TVET CERTIFICATE IV IN WELDING

FITTING

WLDPF301

Perform fitting

Competence

Credits: 12

Learning hours: 120

Sector: Manufacturing

Sub-sector: Welding

Module Note Issue date: October, 2020

Purpose statement

This specific module describes the performance outcomes, skills and knowledge required to perform fitting and elementary maintenance of fitting tools and equipment.

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Total Number of Pages: 47

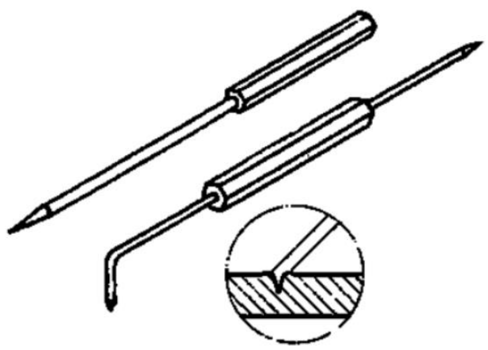
Learning Unit 1 – Use Hand Tools.

LO 1.1 Identify hand tools.

Content /Topic 1: Differentiate hand tools.

A. **Marking out tools:** The main objective of marking out is to provide a visual guide in form of scribed or punched lines so that the component can be or machined roughly to the required size and shape. The component should be marked in such way that there is a provision of machining allowances left on top of the required finished size of the component. Scribed lines are produced by tools which are either slightly notching the surface of the work piece or leaving a thin line by wearing themselves.

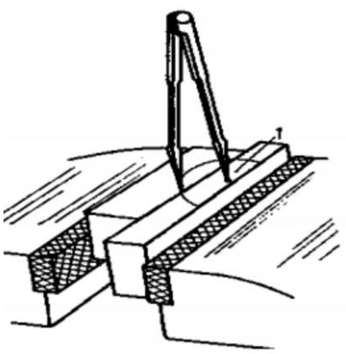
1. **Steel scriber:** Widely used scribing tool with hardened or carbide points which are straight or angular. It is used for rough or rough-machined steel parts and leaves a fine notch.



Steel scriber

Notch-sensitive materials and borders of thin sheet metal to be bent must not be scribed with steel scribers. Risk of breakage!

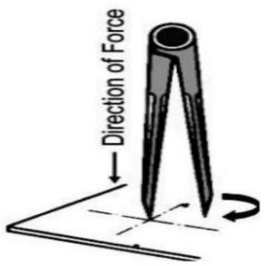
2. **Dividers:** Scribing tool are scribing circular arcs and curvatures. The use of dividers always necessitates a punch mark for the guiding point. It leaves a fine notch!



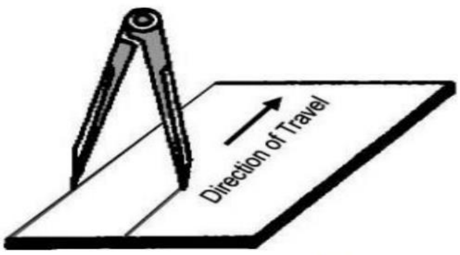
Scribing with toolmakers' dividers using an insert (1)

Laying Out Circles with the Divider

- Lay out the center of the circle
- Punch the center of the circle
- Adjust the divider to the proper radius while using a steel rule or a Vernier caliper
- Place one point of the divider in the center punch hole and give some force to this leg.
- Move around the fixed leg and scratch the surface.

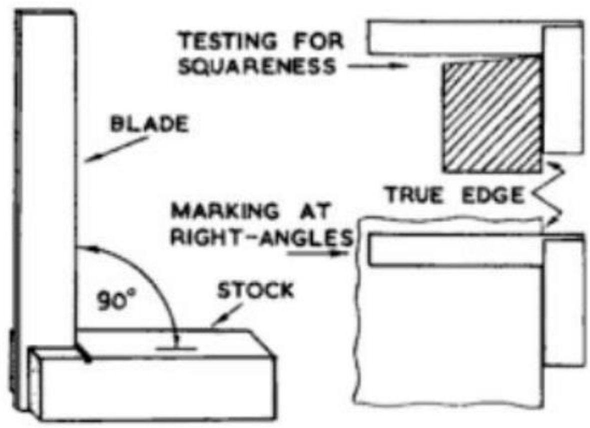


Laying out circles



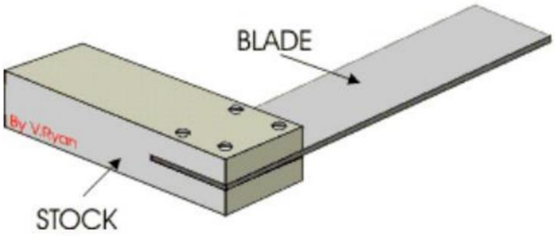
Laying out parallel lines

3. **Engineers Try-Square:** Engineer's square (figure below) is made of hardened tool steel. It is used for checking the straightness and the squareness of a work piece. It can also be used for marking perpendicular lines onto a work piece.



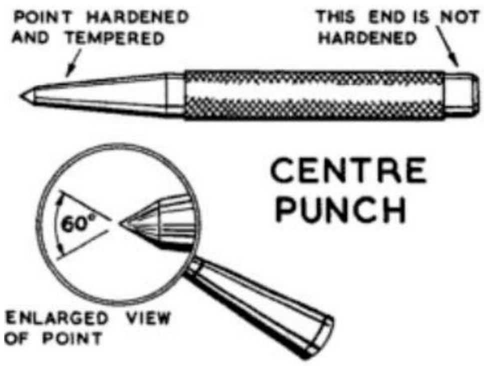
Engineers Try Square

The engineers try-square is composed of two parts, the stock and the blade. They are usually made from bright mild steel with the blade being hardened and tempered so that it resists damage. It is normally used during engineering / metalworking projects



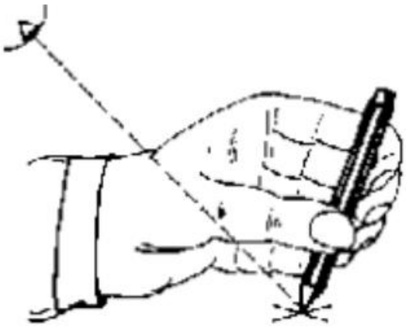
A typical use of an engineer's try-square is to mark out material for cutting/shaping. The try square is pushed against a straight side of the material (e.g. steel). An engineer's scriber is then used to scratch a line onto the surface of the metal. Sometimes engineers blue (a dye/ink) is wiped onto the surface first so that the scratched line can be seen easily. The material is then cut down to this straight line.

4. **Center punch:** In order to be able to recognize clearly a scribed line up to the end of working, prick punch marks are set on the scribed line. This is carried out by means of a prick punch which intrudes with its tip into the work piece metal after a light hammer blow. The punch marks are put in larger distances on straight lines than on curved scribed lines. Crossings and transitions of straight lines to curves are always punched.

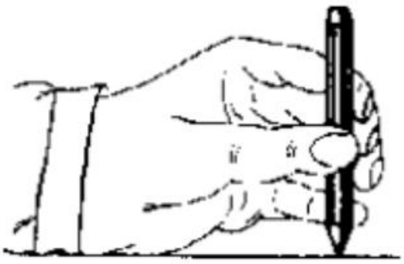


Punch marks are not only made to mark the scribed lines but also to determine insertion points for the dividers and whole centers. Punching serves to mark scribed lines, insertion points of dividers and whole centers.

i. **Manipulation of the center punch**



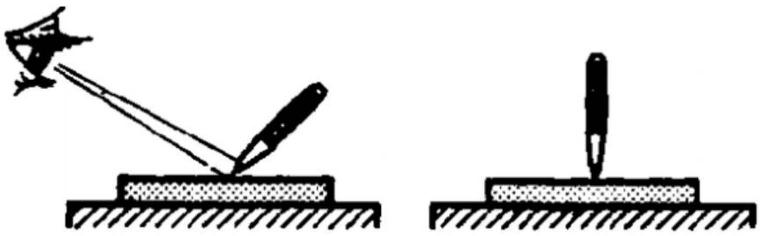
a) Application of the centre punch



b) Erection of the centre punch for the blow

ii. **Centre Punch Procedure**

- Make sure that the point of the punch is sharp before starting.
- Hold the punch at a 45-degree angle and place the point carefully on the layout line.
- Tilt the punch to a vertical position and strike it gently with a light hammer.
- If the punch mark is not in the proper position, correct it as necessary.

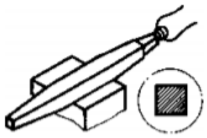


B. Cutting tools: cutting tools are tools used to separate metal into different parts of metals.in those cutting tools we have;

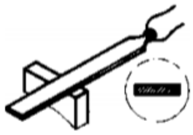
1. **Hand file:** The file is a cutting tool to work materials. It has many cutting edges which are like small chisels (file teeth) and are harder than the material being worked upon. For cutting metals normally Cross-Cut files are used. These files have an overcut, and an up cut. When using a file, several cutting wedges always act at the same time.

- To file different materials there are various courses available, such as smooth-cut, second-cut, and bastard cut.
- The length of the file body normally used is between 100 mm and 350 mm.
- The file handle is either from wood or from plastic.

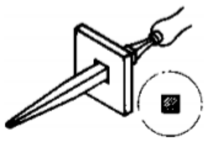
a) Types of Files



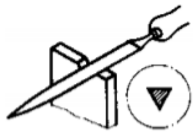
1. Square File large



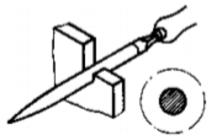
2. Flat File



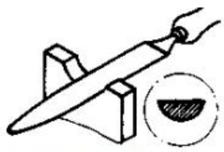
3. Square File small



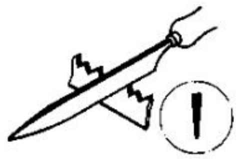
4. Triangle File



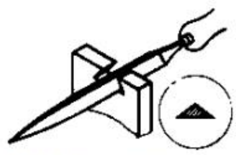
5. Round File



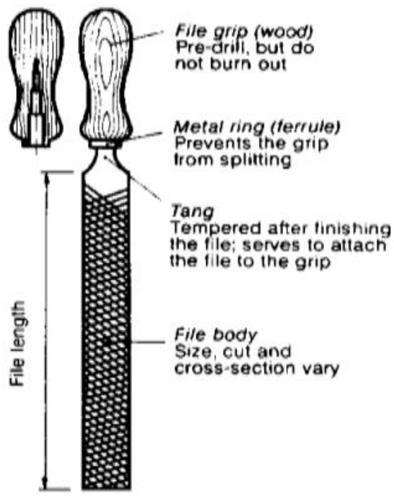
6. Half-Round File



7. Knife File



8. Flat-Triangle File

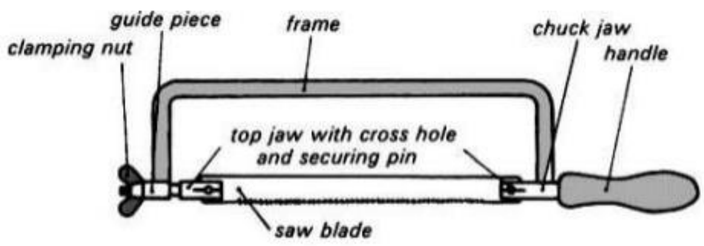


b) File Handling

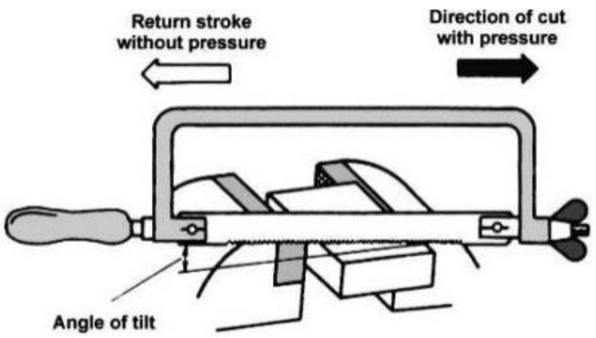
- Clamp the work piece as close as possible to the jaws of the vice. Use protective jaws (Aluminium) to protect the work piece.
- Start with a rough file for removing more material then take a smooth file to reach a good surface.
- Forward stroke with pressure; Return stroke without pressure.
- Move with the file crosswise to control the area of filing.

- Clean the file from time to time (especially smooth files) with a wire brush to prevent messy finishes.
- Never work with a file without a file grip.
- Make sure that the file grip is properly attached, that it has the right dimension and that it is not splitted.

2. **Hand Hacksaw:** A hand hacksaw mainly serves to separate materials and also to produce grooves and slits. It is generally used for cutting a metal into pieces. It consists of a frame and a saw blade as shown below. It is a "U" shaped steel frame with a pistol handgrip and a saw blade as shown below. The frame may be of fixed type to take only one length of blade, or adjustable to take different blade lengths. It has a wing nut to adjust the tension of the blade. Saw in a straight line along the marking line.



Hand hacksaw

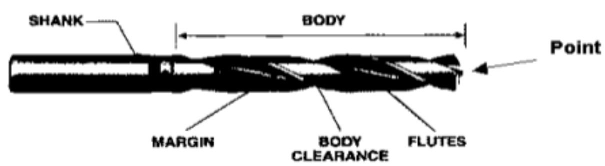


a) Safety and Care of Hacksaw

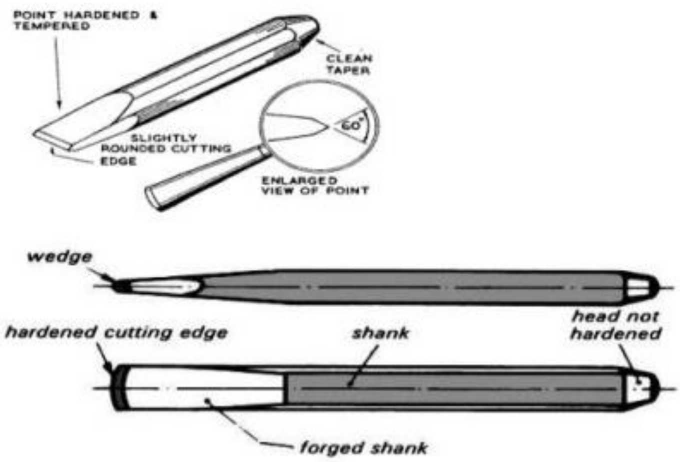
- The cutting action is carried on the forward action only. So, the blade must be mounted with its teeth pointing forward.
- Suitable tension should be applied on the blade to avoid breakage or loosen.
- Change the blade if some teeth are broken.
- Avoid rapid and erratic strokes of cut.
- Avoid too much pressure.
- Work piece must be held firmly.

- When sawing through reduce pressure on hand hacksaw just before the work piece separate

3. **Twist drill:** A twist drill is a cutting-tool used to produce a hole in a piece of metal or other material. The most common drill manufactured has two cutting edges (lips) and two straight or helical flutes. The flutes provide the cutting edges with cutting fluid and allow the chips to escape during the drilling operation.
   a) **Drill bit materials:** High-speed steels drills are the most commonly used drills, since they can be operated at good speeds and the cutting edges can withstand heat and wear.
   Cemented-carbide drills, which can be operated much faster than high-speed steel drills, are used to drill hard materials. They can be operated at high speeds and they can withstand higher heat.
   b) **Twist drill parts and cutting angles:** A twist drill may be divided into three main sections:
      - **Shank:** The shank is the part of the drill that fits into a holding device. It may be either straight or tapered.
      - **Body:** The body contains the flutes, margin, and body clearance of the drill.
      - **Point:** Shape and condition of the point are very important to the cutting action of the drill.

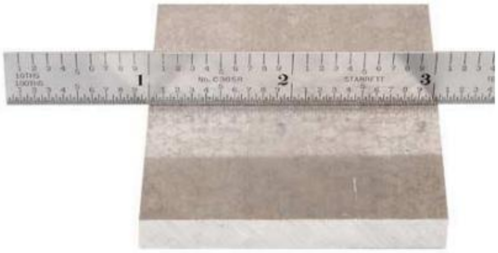


4. **Chisel:** In chiseling the cutting edge of a chisel is driven into a work piece by impact. A chisel must be harder than the piece being worked. Most chisels are made of alloyed tool steels.

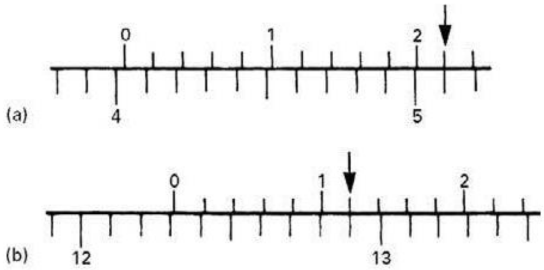


C. **Measuring instruments**

1. **Steel Ruler:** Some people confuse rules and scales. A scale is a measuring device used by architects and engineers that assists them in making drawings to a scale other than full size. A rule is used to measure actual sizes.

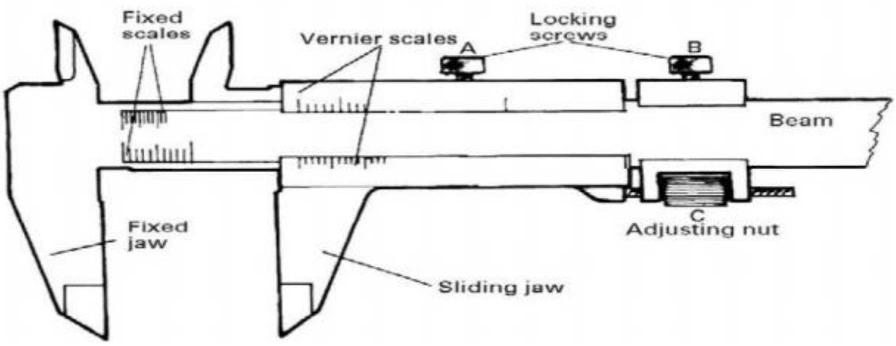


2. **Vernier instruments:** All instruments employing a Vernier consist of two scales: one moving and one fixed. The fixed scale is graduated in millimeters, every 10 divisions equaling 10mm, and is numbered 0, 1,2, 3, 4 up to the capacity of the instrument. If the two scales initially have their zeros in line and the Vernier scale is then moved so that its first graduation is lined up with a graduation on the fixed scale, the zero on the Vernier scale will have moved 0.02mm.



vernier readings

   a) **Vernier caliper:** The most common instrument using the above principle is the Vernier caliper. These instruments are capable of external, internal, step and depth measurements and are available in a range of measuring capacities from 150mm to 1000mm.

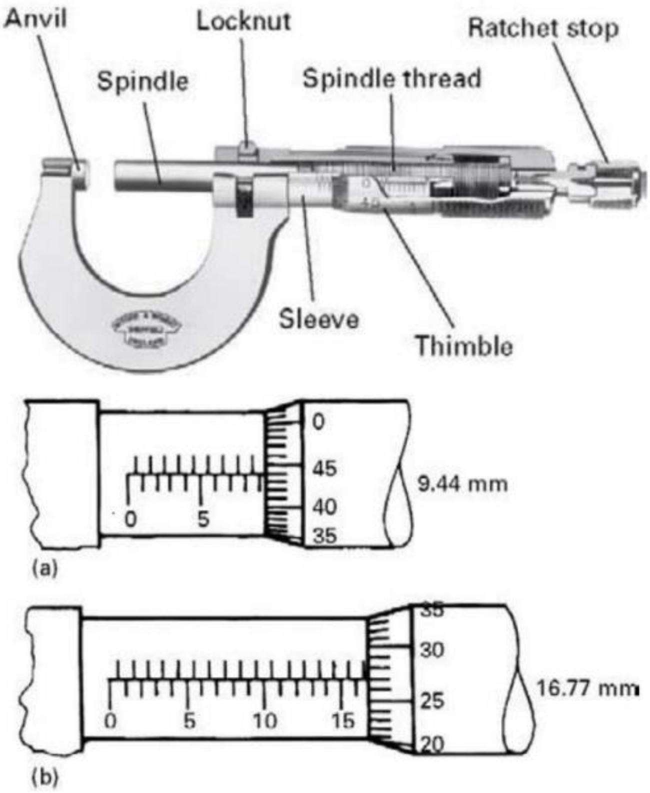


3. **Micrometers:** The micrometer relies for its measuring accuracy on the accuracy of the spindle screw thread. The spindle is rotated in a fixed nut by means of the thimble, which opens and closes the distance between the ends

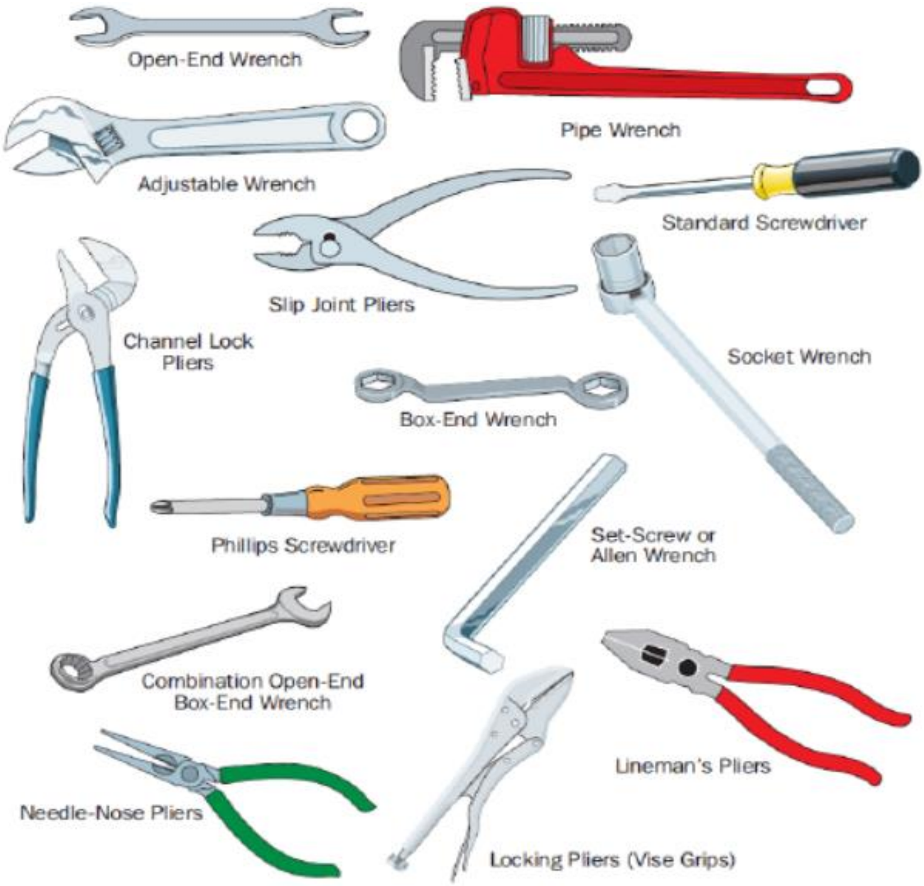
of the spindle and anvil as shown. The pitch of the spindle thread, i.e. the distance between two consecutive thread forms, is 0.5mm. This means that, for one revolution, the spindle and the thimble attached to it will move a longitudinal distance of 0.5mm.

On a 0–25mm micrometer, the sleeve around which the thimble rotates has a longitudinal line graduated in mm from 0 to 25mm on one side of the line and subdivided in 0.5mm intervals on the other side of the line. The edge of the thimble is graduated in 50 divisions numbered 0, 5, 10, up to 45, then 0.

A reading is therefore the number of 1mm and 0.5mm divisions on the sleeve uncovered by the thimble plus the hundredths of a millimeter indicated by the line on the thimble coinciding with the longitudinal line on the sleeve.



D. Common tools: A tool is any instrument or simple piece of equipment that you hold in your hands and use to do a particular kind of work. For example, spades, hammers, and knives are all **tools**. I find the best **tool** for the purpose is a pair of shears.



1. **Hammers:** The type most commonly used is the ball peen hammer, which has a flat striking face and a ball shaped end (call the peen). Hammer heads are made from medium carbon steel. The two ends must be hardened and tempered, the center of the head with the eye being left soft. It is specified according to its weight**.**

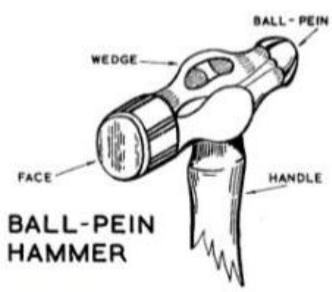
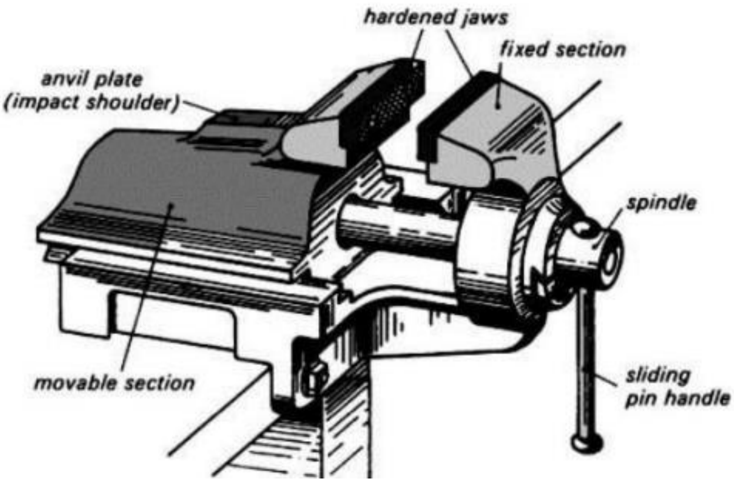


Figure of ball pein Hammer

- A hammer is used nearly in every operation related to metal works.
- They are made of cast steel or carbon steel.

E. Clamping tools: Are those tools used to fix or to hold the piece for different operations? Among clamping tools, we can say bench vice, c-clamp. U-clamp.

1. **Bench vice:** A bench vice is the device for holding the workpiece where most hand processes to be carried out. The body of the vice is made of cast iron while the two clamping jaws are made of hardened tool steel. Some bench vice has a swivel base, which can set the workpiece at an angle to the table. The vice height should be correct ergonomically. Vice clamps, made of copper are fitted over the vice jaws when holding finished work to avoid damage to the finish surfaces.



Anvil

An anvil is a heavy iron block on which hot metals are beaten into shape. a heavy iron or steel block on which metals are hammered during forging an anvil is a metalworking tool consisting of a large block of metal (usually forged or cast steel), with a flattened top surface, upon which another object is struck (or "worked").

Anvils are as massive as is practical, because the higher their inertia, the more efficiently they cause the energy of striking tools to be transferred to the work piece. In most cases the anvil is used as a forging tool. Before the advent of modern welding technology, it was a primary tool of metal workers.

The great majority of modern anvils are made of cast or forged steel (the latter is stronger) that has been heat treated. Inexpensive anvils have been made of cast iron and low-quality steel, but are considered unsuitable for serious use as they deform and lack rebound when struck.

Because anvils are very ancient tools and were at one time very commonplace, they have acquired symbolic meaning beyond their use as utilitarian objects. They have even found their way into popular culture including episodes of Looney Tunes, the name of a heavy metal band, and usage by blacksmiths as well as jewelers and metal smiths.

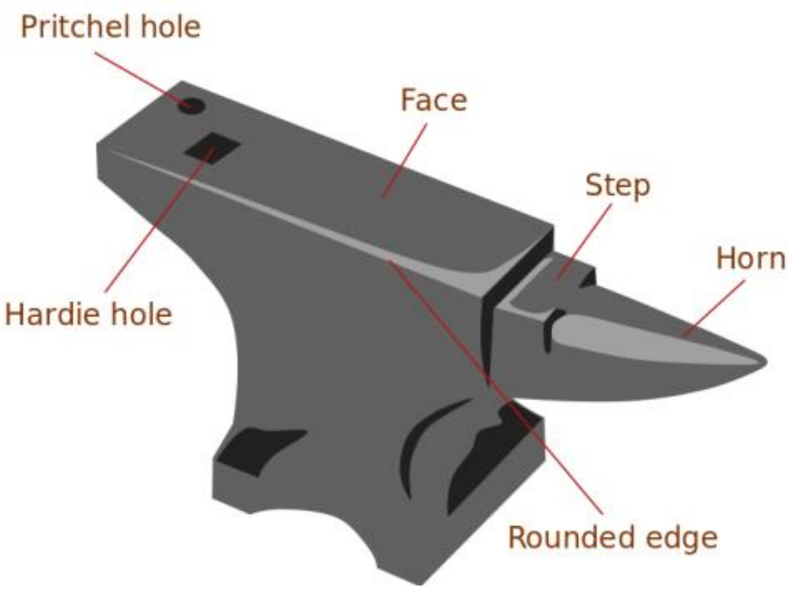
The primary work surface of the anvil is known as the face. It is generally made of hardened steel and should be flat and smooth with rounded edges for most work. Any marks on the face will be transferred to the work. Also, sharp edges tend to cut into the metal being worked and may cause cracks to form in the workpiece. The face is hardened and tempered to resist the blows of the smith's hammer, so the anvil face does not deform under repeated use. A hard anvil face also reduces the amount of force lost in each hammer blow. Hammers, tools, and work pieces of hardened steel should never directly strike the anvil face with full force, as they may damage it; this can result in chipping or deforming of the anvil face.

The horn of the anvil is a conical projection used to form various round shapes and is generally unhardened steel or iron. The horn is used mostly in bending operations. It also is used by some smiths as an aid in "drawing down" stock (making it longer and thinner). Some anvils, mainly European, are made with two horns, one square and one round. Also, some anvils are made with side horns or clips for specialized work.

The step is that area of the anvil between the "horn" and the "face". It is soft and is used for cutting; its purpose is to prevent damaging the steel face of the anvil by conducting such operations there and so as not to damage the cutting edge of the chisel, though many smiths shun this practice as it will damage the anvil over time.

The hardie hole is a square hole into which specialized forming and cutting tools, called Hardy tools, are placed. It is also used in punching and bending operations.

The pritchel hole is a small round hole that is present on most modern anvils. Some anvils have more than one. It is used mostly for punching. At times, smiths will fit a second tool to this hole to allow the smith more flexibility when using more than one anvil tool.



Content /Topic 2: Precautions for using the hand tools

A. Power Hand tools.

To prevent hazards associated with the use of power tools, workers should observe the following general precautions:

- Never carry a tool by the cord or hose.
- Never yank the cord or the hose to disconnect it from the receptacle.
- Keep cords and hoses away from heat, oil, and sharp edges.
- Disconnect tools when not using them, before servicing and cleaning them, and when changing accessories such as blades, bits, and cutters.
- Keep all people not involved with the work at a safe distance from the work area.
- Secure work with clamps or a vise, freeing both hands to operate the tool.
- Avoid accidental starting. Do not hold fingers on the switch button while carrying a plugged-in tool.
- Maintain tools with care; keep them sharp and clean for best performance.
- Follow instructions in the user's manual for lubricating and changing accessories.
- Be sure to keep good footing and maintain good balance when operating power tools.
- Wear proper apparel for the task. Loose clothing, ties, or jewelry can become caught in moving parts.
- Remove all damaged portable electric tools from use and tag them: "Do Not Use."

1. **Hand drill machine:** Hand drills are practically used for repairs or assembly jobs. Drills with a diameter up to 10 mm can be chucked into these machines. In case of the manually driven hand drill, the cutting motion is transmitted by hand force from the crank via bevel gears to the drilling spindle with the drill chuck. Mostly, two different speeds (fast motion, slow motion) can be selected. With the machine shown in fig. below the speed can be changed by resetting the handle and the hand crank. The thrust for feeding is generated by pressure of the breast on the breast plate.

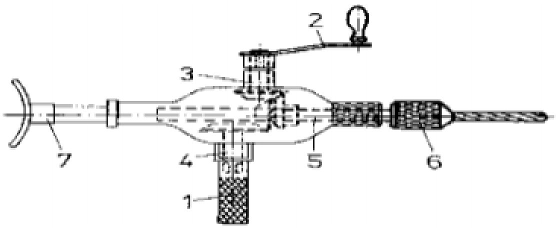


Figure of a Hand drill manually driven

1. Handle 2. Hand crank, 3. Slow motion, 4 Fast motions, 5 Drill spindle, 6 Drill chuck, 7 Breast plate

In case of the electric hand drill (fig. below), the cutting motion is generated by an electric motor and transmitted via a change-speed gear (mostly, for two speeds) to the drilling spindle with the drill chuck. The thrust for feeding is exerted with the right hand via the handle; the left hand clasps the handle and guides the hand drill.

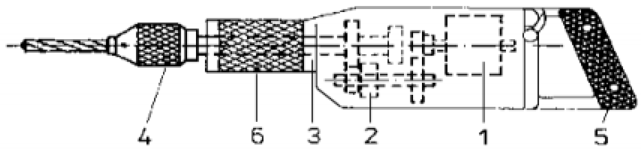
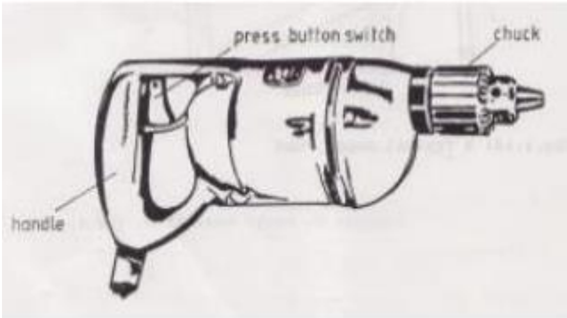


Figure of Electric hand drill parts

1 Electric motor, 2 Change-speed gear, 3 Drill spindle, 4 Drill chuck, 5 Handle, 6 Neck

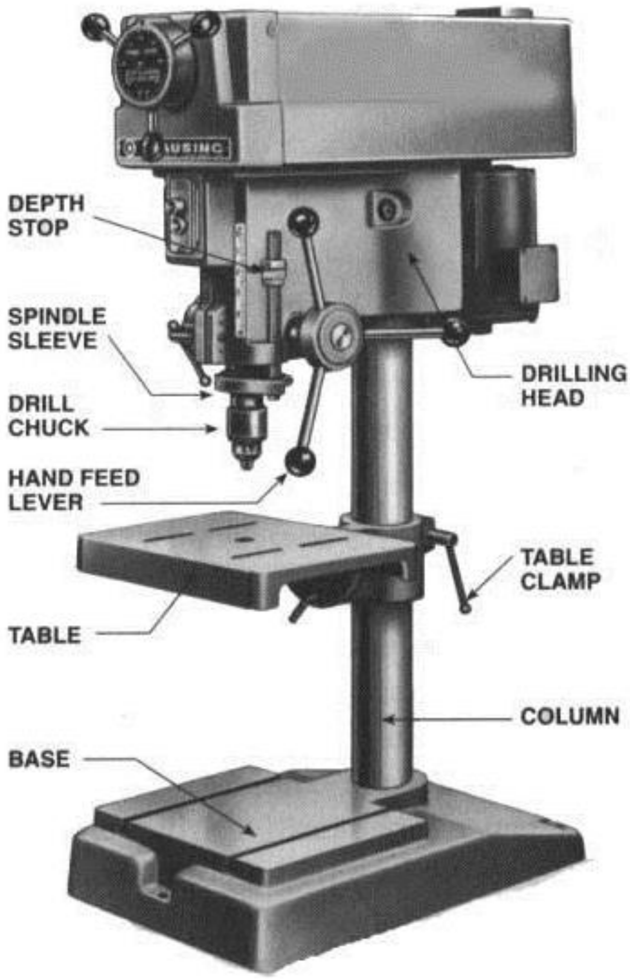


Electric Hand drilling machine

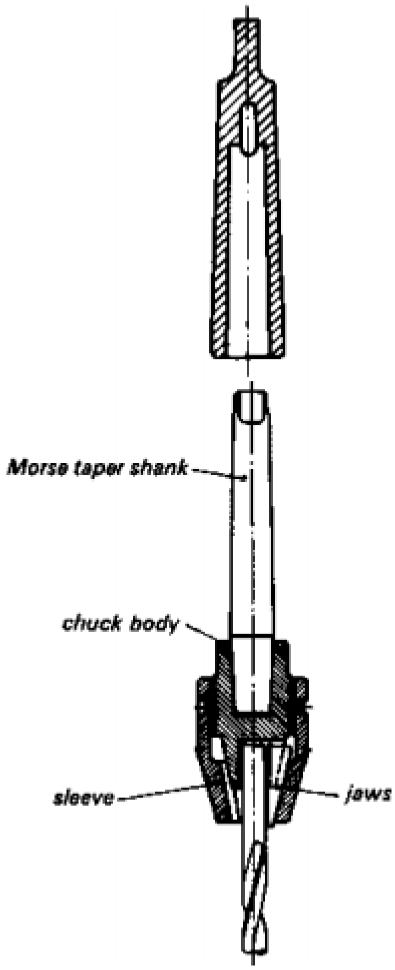
2. **Drill press machine:** Drilling is the process of cutting holes in metals by using a drilling machine. Drills are the tools used to cut away fine shavings of material as the drill advances in a rotational motion through the material.
   A drill press is a machine used for drilling operations available in a wide variety of types and sizes to suit different types and sizes of workpieces. The most common machine type found in a metal shop is the floor-type drill press. Although drill presses are manufactured in a wide variety of sizes, all drilling machines contain certain basic parts.
   a) **Base:** The base, usually made of cast iron, provides stability for the machine and rigid mounting for the column. The base is usually provided with holes so that it may be bolted to a table or bench to keep it rigid. The slots or ribs in the base allow the work-holding device for the workpiece to be clamped to the base.
   b) **Column:** The column is an accurate, vertical, cylindrical post that fits into the base. The table, which is fitted on the column, may be adjusted to any point between the base and head. The head of the drill press is mounted near the top of the column.
   c) **Table:** The table, either round or rectangular in shape, is used to support the workpiece to be machined. The table, whose surface is at 90 degree to the column, may be raised, lowered, and swiveled around the column. On some models it is possible to tilt and lock the table in either direction for drilling holes on an angle. Slots are provided in most tables to allow jigs, fixtures, or large workpieces to be clamped directly to the table.

d) **Drilling Head:** The head, mounted close to the top of the column, contains the mechanism to revolve the cutting tool and advance into the workpiece. The spindle, which is a round shaft that holds and drives the cutting tool, is housed in the spindle sleeve. The spindle sleeve does not revolve, but is moved up and down by the hand feed lever that is connected to the pinion on the rack of the spindle sleeve. The end of the spindle may have a tapered hole to hold taper shank tools, or it may be threaded or tapered for attaching a drill chuck. The hand feed lever is used to control the vertical movement of the spindle sleeve and the cutting tool. A depth stops, attached to the spindle sleeve, can be set to control the depth that a cutting tool enters the workpiece.

e) **Drill Chuck:** Drill chucks are the most common devices used on a drill press for holding straight-shank cutting tools. Most drill chucks contain three jaws that move all at the time when the outer collar is turned. The three jaws hold the straight shank of a cutting tool securely and cause it to run accurately.



f) **Drill Sleeves and Sockets:** The size of the tapered hole in the drill press spindle is generally in proportion to the size of the machine: The larger the machine, the larger the spindle hole. A drill sleeve is used to adapt the cutting tool shank to the machine spindle if the taper on the cutting tool is smaller than the tapered hole in the spindle. Before a taper shank tool is mounted in a drill press spindle, be sure that the external taper of the tool shank and the internal taper of the spindle are thoroughly cleaned. Align the tang of the tool with the slot in the spindle hole and, with a sharp upward snap, force the tool into the spindle.



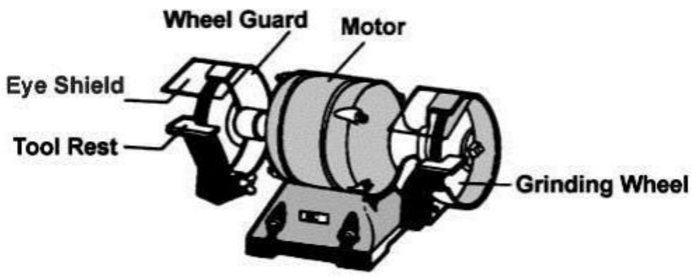
- **Cutting speed:** The cutting speed is given by the following relation:

$$V= \frac{\pi DN}{1000} \text{ in)}$$

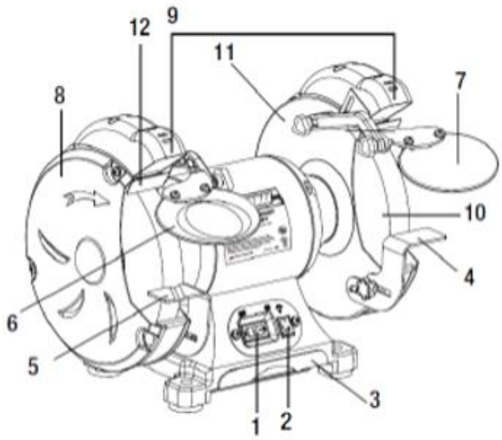
In which, D is the diameter of drill bit, mm; N is the rotational speed of the motor, rpm

- **Drill Press Safety Rules**
    1. Never wear loose clothing around machinery
    2. A hair net or a cap must protect long hair to prevent it from becoming caught in the revolving parts of the drill press.
    3. Never wear rings, watches, bracelets or necklaces while working in a machine shop.
    4. Always wear safety glasses when operating any machine.
    5. Never set the speed, adjust or measure the work until the machine is completely stopped.
    6. Keep the work area and floor clean and free of oil and grease.
    7. Never clamp taper shank drills, end mills, or non-standard tools in a drill chuck.
    8. Never leave a chuck key in a drill chuck at any time.
    9. Always use the brush to remove chips.
    10. Always clamp workpieces when drilling holes larger than ½ in. (12.7 mm) in diameter.
    11. When drilling sheet metal, it is necessary to clamp the sheet on a piece of wood.
    12. Reduce drilling pressure as the drill breaks through the workpiece.
    13. Always remove the burrs from a hole that has been drilled.

3. **Bench grinding machine:** The bench grinder is used for the sharpening of cutting tools and the rough grinding of metal. Because the work is usually held in the hand, this type of grinding is sometimes called "offhand grinding".
   The bench grinder is mounted on a bench while the pedestal grinder being a larger machine, is fastened to the floor. Both types consist of an electric motor with a course abrasive grinding wheel for the fast removal of metal, while the other is a fine abrasive wheel for finish grinding.
    - The grinding wheels are normally made of Aluminum-Oxide or Silicon-Carbide. Aluminum-Carbide is used to grind High-Tensile-Strength Materials. Silicon-Carbide is used to grind Low-Tensile-Strength Materials.
    - The wheel guards give the necessary protection while grinding.
    - The tool rest provide a rest for either the work or hands while grinding.
    - The eye shield is an additional protection for the eyes and should be used.



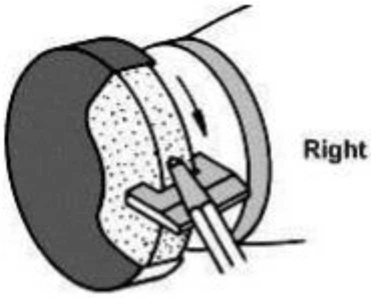
1. On/Off switch
2. Worklight switch
3. Coolant tray
4. Right work rest
5. Left work rest (grooved)
6. Left safety shield (w/ magnifier)
7. Right safety shield
8. Left wheel guard
9. Worklight
10. Grinding wheel
11. Right wheel guard
12. Spark deflector

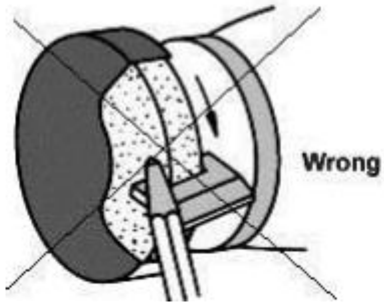


a) **Redressing the grinding wheels:** When a grinding wheel is used, several things can happen to it:
   - Grooves become worn in the face of the wheel
   - The abrasive grains will lose its cutting action
   - Small metal particles imbed themselves in the wheel, causing it to become loaded or clogged.

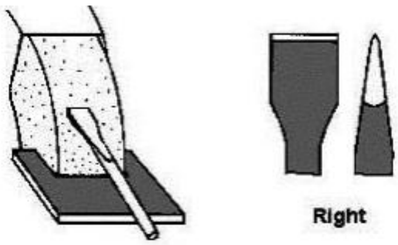
   Use from time to time a disc type dresser or a dressing stone to remove the grooves and the metal particles. This will also re-sharpen the abrasive grains.

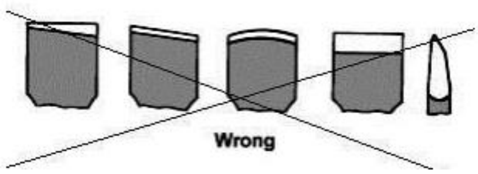
b) **Sharpening of scriber tool:**
   - Scriber and center punch should be ground in the position as shown beside.
   - Use the tool rest to rest your hands while bringing the tool in the right position.
   - Rotate the tool while grinding.
   - Cool the tool down from time to time.
   - Do not overheat the metal.





c) **Sharpening of Chisel tool.**
- Chisels should be ground in the position as shown below.
- Use the tool rest to rest your hands while bringing the tool in the right position.
- Use the whole grinding wheel while grinding. Move with the tool regularly from the left to the right side and back.
- Cool the tool down from time to time.
- Do not overheat the metal.
- Grind the chisel-point parallel and straight. See also the pictures below.





d) **Safety Precautions during bench grinding.**
- When switching on the machine, stand besides, because a damaged wheel might burst during acceleration.
- Always use safety goggles when grinding.

- The tool rest should never have more than 2-3 mm distance to the grinding wheel.
- Small workpieces should be held with clamps or other suitable devices.
- Keep the metal cool by dipping it frequently in water.
- Stand comfortable and don’t gives too much force to the workpiece because in the case of slip off with the workpiece you will grind your fingers or hand.
- While grinding, use only the face of the wheel.

4. **Hand grinding machine / Angle grinder:** An angle grinder, also known as a side grinder, is a handheld power tool used for cutting, grinding and polishing.
   Angle grinders can be powered by an electric motor, petrol engine or compressed air. The motor drives a geared head at a right-angle on which is mounted an abrasive disc that can be renewed when worn. Angle grinders typically have an adjustable guard and a side-handle for two-handed operation.
   Angle grinders may be used both for removing excess material off a piece or simply cutting into a piece. There are many different kinds of discs that are used for various materials and tasks, such as cut-off discs (diamond blade), abrasive grinding discs, grinding stones, sanding discs, wire brush wheels and polishing pads. The angle grinder has large bearings to counter side forces generated during cutting, unlike a power drill, where the force is axial.
   Angle grinders are widely used in metalworking and construction, as well as in emergency rescues. They are commonly found in workshops, service garages and auto body repair shops.

   There are a large variety of angle grinders to choose from when trying to find the right one for the job. The most important factors in choosing the right grinder are the disc size and how powerful the motor is.

Angle grinder

a. Safety Precautions to Take When Using an Angle Grinder

- Wear proper gear. **Angle grinder safety** starts by ensuring you're dressed appropriately from head to toe.
- Ensure the **grinder** itself is in proper condition. The **grinder** itself must be in proper condition
- **Use** the correct disc
- **Use** the disc guard.
- Slow down, speed up
- Keep the **grinder** away from flammables.

b. Advantages and disadvantages of angle grinder.

Advantages	Disadvantages
1. It is portable, means that it can be used on the side during fabricating different items such as trusses, doors, windows etc. 2. It is used to cut any shape of metals (e.g. flat bar, sheet metal, square, pipes, etc 3. When the skilled person is using it, the metal can be cut at a certain angle. 4. The cost is low	1. It cannot be used when there is no electricity 2. When used to cut big thicknesses, a lot of time is required. 3. The care should be taken when using the angle grinder, if the disc is not fixed properly, it can jump and damage the user. 4. Some materials are lost during this process.

5. **Hand riveting machine:** Riveting machines are used to automatically set (squeeze) rivets in order to join materials together. These are portable hand riveting machine using compressed air. They are used to form rivet heads with less distortion as compared to manually welded hammer.
   a) Portable hand riveting machine.
   b) **Swivel Head Hand Riveter:** The swivel head hand-held rivet tool features a patented positive-ratchet locking feature which will allow the swivel head section of the tool to turn 360° and hold in place in any of the forty plus positions. The high strength steel body and cast aluminium head complement this new design in a swivel head riveting tool. This tool sets up to 3/16" steel rivets.

6. **Power shearing machine:** These are electric powered machines which cut by dividing a sheet metal using two edged blades. The two cutting edges which are wedge shaped (750- 850) slide past each other resulting in shearing of the metal. Before shearing takes place, the material is first notched on both edges of the cut.
   When pressure is raised, the internal fibers of the metal are subjected to plastic deformation before complete separation. The sheared surfaces are normally rough and irregular.

   When you use this type of tool, you must follow some important safety precautions.
   - Read the Instruction Manual Before **Use**
   - Wear **Required** Protection.
   - **Use** in the Presence of Combustible or Explosive Materials. ...
   - Wear Appropriate Clothing.
   - Perform Regular Maintenance.

Foot shearing machine

7. **Hand shearing machine:** Hand shears are used for various operations in sheet-metal working such as cutting off, cutting in and out. For thin sheet metal up to a thickness of 1 mm, there are three types of hand shears in various versions. The hand plate shears (Fig. below.) are used for shearing off small strips and corners and for cutting in.

    a) **Hand plate shears:** Plate shears are used for cutting straight cuts of particular length in plates manually. The slightly bent up upper shearing jaw facilitates this work. The plates are retained by the holding-down device; the hand cannot get to the point of shearing.
    Hand-lever shears are mounted on frames and have a long lever arm (Fig below). By means of this type of shears, plates having a greater thickness can be separated. The permissible thickness is marked on the hand-lever shear. The holding-down device prevents the tilting of the plate during shearing. There are a few versions of hand-lever shears which lend themselves to the cutting of sectional bars. Hand-lever shears (1 Work piece, 2 Jaw, 3 Blank holder 4 Lever arm).
    The shorn areas on the work pieces only comply with simple quality requirements. In most cases, these surfaces must be finished, e.g. by filing.

    - Shorn parts of plate have sharp edges!
    - Take care in working and transport!
    - Shear plates of the permissible thickness only otherwise the shearing jaws will break!
    - Secure long hand levers after working by hanging on.
    - **Keep in mind:** Hand shears are used for separating sheet metal and plates. The areas shorn only comply with simple quality requirements.

Sheet Metal Hand Shear

This piece of equipment is a hand operated metal shear used to make quick cuts, usually in smaller pieces, where accuracy is not the prime concern.

- **DO NOT,** uses this equipment unless the technician has instructed you in its safe use and operation.

- **PPE required:**
    - Safety glasses must be worn at all times in work areas.
    - Long and loose hair must be contained.
    - Appropriate footwear with substantial uppers must be worn.
    - Close fitting/protective clothing must be worn.
    - Rings and jewelry must not be worn.
    - Gloves should be worn when handling sheet metal

B. Precautions

1. The hand shear must be securely fastened to a bench or purpose designed stand.
2. Guards or safety devices must never be removed or adjusted, except by an authorized person for maintenance purposes.
3. Shearing edges should be maintained in good condition, should be distortion free and correctly adjusted.
4. Working parts should be well lubricated and the blades free of rust and dirt.
5. Ensure no slip/trip hazards are present in workspaces and walkways.
6. Sufficient space must exist around the machine to prevent accidental contact with Passersby
7. Familiarize yourself with and check all machine operations and controls.
8. Faulty equipment must not be used. Immediately report suspect machinery

C. Operational safety checks

1. Never use the hand shear for cutting metal that is beyond the machine's capacity with respect to thickness, shape, hardness or type.
2. Material should be properly supported during cutting and industrial type gloves should be worn to protect the hands.
3. Use supports for long material - signpost if a tripping hazard.
4. Manual handling tasks should be assessed and appropriate procedures put in place.
5. Hold material securely to prevent it from moving during the cut.
6. Ensure fingers and limbs are clear before operating the hand shear.

D. Potential hazards

1. Closing movements between shearing surfaces and other parts can result in trapping.
2. Sharp edges on cutters and work-pieces can cause cuts
3. Squash/crush and pinch points
4. Impact from handle
5. Manual handling

6. Do not use a chopping motion - pull handle in a smooth & steady fashion

LO 1.2 – Perform Fitting Using Hand Tools.

Content /Topic 1: Fitting operations.

A. **Measuring:** Measuring is a process in which we consider the physical features of an object. We get knowledge about its length, mass, height, internal or external diameters, depths etc. This is done with the help of measuring tools like Vernier calliper, callipers, screw gauge, ruler etc. This is the most basic operation and the initial step of every procedure.

B. **Marking-out:** Marking out or layout is the process of transferring a design or pattern to a work piece, as the first step in the manufacturing process. Marking out consists of transferring the dimensions from the plan to the work piece in preparation for the next step, machining or manufacture. After measuring form measuring tool, some marking tools are used e.g. scriber, tri-square, dividers etc, mark the desired area on workpiece.
C. **Filling:** The process of making up or something putting into a hole, cavity, space or container is called filling.
D. **Drilling:** Making a hole with the help of drill bit is called drilling. Drilling is one of the most complex machining processes. The chief characteristic that distinguishes it from other machining operations is the combined cutting and extrusion of metal at the chisel edge in the centre of the drill. The high-thrust force caused by the feeding motion first extrudes metal under the chisel edge. Then it tends to shear under the action of a negative rake angle tool.
E. **Threading:** The process of cutting a long, spiralling groove into a workpiece with a single-point tool. Threading processes are essential for the creation of fasteners. A thread is a uniform helical groove cut inside of a cylindrical workpiece, or on the outside of a tube or shaft. They are according to desired pitch. It is of two types:
    a) **Internal threading:** When the threads are on the inner surface of workpiece.
    b) **Outer threading:** When the threads are on the upper surface of workpiece.
F. **Reaming:** The process of enlarging the hole is called reaming. There are many different types of reamer and they may be designed for use as a hand tool or in a machine tool, such as a milling machine or drill press. A reamer is a type of rotary cutting tool used in metalworking. Precision reamers are designed to enlarge the size of a previously formed hole by a small amount but with a high degree of accuracy to leave smooth sides. There are also non-precision reamers which are used for more basic

enlargement of holes or for removing burrs. Reaming can be done on a drilling machine by using a hand reamer or using a machine reamer.

G. **Punching:** Punching is the process of engraving or embossing some impression (forcefully or by hammering) on any other surface. In fitting shop, it is divided into:
    a) **Centre punching:** Making an impression of hole in workpiece is called centre punching. It is mainly used in drilling.
    b) **Number punching:** Engraving numbers on workpiece forcefully or by hammering is called number punching.

H. **Hack sawing:** A saw is a tool consisting of a hard blade, wire, or chain with a toothed edge. It is used to cut through relatively hard material, most often wood. The cut is made by placing the toothed edge against the material and moving it forcefully back and forth. This force may be applied by hand, by steam, water, electricity or other power source. An abrasive saw has a powered circular blade designed to cut through metal. Cutting the workpiece through this method is called sawing operation.

I. **Hand shearing:** Shearing is a mechanical operation performed mainly by exerting heavy pressure on the stock. This pressure is usually sup- plied by an eccentric press whilst the shape is imparted by punches.

J. **Chiseling:** A **chisel** is a tool with a characteristically shaped cutting edge (such that wood **chisels** have lent part of their name to a particular grind) of blade on its end, for carving or cutting a hard material such as wood, stone, or metal by hand, struck with a mallet, or mechanical power.

LO 1.3 - Handle hand tools.

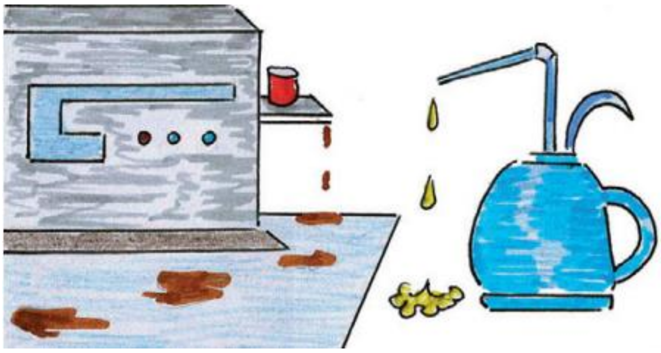
Content /Topic 1: Hand tools cleaning techniques

A. **By brush:** A **brush** is a common tool with bristles, wire or other filaments. It generally consists of a handle or block to which filaments are affixed in either a parallel or perpendicular orientation, depending on the way the brush is to be gripped during use.

B. **By air blower:** Blower is equipment or a device which increases the velocity of air or **gas** when it is passed through equipped impellers. They are mainly used for flow of air/**gas** required for exhausting, aspirating, cooling, ventilating, conveying etc. Blower is also commonly known as Centrifugal Fans in industry

C. **Cleaning cloth:** For other chores, dampen the cloth, then wipe surfaces clean. When the cloth starts to leave behind dirt or lint, or if you've used it a few minutes, re-fold to a fresh section. Continue until the entire cloth has been used or the cleaning chore is complete.

D. **Oil:** Some of the most powerful essential **oils** for **cleaning** are lemon, lime, wild orange, thyme, peppermint, lavender, eucalyptus, melaleuca (tea tree), rosemary, and cinnamon. Mix and match as you wish. Q: Do I have to use glass bottles for my mixes? A: It's a widely known fact that essential **oils** can degrade plastic.



Content /Topic 2: Hand tools convenient storage.

- Tools have to be cleaned and maintained in accordance with manufacturer's specifications and/or local instructions to ensure correct functionality of equipment.
- Any unserviceable tools are repaired, replaced or reported to relevant personnel to ensure correct functionality.
- Tools are transported in a safe, secure, efficient manner to minimize risk of injury to personnel and damage to tools.
- Tools are stored and secured according to manufacturers or workplace procedures to prevent damage to, and losses of, tools.

Learning Unit 2 – Use of Equipment.

LO 2.1. Identify Equipment.

Content /Topic 1: Equipment used in fitting.

A. **Machines**

1. **Drilling machine:** Drilling machine is machine for making holes with removal of chips. Drilling machines are used for drilling, boring, countersinking, reaming, and tapping. Several types are used in metalworking: vertical drilling machines, horizontal drilling machines, center-drilling machines, gang drilling machines, multiple-spindle drilling machines, and special-purpose drilling machines.

2. **Hand shear machine:** A shearing machine is one of two things; an industrial machine that cuts metal or a machine that cuts the wool off sheep. An industrial shearing machine generally presses blades down into metal sheets to punch out shapes. These shapes may be the desired end product or they may be the waste product. While shearing metal sheets is most common, other metallic objects may be processed in one of these machines. A sheep-shearing machine may be anything from a pair of small clippers similar to ones found in a barber shop to a large machine that features an external power supply and multiple clipping arms.

3. **Angle grinder:** An angle grinder, also known as a side grinder or disc grinder, is a handheld power tool used for grinding (abrasive cutting) and polishing. Although developed originally as tools for rigid abrasive discs, the availability of an interchangeable power source has encouraged their use with a wide variety of cutters and attachments.

4. **Cut off machine:** Cut-off machines have a continuous-rim abrasive blade used to cut metal alloys and other hard materials that cannot be cut using a toothed blade. Chop saws use a toothed blade. They spin at a lower rpm and produce less sparking than cut-off a saw, which reduces heat buildup in the blade and workpiece. To view products

5. **Bending machine:** A bending machine is a forming machine tool. Its purpose is to assemble a bend on a workpiece. A bend is manufactured by using a bending tool during a linear or rotating move. The detailed classification can be done with the help of the kinematics.

B. **Bench vice:** A bench vice is a vice that is attached to a bench. When people say vice, they are almost always talking about a bench vice. It is a device for firmly holding an object that someone is working on. It consists of two flat jaws one fixed and the other movable that can be brought together with a screw mechanism.

C. **Work Bench:** A flat table or surface at which carpentry or other mechanical or practical work is done

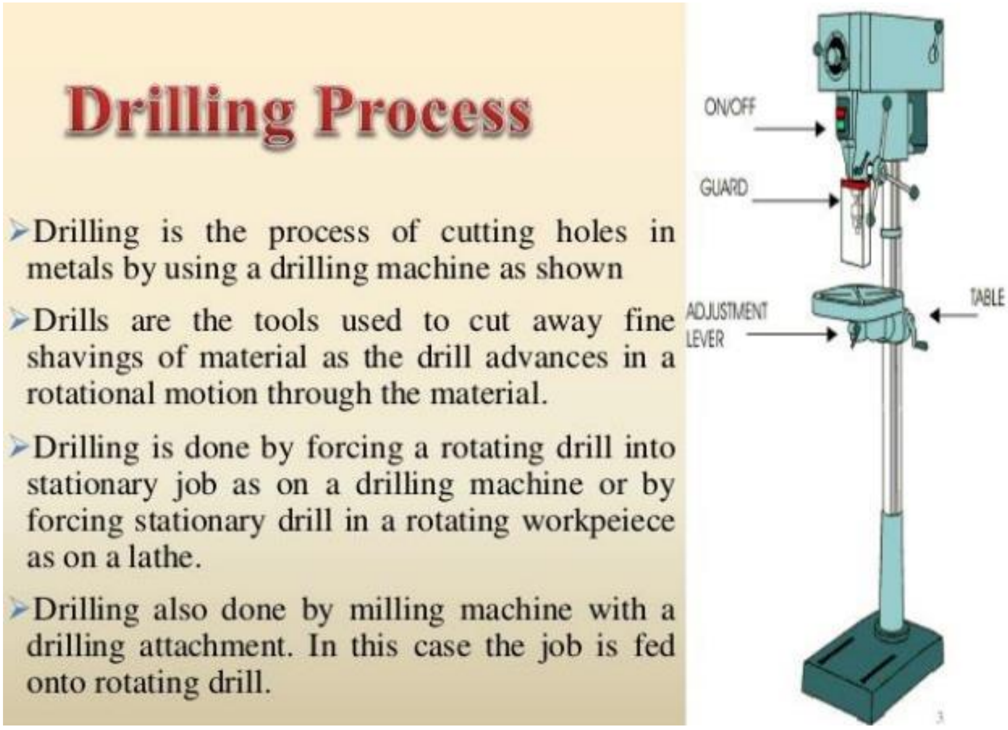
D. **Anvil:** A heavy iron block with a flat top and concave sides, on which metal can be hammered and shaped

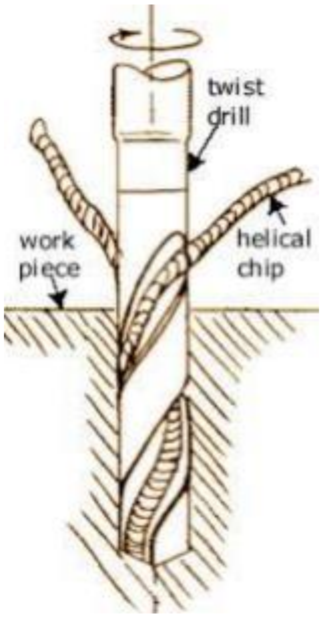
E. **Lifting devices: A** lifting device is a steel component installed between the crane hook and the part you will need to lift. It's specifically designed to hold the component being moved in the correct position for quick and safe installation.

LO 2.2. Perform fitting using machines.

Content /Topic 1: Fitting operations.

A. **Drilling**: Drilling is a cutting process that uses a drill bit to cut a hole of circular cross-section in solid materials. The drill bit is usually a rotary cutting tool, often multi-point. Instead, the hole is usually made by hammering a drill bit into the hole with quickly repeated short movements.





B. **Hand level shearing**: shear is with a compound mechanism to increase the mechanical advantage. It is usually used for cutting rough shapes out of medium-sized pieces of sheet metal, but cannot do delicate work. DO NOT use this equipment unless the technician has instructed you in its safe use and operation.

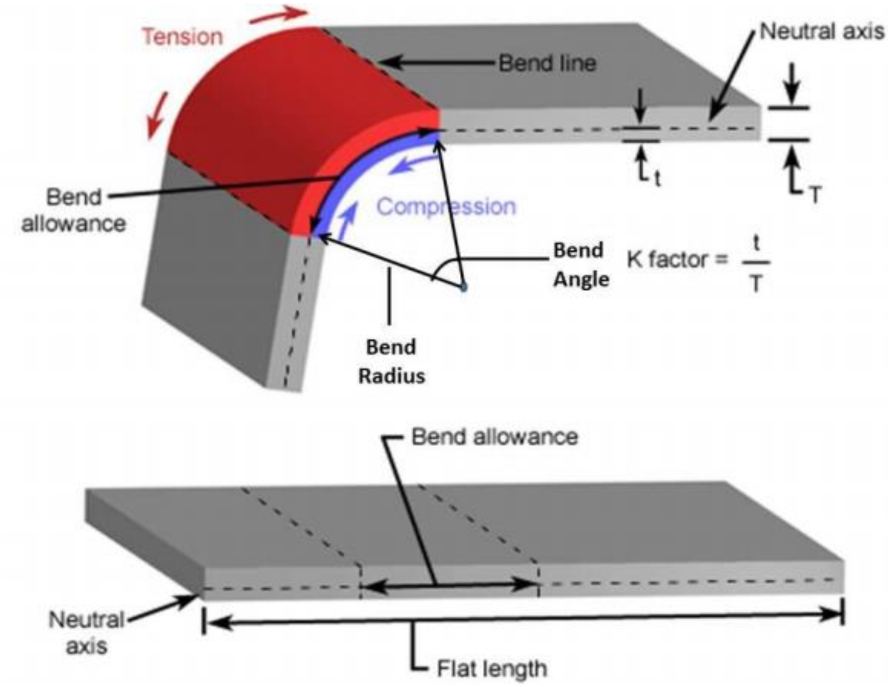
1. **PPE required for:**
   - Safety glasses must be worn at all times in work areas.
   - Long and loose hair must be contained.
   - Appropriate footwear with substantial uppers must be worn.
   - Close fitting/protective clothing must be worn.
   - Rings and jewelry must not be worn.
   - Gloves should be worn when handling sheet metal.

2. **SAFETY-PREOPERATIONAL SAFETY CHECKS.**
   - The hand shear must be securely fastened to a bench or purpose designed stand.
   - Guards or safety devices must never be removed or adjusted, except by an authorized person for maintenance purposes.
   - Shearing edges should be maintained in good condition, should be distortion free and correctly adjusted.
   - Working parts should be well lubricated and the blades free of rust and dirt.
   - Ensure no slip/trip hazards are present in workspaces and walkways.
   - Sufficient space must exist around the machine to prevent accidental contact with passersby.
   - Familiarize yourself with and check all machine operations and controls.
   - Faulty equipment must not be used. Immediately report suspect machinery

3. **OPERATIONAL SAFETY CHECKS**
   a. Never use the hand shear for cutting metal that is beyond the machine's capacity with respect to thickness, shape, hardness or type.
   b. Material should be properly supported during cutting and industrial type gloves should be worn to protect the hands.
   c. Use supports for long material - signpost if a tripping hazard.
   d. Manual handling tasks should be assessed and appropriate procedures put in place.
   e. Hold material securely to prevent it from moving during the cut.
   f. Ensure fingers and limbs are clear before operating the hand shear.

C. **Bending** is a manufacturing process that **produces** a V-shape, U-shape, or channel shape along a straight axis in ductile materials, most commonly sheet metal.

Commonly used equipment includes box and pan brakes, brake presses, and other specialized **machine** presses.



LO 2.3. Handle equipment.

Content /Topic 1: Equipment cleaning techniques

A. **Cleaning equipment purpose:** To prevent contamination of health supplement products by ensuring that proper cleaning procedure for equipment and accessories in the manufacturing area is in place.
B. **Responsibilities;** Execution by the Operator of the equipment, Verification by the Supervisor in respective manufacturing department Procedure
C. **Cleaning of Major Manufacturing Equipment**
    1. Dismantle all the removable parts of the equipment to be cleaned.
    2. Adhere "To be cleaned" sticker on the equipment and transfer the removable parts to the designated washing area.
    3. Clean the immobile part of the equipment according to the manufacturer's suggested cleaning procedure then fill-out the Equipment Log Book after completion.
    4. Reassemble all the cleaned removable parts to the cleaned equipment after assuring that every part is dried.
    5. Affix the signed and dated "Cleaned" sticker on the reassembled cleaned equipment. The "Cleaned" sticker must identify previous batch being processed by the equipment.
    6. Use the cleaned equipment within 72 hours from the date of cleaning. Wipe all product contact parts with clean lint-free cloth prior to next use.

7. If the equipment is not used within 72 hours after the date of cleaning, adhere "To be cleaned" sticker on the equipment and perform cleaning procedure again before use.

D. Cleaning of Accessories and Utensils

1. Transfer the accessories and utensils to the designated washing area.
2. Wash with sufficient potable water.
3. Clean with nylon brush or cleaning pad using potable water and 2.5% Teepol solution.
4. Wash-off clean with potable water until no bubbles are present.
5. Final rinse with purified water.
6. Rinse or wipe with 70% v/v solution of Isopropyl Alcohol
7. Wrap the cleaned and dried accessories and utensils in new polyethylene bag. Affix signed and dated "Cleaned" sticker, with identification of previous product, on the bag.
8. Store the cleaned accessories and utensils in designated equipment storage area until next use.

Content /Topic 2: Equipment convenient storage.

- Equipment has to be cleaned and maintained in accordance with manufacturer's specifications and/or local instructions to ensure correct functionality of equipment.
- Any unserviceable tools are repaired, replaced or reported to relevant personnel to ensure correct functionality.
- Tools are transported in a safe, secure, efficient manner to minimize risk of injury to personnel and damage to equipment.
- Tools are stored and secured according to manufacturers or workplace procedures to prevent damage to, and losses of, equipment.

Learning Unit 3 – Perform Elementary Maintenance of Equipment and Tools.

LO 3.1. Check for Status of Tools and Equipment.

Content /Topic 1: Working conditions.

A. **Safety of workplace machinery, equipment and tools:** All businesses must ensure that they use and maintain their equipment correctly. This reduces the risk of accidents or damage to health. It helps you to meet health and safety requirements.

B. **Equipment maintenance and checks for safety:** A maintenance schedule should be in place to ensure that your equipment is maintained regularly. You should check equipment as often as suggested by the manufacturer or more often if indicated by the risk assessment. Any daily checks should be undertaken as recommended by the manufacturer. This will help prevent problems such as blockages, leaks or breakdowns, which can increase risks.

   In addition to the equipment itself, you'll also need to maintain safety devices around the equipment such as guards, alarms, safety cages and warning signs. If you use heat-producing equipment you should regularly check the environment around it. Floors should be kept clear and there must be adequate ventilation at all times. You also need to remove all combustible materials from the area and regularly maintain and check fire detectors.

C. **Equipment checks required by law:** Some types of equipment - from gas appliances and lifting equipment to pressure systems and power presses - require examinations by law, often known as thorough examinations by a **competent person**, in addition to normal repair and servicing. You need to keep the certificates and records of such checks, detailing the findings and any remedial work carried out to correct faults that were identified.

D. **How to check equipment safely:** If any equipment is to be checked or repaired, it should always be turned off and isolated so it can't be started in error. Most equipment now comes with guidelines for maintenance, including advice on how to carry out equipment checks safely. Many businesses find it useful to establish documented procedures for maintenance and repair work, such as a permit to work scheme. You can also use warning signs as a visible reminder that equipment is temporarily out of use and/or a lock out system, the person doing the maintenance work has a key that prevents the equipment starting up while they work on it.

All tools, equipment and vehicles must be properly maintained so that workers are not endangered. Construction regulations require inspections of vehicles, tools, machines and equipment before use.
Preventive maintenance is the systematic care and protection of tools, equipment, machines and vehicles in order to keep them in a safe, usable condition limit downtime and extend productivity. We must always be aware that maintenance tasks themselves are potentially hazardous and can result in injury. The successful maintenance program is:

- Well organized and scheduled,
- controls hazards,
- defines operational procedures, and
- Trains key personnel.

The degree of detail to include in your company's program regarding equipment maintenance will depend on the kinds of tools/equipment used. Some construction equipment (cranes) has very specific inspection and maintenance requirements. Mobile heavy equipment (dozers, loaders, scrapers) may have different maintenance requirements. Passenger Vehicles (company trucks, cars and vans) may require only basic maintenance. Power Tools should be maintained in good working order. This may be limited to ensuring that blades/bits are replaced when needed and that guard or other safety devices are operable and any damaged electrical cords/plugs are repaired or replaced. Damaged or defective equipment/tools should be tagged and removed from service.

Most manufacturers can provide maintenance schedules for their equipment. Large companies with a fleet of vehicles/equipment typically have a comprehensive maintenance program due to the capital investment and/or leasing agreements. Smaller companies may lease equipment and maintenance services may be included in the leasing agreement

E. Requirements: General requirements for equipment maintenance include:

- Obtaining a copy of the maintenance schedule recommended by the manufacturer.
- Ensuring that maintenance is performed as required.
- Ensuring that the person(s) performing the maintenance are competent (e.g. licensed mechanic).
- Retaining records of maintenance/service conducted.
- Specifying who is responsible for overseeing equipment maintenance and where the records are kept.
- Set up a system for removal and tagging of damaged or defective tools and equipment.

Content / Topic 2: Connection faults and insulation faults.

A fault is any abnormal condition in a power system. The steady state operating mode of a power system is balanced 3-phase AC. However, due to sudden external or internal changes in the system, this condition is disrupted.

When the insulation of the system fails at one or more points or a conducting object comes into contact with a live point, a short circuit or a fault occurs.

The causes of faults are numerous, e.g.

1. Lightning
2. Heavy winds
3. Small animals entering switchgear
4. Line breaks due to excessive loading.

Power system faults may be categorized as one of four types; in order of frequency of occurrence, they are:

1. Single line to ground fault
2. Line to line fault
3. Double line to ground fault
4. Balanced three phase faults

Faults may lead to fire breakout that consequently results into loss of property, loss of life and destruction of a power system network. Faults also leads to cut of supply in areas beyond the fault point in a transmission and distribution network leading to power blackouts; this interferes with industrial and commercial activities that supports economic growth, stalls learning activities in institutions, work in offices, domestic applications and creates insecurity at night.

It is important therefore to determine the values of system voltages and currents during faulted conditions, so that protective devices may be set to detect and minimize the harmful effects of such contingencies

LO 3.2. Maintain tools and equipment.

Content /Topic 1: Types and steps of maintenance.

Maintenance is the combination of all technical and administrative actions, including supervision actions, intended to retain an item in, or restore it to, a state in which it can perform a required function.

Maintenance is a set of organized activities that are carried out in order to keep an item in its best operational condition with minimum cost acquired.

Maintenance Can be defined as all activities necessary in keeping a system in working order. In addition, improperly maintained equipment can lead to safety hazards, employee abuse and misuse of machines that will lead to increased overhead costs and potential liability. Maintenance activities include inspection, lubrication, adjustment, repair, replacement, etc.

i. **Reliability** can be defined as a Probability of a system, or a component, performing its intended Functions satisfactory under specified operating Conditions for a specified period of Time.
ii. **Managemen**t is the act of managing something
iii. **Availability** is the quality of being at hand when needed.

Objectives of Maintenance: Maintenance objectives should be consistent with and subordinate to production goals. The relation between maintenance objectives and production goals is reflected in the action of keeping production machines and facilities in the best possible condition.

1. Maximizing production or increasing facilities availability at the lowest cost and at the highest quality and safety standards.
2. Reducing breakdowns and emergency shutdowns.
3. Optimizing resources utilization.
4. Reducing downtime.
5. Improving spares stock control.
6. Improving equipment efficiency and reducing scrap rate.
7. Minimizing energy usage.
8. Optimizing the useful life of equipment.
9. Providing reliable cost and budgetary control.
10. Identifying and implementing cost reductions

Types of maintenance

1. **According to periodicity we have:**
   - **a. Daily maintenance:** which is composed by inspection, a g control oil level, function of different systems equipment, cleaning, etc.
   - **b. Monthly maintenance** which is composed by lubrication, adjustment,
   - **c. Seasonally maintenance** which is composed by repair, replacement, paint, etc.
2. **According to planning we have:**
   - a. **Unplanned maintenance** which is used for breakdown elimination. It is practicable and profitable when we have a small quantity of Technical equipment's.
   - b. **Planned maintenance** which we can classify into:

A. Preventive Maintenance (PM): It is a set of activities that are performed on plant equipment, machinery, and systems before the occurrence of a failure in order to protect them and to prevent or eliminate any degradation in their operating conditions.

Or can be defined as the maintenance carried out at predetermined intervals or according to prescribed criteria and intended to reduce the probability of failure or the degradation of the functioning and the effects limited.

The factors that affect the efficiency of this type of maintenance:

1. The need for an adequate number of staffs in the maintenance department in order to perform this type of maintenance.
2. The right choice of production equipment and machinery that is suitable for the working environment and that can tolerate the workload of this environment.
3. The required staff qualifications and skills, which can be gained through training.
4. The support and commitment from executive management to the PM programmed.
5. The proper planning and scheduling of PM programmed.
6. The ability to properly apply the PM programmed.

It is good for those machines and facilities which their failure would cause serious production losses.

Its aim is to maintain machines and facilities in such a condition that breakdowns and emergency repairs are minimized.

Its activities include replacements, adjustments, major overhauls, inspections and lubrications. Researchers subdivided preventive maintenance into different kinds according to the nature of its activities.

B. Routine maintenance or planned maintenance: which includes those maintenance activities those are repetitive and periodic in nature such as lubrication, cleaning, and small adjustment.

1. **Running maintenance:** which includes those maintenance activities that are carried out while the machine or equipment is running and they represent those activities that are performed before the actual preventive maintenance activities take place.
2. **Opportunity maintenance:** which is a set of maintenance activities that are performed on a machine or a facility when an unplanned opportunity exists during the period of performing planned maintenance activities to other machines or facilities.

3. **Window maintenance:** which is a set of activities that are carried out when a machine or equipment is not required for a definite period of time
4. **Shutdown preventive maintenance**: which is a set of preventive maintenance activities that are carried out when the production line is in total stoppage situation.
5. **Corrective Maintenance:** Is the one where equipment is maintained after breakdown. This maintenance is often most expensive because worm equipment ca damage other parts and cause multiple damage. In this type, actions such as repair, replacement, or restore will be carried out after the occurrence of a failure in order to eliminate the source of this failure or reduce the frequency of its occurrence. This type of maintenance is subdivided into three types:
    a. **Remedial maintenance**, which is a set of activities that are performed to eliminate the source of failure without interrupting the continuity of the production process.
    The way to carry out this type of corrective maintenance is by taking the item to be corrected out of the production line and replacing it with reconditioned item or transferring its workload to its redundancy.
    b. **Deferred maintenance,** which is a set of corrective maintenance activities that are not immediately initiated after the occurrence of a failure but are delayed in such a way that will not affect the production process.
    c. **Shutdown corrective maintenance**, which is a set of corrective maintenance activities that are performed when the production line is in total stoppage situation.
        i. **The main objectives of corrective maintenance** are the maximization of the effectiveness of all critical plant systems, the elimination of breakdowns, the elimination of unnecessary repair, and the reduction of the deviations from optimum operating conditions.
        ii. **The way to perform corrective maintenance activities is by conducting four important steps:**
            - Fault detection.
            - Fault isolation.
            - 3. Fault elimination.
            - 4. Verification of fault elimination.

        In the fault elimination step several actions could be taken such as adjusting, aligning, calibrating, reworking, removing, replacing or renovation

The difference between corrective maintenance and preventive maintenance is that for the corrective maintenance, the failure should occur before any corrective action is taken.

Corrective maintenance is different from run to failure maintenance in that its activities are planned and regularly taken out to keep plant's machines and equipment in optimum operating condition.

6. **Improvement Maintenance (IM):** It aims at reducing or eliminating entirely the need for maintenance. This type of maintenance is subdivided into three types as follows:
    a. **Design-out maintenance** which is a set of activities that are used to eliminate the cause of maintenance, simplifies maintenance tasks, or raise machine performance from the maintenance point of view by redesigning those machines and facilities which are vulnerable to frequent occurrence of failure and their long-term repair or replacement cost is very expensive.
    b. **Engineering services maintenance** which includes construction and construction modification, removal and installation, and rearrangement of facilities.
    c. **Shutdown improvement maintenance,** which is a set of improvement maintenance activities that are performed while the production line is in a complete stoppage situation.

7. **Predictive Maintenance (PDM):** Predictive maintenance is a set of activities that detect changes in the physical condition of equipment (signs of failure) in order to carry out the appropriate maintenance work for maximizing the service life of equipment without increasing the risk of failure. It is classified into two kinds according to the methods of detecting the signs of failure:
    - Condition-based predictive maintenance.
    - Statistical-based predictive maintenance.

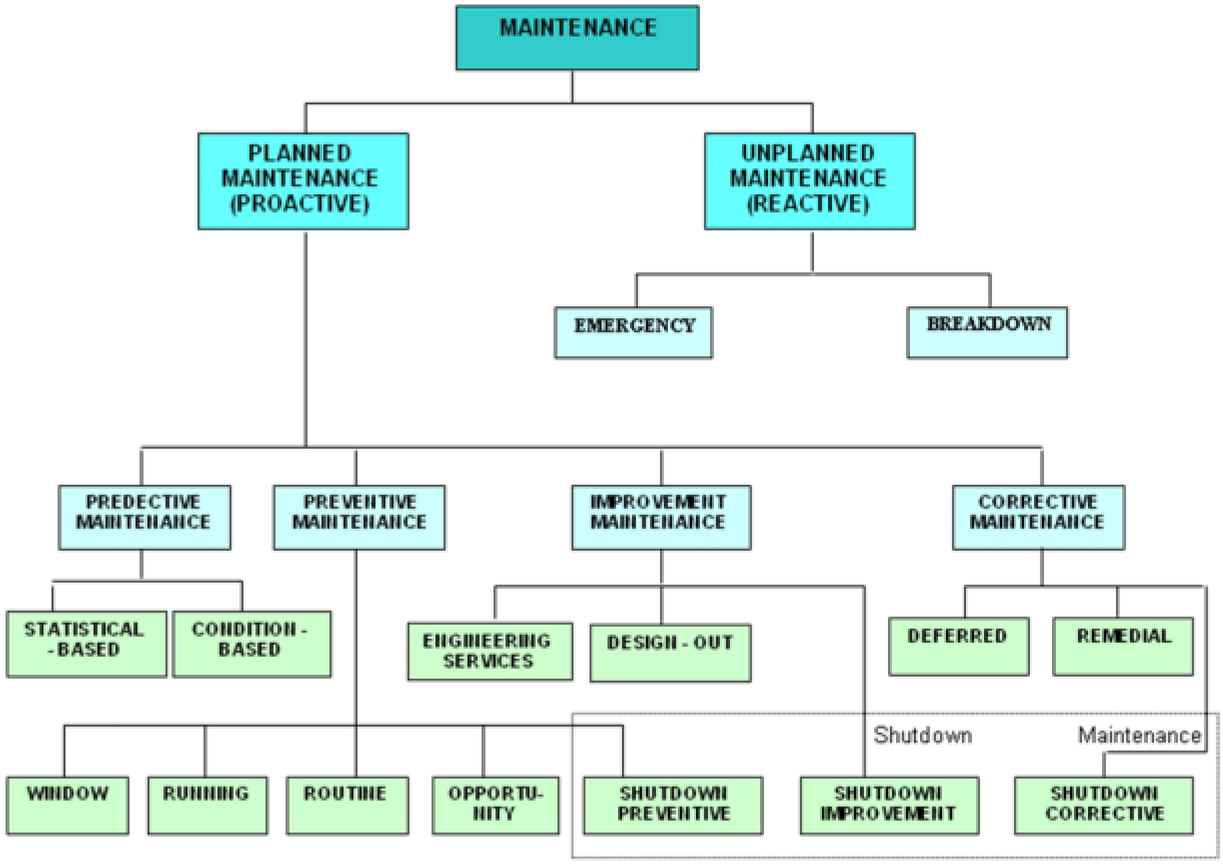
    a. **Condition-based predictive maintenance** depends on continuous or periodic condition monitoring equipment to detect the signs of failure.
    b. **Statistical-based predictive maintenance** depends on statistical data from the meticulous recording of the stoppages of the in-plant items and components in order to develop models for predicting failures.

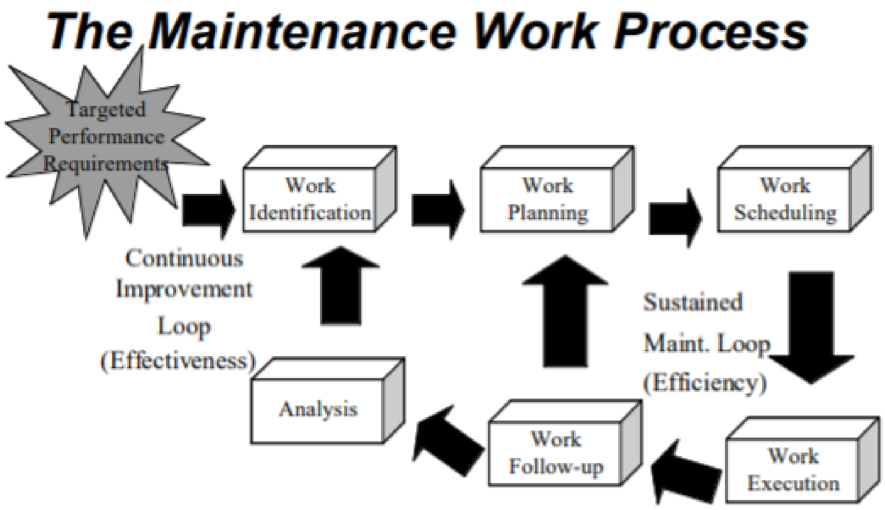
    Some researchers classified predictive maintenance as a type of preventive maintenance. The main difference between preventive maintenance and predictive maintenance is that predictive maintenance uses monitoring the condition of machines or equipment to determine the actual mean time to failure whereas preventive maintenance depends on industrial average life statistics.

8. **Run to Failure Maintenance (RTF):** The required repair, replacement, or restore action performed on a machine or a facility after the occurrence of a failure in order to bring this machine or facility to at least its minimum acceptable condition. It is the oldest type of maintenance. It is subdivided into two types:
    a. **Emergency maintenance**: it is carried out as fast as possible in order to bring a failed machine or facility to a safe and operationally efficient condition.
    b. **Breakdown maintenance:** it is performed after the occurrence of an advanced considered failure for which advanced provision has been made in the form of repair method, spares, materials, labor and equipment.

Disadvantages	Application / useful
1. Its activities are expensive in terms of both direct and indirect cost. 2. Using this type of maintenance, the occurrence of a failure in a component can cause failures in other components in the same equipment, which leads to low production availability. 3. Its activities are very difficult to plan and schedule in advance.	1.The failure of a component in a system is unpredictable. 2.The cost of performing run to failure maintenance activities is lower than performing other activities of other types of maintenance. 3. The equipment failure priority is too low in order to include the activities of preventing it within the planned maintenance budget.

Types of Maintenance flow chart





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