temperature of the neutral flame is of the order of about 3100°C. It has a clear, well defined inner cone, indicating that the combustion is complete. The inner cone is light blue in colour. It is surrounded by an outer flame envelope, produced by the combination of oxygen in the air and superheated carbon monoxide and hydrogen gases from the inner cone. This envelope is usually a much darker blue than the inner cone. A neutral flame is named so because it affects no chemical change on the molten metal. The neutral flame is commonly used for the welding of mild steel, stainless steel, cast Iron, copper, and aluminium.

The carburizing or reducing flame has excess of acetylene and can be recognized by acetylene feather, which exists between the inner cone and the outer envelope. The outer flame envelope is longer than that of the neutral flame and is usually much brighter in colour. A reducing flame has an approximate temperature of 2900°C. A reducing flame ensures the absence of the oxidizing condition. It is used for welding with low alloy steel rods and for welding those metals, (e.g., non-ferrous) that do not tend to absorb carbon. This flame is very well used for welding high carbon steel.

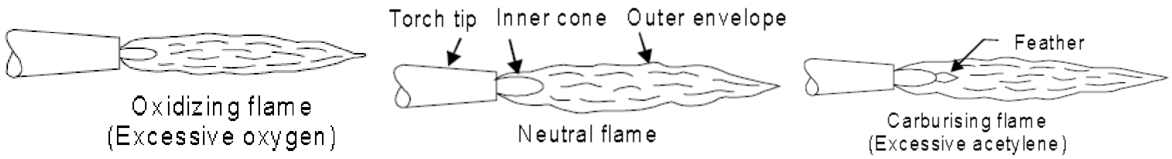
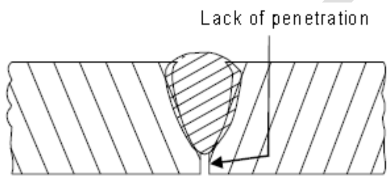


Fig.8.3.Different types of flames

8.6. Welding defects

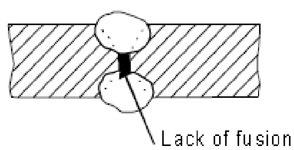
In view of the severe thermal regime through which the welding process proceeds, the weldments are likely to be affected if proper care is not taken. Some of the common welding defects are as follows:

8.6.1. Lack of Penetration



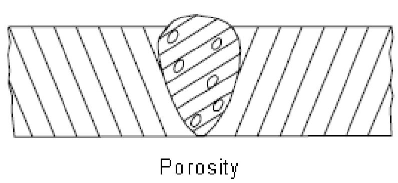
It is the failure of the filler metal to penetrate into the joint. It is due to incorrect edge penetration or incorrect welding technique.

8.6.2. Lack of Fusion



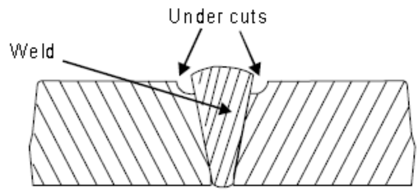
Lack of fusion is the failure of the filler metal to fuse with the parent metal. It is due to too fast a travel and insufficient heat.

8.6.3. Porosity



It is a group of small holes throughout the weld metal. It is caused by the trapping of gas during the welding process, due to chemicals present in the metal, dampness of material and too rapid cooling of the weld.

8.6.4. Undercuts



These are grooves or slots along the edges of the weld caused by too fast a travel, improper welding technique and too great heat build-up due to excessive welding current.

8.6.5. Hot cracking

This generally occurs at high temperature and the size can be very small to visible. The crack magnitude depends upon the strains involved in solidification.

8.7. Brazing

Brazing is a process of joining metals without melting the base metal. Filler material used for brazing has liquidus temperature above 450°C and is below the solidus temperature of the base metal. The filler metal is drawn into the joint by means of capillary action. Due to the higher melting point of the filler material, the joint strength is more than in soldering. Almost all metals can be joined by brazing except aluminum and magnesium which cannot easily be joined by brazing. Dissimilar metals, such as stainless steel to cast iron can be joined by brazing. Because of the lower temperatures used there is less distortion in brazed joints.

8.8. Making a Butt Joint

Aim: To make a Butt joint using the given two M.S pieces by arc welding.

Material Required: Mild steel plate of size ………×…….×……mm-2 Nos.

Welding Electrodes: M.S electrodes Ø……..mm ×……… mm

Tools and Accessories required:

1. Rough and smooth files.
2. Protractor
3. Arc welding machine
4. Mild steel electrode and electrode holder
5. Ground clamp
6. Tongs
7. Face shield
8. Apron
9. Chipping hammer

Sequence of operations:

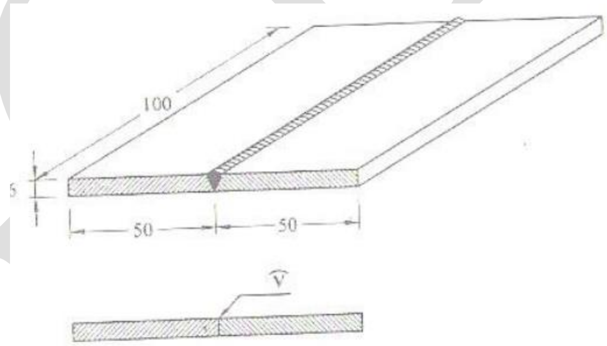
1. Marking
2. Cutting

3. Edge preparation (Removal of rust, scale etc.) by filling
4. Welding
5. Cooling
6. Chipping
7. Cleaning Procedure

Procedure:

1. The given M.S pieces are thoroughly cleaned of rust and scale.
2. One edge of each piece is believed, to an angle of 30^0
3. The two pieces are positioned on the welding table such that, they are separated slightly for better penetration of the weld.
4. The electrode is fitted in the electrode holder and the welding current is set to be a proper value.
5. The ground clamp is fastened to the welding table.
6. Wearing the apron and using the face shield, the arc is struck and holding the two pieces together; first run of the weld is done to fill the root gap.
7. Second run of the weld is done with proper weaving and with uniform movement. During the process of welding, the electrode is kept at 15^0 to 25^0 from vertical and in the direction of welding.
8. The scale formation on the welds is removed by using the chipping hammer.
9. Filling is done to remove any spanner around the weld.

Drawing:



Welded Joint Representation

Result:

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

8.9. Making a Lap Joint

Aim: To make a Lap joint using the given two M.S pieces by arc welding.

Material Required: Mild steel plate of size ………×…….×……mm-2 Nos.

Welding Electrodes: M.S electrodes Ø……..mm ×……… mm

Tools and Accessories required:

1. Rough and smooth files.
2. Protractor
3. Arc welding machine
4. Mild steel electrode and electrode holder
5. Ground clamp
6. Tongs
7. Face shield
8. Apron
9. Chipping hammer

Sequence of operations:

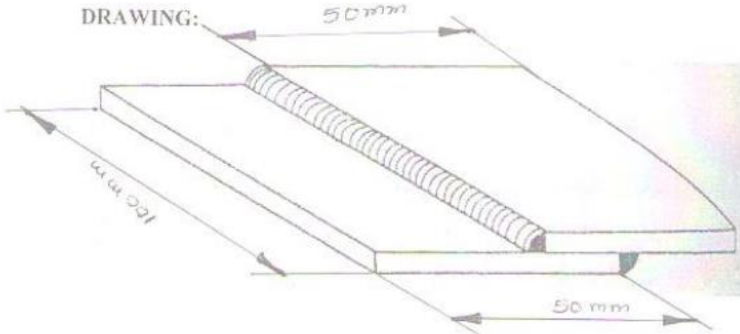
1. Marking
2. Cutting
3. Edge preparation (Removal of rust, scale etc.) by filling
4. Try square leveling
5. Welding
6. Cooling
7. Chipping
8. Cleaning Procedure

Procedure:

1. The given M.S pieces are thoroughly cleaned of rust and scale.
2. The two pieces are positioned on the welding table such that, the two pieces overlapped one over the other as shown in drawing
3. The electrode is fitted in the electrode holder and the welding current is ser to be a proper value.
4. The ground clamp is fastened to the welding table.
5. Wearing the apron and using the face shield, the arc is struck and holding the two pieces together; first run of the weld is done to fill the root gap.
6. Second run of the weld is done with proper weaving and with uniform movement. During the process of welding, the electrode is kept at 15^0 to 25^0 from vertical and in the direction of welding.
7. The scale formation on the welds is removed by using the chipping hammer.
8. Filling is done to remove any spanner around the weld.

Drawing:

DRAWING:



Result:

The Lap joint is thus made, using the tools and equipment as mentioned

MACHINE SHOP

(Contact: 3P)

9.1. Introduction to machine shop

It is a very well known fact that machine shop forms not only an important but an indispensable part of a modern workshop. It not only involves a heavy investment but at the same time, calls for a fairly high skill of workmanship. If carried out successfully, the operations performed on this shop are capable of producing a large number of jobs of different shapes and sizes having a fine finish within very close limit of dimension.

9.2. Machine Tools

Machine tool is a device in which energy is expanded to remove excess material from the parent material in the form of chips by a suitable wedge shaped device call cutting tool.

9.3. Functions of machine tools

The main functions of a machine tool are:

1. To hold and support the job to be machined
2. To hold and support the cutting tool in position
3. To move the cutting tool, work or both of them in a desired direction
4. To regulate the cutting speed and provide the feeding movement to one of these.

9.4. Lathe

The lathe can be defined as a machine tool which holds the work between two rigid and strong supports, called centres, or in a chuck while the latter revolves. The cutting tool is rigidly held and supported in a tool post and is fed against the revolving work. In doing so it produces a cylindrical surface.

9.5. Specification of lathe

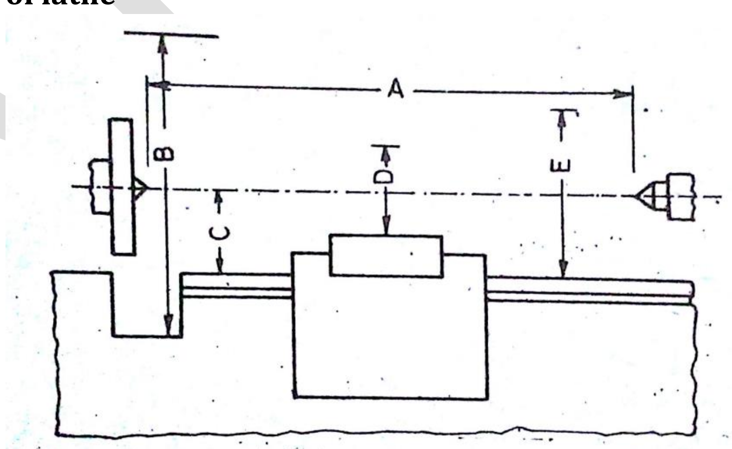


Fig. 9.1: Lathe sizes

The important dimensions required to be mentioned for a lathe are:

1. Maximum distance between centres (A)
2. Maximum swing in gap in case of gap bed lathe (B)
3. Height of centres over bed (C)
4. Maximum swing over carriage (D)
5. Maximum swing over bed (E)
6. Length of the bed

9.6. Parts of a lathe

The lathe carries the following main parts as illustrated by the block diagram. The main part of a lathe are:

i) Bed
ii) Headstock
iii) Tailstock
iv) Carriage
v) Legs

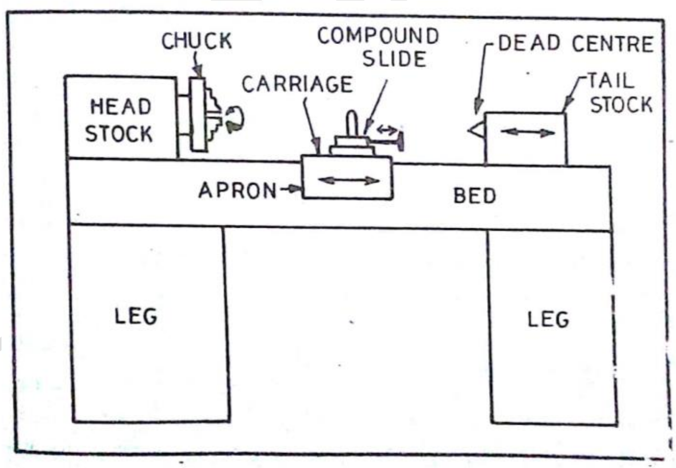


Fig. 9.2: Block Diagram of a Lathe

9.6.1. Lathe Bed

The bed of a lathe acts as a base on which the different fixed and operating parts of the lathe are mounted. It withstands various forces exerted on the cutting tool during the operation. These are usually made as a single piece casting of cast iron during for easy sliding action.

9.6.2. Headstock

The headstock is the part of the lathe which serves as a housing for the driving pulleys and back gears, provides bearing for the machine spindle and keeps the latter in alignment with the bed.

9.6.3. Tailstock

The main function of tailstock is to provide bearing and support to the job which is being worked between centres. In the dead center carbide tipped centres are observed. It helps to retain its shape and size inspite of the high heat produced due to friction at high speeds. Without this type of tip, the tip will fail.

9.6.4. Carriage

Carriage serves the purpose of supporting, guiding and feeding the tool against the job during the operation on the lathe. It consists of the following main parts:

Saddle: Saddle is the part of the carriage which slides along the bed ways and supports the cross slide, compound rest and tool post

Cross slide: It is mounted on the top of the saddle and always moves in the direction normal to the axis of the main spindle.

Compound rest: It is also known as tool rest. It is mounted on the cross slide and carries a graduated circular base called swivel plate.

Tool post: It is the top most part of the carriage and it is used for holding the tool and the tool holder in position.

Apron: It is the hanging part in front of the carriage it serves as a house in a number of gear trains through which power feeds can be given to the carriage.

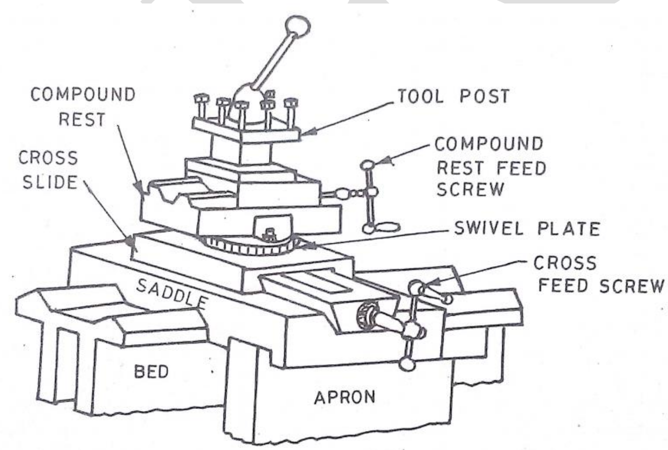


Fig. 9.3: The carriage

9.6.5. Legs

They are the supports which carry the entire load of the machine over them. Both the legs are firmly secured to the floor by means of foundation bolts in order to prevent vibrations in the machine.

9.7. Need for change of speed

There are several reasons due to which different spindle speed are needed.

i) Work piece material: Harder and tougher material needs slower speed while softer material demands faster speed.

ii) Cutting tool material: The harder the tool material, the higher is the cutting speed employed in order to take the full advantage of the higher hot hardness of this material.

iii) Type of operation: For example operations like external and internal threading need much lower speed than operation like turning, drilling, boring, facing etc.

iv) Surface finish: Rough machining where the main requirement is to remove the maximum amount of material needs a deeper depth of cut and slower speed. Against this, in finish machining, the depth of cut is substantially reduced and higher speed is used.

v) Rigidity of machine tool: A rigid machine tool in perfect running condition enable employment of higher spindle speed

9.8. Chucks

They provide a very efficient and true device for holding the work on the lathe during operation. The most common types of chucks used are:

9.8.1. Three jaw Universal chuck

It is also known as self centring chuck. It grasps the work quickly and within a few hundredths of a millimeters or thousandths of an inch of accuracy, because the three jaws move simultaneously when adjusted by the chuck wrench.

9.8.2. Four jaw independent chuck

Each of the jaws can be adjusted independently by a chuck wrench. They are used to held irregular-shaped workpieces. The jaws can be reversed to hold work by the inside diameter.

9.9. Operations in Lathe

In lathe the work/job rotates and the tool remains stationary. Lathe operations involve the turning, drilling, facing, boring, threading and many more. Let’s discuss some these methods.

9.9.1. Facing

Facing is used to make a flat surface at the end of the work piece. The work part should be rotating and the implied feed should be radial.

9.9.2. Straight turning

In this operation of lathe, the tool is fed in a straight path parallel to the axis of the job and the job is held in either a chuck or between two centers.

9.9.3. Taper turning

The tool is not fed parallel to the axis of rotation of the work part. The tool is fed at an angle. This turning operation gives a conical and taper cylindrical shape.

The common methods of expressing the taper is 1 in x form, all measurements are in millimeter. 1 in x means that there is a taper of 1 mm on x mm length of the job.

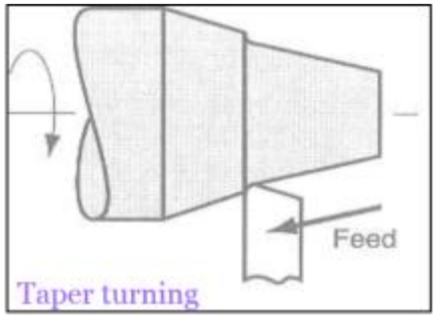


Fig. 9.4: Taper Turning

9.9.4. Chamfering

Only the cutting edge is used at the corner of cylindrical shapes which is used for stress relieving of the work-piece.

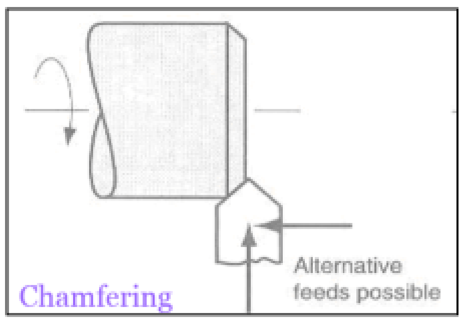


Fig. 9.5: Chamfering

9.9.5. Cutoff or Parting

In parting operation the tool is fed radially and the end part of the work-piece is cut off.

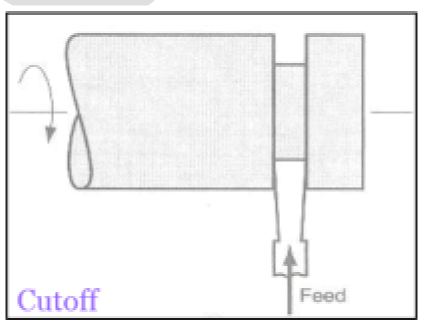


Fig. 9.6: Cutoff

9.10. Cutting tool materials

The main characteristics of a good cutting tool material are its hot hardness, wear resistance, impact resistance, abrasion resistance, heat conductivity, strength etc. They are generally made of high carbon steel, high speed steel, satellite, cemented carbide, ceramics, diamond etc.

9.11. Drilling

Drilling is an operation through which holes are produced in a solid metal by means of a revolving tool called drill. Since it is not possible to produce a perfectly true hole by drilling, it is called a roughing operation.

In this connection it is noteworthy to mention that boring is an operation employed for enlarging an existing hole. Reaming is that operation by which final required dimension of the hole and fine surface finish is obtained by means of a tool called reamer.

9.12. Twist Drill Parts and Terminology

Twist drill is the most widely used tool in modern drilling practice. Twist drills are usually made of high speed Steel. The twist drill consists of two main parts viz., a shank, which is gripped in the drill chuck and the other is the body which forms the main cutting unit (Fig.9.7).

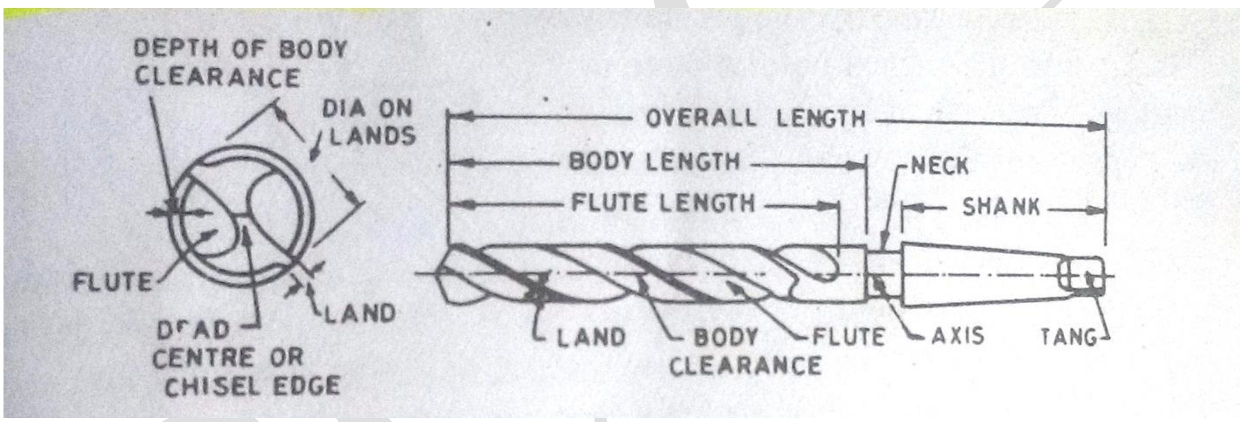


Fig.9.7: Principle parts of a twist drill

Tapered shank drills carry a tang at the end of the shank to ensure positive grip. The body consists of flutes, for removal of chips, the lips or the cutting edge, the point or dead centre, the land or portion of full diameter which guides the drill in the hole and the body clearance or relief. These angles are shown in figure 9.8.

Point angle: It is also known as the cutting angle. Its most commonly used value for a large variety of material is 118°. Smaller point angle is favoured for brittle materials and the larger one for harder and tougher materials.

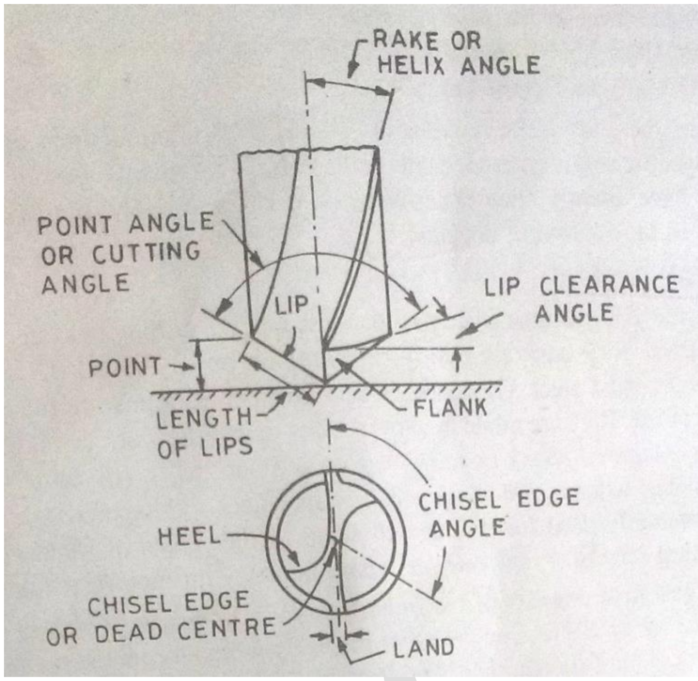


Fig. 9.8: Various angles and terms related to the drill point

The drill should be so ground that the point is exactly in the centre i.e., on the axis of the body and the lips are of equal angle and length. This will enable the production of a perfectly round, smooth, parallel and accurate hole of the desired size and the drill will have better life. Unequal lips will result in oversized hole as shown in fig. 9.9.

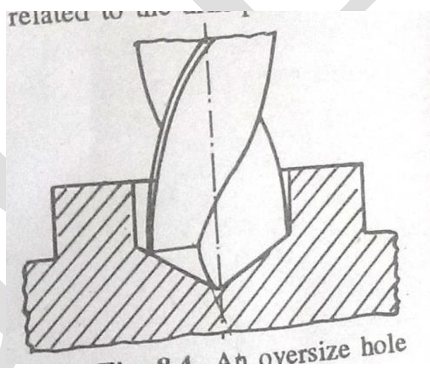


Fig. 9.9: An oversized hole due to unequal lips

The advantages of using twist drill are:

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

2. Cutting edges are retained in good condition for a fairly long time, thus avoiding the frequent regrinding of the drill.

3. Heavier feeds and speeds can be employed quite safely, resulting in a considerable saving of time.

4. For the same size and depth of the hole they need less power in comparison to the other forms of drill.

9.13. Sensitive or bench drill

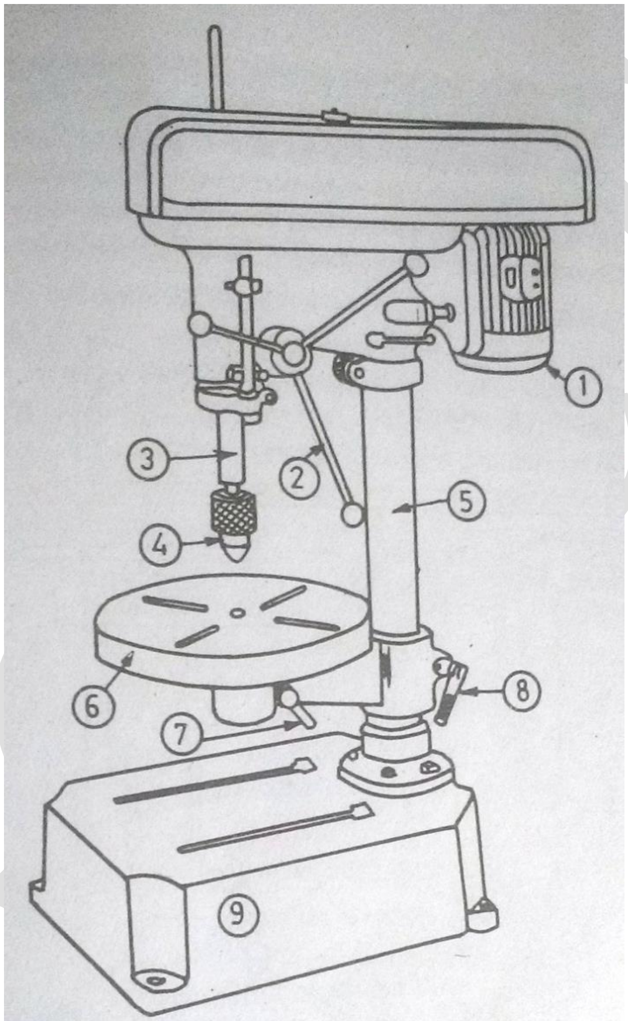


Fig. 9.10: Sensitive or bench drill

1. Motor 2. Feed Handle 3. Spindle 4. Drill Chuck 5. Column 6. Table 7. Table swivel clamp 8. Table clamp 9. Base

This type of drill machine is used for very light work. Its construction is very simple and so is its operation. It is consist, as shown in fig. 9.10, of a cast iron base having a fixed table over it. The vertical column carries a swiveling table, the height of which can be adjusted vertically along the former. Also, it can be swung to any desired position. At the top of the column is provided the drive, which consists of an endless belt running over to V-pulleys. One of these pulleys is mounted on the motor shaft and the other on this machine spindle. Vertical movement to the spindle is given by the feed handle through a rack and pinion arrangement.

The drive mechanism of this machine is illustrated in fig. 9.11.

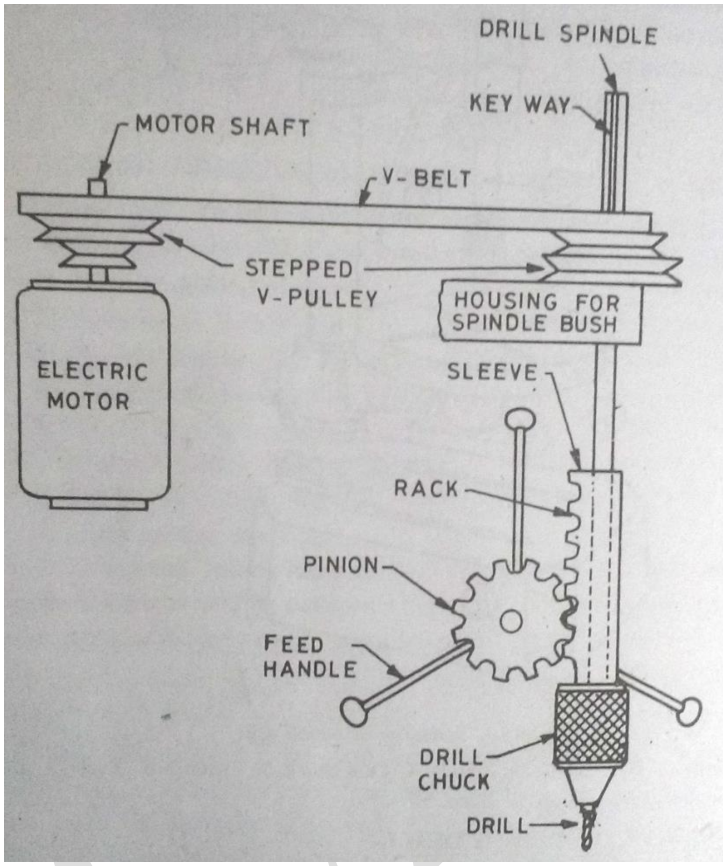


Fig. 9.11: Drive mechanism of a sensitive drill machine.

As the motor is switched on, the motor shaft starts revolving and hence the V-Pulley mounted over it. This, through the V-belt will transmit the motion and power to the other pulley mounted over the drill spindle. Thus, the spindle starts rotating and therefore the cutting tool (drill). When the drill is required to be fed into the work, it is pressed against the work by means of feed handle. As the handle is rotated, which is directly mounted on the pinion shaft, the pinion rotates. It moves the rack longitudinally and hence the spindle and the drill. Different spindle speed can be obtained by shifting the v-belt to different pairs of driving and driven Pulley, while the motor continuous to rotate on the same speed. However, normally there is no arrangement for automatic feed on this machine.

On these machines, the drill rotates at very high speed so that the required cutting speeds can be obtained on the peripheries of the small drills used on these machines. The hand feed enables the operator to feel the gradual penetration of the drill into the work material and also sense the obstruction, if any, in its way. By his hand feel he can also sense if the drill is cutting properly or has become blunt and needs regrinding. For these reasons only it is known as sensitive drill.

9.14. Introduction to Grinding

Grinding is a process of removing Material by the abrasive action of revolving wheel on the surface of a work-piece, in order to bring it to the required shape and size. So far as the cutting action is concerned grinding is very much similar to the other machining operations since the microscopic examination of the removed material reveals that the same is in the form of small chips, similar to those obtained in other machining operations. The wheel used for performing the grinding operation is known as grinding wheel. It consists of sharp crystals called abrasives, held together by a binding material called bond. In most cases, it is a finishing operation and a very small amount of material is removed from the surface during the operation.

Abrasives: It is the material of the grinding wheel which does the cutting action. The common natural abrasives are sand stone, emery, corundum and diamond. The sand stone is used only for sharpening some woodworking tool. Emery and corundum are the materials which are formerly used widely, but now have been replaced by artificial abrasives. Some popular artificial abrasives are silicon carbide (denoted by ‘C’) and Aluminium oxide (denoted by ‘A’).

Bond: In order to give an effective and continuous cutting action, it is necessary that the grains of the abrasive material should be held firmly together to form a series of cutting edges. The material employed for holding them is known as bond.

Symbols used for representing the type of bond

Type of bond	Represented by	Type of bond	Represented by
Silicate	S	Resinoid	B
Shellac	E	Magnesia	Mg
Rubber	R	Vitrified	V

Grain or grit: The term grain or grit denotes the approximate size of the abrasive particles and gives an idea of the coarseness or fineness of the grinding wheel. The coarser grit will remove the stock at a faster rate and finer finish will always require a finer grit.

Standard grain size for grinding wheels

Grit designation	Grain Size or Grit Number
Coarse	10 12 14 16 20 24
Medium	30 36 46 54 60
Fine	80 100 120 150 180
Very Fine	220 240 280 320 400 500 600

Grade: The term grade indicates that the strength of the bond in a wheel i.e. the power of the abrasive particle to hold together and resist disintegration under the cutting pressure. Different wheel grades are represented by English alphabets from 'A' to 'Z'. 'A' being the softest and 'Z' is the hardest. The standard grouping is as follows:

Different grades of grinding wheel

Soft	A B C D E F G H
Medium	I J K L M N O P
Hard	Q R S T U V W X Y Z

Structure: The term structure denotes the spacing between abrasive grains or in other words the density of the wheel. If two wheels of same grit and grade are used on the same material, one having an open structure and the other with closed structure, the former will found to cut faster and more freely in comparison to the latter and also will have more life as compared to it. The above two types of structures are represented by numbers as follows:

Structure of the grinding wheels

Structure type	Represented by numbers
Dense	1 2 3 4 5 6 7 8
Open	9 10 11 12 13 14 15 or up

9.16. Method of specifying a grinding wheel

The methods of specifying a grinding wheel differ slightly in different countries. In order to maintain uniformity throughout the country in the system of marking grinding wheels the Bureau of Indian Standards (BIS) has devised a standard system to be followed by all manufacturers.

Thus a grinding wheel carrying the marking 250×25×32 W A 46 L 4 V 17 will conform to the following specifications:

Wheel diameter= 250 mm

Thickness of wheel =25 mm

Bore diameter = 32 mm

W: Manufacturer's prefix to abrasive. Here it denotes white

A: Type of abrasive Alumina

46: It is the grain size (medium here)

L: Grade, it is a medium grade

4: Structure, it represents dense structure

V: Stands for vitrified Bond

17: It is the bond types

SMITHY

(Contact: 2P)

10.1. Introduction

Forging is a process in which material is shaped by the application of localized forces exerted manually or with power hammers, presses or special forging machines. The process may be carried out on materials in either hot or cold state. When forging is done cold, processes are given special names. Therefore, the term forging usually implies hot forging carried out at temperatures which are above the recrystallization temperature of the material.

Smithy shop has a credit of being used since prehistoric days for making agricultural, household components like, plough, ace, hammers, chisels etc. The forged parts have good strength and toughness; they can be used reliably for highly stressed and critical applications.

Smithy can also be termed as hand forging. But now a days forging is carried out by power tools, which are driven by hydraulic power or mechanical systems and motors.

10.2. Forgeability

The ease with which forging is done is called forgeability. The forgeability of a material can also be defined as the capacity of a material to undergo deformation under compression without rupture.

10.3. Hand forging implements

10.3.1. Anvil

It is a heavy mass on which the workpiece is placed for forging. The top surface is made of hard carbon steel. It has a square and round hole on the top. These are used either for securing the tang of forming tools or for forming operations, such as bending, punching etc. Anvils in forging shop may vary up to about 100 to 150 kg.

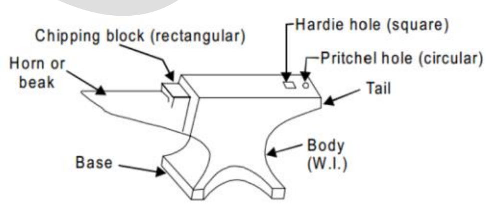


Fig.10.1: Anvil

10.3.2. Swage block

It has circular and square holes of several sizes. Several half sizes are there on its four sides. It can be used for carrying out several operations such as bending, sizing, heading etc.

10.3.3. Hearth

A common furnace used for smithy shop is open hearth furnace. It is equipped with a blower to enhance or reduce the fire intensity. The workpiece is kept submerged under the burning coal. The heated portion is not in direct contact with oxygen of the atmosphere otherwise oxides may form in the grain boundaries and as a result brittle object ends up.

10.4. Forging hand tools

For carrying out smithy operations certain common hand forging tools are employed. These are also called blacksmith's tools.

10.4.1. Hammers

The weight of hand hammers vary within 500 gm to 2 kg. ball peen hammer is most commonly used. The punch is used to make a hole, fuller is used to elongate the material, flatter is used to smoothen the uneven surface created by fuller.

10.4.2. Tongs

These are useful to hold the workpiece or a tool.

10.5. Forging operations

10.5.1. Drawing or Fullering

This operation is used to elongate the workpiece, while the thickness is reduced. The fullering operation is followed by flattering with a flat tool to make the workpiece surface smooth and plane.

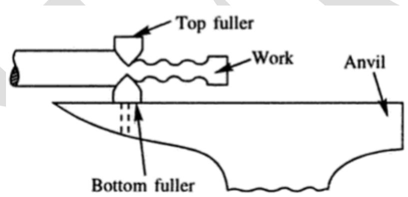


Fig. 10.2: Fullering operation

10.5.2. Upsetting

This is applied to increase the cross sectional area of a stock in the expense of length.

10.5.3. Forge welding

It is a common process in smithy. The iron component ends to be welded are heated to white hot condition (around 1250℃) and are hammered together to drive out the oxide layer and to bring the nascent hot surfaces together in intimate contact. The welding takes place due to interface diffusion and localized melting during striking.

10.6. Safety practices

1. Hold the hot work downwards close to the ground, while transferring from the hearth to anvil, to minimize danger of burns; resulting from accidental collisions with others.
2. Use correct size and type of tongs to fit the work. These should hold the work securely to prevent its bouncing out of control from repeated hammer blows.

3. Care should be exercised in the use of the hammer. The minimum force only should be used and the flat face of hammer should strike squarely on the work; as the edge of the hammer will produce heavy bruising on hot metal.
4. Wear face shield when hammering hot metal.
5. Wear gloves when handling hot metal.
6. Wear steel-toed shoes.
7. Ensure that hammers are fitted with tight and wedged handles.