SUB: INTERNAL COMBUSTION ENGINE & WORKSHOP TECHNOLOGY
Duration: 80 Sessions = 160 Periods
Sub-discipline:- Workshop Technology (Lessons: VIII Sessions: 25)
Lesson-I: Smithing and Forging. **Session-1**: Forging Materials, Heating Devices, Forging Temperatures, Smith Forging Operations

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FORGING MATERIALS

In all plastic deformation processes such as in forgings, the work piece calls for materials that should possess a property describe as ductility – that is, the ability to sustain substantial plastic deformation without fracture even in the presence of tensile stresses. If failure occurs it occurs by the mechanism of ductile fracture and is induced by tensile stresses. A material of a given ductility may fare very differently in various processes, depending on the conditions imposed on it. Therefore, it is proper to think of a more complex property called work-ability in plastic deformation processes, and forge-ability in forging processes. All one can say is that wrought alloys must possess a minimum ductility that the desired shape should possess.

Forgeable Metals

This requirement of wrought metals is amply satisfied by all pure metals with sufficient number of slip planes, and also by most solid solution alloys of the same metals. Two-phase and multi-phase materials are deformable if they meet certain minimum requirements.

Almost all commonly used metals and alloys satisfy these minimum requirements, and can be used for forging. The low and medium carbon steels are readily forged without difficulty, but the high-carbon and alloy steels are more difficult to forge and require greater care. The metals and alloys which are forged include carbon steels; alloy steels including stainless steels, Wrought iron; copper-base alloys, nickel and nickel copper alloys; aluminum alloys and magnesium alloys. Low carbon and low alloy steels and aluminum alloys account for over half the total tonnage. Stainless steels, nickel-based super alloys, and titanium are forged, especially for aerospace uses.

The metal of alloy to be forged is usually purchased as hot rolled bars or billets with round or rectangular cross sections.

Forge ability

The basic lattice structure of metals and their alloys seems to be a good index to their relative forge ability or workability. Forge ability increases with temperature up to a point at which a second phase, e.g., from ferrite to austenite in steel, appears or if grain growth becomes excessive. Certain mechanical properties also influence forge ability. Metals which have low ductility have reduced forge ability at higher strain rates, whereas highly ductile metals are not so strongly affected by increasing strain rates.

Good	**Some what difficult**	**Difficult**	**Very difficult**
Aluminum alloys	Martensitic stainless	Titanium alloys	Nickel-base alloy
Magnesium	Maraging steel	Iron-base super alloys	Tungsten alloy
Copper alloys	Austenitic stainless	Cobalt base supper alloys	Beryllium
Carbon and alloy steels	Nickel alloys Semi-austenitic stainless	Columbium alloys Tantalum alloys	Molybdenum alloys

HEATING DEVICES

The stocks are heated to the correct forging temperature in a smith's hearth or in a furnace located near the forging operations. Gas, oil or electric-resistance furnaces or induction heating classified as open or closed hearths can be used. Gas and oil are economical, easily controlled, and mostly used as fuels.

FORGING TEMPERATURES

For forging, a metal must be heated to a temperature at which it will possess high plastic properties both at the beginning and at the end of the forging process. For instance, the temperature to begin the forging for soft, low carbon steel is 1250^0C to 1300^0C, the temperature to finish forging is 800^0C to 850^0C. The respective temperature for hard, high carbon and alloy steels are 1100^0C to 1150^0C and 825^0C to 875^0C. Wrought iron is best forged at a temperature little below 1300^0C. Nonferrous alloys like brass and bronze are heated to about 600 to 950^0, and aluminum and magnesium alloys to about 350^0C to 500^0C.

SMITH FORGING OPERATIONS

A number of operations are used to change the shape of the raw material to the finished form. The typical forging operations are:

1. Upsetting.
2. Drawing down.
3. Setting down
4. Punching.
5. Bending.
6. Welding.
7. Cutting.
8. Fullering.

Lesson-I: Smithing and Forging. **Session-2**: Forging processes: Hand forging, Power Forging etc.

Hand forging: - ***The forging is done by hammering the piece of metal, when it is heated to the proper temperature, on an*** **anvil*****. While hammering, the heated metal is generally held with suitable tongs.*** **Formers** ***are held on the forging by the smith while the other end is struck with a sledge by a helper. The*** surfaces ***of*** **former** ***have different shapes, and they are used to impart these shapes to the forgings. One type of former, called a*** **fuller*****, having a well-rounded chisel-shaped edge is used to draw out the work. Fullers are also made as anvil fitting so that the metal can be drawn out, using both top and bottom fullers. Anvil of various shapes can be placed in the square hole of the anvil. For cutting the metal, hot*** **chisel** ***are used.*** **Punches** ***and*** **block** ***having proper-sized opening are used for punching out holes.*** **Welding** ***can be done by shaping the surface to be welded, removing any scale or impurities from between the surfaces with a flux, and hammering the surfaces together.***

Hand forging is employed only to shape a small number of light forgings chiefly in repair shops. Hand forging has, of recent years, been superseded by power forging.

Power forging: Large machine part cannot be forged by hand, since the comparatively light blow of a hand-or sledge-hammer is unable to produce a great degree of deformation in the metal being forged. Moreover, hand forging is a lengthy process and requires repeated heating of the metal. This has led to the use of power hammers and presses in forging. Machines which work on forgings by blow are called *hammers,* while those working by pressure are called *presses.*

POWER HAMMERS:-

All power hammers employ the same general principle of operation, a falling weight striking the blow, with the entire energy being absorbed by the work. Where further blows are necessary, the striking weight is raised for the succeeding blow. Some hammers employ only a gravity fall, the energy delivered on the work being the product of the weight of the hammer head and the distance of the fall. Other hammers increase the striking velocity of the hammer head by mechanical means.

The part of the hammer which serves as a rigid support during forging is called the *anvil block.* The anvil block of a forging hammer is built on a foundation separate form the frame so that the shock of the hammer blows will be cushioned by the foundation and will not be transmitted to the frames. The heavy falling part of the hammer is called the *ram.* The anvil block and the ram each has one die called upper-die and lower-die respectively for squeezing the metal to be forged. In smith forging, the working surfaces of both the upper and lower dies are flat and horizontal.

Hammers are classified as mechanical and air- and steam- hammers. In turn, the former is further classified into helve and trip hammer, lever spring hammer, and pneumatic hammer. Air- and steam-hammers are sub-classified into single and double acting hammers. The *capacity* of a hammer is determined by the weight of the falling parts. The weight of the anvil and the reciprocating parts usually has a ration of 15 to 1 (anvil block).

HELVE HAMMERS: Helve hammers are well adapted for general engineering work where the size of the stock is changed frequently. They consist of a *horizontal* wooden helve, pivoted at one end with a hammer at the other end. An adjustable eccentric between the pivot and the hammer end operates the helve. The eccentric raises the hammer which when falls strikes a blow. They are made in sizes from 5 to 200 kg.

Trip HAMMERS: Trip hammers have a vertically reciprocating ram that is actuated by toggle connection driven by a rotating shaft at the top of the hammer. Trip hammers are also built in sizes from 5 to 200 kg. The stroke range of both helve and trip hammers range from about 400 a minute for small sizes to about 175 for large sizes.

Lever –Spring HAMMERS: They are mechanical driven hammers with a practically constant lift ad an insignificantly variable striking power. It only increases with increasing operating speed and thus has increased number of strokes per minute. The ram is driven from rocking lever acting on an elastic rod. The rocking lever consists of a leaf spring so that an elastic drive is brought about.

They are suitable for drawing out and flattening small forgings produced in large numbers their disadvantage is the frequent breaking of springs due to vibrations when in operation.

Spring hammers are built with rams weighing from 30 to 250 kg. The number of strokes varies from 200 to 40 minutes.

Pneumatic hammers: The hammer has two cylinders: compressor cylinder and ram cylinder. Piston of the compressor cylinder compress air, and delivers it to the ram cylinder where it actuates the piston which is integral with ram delivering the blows to the work. The reciprocation of the compression piston is obtained from a crank drive which is powered form a motor through a reducing gear. The air distribution device between the two cylinders consists of rotary valves with ports through which `air passes into the ram cylinder, blow and above the piston, alternately. This drives the ram up and down respectively.

The size of pneumatic hammer may vary in a range form 50 to 1000kg. Hammers operated at 70 to 190 blows per minute.

Steam OR AIR AIR-HAMMERS: Steam or air hammers can be operated by steam or compressed air. They have no built-in compressor and, therefore, require additional facilities for supplying high pressure steam or compressed air to raise the striking stroke.

Both single-acting and double acting steam or air hammer may be constructed for forging. Single acting is made for comparatively light work, while double-acting is made for heave work. Steam pressure at the hammer is usually 6 to 9 kgf per sq. cm. (590 to 790 kN/m^2) and air pressure is bit smaller than that required for steam.

Rated size of steam forging hammers range from about 400 to 8,000 kg.

Introduction:

Welding is a process of joining similar metals by application of heat with or without application of pressure and addition of filler material.

Weldability:

The term "weldability" has been defined as the capacity of being welded into inseparable joints having specified properties such as definite weld strength, proper structure etc.

TYPES OF WELDING:

Modern methods of welding may be classified under two broad heading: (1) plastic welding and (2) fusion welding. They are also called pressure welding, and non-pressure welding, respectively.

` In the plastic welding or pressure welding, the pieces of metal to be joined are heated to a plastic state and then forced together by external pressure. This procedure is used in forge welding, resistance welding, "thermit" welding, and gas welding, in which pressure is required.

In the fusion welding or non-pressure welding, the material at the joint is heated to a molten state and allowed to solidify. This includes gas welding, arc welding, "thermit welding, etc.

It is seen, therefore, that except in cold-welding heat is used to bring about a plastic or molten state at the surface of the metal to be joined. In cold-welding, the joints are produced without the application of heat, but by applying pressure which results in inter surface molecular fusion of the parts to be joined. This process is mainly used for welding nonferrous sheet metal, particularly aluminium and its alloys.

METALLURGY OF WELD

Knowledge of what happens in metal when it is welded is necessary for an understanding of the welding operation, and is explained hereunder:

Fusion Welding:

In the weld metal, whether melted from the edges to be joined (autogenous welding), or supplied separately, solidifies from the liquid state and usually below the recrystallization temperature without any applied deformation. Fusion welds are, therefore, essentially castings. Since the surrounding parts are good conductors of heat the fusion weld may be called a chilled casting, and its structure will, therefore, usually be columnar (dendritic). The actual crystalline structure present, however, depends primarily on the number of "runs" made to deposit the weld metal.

In a single-run weld, long columnar crystals will grow outwards from the sides of the weld. If the temperature is high enough these columnar crystals will meet at the centre of the weld deposit forming a plane of weakness. This will eventually cause intercrystalline cracking within the weld. If, on the other hand, the welding temperature is correct, ***equiaxed*** grains will form at the centre resulting in an appreciably stronger joint.

A multi-run welding exhibits a quite different structure. The first run, as before, shows the structure for a single-run weld. In ordinary steels, the second run normalizes the first layer, causing a considerably degree of grain refinement. Each successive run thus normalizes the preceding one so that the final deposits exhibit the coarse cast structure typical of a single-run weld. However, in a multi-run weld the possibility of defects such as slag and gas inclusions will increase.

Slag inclusions are frequently trapped in fusion welds due to bead contour and the difficulty of melting the slag in subsequent runs. In metallic arc welds, in mild steel, microscopic inclusions are also present. Controlled amounts of nitrogen and manganese together with a dispersion of fine nonmetallic inclusions and especially a fine grain size with high dislocation density provide strengths of 43 to 57 kgf/mm^2 (430 to 570 N/mm^2) with adequate ductility to mild steel arc welds. The contour of welds by forming 'notches' can affect both fatigue and low temperature properties of a structure.

Gas solubility in liquid and solid weld metals, and gas reaction, are important in controlling the porosity of a weld. Metallic arc welds made with a bare wire are liable to contamination by gases from the atmosphere. The nitrogen of the atmosphere frequently appears as needles on certain planes in the crystals in the long run. This causes low impact strength especially after water quench.

The stresses set up in the weld by shrinkage are often of considerable importance as they are found to be responsible for weld metal cracking. These stresses may be relieved by annealing the entire object after welding is finished.

In brief, the action of the atmosphere on the melted metal, its fluidity and surface tension, the solidification process including segregation and shrinkage, all play their anticipated important roles as in castings.

Pressure Welding:

In pressure welding process, the metal in the joint is heated to the plastic condition, or above, and compressed while hot.

GAS WELDING

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

OXY-ACETYLENE WELDING

Oxy-acetylene gas welding is accomplished by melting the edges or surface to be joined by gas flame and allowing the molten metal to flow together, thus forming a solid continuous joint upon cooling. This process is particularly suitable for joining metal sheets and plates having thickness of 2 to 50mm. With materials thicker than 15mm, additional metal called filler metal is added to the weld in the form of welding rod. The composition of the filler rod is usually the same or nearly the same as that of the part being welded. To remove the impurities and oxides present on the surfaces of metal to be joined and to obtain a satisfactory bond a flux is always employed during the welding except mild steel. The temperature of the oxy-acetylene flame in its hottest region is about $3{,}200^0$C.

Gas Flame:

When oxygen and acetylene are supplied to the torch in nearly equal volumes, a neutral flame is produced having a maximum temperature of $3{,}200^0$C. This neutral flame is desired for most welding operations, but in certain cases a slightly oxidizing flame, in which there is an excess of oxygen or slightly carburizing flame, in which there is an excess of acetylene is needed. The condition of the flame is readily determined by its appearance. A carburizing flame is one in which there is an excess of acetylene. When welding steel, this will tend to give the steel in the weld a higher carbon content than the parent metal, resulting in a hard and brittle weld. This flame is necessary for welding brass.

Gas Cylinders:

Oxygen gas in cylinders is usually charged with about 40 liters of oxygen at a pressure of about 154 kgf per sq. cm (15400kN/m^2) at 21^0C. A full cylinder has the weight of about 80kg. Acetylene gas can be manufactured either by the water-to-carbide method or the carbide-to-water method.

High pressure acetylene cylinders are charged to a pressure of about 1 kgf per sq cm (100kN/m^2) It is not allowed to bring acetylene to a pressure over 2kgf per sq. cm (200kN/m2) otherwise it decomposes and explodes. The cylinder is therefore packed with 80 per cent porous material such as asbestos, balsawood, charcoal, industrial earth, silk fiber or kapok.

The arc column is generated between an anode, which is the positive pole of dc (direct current) power supply, and the cathode, the negative pole. When these two conductors of an electric circuit are brought together and separated for a small distance (2 to 4mm) such that the current continues to flow through a path of ionized particles (gaseous medium), called plasma, an electric arc is formed. This ionized gas column acts as a high resistance conductor that enables more ions to flow from the anode to the cathode. Heat is generated as the ions strike the cathode. Approximately 1 kWh of electricity will create 250 calories (1000J), the temperature of an electric arc, of course, depends upon the type of electrodes between which it is struck.

The heat of the air raises the temperature of the parent metal which is melted forming a pool of molten metal. The electrode metal or welding rod is also melted and is transferred into the metal in the form of globules of molten metal. The deposited metal serves to fill and bond the joint, or to fuse and build up the parent metal surface. Two thirds of the heat is developed near the positive pole. As a result, an electrode that is connected to the positive pole will burn away approximately 50 per cent faster than that is connected to the negative pole. This is helpful in obtaining the desired penetration of the base metal.

AIR-ACETYLENE WELDING

This process uses a torch similar to a Bunsen burner and operates on the Bunsen burner principle. The air is drawn into the torch as required and mixed with the fuel gas. The gas is then ejected and ignited, producing an air-fuel flame. The common fuels used in the air-fuel welding are acetylene, natural gas, propane and butane. This type of welding has limited use in since the temperature is lower than that attained by other gas processes. The air-fuel welding processes are used successfully in lead welding and many low-melting-temperature metals and alloys such in brazing and soldering processes.

OXY-HYDROGEN WELDING

The oxygen-hydrogen process was once used extensively to weld low-temperature metals such as aluminium, lead and magnesium; but it is not as popular today because more versatile and faster welding process such as TIG (tungsten inert gas) and MIG (metal inert gas) have replaced the oxygen-acetylene system, with the only difference being a *special regulator* used in metering the hydrogen gas.

ARC WELDING EQUIPMENTS

Arc Welding Machine:

Both direct current and alternating current are used for electric arc welding, each having its particular applications; in some cases either is suitable. D.C. welding supply is usually obtained from generators driven by electric motor or if no electricity is available by internal combustion engines. For ac welding supply, transformers are predominantly used for almost all arc welding where mains electricity supply is available. They have to step down the usual supply voltage (200-400 volts) to the normal open circuit welding voltage (50-90 volts). A 100 to 200A machine is small but portable and satisfactory for manual welding of average work.

With direct current the greater heat is generated at the positive pole of the arc, and in metal-arc welding, it has been the general practice to connect the work to the positive pole of the D.C. generator and the filler rod to the negative pole, in order to melt the greater mass of metal in the base material. On the other hand, certain types of modern electrodes due to their coating and material properties, are connected advantageously to the positive pole of the generator. The electric energy consumption per kg of deposited metal in a.c. welding is from 3 to 4 kWh while for D.C. welding it is as high as 6 to 10 kWh. One disadvantage of A.C. welding is the comparatively low power factor at the welding station, usually not exceeding 0.3 or 0.4. The motor in a D.C. welding has a power factor of 0.6 to 0.7.

Arc Welding Current and Voltage:

Open circuit voltage (no load voltage), i.e., the voltage needed to strike the arc, is higher than the arc voltage in order to facilitate easy starting of the arc. With direct current, the open-circuit voltage must be at least 30 to 35V.

In a Table gives a survey of permissible intensities of current.

Diameter of Electrode mm	Cross-sectional area of electrode mm^2	Mean Total A	Intensity Per mm^2 A/mm^2
2	3.14	45	14.3
2.5	4.90	70	14.3
3.25	8.29	105	12.7
4	12/56	140	11.1
5	19.63	180	9.4
6	28.27	235	8.3
8	50.26	310	5.9

RESISTANCE WELDING

In resistance welding the metal parts to be joined are heated to a plastic state over a limited are by there resistance to the flow of an electric current and mechanical pressure is used to complete the weld. Recently, with air and hydraulic systems for applying pressure at the correct time and in right amount through electronic controls, resistance welding has been advanced. In this process, preferably two copper electrodes are incorporated in a circuit of low resistance and the metals to be welded are pressed between the electrodes. The circuit is thus completed and the electrical resistance at the joint of the metals to be welded is so high, in comparison with the rest of the circuit, that if the current is heavy enough the highest temperature will be produced directly at the joint. The heat generated in the weld may be expressed by

$$H = I^2 RT$$

Where H is the heat, I the current, R the resistance of the assembly and T the time or duration of current flow. That is the heat developed by the current is in proportion to the electrical resistance of the joint.

Resistance Welding Methods

The field of resistance welding can be subdivided into several processes, the most important being:

a) Butt.
b) Spot
c) Seam
d) Projection
e) Percussion welding

WELDING RELATED PROCESSES

SOLDERING

Soldering is the method of uniting two or more pieces of metal by means of a fusible alloy or metal, called *solder*, applied in the molten state. Soldering is divided into two classifications: soft and hard.

Soft soldering is used extensively in sheet-metal work for joining parts that are not exposed to the action of high temperatures and are not subjected to excessive loads and forces. Soft soldering is also employed for joining wires and small parts. The solder, which is mostly composed of lead and tin, has a melting range of 150 to 350 ^{0}C. A suitable flux is always used in soft soldering. Its function is to prevent oxidation of the surfaces to be soldered or to dissolve oxides that settle on the metal surfaces during the heating process.

The different compositions of solder for different purpose are as follows:

1. Soft solder – lead 37 percent, tin 63 percent.
2. Medium solder – lead 50 percent, tin 50 percent.
3. Plumber’s solder – lead 70 percent, tin 30 percent.
4. Electrician’s solder – lead 58 percent, tin 42 percent.

Hard soldering employs solders which melt at higher temperatures (600-900^{0}C) and are stronger than those used in soft soldering. *Silver soldering* is a hard soldering method, and silver alloyed with tin is used as solder.

BRAZING

Brazing is essentially similar to soldering, but it gives a much stronger joint than soldering. The principal difference is the use of a harder filler material commercially known as *spelter*, which fuses at some temperature above red heat, but below the melting temperature of the parts to be joined. Filler metals used in this process may be divided into two classes: copper-base alloys, and silver-base alloys.

Silver alloys (silver and copper or silver, copper and zinc) having a melting range of 600 to 850^{0}C are suitable for brazing any metals capable of being brazed. They give a clean finish and a strong ductile joint.

The parts to be joined by brazing are carefully cleaned, the flux applied and the parts clamped in position for joining. Borax is widely used flux, but many proprietary brands are available. They are then heated to a temperature above the melting point of the spelter to be used, and molten spelter is allowed to flow by capillary action into the space between the parts and to cool slowly. The actual heating may be done in a number of ways. *Torch brazing* in which heating is done by a blow torch is very common. *Furnace brazing,* particularly in controlled atmospheres, is a favourite for production. Induction heating is useful to confine the heat to the joint, if general heating must be avoided. *Resistance brazing* is done on some small parts in production. *Immersion brazing* is used in large scale production. The parts are cleaned and fluxed, clamped together, and then immersed into a tank of molten spelter.

Lesson-II: Welding and Related Processes Session-7: Procedure for welding of tamping tool and defects in tamping tool welding.

PROCEDURE FOR WELDING OF TAMPING TOOL

After continuous working with Tamping tools, these tools need reconditioning as the tools gets worn out. Maximum 20% wear in X-section area is allowed. For the purpose of reconditioning of Tamping tools hard facing electrodes are used. Normally C-2 RL-3 L & T electrodes are used for the welding of tamping tools. With the help of hard facing electrodes a layer of sufficient thickness matching with the parent surface is made. Front size of 140 X 70 mm and side thickness 20 mm at top & 5 mm at bottom is maintained. The reconditioning work is done by electric Arc welding.

Following precautions should be observed while welding the Tamping Tool

1. Before recondition of tool, surface should be cleaned properly. It should not contain grease or oil.
2. While reconditioning of Tamping tool, positive supply is given to Electrode and negative supply is given to the tool.
3. A small gap of 2 to 4 mm between Anode and Cathode (Electrode and Work piece is maintained.
4. Hard facing electrode should be used for reconditioning of Tools. Mild Steel electrodes should not be used.
5. Continuous welding should not be done to avoid excess heat generation.
6. One welding layer should be cooled up to hand bearing temperature, and then another layer should be welded.

DEFECTS IN TAMPING TOOL WELDING

1. Incomplete penetration: – It occurs due to improper cleaning of surface.
2. Lack of fusion: – Due to improper Electrode.
3. Under cutting: – It happens due to high current and more Arc gap.
4. Shape deformation:- Due to excess heat generation.
5. Size defects.
6. Slag inclusion.
7. Porosity.
8. Burnt metal.
9. Cracks.

Lesson-II: Welding and Related Processes. Session-8: Welding of BCM turret gears, Main links, Intermediate links and cutter bar and grinding operation.

Welding of BCM (Turret gear) Dredger Drum:

For the purpose of welding of dredger drum of BCM, 2B Electrode L&T is used to recondition and hardness is maintained to 350 BHN. The process of welding is done at slow rate and also at the same time, excess heat should not develop other wise it will be subjected to deformation. It is then done in different layers. Afterwards the grinding is done to give proper shape to the component. Templates are also used to guide the Welder or the Grinder.

Main (Links) Shovel and Intermediate (Links) Shovel Welding:

The welding of shovel is done by high manganese electrodes as 12 to 14% Mn is available in the parent material. Mostly L&T and more Mn-electrodes are used. For the purpose of welding templates are also used.

Method of Welding:

The job is immersed in a container up to ½ portions. Then the welding is done at the portion which is out of water and then the job is reversed to weld the other half portion. This method is adopted to avoid cracking of material. The welding is done at slow-rate as heat generation is very high. Excess temperature should not be allowed

Welding of Cutter Bar:

For the purpose of welding of cutter bar, worn out portion is removed through gas cutting and either a new plate or flange of rail is welded by M.S. Rod. Uniform welding is to be done otherwise it is subjected to deformation.

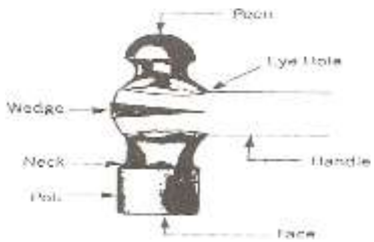
Grinding Operation:

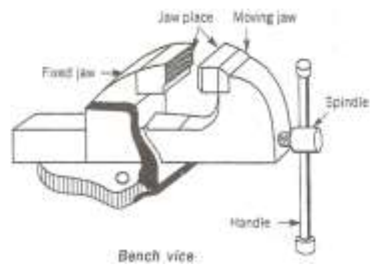
Grinding is done by hand grinder.

COMMON HAND TOOLS

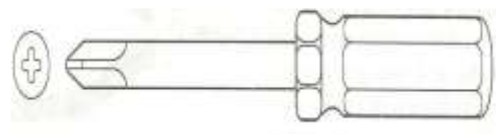
1. Hammers: - Hammers are of following types :- (i) Ball peen hammer(ii) Cross peen hammer(iii) Claw hammer(iv) Double face hammer(v) Mallet hammer or Soft hammer.

2. Vice: - It consists of one fix jaw and another movable jaw; jaw plates are fixed to the jaws by set screws and replaced when worn out. Jaw plates have cross-cut for gripping the job. The size of the vice is known by the width of its jaws. The width suitable for common work varies from 80 to 140mm, the maximum opening being 95 to 180mm.





Bench vice


Philips screw driver.

3. Screw Driver: - It consists three main parts: - (i) Handle (ii) Shank (iii) Blade or tip According to length of shank, screw drivers are of various sizes. According to shape the screw drivers used on machine are - (a) Standard screw driver. (b)Philips screw driver.

Safety precautions:-1. Small jobs should not be kept in hand while using screw driver.
2. Don't use screw driver with oily hand.

4. Pliers: - Following pliers comes in our use-(i) Combination pliers (ii) Long nose pliers (iii) Side cutting pliers (iv) Adjustable pliers(v) Circlip pliers (External and internal)

5. Spanner and Wrenches: - These are of following types: - (i) Open ended spanner (ii) Box Type spanner (iii) Adjustable spanner (iv) C-Spanner

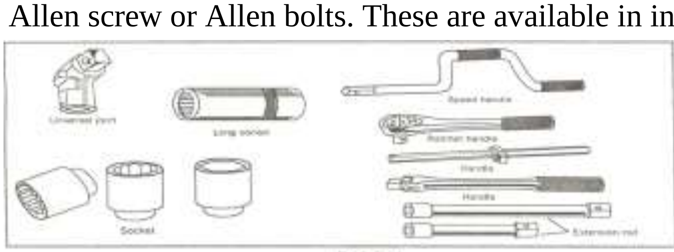
(i) Open ended spanner: - These are of two types (a) Single ended spanner (b) Double ended spanner.

(ii) Box type spanner: - These are of following types: - (a) Ring spanner (b) Socket spanner (c) Tubular spanner.

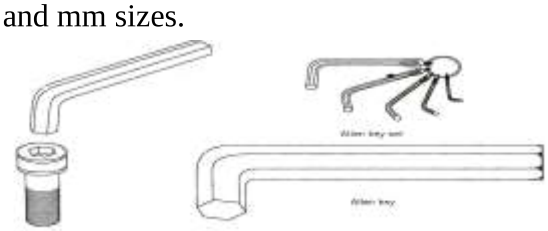
(iii) Adjustable spanner: These are of following types: - (a) Screw wrench (b) Pipe wrench

(iv) C-Spanner: - This is used for opening and tightening of round nuts. There are single or double slots in the round nuts, by which the nuts can be opened or tightened.

6. Allen key: - There are six sides on these spanners and are used for opening and tightening the Allen screw or Allen bolts. These are available in inch and mm sizes.

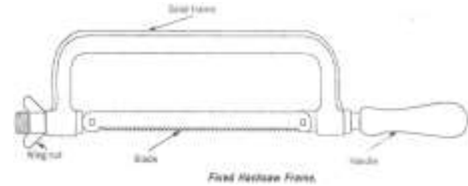


Socket set


Allen key.

7. Stud extractor: - This is used for removing broken bolts or studs.

8. Chisels: -(i) Hot chisel (ii) Cold chisel: - This is used in workshop for cutting cold irons. This is made of high carbon steel. As per requirement of job it is also made of tool steel or cast steel.



9. Hacksaw: - It consists two main parts- (i) Frame
(ii) Blade: - Blades are generally made of high carbon steel, high speed steel or low alloy steel and tempered.

Precautions: - (i) A cut should be marked by a triangular file.
(ii) Hacksaw should be driven slowly at the start.
(iii) Force should be more in forward stroke and less in return stroke.
(iv) During end of cut, job should be held by hand at one end and hacksaw should be driven slowly.
(v) Drive 40-50 strokes in one minute.
(vi) Blade should be driven in full length.
(vii) Blade should be driven straight.
(viii) Force should be applied according to material.

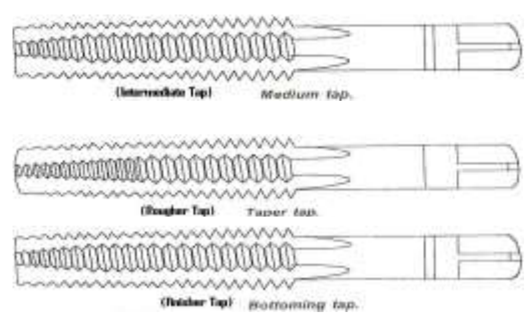
10. Files: - According to shape or section files are of following types:-1. Hand files 2.Flat files 3. Half round files 4.Triangular files 5. Square files 6. Round files 7. Knife edge files 8. Needle file set.

Precautions: - (i) Make sure that the handle is firmly fixed to the file.
(ii) Job surface and file surface should be free from any oil or grease.
(iii) Files are brittle hence should be placed carefully.
(iv) Files should be operated in full length on the job.
(v) Any rust on the job surface should be cleaned by file nose.
(vi) Files should not be operated too fast on the job.

11. Drill: - It is made of High carbon steel: - For soft metals. High speed steel: - For hard metals. Twisted fluted drill is used for metal works. Lip angle for general work is 118°.

Precautions: - (i) Cutting edge of drill should be sharp. Blunt cutting edge should be ground on grinder to make sharp. The length of the both cutting edges should be kept equal.
(ii) Before drilling make a mark on the job by centre punch.
(iii) Drill should be tightened properly by key in the chuck.
(iv) Small diameter drill should be given more speed and less pressure.
(v) Coolant should be used during drilling.

12. Taps: - There are generally three taps in a set
(i) Rougher Tap (Taper Tap): -6-8 threads are ground in taper.
(ii) Intermediate Tap (Medium Tap): - 3-5 threads are ground in taper.
(iii) Finisher Tap (Bottoming Tap): - 1-2 threads are ground in taper.



Tap Wrench: - It is a tool for holding the tap. It is also called a tap handle.
Tap-Drill size: - Drill size should be proper in accordance with tap size for exact cutting of threads.

Formula: - T.D.S = T.S-2d Where, T.D.S = Tap drill size
d = 0.61p T.S = Tap size
Thumb rule: - T.D.S= T.S*0.8 P = Pitch= 1/Thread per inch

Precautions: - (i) Hole size should be proper in accordance with tap size.
(ii) Taps should be operated in correct sequence of rougher, intermediate and finisher.
(iii) Tap should be moved quarter round back for half round forward.
(iv) Tap handle should be kept balance.

13. Scrapers: - Three types of scrapers are mostly used: -
(i) Flat scrapers. (ii) Half round scrapers. (iii) Triangular scrapers.

MEASUREMENT AND INSPECTION:

A measuring instrument is any device that may be used to obtain a dimensional or surface measurement. While a gauge is intended for quickly checking parts in production that is to determine whether or not a dimension is within its specified limits. A gauge usually does not reveal the actual size of dimension.

Standards of Measurement: ***International standard meter has been defined in terms of a wavelength of light, being the length equal to 1650 763.73 vacuum wave lengths of orange radiation of Krypton-85.***

Line and End Standards:

The length standard can be classified as the line standard and end standard. In the length standard, the unit of length is defined as the distance between the centers of engraved lines as in a steel rule, whereas in the end standards it is the distance between the end faces of the standard as in a micrometer.

Classification of Measuring Instruments:

1. **Precision Instruments:**
   Precision instruments are those which have the ability to measures parts within an accuracy of 0.01mm or more.
2. **Non-precision:**
   Non-precision instruments are limited to the measurement of parts to a visible line graduation on the instrument used, such as a graduated rule or scale.

External Micrometer:

The essential parts of the instrument are as follows:

1. **Frame:** The frame is made of steel, cast steel, malleable cast iron or light alloy.
2. **Hardened anvil:** The anvil shall protrude from the frame for a distance of at least 3mm in order to permit of the attachment of a measuring wire support.
3. **Screwed spindle**. This spindle does the actual measuring and possesses threads of 0.5mm pitch.
4. **Graduated sleeve or barrel**. It has datum or fiducial line and fixed graduations.
5. **Thimble**. This is a tubular cover fastened with the spindle and moves with the spindle. The beveled edge of the thimble is divided into 50 equal parts, every fifth being numbered.
6. **Ratchet or friction stop**. This is a small extension to the thimble. The ratchet slips when the pressure on the screw exceeds a certain amount. This produces uniform reading and prevents any damage of distortion of the instrument.
7. **Spindle clamp or clamp ring.** This is used to lock the instrument at any desired setting.

Reading: The graduation on the barrel is in two parts, namely one above the reference line and the other below. The graduation above the reference line is graduated in 1mm intervals. The first and every fifth are long and numbered 0, 5, 10, 15, 20, and 25. The lower graduations are graduated in 1 mm intervals but each graduation shall be placed at the middle of the two successive upper graduations to be read 0.5mm.

The micrometer screw has a pitch of 0.5mm, while the thimble has a scale of 50 divisions round its circumference. Thus, on going through one complete turn, the thimble moves forward or backward by one thread pitch of 0.5 mm and one division of thimble is 0.01 mm.

Comparators:
Comparators are instruments which derive their name from the fact that they are used for simple and accurate comparison of parts as well as working gauges and instruments with standard precision gauge blocks, comparators of every type incorporate some kind of magnifying device to magnify how much a dimension deviates, plus or minus, from an ideal. The common types are:

1. Mechanical Comparators
2. Electrical Comparators
3. Optical Comparators
4. Pneumatic Comparators.

Mechanical Comparators:
A mechanical comparator employs mechanical means for magnifying the small movement of the measuring stylus brought about due to the difference between the standard and the actual dimension being checked. Mechanical comparators are available having magnifications from 300 to 5000 to 1. Dial indicators as mechanical comparators.

Dial Indicators – The essential parts of the instrument is like a small clock with a plunger projecting at the bottom. Very slight upward pressure on the plunger moves it upward and the movement is indicated by the dial pointer. The dial is graduated into 100 divisions. A full revolution of the pointer about this scale corresponds to 1mm travel of the plunger. Thus a turn of the hand by one scale division represents a spindle travel of 0.01mm.The indicator is adjusted to zero by either turning the rim of the dial or turning the head of the plunger while holding the dial stationary.

Electrical Comparators:
Electrical Comparators are used as a means of detecting and amplifying small movements of a work contacting elements.
An electrical comparator consists essentially of a pick-up head or transducer for converting a displacement into a corresponding change in current and a meter or recorder connected in the circuit to indicate the electrical change, calibrated to show in terms of displacement. Generally, an amplifier is needed to provide the requisite sensitivity and to match the characteristics of different parts of the circuit. Electrical comparators can be classified according to the electrical principle used in the pick-up head. Most of the comparators use either a differential transformer, an inductance bridge, a strain gauge or a capacitor as a means of detecting movement of the gauging element.

Optical Comparators:
Optical Comparators have a high degree of precision and the magnification is obtained with the help of light beams which have the advantage of being straight and weightless. Optical comparators, therefore, suffer less wear during usage than the mechanical type.

Pneumatic Comparators:
In recent years, pneumatic comparators have been extensively used specially in automatic size control. They are cheap, independent of the contact pressure, and simple to operate. Besides, this form of comparator is free from mechanical wear. However, pneumatic comparators are sensitive to temperature and humidity changes and their accuracy may be influenced by the surface

roughness of the parts being checked. The magnification of this type of comparator is as high as 10,000.

Angular Measurement:
The accuracy of these tools and instruments varies considerably according to particular application from that of the angle gauge or protractor to high precision optical and spirit level instruments. In angular measurement two types of angle measuring devices are used. They are angle gauges corresponding to slip gauges, and divided scales corresponding to line standards.
Protractors:
The instrument consists of two arms which can be set along the faces and a circular scale which indicates the angle between them. The body of the instrument is extended to form one of the arms, and this is known as the stock. The other arm is in the form of a blade which rotates in a turret mounted on the body.

Bevel Gauge:
This tool, consists of two adjustable blades which may be moved into almost any position to give any desired angle. But no direct reading is obtained, and the angle must be set or checked from some other angular measuring device.

Engineers Square:
With either plain or bevel square, it is possible to finish a surface and measure angles to extreme accuracy. The square should be held firmly against the true side and then lowered on to the face which is to be checked, the observation then being made against a good light and viewed along the plane of the surface and not at an angle to it.

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

Bevel Protractor:
The universal bevel protractor is an instrument used for measuring and testing angles. It is well adapted for all classes of work where angles are to be laid out or measured to within the limits of five minutes.

Dividing Head:
Although the index or dividing head was originally developed for use on milling machine, it is used in inspection work for checking angles about a common centre. The head consists of a worm and worm gear set having a ratio of 40 to 1. So, one turn of the crank will turn the spindle one-fortieth of a revolution or 9 degrees. By using index plates with the head, a desired angle can be obtained with close accuracy.

Sine Bar:
Measurement of angles using bevel protractor is direct, whereas sine bars make indirect measurements. Sine bars are frequently used in conjunction with slip gauges for setting of angles and of tapers from a horizontal surface, preferably a clean surface plate. The accuracy attainable with this instrument is quite high and the errors in angular measurement are less than 2 seconds for angles unto 45 degree.
The most common type of sine bar consists of an accurately lapped steel bar which is stepped at the ends, with a roller secured in to each step by a screw which holds it in contract with both faces of the step. A sine bar is specified by the distance between the centers of two rollers, i.e.

100 mm or 250mm; a 100mm bar is very common. For accurate measurements, the following points in its construction are important:

1. The rollers must be of the same diameter.
2. The distance between their centers, i.e. 100mm or 250mm must be absolutely correct.
3. The centre line of roller centre must be absolutely parallel with bottom and top edges of the bar.

Angle Gauges:

Angle gauges are used for measuring and setting out angles in the workshops where precision work in the measurement of angles are required. These are wedge shaped steel blocks and their working faces are finished in the same manner as slip gauges, enabling them to be wrung together in combinations. A full set comprises twelve pieces divided into three series: degrees, minutes and fractions of a minute as follows: 1.3, 9.27 and 41 degrees, minutes ; 1, 3, 9 and 27 minutes; 0.1.0.3 and 0.5 minute. With twelve separate gauges used in conjunction with a precision square, it is possible to set up any angle between 0 and $36^{0}0$ to be built up in steps of 6 seconds by wringing blocks together in additive or subtractive manner. Thus taking the 1^{0}, 3^{0}, 9^{0} blocks.

$$3^{0} + 1^{0} = {}^{40},\ 9^{0} = (3+1)^{0} = 5^{0},\ 9^{0} - 1^{0} = 8^{0} \text{ and so on.}$$

There are two sets of gauges available, designated as A and B. The standard B contains all the 12 gauges, while standard A contains one additional gauge of 0.05' (3") which enables combinations to be built up to 3".

The block formed by a combination of a number of these gauges is rather bulky, and can not always be conveniently used directly to the work, but it is usually possible to use the gauges as a reference in conjunction with angle measuring device such as a bevel or autocollimator.

Taper Measurement:

The taper angle is measured by the following measuring instruments:

1. Bevel protractor
2. Tool room microscope
3. Autocollimator
4. Sine bar and dial gauge
5. Rollers, slip gauges and micrometers

Taper Micrometer:

This measuring instrument makes it possible to check both internal and external tapers ten times faster than with older conventional methods and does not require sine bars or more elaborate equipment. The instrument has within itself the sine bar principle, and it gives the actual value of the taper of small angles. Larger tapers can be directly obtained from micrometer reading.

SUB-DISCIPLINE:- WORKSHOP TECHNOLOGY (Lessons: VIII Sessions: 25)
Lesson-V: Measurement and inspection. Session-12: Demonstration in model room.

1. To demonstrate various tools such as Open end spanner, Ring spanner, Allen key, Hacksaw, Taps etc.

2. To demonstrate the components of Micrometer and taking dimension of a job.

3. To demonstrate the components of Vernier and taking dimension of a job.

SUB-DISCIPLINE:- WORKSHOP TECHNOLOGY (Lessons: VIII Sessions: 25)
Lesson-V: Limits, Fits and Surface Quality. Session-13: Interchangeability, Limits, Fits, Allowances, Tolerances and Surface Finish.

INTERCHANGEABILITY:

The object of all modern methods of manufacturing is to produce parts of absolute accuracy. But it is not always possible, particularly in mass production, to keep the exact measurement. Given sufficient time, any operator could work to and maintain the sizes to within a close degree of accuracy, but there would still be small variation. It is known that if the deviations are within certain limits, all parts of equivalent size will equally fit for operating in machines and mechanisms. Certain deviations are, therefore, recognized and allowed to ensure interchangeability of mating parts, coupled with the desired degree of tightness or looseness on assembly. When a system of this kind has been worked out, so that one component will assemble correctly with any mating component, both being chosen at random, the system is called an interchangeable system, sometimes called a limit system or a system of limits and fits.

If interchangeability is not achieved, selective assembly will be required; that is each part must be selected to fit its mating part. Selective assembly is costly and should be avoided wherever possible.

1. The basic size is the size in relation to which all limits of variation are determined. This is fixed up by the designer from its functional considerations.
2. The nominal size is the size specified in the drawings as a matter of convenience. The nominal size is used primarily for the purpose of identification of a component, and is never used in the precision measurement of parts.
3. The actual size of a dimension or part is its measured size. An actual size of a ready part will, therefore, always deviate from one specified in the drawing, i.e., from the nominal or basic size. But the difference between the basic size and actual size must not exceed a certain limit.

Deviation and Zero Line:

The algebraic difference between size (actual, maximum, etc.) and the corresponding basic size is called the deviation.

The upper deviation is the algebraic difference between the maximum limit of size and the corresponding basic size.

The lower deviation is the algebraic difference between the minimum limit of size and the corresponding basic size.

Tolerances of Parts:

Tolerance on a dimension is the difference between the maximum limit of size and minimum limit of size. The tolerance, however, is equal to the algebraic difference between the upper and lower deviations and has an absolute value without sign.

There are two basic ways of specify tolerance: (1) bilateral and (2) unilateral, tolerances. Bilateral tolerances are used where the parts may vary in either direction from the desired or nominal size. The dimension $25^{+0.05}_{-0.05}$ is n example of bilateral tolerance. It is not necessary that the variation should be equal.

Unilateral tolerances are used where it is important for the dimension to vary in only one direction.

In an example. $40^{+0.03}_{-0.02}$ the basic size is 40mm, the upper deviation is 0.03mm, the lower 0.02mm. Hence, the maximum limit size is (40+0.03) = 40.03mm, the minimum limit size being (40-0.02) = 39.98mm. Therefore, the tolerance in this case is (40.03-39.98) = 0.05mm.

FITS, ALLOWANCES, CLEARANCES AND INTERFERENCES:

One which enters into the other is known as the enveloped surface or male part, and the other in which one enters is the enveloping surface or female part. The enveloped surface of a cylindrical part is considered as a shaft whiles the enveloping surface as a hole. The dimensions corresponding to them are called a shaft diameter and a hole diameter. In the case of a key and its keyway, the key represents a shaft, while the keyway represents a hole.

Fits: The relation between the two parts where one is inserted into the other with a certain degree of tightness or looseness is known as a fit.
Allowance: An intentional difference between the hole dimensions and shaft dimension for any type of fit is called the allowance.
An allowance may be either a positive (+) or a negative (-) amount according to the type of fit required. If the conditions are such that the shaft is smaller than the hole we say that there is positive allowance, but if the shaft is larger than the hole we say that there is negative allowance.

Types of fit:

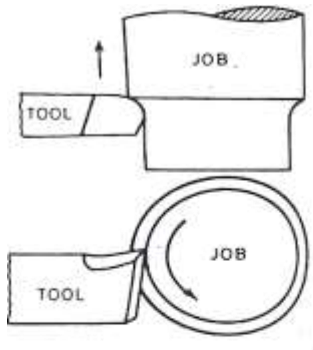
Clearance Fits: In a clearance fit there is a positive allowance between the largest possible shaft and the smallest possible hole. With such fits the minimum clearance is greater than zero. Such fits give loose joints, i.e. there must be same degree of freedom between a shaft and a hole.
Clearance fits may be subdivided as: (1) Slide fit, (2) Easy slide fit, (3) Running fit, (4) Slack running fit and (5) Loose running fit.

Interference Fits: In an interference fit there is a negative allowance or interference between the largest hole and the smallest shaft, the shaft being larger than hole. Interference fits may be classified as: (1) Shrink fit (2) Heavy drive fit and (3) Light drive fit.

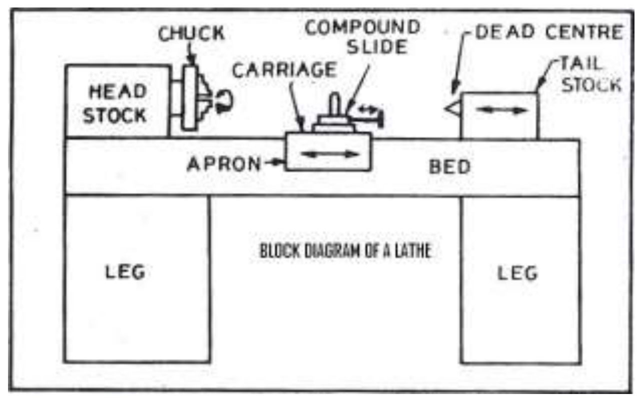
Transition: Fits: The use of transition fits does not guarantee either an interference or a clearance, i.e., any pair of parts mating with a transition fit may fit with interference, while another pair with the same fit may have a clearance fit.
Transition fits may be classified as: (1) force fit, (2) tight fit, (3) wringing fit, and (4) push fit.

LATHE

The first useful form of lathe was made by H. Moudslay (British) in 1800. Lathe was the first useful machine which came into existence as a useful machine for metal cutting. Lathe is a machine tool which holds the work between two rigid and strong supports, the work piece revolves and tool is fed against the work. The work revolves about its own axis to cut the desired material.



. Working principle on a lathe.



MAIN PARTS OF A LATHE:-1.Bed 2.Head stock 3.Tail stock 4.Carriage 5.Feed Mechanism 6.Legs.

Bed: - The bed of the lathe is the base on which different fixed and operating parts of the lathe are mounted. It provides inverted guide ways for well guided and controlled movement of the operating parts (Carriage). It withstands various forces exerted on the cutting tool during operation .Bed is made of cast iron alloyed with nickel and aluminum.

Head Stock: - Head stock is housing for the driving pulleys and back gears. The head stock is secured at the left end of the lathe bed. It provides mechanism for work rotation at multiple speeds. It contains a hollow spindles and mechanism for driving and altering the spindle speed.

Tail Stock:-The tail stock is located on the ways at the right end of the bed. It has two main uses: - (1) It supports the other end of the work (2) It holds tool for performing operations such as drilling, reaming, tapping etc.

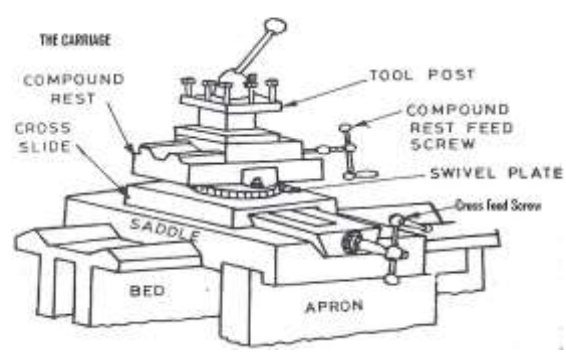
To accommodate different lengths of work the tail stock is slided to a desired position and is clamped. The tail stock spindle can be moved forward and reverse by a hand wheel.

Carriage: The carriage of a lathe serves the purpose of supporting, guiding and feeding the tool against the job during the operation. It consists of several parts:-

(a) Saddle (b) Cross slide (C) Compound rest (d) Tool post (e) Apron

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

Cross Slide: It is mounted on the saddle and moves in a direction normal to the axis of main spindle. It may be operated by hand; cross feed may be given by power feed through apron mechanism.



Compound Rest: It is mounted on the cross slide and carries a graduated circle base. The circle is graduated on the cross slide in degrees and compound rest may swivel to any angle on horizontal plane on the circular base. The upper part of the compound rest called compound slide can be moved by a feed screw.
Tool Post: It is the top most part of the carriage and it is used for holding the tool.
Apron: It is the hanging part in front of the carriage. It serves as housing for a no. of gear trains through which power feed can be given to the carriage and cross slide.
Legs: They are the supports which carry the entire load of the machine over them.

Centering: The centering is the process of making the longitudinal axis of job coinciding with the axis of chuck.

LATHE OPERATIONS:

Facing: In this operation feeding of the tool is perpendicular to the axis of rotation of the job. By this operation ends of a job is machined to produce a flat surface perpendicular to the axis.

Turning: Turning is the operation of removing excess material from the work piece to produce a cone shaped or cylindrical surface. Various turnings are as follows:
Straight Turning: In this operation the job is rotated about the lathe axis and the tool is fed parallel to the lathe axis. The straight turning produces a cylindrical by removing excess metal from the work piece.
Taper Turning: Taper turning means to produce a conical surface on the job. In this operation job rotates about the lathe axis and the tool is fed at an angle to the lathe axis.

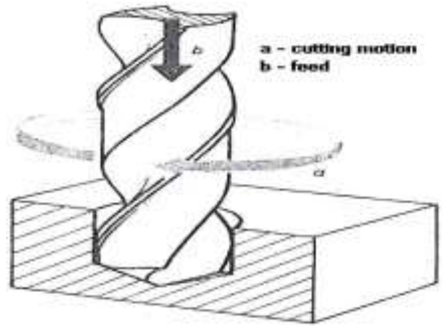
Chamfering: It is the operation of beveling the extreme end of work piece. This is done to remove the burrs to have a better look, to pass the nut freely on the threaded work piece.

Thread Cutting: It is the most important operation performed on a lathe. The principle of thread cutting is to produce a helical groove on job surface by feeding the tool longitudinally when the job is rotated by a chuck.
The longitudinal feed should be equal to the pitch of the thread to be cut per revolution of the work piece.

Knurling: It is the process of embossing a diamond shaped pattern on the surface of a work piece. The operation is performed by a special knurling tool. 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, producing depressions on the surface of work piece.

Some other operations are: 1. Drilling 2.Reaming 3.Tapping 4.Boring 5. Parting off etc. Following operations are performed by using special attachments:
1. Grinding 2.Milling

DRILLING

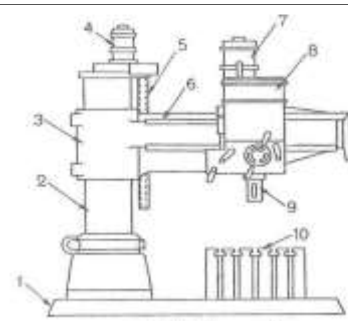


Drilling machine is used for generating holes in a work piece. The hole is generated by the rotating edge of a cutting tool, known as drill. The drill exerts pressure on the job clamped on the table and rotates generating holes.

Types of drilling machine

1. Portable drilling machine
2. Sensitive drilling machine
3. Upright drilling machine
   (a) Round column section
   (b) Box column section
4. Radial drilling machine
   (a) Plain (b) Semi universal
   (c) Universal
5. Gang drilling machine
6. Multiple spindle drilling machine
7. Automatic drilling machine
8. Deep hole drilling machine

The principle parts of a drilling machine are explained below.



Radial drilling machine
1. Base, 2. column, 3. Radial arm, 4. Motor for elevating the arm, 5. Elevating screw, 6. Guide ways, 7. Motor for driving the drill spindle, 8. Drill head, 9. Drill spindle, 10. Table

Base: The base is the part of the machine on which vertical column is mounted.
Column: The column is a vertical member of the machine which supports the table and head containing all driving mechanisms. At the face of the column, rack teeth may be cut for vertical movement of the table.
Table: The table is mounted on the column and is provided with T-slots for clamping the job directly on its face. The table may have 3 types of adjustment i.e. vertical adjustment, circular adjustment about its own axis and radial adjustment.

Head: The head is mounted on the top of the column and houses the driving and feeding mechanism for the spindle .The head may have vertical adjustment for accommodating different height of job.
Spindle and drill head assembly: The spindle is a vertical shaft which holds the drill. It receives its motion from the top shaft. The spindle has vertical adjustment for setting the drill on the job.
Spindle drive and feed mechanism: The spindle drive mechanism incorporates an arrangement for obtaining multiple speed of the spindle. The feed is effected the vertical movement of the vertical movement of the drill into work.
Drill Material: 1.High speed steel. 2. Carbon steel.
Drill Size: In metric system drills are nominated by their mm size. These are manufactured commonly from 0.2 mm to 10 mm. In British system drills are nominated by their inch size.
Tap- Drill Size: Dia. of hole, $D = T - 2d$
Where T = Dia of tap d = depth of thread = 0.61p p = pitch of thread
REAMER:-Reamer is a tool used for enlarging/finishing the hole previously drilled to give an accuracy of dimension. It is a multi tooth cutter which gives the removal of metal in relatively small amount.

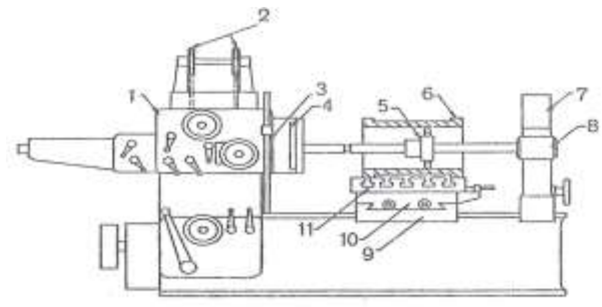
BORING MACHINE

Boring machine is used to bore holes in large and heavy parts, which are practically impossible to hold and rotate in an engine lathe or a drilling machine. These parts are – engine frames, steam engine cylinders, machine housing etc.

Types Of Boring Machines:-

1. Horizontal boring machine.
   (a) Table type.
   (b) Floor type.
   (c) Planer type.
   (d) Multiple head type.
2. Vertical boring machine.
   (a) Vertical turret lathe.
   (b) Standard Vertical boring machine.
3. Precision boring machine.
4. Jig boring machine
   (a) Vertical milling machine type.
   (b) Planer type.

1. Horizontal Boring machine: - In this machine work is supported on a table which is stationary and the tool revolves in a horizontal axis.



Horizontal boring machine
1. Headstock, 2. Pulley for counter balancing weight of headstock, 3. Headstock elevating screw, 4. Boring head, 5. Boring cutter on boring bar, 6. Work, 7. End supporting column, 8. Bearing block, 9. Saddle, 10 Cross-slide, 11. Table.

Parts of a horizontal Boring Machine:-

Bed: - The bed is that part of the machine which is fitted on the floor of the shop and has a box like casting. It supports the columns, tables and other parts of the machine.

Head stock supporting column: - The column provides support to the head stock and guides it up and down accordingly by the guide ways provided on the face of the column.

End supporting columns: - The end supporting column houses the bearing block for supporting a long boring bar. The column may be adjusted on the slide ways of the bed towards or away from the spindle for supporting different lengths of boring bars or it may be moved at right angles to the spindle as in the case of a floor type machine.

Head stock: - The head stock mounted on the column supports drives and feeds the tool. The head stock may be moved up and down on the column for setting the tool for different height of the work. The head stock and the end supporting bearing block are raised or lowered in unison by the help of screws.

Saddle and Table: - The table supports the work and is therefore provided with T-slots for clamping the work or for holding various devises. The saddle permits the work to be moved longitudinally on the bed .The table may be moved crosswise on the saddle. These movements may be slow or rapid.

Boring Bar: - The boring bar supports the cutter for boring operations on jobs having large bore diameters. For short holes the bar may be supported on the head stock spindle end only, where as for long work the bar is also supported on the column bearing block.

Size of a Horizontal Boring Machine: -The size is specified by diameter of its spindle in mm. The diameter of spindle varies from 75 to 355mm.Other important dimensions are:-Motor horse power, column heights, size of the table or size of the floor plate ,spindle speeds, feeds and length of feeds, floor space, weight of machine etc.

2. Vertical boring machine: - The work rotates on a horizontal table about a vertical axis and the tool is stationary except for the feed.

3. Precision boring machine: -The machine uses single point tools to machine surfaces rapidly and accurately. Cemented carbide and diamond tipped single point tools are operated at very high speed to produce accurately sized holes with a fine surface finish .The machine may be horizontal or vertical type.

4. Jig boring machine: - These machines are used for production of jigs, fixtures, tools and other precision parts which require high degree of accuracy. The machine accuracy is very high within a range of 0.0025mm.

SHAPER

WORKING PRINCIPLE:-The job is rigidly held in a vice or clamp directly on the machine table. The tool is held in the tool post mounted on the ram of the machine. This ram reciprocates to and fro. In doing so the tool cuts materials in the forward stroke. Return stroke is called idle stroke because no material cutting takes place in that stroke. The job is given an indexed feed in a direction normal to the line of action of cutting tool.

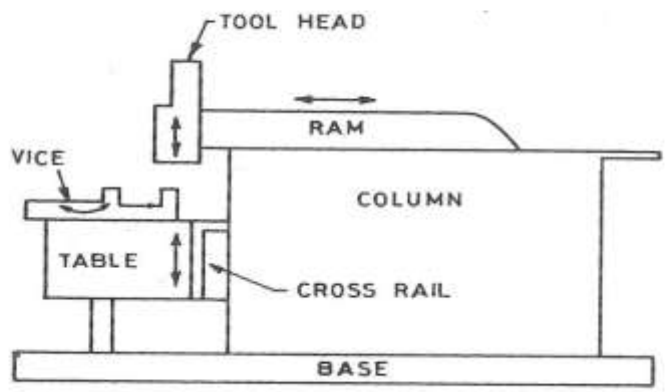
The time spent in return stroke is obviously a waste. We cannot make this time equal to zero, but it can be reduced. A mechanism called Whitworth Quick Return Mechanism is fitted in the shaper to reduce the time wastage during return (idle) stroke.

MAIN PARTS OF SHAPER MACHINE:

1. Base 2. Column 3.Cross rail.
4. Table 5. Ram 6. Tool head
7. Vice.

CUTTING TOOL MATERIAL:

1. High Speed Steel
2. Carbide Tipped tools for hard materials.



Main parts of a shaper.

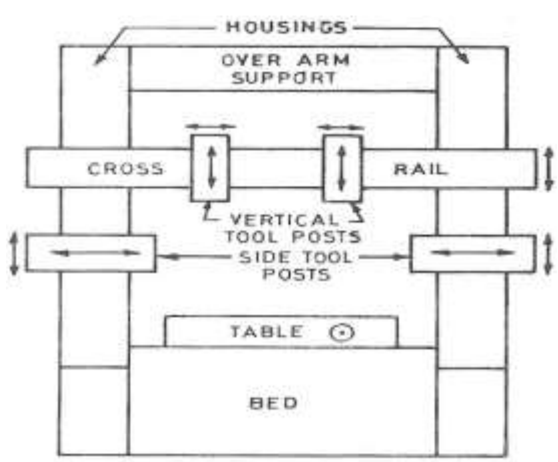
PLANER

WORKING PRINCIPLE: - The work is rigidly held on the work table of the machine. The tool is held vertically in the tool head mounted on cross-rail. The work table together with the job is made to reciprocate past the vertically held tool .The indexed feed, after each cut, is given to the tool during the idle stroke of the table. The machine may comprise side tool posts also. This is used to machine side surfaces of the job.

The fundamental difference between a shaper and a planer is that in planer, the job which is mounted on table reciprocates past the stationary cutting tool and the feed is supplied by the lateral movement of the tool, but in shaper the tool which is mounted upon the ram reciprocates and the feed is given by the crosswise movement of the table.

MAIN PARTS:

1. Bed 2.Table
3. Column / Housing
4. Cross rail 5.Tool head
6. Controls



Main parts of a planer.

SLOTTING MACHINE

It operates almost on the same principle as that of a shaper. The major difference between a slotter and a shaper is that in a slotter the ram holding the tool reciprocates in a vertical axis, where as in shaper the ram holding a tool reciprocates in a horizontal axis. A vertical shaper and a slotter are almost similar. The only difference, in the case of a vertical shaper, the ram holding the tool may also reciprocate at an angle to the horizontal table in addition to the vertical stroke. The ram can be swiveled not more than 5° to the vertical. The slotter is used for cutting grooves, key ways and slots of various shapes, for making regular surfaces both internal and external etc.

Types of slotting machines: - 1. Punch slotter. 2. Precision slotter.

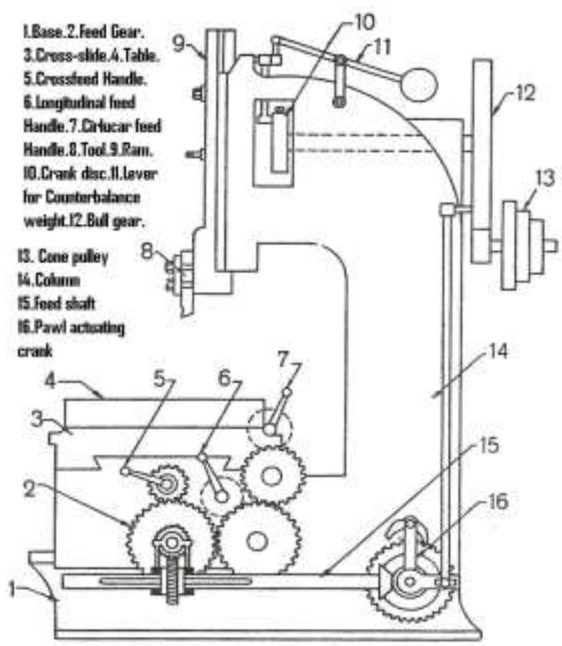
1. Puncher slotter: - The puncher slotter is a heavy, rigid machine designed for removal of large amount of metal from large forging or castings. The length of a puncher slotter is sufficiently large. It may be as long as 1800 to 2000 mm.

2. Precision slotter: - The precision slotter is a lighter machine and is operated at high speeds. The machine is designed to take light cuts giving accurate finish.

Slotter Size: - The size of a slotter is specified by the maximum length of stroke of the ram, expressed in mm. The size of a general purpose or precision slotter usually ranges from 80 to 900 mm. Other important dimensions are diameter of the table in mm, amount of cross and longitudinal travel of the table expressed in mm, number of speed and feeds available, H.P. of the motor, floor space required, etc.

Slotting Machine Parts: -The different parts of a slotting machine are as follows: -
1. Base. 2. Column. 3. Saddle. 4. Cross-slide. 5. Rotating table.6. Ram and tool head assembly. 7. Ram drives mechanism. 8. Feed mechanism.

Slotter Operations: - The operations performed in a slotter are:
1. Machining flat surface. 2. Machining cylindrical surface.3. Machining irregular surfaces and cams machining. 4. Machining slots, key ways and grooves



Slotter Tools: - In a lathe, shaper or a planer tool the cutting pressure acts perpendicular to the tool length, whereas in a slotter the pressure acts along the length of the tool. Slotter tools are provided with top rake, front clearance and side clearance, but no side rake is given. The nose of the tool projects slightly beyond the shank to provide clearance. Different slotter tools are used in different operations. Keyway cutting tools are thinner at the cutting edges. Round nose tools are used for machining circular or contoured surfaces. Square nose tool are used for machining flat surfaces.

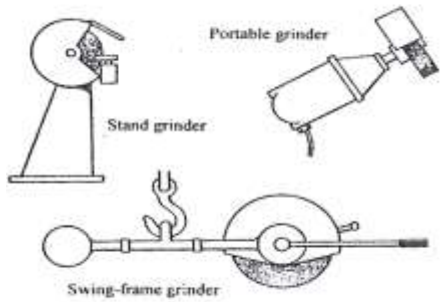
GRINDING

Grinding is a cutting operation performed by means of a rotating abrasive wheel that acts as a tool. The abrasive wheel is called grinding wheel .It is used to remove comparatively little material 0.25mm to 0.5mm.

GRINDING MACHINES: 1.Rough grinders (**Floor stand grinder)** and 2.Presion grinder (**Bench grinder)**

Abrasive: An abrasive is a substance that is used for grinding and polishing operations. The abrasives are mainly:-

1. Natural Abrasives: (a) Sand stone (Solid quartz)
   (b) Emery (Natural Al_2O_3)
   (c) Corundum (Natural Al_2O_3)
   (d) Diamond
2. Artificial Abrasive: (a) Silicon carbide (SiC)
   (b) Aluminum oxide (Al_2O_3)



Rough grinding machines
1. Stand grinder, 2. Portable grinder, 3. Swing frame grinder.

Bonds: A bond is an adhesive substance that is employed to hold abrasive grains in the form of grinding wheel. Bonding materials are:

1. Vitrified bond (V) | Mostly used in Industrial Application
2. Silicate bond (S)
3. Shellac bond (E)
4. Resinoid bond (B)
5. Rubber bond (R)
6. Oxy – Chloride bond (O)

Grit: Grit means grain size and is denoted by a number indicating the no. of meshes per linear inch of the screen through which the grains pass when they are graded after crushing.

Coarse	10	12	14	16	20	24
Medium	30	36	46	54	60	
Fine	80	100	120	150	180	
Very Fine	220	240	280	320	400	500

Grade: Grade means hardness with which the bond holds the abrasive grains in a grinding wheel.

Soft grade → A TO H
Medium grade → I TO P
Hard grade → Q TO Z.

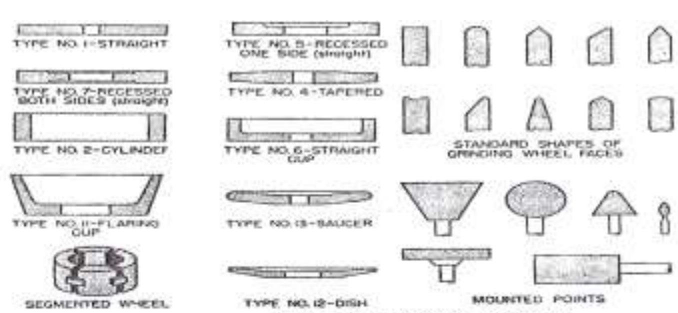
Structure: The relative spacing of an abrasive is known as structure. It is denoted by the no. of cutting edges per unit area of wheel face. It is also denoted by the no. of voids spaces between grains.

Dense Structure ----	1	2	3	4	5	6	7	8
Open Structure -----	9	10	11	12	13	14	15	or higher

Marking of Grinding Wheel: w A 46 K 5 V 17

1. Manufacturer's code → w
1. Abrasive type (Al_2O_3) → A
2. Grain size (Medium) → 46
3. Grade (Medium) → K
4. Structure (Open) → 5
5. B o n d (Vitrified) → V
6. Manufacturer code. → 17

Wheel Shapes and Sizes: Grinding wheels are made in many different shapes and sizes for use on different types of grinding machines and on different classes of work. They fall into the following broad groups: straight-side grinding wheels, cylinder wheels, cup wheels, and dish wheels.



Standard grinding wheel shapes

SUB-DISCIPLINE:- WORKSHOP TECHNOLOGY (Lessons: VIII Sessions: 25)
Lesson-VI: Workshop Machines. Session-18: Milling machine and Gear cutting

MILLING MACHINE

It is a machine tool that removes metal as the work is fed against a rotating multiple tooth cutter. The cutter rotates at a high speed and because of multiple cutting edges; it removes metal at a very fast rate. The machine can also hold more than one cutter at a time.

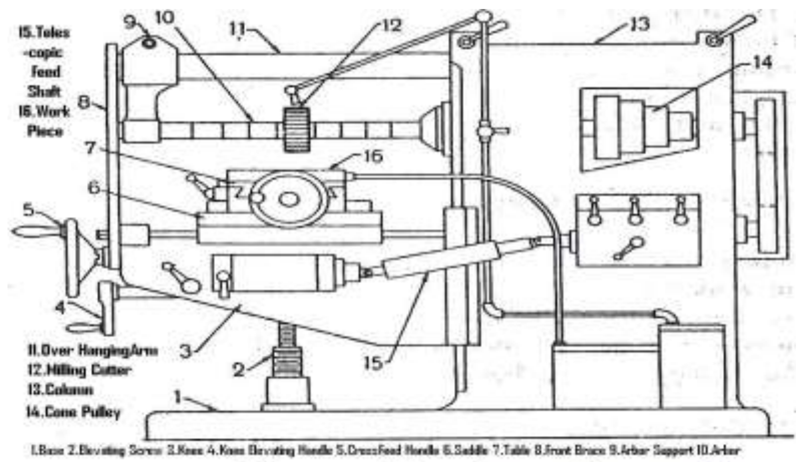
TYPES OF MILLING MACHINES:

1. COLUMN AND KNEE TYPE:
   - (a) Hand milling
   - (b) Plain milling
   - (c) Universal milling
   - (d) Omniversal milling
   - (e) Vertical milling
2. Manufacturing and fixed bed type milling machine
3. Planer type milling machine
4. Special type milling machine

1. COLUMN AND KNEE TYPE:-Table is mounted on the knee casting. Knee casting is mounted on the vertical slide of the main column. The knee is vertically adjustable on the column to accommodate works of various sizes. These machines are classified according to the various methods of supplying power to the table, different movement of the table & different axis of rotation of the main spindle.

Main Parts: Base, Column, Knee, Table, Over Hanging, Arm, Front Brace, Spindle, Arbor

MILLING CUTTER:-The milling cutters are revolving tools having one or several cutting edges equally spaced on the circumference of the cutter. Milling cutters are classified as:

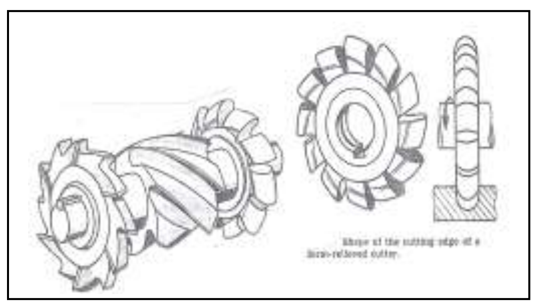


Column and knee type milling machine

1. Solid cutters
2. Tipped solid cutters
3. Inserted teeth cutter.
4. Arbor type cutter
5. Shank type cutter
6. Right hand cutter
7. Left hand cutter
8. Straight teeth cutter
9. Helical teeth cutter
10. Standard milling cutter
11. Special milling cutter

CUTTER MATERIALS:

1. High Speed Steel
2. Super High Speed Steel
3. Non Ferrous cast alloys etc.



GEAR CUTTING

Gears may be manufactured by casting, stamping, machining or by powder metallurgical process, but the most common and accurate method is machining. The different methods of production of gears by machining are as follows:-

1. **Formed cutter method :-**(a) By a formed disc cutter in a milling machine.
   (b) By a formed end mill in a milling machine.
   (c) By a formed single point tool in a shaping or planning machine.
   (d) By a formed cutter in a “shear speed” gear shaper.
   (e) By a formed cutter in a broaching machine.
2. **Template Method in a gear cutting machine**.
3. **Generating method :-** (a) By a rack tooth cutter in a gear cutting machine.
   (b) By a pinion cutter in a gear cutting machine.

(c) By a hob cutter in a gear cutting machine. (d) By a bevel gear generator.

1. **Formed cutter method: -** A single point cutting tool or a milling cutter has the same form of cutting edge as the space between the teeth being cut is used. The method uses simple and cheap tools in conventional machines.

Disadvantages: - (1) Accuracy is very poor. (2) The production capacity is very low.

(a)Gear cutting by formed disc cutter:-The method involves the mounting of a gear blank at the end of a dividing head spindle fitted on the table of a horizontal, column and knee type milling machine and then feeding the work past a rotating, formed, peripheral type of cutter mounted on the horizontal arbor of the machine.

(b)Gear cutting by a formed end mill: - The end mills having cutting edges formed to correspond to the tooth space of a gear employed to cut a spur, helical or a herring bone gear in a milling machine. The end mills are used to cut gears of large module from 20 mm and larger where ordinary disc type cutters are unsuitable due to excessive pressure required.

(c)Gear cutting by a formed single point tool: - A single point cutting tool having cutting edges formed to correspond to the tooth space of a gear is employed to cut a spur or a bevel gear in a shaping or a planning machine by using the shaper centre.

(d)Gear cutting by shear speed process: -The shear speed process involves the production of all the teeth on a gear simultaneously by a ring of formed blades arranged on the periphery of the gear blank. Each blade having formed cutting edges cuts one tooth space and the number of blades on the cutter equals the number of tooth spaces on the gear. The shear speed process is the quickest method of producing external and internal spur gears, splines toothed clutches, ratchet wheels etc.

(e) Broaching gear teeth:- A broaching tool having formed cutting edge is employed for producing internal gears of accurate shapes on a broaching machine.

2. Template gear cutting process:- The template gear cutting process involves the production of a gear tooth profile by a single point cutting tool which is reciprocated and made to follow a guided path by a template whose profile corresponds to the shape of the gear tooth being cut. After one tooth is finished, the blank is indexed by the usual manner. The template method is employed for producing very large spur gear teeth and for cutting accurate bevel gears.

3. Generating methods: - The generating methods of gear production enable to cut mathematically correct tooth profile by means of relative motions between the cutters and the gear blanks. The principle of generating process is based on the fact that any two involute gears of the same module will mesh together. If out of two mating gears one is used as a cutter and is made to reciprocate or fed continuously along the entire width of the gear blank, while still rotating as a mating gear, so that the pitch surface of the cutter rolls without slipping on the pitch surface of the gear, an accurate tooth profile can be generated. As the principle of generating gears is based upon involute system, cycloidal gears cannot be produced by this method. The gears may be generated by a rack cutter, pinion cutter or a hob.

(a)Rack cutter generating process: - The rack cutter generating process is also called shaping process. In this method, the generating cutter has the form of a basic rack for the gear to be generated. The cutting action is similar to a shaping machine.

(b)Pinion cutter generating process:-The pinion cutter generating process is fundamentally the same as the rack cuter process, and instead of using a rack cutter it uses a pinion to generate the tooth profile.

(c)Gear hobbing: - Hobbing is a process of generating a gear by means of a cutter, called a hob, that revolves and cuts like a milling cutter. In gear hobbing, the gear blank is first moved in towards the rotating hob until the proper depth is reached. The action is the same as if the gears were meshing with a rack. As soon as the proper depth is reached, the hob cutter is fed across the face of the gear until the teeth are complete, both gear and cutter rotating during the entire process.

(d)Bevel gear generating process: - The fundamental of bevel gear generating process involves the rolling of a bevel gear blank on a crown wheel.

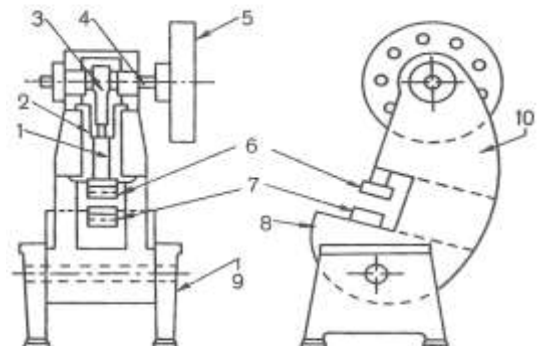
Press: - The press is a metal forming machine tool designed to shape or cut metal by applying mechanical force or pressure. The metal is formed to the desired shape without removal of chips.
Types of presses: - The classification of different types of presses are given below:-

1. Classification based on source of power :
   (a) Hand press or ball press or fly press (b) Power press.
2. Classification based on design of frame:
   (a) Gap (b) Inclinable (c) Adjustable (d) Horn (e) Straight side (f) Pillar

Power press parts: 1. Base 2. Frame 3. Bolster plate 4. Ram 5. Pitman 6. Crank, eccentric or other driving mechanism 7. Fly wheel 8. Clutch 9. Brakes:

Press Tools: A punch is the parts of the press tool which enters into the cavity formed in the die section. The punch is usually the upper member of the press tool which is mounted on the lower end of the ram and slides with it.

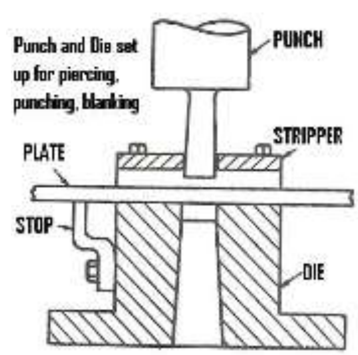
A die is that part of the press tool which has an opening or cavity to receive the punch. The die is usually the lower member of the press tool which is clamped on the bolster plate fitted on the table and remains stationary.



POWER PRESS
1. Ram 2.Ram guide 3.Pitman 4. Crankshaft 5. Flywheel 6.Punch 7.Die 8.Bolster plate 9.Base 10.Frame

The punches and dies are generally made of high speed steel.

Types of dies and operations
1. Classification based on operations performed:
(A) Shearing operation: As the punch descends upon the work piece, the pressure exerted by the punch causes the metal to be deformed plastically in the die. As the clearance between the punch and the die is very small, the plastic deformation takes place in a localized area and the metal adjacent to the cutting edges of the punch and the die becomes highly stressed. When the stress reaches beyond the ultimate strength of the material, the fracture starts from both the sides of the plate along the cutting edges of both die and the punch, and as the punch continues to descend,
the fracture meet at the centre of the plate. The metal is now completely severed from the sheet metal and drops out through the die opening.



(a)Piercing: The piercing is the operation of production of hole in a sheet metal by the punch and die. The materials punched out to form the hole constitute the waste.

(b) Punching: The punching operation is similar to the piercing operation. While punching the formation of the hole is the desired result. The difference between the punching and the piercing is that in the case of punching a cylindrical hole is produced, whereas in the case of piercing the hole produced may be of any other shape.

(B) Bending operation: While bending the metal is stressed in both tension and compression at the two sides of the neutral axis beyond the elastic limit but below the ultimate strength of the material. As the material is loaded beyond the elastic limit, some amount of plastic deformation takes place and when load is removed, the metal retains the bent shape given by the die. There is, of course, some amount of elastic recovery of the metal when the load is removed, resulting in a slight decrease in the bent angle. The effect is known as spring back. To correct the effect of spring back, the metal is bent through a greater angle so that when the load is removed, the component will spring back to the desired angle.

(a) Angle bending,(b) Curling, (c) Forming, (d) Plunging

(C) Drawing operation: The drawing is the operation of production of cup shaped parts from flat sheet metal blanks by bending and plastic flow of the metal.

(a) Squeezing operation, (b) Coining, (c) Embossing, (d) Flattening or planishing

2. Classification based on construction:

(a) Simple die: In a simple die, only one operation is performed at each stroke of the ram.

(b)Follow or progressive die: In a progressive die, two or more operations are performed simultaneously at a single stroke of the press by mounting separate sets of dies and punches at two or more different stations. The metal is progressed from one station to the other till the complete part is obtained.

(c)Compound die: In a compound die two or more cutting operation are accomplished at one station of the press in every stroke of the ram.

(d)Combination die: In a combination die, both cutting and noncutting operation are accomplished at one station of the press in every stroke of the ram.

(e) Rubber die: In a rubber die, the rubber is used as a medium of applying pressure on the sheet metal blanks.

Jig and fixtures: The jig and fixture are the economical means to produce repetitive type of work by incorporating special work holding and tool guiding devices.

Jig: A jig may be defined as a device which holds and locates a work piece and guides and controls one or more cutting tools. The holding of the work and guiding of the tools are such that they are located in true position relative to each other.

Fixture: A fixture may be defined as device which holds and locates a work piece during an inspection or for a manufacturing operation. The fixture does not guide the tool. Difference between a fixture and a jig is as follows:

1. A fixture holds and positions the work but does not guide the tool, whereas a jig holds, locate and as well as guides the tool.
2. The fixtures are generally heavier in construction and are bolted rigidly on the machine table, whereas the jigs are made lighter for quicker handling, and clamping with the table is often unnecessary.
3. The fixture are employed for holding work in milling grinding, planning, or turning operations, whereas the jigs are used for holding the work and guiding the tool particularly in drilling, reaming or taping operations.

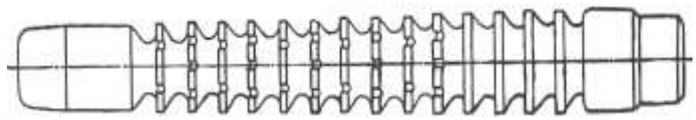
Advantages of jigs and fixtures: -

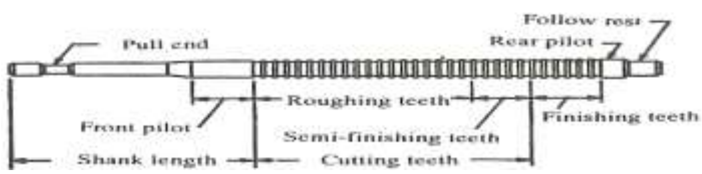
(i) It eliminates the marking out, measuring and other setting methods before machining.
(ii) It increases the machining accuracy.
(iii) It enables productions of identical parts which are interchangeable.
(iv) It increases the production capacity.
(v) It reduces the operators labour as handling operations are minimizes.
(vi) It facilitates the use of semiskilled operator.
(vii) It reduces the expenditure of quality control.
(viii) It reduces the over all production cost by fully or partly automatising the manufacturing process.

BROACHING MACHINE

Broaching is a method of removing metal by pushing or pulling a cutting tool called a broach which cuts in fixed path. Surfaces finished by broaching may be flat or contoured and may be either internal or external. Broaching is generally limited to the removal of about 6 mm of stock or less.

BROACHES: - A broaches is a multiple-edge cutting tool that has successively higher cutting edges along the length of the tool.





Types of Broaches*:* - Broaches may be classified in various ways, according to:-

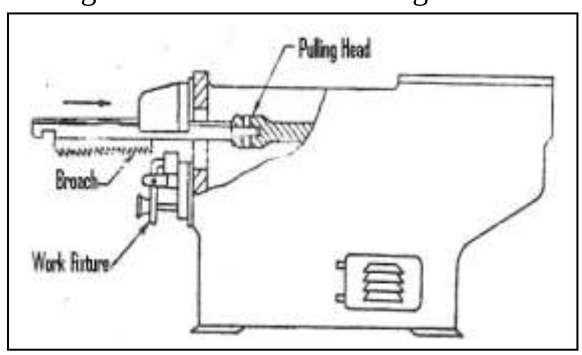
1. Type of operation: - internal or external.
2. Method of operation: - push or pull.
3. Types of construction: solid, built-up, inserted tooth, progressive cut, rotor cut double jump, or overlapping tooth.
4. Function: - surface, keyway, round hole, splint, spiral, burnishing, etc.

Broach material:-Most broaches are made from 18-4-1 tungsten chromium vanadium steel ground after hardening. Carbide broaches are used extensively in the broaching of cast iron in the automotive field.

BROACHING METHODS: - Broaching, according to the method of operation, may be classified as follows:-

1. Pull Broaching. 2. Push broaching 3. Surface broaching 4. Continuous broaching

BROACHING MACHINES



Horizontal Broaching Machines:-Nearly all horizontal machines are of the pull type. They may be used for either internal or external broaching, although internal work is the most common. A horizontal broaching machine consists of a bed or a base a little more than twice the length of the broaching stroke, a broach pilot and the drive mechanism for pulling the broach.

Vertical broaching machines: - The vertical type may be obtained in either push or pull type. The push type is the most popular. A vertical broaching machine is employed in multiple operations, since they are convenient to pass work from one machine to another, and they are more likely to be found doing surface operations. Of the three models available, pull up, pull down, and push down, the pull up type is most popular.

Surface broaching machine: - Surface broaching machines have their broaching tools attached to a ram or rams forced in a straight path along guide ways past the work piece.

Continuous broaching machines: - For mass production of small parts, the highly productive continuous broaching method is used on rotary or horizontal continuous broaching machines.

Broaching machine sizes: - The size of a broaching machine is specified mainly by the length of stroke in mm and the force in tones that can be applied to the broach. Thus a 1000-10 machine has a 1000 mm stroke with a 10 tones nominal broach driving force. Other important parameters for specifying a broaching machine are broaching speed, return speed and machine horse power.

Broaching operation: - Broaching is applied for machining various internal and external surfaces, for round or irregular shaped holes from 6 to 100 mm in diameter, for external flat and contoured surfaces. Certain types of surfaces, for example, spline holes, are machined at the present time only by broaching due to the exceptional difficulties in machining such surfaces by other methods. Most broaching operations are completed in one pass, but some are arranged for repeated cuts to simplify the design of the broach.

SAWING

In sawing, the individual teeth of the saw, “track” through the work, deepening the cut made by the preceding tooth in the direction of feed. Either the saw or the work may be fed and, by controlling the direction of feed, either straight or curved cut can be produced. The width of the cut is approximately equal to the width of the saw itself.

Sawing machines: - Sawing machines may be classified by the motion used for the cutting action.

1. Reciprocating saw.
   (a) Horizontal sawing machine. (b) Vertical sawing machine.
2. Circular saw.
   (a) Cold saw. (b) Friction disk. (c) Abrasive disk.
3. Band saw.
   (a) Contour band saw. (b) Friction blade.

Reciprocating saw: - Reciprocating saws are represented by power hacksaws. A power hacksaw consists of a saw frame, a means for reciprocating the saw and frame, a work table and vice, a supporting base, and a source of power. In operation, machine drives a blade back and forth through a work piece, pressing down on the cutting stroke and releasing the pressure on the return. The stock to be cut is held between the clamping jaws. Several pieces of bar stock can be clamped together and cut at the same time. Both square and angular cuts can be made.

Circular saws: - Circular saws are cut by means of a revolving disc. The disc may have large teeth or almost no teeth. Machines of this type are divided into three classifications as given before.

The **cold saw** has a circular blade with inserted teeth for cutting small or large bars to length.

Friction disc are circular blades having almost no teeth. They operate at high speeds and generate heat. The heat of friction softens the metal of the work piece in contact with the disc, and the soft metal is rubbed away.

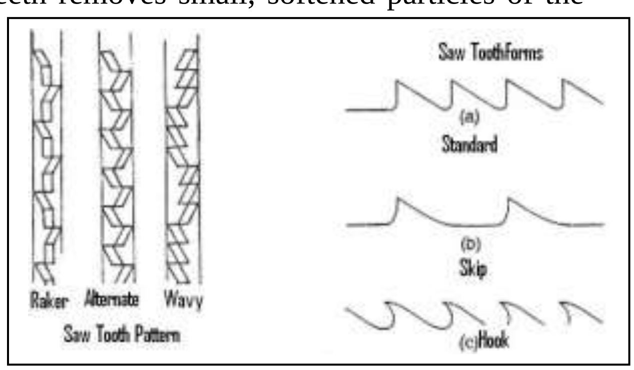
Abrasive discs, as the name implies, are thin flexible grinding wheels. Thin resionoid or rubber bonded wheels rotating at high speeds are generally used.

Band saws: - In a band saw, a continuous saw blade runs over the rims of two wheels, one of which drives the saw at the desired cutting speed. The work is mounted on the table between the two wheels. They are mainly divided into two classifications as given before.

The **contour band saw** is the most versatile of all types of sawing machines in application. The work may be fed in any direction on the table, and the direction of feed is readily controlled and changed while cutting is in process to produce any desired out line. These machines are widely used for making dies or other parts with a contour internal shape.

A **friction band saw** operates on the same principle as the friction circular saw. The dull blade produces great friction and the kerf of the teeth removes small, softened particles of the work.

Selecting a blade for sawing machine: - Blade materials include standard carbon steel, high speed steel and bimetallic high speed steel. There are three tooth sets that can be used; raker, alternate and wavy. There are tooth forms also, standard, skip and hook.



SUB-DISCIPLINE:- WORKSHOP TECHNOLOGY (Lessons: VIII Sessions: 25)

Lesson-VI: Workshop Machines. Session- 21, 22, 23: Workshop visit.

1. To note down the various components of the Track Maintenance Machines being assembled at M/s Plasser India Pvt. Ltd. and to understand the manufacturing process.

2. To see & note down the various components of Workshop Machines available at M/s Plasser India Pvt. Ltd. Such as

   i) Lathe Machines
   ii) Radial drill Machine
   iii) Shaper
   iv) Planner etc.
   v) Cropping machine

3. To visualize inert gas welding.

4. To visualize the hydraulic pipe end fittings crimping process.

5. To visualize and note down any other production activities.

THREAD:
The helical groove cut on an internal or external cylindrical surface is called thread. The thread on internal cylindrical surface is called internal thread and that on external cylindrical surface is called external thread. According to movement, threads are of two types: - 1. Right hand threads 2. Left hand threads.

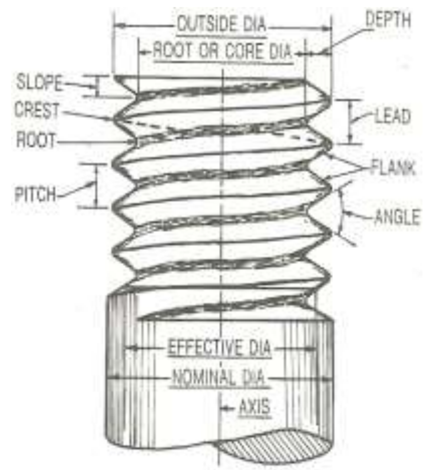
Terms of Screw Threads:-

Major diameter, Minor diameter, Pitch diameter

Pitch Dia. = Major Dia.— single Depth of thread

Pitch: - It is the distance measured parallel to the axis, between a point on one thread form and a corresponding point on the adjacent thread form, i.e. form crest to crest or root to root

Lead: - It is the distance measured parallel to the axis from a point on a thread to a corresponding point on the same thread after one revolution. It is also described as the distance moved by a Nut in the axial direction in one complete revolution. The lead is equal to the pitch in case of single start threads, twice in double start thread; thrice in triple start thread etc.



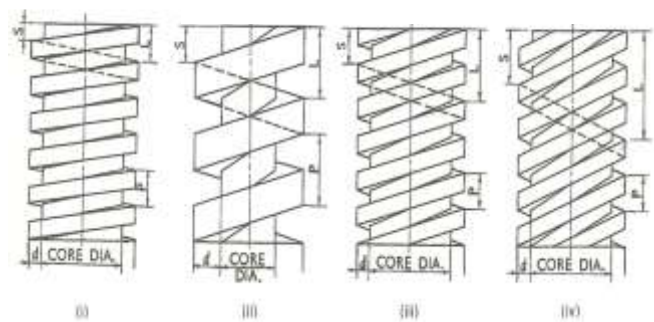
Screw thread

Crest, **Root**, **Flank or side**

Angle of thread: - It is the angle between the flanks measured on an axial plane.

Helix angle: - The angle of inclination of thread is called helix

Depth of thread, Number of thread,



Single-start and multiple-start threads

Types of threads:-1. 'V'- Thread 2. Square Thread 3. Acme Thread 4. Worm Thread 5. Knuckle Thread 6. Buttress Thread.

1. 'V'-Thread: - These threads are in 'V' shape. According to thread angle these are of following types:-

(a)British standard Whitworth thread or B.S.W:-Included angle of this thread is 55° and routes and crests are rounded. The theoretical depth D=0.96P, where P= pitch of the thread; 1/6 of the theoretical depth is rounded off at the top and the bottom. This thread was invented by Sir Joseph Whitworth in 1841.

(b)British standard fine thread:-These have the same witworth profile (included angle 55°) but their pitches are finer and hence the depths smaller. Thus they have larger effective and core diameters than the B.S.W threads. B.S.W threads are generally used automobile and aircraft work.

(c)British Association thread: - This is a very fine thread. This thread is used for nominal diameter less than 1/4" or 6mm such as instruments, watches, radio etc. The included angle is 47 ½ °. 0.236 of the theoretical depth is rounded off at the top and at the bottom, leaving the actual depth equal to 0.6P.

Theoretical depth, D = 1.136P Actual depth, d = 0.6P.

(d) British Standard Pipe thread:- These threads are used for gas, steam or water pipes. They are specified by the bore of the pipe and not by the out side diameter. Thus, the out side diameter of a thread pipe having a bore of 1”normal diameter is 1.309”. The pipes of 1”to 6”diameters have the same number of threads per inch, viz. 11. These threads are cut taper ¾” per foot. The included angle is 55°.

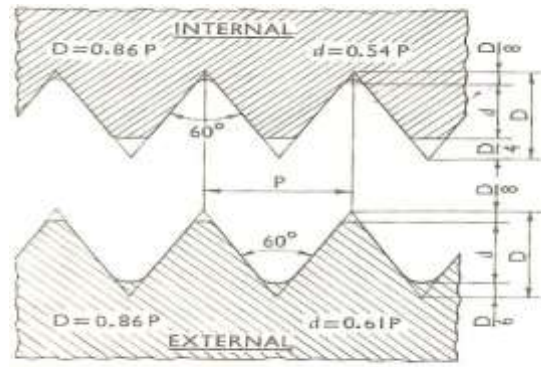
(e)American national thread (Seller’s thread):- It has an included angle of 60°. One-eighth of the theoretical depth is cut-off parallel to the axis of the screw at the top and at the bottom. Therefore, the crests and the roots of this thread are parallel.

Theoretical depth, D = 0.866P Actual depth, d = 3/4 D = 0.649P

(f)International Standard thread (Unified thread):-

This is the I.S.O basic profile recognized in two series based on inch and metric systems of measurements. In this form, the external thread (on a bolt) varies slightly from the internal thread (inside a nut). The angle of the thread is 60°. Roots of both-internal and external threads are rounded, while the crests are cut parallel to the axis of screw. The root of the internal thread is rounded within the depth of D/8.

The maximum depth of engagement between the internal and external threads is 5/8D



Unified thread

(g)Metric Thread: - The Bureau of Indian standards has recommended the adopting of Unified screw thread profile based on metric system and has designated it as Metric thread. In this system pitch of the thread is fixed (not thread per unit length.).These threads are designated by the letter M followed by nominal diameter and pitch in mm. Ex: - M10X1.5

2. Square thread: - This thread has its flanks or sides normal to the axis. The depth and the thickness of the thread are each equal half of the pitch. The thread is much stronger than the ‘V’ threads. It is generally used for power transmission in jacks, vice etc.

3. Acme thread: - This thread is a modification of the square thread - thicker at the root and less thick at the crest, hence stronger at the root. The thread angle is 29°.

Depth, d = 0.5P + 0.25 mm Thickness at the crest = 0.3707P.

It is particularly used where the nut, which is made in two parts, is required to engage or disengage from a screw at frequent intervals such as in lead screw of the lathe.

4. Worm thread: - This is like an acme thread with the difference that depth of thread is some what more.

5, Knuckle thread: - It is formed by rounding off the corners of the square thread to such an extent that it has a completely rounded profile. Its section comprises of semicircles of radius R = 0.25P Depth d = 0.5P

This thread can withstand heavy wear and rough usage. They are used in coupler of railway carriage and electrical bulbs.

6. Buttress thread: - This thread is a combination of the triangular and the square threads. One flank of the thread is perpendicular to the axis of the screw. The angle between its two flanks is 45°. The theoretical depth is equal to the pitch. One-eighth of which is cut off parallel to the axis at the crest and at the root. This thread is suitable only when the force acts entirely in one direction. It is used commonly in screw of bench vice.

Theoretical depth D = P Actual depth d = ¾ D = 0.75P

INTRODUCTION

The basic purpose of manufacturing is to produce engineering materials and parts to specified shape, size and finish. The specifications for the shape, sizes and finishes are furnished to the shop by part drawings or manufacturing drawings. These specifications are often called quality characteristics.

The measured quality of manufactured product is always subject to a certain amount of variation as a result of chance. Some stable "system of chance causes" is inherent in any particular scheme of production and inspection. The reason for variation outside this stable system should be discovered and corrected to avoid wastage and finally to improve quality.

INSPECTION AND QUALITY CONTROL

Inspection:-Inspection is the method of measuring and/or checking the quality of product in terms of specified standard. There are three basic areas of inspection: - (1) Receiving inspection, (2) In process inspection and (3) Final inspection.

Quality Control: - The word "quality" as used in manufacturing implies "the best for the money in vested" and does not necessarily mean the "best". A component is said to be of good quality if it works well in a particular situation for which it is meant while in other situation it may not work well and it is said to be bad quality. The word "control" implies regulation and regulation implies observation and manipulation. It suggests when to inspect and how much to inspect.

Inspection is considered to be tool of quality control. It checks the products while quality control attempts to bring the variable factors under control.

SATISTICAL QUALITY CONTROL

Certain statistical techniques have been devised to evaluate machines, materials and processes by observing capabilities and trends in variations so that continual analysis predictions may be made to control the desired quality level. These statistical techniques are called statistical quality control methods. These methods or tools are:-

1. The Shewhart Control Charts for measurable quality characteristics. These are described as charts for, variables, or as charts for $\bar{X}$ and R (average and range) and charts for $\bar{X}$ and σ (average and standard deviation).
2. The Shewhart control chart for fraction defective. This is described as the *p* chart.
3. The Shewhart Control Chart for number of defects per unit. This is described as *c* chart.
4. Sampling plans dealing with the quality production

CONTROL CHARTS FOR VARIABLES($\bar{X}$ AND R Chart)

$\bar{X}$-Chart: Sample of consecutive parts are taken from the machine at frequent time intervals and recorded on the chart in their sequence of manufacture. A sample consists of subgroups, the size of which should be carefully measured. Generally, the sub group size is five to ten. It is always better to take frequent small subgroup than infrequent large subgroups. The parts are measured and the average of these measurements is plotted on the $\bar{X}$ chart. Average values are plotted instead of individual readings because sample averages tend to approach the normal distribution curve more closely than to individual values. The central line, $\bar{X}$ shown on the $\bar{X}$ chart is average of the averages or grand average of the subgroup (5 to 10) average. This is expressed as

$$\bar{X} = \sum \bar{X}/K$$

Where $\bar{X}$ is the average value of each subgroup and K is the number of subgroups. The control limits are set at three standard deviations (3σ) of the sample average from the mean $\bar{X}$, and are called upper control limit. ($UCLx = X + 3\sigma x$) and the lower control limit ($LCLx = X - 3\sigma x$), where

R-chart: The chart for ranges, the R chart is obtained from the same sample groups that were used in determining the values of $\bar{X}$. the central line or the mean, of the R chart represents the average of the subgroup ranges. Control limits on range chart can be calculated as:

$UCLr = D_4 R$ $\qquad\qquad$ $LCLr = D_3 R$

Where D_3 and D_4 are constant factors, the values of which are found in the table.

CONTROL CHART FOR ATTRIBUTES (p charts)

The control charts for fraction defective p is used to quality characteristics that can be observed only as attributes - for example, dimensions checked by go and non-go gauges even though they might have been measured as variables.

Fraction defective, p, may be defined as the ratio of the number of defective articles found in any inspection or series of inspections to the number of articles actually inspected. Fraction defective is nearly always expressed as a decimal fraction. This may be expressed as:

P = number of defectives in subgroup / number inspected in subgroup (n)

and $\bar{P}$ = total number of defectives during period / total number inspected during period ($\sum n$).

$UCLp = p + 3\sigma p$ $\qquad$ $LCLp = p - 3\sigma p$ $\qquad$ where $\sigma p = \sqrt{\{p(1-p)/n\}}$

CONTROL CHART FOR DEFECTIVES (c CHART)

The c chart applies to the number of defects in subgroups of constant size. A defective is an article whereas articles lacking conformity to specification is a defect.

The c chart is plotted in the same manner as p chart except that the control limits are based on Poisson distribution which describes more appropriately the distribution of defects.

The value of c is first computed. The 3-sigma limits are:

$UCLc = c + 3\sqrt{c}$ $\qquad\qquad$ $LCLc = c - 3\sqrt{c}$

For example, if there are 200 defects in 25 machines, the average c is 200/25=8.0. Control limits computed from the averages are follows:

$UCLc = c + 3\sqrt{c} = 8 + 3\sqrt{8} = 16.5$ $\qquad\qquad$ $LCLc = c - 3\sqrt{c} = 8 - 3\sqrt{8} = 0$

Whenever calculations give a negative value of the lower control limit of a chart, that limit is recorded as zero.

THE ISO 9000

ISO 9000 is a family of international standards for quality management and assurance. ISO 9001, ISO 9002, and ISO 9003 detail the requirements, which must be met. ISO 9000 and ISO 9004 are guidelines. Listed below are the models that make up the ISO 9000 family of standards.

ISO9001 Quality System is a model for quality assurance in design/development, production, installation, and servicing. ISO 9001 is made up of 20 sets of quality system requirements.

ISO 9002 Quality System is a model for quality assurance in production and installation.

ISO 9003 Quality System is the model for quality assurance in final inspection and test.

ISO 9004-1 and the other parts of ISO 9004 are the standards of guidelines on the elements of quality management and a quality system.

In its most basic form it requires that you:

Say what you do: Have documented procedures for performing the work that affects product or service quality.

Do what you say: Work according to the written procedures.

Record what you do: Retain records of the activities to provide objective evidence of compliance.

Improvement: Compare what you actually achieve with what is planned and use the information to correct any shortcomings.