Indian Institute of Technology Hyderabad

ME 101: WORKSHOP PRACTICE I

INDIAN INSTITUTE OF TECHNOLOGY HYDERABAD

Pushing frontiers…

April 2009

PREFACE

The engineers can create a new kind of civilization, based on technology, where art, beauty and finer things of life are accepted as everyone's due. Engineers, whatever be their line of activity, must be proficient with all aspects of manufacturing. However, it should not be forgotten that practice without theory is blind and the theory without practice is lame. A person involved in acquiring manufacturing skills must have balanced knowledge of theory as well as practice.

This book is written to meet the objectives of the training courses in *workshop practice* for all the first year engineering courses in Indian institute of technology Hyderabad. It imparts basic knowledge of various tools and their use in different sections of manufacture such as fitting, carpentry, welding, machine shop etc.

The study of workshop practice acts as the basis for further technical studies. This book gives the perception to build technical knowledge by acting as a guide for imparting fundamental knowledge. Numerous neatly drawn illustrations provided in the text will help the students in understanding the subject, and the concepts related it, better.

Sincere attempts have been made to present the contents in a simple language, supplemented with line diagrams, which are self explanatory and easy to reproduce.

We would like to express our sincere thanks to professors and colleagues for their consistent support. Suggestions for improvement in this book will be thankfully acknowledged and incorporated in the next edition.

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P. Raju

25 April 2009

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Chapter 1

FITTING SHOP

1.1 INTRODUCTION

Machine tools are capable of producing work at a faster rate, but, there are occasions when components are processed at the bench. Sometimes, it becomes necessary to replace or repair component which must be fit accurately with another component on reassembly. This involves a certain amount of hand fitting. The assembly of machine tools, jigs, gauges, etc, involves certain amount of bench work. The accuracy of work done depends upon the experience and skill of the fitter.

The term 'bench work' refers to the production of components by hand on the bench, where as fitting deals which the assembly of mating parts, through removal of metal, to obtain the required fit.

Both the bench work and fitting requires the use of number of simple hand tools and considerable manual efforts. The operations in the above works consist of filing, chipping, scraping, sawing drilling, and tapping.

1.2 HOLDING TOOLS

1.2.1 Bench vice

The bench vice is a work holding device. It is the most commonly used vice in a fitting shop. The bench vice is shown in Figure 1.1.

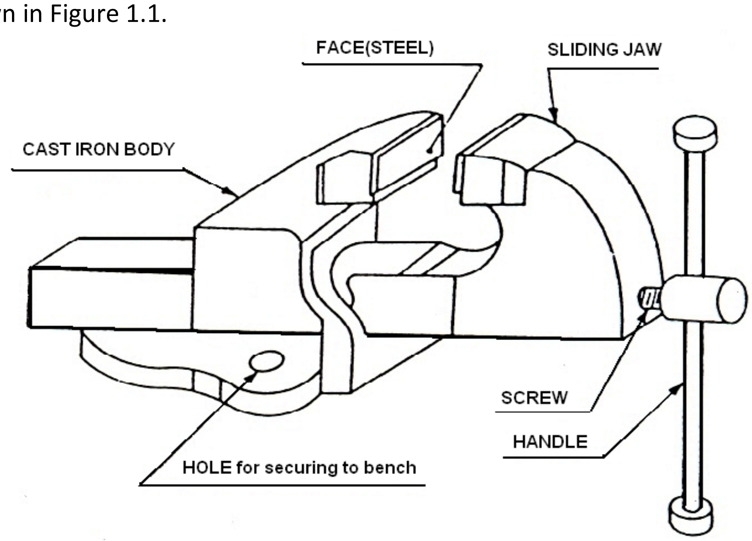


Figure 1.1: Bench Vice

It is fixed to the bench with bolts and nuts. The vice body consists of two main parts, fixed jaw and movable jaw. When the vice handle is turned in a clockwise direction, the sliding jaw forces the work against the fixed jaw. Jaw plates are made of hardened steel. Serrations on the jaws ensure a good grip. Jaw caps made of soft material are used to protect finished surfaces, gripped in the vice. The size of the vice is specified by the length of the jaws.

The vice body is made of cast Iron which is strong in compression, weak in tension and so fractures under shocks and therefore should never be hammered.

1.2.2 V-block

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

1.2.3 C-Clamp

This is used to hold work against an angle plate or v-block or any other surface, when gripping is required.

Its fixed jaw is shaped like English alphabet 'C' and the movable jaw is round in shape and directly fitted to the threaded screw at the end .The working principle of this clamp is the same as that of the bench vice.

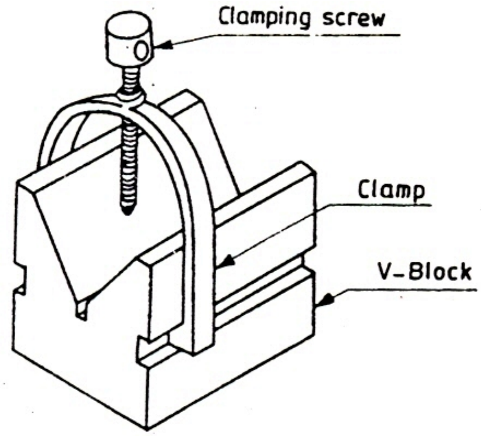


Figure 1.2: V-block

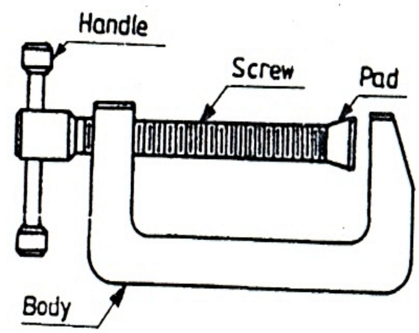


Figure 1.3: C-clamp

1.3 MARKING AND MEASURING TOOLS

1.3.1 Surface plate

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

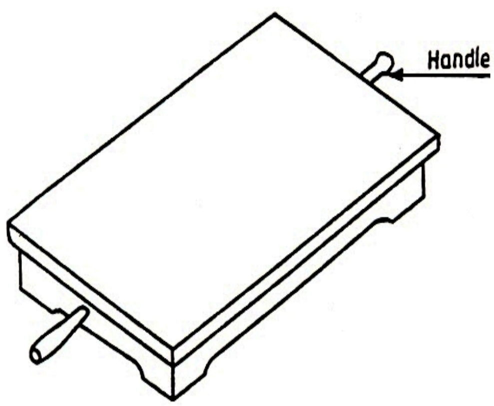


Figure 1.4: Surface plate

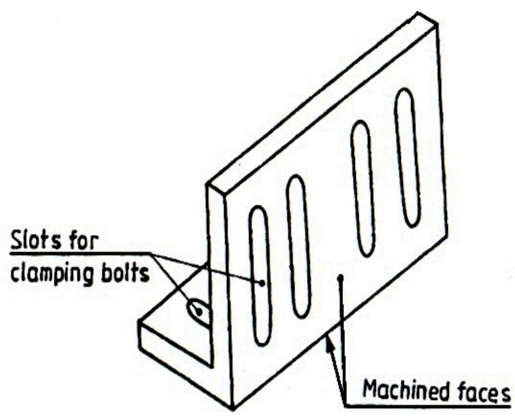


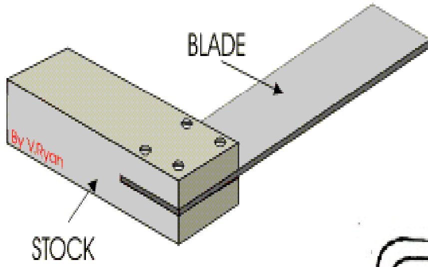
Figure 1.5: Angle plate

1.3.2 Try square

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

1.3.3 Scriber

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



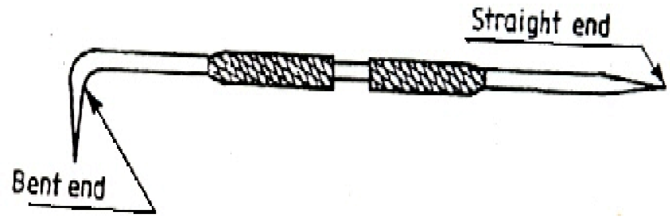


Figure 1.6: Try square

Figure 1.7: Scriber

1.3.4 Odd leg Caliper

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

1.3.5 Divider

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

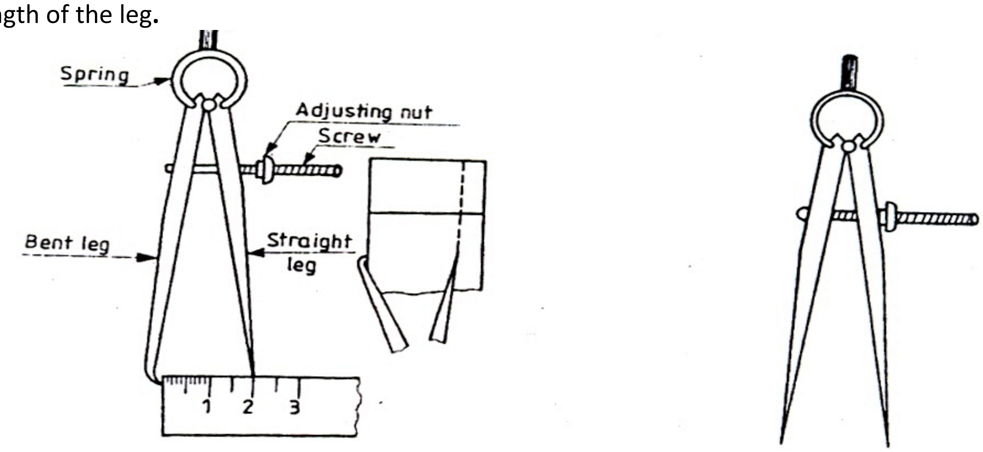


Figure 1.8: Odd leg caliper and divider

1.3.6 Trammel

Trammel is used for drawing large circles or arcs.

1.3.7 Punches

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

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

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

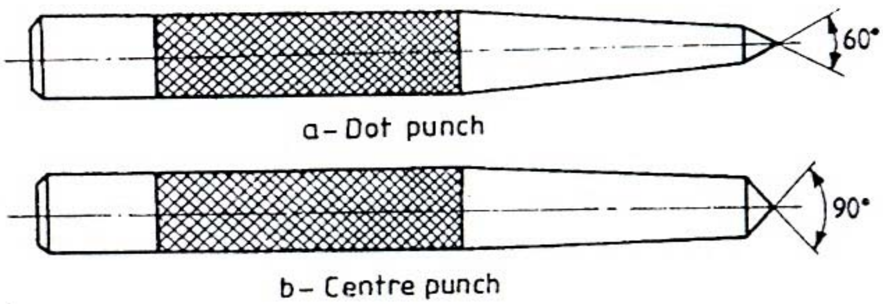


Figure 1.9: Punches

1.3.8 Calipers

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

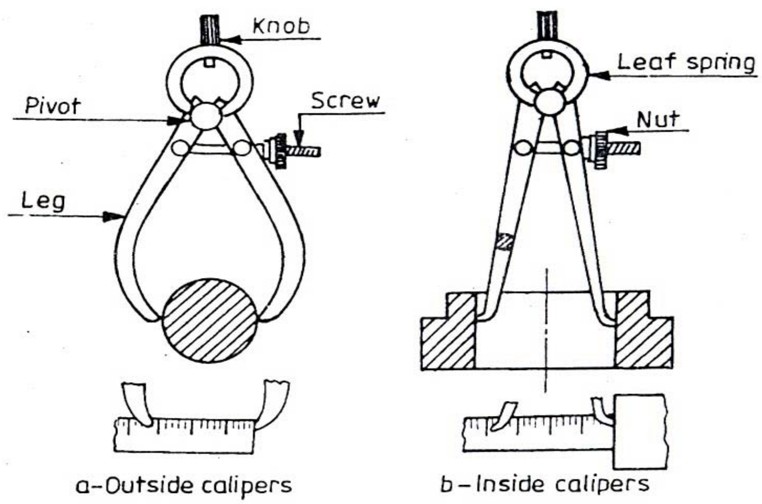


Figure 1.10: Calipers

1.3.9 Vernier Calipers

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

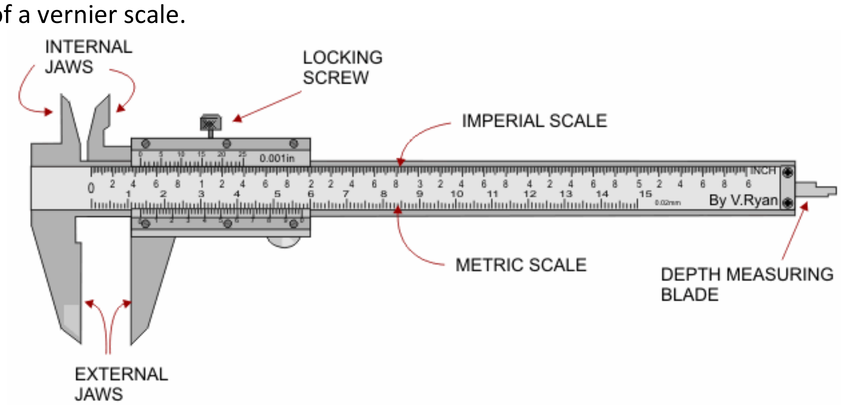


Figure 1.11: Vernier caliper

1.3.10 Vernier Height Gauge

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

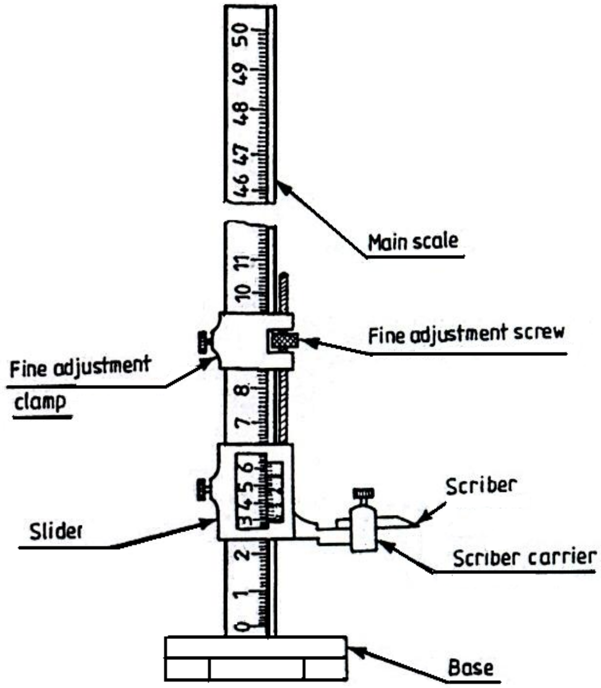


Figure 1.12: Vernier Height gauge

1.4 CUTTING TOOLS

1.4.1 Hack Saw

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

Hacksaw blades are classified as (i) All hard and (ii) flexible type. The all hard blades are made of H.S.S, hardened and tempered throughout to retain their cutting edges longer. These are used to cut hard metals. These blades are hard and brittle and can break easily by twisting and forcing them into the work while sawing. Flexible blades are made of H.S.S or low alloy steel but only the teeth are hardened and the rest of the blade is soft and flexible. These are suitable for use by un-skilled or semi-skilled persons.

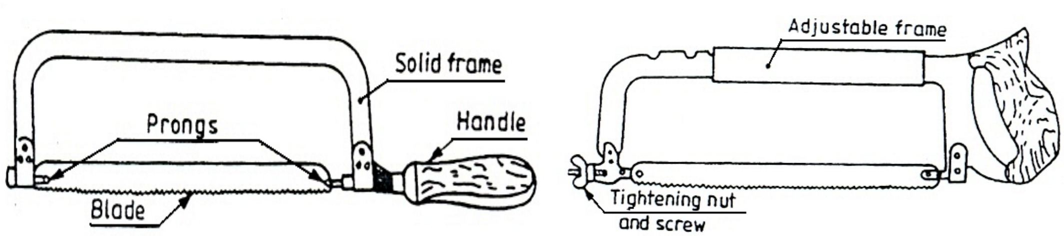


Figure 1.13: Hacksaw frame with blade

The teeth of the hacksaw blade are staggered, as shown in figure and known as a ‘set of teeth’. These make slots wider than the blade thickness, preventing the blade from jamming.

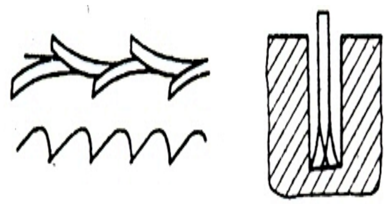


Figure 1.14: Set of teeth

1.4.2 Chisels

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

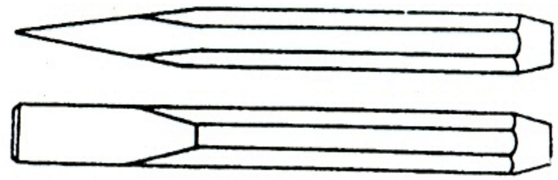


Figure 1.15: Flat chisel

1.4.3 Twist Drill

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

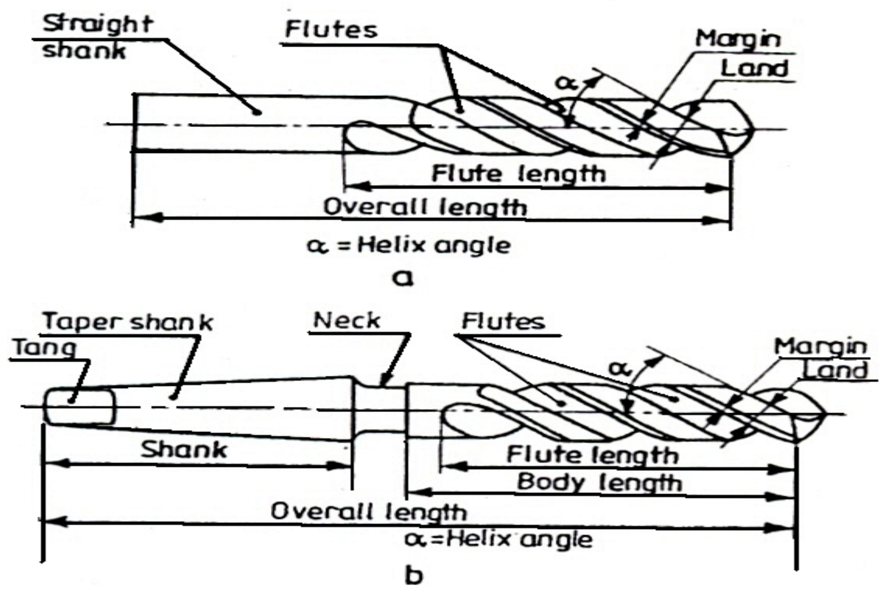


Figure 1.16: Twist drills

1.4.4 Taps and Tap wrenches

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

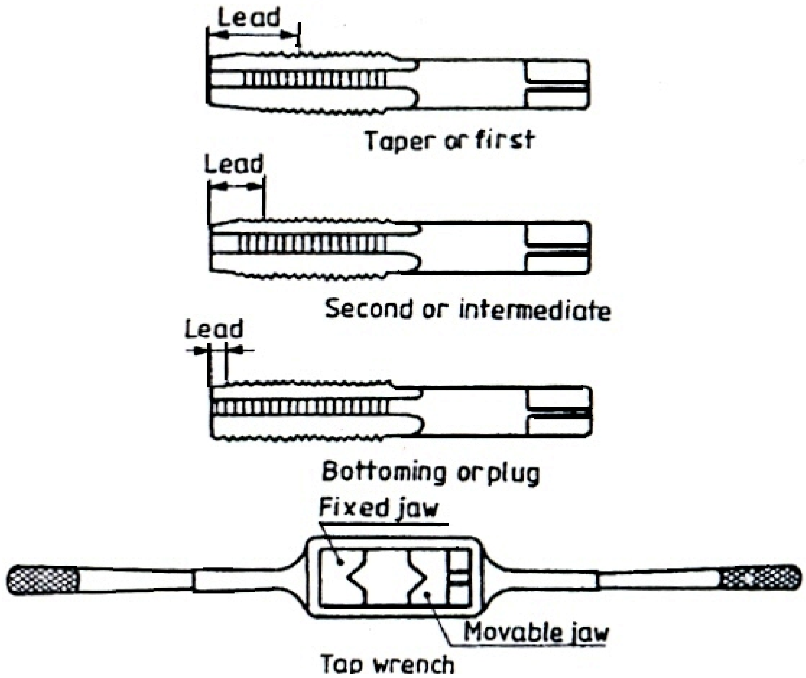


Figure 1.17: Taps and tap wrench

1.4.5 Dies and die-holders

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

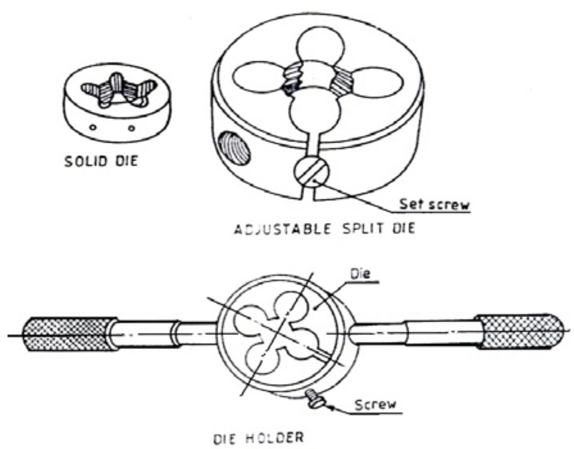


Figure 1.18: Dies and die holder

1.4.6 Bench Drilling Machine

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

Following are the stages in drilling work

1. Select the correct size drills, put it into the check and lock it firmly
2. Adjust the speed of the machine to suit the work by changing the belt on the pulleys. Use high speed for small drills and soft materials and low speed for large diameter drills and hard materials.
3. Layout of the location of the pole and mark it with a center punch.
4. Hold the work firmly in the vice on the machine table and clamp it directly on to the machine table.
5. Put on the power, locate the punch mark and apply slight pressure with the Feed Handle.

6. Once Drilling is commenced at the correct location, apply enough pressure and continue drilling. When drilling steel apply cutting oil at the drilling point.
7. Release the pressure slightly, when the drill point pierces the lower surface of the metal. This prevents the drill catching and damaging the work or drill.
8. On completion of drilling retrace the drill out of the work and put-off the power supply.

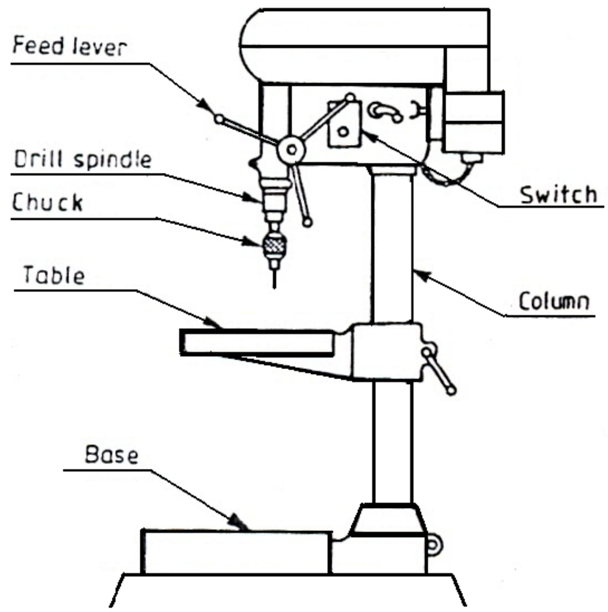


Figure 1.19: Bench drill

1.5 FINISHING TOOLS

1.5.1 Reamers

Reaming is an operation of sizing and finishing a drilled hole, with the help of a cutting tool called reamer having a number of cutting edges. For this, a hole is first drilled, the size of which is slightly smaller than the finished size and then a hand reamer or machine reamer is used for finishing the hole to the correct size.

Hand Reamer is made of High Carbon Steel and has left-hand spiral flutes so that, it is prevented from screwing into the whole during operation. The Shank end of the reamer is made straight so that it can be held in a tap wrench. It is operated by hand, with a tap wrench fitted on the square end of the reamer and with the work piece held in the vice. The body of the reamer is given a slight tapper at its working end, for its easy entry into the whole during operation, it is rotated only in clock wise direction and also while removing it from the whole.

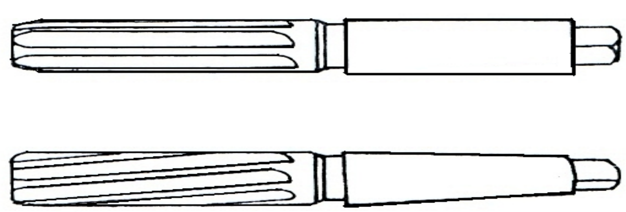


Figure 1.20: Reamers

1.5.2 Files

Filing is one of the methods of removing small amounts of material from the surface of a metal part. A file is hardened steel too, having small parallel rows of cutting edges or teeth on its surfaces.

On the faces, the teeth are usually diagonal to the edge. One end of the file is shaped to fit into a wooden handle. The figure shows various parts of a hand file. The hand file is parallel in width and tapering slightly in thickness, towards the tip. It is provided with double cut teeth. On the faces, single cut on one edge and no teeth on the other edge, which is known as a safe edge.

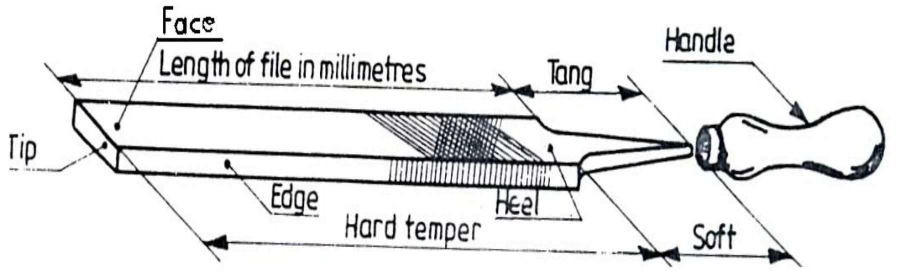


Figure 1.21: Parts of a hand file

Files are classified according to their shape, cutting teeth and pitch or grade of the teeth. The figure shows the various types of files based on their shape.

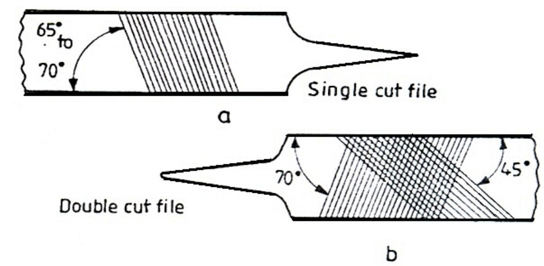
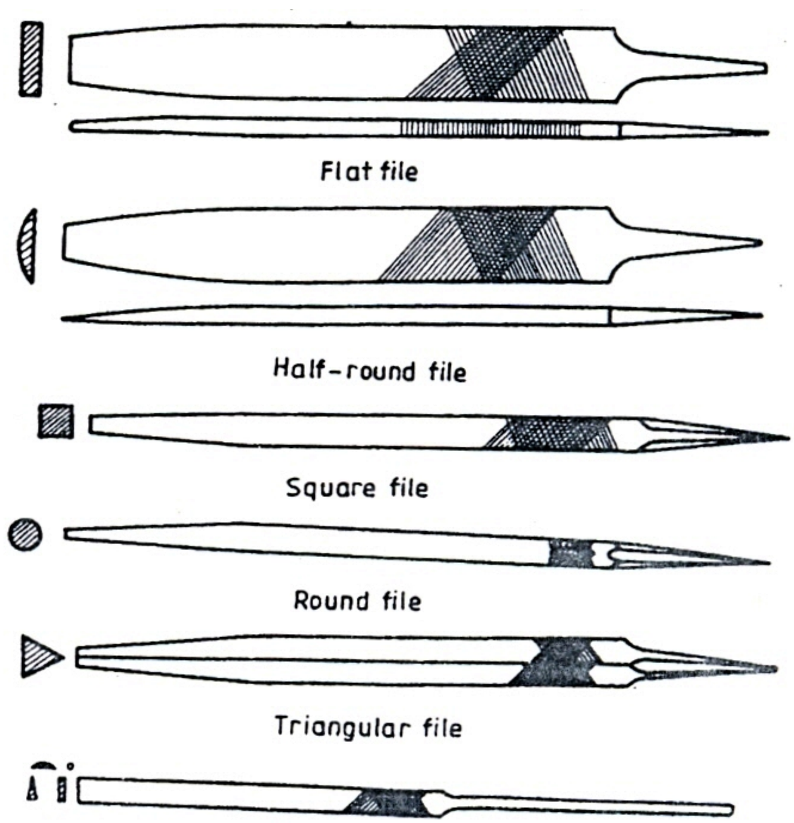


Figure 1.22: Single and double cut files



Needle file

Figure 1.23: Types of files

1.6 MISCELLANEOUS TOOLS

1.6.1 File card

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

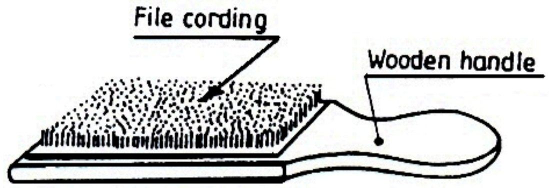


Figure 1.24: File card

1.6.2 Spirit level

It is used to check the leveling of machines.

1.6.3 Ball- Peen Hammer

Ball- Peen Hammers are named, depending upon their shape and material and specified by their weight. A ball peen hammer has a flat face which is used for general work and a ball end, particularly used for riveting.

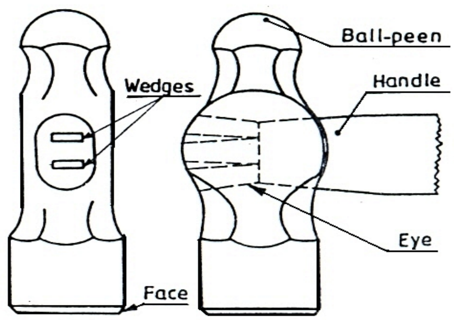


Figure 1.25: Ball peen hammer

1.6.4 Cross-Peen Hammer

It is similar to ball peen hammer, except the shape of the peen. This is used for chipping, riveting, bending and stretching metals and hammering inside the curves and shoulders.

1.6.5 Straight-Peen Hammer

This is similar to cross peen hammer, but its peen is in-line with the hammer handle. It is used for swaging, riveting in restricted places and stretching metals.

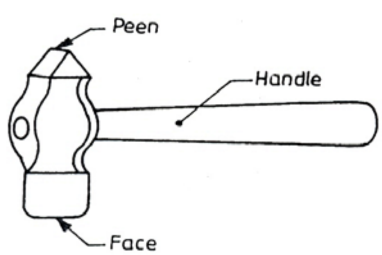


Figure 1.26: Cross peen hammer

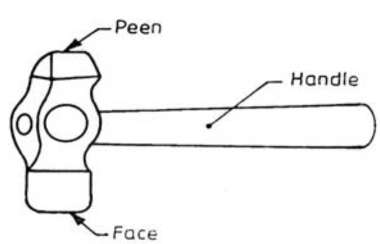


Figure 1.27: Straight peen hammer

1.6.6 Screw driver

A screw driver is designed to turn screws. The blade is made of steel and is available in different lengths and diameters. The grinding of the tip to the correct shape is very important.

A star screw driver is specially designed to fit the head of star screws. The end of the blade is fluted instead of flattened. The screw driver is specified by the length of the metal part from handle to the tip.

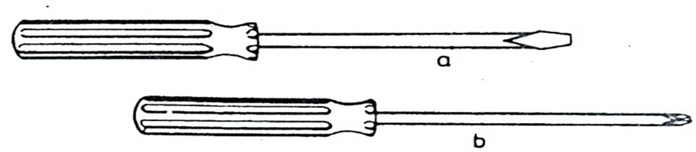


Figure 1.28: Screw drivers

1.6.7 Spanners

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

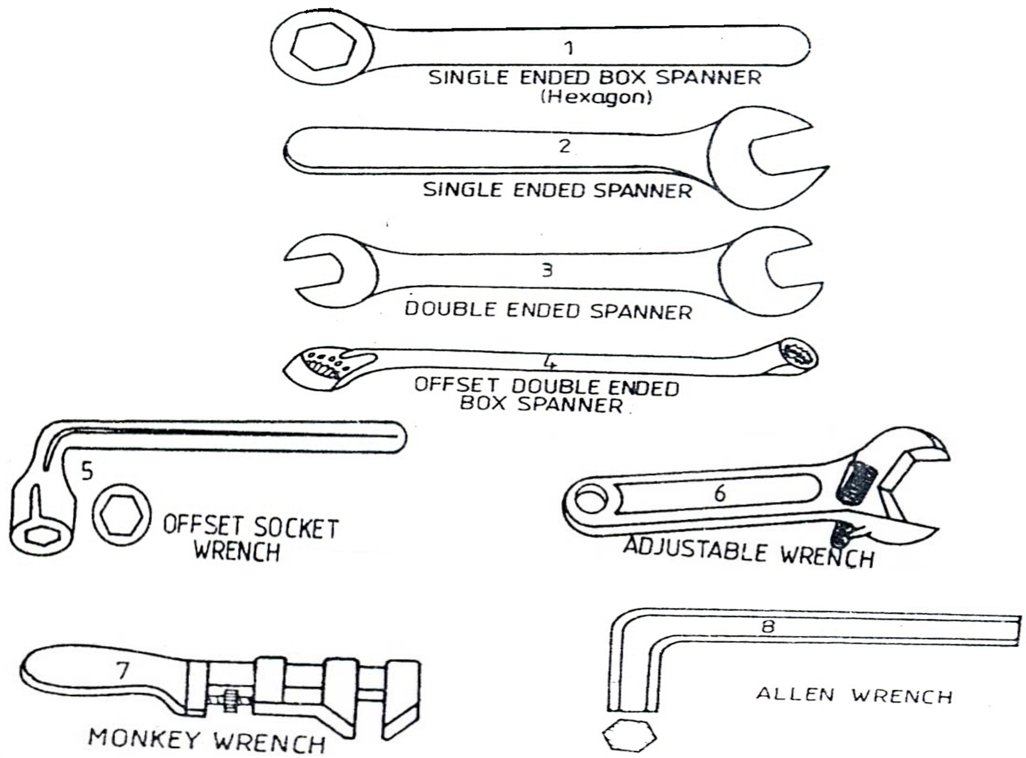


Figure 1.28: Spanners

1.7 SAFE PRACTICE

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

1. Keep hands and tools wiped clean and free of dirt, oil and grease. Dry tools are safer to use than slippery tools.
2. Do not carry sharp tools on pockets.
3. Wear leather shoes and not sandals.
4. Don't wear loose clothes.
5. Do no keep working tools at the edge of the table.
6. Position the work piece such that the cut to be made is close to the vice. This practice prevents springing, saw breakage and personal injury.
7. Apply force only on the forward (cutting) stroke and relieve the force on the return stroke while sawing and filing.
8. Do not hold the work piece in hand while cutting.
9. Use the file with a properly fitted tight handle.
10. After filing, remove the burrs from the edges of the work, to prevent cuts to the fingers.
11. Do not use vice as an anvil.

12. While sawing, keep the blade straight; otherwise it will break
13. Do not use a file without handle.
14. Clean the vice after use.

1.8 MODELS FOR PRACTICE

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

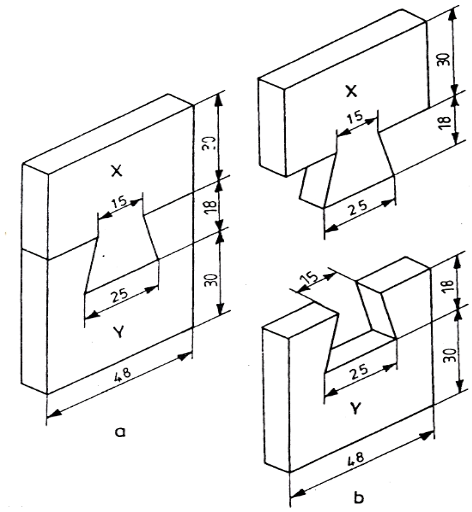


Figure 1.30: Dovetail Fitting

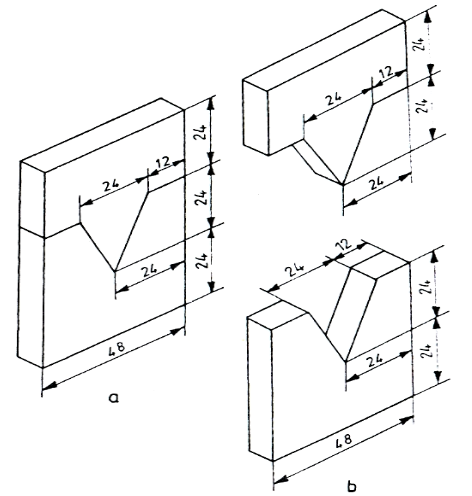


Figure 1.31: V-fitting

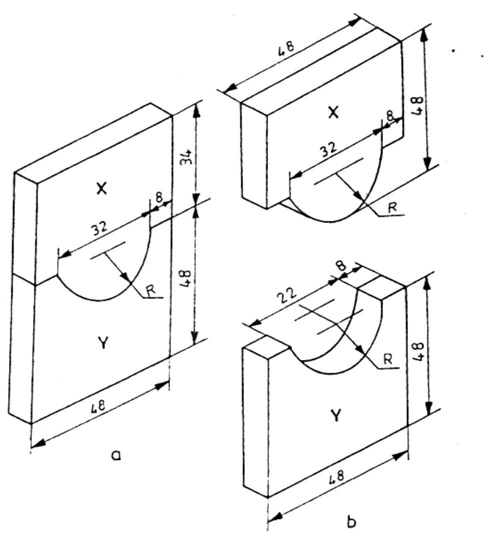


Figure 1.32: Half-round fitting

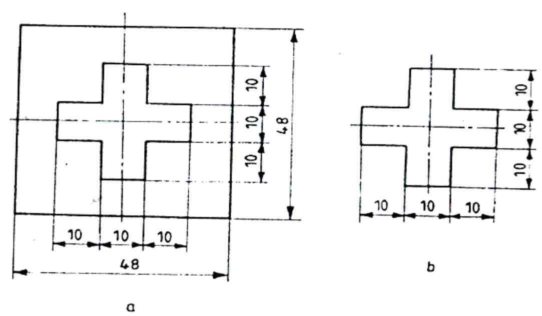


Figure 1.33: Cross fitting

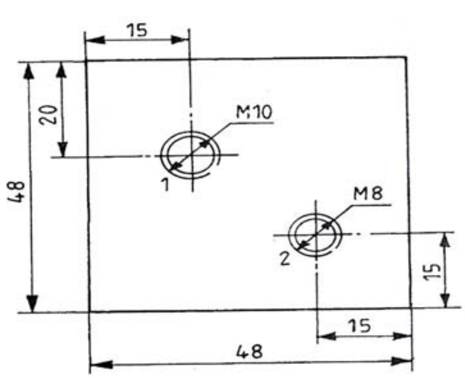


Figure 1.34: Drilling and Tapping

Exercise 1

Square Filing

Aim

To file the given two Mild Steel pieces in to a square shape of 48 mm side as shown in Figure F-E1

Tools required

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

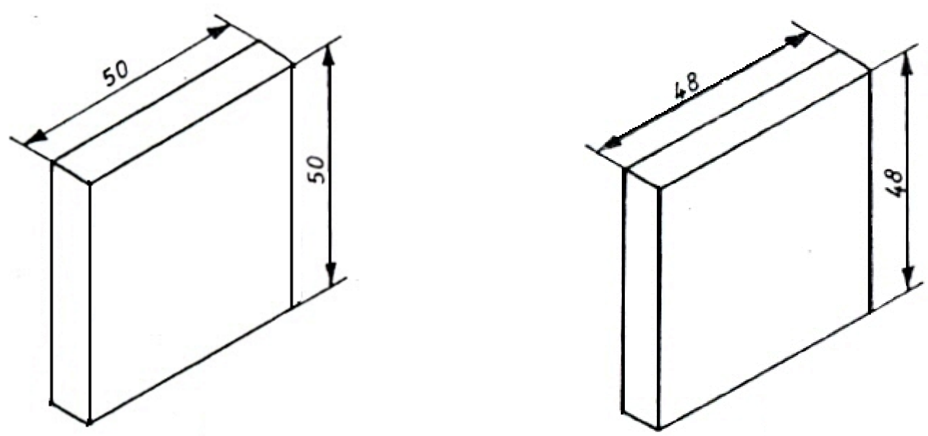
Sequence of operations

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

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

Result

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



a. Raw material b. Finished job

Figure F- E1: Square filing

Exercise 2

V-Fitting

Aim

To make V- fit from the given two MS plates and drilling and Tapping as shown in Figure F-E2

Tools required

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

Sequence of operations

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

Result

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

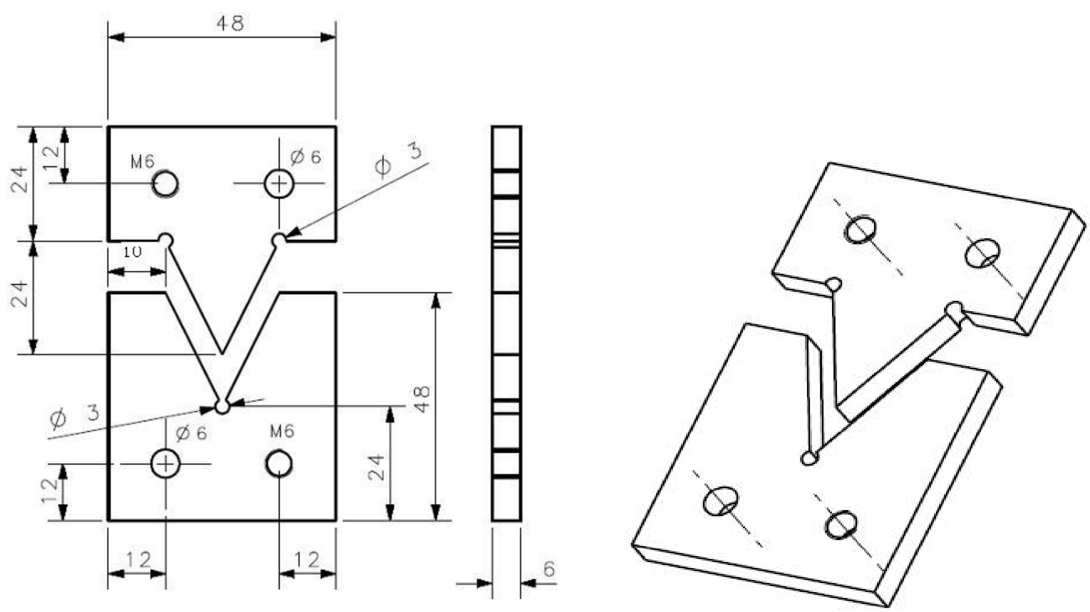


Figure F- E2: V-Fitting

Chapter 2
CARPENTRY

2.1 INTRODUCTION

Carpentry may be defined as the process of making wooden components. It starts from a marketable form of wood and ends with finished products. It6 deals with the building work, furniture, cabinet making. Etc. joinery, i.e., preparation of joints is one of the important operations in all wood-works. It deals with the specific work of carpenter like making different types of joints to form a finished product.

2.2 TIMBER

Timber is the name given to the wood obtained from well grown trees. The trees are cut, sawn into various sizes to suit building purposes.

The word, 'grain', as applied to wood, refers to the appearance or pattern of the wood on the cut surfaces. The grain of the wood is a fibrous structure and to make it strong, the timber must be so cut, that the grains run parallel to the length.

2.2.1 Timber sizes

Timber sold in the market is in various sizes and shapes. The following are the common shapes and sizes.

a. Log - The trunk of the tree which is free from branches.
b. Balk - The log, sawn to have roughly square cross section.
c. Post - A timber piece, round or square in cross section, having its diameter or side from 175 to 300mm.
d. Plank - A sawn timber piece, with more than 275 mm in width, 50 to 150 mm in thickness and 2.5 to 6.5 meters in length.
e. Board - A sawn timber piece, below 175 mm in width and 30 to 50 mm in thickness.
f. Reapers - Sawn timber pieces of assorted and non-standard sizes, which do not confirm to the above shapes and sizes.

2.2.2 Classification of Timber

Wood suitable for construction and other engineering purposes is called timber. Woods in general are divided into two broad categories: Soft woods and Hard woods.

Soft woods are obtained from conifers, kair, deodar, chir, walnut and seemal. Woods obtained from teak, sal, oak, shisham, beach, ash mango, neem and babul are known as *hard wood*, but it is highly durable.

Another classification of woods is based on the name of the trees like teak, babul, shisham, neem, kair, chir, etc.

2.2.3 Seasoning of Wood

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

2.2.4 Characteristics of Good Timber

The good timber must possess the following characteristics

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

2.3 MARKING AND MEASURING TOOLS

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

2.3.1 Steel rule and Steel tape

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

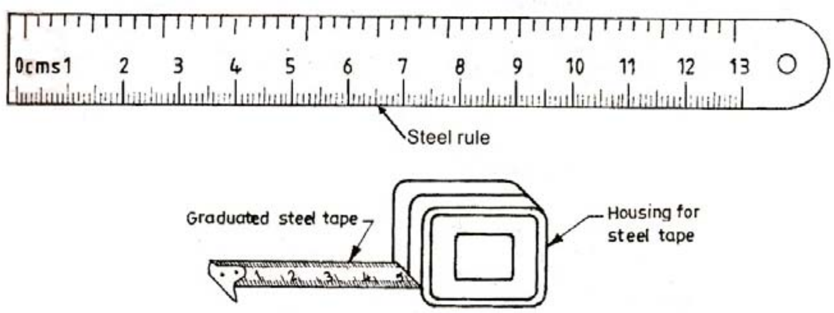
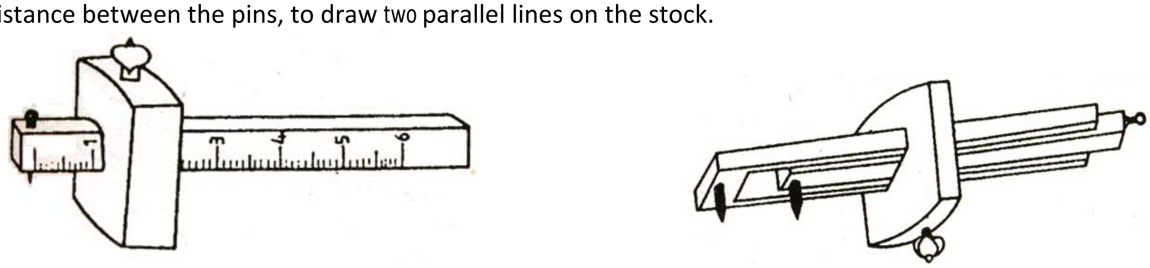


Figure 2.1: Steel rule and Steel tape

2.3.2 Marking gauge

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



a. Marking gauge b. Mortise gauge

Figure 2.2: Marking gauges

2.3.3 Try-square

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

Figure 2.3: Try square

2.3.4 Compass and divider

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

2.3.5 Scriber or marking knife

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

2.3.6 Bevel

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

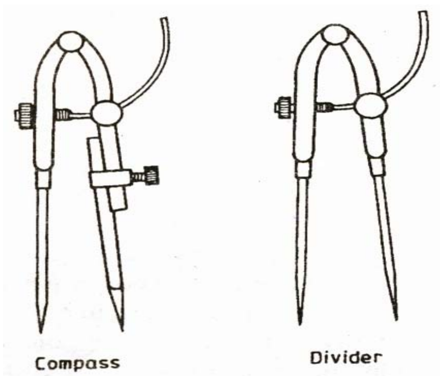


Figure 2.4: Compass and Divider

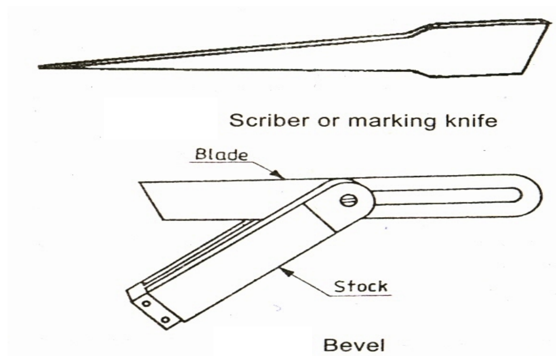


Figure 2.5: Scriber and Bevel

2.4 HOLDING TOOLS

2.4.1 Carpenter's vice

Figure 2.6 shows the carpenter's bench vice, used as a work holding device in a carpenter shop. Its one jaw is fixed to the side of the table while the other is movable by means of a screw and a handle. The Carpenter's vice jaws are lined with hard wooden' faces.

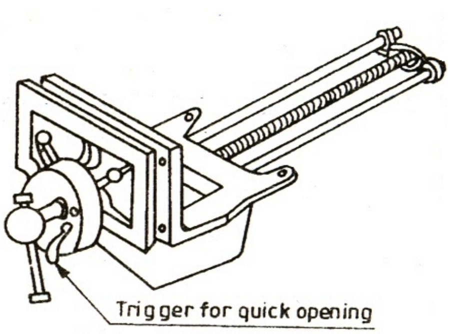


Figure 2.6: Carpenters vice

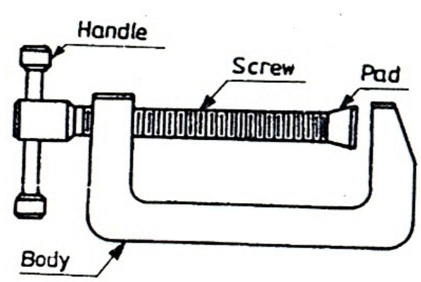


Figure 2.7: C-clamp

2.4.2 C-clamp

Figure 2.7 shows a C-clamp, which is used for holding small works.

2.4.3 Bar cramp

Figure 2.8 shows a bar cramp. It is made of steel bar of T-section, with malleable iron fittings and a steel screw. It is used for holding wide works such as frames or tops.

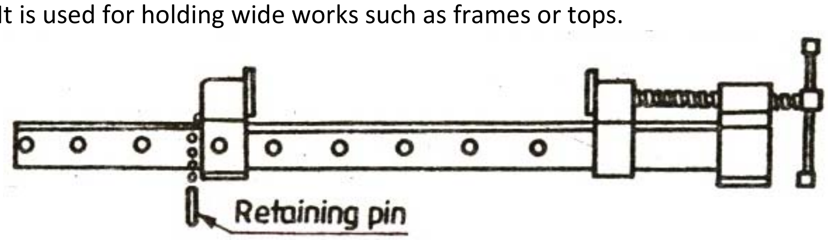


Figure 2.8: bar cramp

2.5 PLANING TOOLS

Planing is the operation used to produce flat surfaces on wood. A plane is a hand tool used for this purpose. The cutting blade used in a plane is very similar to a chisel. The blade of a plane is fitted in a wooden or metallic block, at an angle.

2.5.1 Jack plane

It is the most commonly used general purpose plane. It is about 35 cm long. The cutting iron (blade) should have a cutting edge of slight curvature. It is used for quick removal of material on rough work and is also used in oblique planning.

2.5.2 Smoothing plane

It is used for finishing work and hence, the blade should have a straight cutting edge. It is about 20 to 25 cm long. Being short, it can follow even the slight depressions in the stock, better than the jack plane. It is used after using the jack plane.

2.5.3 Rebate plane

It is used for making a rebate. A rebate is a recess along the edge of a piece of wood, which is generally used for positioning glass in frames and doors.

2.5.4 Plough plane

It is used to cut grooves, which are used to fix panels in a door. Figure 2.9 shows the various types of planes mentioned above.

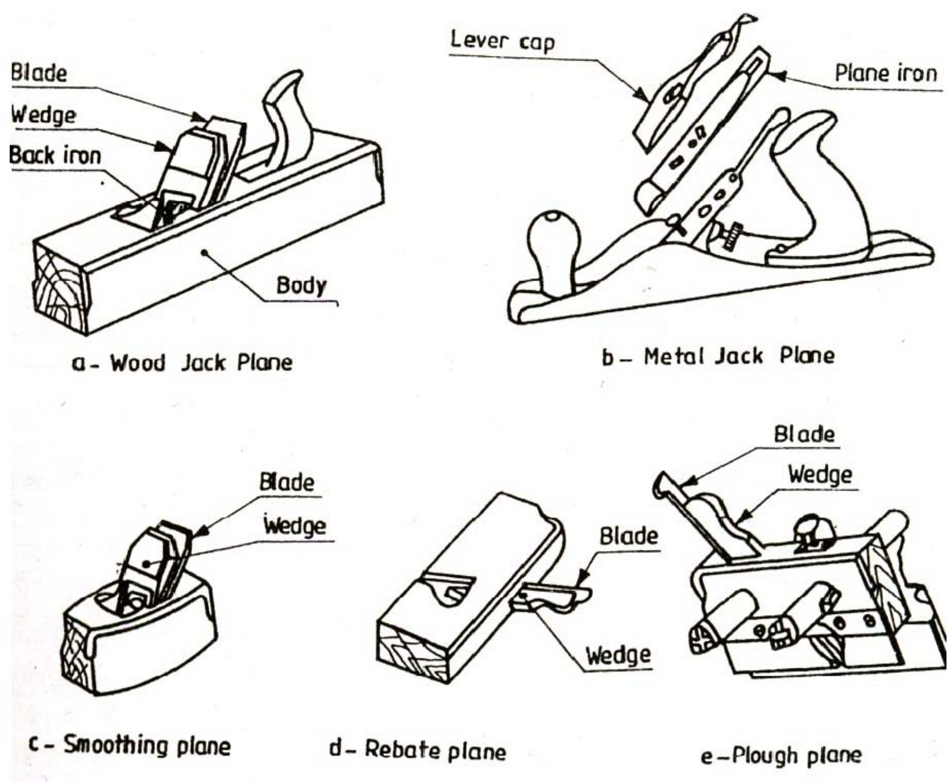


Figure 2.9: Types of planes

2.6 CUTTING TOOLS

2.6.1 Saws

A saw is used to cut wood into pieces. There are different types of saws, designed to suit different purposes. A saw is specified by the length of its toothed edge.

2.6.1.1 Cross-cut or hand saw

It is used to cut across the grains of the stock. The teeth are so set that the saw kerf will be wider than the blade thickness. This allows the blade to move freely in the cut, without sticking.

2.6.1.2 Rip saw

It is used for cutting the stock along the grains. The cutting edge of this saw makes a steeper angle, i.e., about 60° whereas that of crosscut saw makes an angle of 45° with the surface of the stock.

2.6.1.3 Tenon saw

It is used for cutting the stock either along or across the grains. It is used for cutting tenons and in fine cabinet work. However, it is used for small and thin cuts. The blade of this saw is very thin and so it is stiffened with a thick back steel strip. Hence, this is sometimes called as back-saw. In this, the teeth are shaped like those of cross-cut saw.

2.6.1.4 Compass saw

It has a narrow, longer and stronger tapering blade, which is used for heavy works (Fig. 1.13). It is mostly used in radius cutting. The blade of this saw is fitted with an open type wooden handle.

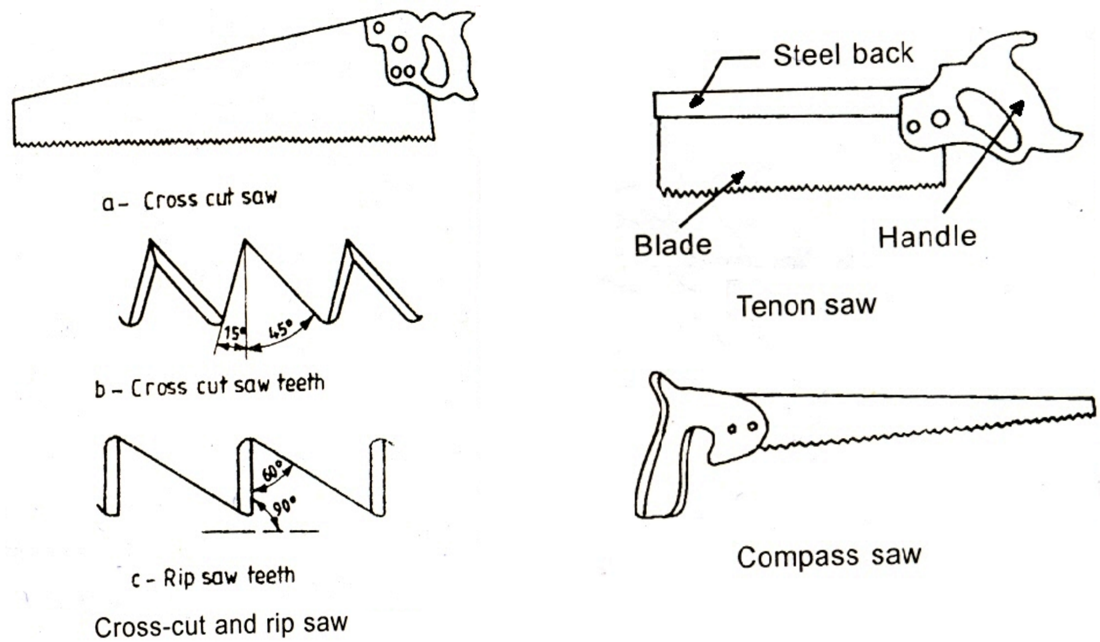


Figure 2.10: Types of saws

2.6.2 Chisels

Chisels are used for cutting and shaping wood accurately. Wood chisels are made in various blade widths, ranging from 3 to 50 mm. They are also made in different blade lengths. Most of the wood chisels are made into tang type, having a steel shank which fits inside the handle. These are made of forged steel or tool steel blades.

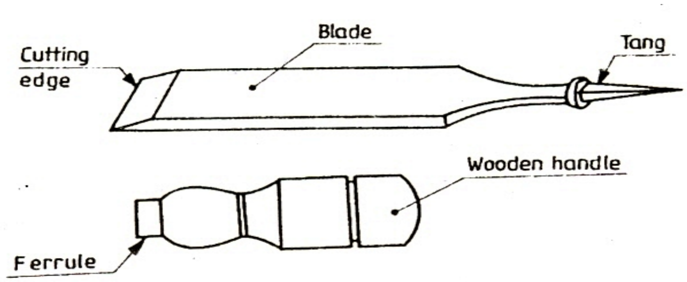


Figure 2.11: Parts of chisel

2.6.2.1 Firmer chisel

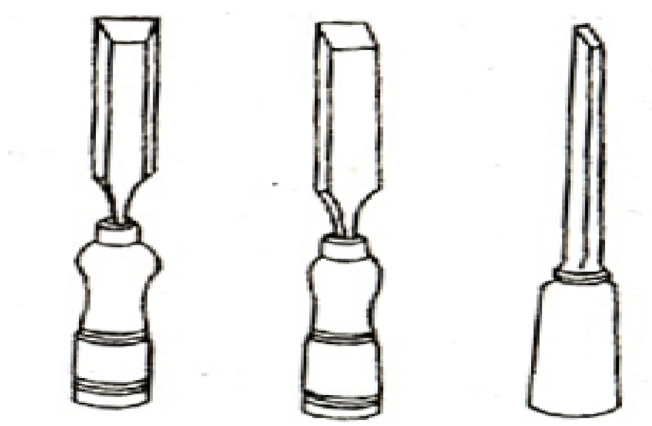
The word 'firmer' means 'stronger' and hence firmer chisel is stronger than other chisels. It is a general purpose chisel and is used either by hand pressure or by a mallet. The blade of a firmer chisel is flat, as shown in Figure 2.12 a.

2.6.2.2 Dovetail chisel

It has a blade with a beveled back, as shown in Figure, due to which it can enter sharp comers for finishing, as in dovetail joints.

2.6.2.3 Mortise chisel

It is used for cutting mortises and chipping inside holes, etc. The cross-section of the mortise chisel is proportioned to withstand heavy blows during mortising. Further, the cross-section is made stronger near the shank.



a. Firmer b. Dovetail c. Mortise

Figure 2.12: Types of chisels

2.7 DRILLING AND BORING TOOLS

2.7.1 Carpenter’s brace

It is used for rotating auger bits, twist drills, etc., to produce holes in wood. In some designs, braces are made with ratchet device. With this, holes may be made in a corner where complete revolution of the handle cannot be made. The size of a brace is determined by its sweep.

2.7.2 Auger bit

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

2.7.3 Hand drill

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

2.7.4 Gimlet

It has cutting edges like a twist drill. It is used for drilling large diameter holes with the hand pressure.

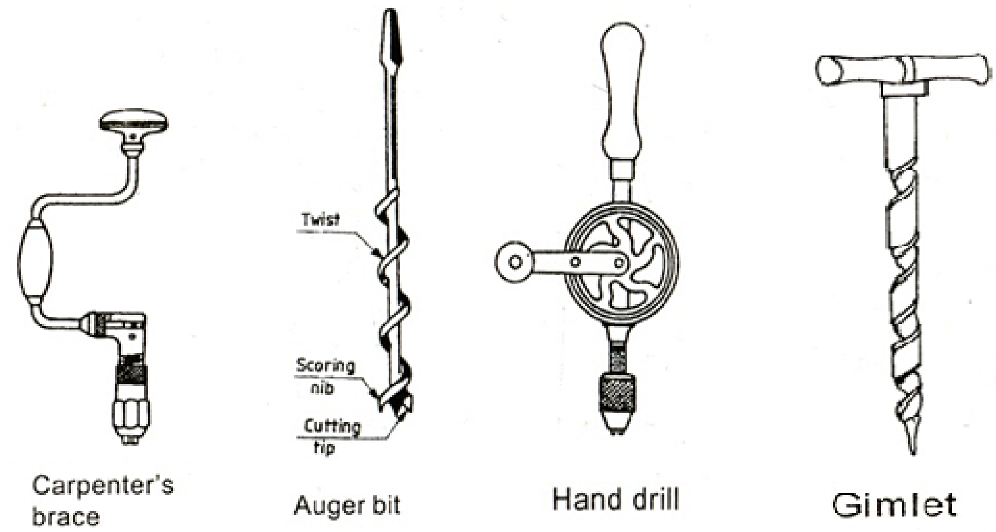


Figure 2.13: Drilling tools

2.8 MISCELLANEOUS TOOLS

2.8.1 Mallet

It is used to drive the chisel, when considerable force is to be applied, which may be the case in making deep rough cuts. Steel hammer should not be used for the purpose, as it may damage the chisel handle. Further, for better control, it is better to apply a series of light taps with the mallet rather than a heavy single blow.

2.8.2 Pincer

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

2.8.3 Claw hammer

It has a striking flat face at one end and the claw at the other, as shown in figure. The face is used to drive nails into wood and for other striking purposes and the claw for extracting relatively large nails out of wood. It is made of cast steel and weighs from 0.25 kg to 0.75 kg.

2.8.4 Screw driver

It is used for driving screws into wood or unscrewing them. The screw driver of a carpenter is different from the other common types, as shown in figure.

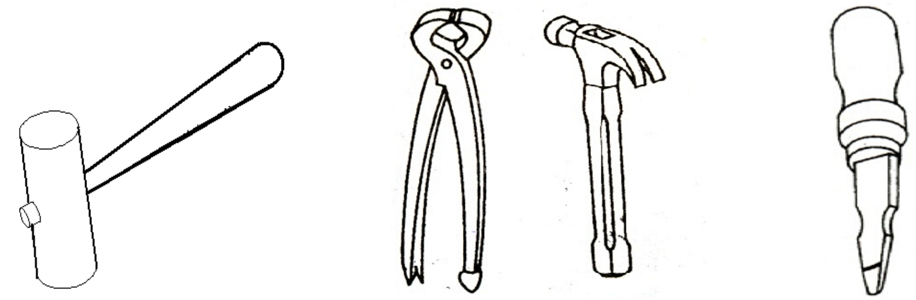
The length of a screw driver is determined by the length of the blade. As the length of the blade increases, the width and thickness of the tip also increase.

2.8.5 Wood rasp file

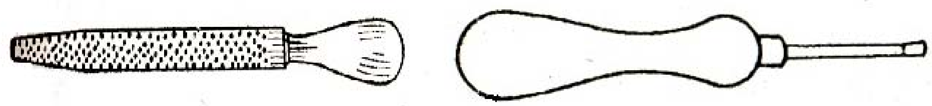
It is a finishing tool used to make the wood surface smooth, remove sharp edges, finish fillets and other interior surfaces. Sharp cutting teeth are provided on its
surface for the purpose. This file is exclusively used in wood work.

2.8.6 Bradawl

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



a. Mallet b. Pincer c. Claw hammer d. Bradawl

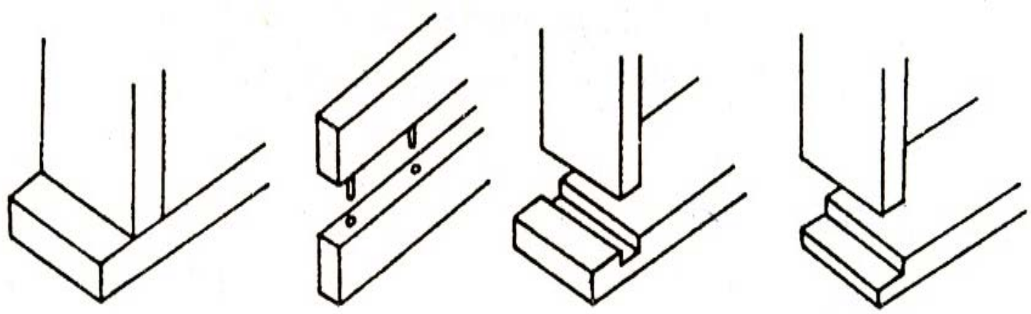


e. Wood rasp file f. Screw driver

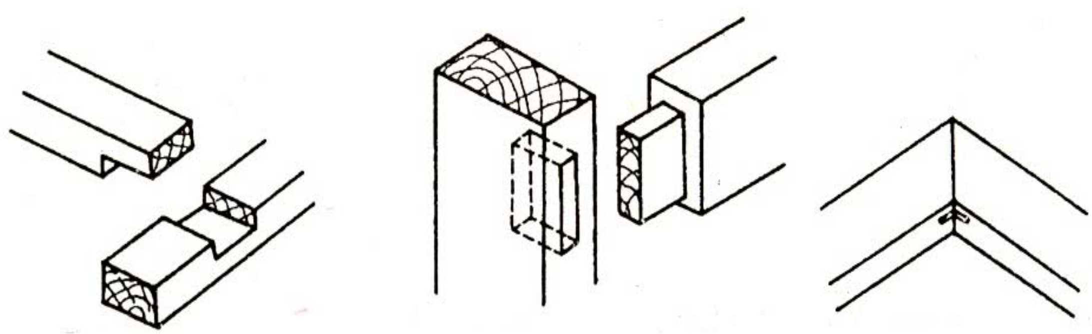
Figure 2.14: Miscellaneous tools

2.9 WOOD JOINTS

There are many kinds of joints used to connect wood stock. Each joint has a definite use and requires lay in-out, cutting them together. The strength of the joint depends upon amount of contact area. If a particular joint does not have much contact area, then it must be reinforced with nails, screws or dowels. The figure 2.15 shows some commonly used wood joints.



a. Butt b. Dowell c. Dado d. Rabbet



e. Lap f. Mortise and tenon g. Miter

Figure 2.15: Common wood joints

2.9.1 Lap joints

In lap joints, an equal amount of wood is removed from each piece, as shown in figure 2.16. Lap joints are easy to layout, using a try-square and a marking gauge. Follow the procedure suggested for sawing and removing the waste stock. If the joint is found to be too tight, it is better to reduce the width of the mating piece, instead of trimming the shoulder of the joint. This type of joint is used for small boxes to large pieces of furniture.

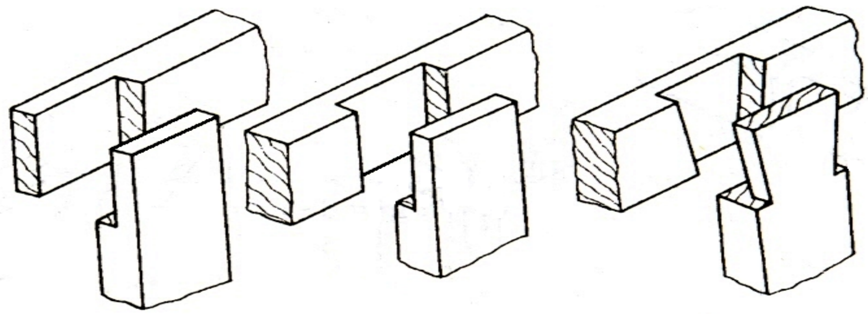


Figure 2.16: Lap joints

2.9.2 Mortise and Tenon Joints

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

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

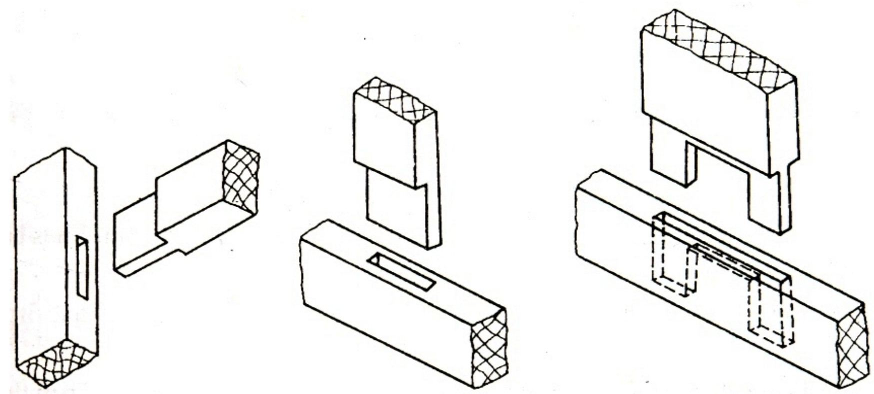


Figure 2.17: Mortise and Tenon joints

2.9.3 Bridle joint

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

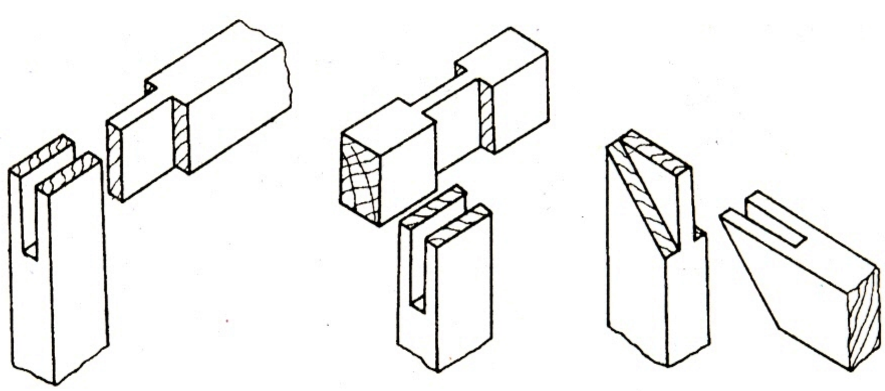


Figure 2.18: Bridle joint

2.10 SAFE PRACTICE

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

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

Exercise 1

T-Lap joint

Aim

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

Tools required

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

Sequence of operations

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

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

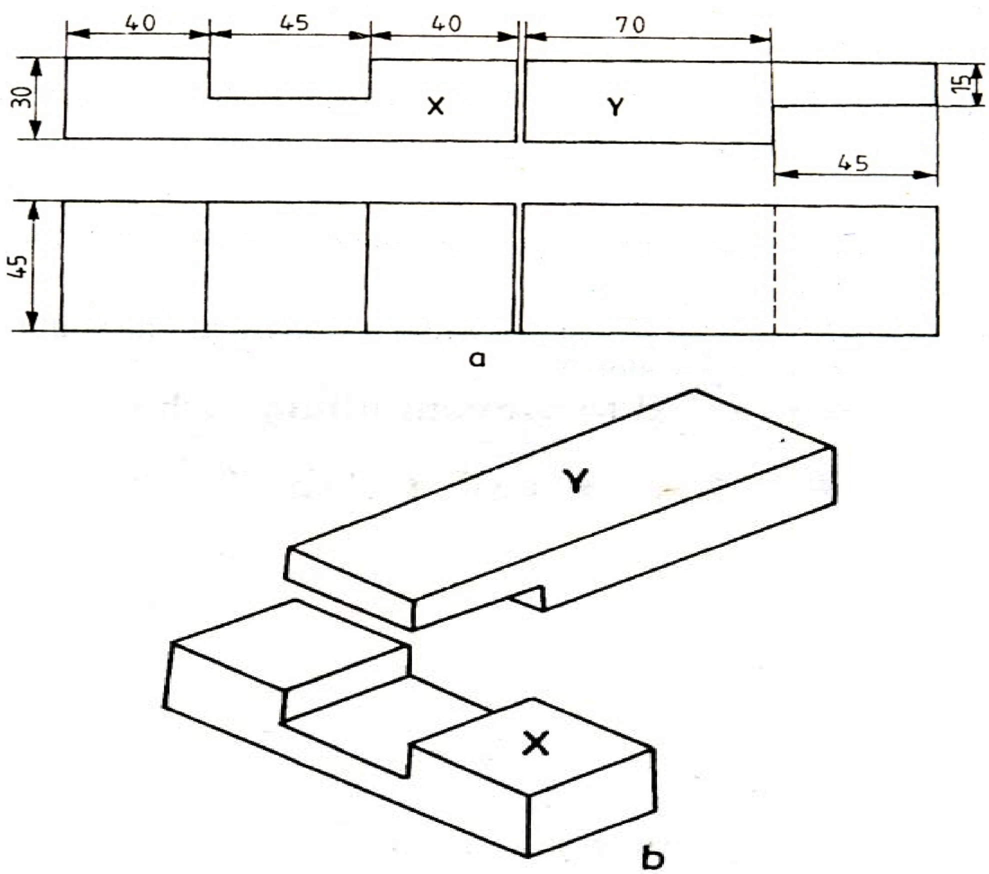


Figure C- E1: T- lap joint

Exercise 2

Dovetail lap joint

Aim

To make a dovetail lap joint as shown in Figure 2.20, from the given reaper of size 50 x 35 x 250 mm.

Tools required

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

Sequence of operations

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

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

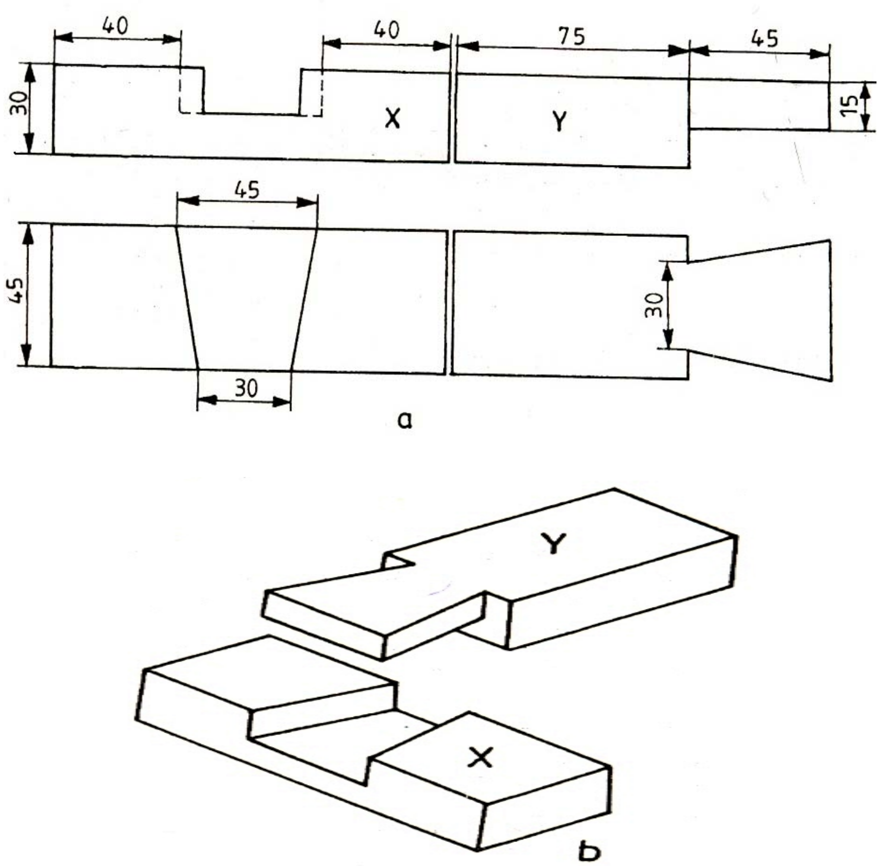


Figure C- E2: Dovetail lap joint

Exercise 3

Mortise and Tenon joint

Aim

To make a mortise and tenon joint as shown in Fig. 1.34b, from the given reaper of size 50 x 35 x 250 mm.

Tools required

Carpenter's vice, steel rule, jack plane, try-square, marking gauge, 25 111m firmer chisel, 6 mm mortise chisel, cross-cut saw, tenon saw, scriber and mallet.

Sequence of operations

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

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

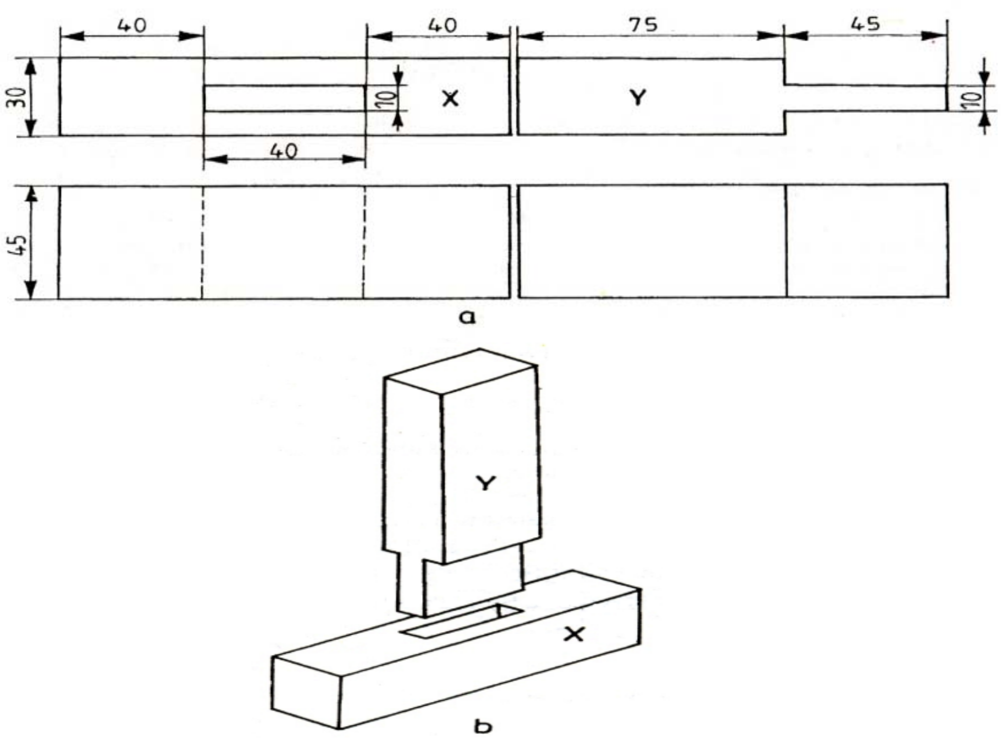


Figure C-E 3: Mortise and Tenon joint

Chapter 3
WELDING

3.1 INTRODUCTION

Welding is the process of joining similar metals by the application of heat, with or without application of pressure or filler metal, in such a way that the joint is equivalent in composition and characteristics of the metals joined. In the beginning, welding was mainly used for repairing all kinds of worn or damaged parts. Now, it is extensively used in manufacturing industry, construction industry (construction of ships, tanks, locomotives and automobiles) and maintenance work, replacing riveting and bolting, to a greater extent.

The various welding processes are:

1. Electric arc welding,
2. Gas welding
3. Thermal welding
4. Electrical Resistance welding and
5. Friction welding

However, only electric arc welding process is discussed in the subject point of view.

3.2 ELECTRIC ARC WELDING

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

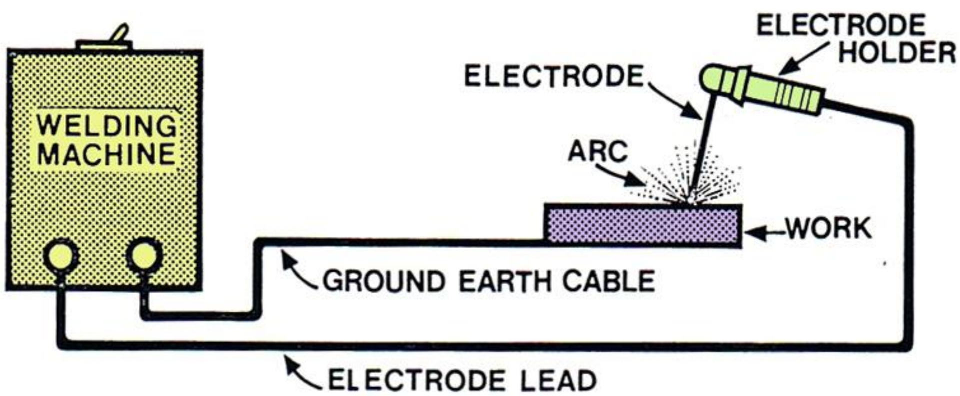


Figure 3.1: Arc welding set up.

Any arc welding method is based on an electric circuit consisting of the following parts:

a. Power supply (AC or DC);
b. Welding electrode;
c. Work piece;
d. Welding leads (electric cables) connecting the electrode and work piece to the power supply.

Electric arc between the electrode and work piece closes the electric circuit. The arc temperature may reach 10000°F (5500°C), which is sufficient for fusion the work piece edges and joining them. When a long joint is required the arc is moved along the joint line. The front edge of the weld pool melts the welded surfaces when the rear edge of the weld pool solidifies forming the joint.

Transformers, motor generators and rectifiers' sets are used as arc welding machines. These machines supply high electric currents at low voltage and an electrode is used to produce the necessary arc. The electrode serves as the filler rod and the arc melts the surface so that, the metals to be joined are actually fixed together.

Sizes of welding machines are rated according to their approximate amperage capacity at 60% duty cycle, such as 150,200,250,300,400,500 and 600 amperes. This amperage is the rated current output at the working terminal.

3.2.1 Transformers

The transformers type of welding machine produces A.C current and is considered to be the least expensive. It takes power directly from power supply line and transforms it to the voltage required for welding. Transformers are available in single phase and three phases in the market.

3.2.2 Motor generators

These are D.C generators sets, in which electric motor and alternator are mounted on the same shaft to produce D.C power as pert the requirement for welding. These are designed to produce D.C current in either straight or reversed polarity. The polarity selected for welding depends upon the kind of electrode used and the material to be welded.

3.2.3 Rectifiers

These are essentially transformers, containing an electrical device which changes A.C into D.C by virtue of which the operator can use both types of power (A.C or D.C, but only one at a time).In addition to the welding machine, certain accessories are needed for carrying out the welding work.

3.2.4 Welding cables

Two welding cables are required, one from machine to the electrode holder and the other, from the machine to the ground clamp. Flexible cables are usually preferred because of the case of using and coiling the cables. Cables are specified by their current carrying capacity, say 300 A, 400 A, etc.

3.2.5 Electrodes

Filler rods are used in arc welding are called electrodes. These are made of metallic wire called core wire, having approximately the same composition as the metal to be welded. These are coated uniformly with a protective coating called flux. While fluxing an electrode; about 20mm of length is left at one end for holding it with the electrode holder. It helps in transmitting full current from electrode holder to the front end of the electrode coating. Flux acts as an insulator of electricity. Figure.4 shows the various parts of an electrode.

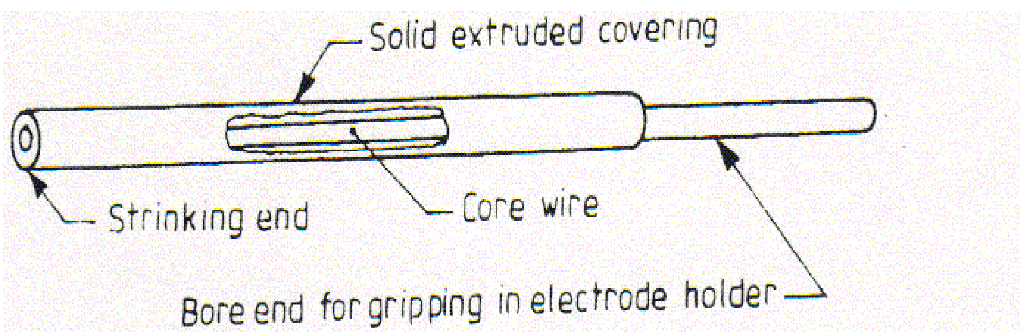


Figure 3.2: Parts of an electrode

In general, electrodes are classified into five main groups; mild steel, carbon steel, special alloy steel, cast iron and non-ferrous. The greatest range of arc welding is done with electrodes in the mild steel group.

Various constituents like titanium oxide, potassium oxide, cellulose, iron or manganese, Ferro-silicates, carbonates, gums, clays, asbestos, etc., are used as coatings on electrodes. While welding, the coating or flux vaporizes and provides a gaseous shield to prevent atmospheric attack.

The size of electrode is measured and designated by the diameter of the core wire in SWG and length, apart from the brand and code names; indicating the purpose for which there are most suitable.

Electrodes may be classified on the basis of thickness of the coated flux. As

1. Dust coated or light coated
2. Semi or medium coated and
3. Heavily coated or shielded

Electrodes are also classified on the basis of materials, as

1. Metallic and
2. Non-metallic or carbon

Metallic arc electrodes are further sub-divided into

1. Ferrous metal arc electrode (mild steel, low/medium/high carbon steel, cast iron, stainless steel, etc)
2. Non-ferrous metal arc electrodes (copper, brass, bronze, aluminum, etc).

In case of non-metallic arc electrodes, mainly carbon and graphite are used to make the electrodes.

3.3 WELDING TOOLS

3.3.1 Electrode holder

The electrode holder is connected to the end of the welding cable and holds the electrode. It should be light, strong and easy to handle and should not become hot while in operation. Figure shows one type of electrode holder. The jaws of the holder are insulated, offering protection from electric shock.

Figure 3.3: Electrode holder

Figure 3.4: Ground clamp

3.3.2 Ground clamp

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

3.3.3 Wire brush and chipping hammer

A wire brush is used for cleaning and preparing the work for welding. A chipping hammer is used for removing slag formation on welds. One end of the head is sharpened like a cold chisel and the other, to a blunt, round point. It is generally made of tool steel. Molten metal dispersed around the welding heads, in the form of small drops, is known as spatter. When a flux coated electrode is used in welding process, then a layer of flux material is formed over the welding bead which contains the impurities of weld material. This layer is known as slag. Removing the spatter and slag formed on and around the welding beads on the metal surface is known as chipping.

Figure 3.5: Wire brush

Figure 3.6: Chipping hammer

3.3.4 Welding table and cabin

It is made of steel plate and pipes. It is used for positioning the parts to be welded properly. Welding cabin is made-up by any suitable thermal resistance material, which can isolate the surrounding by the heat and light emitted during the welding process. A suitable draught should also be provided for exhausting the gas produced during welding.

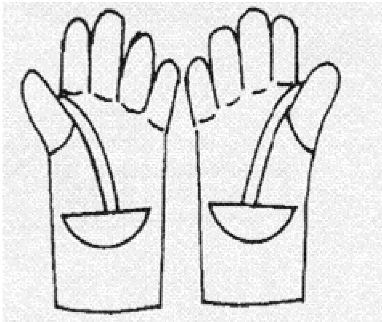
3.3.5 Face shield

A face shield is used to protect the eyes and face from the rays of the arc and from spatter or flying particles of hot metal. It is available either in hand or helmet type. The hand type is convenient to use wherever the work can be done with one hand. The helmet type though not comfortable to wear, leaves both hands free for the work.

Shields are made of light weight non-reflecting fiber and fitted with dark glasses to filter out the harmful rays of the arc. In some designs, a cover glass is fitted in front of the dark lens to protect it from spatter.

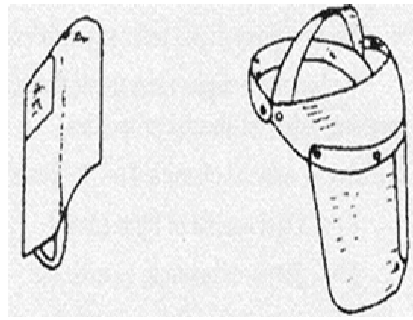
3.3.6 Hand gloves

These are used to protect the hands from electric shocks and hot spatters



Hand-held type

Figure 3.7: Hand gloves



Helmet type

Figure 3.8: Face shield

3.4 TECHNIQUES OF WELDING

3.4.1 Preparation of work

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

Before commencing the welding process, the following must be considered

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

Table 3.1 Electrode current Vs electrode size Vs plate thickness.

Plate thickness, mm	Electrode size, mm	Electrode current range, amp
1.6	1.6	40-60
2.5	2.5	50-80
4.0	3.2	90-130
6.0	4.0	120-170
8.0	5.0	180-270
25.0	6.0	300-400

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

3.4.2 Striking an arc

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

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

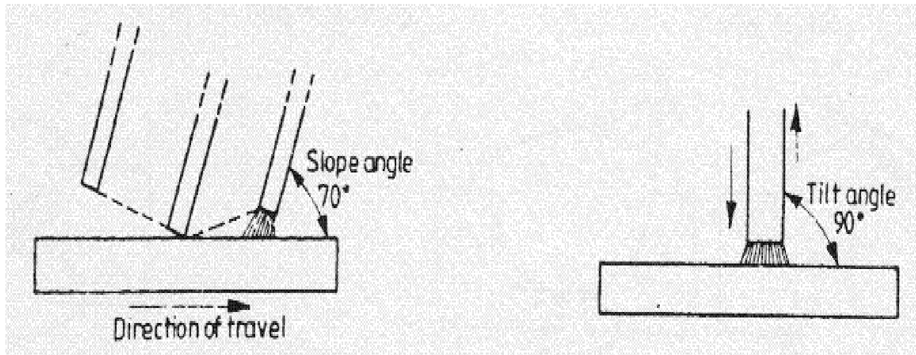
Strike and withdraw

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

Touch and with draw

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

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



Strike and withdraw   Touch and withdraw

Figure 3.9: striking an arc

3.4.3 Weaving

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

3.5 TYPES OF JOINTS

Welds are made at the junction of the various pieces that make up the weldment. The junctions of parts, or joints, are defined as the location where two or more numbers are to be joined. Parts being joined to produce the weldment may be in the form of rolled plate, sheet, pipes, castings, forgings, or billets. The five basic types of joints are listed below.

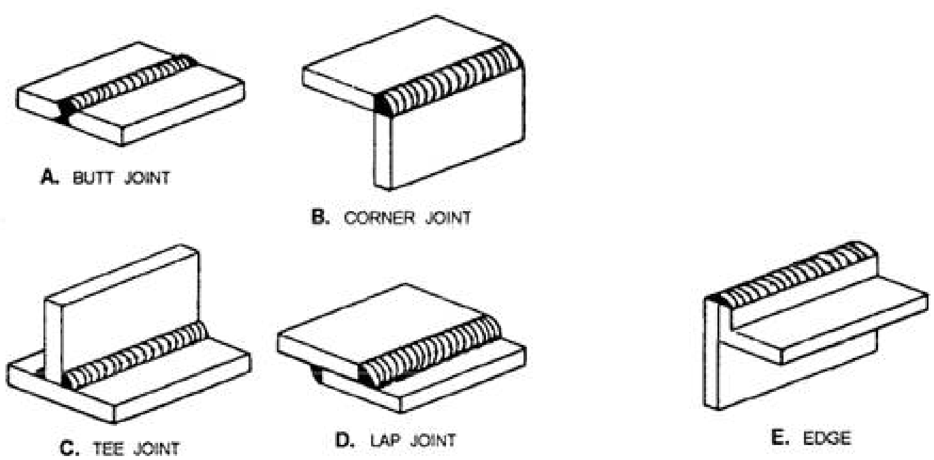


Figure 3.10: Types of welding joints.

A butt joint is used to join two members aligned in the same plane (fig. 3.10, view A). This joint is frequently used in plate, sheet metal, and pipe work. A joint of this type may be either square or grooved.

Corner and tee joints are used to join two members located at right angles to each other (fig. 3.10, views B and C). In cross section, the corner joint forms an L-shape, and the tee joint has the shape of the letter T. Various joint designs of both types have uses in many types of metal structures.

A lap joint, as the name implies, is made by lapping one piece of metal over another (fig. 3.10, view D). This is one of the strongest types of joints available; however, for maximum joint efficiency, you should overlap the metals a minimum of three times the thickness of the thinnest member you are joining. Lap joints are commonly used with torch brazing and spot welding applications.

An edge joint is used to join the edges of two or more members lying in the same plane. In most cases, one of the members is flanged, as shown in figure 3.10, view E. While this type of joint has some applications in plate work, it is more frequently used in sheet metal work. An edge joint should only be used for joining metals 1/4 inch or less in thickness that are not subjected to heavy loads.

3.6 WELDING POSITIONS

Depending upon the location of the welding joints, appropriate position of the electrode and hand movement is selected. The figure shows different welding positions.

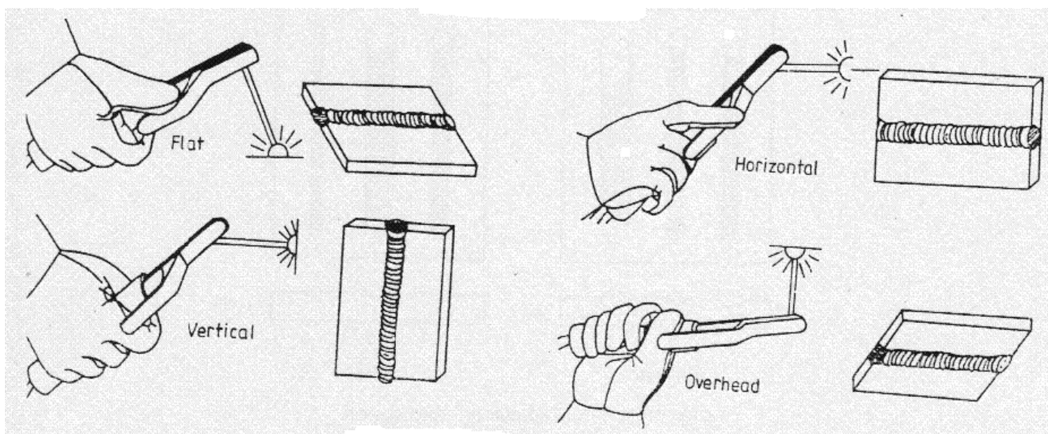


Figure 3.11: Welding positions

3.6.1 Flat position welding

In this position, the welding is performed from the upper side of the joint, and the face of the weld is approximately horizontal. Flat welding is the preferred term; however, the same position is sometimes called down hand.

3.6.2 Horizontal position welding

In this position, welding is performed on the upper side of an approximately horizontal surface and against an approximately vertical surface.

3.6.3 Vertical position welding

In this position, the axis of the weld is approximately vertical as shown in figure.

3.6.4 Overhead position welding

In this welding position, the welding is performed from the underside of a joint.

3.7 ADVANTAGES & DISADVANTAGES OF ARC WELDING

Advantages

1. Welding process is simple.
2. Equipment is portable and the cost is fairly low.
3. All the engineering metals can be welded because of the availability of a wide variety of electrodes.

Disadvantages

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

3.8 SAFE PRACTICE

Always weld in a well ventilated place. Fumes given off from welding are unpleasant and in some cases may be injurious, particularly from galvanized or zinc coated parts.

1. Do not weld around combustible or inflammable materials, where sparks may cause a fire.
2. Never weld containers, which have been used for storing gasoline, oil or similar materials, without first having them thoroughly cleaned.
3. Check the welding machine to make sure that it is properly grounded and that all leads properly insulated.
4. Never look at the arc with the naked eye. The arc can burn your eyes severely. Always use a face shield while welding.
5. Prevent welding cables from coming in contact with hot metal, water, oil, or grease. Avoid dragging the cables around sharp corners.
6. Ensure proper insulation of the cables and check for openings.
7. Always wear the safety hand gloves, apron and leather shoes.
8. Always turn off the machine when leaving the work.
9. Apply eye drops after welding is over for the day, to relieve the strain on the eyes.
10. While welding, stand on dry footing and keep the body insulated from the electrode, any other parts of the electrode holder and the work.

Exercise 1

Single V - Butt joint

Aim

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

Material used

Two mild steel pieces of 100X40X6 mm.

Tools and equipment used

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

Sketch

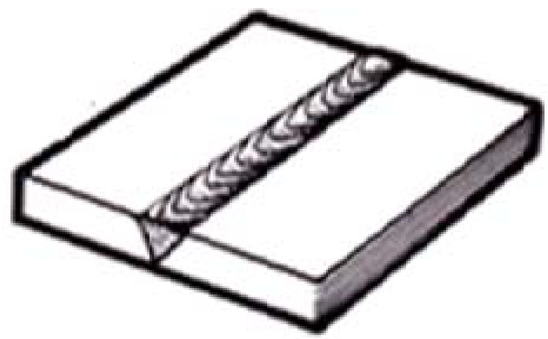


Figure 3.12: Single-V butt joint

Operations to be carried out

1. Cleaning the work pieces
2. tack welding
3. full welding
4. cooling
5. chipping
6. finishing

Procedure

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

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

Exercise 2

Double -Lap joint

Aim

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

Material used

Two **mild steel** pieces of 100X40X6 mm.

Tools and equipment used

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

Sketch

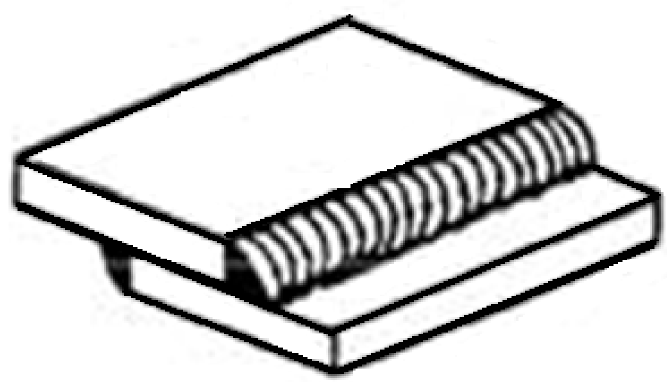


Figure 3.13: Double lap joint

Operations to be carried out

1. Cleaning the work pieces
2. tack welding
3. full welding
4. cooling
5. chipping
6. finishing

Procedure

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

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

Exercise 3

Corner joint

Aim

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

Material used

Two **mild steel** pieces of 100X40X6 mm.

Tools and equipment used

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

Sketch

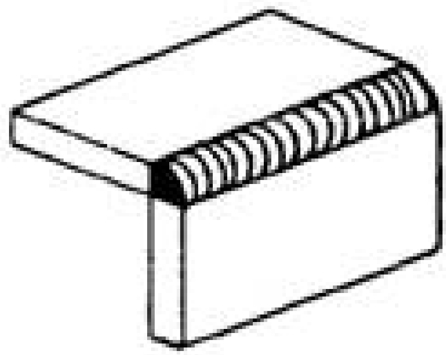


Figure 3.14: Corner joint

Operations to be carried out

1. Cleaning the work pieces
2. tack welding
3. full welding
4. cooling
5. chipping
6. finishing

Procedure

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

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

Exercise 4

T- joint

Aim

To make a T- joint, using the given mild steel pieces and by arc welding.

Material used

Two **mild steel** pieces of 100X40X6 mm.

Tools and equipment used

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

Sketch

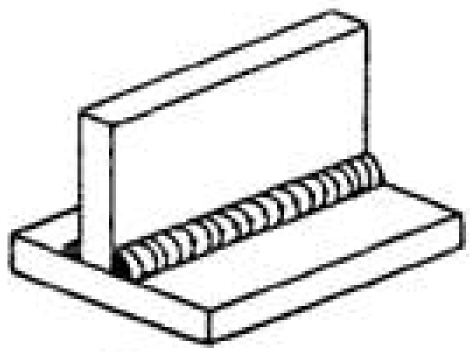


Figure 3.15: T-joint

Operations to be carried out

1. Cleaning the work pieces
2. tack welding
3. full welding
4. cooling
5. chipping
6. finishing

Procedure

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

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

Chapter 4

MACHINE SHOP

4.1 INTRODUCTION

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

4.2 PRINCIPAL PARTS OF A LATHE

Figure 4.1 shows a center lathe, indicating the main parts. The name is due to the fact that work pieces are held by the centers.

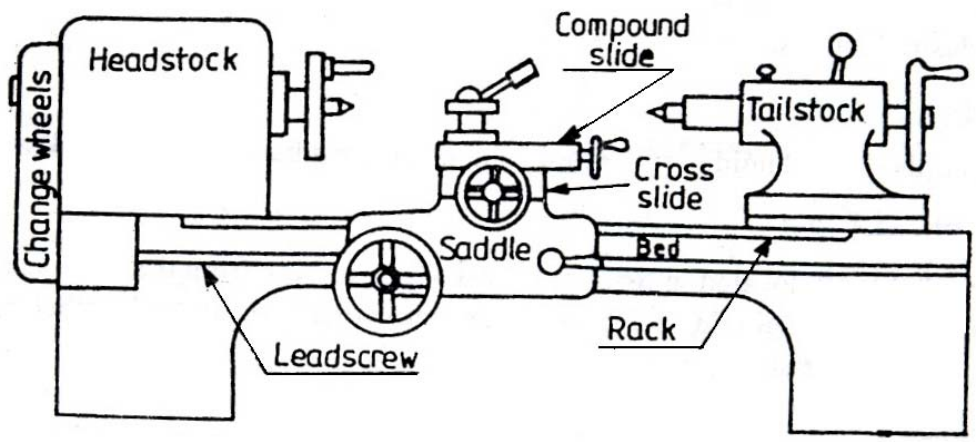


Figure 4.1: Parts of a center lathe

4.2.1 Bed

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

4.2.2 Head stock

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

4.2.3 Tail stock

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

4.2.4 Carriage or Saddle

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

4.2.5 Compound Rest

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

4.2.6 Tool Post

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

4.2.7 Lead Screw

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

4.2.8 Centers

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

4.3 WORK-HOLDING DEVICES

4.3.1 Three jaw chuck

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

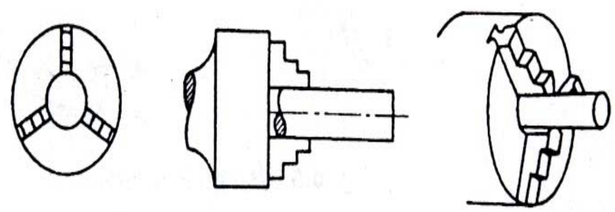


Figure 4.2: Three jaw chuck

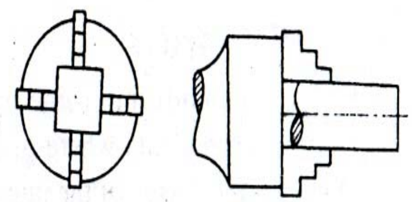


Figure 4.3: Four jaw chuck

4.3.3 Face plate

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

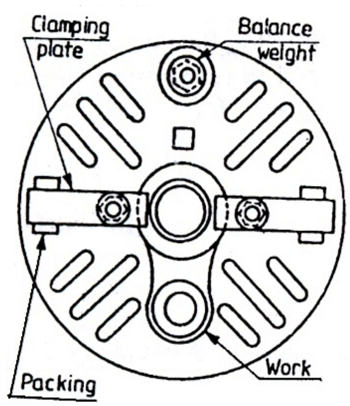


Figure 4.4: Face plate

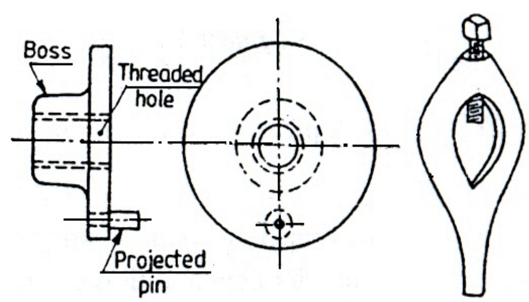


Figure 4.5: Lathe dog and driving plate

4.3.4 Lathe dogs and driving plate

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

4.4 MEASURING INSTRUMENTS

4.4.1 Outside and inside Calipers

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

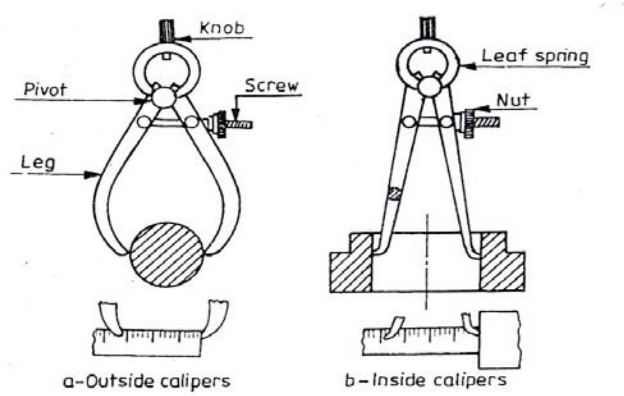


Figure 4.6: Calipers

4.4.2 Vernier Calipers

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

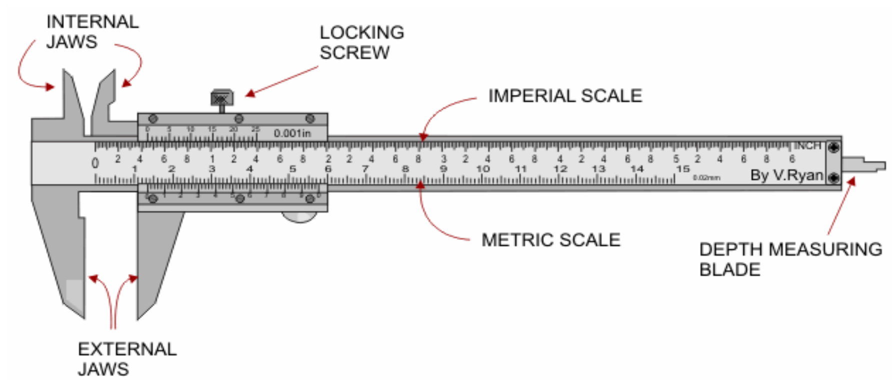


Figure 4.7: Vernier Caliper

4.4.3 Micrometers

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

4.5 CUTTING PARAMETERS

4.5.1 Cutting speed

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

Spindle speed (RPM) = cutting speed x 1000 / (πD)

Where D is the work piece diameter in mm.

4.5.2 Feed

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

4.5.3 Depth of Cut

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

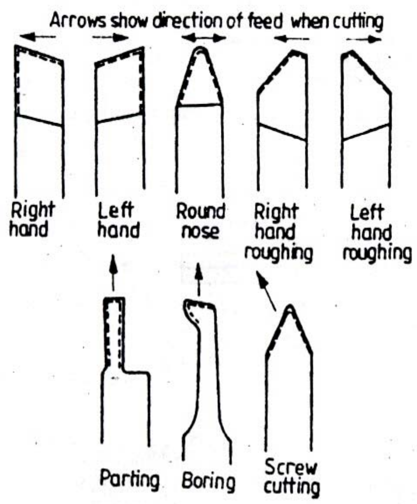
4.6 TOOL MATERIALS

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

Carbide tipped tools fixed in tool holders, are mostly used in production shops.

4.7 TOOL GEOMETRY

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



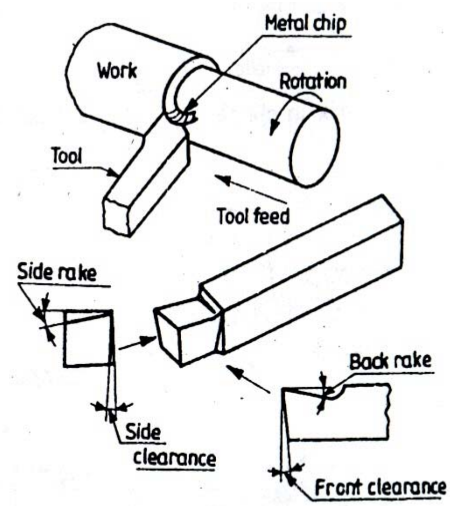


Figure 4.8: Common turning tools **Figure 4.9:** Tool geometry

4.8 LATHE OPERATIONS

4.8.1 Turning

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

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

4.8.2 Boring

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

4.8.3 Facing

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

4.8.4 Taper Turning

A taper is defined as the uniform change in the diameter of a work piece, measured along its length. It is expressed as a ratio of the difference in diameters to the length. It is also expressed in degrees of half the included (taper) angle.

Taper turning refers to the production of a conical surface, on the work piece on a lathe.
Short steep tapers may be cut on a lathe by swiveling the *compound rest* to the required angle. Here, the cutting tool is fed by means of the compound slide feed handle. The work piece is rotated in a chuck or face plate or between centers.

4.8.5 Drilling

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

4.8.6 Knurling

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

4.8.7 Chamfering

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

4.8.8 Threading

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

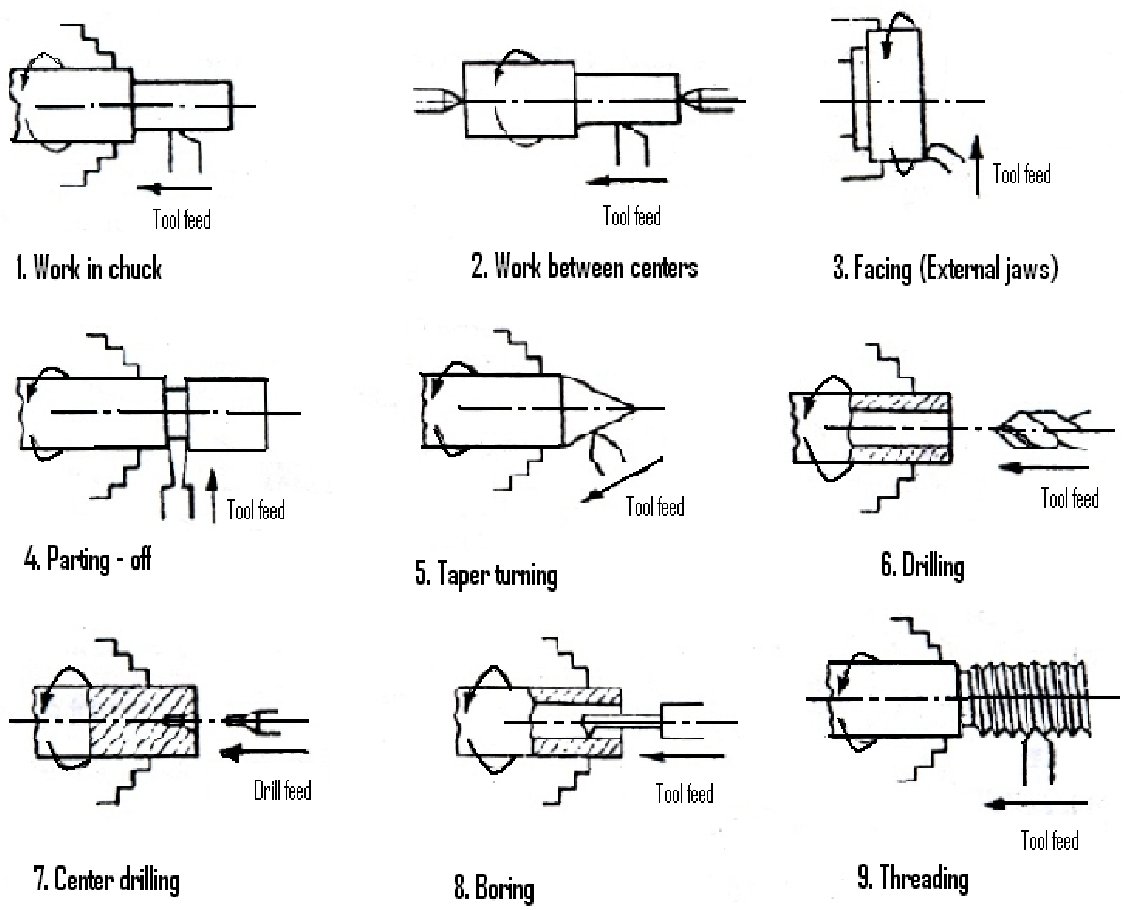


Figure 4.10: Operations of Lathe

4.9 SAFETY PRECAUTIONS

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

Exercise 1
Facing and plain turning

Aim
To obtain required diameter of a cylindrical work piece with the given length(Fig4.11).
Tools & Equipment
Lathe machine. Mild steel bar, right hand cutting tool, box key or tool post key, chuck key, steel rule, outside calipers or vernier calipers.
Sketch

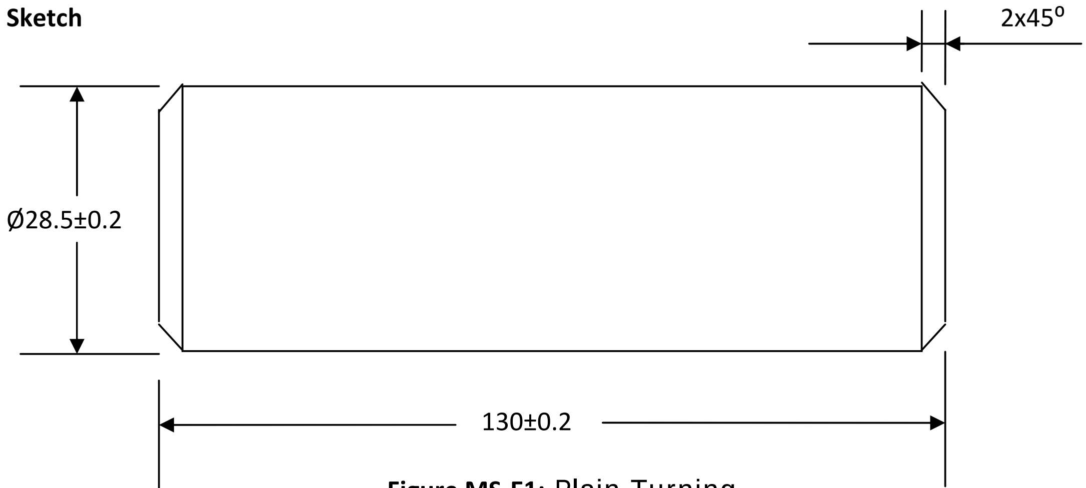


Figure MS-E1: Plain Turning

Theory
Facing is the operations of finishing the ends of work to make ends flat, smooth and to required length. Rough turning operation is used where excessive stock is to be removed and surface finish is not critical. For such a operation deep cuts with coarse feed are used. During rough machining, maximum metal is removed and very little oversize dimension is left for finishing operation.
Procedure
1. The given work piece is held in the 3-jawchuck of the lathe machine and tightened firmly with chuck key.
2. Right hand single point cutting tool is taken tightened firmly with the help of box key in the tool post.
3. Machine is switched on and the tool post is swiveled and the cutting point is adjusted such that it positioned approximately for facing operation then the tool is fed into the work piece and the tool post is given the transverse movement by rotating the hand wheel of the cross slide.
4. With this facing is completed and the tool post is swiveled and cutting point is made parallel to the axis of work piece.
5. Depth of cut is given by cross slide to the tool post and the side hand wheel is rotated to give the longitudinal movement for the tool post and job is turned to the required length and diameter.
6. After completion of the job it is inspected for the dimensions obtained with the help of steel rule and outside caliper or vernier caliper.

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

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

Exercise 2
Step turning

Aim
To obtain required diameters(steps) on a cylindrical work piece with the given lengths.
Tools & Equipment
Lathe machine. Mild steel bar, right hand cutting tool, box key or tool post key, chuck key, steel rule, outside calipers or vernier calipers.
Theory
Step turning is the operation of creating various cylindrical cross sections on a metal blank. Rough turning operation is used where excessive stock is to be removed and surface finish is not critical. For such a operation deep cuts with coarse feed are used. During rough machining maximum metal is removed and very little oversize dimension is left for finishing operation.
Sketch

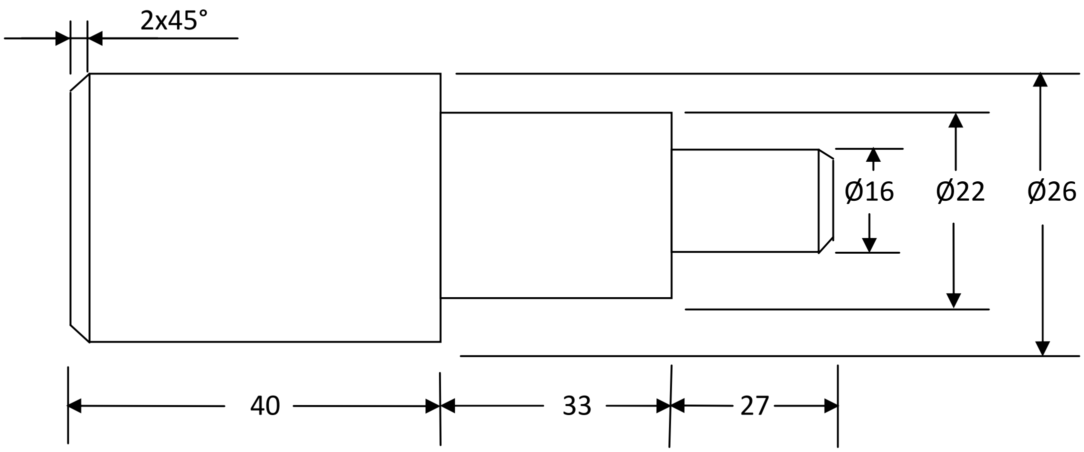


Figure MS-E2: Step Turning

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

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

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

Exercise 3
Shoulder turning

Aim
To obtain required diameters on a cylindrical work piece with the given dimensions.
Tools & Equipment
Lathe machine, Mild steel bar, right hand cutting tool, box key or tool post key, chuck key, steel rule, outside calipers or vernier calipers.
Sketch

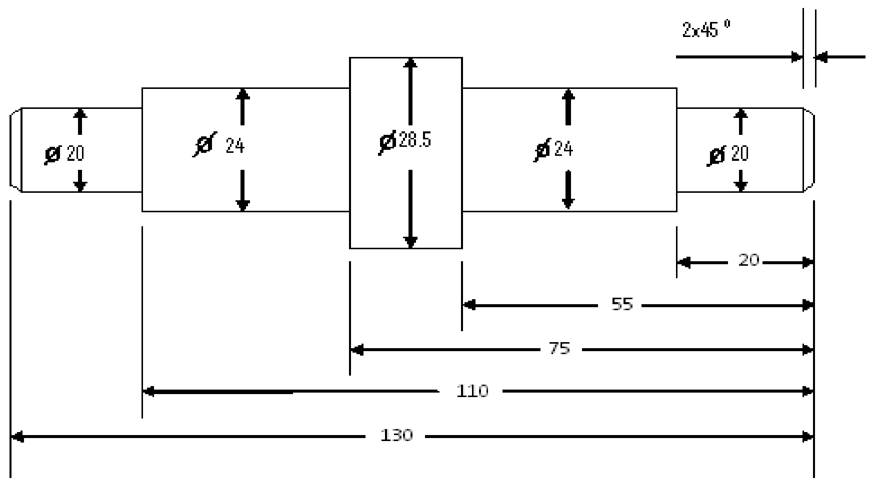


Figure 4.13: Shoulder Turning

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

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

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

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