AIR UNIVERSITY

DEPARTMENT OF MECHANICAL & AEROSPACE ENGINEERING

WORKSHOP TECHNOLOGY

Carpentry Shop

Note: This is only for reference purposes and not for publication.

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Carpentry Shop

1 Introduction

Wood obtained from tree is the chief product of forest. It has been universally acceptable as raw material for manufacturing wooden products or appliances. From the pre-historic times, wood has been utilized an important source of getting heat by firing it. It has been utilized as a major construction material for making shelter for the basic need of human being. As the civilization advanced, it gained tremendous importance as special material for boatbuilding, for piling to support docks and railroad tracks. But in modern times, with the advance of wood chemistry, the uses of wood have recognized its importance in manufacturing cheap useful products used in day today life such as paper, furniture, textiles, plastics and hundreds of chemicals and extractives. The wooden products as plywood have superseded in some products in comparison metallic and ceramic materials. Compressed wood has also replaced some metals for gears and die casts. The useful work on wood is being generally carried out in a most common shop known as **Carpentry shop.** The work performed in carpentry shops comprises of cutting, shaping and fastening wood and other materials together to produce the products of woods. Therefore, carpentry shop deals with the timber, various types of tools and the art of joinery.

1.1 The Vegetative Structure of the Tree

Trees are the source of wood. The structure of tree is given below

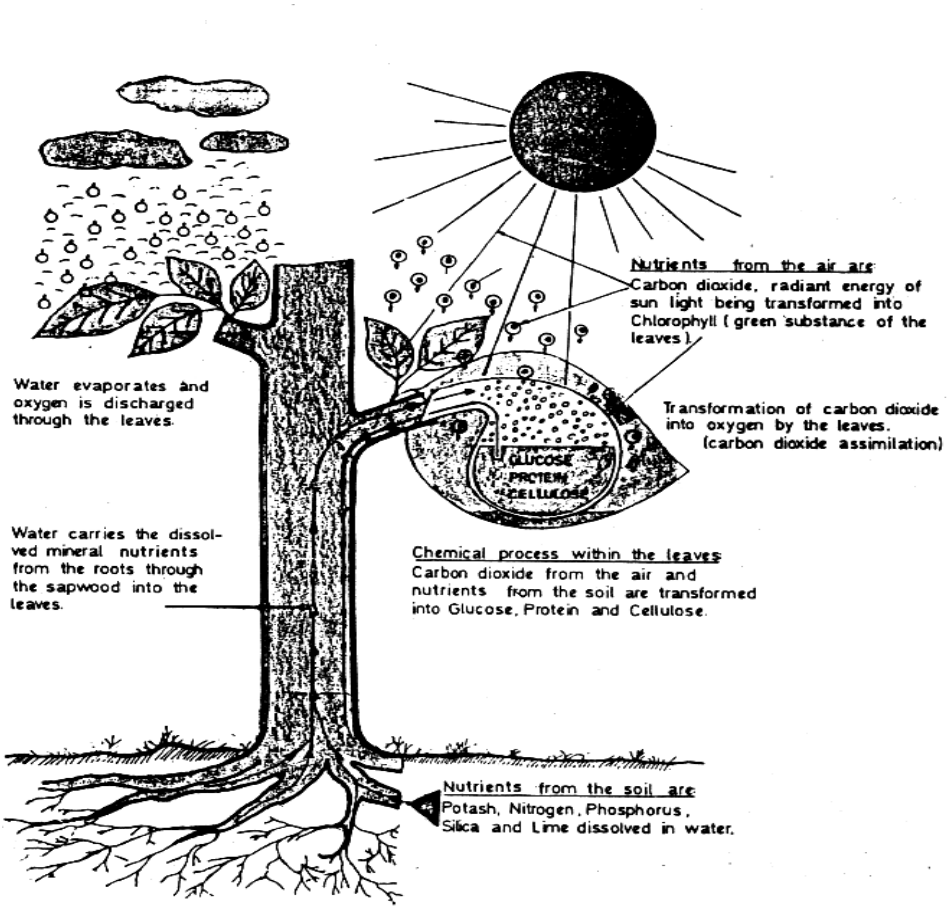


Fig.1.1 Vegetative Structure of Tree

1.2 Types of Trees

Trees are generally classified into exogenous and endogenous types according to manner of growth.

a) **Exogenous types** are also known as outward growing trees producing timber for commercial use. They grow outward and the additional growth takes place on the outside of the trunk just underneath its bark, while the innermost timber continues to mature. Each time the growth cycle is completed, the tree gains one more growth ring or annual ring. In counting these rings, the age of a tree can be determined, as each ring represents one year of growth.

b) **Endogenous trees** are also known as inward growing. They grow inwards i.e., every fresh layer of sapwood is added inside instead of outside. Cane, bamboo and coconut are examples of such endogenous trees.

1.3 Timber

Timber is a common name imparted to wood suitable for engineering, construction and building purposes. Timber is obtained from trees by cutting the main body of tree in the suitable sizes after the full growth of tree. The timber structure consists of annual rings, heartwood, sapwood, pith, cambium layer, bast, medullary rays and bark.

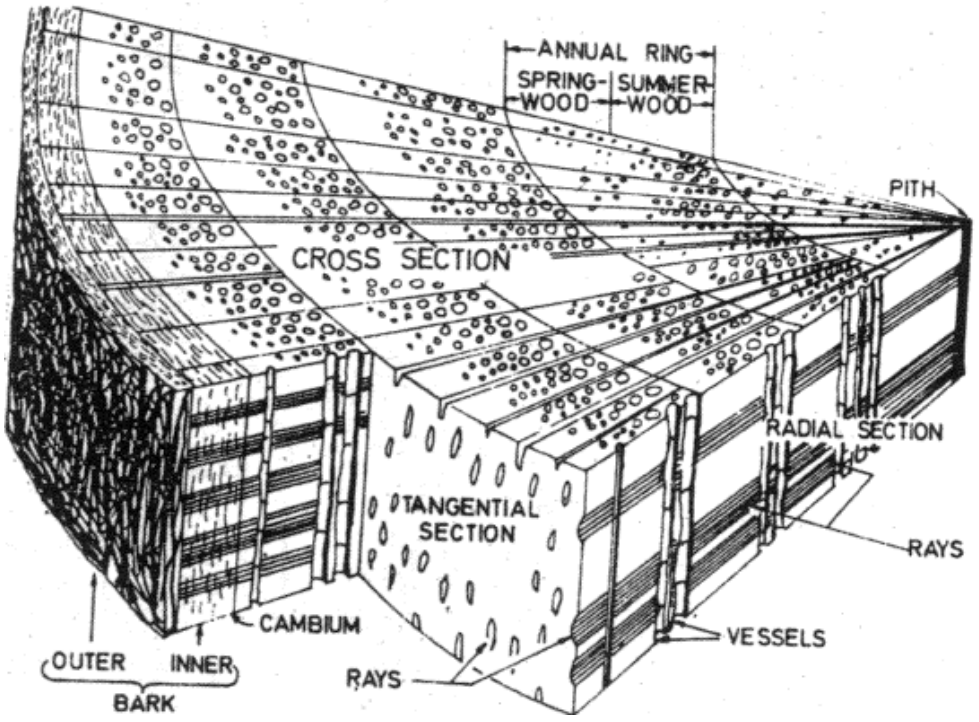


Fig.1.2 Detail of log in cross section

Commercial timbers are commonly classified into hardwoods and softwoods. Hardwoods comprises of oak and beech that have a broad leaf. Whereas softwoods include pine and spruce which have narrow needle like leaf.

1.3.1 Hard and Soft Wood

Hard wood is generally obtained from broad leaves or deciduous trees where as the softwood from trees having needle shaped conifers. The major differences between hard wood and soft wood are given as under.

Table 1.1 Differences between Hard and Soft Wood

S.No.	Hard Wood	Soft Wood
1	It is dark in color	Its color is light
2	It is heavy in weight.	It is light in weight
3	Hard woods are harder and denser.	Soft woods are comparatively lighter
4	It has less resin content	Few softwoods are resinous.
5	It does not split quickly	It gets splitted quickly
6	It is difficult to work.	It is easy to work.
7	It's annual rings are close and often indistinct	Its annual rings are well spaced and quit distinct
8	It is slow growing.	It is fast growing.
9	It has good tensile and shear resistance.	It has good tensile resistance but is weak across the fibers.
10	It does not catch fire very soon	It catches fire very soon.

1.3.2 Types of Common Timbers, Their Qualities and Uses

The common types of timbers available are Shisham, Sal, Teak, Deodar, Mango, Mahogany, Kail, Chir, Babul, Fir wood, Walnut and Haldu,oak,beach. Out of these, Deodar, Chid, Kail, Fir wood and Haldu fall in the categories of softwoods and Shisham, Sal,Teak, Kiker, Mango, Walnut fall in the categories of hardwoods.

1. Shisham is dark brown in color and it possesses golden and dark brow stripes. It is very hard to work and generally wears or blunts the sharp edge of cutting tool very soon. It is recognized as highly strong and durable wood and it is mainly used for making good variety of furniture, tool handles, beds, cabinets, bridge piles, plywood etc.

Fig.1.3 Shisham

2. Sal exists in rose brown color which slowly turns into dark brown. It is free from attack of white ants insects and it is very difficult to work. It has poor finish and therefore is not used for decorative furniture. It finds vast applications in making doors, windows, cots, wooden handles, furniture and railway sleepers etc.

Fig.1.4 Sal

3. Teak Wood is hard. It is available in golden yellow or dark brown color. Special stripes on it add to its beauty. It is very strong, durable and it maintains good polish. It is mainly used for making good quality furniture, plywood, ships etc.

Fig.1.5 Teak Wood

4 .Deodar is white in color when soft. But when it is hard, its color turns toward light yellow. It is strong and durable. It provides fragrance when smelled. It is not easily attacked by insects as it has some quantity of oil in it. It is used for manufacturing of doors, furniture, patterns, railway sleepers etc.

Fig.1.6 Deodar

5. Mango is brown in color and it can be easily shaped in various products. It is widely used as a cheap wood for making doors, packing cases, toys and inferior furniture.

6. Mahogany is reddish brown in color which is highly strong when dry. It also contains some oil in it that prevents it from the attack of insects. It is commonly used for manufacturing cabinet, fine furniture, pattern making work etc.

7 .Kail Wood has many knots in it. It gives a close grained, moderately hard and durable wood which can be easily painted. It is commonly utilized for making cheap furniture, wooden doors, packing cases etc.

Fig.1.7 Kail Wood

8 .Chid is also known as Chir. Its color is dark brown when is soft, but it is reddish brown when hard. It has stripes of dark brown color. It has oily smell and is used for interior work in the house.

Fig.1.8 Chid

9. Babul is close grained tough and pale red colored wood and is used for making tool handles etc.

Fig.1.9 Babul

10. Fir wood is light brown in color when soft but harder variety is found in dark brown color. It is commonly utilized for making drawers, packing cases, doors etc.

Fig.1.10 Fir Wood

11. Walnut is a good variety of wood which resists the attack of white ants. It can be polished easily in a better way. This wood is generally used for making musical instruments, furniture, cabinet work, decoration work etc.

Fig.1.11 Walnut

12 Haldu is white in color at the time of cutting, but once cut, its color becomes yellow. It can be dried and polished. It is widely used for making small objects such as stool, picture frames, trays, cabinet etc.

Fig.1.12 Haldu

1.4 Felling, Conversion and Seasoning of Wood

Cutting of trees to obtain timber is called felling of trees. Trees are cut at appropriate time. The best time for sawing the tree is immediately after the tree has achieved its full growth or maturity age so that the maximum quantity and best quality of wood can be obtained. If an immature tree is cut, it will carry a lot of sapwood which may not be much useful for the carpentry work. Contrary to this, if the tree is allowed to stand for long after attaining the maturity the most valuable part of timber will be subjected to decay. Therefore enough care must be taken to see that felling is accomplished only at the appropriate time. The proper time of cutting of a tree depends largely on its age and season of the year. Cutting of trees for getting wood for use is done generally in mid-summer or mid-winter because the sap of the tree is at rest during this period and therefore, the chances of any decay of useful wood are minimized. The time taken for a tree to mature depends whether it is softwood or hardwood. After cutting the trees from bottom, the branches are removed from it and form of log is obtained.

1.4.1 Conversion

The process of sawing wooden logs into useful sizes and shapes (boards, planks squares and other planes section and sizes etc.) for commercial requirements is known as **conversion**. Conversion is carried over prior to seasoning by two methods namely plain, through, through sawn process and quarter and rift sawn process.

Plain sections of wood may likely to warp and hence cannot be used for quality work. Quarter sawing almost eliminates the chances of warping. Quarter sawn sections are used as quality wood in cabinet making, decoration and framework.

Methods of Conversion

The three methods of conversion commonly adopted are discussed as under.

a) The first method is called as **flat or ordinary cutting** which is the simplest procedure of sawing but the cut sections are likely to warp. Therefore, the wood cut through this procedure cannot be called as quality work. In this method, the timber log is cut into a number of boards by taking various parallel saw cuts into the suitable forms.

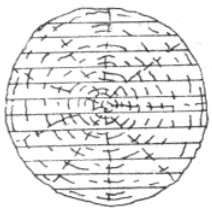


Fig.1.13 Common flat sawing

b) The second method is known as **tangential cutting** in which cutting takes place in such a way that the widths of the boards are tangential to the annual rings. The timber cut by this method is seasoned quickly and cutting wastage is also less but it may warp like flat sawn wood.

c) The third procedure is known as **quarter or radial sawing** in which the timber logs are sawn so that the width of the sawn boards falls along the medulary rays which mean they run across the section of the log. The normal defect of warping is almost eliminated by this procedure of sawing and the timber is very suitable for all sorts of wood work involving cabinet-making, decoration and framework.

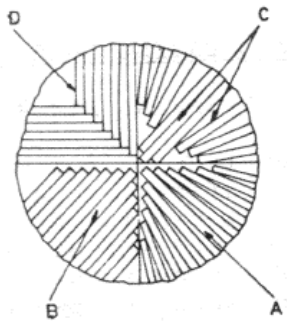


Fig.1.14 Four methods of quarter sawing. (A) Radial (B) Tangential
(C) Combined radial and tangential (D) Quarter tangential

1.4.2 Seasoning

Seasoning of wood is the reduction of the moisture or sap content of it to the point where, under normal conditions, no further drying out will take place .Minimum moisture content of wood should be 12.5 %. The main purpose of seasoning is to reduce the unwanted amount of moisture from the timber. As the moisture contained in the cell walls evaporates, shrinkage of the timber takes place which is greatest along the growth rings. Certain other defects such as shaking and warping may develop during seasoning. Therefore for these reasons green or unseasoned timber should not used for any work but for rough work. Once the timber is seasoned before use, it will not shrink, twist or swell during its further use. Need for seasoning of timber before its use is necessary in order to achieve the required moisture content, to reduce fungi decay, to minimize attack of insects, to increase strength of wood and for reduction of wood warpage

1.4.2.1 Classification of Seasoning

Seasoning is classified into two categories namely natural seasoning and artificial seasoning.

a) **Natural Seasoning** is carried out generally in air, or in water or in smoke. Air seasoning is the oldest method of drying timber and it depends entirely upon the free flow of air around the wood to evaporate moisture. A timber stack in a shade for air seasoning is shown in Fig below.

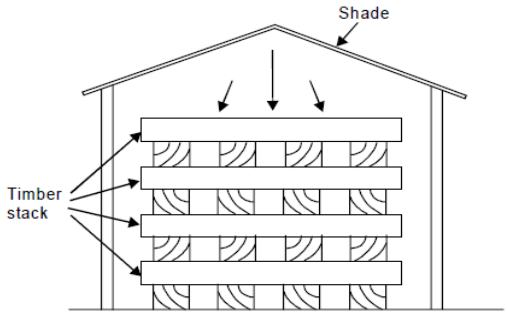


Fig.1.15 Timber stack in a shade for air seasoning

In water seasoning, the timber balks are immersed in water for 15-20 days. During period, the flowing water drives away the sap of wood it. Timber is then taken out and dried in open air for about a month. Water seasoning takes less time than air seasoning, but the strength of wood is reduced. However by water seasoning, the timber is less liable to warp, crack and distort. This method of seasoning is highly suitable for seasoning green wood full of sap. This seasoning process renders timber less liable to rot decay. In smoke seasoning, the wood is dried by using the smoke of rough burning timber and waste leaves. The smoke seasoning is used for woods in boats.

b) **Artificial seasoning** is controlled by application of both heat and humidity which enables to reduce the moisture content quickly and accurately. After artificial seasoning the wood becomes harder, whereas in natural seasoning the wood becomes soft. Kiln seasoning is an important type of artificial seasoning as shown in fig

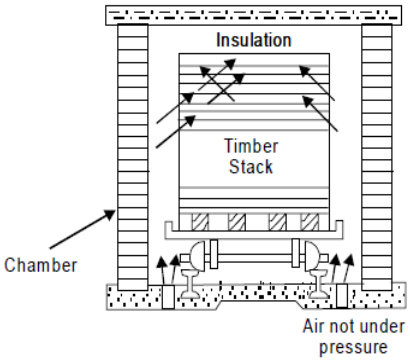


Fig.1.16 Timber stack in kiln seasoning

In this, the timber is seasoned by the use of a forced draught of warm air in which brings about a rapid reduction in moisture content.

1.4.2.2 Calculation of Moisture Content

Moisture content of wood can be calculated as

1. (W-D)/D ×100 %
   Where
   W =Wet wood
   D = Dry Wood
2. By simply checking weight
3. Different types of moisture meters.

1.5 Defects in Timber

Defects in timber may be broadly classified into three major categories

1. Due to abnormal growth of trees
2. Due to conversion or seasoning
3. Due to fungi and insects.

The defects in each category are described as under.

1. Defects Due to Abnormal Growth of Trees

Defects due to abnormal growth of trees are natural in nature and they are knots, stakes, twisted fiber and rind galls.

a) **Knots** are too much frequent in many trees. They break the continuity of fiber and weaken the timber. These defects may be of dead or live kind. A **dead knot** will come out of the wooden piece leaving a knot hole. It is produced when a branch is broken off before the tree has finished growing. A **live knot** occurs when a branch separates from the tree after felling of the tree. Live knot will not become loose and fall out of its position but may tend to crack. This provides inlets for any fungi to attack the wood. If these knots are not too large and not too near the edge of the plank, they will not present a great problem however dead knots in timber makes the wood unsuitable for structural use.

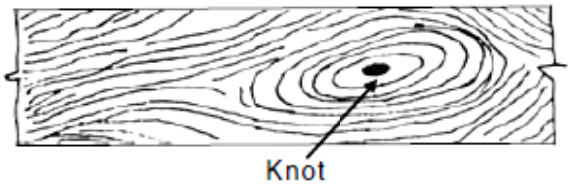


Fig.1.17 Knot defect in timber

b) **Shakes** in timber are splits in the grain and often arise as a result of uneven seasoning. They may be of radial, heart, star, cup and upset kind. An upset or rupture is a shake in which the fracture occurs across the grain. This is thought to be caused by violet jarring of the timber during felling and is often found in mahogany.

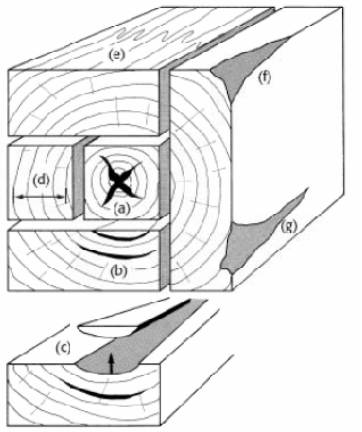


Fig.1.18 Shakes

c) Sometimes, the fibers of a tree may get twisted due to wind action in branches. This defect is known as **twisted fibers** defect in timber. The fibers of wood have different inclinations with its axis. They are no more parallel to the axis of the wood. Twisted fibers in timber offer difficulty in working and a smooth surface cannot be obtained.

d) **Rind gall** is the defects due to abnormal growth of trees. It is the wound created on the tree while a branch breaks and parts off or gets cut. Decay may occur at that point.

2. Defects Due to Conversion and Seasoning

Defects due to conversion and seasoning of timber involve shakes, warping, bowing, twist, diamonding, case hardening and honey combing. Some of such important defects are discussed as under.

a) **Warping** is a kind of variation from a true or plain surface and may include a one or combination of cup, bow, crook and twist. Warping board which is tangentially sawn may invariably warp. This takes the form of a hollowing or cupping across the face of the board and when wide flat boards are required this will act as a serious drawback.

b) **Wind or twist defect** occurs when thin boards are cut from a log having curved longitudinal grain. This tendency is for the board distort spirally.

c) **Diamonding** in timber is the tendency of square cut pieces to become diamond shaped when cut from certain areas of the log. This happens when the piece has been cut with growth rings running diagonally, causing the unequal shrinkage between summer and spring growth to pull it out of shape.

3. Defects due to Fungi and Insects

Defects due to fungi and insects in timber involve fungi, dry rot, and wet rot which are discussed as under.

Fungi in timber use the wood as their food and destroy the same. It acts on the wood tissues and cells and cause decay. There are two types of defects in wood because of fungi and insects which are known as dry rot and wet rot.

a) **Dry rot** is a type of fungus on dry wood which feeds on damp wood and breaks it down. Dry rot is so called because infected wood eventually becomes lighter in weight and takes on the appearance of being badly charred by fire, except that it is brown in color instead of black and crumbles under slight pressure. This fungus cannot develop in wood which has a sap content of less than 20% so that to prevent it, all that is really necessary is to use seasoned timber and to keep it dry.

b) **Wet rot** in timber is the decay due to dampness. The wood looks wet due to fungi attack on living trees. The effected positions of wood are reduced to a gray brown powder. Well seasoned wood, protected by painting will avoid wet rot. Insects such as beetles, borers and white ant attack the wood and render it of no use. The insect attack may be controlled through the use of insecticides. In another method, the timbers are placed in a kiln where steam and heat are used to suffocate the pests.

1.6 Timber Preservation

It is highly essential to protect timber from attack of fungus and any damage from insect attack. Timber products require protection if it is exposed to weather such as doors, windows, poles etc. Extending the life of the timber through preservation is a much cheaper deal. The object of treating timber with a preservative is to render it immune to decay, even though it may become quite damp and to prevent attack by timber boring insects. Most timber preservatives belong to one of three main group tar-oil derivatives creosote, water soluble type and organic solvent chemicals.

1.7 Characteristics of a Good Timber

Timber is free from knots, insects attack, excessive moisture, discoloration, twisted fibers, cup and ring shake, sound, bright and free from any discoloration. It is solid with annual rings but not hallow in the center. Timber should be well seasoned for easily workable specific use. It should possess straight fibers and high fire resistance. It should not split when nails are driven in it. It should not clog with the saw teeth during the sawing operation. Timber should be highly suitable for polishing and painting.

1.8 Common Tools Used In Carpentry Shop

Commonly used tools to shape wood for various types of joints by driving in and driving out nail involve cutting and smoothening of wood surfaces. A broad classification of tools used in the wood working or carpentry shop are measuring and marking tools, supporting and holding tools, cutting tools, striking tools and miscellaneous tools. Some important such tools and instruments are discussed as under.

1.8.1 Marking and Measuring Tools

Marking in order to make wooden components of the required size or the marking of exact dimensions on the wooden piece is essential to produce quality jobs. A number of marking and measuring instruments namely Rules, Try Square, Combination Set, Bevel Gauge, Marking Gauge, Mortise Gauge, Cutting Gauge, Spirit Level, Trammel and Compass are commonly used for this purpose. Some of commonly used marking and measuring instruments are discussed below

a) Rules

Rules are straight edge of wood or steel engraved in millimeters- centimeters or in inches-foot or in both. These are used to mark, measure the length, widths and thicknesses of wood part. Fig.1.17 show steel rule, folding rule and flexible steel rule.

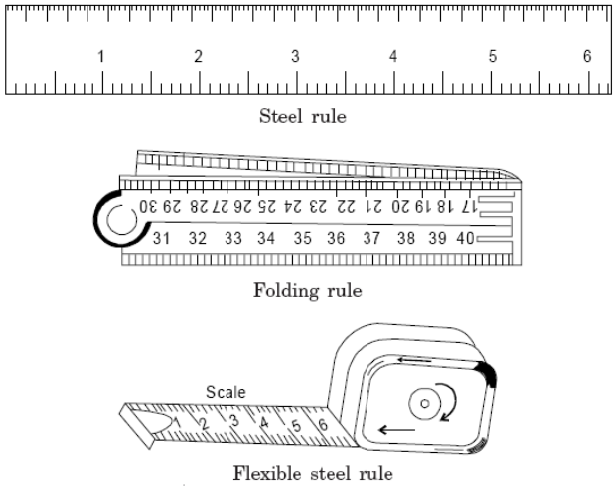


Fig.1.19 Different type of rules

b) Try Square

Try square is used for measuring and checking of squareness, perpendicularity, dimensions, testing of finish of planned surfaces and drawing parallel and perpendicular lines. The steel blade and metallic or wooden handle of try square are at right angles to each other. Try square is used for testing the level, edge and squareness of the wooden surfaces. It is also used for marking lines across the face or edge of wooden block. There are graduations along the blade of the rule that are used for measuring and marking purposes on the wooden jobs.

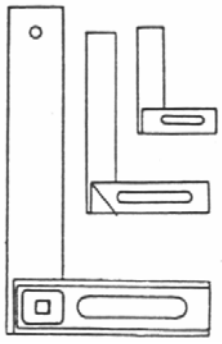


Fig.1.20 Try Square

c) Combination Set

Combination set is frequently used in the carpentry shop for different kind of measurements. It consists of blade and a head. The blade has a groove cut along its length so that it can slide into the head. One side of the head makes a 90° angle with the blade and the other side a 45° angle. It can be making, measuring and setting different angle. It also acts as a try square, angle gauge to set 45° angles, a depth gauge and level checking tool.

d) Bevel Gauge

Bevel gauge is also known as an **adjustable bevel** which is mainly used for marking, measuring and inspecting angles from 0 to 180 degree. Its blade can be adjusted and set to any desired angle.

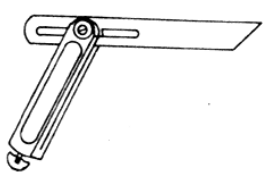


Fig.1.21 Iron sliding T bevel

e) Marking Gauge

The marking gauge is made of wood which is important tool utilized to make lines at a uniform distance from the edge of a board or piece of work and is used principally when preparing wooden components to size before joining. The marking gauge like the mortise gauge and cutting gauge in use should be positioned correctly. For marking purposes, the gauge is drawn towards the body or pushed away from it but in either case, if the spur does not trail. It will tend to jump and run with the grain. Thumb screw of the marking gauge locks the stock at any position. The spur made of hardened steel should be ground to a fine point. And for ease of working, it should not project too far from the face of the stem. It is commonly used to mark or scribe line parallel to and at any desired distance from a finished edge or face of a surface.

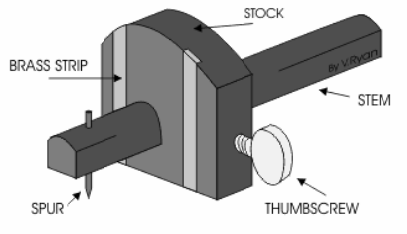


Fig.1.22 Marking gauge

f) Cutting Gauge

Cutting gauge is similar in construction to the marking gauge but having a knife in place of the marking pin or spur. It can be utilized for gauging and marking deep lines across the grain of wood in thicker sections.

g) Mortise Gauge

This is an improved form of marking gauge which consists of main components as fixed pin, sliding pin, brass strip, stem, rose wood stock and thumb screw. The fixed pin of the gauge is attached to a short brass strip which is screwed to the stem. The sliding pin is fixed to a long brass strip or slider is adjusted by means of a thumbscrew. The threaded portion of which engages in a cylindrical nut which is embedded in the stem. The stock is locked in position by a metal set screw. This gauge is used for marking out of the parallel sides of mortises or tenons and other similar joint.

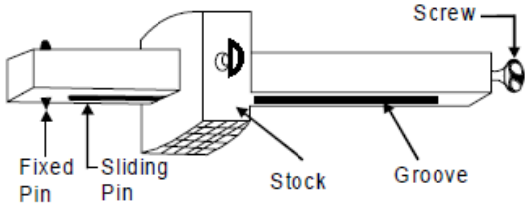


Fig.1.23 Mortise gauge

1.8.2 Holding and Supporting Tools

Sometimes it is desirable to support and hold a wooden board while the work is being carried out. For these purposes, various supporting and holding devices are needed, some of which are discussed as under.

a) Work Bench

Every carpenter generally needs a good solid bench or table of hard wood on which he can perform the carpentry operations. Work bench should be equipped with a vice for holding the work and with slots and holes for keeping the common hand tools. One jaw of the vice is tightened to the table and is kept moveable for holding the articles Work benches are built solidly with good heavy tops for providing a good working surface for cutting, as well. The vice on the bench is equipped with an adjustable dog that is, a piece of wood or metal can be moved up and down in the outside jaw of the vice.

b) Carpenter Vice

Carpenter vice is very important tool in wood working shops for holding wooden jobs. There are several varieties of vices, each possessing its own particular merit.

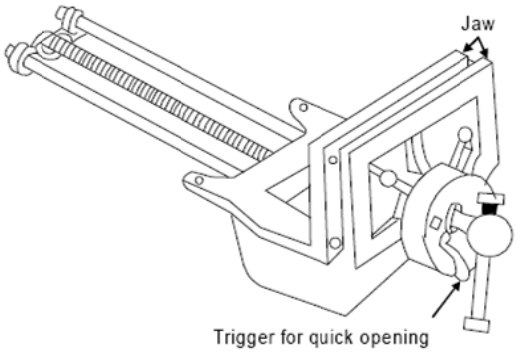


Fig.1.24 Carpenter vice

Clamp

Clamps are commonly used in pairs in gluing up operations at the final assembly of wood joinery work. These clamps can provide pressure required to hold joints together until they are secured due to the setting of glues. Clamps are of two types namely plain rectangular **bar type** and **T-bar** type. The former is made of mild steel and is usually rectangular in section. The later may be of T-section, which can easily afford greater rigidity under stress. The coarse adjustment jaw may be located in any position on the bar by means of a steel pin which fits into any of the holes drilled at intervals along the bar. The fine adjustment jaw of the sash clamp is moved along the bar by a square threads screw which passes through a special nut fixed to the end of bar. Considerable pressure can be applied by turning the screw with the Tommy bar for holding a wooden job. Both jaws of the sash clamp are generally made of malleable cast iron which is tougher and less brittle than ordinary cast iron. There are other similar types of such clamps named as rack clamp, screw clamps, light duty parallel clamp, adjustable bar clamp, G or C-clamp and double bar clamp which are useful for holding different sizes and shapes of wooden jobs.

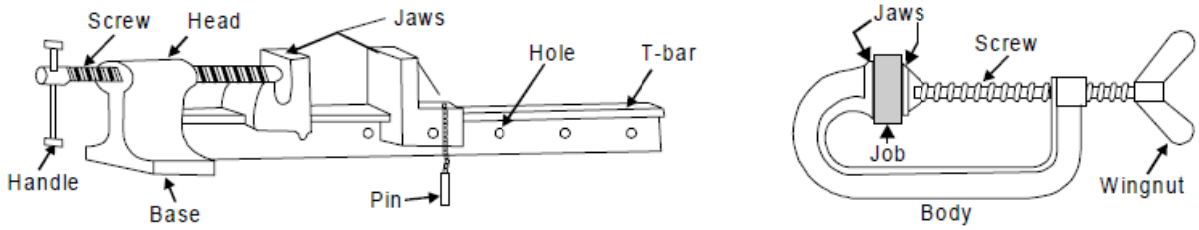


Fig.1.25 Bar clamp or C-clamp

1.8.3 Cutting Tools

Various kinds of cutting tools namely various kinds of saws, planes, chisels, scraper, files, and rasp and boring tools such as brace and bits, bradawl, auger, gimlet are used in the carpentry shop. Few important types of cutting tools are described as under.

1.8.3.1 Saws

Saws are wood cutting tools having handle and a thin steel blade with small sharp teeth along the edge. They are utilized to cut wood to different sizes and shapes used for making the wooden joints that hold parts together. They can be further classified into three major types namely hand Saws (Rip, Cross-cut, Panel, Keyhole and, Pad saw), Snuff Saws (Tenon and Dovetail) and Frame Saws (Coping, Bow and Fret). Some of them are described as under.

a) Rip Saw

It is used for cutting timber along the grains. The teeth of rip saw are chisel-shaped and are set alternately to the right and left. Depending upon whether the saw is designed to rip or cross-cut, the shape of the teeth will also vary. In the case of a ripsaw, the teeth are shaped like chisels.

b) **Crosscut Saw**

Cross cut saw is similar to rip saw in shape. It is primarily designed for cutting across the grains of wood. The teeth are knife shaped and bent alternately to the right and left for making the saw to cut wider than the blade. The saw cut is called the kerf. Since the kerf is wider than the blade, the blade will not stick as the sawing is done. The saw teeth may be coarse (with only 4 or 5 teeth per inch) or fine (with ten or twelve teeth per inch). A jaw for general purpose cutting should have about eight or nine points per inch (there is one more point than teeth per inch) and should be about 24 inches long.

c) Turning Saw

The turning saw is similar to the copying saw which is designed for cutting curves, scrolls and roundings on wooden jobs. It is used chiefly on heavier work where long fast stroke and less accuracy of cutting are required. The thin blade of the turning saw is removable. This saw can be pivoted between the handles. The saw generally cuts in the pulling stroke.

d) Dovetail Saw

Dovetail saw is little and is closely similar as related to the backsaw or tennon saw. It is lighter and however possesses a thinner blade and finer teeth. The handle is round, to provide a delicate grip for fine cutting. This saw is used where absolutely finer and delicate cutting is required in wood work.

e) Compass Saw

Compass saw carries a tapered blade which is long and is one of the special saw having thin, narrow and flexible blade. With a blade resembling the beak of a swordfish, this type of saw is commonly used for making cutouts on the inside surface of a piece of work. A hole is first bored inside the portion which is to be cut out and the pointed compass saw is pushed into the hole to start the sawing operation. Its blade contains about 12 teeth per cm length.

f) Keyhole Saw

The keyhole saw is used in the same manner as the compass saw. For this reason it is generally employed for fine internal and intricate work where the compass saw would be too big and clumsy for the carpentry job.

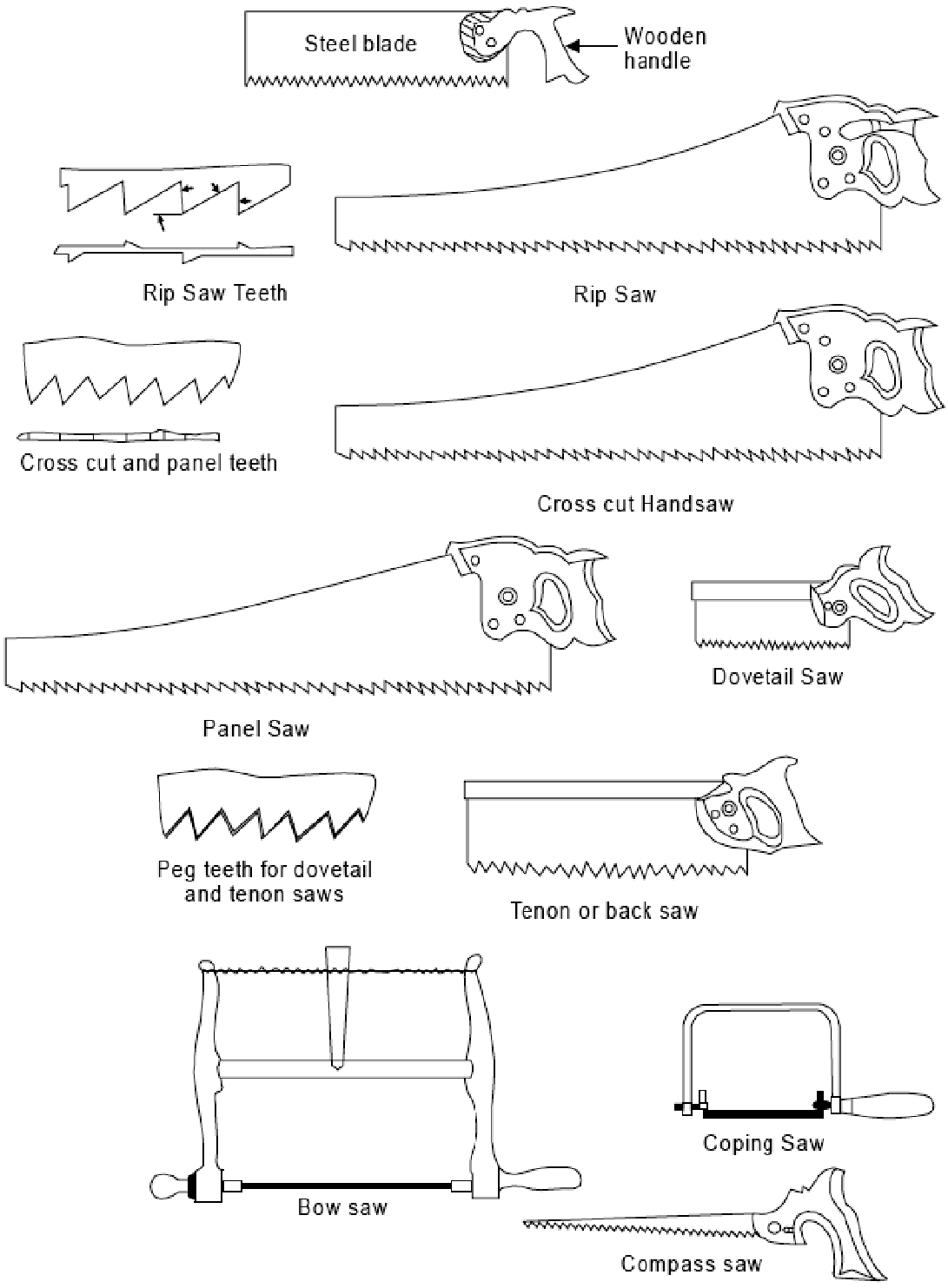


Fig.1.26 Few important types of saws

g) Hacksaw

Hacksaw consists of steel frame and a hacksaw blade. While essentially designed for cutting metal, this tool comes in for a variety of uses in the woodworking shop. The frame of hacksaw is designed in different ways, some with pistol grips, and others with handles similar to those used on a conventional saw and others with turned handles. Blades of hacksaw are detachable and can be obtained with teeth of varying coarseness.

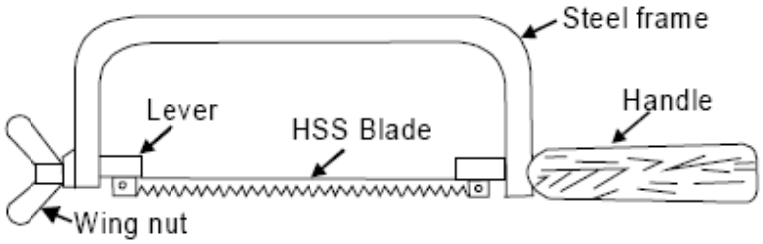


Fig.1.27 Hacksaw

1.8.3.2 Planes

A plane is a special tool with a cutting blade for smoothing and removing wood as shavings. It is just like a chisel fixed in a wooden or steel body. Fig.1.25 shows a simple plane. The modern plane has been developed from the chisel. They can also be classified as jack plane, smooth plane, jointer plane, trying plane, rabbit plane, and circular plane and for plane. Few important planes are discussed as under.

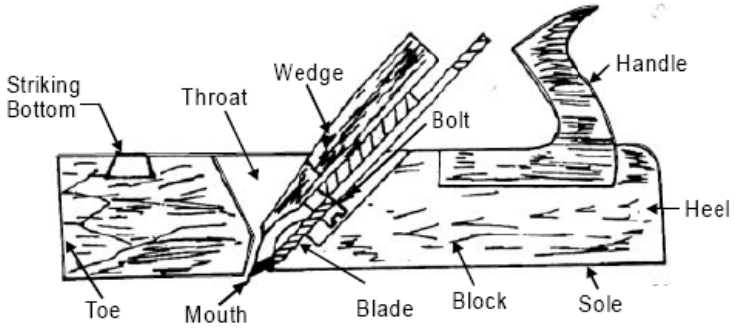


Fig.1.28 Simple plane

a) **Jack Plane**

Jack plane is most commonly used plane and comprises of its body, blade and handle. It is good for rough surfaces that require a heavier chip. It is ideal for obtaining a smooth and flat surface. There are actually forty-six different parts of jack plane. The main working parts are the cutting blade or plane iron. The adjusting nut is operated to raise or lower the blade and the adjusting lever which regulates the blade so as to make possible an even or slanted cut. The cutting blade of the jack plane is guarded with a metal cap which is adjusted on top of the blade to within about 2.4 mm of the cutting edge. The metal cap of the jack plane eases the cutting action by curling and breaking off the wood shavings evenly, thus preventing splitting or splintering of the wooden part.

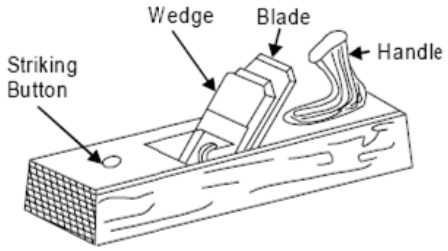


Fig.1.29 Jack plane

b) Smoothing Plane

Smoothing plane is somewhat smaller than the jack plane, measuring between 6 and 10 inches in lengths. It is a fine utility tool, especially useful for planning end grain, chamfering, and other edge shaping of wooden part. This plane is also used for cleaning up after gluing and assembly, but owing to its short length should not be used for producing very true surfaces.

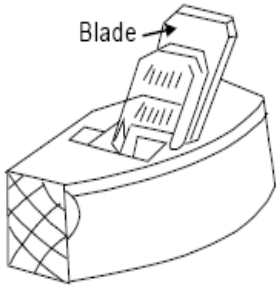


Fig.1.30 Smoothing plane

c) Jointer Plane

When a fairly long board is to be planed absolutely straight and square along the edge, it is easier to obtain a straight and level surface with the jointer plane in comparison to any other type of plane. This plane is made up in various sizes but the most popular type of jointer plane is 24 inches in teeth.

d) Trying Plane

The wooden trying plane is similar in construction to the jack plane except that its blade is wider and much longer than jack plane. Its mouth is also narrower than that of the jack plane.

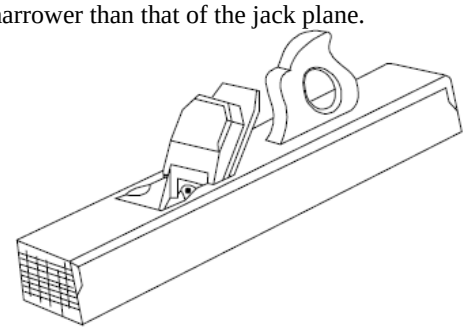


Fig.1.31 Trying plane

e) Rabbet Plane

Rabbet plane is used for sinking one surface below another and shouldering one piece into another. If the edge of a piece of wooden board is to be rabbeted, this plane is being generally used. The side guide and the cutting blade of the rabbit plane may be adjusted so as to cut rabbets of varying widths and depths. The plane is useful for various types of edge shaping. Rebate or rabbet means a recess or step cut into the edge or end of a wooden board.

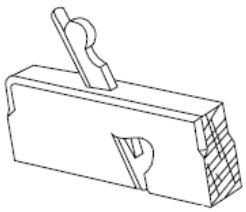


Fig.1.32 Rabbet Plane

f) Circular Plane

The shape of circular plane adapts it for planning either convex or concave surfaces and for shaping round edges. This plane may be adjusted so that the flexible bed will conform to circles of various sizes.

g) Fore Plane

This plane may be said as a junior jointer plane. It is slightly shorter than the conventional jointer plane. It is mainly used for planning edges of medium length.

1.8.3.3 Chisels

A Chisel is a strong sharp edge cutting tool with a sharp bevel edge at one end. It is composed of handle, tang, ferrule, shoulder, and blade. Chisels are generally **made up of high carbon steel.**

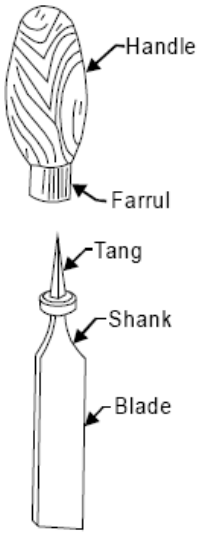


Fig.1.33 Chisel

They are used to shape and fit parts as required in joint making. A gouge is a curved chisel. It may be outside or inside ground. Outside ground gouges are called **firmer gouges** and inside ground gouges are called **scribing gouges**. The scribing gouges are made long and thin, they are known as **paring gouges**. Several varieties of chisels are available, each having special characteristics which fit it for its special use. There are two types of construction employed in the making of chisels named as tang and socket types. The tang chisel is made with a ranged or pointed end which pierces into the handle. The socket chisel reverses the process by having the handle fit into the socket collar on the blade.

a) Firmer Chisel

Firmer chisel possesses a blade of rectangular section. It consists of the following parts blade made of cast tool steel and it is used for general bench work. The shoulder of the chisel prevents the tang from being driven farther into the handle when the chisel is struck with a mallet. The ferrule is short length of brass tube (mild steel tube in the case of some mortise chisels) which fits tightly over the lower end of the handle, and helps to prevent its splitting by the tang. The tang is not hardened as to fit in the handle. The handles turned from ash or beech wood as these timbers are resistant to splitting.

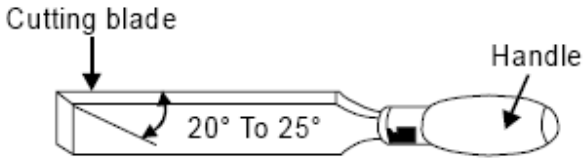


Fig.1.34 Firmer Chisel

b) Beveled edge firmer chisel

Beveled edge firmer chisel is identical to the firmer chisel except that the edges of the back of the blade are beveled. This enables the chisel to be used for cutting right into the corner of acute-angled wood work such as the base of a dovetail.

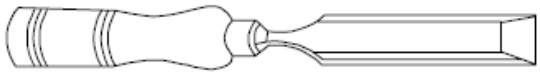


Fig.1.35 Beveled edge firmer chisel

c) Paring Chisel

Paring chisel has a longer and usually slightly thinner blade than firmer chisel. It may be obtained with a blade of rectangular or beveled edge section and is used in pattern making and where long accurate paring is required. The paring chisel should not be struck with a mallet. This chisel is intended for manipulation by hand only, and not for driving with a mallet like a firmer chisel for cutting of wooden jobs.

Fig.1.36 Paring chisel

d) Mortise Chisel

Mortise chisel is designed for heavy work. A mortise chisel has a blade which is very nearly square in section and so may be used as a lever for removing chips and will withstand heavy blows from a mallet. Various types of handles are fitted to mortise chisel depending upon use. Mortise chisel has an oval beech handle, whilst the heaviest type of all has a socket handle. This socket replaces the ferrule and affords greater resistance to splitting when used for very heavy work. The leather washer acts as a shock absorber.

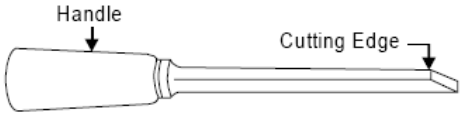


Fig.1.37 Mortise chisel

1.8.3.4 Scraper

The scraper for wooden work is used in carpentry shop. It is used after planning to obtain a smooth surface before final glass papering. Where the grain in wood is particularly twisty so that even a finely set plane tends to tear it, a sharp scraper will be found most useful to tackle this problem. It is also used for cleaning up veneered work as its curved edges are used for cleaning up large molding of concave section and other similar work. The scraper is held as the thumbs being positioned low down and pushed forward to curve the blade so that the center of the edge rather than the outer corners comes into contact with the surface of the wood. A sharp scraper will produce fine shavings on wooden surfaces.

1.8.3.5 Files and Rasps

Rasps are shown in Fig. below. They are used for maintaining other wood working tools and equipment. They are made of hardened tool steel which is tempered and they should never be dropped as they are very brittle to break. They are of various types depending upon their size, shape, cuts and degree of their coarseness.

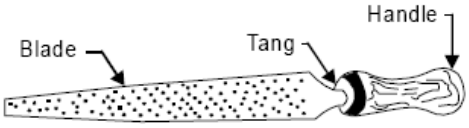


Fig.1.38 Rasps

Files are used in many different trades and many different purposes. They are classified according to the shape of their cross section for instance square, round, triangular, flat, half round etc and according to the manner in which the serrations or teeth are cut, as single cut or double cut. Single cut means, single parallel lines across the surface and double cut means, two sets of parallel lines crossing each other obliquely. Triangular files with pointed corners are made for sharpening hand saws. The second type with slightly round corners is for sharpening hand saws. Files for wood are made in several cuts, sizes and shapes and teeth are pitched more forward than those of metal-working file, giving a sharper cut. Half round files are the most useful.

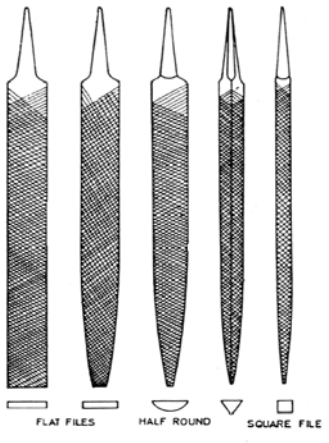


Fig.1.39 Files

1.8.3.6 Oil Stones

There are two main types of oilstones, natural and artificial, each obtainable in various grades. Of the natural stones the 'Arkansas' or American stone and the 'Belgium Rock' are perhaps the most popular ones. The Arkansas stone is a very hard and fine cutting stone and mainly used to produce on extremely keen edge. This stone is used with a kerosene oil mixture but the Belgium Rock is only used with water. Stones are made in three grades as coarse, medium and fine. They are made of carbon medium and should be fitted into a wooden case if they are not brought ready cased, both for protection of stones, which are fairly brittle and for convenience in sharpening. Oilstones become uneven with wear and it becomes difficult to maintain a straight edge when sharpening. Returning the face can be done by rubbing the stone on a sheet of coarse emery cloth fixed on flat surface. Stones worn too much for re-facing may be split and sharped into slips for sharpening curved tools.

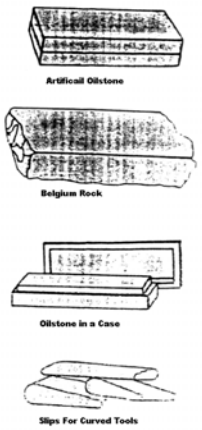


Fig.1.40 Oil stones

1.8.4 Boring Tools

Boring is cutting a hole in wood with a tool called a bit. Boring is the first step in making any kind of shaped opening or making holes. The commonly used boring tools bits are discussed as under.

a) The center bit

The center bits are available in sizes ranging .from 4 mm to 50 mm and are useful for boring holes through thin wood. They are not recommended for deep boring as it has a tendency to wander or drift as a result of varying grain texture and direction in wood. The screwed center of the improved center bit helps to draw the bit into the wood and therefore requires less pressure to obtain a cutting action.

Fig.1.41 Center bit

b) Auger bits

The auger bits are also known as twist bit. They are the most commonly used hole making tools used in wooden wood. They may possess a single twist auger bit or a double-twist auger bit. These bits are more costly than center bits. They can produce holes easily and accurately from 5mm to 35 mm in diameter in wooden jobs. The hollow features are important in both types of auger bits, because the parallel sides of the bit help to prevent drifting. And the twisted form of the body of the bit helps in the removal of cuttings. Both these bits have two cutters and two spurs as well as a screw center for quick and clean boring action in wood work

Fig.1.42 Auger bit

c) Countersink bits

Countersink bit is used for countersinking the predrilled holes to placement of heads of screws.

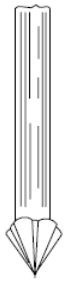


Fig.1.43 Countersink bit

d) Shell and spoon bit

Shell and spoon bits are the traditional kinds of bit which are now superseded by the carpenter's twist drills or bits.

e) Expanding bits

These are commonly used forms of screw center bit which are adjustable for cutting holes of from 15 mm to 75 mm in diameter. The two combined cutter-spurs are provided in each case to cover the range of whole sizes.

f) Forstner bits

These are used for boring clean sided stopped holes of flat bottom kind.

g) Snail bits
The snail bits have only one cutter which gives a clean cutting action.

h) Rose bits
The rose bit tends to scrape rather than cut. It is generally used on soft metals in addition to wood.

i) Bradawl
Bradawl is used for making fine holes, especially nail holes in soft woods. The cutting edge of the blade, which is sharpened equally from both sides, is placed across the grain so that the wood fibers are severed and not merely forced outwards. The blade is forced into the wood and it is then allowed to twist for enlargement of the diameter of the hole being bored and then finally removed. The cutting edge of the blade of bradawl is flared out to give clearance to the body of the blade which is fixed to the handle by means of a square-tapered tang. A brass ferrule is fitted to prevent the tapered tang splitting the handle when being pushed into it. The blade of bradawl is shouldered to prevent its being forced further into the pear-shaped handle which is usually turned from ash, box or wood.

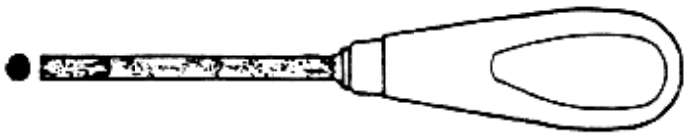


Fig.1.44 Bradawl

j) Auger
The auger is a carpentry hand tool (made up of steel bar) and is used to make holes in the wooden jobs. It possesses a screw point to center the tool at the point where hole is to be produced in the wooden part. Fluted body of the auger is to allow removal of wooden chips from wooden jobs using handle to apply pressure to rotate the auger for making the hole. Holes up to 25 mm diameter can be produced.

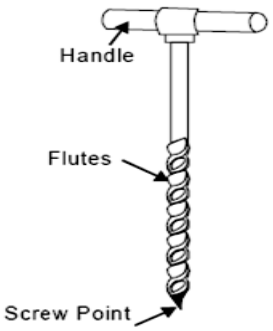


Fig.1.45 Auger

k) Reaming Bit
The reaming bit is also a sort of boring tool and its appearance is like an aid but it is sharpened square to a point and has one handle. It is used to make holes by forcing the reamer into the wood with a twisting motion. If carefully handles, It does not force the wood fibers apart because it has a cutting action.

1.9 Striking tools

Mallets and various types of hammers are generally used as striking tools in carpentry shop. A hammer delivers a sharp blow, its steel face being likely to damage the chisel handle whereas the softer striking surface such as mallet will give better result. Some of important such tools are discussed as under.

a) Mallet

A mallet is a short handled wooden hammer with a large head. It is used to strike a chisel for heavy cutting waste wood, from joints such as mortises and halving joints and also for removing unwanted, wood on shaped work etc. Mallet is frequently also used to tap parts of a project together during the assembly process.

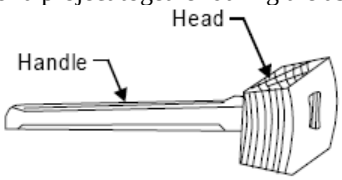


Fig.1.46 Mallet

b) Hammers

Warrington, peen and claw hammers are generally used by carpenters. They are described as under.

Warrington Hammer

Warrington hammer is used for knocking in nails, assembling joints and setting wooden plane blades.

The head is forged from tool steel and is obtainable in various weights. The face of hammer is hardened, tempered and ground slightly convex. The center part of the head is not hardened as a precaution against breakage in use through its being to brittle. The handle is made of wood and is oval in cross-section to have a comfortable grip. The end of the handle fits into a hole in the head and is held in position by wooden or metal wedges which open out the grain, thus securely locking the two parts together.

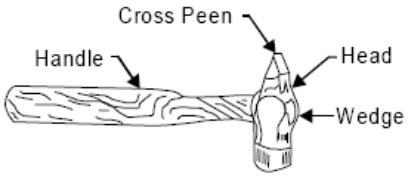


Fig.1.47 Warrington hammer

Peen Hammer

The peen hammer is used for striking nails where the use of the face is impracticable. The peen hammer is very light and is used for driving the panel pins and fine nails.

Claw Hammer

The claw hammer is shown in Fig.1.44. One of its end possesses curved claw which is used for extracting nails in order to provide the extra strength needed for this levering action. The other end is used for light striking work. A strong handle on claw hammer is always necessary for carrying out the task.

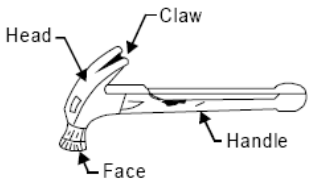


Fig.1.48 Claw hammer

1.10 Miscellaneous Tools

Other some miscellaneous carpentry hand tools that are also used in carpentry shop include screw driver, pincer and fasteners which are discussed as under.

a) Screw Driver

Screw driver is used to drive the screws into the wood. The tip of screw driver should be slightly hollow-ground so that it will fit accurately in the slot in the screw-head. The blade of a screwdriver is made of hardened tempered tool steel so that its tip can withstand the great strain put upon it while screwing. The tang of screw driver is not hardened. It is wide and rectangular in section so that it will restrict the twisting action put upon it during use. The ferrule is slotted to receive the tang and to hold it firmly in place in the handle. The handle, if made of wood, is usually pear-shaped or if made of unbreakable plastic, is generally of a fluted cylindrical shape. Some screwdrivers are fitted with a ratchet device used for clockwise anti-clockwise turning.

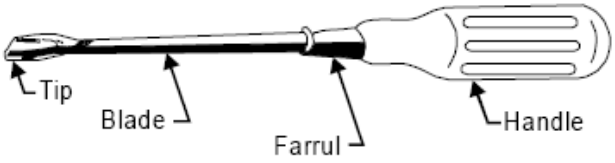


Fig.1.49 Screw driver

b) Pincer

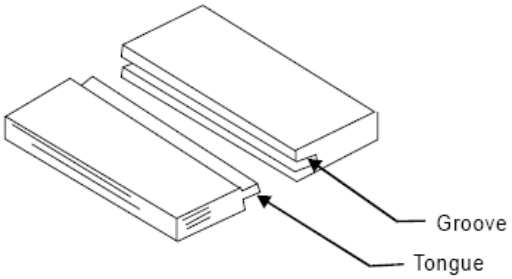
Pincers are commonly used for withdrawing nails. They are made of cast steel, the jaws being hardened. The end of one of the arms is shaped to form a claw for removing nails. The nail head is firmly gripped between the jaws as the long arms permit considerable pressure to be exerted by them. The nail is extracted from the wooden body by a leveling action, using the curved side of one of the jaws as a fulcrum. A small block of wood placed between the steel jaw and the work prevents damage to the surface of the wood

.

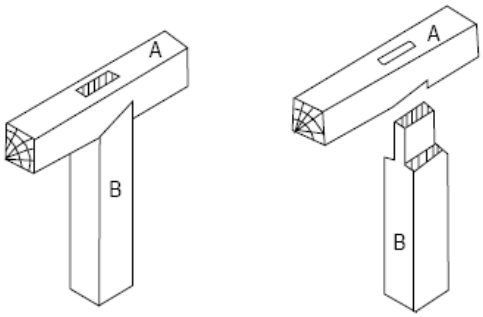
Fig.1.50 Pincer

1.11 Types of Wood Joints

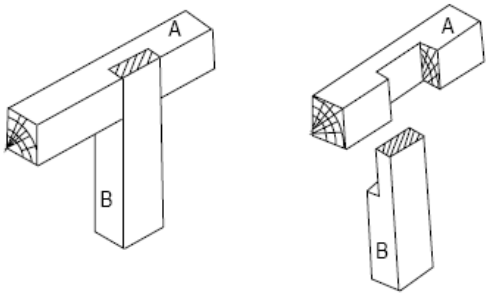
All wooden objects whether doors, windows, furniture, pattern, core boxes, handicrafts, toys, cots, etc., are all assembled with joints. The various common used wood working joints are shown below



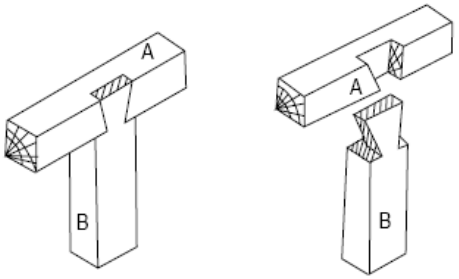
Groove and tongue joint



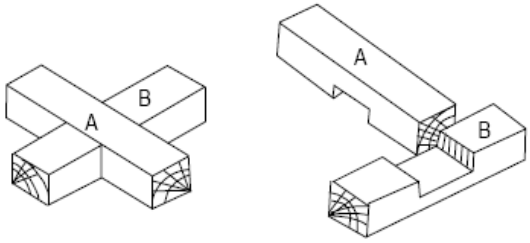
Mortise and tennon joint



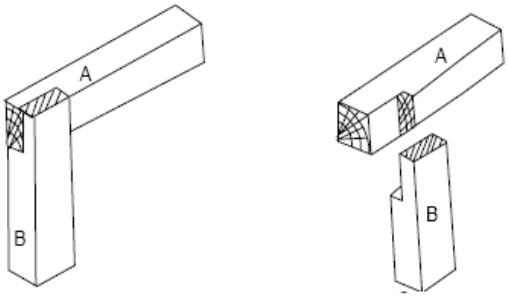
T-lap joint



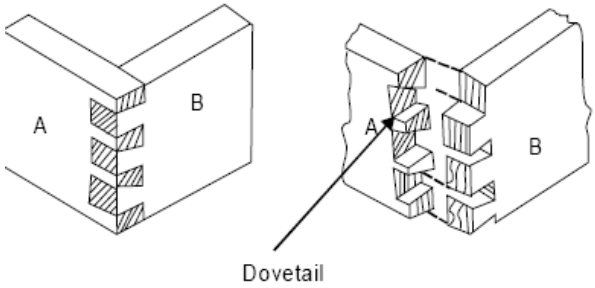
Open or through dove-tail joint



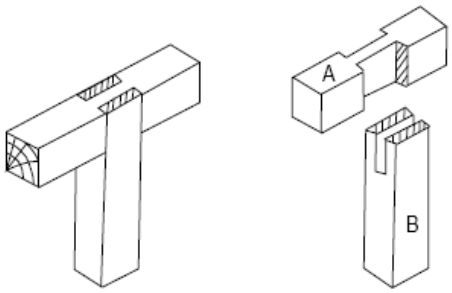
Cross-lap joint



Corner-lap joint



Dovetail joint



Briddle joint

Fig.1.51 Different types of wood joints

1.12 Carpentry Machines

Wood working machines are employed for large production work. These possess the following advantages over the hand tools.

1. The carpentry machines help to reduce fatigue of carpenter.
2. The carpentry machines are used for production work.
3. The carpentry machines save time and are used for accuracy work.
4. They are used for variable job variety and more designs are possible.

Different machines are needed to save time and labor in carpentry work for various quick wood working operations especially for turning and sawing purposes. The general wood working machines are wood working lathe, circular saw and band saw. These machines are discussed as under

1. Wood Working Lathe

A general wood working lathe is shown in Fig.1.48. It consists of a cast iron bed, a headstock, tailstock, tool rest, live and dead centers and drawing mechanisms. The long wooden cylindrical jobs are held and rotated between the two centers. The tool is then fed against the job and the round symmetrical shape on the jobs is produced. Scrapping tool and turning gauge are generally used as a turning tool on a woodworking lathe.

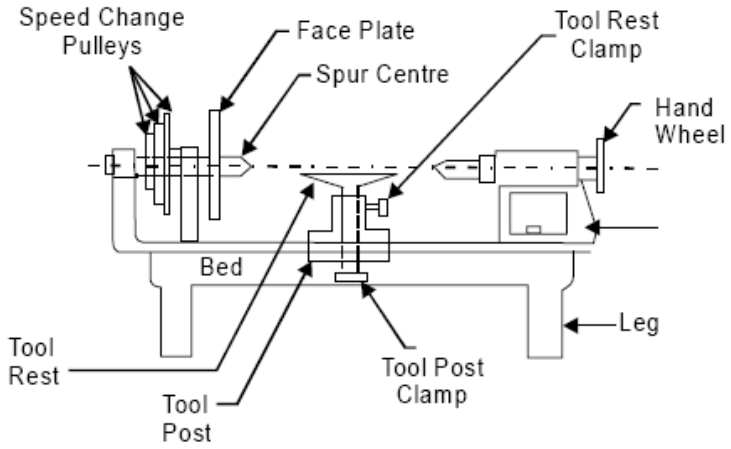


Fig.1.52 Wood turning lathe

2. Circular Saw

It is also called as table or bench saw which is used to perform various operations such as grooving, rebating, chamfering etc. It consists of a cast iron table, a circular cutting blade, cut off guides, main motor, saw guide, elevating hand wheel, tilting hand wheel etc. The work is held on the table and moved against the circular saw to perform the quick and automatic sawing operation and other operation on wood. The principal parts include the frame, arbor, table, blade, guides for taking cuts, guards and fencing.

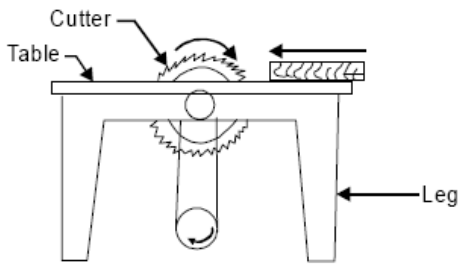


Fig.1.53 Circular saw

3. Band Saw

Band saw is generally used to cut the heavy logs to required lengths, cutting fine straight line and curved work. It consists of a heavy cast bed, which acts as a support for the whole machine, a column, two wheel pulleys, one at the top and other at the bottom, an endless saw blade band, a smooth steel table and guide assembly. It is manufactured in many sizes ranging from little bench saw to a larger band saw mill.

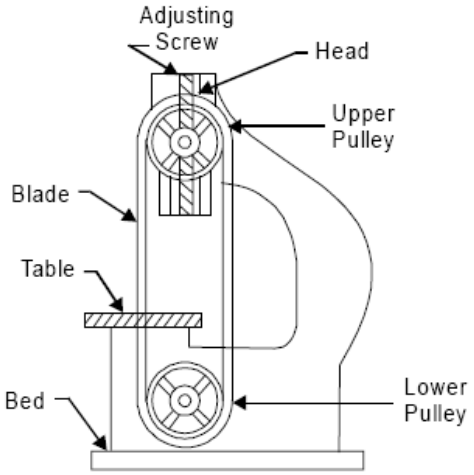


Fig.1.54 Band saw

4. Portable Electric Handsaw

The portable electric handsaw is sometimes called fin electric circular handsaw. This power tool has been improved with the development of a built-in blade brake. This is a good safety factor and also saves time by stopping the blade quickly so that either adjustment; or succeeding cuts can be made. Other safety devices include a kickproof clutch and telescoping guard. It is also useful for cutting grooves, dadoes and rabbets.

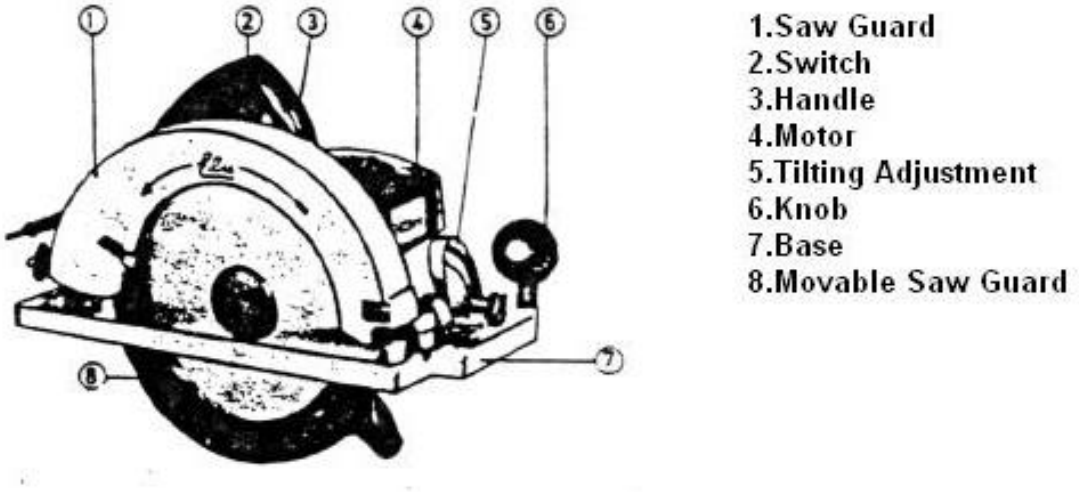


Fig.1.55 Portable electric handsaw

5. Portable Electric Router

The portable electric router is a precision build machine and can also be used in work-shops. This machine works on the same principle as the high speed router. Available router accessories make it possible to complete a large number of operations and decorative cuts. It can also be used to shape edges cut recesses for all kind of hardware and it can even be used to make dovetail joints. Portable electric routers are available in different designs, sizes and capacities.

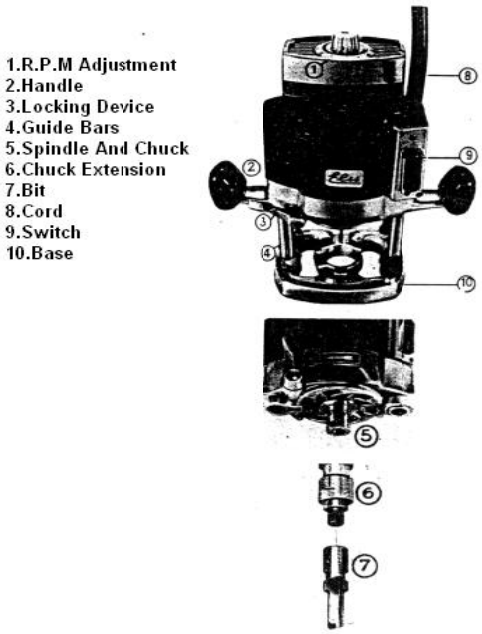


Fig.1.56 Portable electric router

6. The Portable Electric Jig Saw

The portable jig saw is a very competent machine tool for cutting wood composition boards, veneer materials plastics thin metal, cardboard and even leather. This broad range of possibilities make it an ideal portable electric saw for use in cabinet shops, furniture factories and the building trade. The general appearance of the jig saws would seem to indicate that all are the same size. The difference, however, lies in construction, cutting ability and motor power. They are designed to operate on normal 110 or 220 volts. The cutting speed is approximately 4200 'strokes' per minute (spm). A stroke is a straight up-and-down motion of the saw blade. The blade cuts only on the up-stroke, backing away on the return stroke. Some jig saws are equipped with a guide to aid straight ripping or cross-cutting.

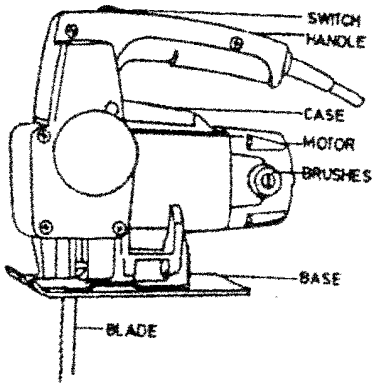


Fig.1.57 Portable electric jig saw

7. Drill Press

The drill press was originally designed for the metal work, but it has been adapted to woodworking. It is one of the most practical machines. Drill presses are made in bench and floor models. The only difference between the models is the length of the upright column. The more practical sizes of drill presses vary from 300 mm (12 inches) 550 mm (20 inches).The size is determined by the distance from the centre of the chuck to the front of the Vertical column. The speed of this machine varies from approximately 300 to 6000 r.p.m. On most drill presses, the speed -is controlled by shifting the drive belt, or belts, on a set of cone or V pulleys located in the head. Slow speeds are used for metal working faster ones are for woodworking. The numerous jobs the drill press can do depend up on the many types of bits, cutters and accessories which are available.

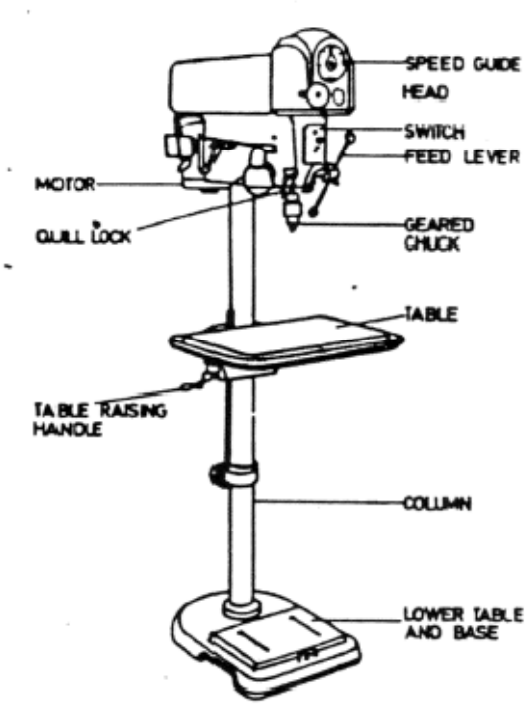


Fig.1.58 Drill press

1.13 Safety Precautions

There are some general safety precautions to be taken care of while working in carpentry shop. Some of which are discussed as under.

1. Before starting any wood working machine, it should be ensured that all the safety guards are in proper places and secured well.
2. While working on a circular saw, one should not stand in a line with the plane of the rotating blade and always keep your fingers always away from the reach of blade.
3. The wooden pieces should not be fed to the sawing machines faster than the cutting speed of the machine.
4. While working on wood lathes, the job should be properly held.
5. One should not use defective or damaged carpentry tools while carrying out carpentry work.
6. Nails, screws should be properly kept in a box for proper housekeeping.
7. Sufficient safety precautions are to be taken for preventing fire in the carpentry shop.
8. No carpentry tools should be thrown for saving time in handling.

2 Pattern Development

A pattern is a model or the replica of the object (to be casted). It is embedded in molding sand and suitable ramming of molding sand around the pattern is made. The pattern is then withdrawn for generating cavity (known as mold) in molding sand. Thus it is a mould forming tool. Pattern can be said as a model or the replica of the object to be cast except for the various al1owances a pattern exactly resembles the casting to be made. It may be defined as a model or form around which sand is packed to give rise to a cavity known as mold cavity in which when molten metal is poured, the result is the cast object. When this mould/cavity is filled with molten metal, molten metal solidifies and produces a casting (product). So the pattern is the replica of the casting. A pattern prepares a mold cavity for the purpose of making a casting. It may also possess projections known as core prints for producing extra recess in the mould for placement of core to produce hol1owness in casting. It may help in establishing seat for placement of core at locating points on the mould in form of extra recess. It establishes the parting line and parting surfaces in the mold. It may help to position a core in case a part of mold cavity is made with cores, before the molding sand is rammed. It should have finished and smooth surfaces for reducing casting defects. Runner, gates and risers used for introducing and feeding molten metal to the mold cavity may sometimes form the parts of the pattern. The first step in casting is pattern making. The pattern is a made of suitable material and is used for making cavity called mould in molding sand or other suitable mould materials. When this mould is filled with molten metal and it is allowed to solidify, it forms a reproduction of the, pattern which is known as casting. There are some objectives of a pattern which are given as under.

2.1 Objectives of a Pattern

1. Pattern prepares a mould cavity for the purpose of making a casting.
2. Pattern possesses core prints which produces seats in form of extra recess for core placement in the mould. It establishes the parting line and parting surfaces in the mould.
3. Runner, gates and riser may form a part of the pattern.
4. Properly constructed patterns minimize overall cost of the casting.
5. Pattern may help in establishing locating pins on the mould and therefore on the casting with a purpose to check the casting dimensions.
6. Properly made pattern having finished and smooth surface reduce casting defects.

Patterns are generally made in pattern making shop. Proper construction of pattern and its material may reduce overal1 cost of the castings.

2.2 Common Pattern Materials

The common materials used for making patterns are wood, metal, plastic, plaster, wax or mercury. The some important pattern materials are discussed as under.

2.2.1 Wood

Wood is the most popular and commonly used material for pattern making. It is cheap, easily available in abundance, repairable and easily fabricated in various forms using resin and glues. It is very light and can produce highly smooth surface. Wood can preserve its surface by application of a coating for longer life of the pattern. But, in spite of its above qualities, it is susceptible to shrinkage and warpage and its life is short because of the reasons that it is highly affected by moisture of the molding sand. After some use it warps and wears out quickly as it is having less resistance to sand abrasion. It cannot withstand rough handily and is weak in comparison to metal. In the light of above qualities, wooden patterns are preferred only when the numbers of castings to be produced are less. The main varieties of woods used in pattern-making are shisham, kail, deodar, teak and mahogany.

Advantages of wooden patterns

Wood can be easily worked.

1. It is light in weight.
2. It is easily available.
3. It is very cheap.
4. It is easy to join.
5. It is easy to obtain good surface finish.
6. Wooden laminated patterns are strong.
7. It can be easily repaired.

Disadvantages

1. It is susceptible to moisture.
2. It tends to warp.
3. It wears out quickly due to sand abrasion.
4. It is weaker than metallic patterns.

2.2.2 Metal

Metallic patterns are preferred when the number of castings required is large enough to justify their use. These patterns are not much affected by moisture as wooden pattern. The wear and tear of this pattern is very less and hence posses longer life. Moreover, metal is easier to shape the pattern with good precision, surface finish and intricacy in shapes. It can withstand against corrosion and handling for longer period. It possesses excellent strength to weight ratio. The main disadvantages of metallic patterns are higher cost, higher weight and tendency of rusting. It is preferred for production of castings in large quantities with same pattern. The metals commonly used for pattern making are cast iron, brass and bronzes and aluminum alloys.

a) Cast Iron

It is cheaper, stronger, tough, and durable and can produce a smooth surface finish. It also possesses good resistance to sand abrasion. The drawbacks of cast iron patterns are that they are hard, heavy, and brittle and get rusted easily in presence of moisture.

Advantages

1. It is cheap
2. It is easy to file and fit
3. It is strong
4. It has good resistance against sand abrasion
5. Good surface finish.

Disadvantages

1. It is heavy
2. It is brittle and hence it can be easily broken
3. It may rust

b) Brasses and Bronzes

These are heavier and expensive than cast iron and hence are preferred for manufacturing small castings. They possess good strength, machinability and resistance to corrosion and wear. They can produce a better surface finish. Brass and bronze pattern is finding application in making match plate pattern

Advantages

1. Better surface finish than cast iron.
2. Very thin sections can be easily casted.

Disadvantages

1. It is costly
2. It is heavier than cast iron.

c) Aluminum Alloys

Aluminum alloy patterns are more popular and best among all the metallic patterns because of their high lightness, good surface finish, low melting point and good strength. They also possess good resistance to corrosion and abrasion by sand and thereby enhancing longer life of pattern. These materials do not withstand against rough handling. These have poor repair ability and are preferred for making large castings.

Advantages

3. Aluminum alloys pattern does not rust.
4. They are easy to cast.
5. They are light in weight.
6. They can be easily machined.

Disadvantages

3. They can be damaged by sharp edges.
4. They are softer than brass and cast iron.
5. Their storing and transportation needs proper care.

d) White Metal (Alloy of Antimony, Copper and Lead)

Advantages

1. It is best material for lining and stripping plates.
2. It has low melting point around 260°C
3. It can be cast into narrow cavities.

Disadvantages

1. It is too soft.
2. Its storing and transportation needs proper care
3. It wears away by sand or sharp edges.

2.2.3 Plastic

Plastics are getting more popularity now a days because the patterns made of these materials are lighter, stronger, moisture and wear resistant, non sticky to molding sand, durable and they are not affected by the moisture of the molding sand. Moreover, they impart very smooth surface finish on the pattern surface. These materials are somewhat fragile, less resistant to sudden loading and their section may need metal reinforcement. The plastics used for this purpose are thermosetting resins. Phenolic resin plastics are commonly used. These are originally in liquid form and get solidified when heated to a specified temperature. To prepare a plastic pattern, a mould in two halves is prepared in plaster of paris with the help of a wooden pattern known as a master pattern. The phenolic resin is poured into the mould and the mould is subjected to heat. The resin solidifies giving the plastic pattern. Recently a new material has stepped into the field of plastic which is known as foam plastic. Foam plastic is now being produced in several forms and the most common is the expandable polystyrene plastic category. It is made from benzene and ethyl benzene.

2.2.4 Plaster

This material belongs to gypsum family which can be easily cast and worked with wooden tools and preferable for producing highly intricate casting. The main advantages of plaster are that it has high compressive strength and is of high expansion setting type which compensate for the shrinkage allowance of the casting metal. Plaster of paris pattern can be prepared either by directly pouring the slurry of plaster and water in moulds prepared earlier from a master pattern or by sweeping it into desired shape or form by the sweep and strickle method. It is also preferred for production of small size intricate castings and making core boxes.

2.2.5 Wax

Patterns made from wax are excellent for investment casting process. The materials used are blends of several types of waxes, and other additives which act as polymerizing agents, stabilizers, etc. The commonly used waxes are paraffin wax, shellac wax, bees-wax, cerasin wax, and micro-crystalline wax. The properties desired in a good wax pattern include low ash content up to 0.05 per cent, resistant to the primary coat material used for investment, high tensile strength and hardness, and substantial weld strength. The general practice of making wax pattern is to inject liquid or semi-liquid wax into a split die. Solid injection is also used to avoid shrinkage and for better strength. Waxes use helps in imparting a high degree of surface finish and dimensional accuracy castings. Wax patterns are prepared by pouring heated wax into split moulds or a pair of dies. The dies after having been cooled down are parted off. Now the wax pattern is taken out and used for molding. Such patterns need not to be drawn out solid from the mould. After the mould is ready, the wax is poured out by heating the mould and keeping it upside down.

2.3 Factors Effecting Selection of Pattern Materials

The following factors must be taken into consideration while selecting pattern materials.

1. Number of castings to be produced. Metal pattern are preferred when castings are required large in number.
2. Type of mould material used.
3. Kind of molding process.
4. Method of molding (hand or machine).
5. Degree of dimensional accuracy and surface finish required.
6. Minimum thickness required.
7. Shape, complexity and size of casting.
8. Cost of pattern and chances of repeat orders of the pattern

2.4 Types of Pattern

The types of the pattern and the description of each are given as under.

1. One piece or solid pattern
2. Two piece or split pattern
3. Cope and drag pattern
4. Three-piece or multi- piece pattern
5. Loose piece pattern
6. Match plate pattern
7. Follow board pattern
8. Gated pattern
9. Sweep pattern
10. Skeleton pattern
11. Segmental or part pattern

1. Single-piece or solid pattern

Solid pattern is made of single piece without joints, partings lines or loose pieces. It is the simplest form of the pattern. Typical single piece pattern is shown in Fig.2.1.

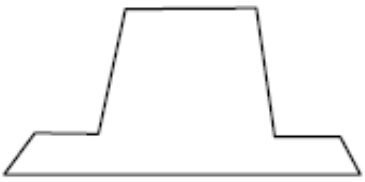


Fig.2.1 Single piece pattern

2. Two-piece or split pattern

When solid pattern is difficult for withdrawal from the mold cavity, then solid pattern is splited in two parts. Split pattern is made in two pieces which are joined at the parting line by means of dowel pins. The splitting at the parting line is done to facilitate the withdrawal of the pattern.

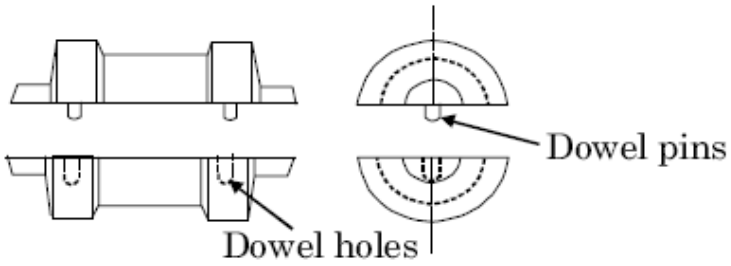


Fig.2.2 Two piece pattern

3. Cope and drag pattern

In this case, cope and drag part of the mould are prepared separately. This is done when the complete mould is too heavy to be handled by one operator. The pattern is made up of two halves, which are mounted on different plates. A typical example of match plate pattern is shown in Fig.2.3

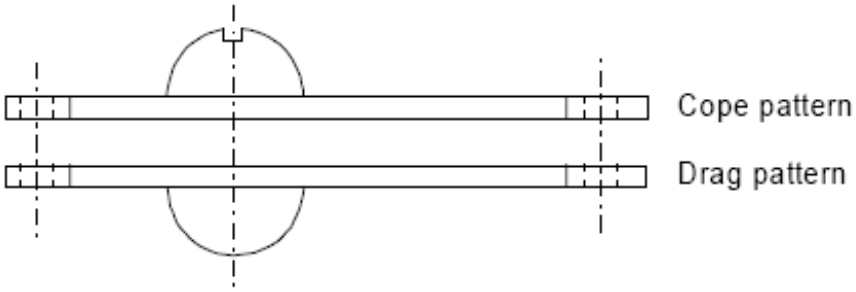


Fig.2.3 Cope and drag pattern

4. Three-piece or multi-piece pattern

Some patterns are of complicated kind in shape and hence cannot be made in one or two pieces because of difficulty in withdrawing the pattern. Therefore these patterns are made in either three pieces or in multi-pieces. Multi molding flasks are needed to make mold from these patterns.

5. Loose-piece Pattern

Loose piece pattern is used when pattern is difficult for withdrawal from the mould. Loose pieces are provided on the pattern and they are the part of pattern. The main pattern is removed first leaving the loose piece portion of the pattern in the mould. Finally the loose piece is withdrawal separately leaving the intricate mould.

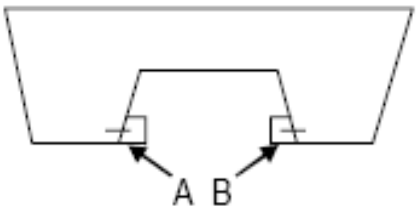


Fig.2.4 Loose piece pattern

6. Match plate pattern

This pattern is made in two halves and is on mounted on the opposite sides of a wooden or metallic plate, known as match plate. The gates and runners are also attached to the plate. This pattern is used in machine molding. A typical example of match plate pattern is shown in Fig.2.5.

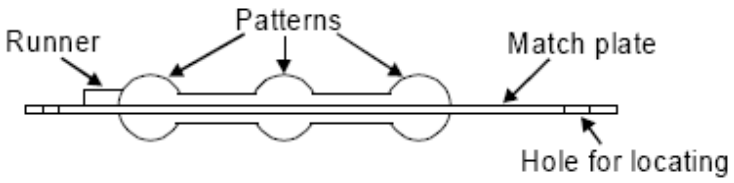


Fig.2.5 Match plate pattern

7. Follow board pattern

When the use of solid or split patterns becomes difficult, a contour corresponding to the exact shape of one half of the pattern is made in a wooden board, which is called a follow board and it acts as a molding board for the first molding operation as shown in Fig.2.6.

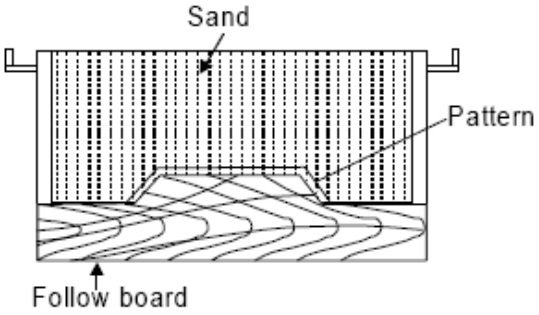


Fig.2.6 Follow board pattern

8. Gated pattern

In the mass production of casings, multi cavity moulds are used. Such moulds are formed by joining a number of patterns and gates and providing a common runner for the molten metal, as shown in Fig. These patterns are made of metals, and metallic pieces to form gates and runners are attached to the pattern.

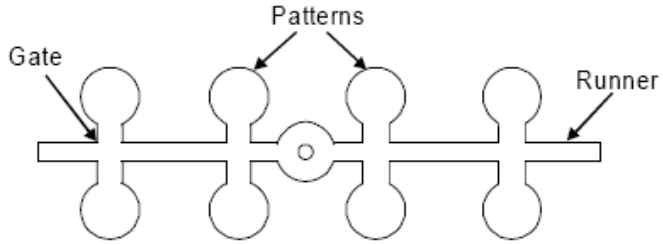


Fig.2.7 Gated pattern

9. Sweep pattern

Sweep patterns are used for forming large circular moulds of symmetric kind by revolving a sweep attached to a spindle as shown in Fig.2.8. Actually a sweep is a template of wood or metal and is attached to the spindle at one edge and the other edge has a contour depending upon the desired shape of the mould. The pivot end is attached to a stake of metal in the center of the mould.

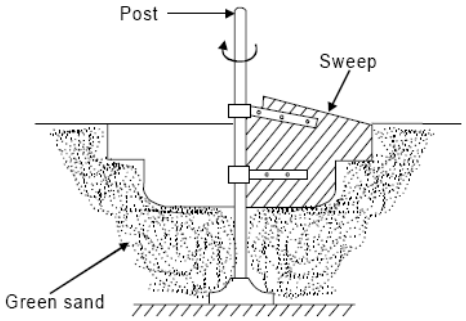


Fig.2.8 Sweep pattern

10. Skeleton pattern

When only a small number of large and heavy castings are to be made, it is not economical to make a solid pattern. In such cases, however, a skeleton pattern may be used. This is a ribbed construction of wood which forms an outline of the pattern to be made. This frame work is filled with loam sand and rammed. The surplus sand is removed by strickle board. For round shapes, the pattern is made in two halves which are joined with glue or by means of screws etc .A typical skeleton pattern is shown in Fig.2.9.

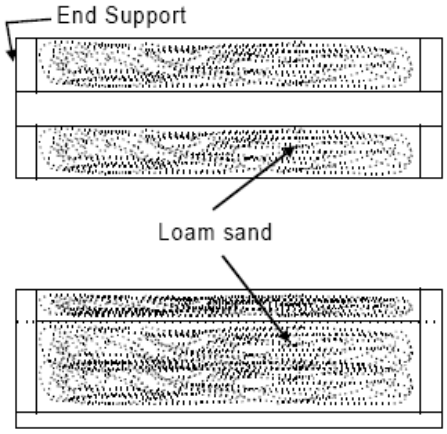


Fig.2.9 Skeleton pattern

11. Segmental pattern

Patterns of this type are generally used for circular castings, for example wheel rim, gear blank etc. Such patterns are sections of a pattern so arranged as to form a complete mould by being moved to form each section of the mould. The movement of segmental pattern is guided by the use of a central pivot. A segment pattern for a wheel rim is shown in Fig.2.10.

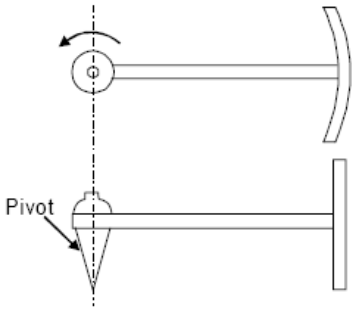


Fig.2.10 Segmental or part pattern

2.5 Pattern Allowances

Pattern may be made from wood or metal and its color may not be same as that of the casting. The material of the pattern is not necessarily same as that of the casting. Pattern carries an additional allowance to compensate for metal shrinkage. It carries additional allowance for machining. It carries the necessary draft to enable its easy removal from the sand mass. It carries distortions allowance also. Due to distortion allowance, the shape of casting is opposite to pattern. Pattern may carry additional projections, called core prints to produce seats or extra recess in mold for setting or adjustment or location for cores in mold cavity. It may be in pieces (more than one piece) whereas casting is in one piece. Sharp changes are not provided on the patterns. These are provided on the casting with the help of machining. Surface finish may not be same as that of casting. The size of a pattern is never kept the same as that of the desired casting because of the fact that during cooling the casting is subjected to various effects and hence to compensate for these effects, corresponding allowances are given in the pattern. These various allowances given to pattern can be enumerated as, allowance for shrinkage, allowance for machining, allowance for draft, allowance for rapping or shake, allowance for distortion and allowance for mould wall movement. These allowances are discussed as under.

2.5.1 Shrinkage Allowance

In practice it is found that all common cast metals shrink a significant amount when they are cooled from the molten state. The total contraction in volume is divided into the following parts:

1. Liquid contraction, i.e. the contraction during the period in which the temperature of the liquid metal or alloy falls from the pouring temperature to the liquidus temperature.
2. Contraction on cooling from the liquidus to the solidus temperature, i.e. solidifying contraction.
3. Contraction that results thereafter until the temperature reaches the room temperature. This is known as solid contraction.

The first two of the above are taken care of by proper gating and risering. Only the last one, i.e. the solid contraction is taken care by the pattern makers by giving a positive shrinkage allowance. This contraction allowance is different for different metals. The contraction allowances for different metals and alloys such as Cast Iron 10 mm/mt, Brass 16 mm/mt, Aluminium Alloys. 15 mm/mt ,Steel 21 mm/m, Lead 24 mm/mt. In fact, there is a special rule known as the pattern marks contraction rule in which the shrinkage of the casting metals is added. It is similar in shape as that of a common rule but is slightly bigger than the latter depending upon the metal for which it is intended.

2.5.2 Machining Allowance

It is a positive allowance given to compensate for the amount of material that is lost in machining or finishing the casting. If this allowance is not given, the casting will become undersize after machining. The amount of this allowance depends on the size of casting, methods of machining and the degree of finish. In general, however, the value varies from 3 mm. to 18 mm.

2.5.3 Draft or Taper Allowance

Taper allowance is also a positive allowance and is given on all the vertical surfaces of pattern so that its withdrawal becomes easier. The normal amount of taper on the external surfaces varies from 10 mm to 20 mm/mt. On interior holes and recesses which are smaller in size, the taper should be around 60 mm/mt. These values are greatly affected by the size of the pattern and the molding method. In machine molding its, value varies from 10 mm to 50 mm/mt.

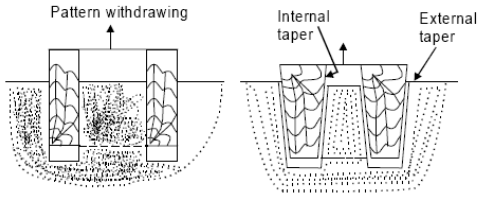


Fig.2.11 Draft Allowance

2.5.4 Rapping or Shake Allowance

Before withdrawing the pattern it is rapped and thereby the size of the mould cavity increases. Actually by rapping, the external sections move outwards increasing the size and internal sections move inwards decreasing the size. This movement may be insignificant in the case of small and medium size castings, but it is significant in the case of large castings. This allowance is kept negative and hence the pattern is made slightly smaller in dimensions 0.5-1.0 mm.

2.5.5 Distortion Allowance

This allowance is applied to the castings which have the tendency to distort during cooling due to thermal stresses developed. For example a casting in the form of U shape will contract at the closed end on cooling, while the open end will remain fixed in position. Therefore, to avoid the distortion, the legs of U pattern must converge slightly so that the sides will remain parallel after cooling.

2.5.6 Mold wall Movement Allowance

Mold wall movement in sand moulds occurs as a result of heat and static pressure on the surface layer of sand at the mold metal interface. In ferrous castings, it is also due to expansion due to graphitisation. This enlargement in the mold cavity depends upon the mold density and mould composition. This effect becomes more pronounced with increase in moisture content and temperature.

2.6 Core and Core Box

Cores are compact mass of core sand that when placed in mould cavity at required location with proper alignment does not allow the molten metal to occupy space for solidification in that portion and hence help to produce hollowness in the casting. The environment in which the core is placed is much different from that of the mold. In fact the core has to withstand the severe action of hot metal which completely surrounds it. Cores are classified according to shape and position in the mold. There are various types of cores such as horizontal core, vertical core, balanced core drop core and hanging core.

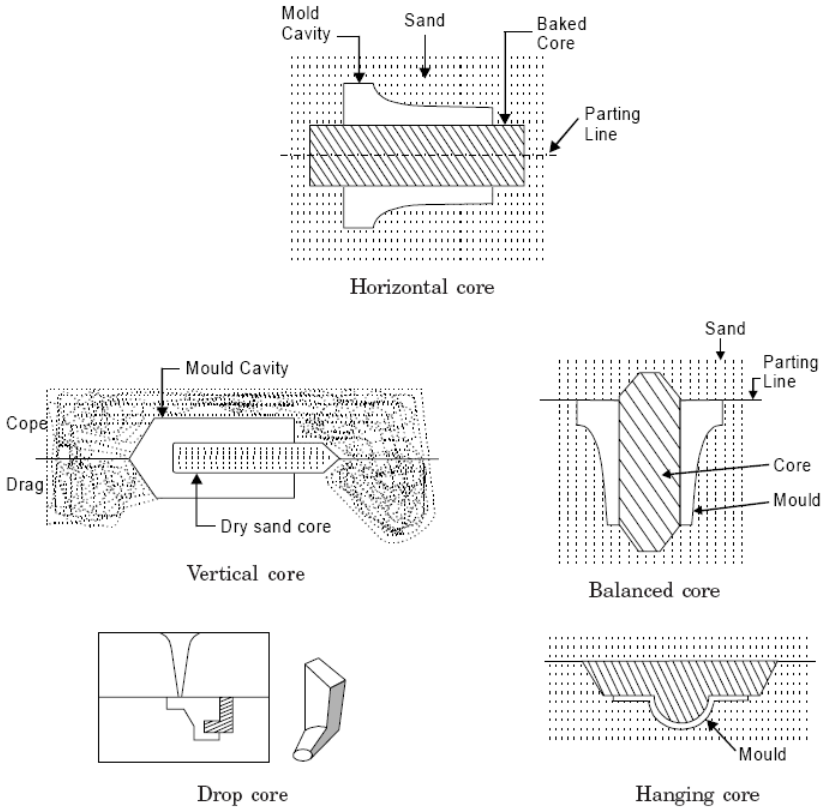


Fig.2.12 Core and core box

There are various functions of cores which are given below

1. Core is used to produce hollowness in castings in form of internal cavities.
2. It may form a part of green sand mold
4. It may be deployed to improve mold surface.
5. It may provide external undercut features in casting.
6. It may be used to strengthen the mold.
7. It may be used to form gating system of large size mold
8. It may be inserted to achieve deep recesses in the casting

2.6.1 Core Box

Any kind of hollowness in form of holes and recesses in castings is obtained by the use of cores. Cores are made by means of core boxes comprising of either single or in two parts. Core boxes are generally made of wood or metal and are of several types. The main types of core box are half core box, dump core box, split core box, strickle core box, right and left hand core box and loose piece core box.

1. Half core box

This is the most common type of core box. The two identical halves of a symmetrical core prepared in the half core box are shown in Fig. Two halves of cores are pasted or cemented together after baking to form a complete core.

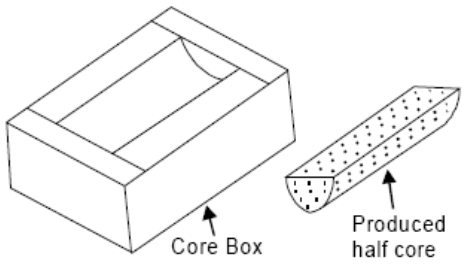


Fig.2.13 Half core-box

2. Dump core box

Dump core box is similar in construction to half core box as shown in Fig.2.14. The cores produced do not require pasting, rather they are complete by themselves. If the core produced is in the shape of a slab, then it is called as a slab box or a rectangular box. A dump core-box is used to prepare complete core in it. Generally cylindrical and rectangular cores are prepared in these boxes.

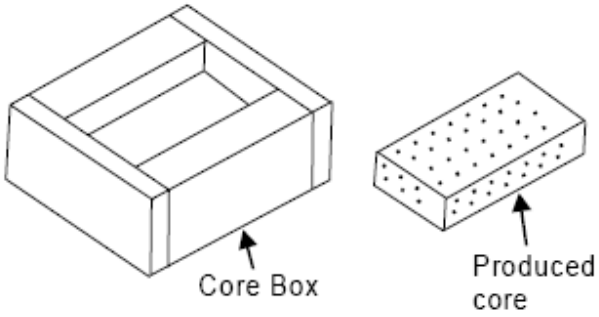


Fig.2.14 Dump core-box

3. Split core box

Split core boxes are made in two parts as shown in Fig.2.15. They form the complete core by only one ramming. The two parts of core boxes are held in position by means of clamps and their alignment is maintained by means of dowel pins and thus core is produced.

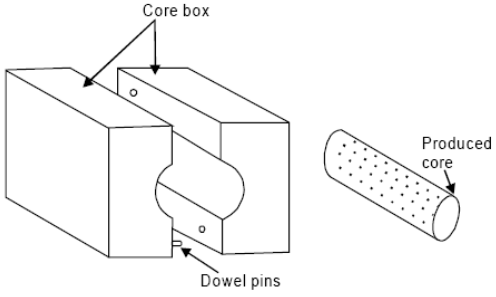


Fig.2.15 Split core-box

4. Right and left hand core box
Sometimes the cores are not symmetrical about the center line. In such cases, right and left hand core boxes are used. The two halves of a core made in the same core box are not identical and they cannot be pasted together.

5. Strickle core box
This type of core box is used when a core with an irregular shape is desired. The required shape is achieved by striking of the core sand from the top of the core box with a wooden piece, called as strickle board. The strickle board has the same contour as that of the required core.

6. Loose piece core box
Loose piece core boxes are highly suitable for making cores where provision for bosses, hubs etc. is required. In such cases, the loose pieces may be located by dowels, nails and dovetails etc. In certain cases, with the help of loose pieces, a single core box can be made to generate both halves of the right-left core.

2.7 Core Box Allowances

Materials used in making core generally swell and increase in size. This may lead to increase the size of core. The larger cores sometimes tend to become still larger. This increase in size may not be significant in small cores, but it is quite significant in large core sand therefore certain amount of allowance should be given on the core boxes to compensate for this increase the cores. It is not possible to lay down a rule for the amount of this allowance as this will depend upon the material used, but it is customary to give a negative allowance of 5 mm /mt.

2.8 Color Codification for Patterns and Core Boxes

There is no set or accepted standard for representing of various surfaces of pattern and core boxes by different colors. The practice of representing of various pattern surfaces by different colors varies with from country to country and sometimes with different manufactures within the country. Out of the various color codifications, the American practice is the most popular. In this practice, the color identification is as follows. Surfaces to be left unfinished after casting are to be painted as black. Surface to be machined are painted as red. Stop-offs is painted as black stripes on yellow base.

Core Prints
When a hole blind or through is needed in the casting, a core is placed in the mould cavity to produce the same. The core has to be properly located or positioned in the mould cavity on pre-formed recesses or impressions in the sand. To form these recesses or impressions for generating seat for placement of core, extra projections are added on the pattern surface at proper places. These extra projections on the pattern (used for producing recesses in the mould for placement of cores at that location) are known as core prints. Core prints may be of horizontal, vertical, balanced, wing and core types. Horizontal core print produces seats for horizontal core in the mould. Vertical core print produces seats to support a vertical core in the mould. Balanced core print produces a single seat on one side of the mould and the core remains partly in this formed seat and partly in the mould cavity, the two portions balancing each other. The hanging portion of the core may be supported on chaplets. Wing core print is used to form a seat for a wing core. Cover core print forms seat to support a cover core.

2.9 Wooden Pattern and Wooden Core Box Making Tools

The job of patternmaker is basically done by a carpenter. The tools required for making patterns, therefore do not much differ from those used by a carpenter, excepting the special tools as per the needs of the trade. In addition to tools used by a carpenter, there is one more tool named as the contraction rule, which is a measuring tool of the patternmaker’s trade. All castings shrinks during cooling from the molten state, and patterns have to be made correspondingly larger than the required casting in order to compensate for the loss in size due to this shrinkage. Various metals and alloys have various shrinkages. The allowance for shrinkage, therefore, varies with various metals and also according to particular casting conditions, and hence the size of the pattern is proportionally increased. A separate scale is available for each allowance, and it enables the dimensions to be set out directly during laying out of the patterns. The rule usually employed the one that has two scales on each side, the total number of scales being four for four commonly cast metals namely, steel, cast iron, brass and aluminum. To compensate for contraction or shrinkage, the graduations are oversized by a proportionate amount, e.g. on 1 mm or 1 per cent scale each 100 cm is longer by 1 cm. The general tools and equipment used in the pattern making shop are given as under.

1. Measuring and Layout Tools

a) Wooden or steel scale or rule
b) Dividers
c) Calipers
d) Try square
e) Caliper rule
f) Flexible rule
g) Marking gauge
h) T-bevel
i) Combination square

2. Sawing Tools

a) Compass saw
b) Rip saw
c) Coping saw
d) Dovetail saw
e) Back saw
f) Panel saw
g) Miter saw

3. Planning Tools

a) Jack plane
b) Circular plane
c) Router plane
d) Rabbet plane
e) Block plane
f) Bench plane
g) Core box plane

4. Boring Tools

a) Hand operated drills
b) Machine operated drills
c) Twist drill
d) Countersunk
e) Brace
f) Auger bit
g) Bit gauge

5. Clamping Tools

a) Bench vice
b) C-clamp
c) Bar clamp
d) Hand screw
e) Pattern maker’s vice
f) Pinch dog

6. Miscellaneous Tools

a) Screw Driver
b) Various types of hammers
c) Chisel
d) Rasp
e) File
f) Nail set
g) Screw driver
h) Bradawl
i) Brad pusher
j) Cornering tool

2.10 Wooden Pattern and Wooden Core Box Making Machines

Modern wooden pattern and wooden core making shop requires various wood working machines for quick and mass production of patterns and core boxes. Some of the commonly machines used in making patterns and core boxes of various kinds of wood are discussed as under.

1. **Wood Turning Lathe.** Patterns for cylindrical castings are made by this lathe.
2. **Abrasive Disc Machine.** It is used for shaping or finishing flat surfaces on small pieces of wood.
3. **Abrasive Belt Machine.** It makes use of an endless abrasive belt. It is used in shaping the patterns.
4. **Circular Saw.** It is used for ripping, cross cutting, beveling and grooving.
5. **Band Saw.** It is designed to cut wood by means of an endless metal saw band.
6. **Jig or Scroll Saw.** It is used for making intricate irregular cuts on small work.
7. **Jointer.** The jointer planes the wood by the action of the revolving cutter head.
8. **Drill Press.** It is used for drilling, boring, mortising, shaping etc.
9. **Grinder.** It is used for shaping and sharpening the tools.
10. **Wood Trimmer.** It is used for mitering the moldings accurately.
11. **Wood Shaper.** It is used for imparting the different shapes to the wood.
12. **Wood Planer.** Its purpose is similar to jointer but it is specially designed for planning larger size.
13. **Tennoner.** These are used for sawing (accurate shape and size).
14. **Mortiser.** It is used to facilitate the cutting of mortise and tenon.

2.11 Design Considerations in Pattern Making

The following considerations should always be kept in mind while designing a pattern.

1. All Abrupt changes in section of the pattern should be avoided as far as possible.
2. Parting line should be selected carefully, so as to allow as small portion of the pattern as far as possible in the cope area.
3. The thickness and section of the pattern should be kept as uniform as possible.
4. Sharp corners and edges should be supported by suitable fillets or otherwise rounded off. It will facilitate easy withdrawal of pattern, smooth flow of molten metal and ensure a sound casting.
5. Surfaces of the casting which are specifically required to be perfectly sound and clean should be so designed that they will be molded in the drag because the possible defects due to lose sand and inclusions will occur in the cope.
6. As far as possible, full cores should be used instead of cemented half cores for reducing cost and for accuracy.
7. For mass production, the use of several patterns in a mould with common riser is to be preferred.
8. The pattern should have very good surface finish as it directly affects the corresponding finish of the casting.
9. Shape and size of the casting and that of the core should be carefully considered to decide the size and location of the core prints.
10. Proper material should always be selected for the pattern after carefully analyzing the factors responsible for their selection.
11. Try to employ full cores always instead of jointed half cores as far as possible. This will reduce cost and ensure greater dimensional accuracy.
12. The use of offset parting, instead of cores as for as possible should be encouraged to the great extent.
13. For large scale production of small castings, the use of gated or match- plate patterns should be preferred wherever the existing facilities permit.
14. If gates, runners and risers are required to be attached with the pattern, they should be properly located and their sudden variation in dimensions should be avoided.
15. Wherever there is a sharp corner, a fillet should be provided, and the corners may be rounded up for easy withdrawal of patterns as well as easy flow of molten metal in the mould.
16. Proper allowances should be provided, wherever necessary.
17. As for as possible, the pattern should have a good surface finish because the surface finish of the casting depends totally on the surface finish of the pattern and the kind of facing of the mold cavity.

2.12 Pattern Layout

After deciding the molding method and form of pattern, planning for the development of complete pattern is made which may be in two different stages. The first stage is to prepare a layout of the different parts of the pattern. The next stage is to shape them. The layout preparation consists of measuring, marking, and setting out the dimensions on a layout board including needed allowances. The first step in lying out is to study the working drawing carefully and select a suitable board of wood that can accommodate at least two views of the same on full size scale. The next step is to decide a working face of the board and plane an adjacent edge smooth and square with the said face. Select a proper contraction scale for measuring and marking dimensions according to the material of the casting.

Further the layout is prepared properly and neatly using different measuring and making tools specifying the locations of core prints and machined surfaces. Finally on completion of the layout, check carefully the dimension and other requirements by incorporating all necessary pattern allowances before starting construction of the pattern.

2.13 Pattern Construction

On preparing the pattern layout, the construction for making it is started by studying the layout and deciding the location of parting surfaces. From the layout, try to visualize the shape of the pattern and determine the number of separate pieces to be made and the process to be employed for making them. Then the main part of pattern body is first constructed using pattern making tools. The direction of wood grains is kept along the length of pattern as far as possible to ensure due strength and accuracy. Further cut and shape the other different parts of pattern providing adequate draft on them. The prepared parts are then checked by placing them over the prepared layout. Further the different parts of the pattern are assembled with the main body in proper position by gluing or by means of dowels as the case may be. Next the relative locations of all the assembled parts on the pattern are adjusted carefully. Then, the completed pattern is checked for accuracy. Next all the rough surfaces of pattern are finished and imparted with a thin coating of shellac varnish. The wax or leather fillets are then fitted wherever necessary. Wooden fillets should also be fitted before sanding and finishing. The pattern surface once again prepared for good surface and give final coat of shellac. Finally different parts or surfaces of pattern are colored with specific colors mixed in shellac or by painting as per coloring specifications.

References

1. “Introduction to Basic manufacturing Processes and Workshop Technology” by Rajender Singh.

2. “Principles of Wood Technology” by J.ULLRICH.