Military Institute of Science & Technology (MIST)

Department of Mechanical Engineering

SHOP 162

Workshop Technology Sessional
LEVEL-1, TERM-I
Contact Hr: 3 Credit: 1.5

Name of the Experiments:

1. **Study of Foundry Shop**
   a) **Patterns**
   b) **Molding**
   c) **Cores**
2. **Study of Foundry Shop**
   a) **Metal melting and Casting**
   b) **Inspection of casting and casting defects**
3. **Study of Electric arc welding**
4. **Study of Gas welding**
5. **Study of Metal Inert Gas (MIG) welding, Brazing and Soldering**
6. **Study of Engine Lathe and Practice**
7. **Study of Different Operations in Engine Lathe and Manufacturing a Part**
8. **Study of Milling Machine**
9. **Study of Shaper Machine**
10. **Manufacturing a Job using Bench, Drilling Machine and Grinding Machine**

General Guidelines:

- Student must remain present in lab/ workshop in time.
- Student must wear apron and put on shoes during experiment.
- Student should submit report before the class starts.
- Final quiz will be taken based on daily report submitted, lectures given during experiment and provided instruction sheet

Report must contain:

- Top sheet with necessary information (name of the experiment, no of experiment, date of performance, date of submission, group number etc)
- Objectives
- Work material/ Machines / Tool/ Equipments used (with their specifications)
- Experimental condition (speed, feed, depth of cut, cutting fluid)
- Necessary figures
- Discussion
- Assignment

General safety notes for the students:

1. The students must always use an apron, close-toed shoes, and safety goggles in the laboratory.
2. The chips generated are hot and therefore do not touch them immediately.
3. Female students should keep their hair tied and their scarfs pinned so that they do not come in contact with the rotating and moving parts.

Operational Safety Notes:

1. Put safety glass on before starting anything for this lab.
2. Do not Touch the Rotating Chuck or Workpiece.
3. For Foundry shop: Do not get the sand too wet. Water is enemy to molten metal.
4. Never stand or look over the mold during the pouring or immediately after the pouring because the molten metal might spurt out of the mold.
5. Make Sure the Workpiece is held tight by the chuck before starting the machine.
6. Make Sure the cutting tool is held tight by the tool holder before starting the machine.
7. Remove all tools, measuring instruments, and other objects from the saddle and lathe machine bed before starting machining.

8. Do not change the spindle speed while the machine is running.
9. Stop the Lathe machine before taking any measurement.
10. Keep the working area around the lathe/ shaper/ milling machine clean.

Welding Shop Safety:

1. Welders, assistants, and anyone else in the welding area shall wear glasses or shields of recommended shades during welding operations
2. When arc welding, make sure work and/or work table is properly grounded.
3. Do not arc weld in a wet area.
4. Be alert to possible fire hazards. Move the object to be welded to a safe location, or, remove all flammable materials from the work area.
5. Never weld in the same area where degreasing or other cleaning operations are performed.
6. Keep suitable fire extinguishing equipment nearby and know how to operate it
7. Gas cylinders should be handled in a correct manner. They should be maintained in an upright position and regulators should not be switched between the cylinders.

Potential Hazards

Hot Metal, Sparks, Noise, molten metal, Eye Injuries, Entanglement, Sharp Edges, and Burrs.

Students Evaluation:

Reports and assignments	20%
Class Attendance	10%
Class Participation	10%
Quiz	40%
Viva	20%
Total	100%

Reference books:

- Materials & Processes In Manufacturing; E. Paul DeGarmo, J.T.Black, Ronald A. Kohser; Printice Hall
- Manufacturing Engineering & Technology; S.Kalpakjian & S.R. Schmid
- Shop Theory; James Andersom

FOUNDRY SHOP

Experiment 01:

Study of Foundry Shop

a) Patterns
b) Molding
c) Cores

Foundry work deals with the melting of metals and the pouring of molten metal into molds from which castings are obtained. It is a basic industry. Let us consider its importance in the world of today, which depends extensively upon metal and products.

The convenience enjoyed in the modern home and society depends largely on foundry products. As we leave our homes to go about our daily work, we find that castings produced in the foundry play a most important part in our lives. Our modern land, sea and air transportation systems depend upon castings for their operation. On an average, an automobile has 600 pounds or more of cast metal parts in its construction. Modern communication and lighting system would be impossible without castings.

The electrical machinery group and automobiles are the heaviest uses of iron castings, while heavy tonnages into cast iron pipe and car wheels. Railroads take a large percentage on steel castings. Castings are used very extensively in heavy machinery. Non-ferrous castings of the brass and bronze type go largely into the automobile industry and machine tool group. Aluminum and manganese casting are used where lightness is required.

The industry's product, casting enters into every field in which metals serve man. Castings are used in transportation, communication, construction, agriculture, and power generators. In aerospace and atomic energy applications and in other activities are too numerous to describe.

Modern civilization would not be so far advanced as it is today if it were not for the foundry and its products. The foundry industry is a progressive one, always, looking ahead and as it improves, so will civilization.

Foundry in metals:

A metal casting is made by allowing liquid metal to solidify in a cavity (Mold) of desired shape. Metal casting is usually carried out in a foundry. The first castings were made of brass and bronze. Then came cast iron. Now many metals or alloys of metals are used, the principle type being iron, brass and bronze, malleable cast iron steel, aluminum and magnesium.

Most castings are sand casting made by pouring molten metal into a form (Mold). The mold is made in a box (flask) of wood or metal that is filled with packed, rammed sand containing a cavity formed by a pattern. Some castings are made in metal mold.

The foundry men use a pattern made of wood, metal, plastic etc. shaped like the desired shape of product for castings. Some castings are hollow. These hollows are made by placing cores in the mold. Cores are sand formed in a box that shapes the core to the form of the hollow casting. Core sand is mixed with a binder like linseed oil, molasses, resin, fish oil etc. The core held in shape by the binder is then baked in an oven to dry thoroughly to make it easy to handle.

Moldings:

The making of molds required great care and skill, since castings of tin must meet close tolerances as to size and other physical and chemical properties. In hand made molds, particular skill and knowledge are necessary for-

1. ‘Ramming up’ a sand mold to the right hardness.
2. Placing ‘Runner’ and ‘Riser’ and ‘Cutting Gate’ in the sand through which the molten metal would be poured into the mold cavity.
3. Cutting and shaping the sand around the pattern in the bottom part of the mold (drag) so that the top part (cope) of the mold would be lifted from the drag without having the sand tear or break in the process.
4. Patching any torn parts of the mold so that the casting when poured would be a true reproduction of the original pattern.
5. Settings of cores if it is required.
6. Pouring molten metal into the cavity of the mold.

1) **Foundry:** It is the process of producing a metallic object by molding and casting.
2) **Molding:** It is the process of creating an impression in the sand bed by a pattern of the desired casting product.
3) **Casting:** It is the process of melting metal in a furnace and pouring in the mold.
4) **Pattern:** It is the model of desired casting with exactly same shape and size with or without the addition of allowances and core prints.
5) **Core print:** It is the extended portion of the pattern that forms an impression in the mold that locates the right position to place the dry-sand core in the mold.
6) **Core-box:** It is a pattern that represents the internal shape of the casting and is used for making core.
7) **Draft allowance:** It is the allowance in the form of types given on the vertical side of the pattern for its easy removal from the mold. It is not always used to make a pattern.
8) **Shrinkage allowance:** It is the tolerance dimension provided all over the pattern to compensate the shrinkage of metal during solidification and cooling after casting.
9) **Machining allowance:** It is the tolerance in dimension provided in the added to make a pattern for machining.
10) **Molding sand:** It is the mixture of clay, water and a blend of carefully selected grains of silica which in a semi-plastic form.
11) **Core-sand:** It is used for making cores generally contains clean silica grain with a suitable binding materials such as resin, dextrin molasses etc.
12) **Crucible:** It is a container for molten metal in the furnace. It is made of graphite and fire clay.
13) **Cupola:** It is a cylindrical vertical furnace used for melting cast iron. It is used for continuous melting of metal in a mass production foundry.
14) **Pig iron:** It is the casting of molten iron into pieces of convenient size for handling that is produced by smelting iron ores in blast furnace.
15) **Scrap metals:** All metals that have no particular use in either existing forms may be considered as scrap metals.
16) **Mold coatings:** It is a common practice to coat the surface of sand molds with refractor materials to prevent the fusing of the sand to the coatings and to resist the cutting action of molten metal. The materials are ordinarily used for this purpose are graphite, silica, mica talc etc.
17) **Refractoriness:** It is the property of molding sand to resist high temperature without fusing. Melting point of silica sand is 3600°F.
18) **Permeability:** It is the property of molding sand to permit the escape of gases and steam formed in the mold.
19) **Cohesiveness:** It is the property to provide sufficient bond hold together which gives strength to retain the impression made by the pattern in the mold.

TOOLS AND EQUIPEMENT FOR MOLDING WORK

- **RIDDLE:** A riddle, as shown in Fig.1, has a standard wire mesh fixed into a circular or square wooden frame. It is used for cleaning the molding sand. The riddles are specified by the diameter of the frame and the mesh number. When large volumes of sand are to be cleaned, then power operated riddles are used.

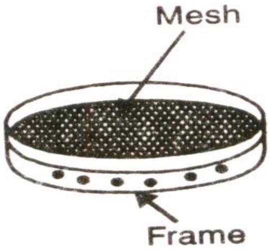


Figure-1: Riddle

- **RAMMER:** A hand rammer generally made of wood is used to pack the sand in the mold. It has got two ends, one end is sharp and the other end is blunt. The sharp end of the rammers called the PEEN END which is used to pack the molding sand through the corner of the molding flask and the other end is called the BUTT which is used to pack the sand finally.

Figure-2: Rammer

- **TROWEL:** The trowels, as shown in Fig.3, consist of a metal blade with a wooden handle. The small trowels of various shapes are used for finishing and repairing mold cavities as well as for smoothing over the parting surface of the mold. The usual trowel is rectangular in shape and has either a round or a square end.

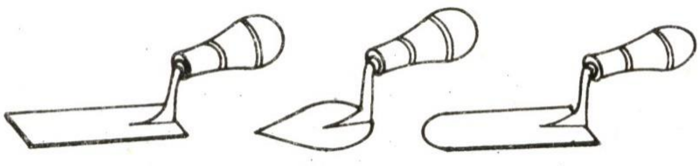


Figure-3: Trowel

- **SLICK-SPOON:** The principal hand tool for repairing molds is called a slick-spoon. It is a small double-ended tool having a flat on one end and a spoon on the other end. This tool is also made in variety of other shapes.

Figure-4: Slick-spoon

- **BELLOW:** The hand operated bellow, as shown in Fig. 5, is used to blow loose particles of sand from the cavities and surface of the mold.

Figure-5: Bellow

- **LIFTER:** Lifter is used for smoothing and clearing our loose sand depression in the mold. They are made of thin section of steel of various width and length with one end bent at right angles. A combination of silica and lifter is known as a YANKEE-LIFTER.

Fig.6: A simple lifter or cleaner

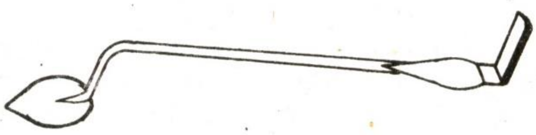


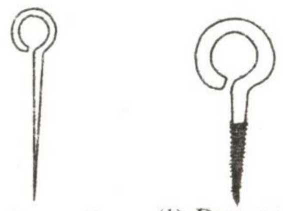
Fig.7: A Yankee lifter

♦ **SWAB:** It is made of hemp fibers and is used for applying water to the mold around the edge of the pattern. This prevents the sand edges from crumbling when the pattern is removed from the mould.

(*a*) Simple swab. (*b*) Bulb swab.

Fig.8: Swab

♦ **DRAW SPIKE OR SCREW:** The draw spike is a pointed steel rod with loops at one end. It is driven into a wooden pattern when it is withdrawn from the sand. The draw screw is similar in shape but threaded on the end to engage metal patterns.



(*a*) Draw spike. (*b*) Draw screw.

Fig.9: Draw spike and screw

♦ **VENTWIRE:** It is a wire rod used for making opening called 'vents' in the mold. In this manner the mold is provided with vents that carry off the steam and gases generated by the hot metal in contact with the sand.

Fig.10: Ventwire

♦ **GATE CUTTER:** It is a piece of sheet metal used to cut the opening that connects the sprue with the mold cavity. This opening is called a 'gate'.

- **SPRUE CUTTER:** A sprue cutter (also called a runner peg), as shown in Fig.11, is a tapered wooden peg. It is forced into the top part of the mold (known as cope) at the correct position. When the peg is withdrawn, it leaves a cavity (known as down gate) through which the molten metal is poured.

Fig.11: Sprue cutter

- **GAGGERS:** The gaggers (also called lifters), are iron rods bent at one end or both ends. It is used for reinforcement of sand in the top part of a molding box and to support hanging bodies of sand. The length of the gaggers varies from 125mm to 600mm and they are coated with clay wash to cause the sand to adhere to them.

- **SHOVEL:** It is long wooden handled tool generally made of thick sheet of hardened steel like as spade can be used shifting sand from one place to another place or to mix sand and water properly for making mold.

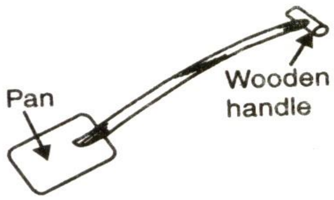


Fig.12: Shovel

MAJOR COMPONENTS OF SAND MOLDS

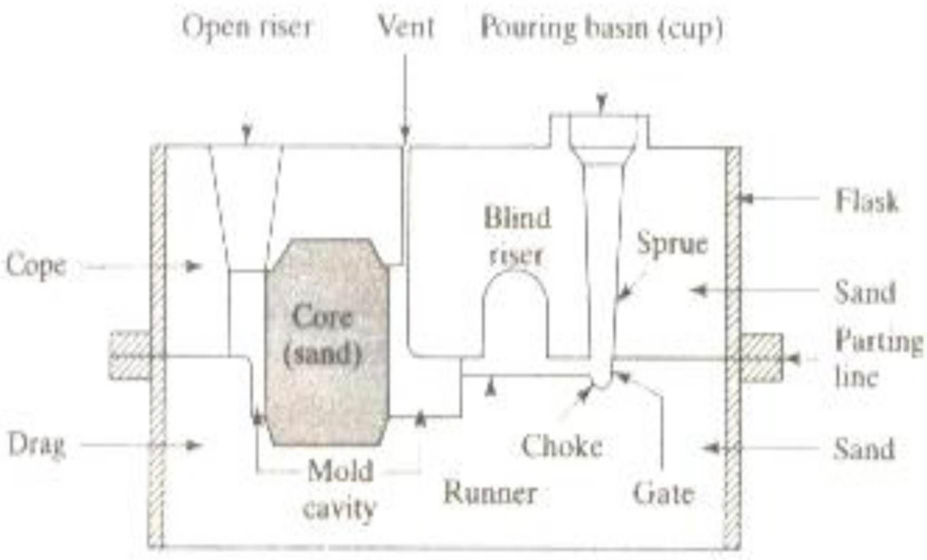


Figure13: Schematic illustration of sand mold showing various features

- **The mold itself**, which is supported by a flask. Two piece molds consists of a cope on top and a drag on the bottom. The seam between them is the parting line. When more than two pieces are used, the additional parts called cheeks.
- **The molding board** is a smooth surface board made of either wood or metal on which the flask and pattern are placed when the mold is started. The board should be perfectly flat and should be reinforced with cleats on the bottom. When the mold is turned over the mold surface of the board is finished. When the mold is placed on the similar board called BOTTOM BOARD, which acts as a support for the mold until the metal is poured.
- **A Pouring system or pouring cup**, into which the molten metal is poured.
- **A Sprue**, through the molten flows downward.
- **Cores**, which are inserts made from sand. They are placed in the mold to form hollow regions or otherwise define the interior surface of the casting. Cores are also used on the outside of the casting to form features such as lettering on the surface of a casting or deep external pockets.
- **Vents**, which are placed in molds to carry off gases produced when the molten metal comes into contact with the sand in the mold and core. They also exhaust air from the mold cavity as the molten flows into the mold.
- **The runner system**, which has channels that carry the molten metal from the sprue to the mold cavity. Gates are the inlets into the mold cavity.
- **Riser**, which supply additional metal to the casting as it shrinks during solidification. Figure 1m shows two different types of risers: a blind riser and an open riser.

MOLDING SAND

The principal material used in making a mold is sand. The sand is defined as the granular particles resulting from the breakdown of rocks. Quartz and other silica rocks are the source of silica sand, which is commonly used for molding. The silica sand is found in nature on the bottoms and banks of rivers, lakes and large bodies of water. The silica sand comprises from 50 to 95 percent of the total material in any molding sand. Good molding sand contains the following ingredients:

Silica sand (SiO_2)	-	80.8%
Alumina (Al_2O_3)	-	14.9%
Iron oxide (Fe_2O_3)	-	1.3%
Combined water	-	2.5%
Other inert materials	-	1.5%

Properties of molding sand: The molding sand must posses the following properties:

1) Porosity or permeability,
2) Plasticity,
3) Adhesiveness,
4) Cohesiveness,
5) Refractoriness,
6) Flow ability,
7) Collapsibility.

Natural and synthetic molding sands: The natural sand is one, which contains sufficient clay as mined from the sand pit so that it can be used directly. It needs only to be tempered and conditioned. Since the natural sands have the advantages of simplicity in their preparation, handling and use, therefore these are used for most of the ferrous and non-ferrous castings.

The synthetic sand is one, which is artificially compounded by mixing sand grains and selected type of clay. These sands have the advantages of lower cost in larger volume, wide spread availability and the possibility of sand reclamation and reuse.

The advantages and disadvantages of synthetic molding sands compared with natural sands are:

Advantages	Disadvantages
1. Synthetic molding sands are greater durable and will maintain more strength than that of natural sand	1. Synthetic sands are workable over a narrow moisture range.
2. More uniform than natural sand results better control over foundry sand condition.	2. It dries out more rapidly.
3. Free of slit of fines. This results in higher permeability, better flow ability and considerably less water for tempering.	3. Preparation of synthetic sand requires more mechanical equipment.
4. More refractory than natural sand.	4. More skill required when patching synthetic sand molds.

TYPES OF MOLDS

The various types of molds, according to type of material used, are as follows:

Green sand mold: The sand mold prepared from natural molding sand in its green state is called green sand mold. The green sand mixture is prepared by mixing thoroughly silica sand (80 percent), clay (10 to 15 percent) and water (4 to 6 percent). This mixture should be properly tempered before it is used. The green sand molds may be used for small and medium castings of ferrous and non-ferrous alloys. Since the green sand molds contain moisture, therefore certain defects like blow holes may occur in casting. The surface finish of castings made in green sand molds is also not good.

Dry sand mold: The sand mold prepared from fine-grained sand mixed with suitable binder is called dry sand mold. These molds must be backed in an oven. The dry sand molds are stronger and may be handled more easily with less damage. These molds are mostly used in small and medium-sized casting. For large castings, the dry sand molds may be made in sections. These molds may be used for many alloys but are more common in casting of steel.

Loam mold: The mold made with loam sand (a mixture of sand and clay) is called loam mold. The loam sand also contains fire clay or ganisters. The loam molds are similar to pit molds and are used for large work where the pattern required will be too expensive to make. The mold is first built up with bricks or large iron parts. These parts are then plastered with a thick loam sand mixture consisting of silica sand (22 volumes), clay (5 volumes), coke (10 percent) and moisture (18-20 volumes). The shape of mold is obtained by either with sweep or skeleton patterns. The mold is then allowed to dry thoroughly so that it resists the heavy rush of molten metal and withstand heavy temperature. Since much time is required to make a loam mold, therefore these are not extensively used.

Skin-dried mold: The sand mold with a dry sand facing and a green sand backing is called skin-dried mold. These molds may be used for casting all ferrous and non-ferrous alloys. These molds are more commonly used for large molds. The skin-dried molds are less expensive to construct than dry sand molds but more expensive than green sand molds. It requires less floor space and time for comparable sizes of dry sand molding. The skin-dried molds are not so strong as dry sand molds.

Metal molding: The mold made of metal is called metal mold. The metal molds are used in casting of low melting temperature alloys. Since castings produced by metal molds have a smooth finish, therefore much of the machine work is eliminated.

MOLDING PROCESS

Bench molding: For small work, this type of molding is done on a bench of suitable height.

Floor molding: Large casting with difficulty in handling, the mold is done on the floor.

Pit molding: Extremely large castings are molded in a pit instead of a flask. The pit acts as drag part of the mold. A separate cope is used above it.

Machine molding: Some of the molding operations such as ramming the sand, rolling the mold over, forming the gate and drawing the pattern can be done by these machines much better and more efficiently than by hand.

To illustrate a few fundamentals in molding the following exercise is given. (The pattern is a flange):

1. Prepare enough sand to fill the flask when removed.
2. Place drag on molding board, joint side to the board, guide pins pointing downward.
3. Place pattern, large side down, in drag.
4. Riddle ½ in, sand over the pattern.
5. Fill drag with sand and peen all around with bench rammer, keeping at least 2" away from pattern. Don’t ram over pattern.
6. Refill drag, peen all over, ram again and put off a lower.
7. Strike off excess sand to the level of drag using straight-edge.
8. Vent around and over pattern with vent wire.
9. Roll handfuls of loose sand over mold. Rub bottom board over sand in order to make it bear evenly. This is absolutely necessary. If the bottom board does not fit snugly against the sand; the mold will crack.
10. Roll drag over and remove molding board.

11. Place cope on drag, with binges and latches corresponding.
12. Shake parting compound over joint.
13. Flow parting compound off pattern with the billow.
14. Place gate pin 2 in from side of pattern.
15. Riddle ½ in sand over pattern.
16. Refill cope, peen all over, refill again and butt all aver.
17. Fill cope with sand and peen all around close to flask.
18. Strike off and level with top of cope.
19. Vent over pattern with vent wire.
20. Remove gate pin and cut poring basin into the cope.
21. Remove cope, blow excess parting compound off the drag.
22. Swab around pattern, Rap and draw pattern.
23. Cut gate in drag ½" deep, 1" wide and remove any loose sand from the mold.
24. Put board on outside of cope and lay it down flat, board underneath.
25. Shake blacking on gate and on mold surfaces in cope and drag.
26. Stand cope on its side molding board in place. Remove board and clean pouring basin.
27. Dust blacking in pouring basin.
28. Put cope on drag in its original position.
29. Set mold level on the floor carrying it with bottom plate held firmly in place.
30. Uncover pouring basin and place suitable weight on cope to hold it down against the lift of the molten metal.

PATTERN

Pattern: It is the model of desired casting with exactly same shape and size with or without the addition of allowance and core prints.

Pattern may be made of wood, metal, plaster or plastic. The type of pattern material chosen depends on the design of the casting, the number of castings to be produced, method of production, the degree of accuracy and surface finish required.

PATTERN MATERIALS

WOOD PATTERN: It is widely used material for patterns. It is used when small number of castings is to be produced. The wood as a pattern material has the following advantages and disadvantages.

Advantages:

(a) It is cheap and light,
(b) It can be easily worked and shaped as desired,
(c) It can be cut and fabricated into numerous forms by gluing, bending and carving,
(d) It is easily planned and sanded to smooth surface and can be preserved fairly for a long time with shellac.

Disadvantages:

(a) It has the tendency to wear out by the constant contact with damp sand,
(b) Since it cannot withstand the continuous abrasive action of sand, therefore it is unsuitable for repetition work.

<u>METAL PATTERN</u>: Metal pattern are made of brass, bronze, white metal, cast iron and aluminum alloys etc. When large number of castings is required, the pattern is made of a metal.

Small patterns are frequently made of brass or bronze. They draw well from the mold and maintain a smooth finish because of their resistance to atmospheric corrosion. Certain alloys called white metals because of their low shrinkage characteristics. They are safer and less durable by they are less expensive to produce because of the casting of finishing.

Patterns allowance: Some allowance should be considered to make the patterns.

i. **<u>Shrinkage allowance</u>:** It is the tolerance dimension provided all over the pattern to compensate the shrinkage of metal during solidification and cooling after casting.
Shrinkage allowance for:

Steel	1/4" per foot
Cast iron	1/10" per foot
Aluminum	9/32" per foot

ii. **<u>Finishing allowance</u>:** It is the tolerance in dimension provided in the added to make a pattern for machining to surface of casting.
Machining allowance depends on (1) Machining method, (2) Characteristics of metal, (3) Size and shape of the casting, (4) Method of casting.

iii. **<u>Draft allowance</u>:** To facilitate the withdrawal of a pattern from a mold proper draft should be applied to the pattern surface. The amount of draft on the average pattern varies from ¼ to 1 degree, depending on the method of molding.

Types of pattern:

I. Single piece pattern
II. Loose piece pattern
III. Split pattern
IV. Match plate pattern
V. Gated pattern

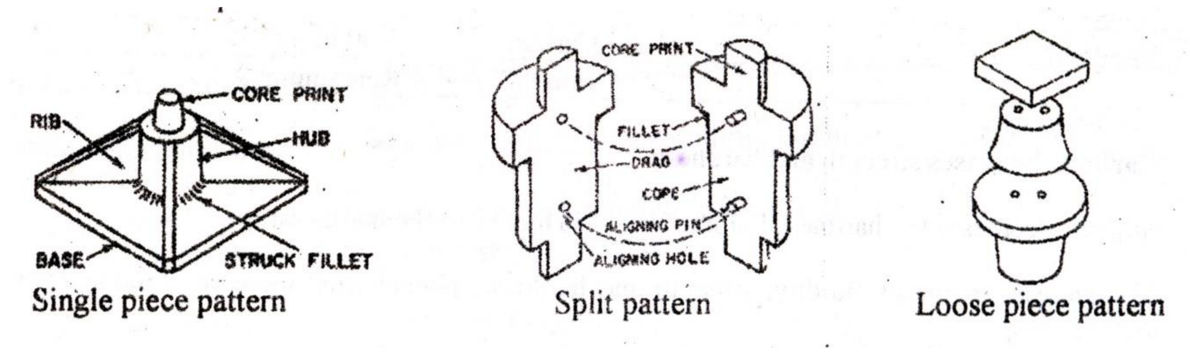


Figure-14: Types of pattern

CORE

Core: Core is a sand body form by the pattern or core box, which placed in the mold cavity to get hold slot, or cavity in any require in casting.

<u>Types of core:</u>

The cores used in foundries are classified according to their shape and position in the mold as under:

i. **Horizontal core:** It is the most common type. It is usually in a cylindrical form laid in the mold horizontally. The ends of the Core Rest in seats provided by the Core prints on the Pattern

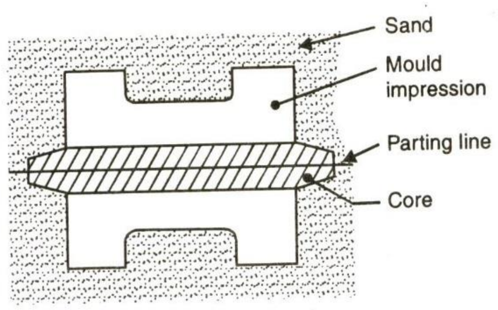


Figure-15: Horizontal core

ii. **Vertical core:** The core, when required to be placed along a vertical axis in the mold is known as vertical core. The upper end on the core is forced in the cope and the lower end in the drag.

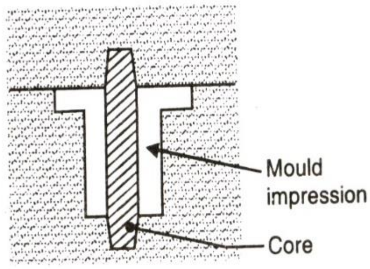


Figure-16: Vertical core

iii. **Balance core:** A balance core has a single core print and produces a single opening in casting.

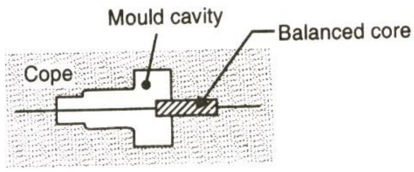


Figure-17: Balance core

CORE SAND: Various qualities of sand are used in making cores depending on the properties in the core. High silica sand containing very little if any clay bond is generally used. In choosing core sand the foundry men consider grain size distribution and shape mineralogical composition. A high percentage of quartz is desirable because quartz does not fracture when exposed to heat.

CORE BINDERS: The core binders serve to hold the sand grains together and impart strength, resistance to erosion and to breakage and degree of collapsibility. They may be classified as organic and inorganic binders. The organic binders are combustible and are destroyed by heat. Hence they contribute a degree of collapsibility to the core sand mixture. The inorganic binders are not combustible and may have considerable strength at high temperatures, may have resistance to erosion and may be relatively non-collapsible, depending upon their nature.

CORE BOXES: A core box is essentially a type of pattern made of wood or metal in which sand is rammed or packed to form a core.The core box is made exactly to the shape and size of the core required. Several types of core boxes are used according to the shape of the core.

INSPECTION OF CASTING –DEFECTIVE CASTING AND CAUSES OF DEFECTS

The degree of care required in the inspection of casting depends upon the uses for which the castings are made. Most foundries inspect for external defects only, that is, if no noticeable imperfections are present, the castings are considered good. Some castings have hidden or internal defects that become visible only when the castings are machined. Frequently, however, these concealed defects will never be discovered until the casting is scrapped and broken up to be re-melted, having given satisfactory service meanwhile. Depending on the inspection for external imperfections, or machining away the defective portion, is not sufficient. In such cases the inspections are often made by using an X-ray machine.

CAUSES OF DEFECTIVE CASTINGS

1) **Blow holes:** Blow holes in castings are very common and result from many different causes, as follows:
    1. High moisture content in molding sand,
    2. Low permeability of sand.
    3. Hard ramming of sand.
    4. Defective gating system.
    5. Improper venting of sand.

2) **Cold shuts or misruns:** Misruning castings results from the following:
    1. Pouring too cold metal into the mold.
    2. Using either too few or small gates.
    3. Pouring metal into the mold too slowly.

3) **Cracked castings:** Some castings are likely to crack while cooling in the mold and others after they come from the molds. Owing usually to the following causes:
    1. Poorly designed casting, which is those having too light and too heavy sections.
    2. Allowing the light section of a casting to coal before the heavy section.
    3. Cracks in castings can be prevented by removing sand from the heavy but allowing it to remain on the light section until the casting is cold.

4) **Crushed castings:** These are often caused by the following:
    1. If the sand in any cope does not fit the sand in the drag, when the mold is closed it may cause a crushed casting.
    2. If a dry sand core that is too large for the core rings is placed in a mold, it will causes a crushed casting
    3. If a mold clamped too hard, it can cause a crushed castings.

5) **Hard casting:** Some gray iron castings are too hard to be machined. Whereas others machine easily, some causes of hard castings are as follows:

1. Coatings small gray iron castings too fast will make them hard.
2. Having molding sand too wet may also make small gray iron castings too hard.
3. Using iron too low in silicon.
4. Using iron too high in sulpher or manganese.
5. Metal boiling in the ladle when the mold is poured is likely to make casting hard.

6) **Porosity:** Porosity in castings is usually found on the inside of the heavy sections and is casted by metal being drag from the heavy sections while the light sections are solidifying. In some cases feeders on castings help to prevent porosity, but in other cases are not much help. Some causes of the porosity are as follows:

1. Poor design as to metal thickness in the castings.
2. Having metal too hot when pouring the mold.
3. In gray castings, using metal too high in silicon or phosphorus.

7) **Rough castings:** The surfaces of some castings can be rough without disqualifying them, whereas others should be very smooth. Castings that are to be used as they come from the foundry, without any other kind of finish, should have smooth surfaces but as a role castings need not be smooth if they are to be used under ground and covered or of they are to be machined. There as different causes for rough castings, some of them as follow:

1. Making the mold from sand that is too coarse.
2. Having the molding sand too damp when making the mold.
3. Pouring metal into mold that is rammed to soft.

8) **Shifts:** Frequently castings have shifts that disqualify them for used. Most shifts, however, can be prevented easily if the molder pays close attention to the following:

1. Pins on flask should fit smoothly when the mold is made. They should be neither loose no tight.
2. When a snap flask mold, with the flask removed, is carried from the molding bench to the mold should be kept level because the cope may slip on the drag causing a shift in the casting.
3. When split patterns are used, the dowel should fit in the dowel pinholes.
4. Slip jackets put over nap flask molds in a careless manner also cause shifts.

9) **Swelled casting:** Swell is a local displacement of the face of the sand by the pressure of the fluid metal.

Causes:

1. Ramming is too soft.
2. Defecting ramming of mold.
3. Pressure of pouring metal is too high.

Assignment

1. Which types of allowance should be considered to make a metal pattern? Also, list down the advantages of using metal pattern over wooden.
2. Draw the Schematic illustration of sand mold showing various features.
3. Write the requirements of good pattern

Experiment 02

MELTING OF METAL

All type of metal melting furnace can be used for foundry operations. However, foundry requirements are some times unique and one or another type of furnace may be best for a particular operation.

The choice of furnace may be detailed by:

1. Consideration of initial cost.
2. Relative average cost of maintenance and repair.
3. Base cost of operation.
4. Availability and relative cost of various fuels.
5. Cleanliness and noise level in operation.
6. Melting efficiency in particular the speed on melting.
7. Degree of control.
8. Composition and melting temperature of metal.

Cupolas: The cupola is the standard melting unit of the iron foundry. Cupola melting is generally cheapest netgid. Fuel of the cupola is preferably a good grade. Low sulpher coke anthracite coal may also be used. The furnace is charged at frequent intervals with proportional amounts of coke lime stone and metal.

It consists of a 20-35 ft refractory lined cylindrical steel stack resting on an iron bottom plate which is supported by four steel legs.

It has some part, tuyeres- superheating zone, melting zone, preheating zone stack charging door is 10-20 ft above the bottom doors. Tuyeres through which the air blast enters the cupola are located some 10-20 in above the bottom doors.

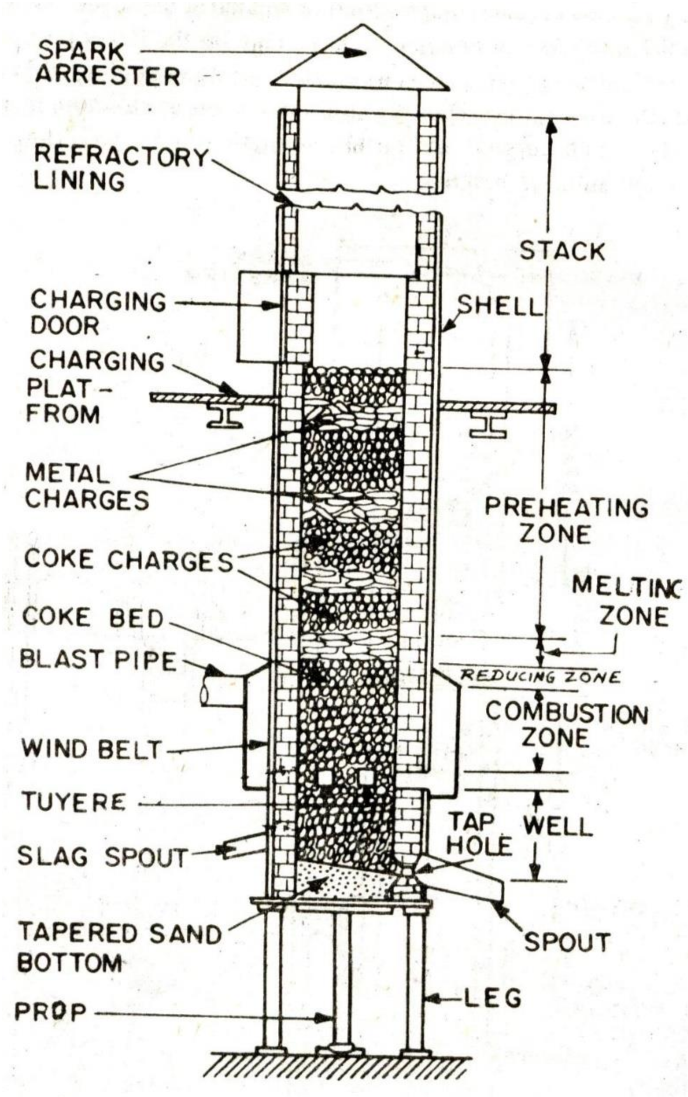


Figure-18: Cross-section through a cupola

Crucible furnace: The crucible furnace is the oldest type of melting furnace. This crucible was placed in a pit dug into the ground. Wood or coke was packed around the crucible and ignited. But today coke oil or gas can be used as fuel. All non-ferrous metal are melted is pit furnace in coke fired units and cast iron can be melted if enough time allowed.

The cupola is a melting pot of a clay and graphite composition, which is molded to a standard shape and size from 1 to 400. The crucible number represents its approximate capacity in pound of aluminum.

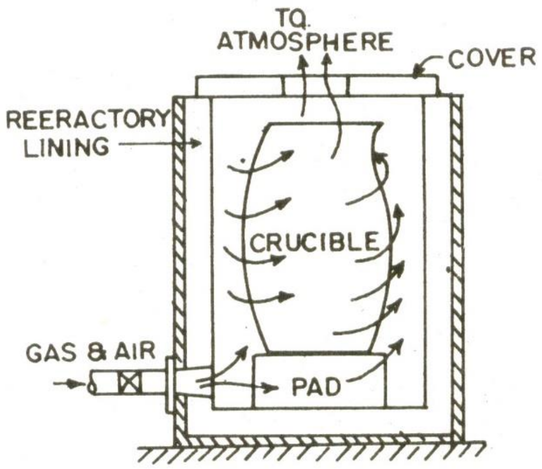


Figure-19: A gas fired crucible furnace

Open hearth furnace: Open hearth furnace is used by a few large foundries and all shops producing ingots. The melting rate is relatively slow depending upon the furnace size 10 to 200 tons metal may be melted at one time oil and gas used as fuel.

Assignment

1. What is casting defect?
2. What type of casting defect was identified, while you were doing the experiment?
3. Mention the furnaces used melting of metal.
4. What are the causes for blow holes?

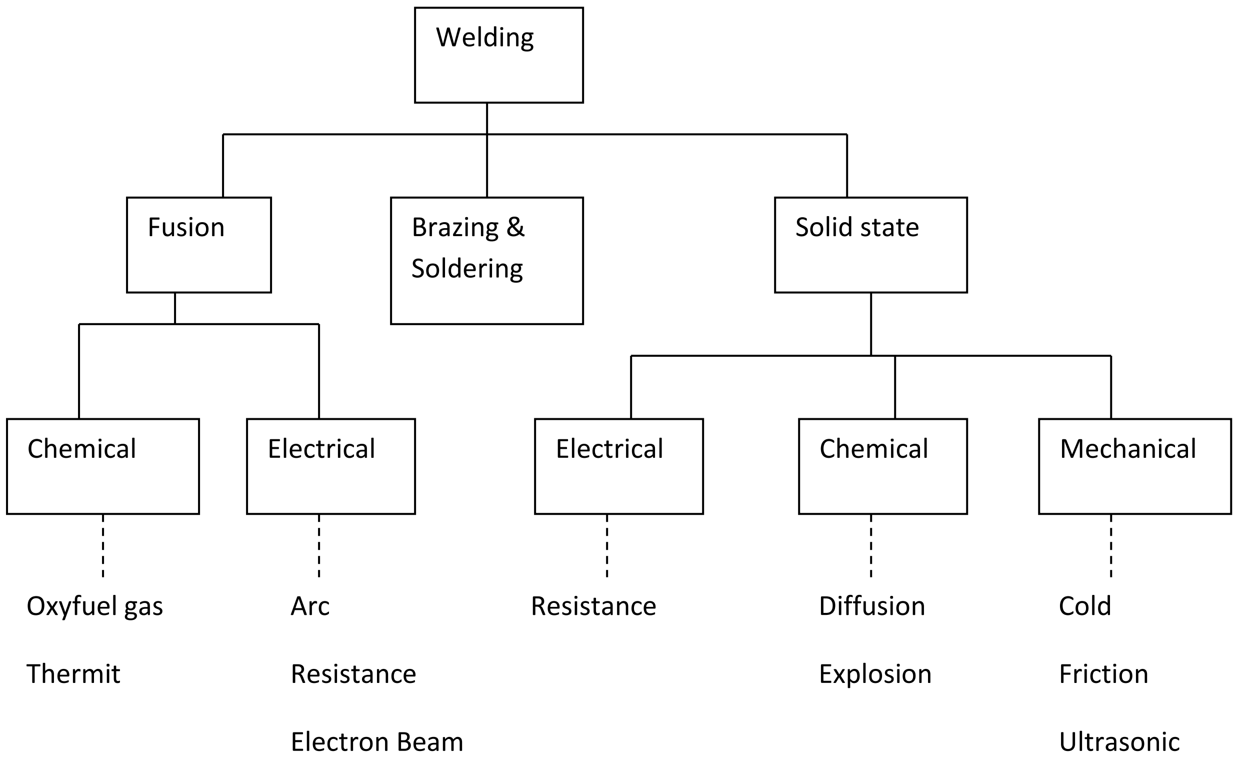
Experiment 03

<u>WELDING SHOP</u>

Definition of welding

Pieces of metals are joined together by fusing and coalescing them with the application of heat and filler metal.

Classification of welding



Arc welding (SMAW)

Metallic arc welding uses a metallic electrode of soft grade of iron, low carbon steel or other kind of filler rod or wire according to kind of work which is required to be done. The size of the wire used varies from 1/16 in to 3/16 in dia.

The heat of the arc is not only sufficient to melt the end of the electrode, but also fuse the surface of the work being welded over a small area. The two metal being fused and at the same time coming into close contact cause complete intermixing. As supply of heat to the arc is constant, the deposition of metal from the electrode remains continuous and uniform.

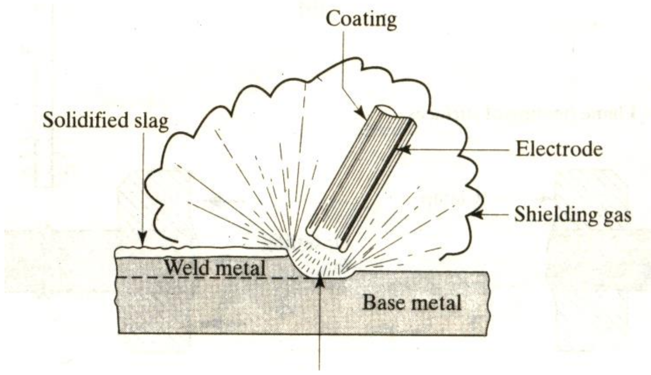


Figure-20: Schematic illustration of the shielded metal arc welding process.

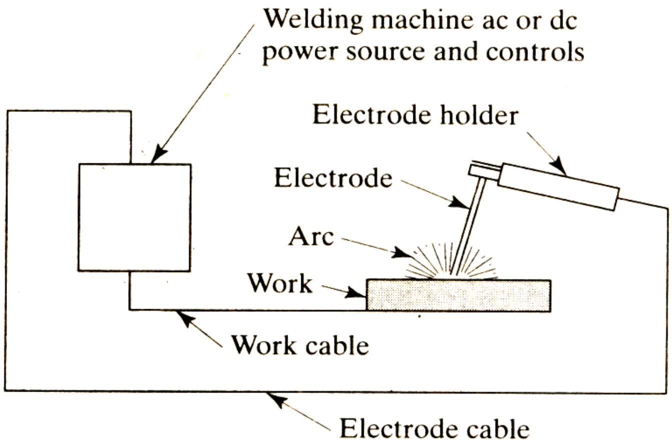


Figure-21: Schematic illustration of the shielded metal-arc welding operation (also known as stick welding, because the electrode is in the shape of a stick)

Characteristics of arc welding

Metal arc welding consists essentially of localized progressive melting and flowing together of adjacent edge of base metal parts by means of temperatures approximately 10000ºF of a sustained electric arc between a metal electrode and the base metal.

Polarity:

Polarity means the relative connection of electrode and work piece with power source.

There are two system of polarity. Namely:-

(a) <u>Straight polarity</u>: The arrangement of arc welding leads where work is connected with the positive pole and the electrode is connected with the negative pole of the circuit.

(b) <u>Reverse polarity</u>: Reverse polarity is just opposite of Straight polarity.

Application of arc welding

The principal advantages derived from the source of arc welding are (1) High quality welds, (2) great flexibility, (3) Rapid deposition rates, and (4) favorable unit welding costs. Some of the structures built by using arc welding are Tank, Bridge, Boilers etc.

Electrode

In electric arc welding, the weld metal is supplied through the action of the electric current as it passes through a metal rod called electrode.

Physical feature of electrode

Electrode consists of core wire and flux, Core wire is made of soft grade of Iron, Low carbon steel, or other kind of filler rod.

Metal electrode

Metal electrodes are generally used in hand welding. They are commercially manufactured in diameter size ranging from 1/16 in to 3/8 in and usually in length of 14 to 18 inches. The proper size of electrode to be used depends upon the requirements of the weld and the materials to be welded. The type of work and the composition of material to be welded determine the composition of the electrode. Among the several type of electrodes now in common use are bare electrode, dust and light coated electrode or semi coated and heavy coated or cover electrode.

The electric arc as a heat source

A source of AC or DC power is the ultimate source of heat in the electric arc. The arc itself is struck between the electrode and the work thus closing the electrical circuit. In DC welding, there is about 60 volts potential drop between the electrode and the work when no current is flowing. In AC welding, since the arc goes out 120 times a second, we require a slightly higher voltage e.g. 80 volts. The source of e.m.f. with either current is a rather specialized piece of equipment designed to have a high starting voltage in comparison to its working voltage but while the arc is burning the voltage drop across the arc is around 20-30 volts. The AC source is generally a transformer; the DC source is rotating generator.

Function of flux

It is a substance used in weld helps to reduce the melting point of the metal piece to be welded, prevent or remove oxidation. The brown colored coating on the electrode is called flux. This also serves the purpose of gradually cooling the depositing metal which is welded.

Assignment

1. Explain the functions of electrode covering (flux) in welding process.
2. Draw the schematic illustration of the Shielded Metal Arc Welding (SMAW) operation.
3. Why tack welding was done in your experiment?

Experiment 04,05

Gas metal arc welding

In Gas metal-arc welding (GMAW), formerly called metal inert gas welding, the weld area is shielded by an effectively inert atmosphere of argon, helium, carbon dioxide, or various other gas mixtures. The consumable bare wire is fed automatically through a nozzle into the weld arc.

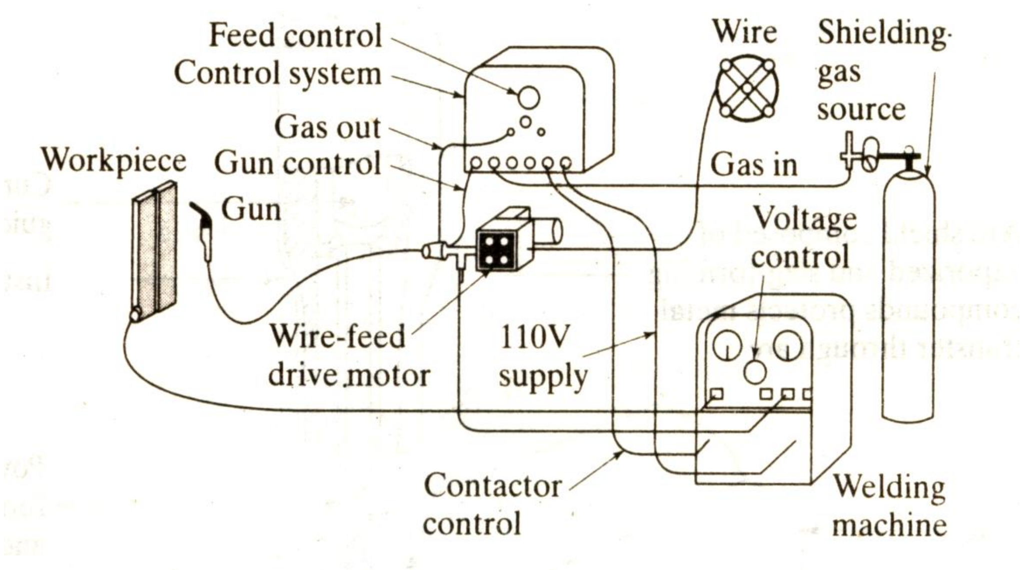


Figure-22: Basic Equipments Used In Gas Metal Arc Welding Operations

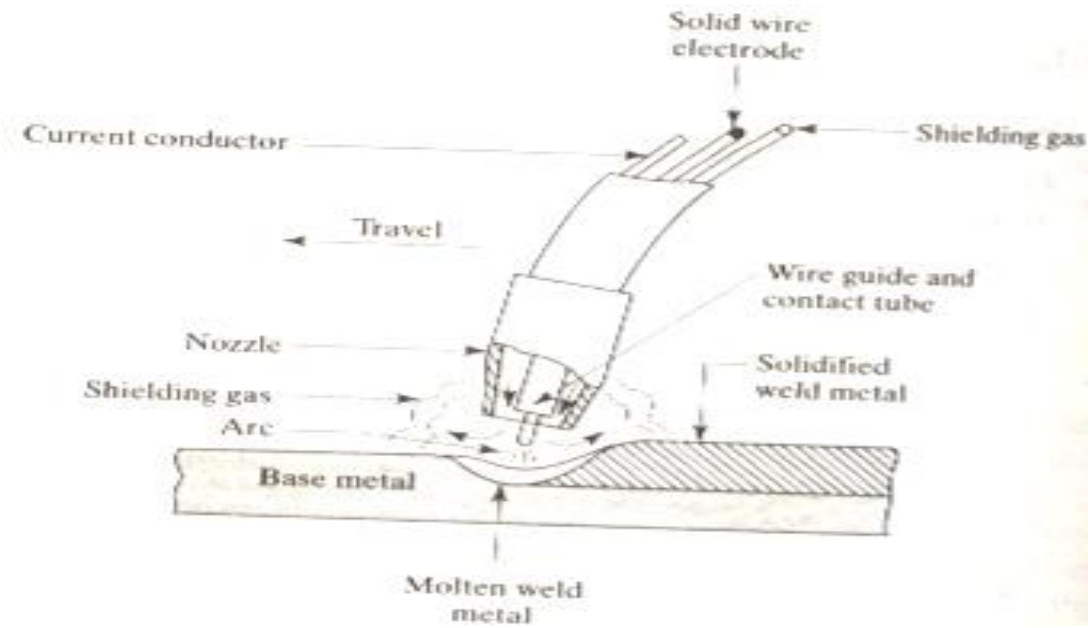


Figure-23: Schematic illustration of the gas metal arc welding process

Gas welding

Introduction of gas welding

Satisfactory Oxygas welding requires that a fuel gas be employed which will produce high temperature concentrated flame when burned at the presence of commercial oxygen. Gas welding consists of the use of a fuel gas flames as a source of heat to raise the temperature of a metal work piece to its fusion. The liquid bodies flow together and solidify subsequently to make the bond.

Definition of gas welding

Oxy acetylene fed to blow pipe where they are burned to form sources of intense heat. This is used to heat and fused the edge of the joint and to melt a filter rod, which is thus deposited in the molten state at the joint.

Application of oxy-acetylene welding

Most commercial metal are welded satisfactorily with the oxy-acetyling process. This probably accounts for its wide acceptance in dodder industry

Characteristics of oxy acetylene flame

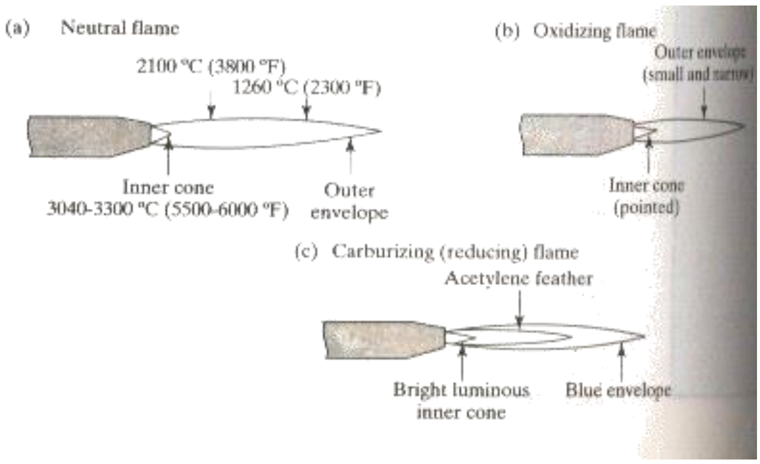


Figure-24: Different Oxy-Acetylene Flames

(1) **<u>Neutral flame</u>:** Equal proportion of oxy-acetylene Temperature 5850°F

(2) **<u>Oxidizing flame</u>:** Excess of oxygen. Temperatures 6300 °F

(3) **<u>Reducing / Carburizing flame</u>:** Excess of acetylene temperature 5550°F

Different types of flame used for welding different materials

<u>Cast Iron</u>: A neutral flame should be used along with cast iron filler rod of proper size. Flux is required for proper welding. It contains a mixture of iron oxide carbonate of soda

<u>Aluminum</u>: Neutral flame should be used when welding large aluminum casting The casting should be preheated about 600°F. Flux should be required for proper welding steel, stainless steel and

<u>Counter</u>: Flame should be used when welding large casting copper precept should be required Flux should be required for proper welding.

<u>Brass</u>: Oxidizing flame should be used including with flux.

Pressure in oxygen and acetylene cylinder

Cylinder is charged with oxygen at a pressure of 2200 lbs to 3000 lbs per square inch at 70°F. Since all gases expand when heated and contract when cooled, the pressure of the oxygen in the close cylinder will of course increase and decrease with the temperature changes as the cylinders volumes remain constant. if for an example a full cylinders of oxygen is allowed to stand outdoor for several hours when the temperature is say 30°F or just below freezing point the pressure of the cylinder with register approximately 2000 P.S.I; when temperature goes above 70°F the pressure in a full cylinder will raise above 2200 P.S.I and also acetylene cylinder changed with dissolve acetone with a pressure of 225 P.S.I at 60 to 70°F.

Technique of welding:

Butt joint:

The execution of butt joint is a frequent part of welding practice of brass with joint thickness being 1/32’’ and more. In dealing with such work there is a choice between two methods of workings.

a. Leftward (forward)
b. Rightward (or backward) method.

The leftward weld is made working from right to left. Whilst the receive direction is followed for right word working in each case the filler rod being held in the left carried to the left of the blow pipe. The left word method is fond most advantages on the sheet plate 1″/4 and non ferrous metals whilst sheet work over 1″/4 the right word method is used angle for the rod and two blow pipe are

a. Filler rod at angle of 30°-40° and blow pipe 60°-70°F
b. Filler rod at an angle of 30°-40°F and blow pipe 40°-50° right hand method.

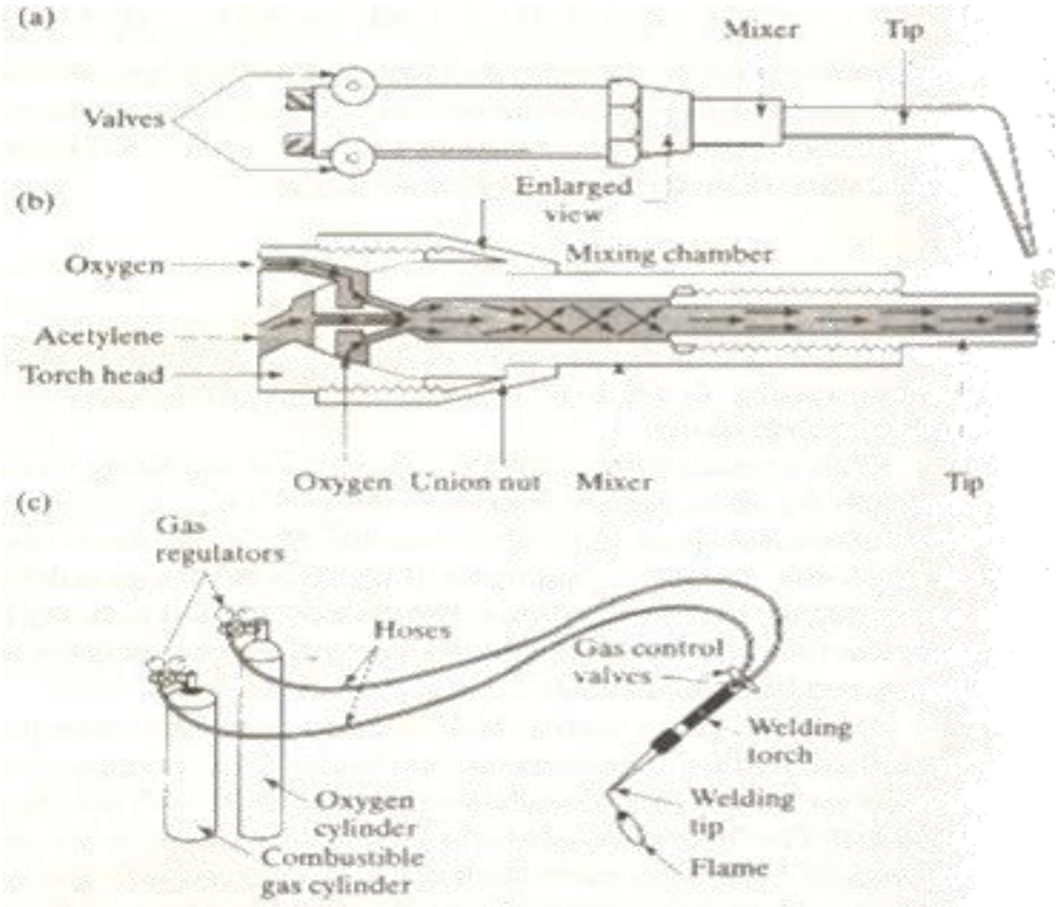


Figure-25: Gas Welding Equipment And Mixing Mechanism

The place of oxygen cutting in industry:

<u>Definition and classification</u>: the process of oxygen cutting consists of burning the materials along with pre determined path and removing the resultant oxide from the cut by jet of oxygen.

The Tip To Metal Distance

The time necessary to take the work piece to melting temperature greatly depends on the distance from the tip to the metal surface. The flame is hottest within 1.5 to 2 mm of its inner cone. Therefore in preheating the torch should be positioned so as to maintain this distance making the inner cone touches the surface. Otherwise cut surfaces may be cut and bruised. The piece separation between the tip and the work is of special importance in the case of height gauge. The metal is best pre heated when the hottest parts of the flame is concentrated on the surface of the work piece. Practically this distance is 1-5 to2-5 mm.

Starting Of Flame Cut

The pre heating flame is made to play on the edge piece until a small area around the start of cut raised to kindling temperature. In practice the start of a cut is usually heated until the surface layer of the metal is melted.

In cutting heavy section, the cutting tip is initially at an angle of 5 to 10 deg, to the surface of the piece to facilitate pre heating cross the entire thickness of the metal. In the case of height gauge (up to 50 mm) the tip should be hold vertically.

Brazing

Braze welding (for Bronge welding as it is sometimes refereed to) is similar to brazing in that it uses non ferrous filter metal which melts at temperature above 800 °F but below melting point of the base metal. It differs in that the filler metal is not distributed throughout the joint by capillary attraction. Brazing and braze welding are highly suitable method for joining dissimilar metals, repairing gray cast-iron casting and joining pipes thin gauge metals and small assemblies. They are extensively used in such industries and occupations as refrigeration, heating, air conditioning, electronics and auto automotive etc.

Soldering

Soldering is similar to brazing in that also filler metal is used to join the two metal surfaces without melting base metal. It is different from brazing in that the filler metal melts at temperature below 800 °F.

Joining of metal pieces by welding

There are five types of important joints in welding

1. Butt joint
2. Lap joint
3. Tee or fillet joint
4. Corner joint
5. Edge joint

Sub division of the above types of joint

Butt joints are classified as

1. open square butt joint
2. single VEE butt joint
3. double VEE butt joint
4. single W butt joint
5. Single U butt joint

Lap joint

1. Single fillet lap joint
2. Double fillet lap joint

TEE fillet joint

1. Single TEE joint
2. Single bevel TEE joint
3. Single J TEE joint
4. Double J TEE joint
5. Double bevel TEE joint

Corner joints are as follows

1. flash corner joint
2. Half open corner joint
3. Full open corner joint

Edge joint

1. Single edge joint
2. Double edge joint

Properties of weld

Penetration:

Penetration is an important property of any fusion weld. An appreciable depth of fusion assures through inter mingling of the filler and parent metal homogeneously in the fusion zone and elimination of void that would otherwise appear in the weld.

Distortion

When a metal is heated it expands and when it is cooled it Contracts. The contraction of weld metal as it cools after deposition causes distortion.

Reduce distortion

Distortion may be reduced by the use of a cooling jig that is a jig made of a material such as copper which serve the double function of holding the job in position and also conducting away the heat of welding.

Under Cut

A groove melted in to the base metal adjacent to the weld and left unfilled.

Defects of weld

1. blow holes/ porosity
2. Under cut
3. Distortion
4. Over lapping

Weld test

- **Non-destructive Tests**

1) Visual Inspection
2) Magnetic Particles
3) Penetrant method
4) Radio graphic method
5) Ultrasonic
6) Eddy current

- **Destructive test**

1) The bend test.
2) The impact test.
3) The tensile test.
4) The nick break test.
5) The hardness test.
6) The etch test.

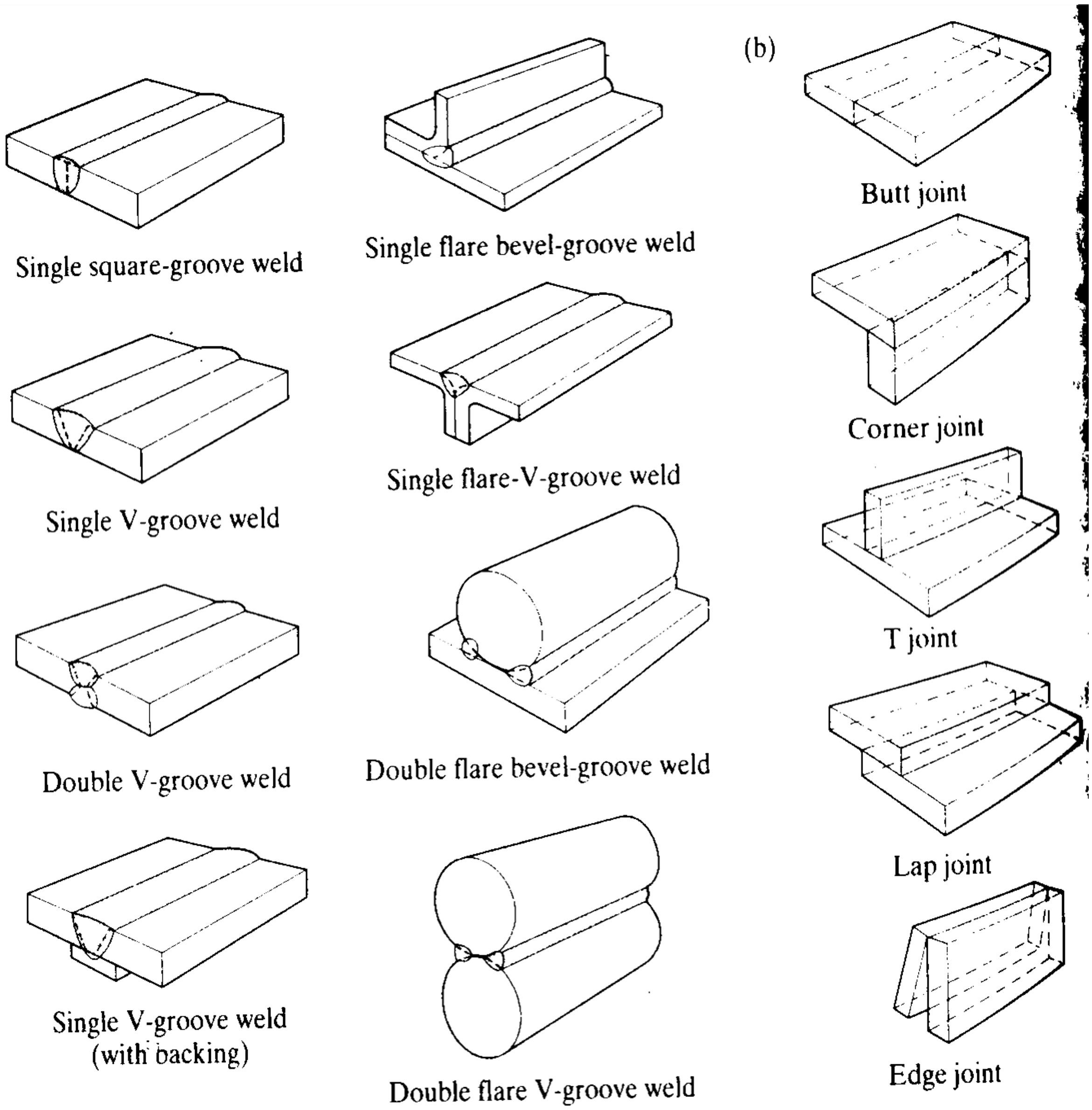


Figure-26: Example of Joints

Assignment:

1) Name potential reasons behind the following welding defects
   i. Distortion
   ii. Porosity
   iii. Undercutting

2) Is it essential to learn about the different types of flames characteristics before carrying out any Oxy-acetylene welding operation? Justify your answer.
3) Describe the necessity of a shielding gas medium in MIG welding.
4) Why Acetylene gas is used as fuel in gas welding instead of Propane and Butane?

Experiment 06

Study of Engine Lathe and Practice

Objectives:

- To introduce with lathe machine and lathe accessories
- To operate lathe to produce an assigned job

Theory:

In a lathe machine, material is removed from a work piece by rotating it when a cutting tool is moved longitudinally with a depth of cut. Lathe machines are widely used to work on cylindrical work pieces. Various lathe operations are turning (straight & taper), facing, threading, chamfering, parting, boring, drilling, knurling etc.

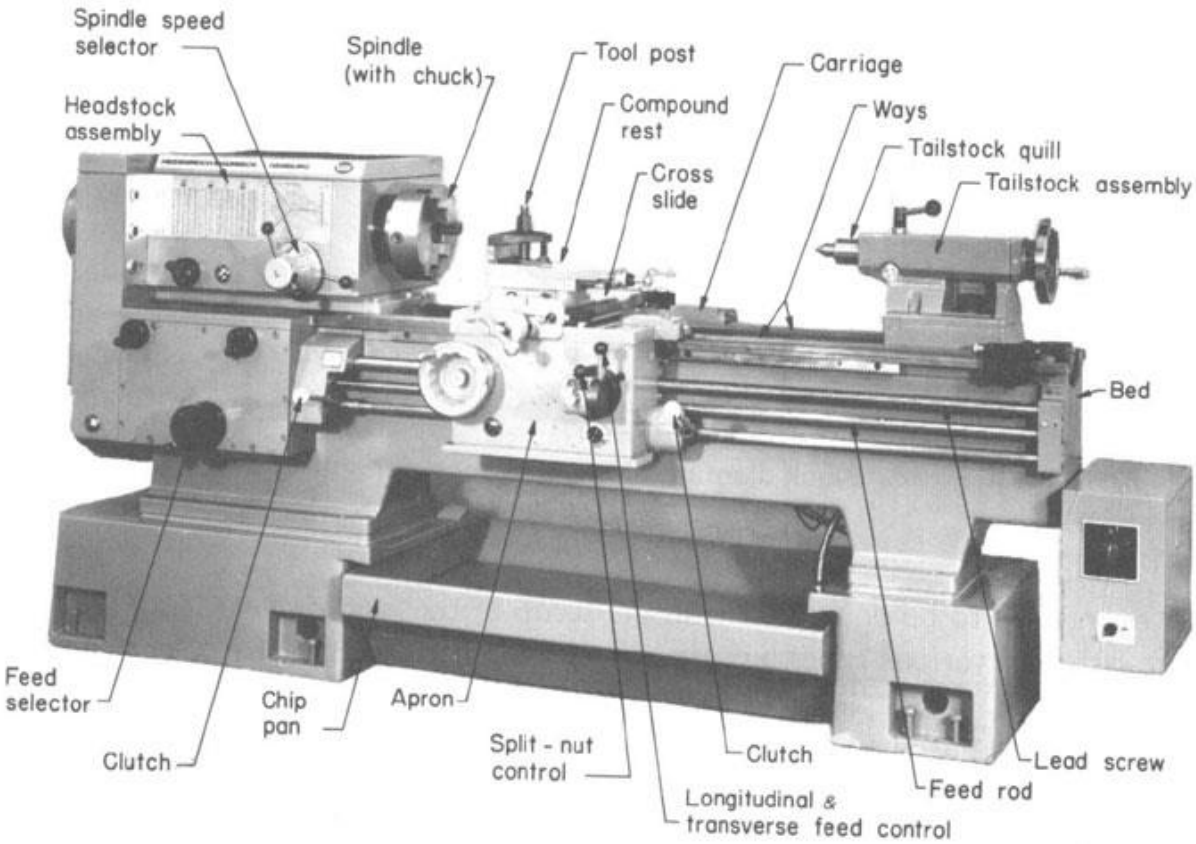


Figure-27: Engine lathe with principal parts named

The principal movement of lathe is the rotation of spindle. The feed is given by the longitudinal travel of carriage and cross traverse of cross slide. The auxiliary movement is the rapid traverse of carriage & cross slide.

Principle units:

All engine lathes have practically the same arrangement of the principal units. In a typical engine lathe, the principal units are:

1.Bed	2.Motor Drive	3.Feed Gear Box
4.Headstock	5. Tailstock	6.Spindle
7.Slide Ways	8.Lead Screw	9.Feed Rod
10.Saddle	11.Carriage	12.Cross Slide
13.Swivel Plate	14.Compound Rest	15.Top Slide
16.Tool Post	17.Half Nut	

Lathe accessories:

1.Lathe Centers	2.Lathe Dogs	3.Chuck
4.Steady Rest	5. Follower Rest	6.Faceplate
7.Mandrels	8.Tool Holders	9.Taper Attachments

Dimensions:

The size of a lathe is designated by two dimensions. The first is known as swing. This is the maximum diameter of work that can be rotated on a lathe. The second size dimension is the maximum distance between centers. This indicates the maximum length of the work piece that can be mounted between centers.

Applications:

Lathe is a very popular machine tool used for higher accuracy, improved control system, wider range of speed & feed and wider diversity of attachments. It is used for various purposes, such as

- Turning external cylindrical, taper & contour surfaces
- Boring cylindrical & taper holes
- Cutting external & internal threads
- Machining face surfaces
- Drilling, counter boring, counter sinking, reaming
- Cutting off, spot-facing etc.

Assignments:

1. Write down the functions of bed, headstock, and tailstock, cross slide, swivel plate, compound rest, top slide and tool post.
2. In which cases rest is used? What is the difference between steady rest & follower rest?
3. What fluids are used as coolants and why?
4. What is center drilling?

Experiment 07

Study of Different Operations in Engine Lathe and Manufacturing a Part

Objectives:

- To introduce with lathe machine and lathe operations
- To operate lathe using various operations to produce an assigned job

Theory:

Various operations can be done using lathe. Among them turning, facing, boring, parting, drilling, reaming, knurling etc are notable. Turning is the process of machining external cylinder and conical surfaces. It is usually performed on lathe. Relatively simple work and tool movements are involved in turning a cylindrical surface. The work piece is rotated longitudinally fed, single point cutting tool.

If the tool is fed at angle to the axis of rotation, an external conical surface is resulted, which is called "taper turning". If the tool is fed at 90^0 to the axis of rotation, using a tool that is wider than the width of the cut, the operation is called "facing".

Boring is internal turning. Boring can use single point cutting tools to produce internal cylinder or conical surfaces. It does not create the hole but rather machines or opens the hole up to a specific size.

Parting is the operation by which one section of a work piece is severed from the remainder by means of a cutoff tool. Because parting tools are quite thin and must have considerable overhang, this process is more difficult to perform accurately.

Assignments:

1. What operations are used to manufacture the assigned part in this experiment? Write down the name of operations with schematic figures sequentially.
2. What are the principal parts of Engine lathe machine?
3. What is the main different of a lathe & milling machine?
4. Why lathe machine is called mother of all machines?
5. Explain the purpose of a face plate, study rest & flower rest

Experiment 08

Study of Milling Machine

Objective:

- To introduce with different types of milling machine & milling cutter
- To study & operate milling machine

Theory:

Milling machine is a machine tool that removes material from a work piece by rotating a cutter and moving it into the material. Milling machines are a very versatile machine tool. Milling machines are capable of machining one or two pieces as well as large volume production runs. The milling machines can produce a variety of surfaces by using a circular cutter with multiple teeth that progressively produce chips as the cutter rotates.

Types of milling machines:

There are two major types of milling machines, the vertical milling machine and the horizontal milling machine. As their names imply, a vertical milling machine spindle is vertical and the horizontal milling machine spindle axis is horizontal

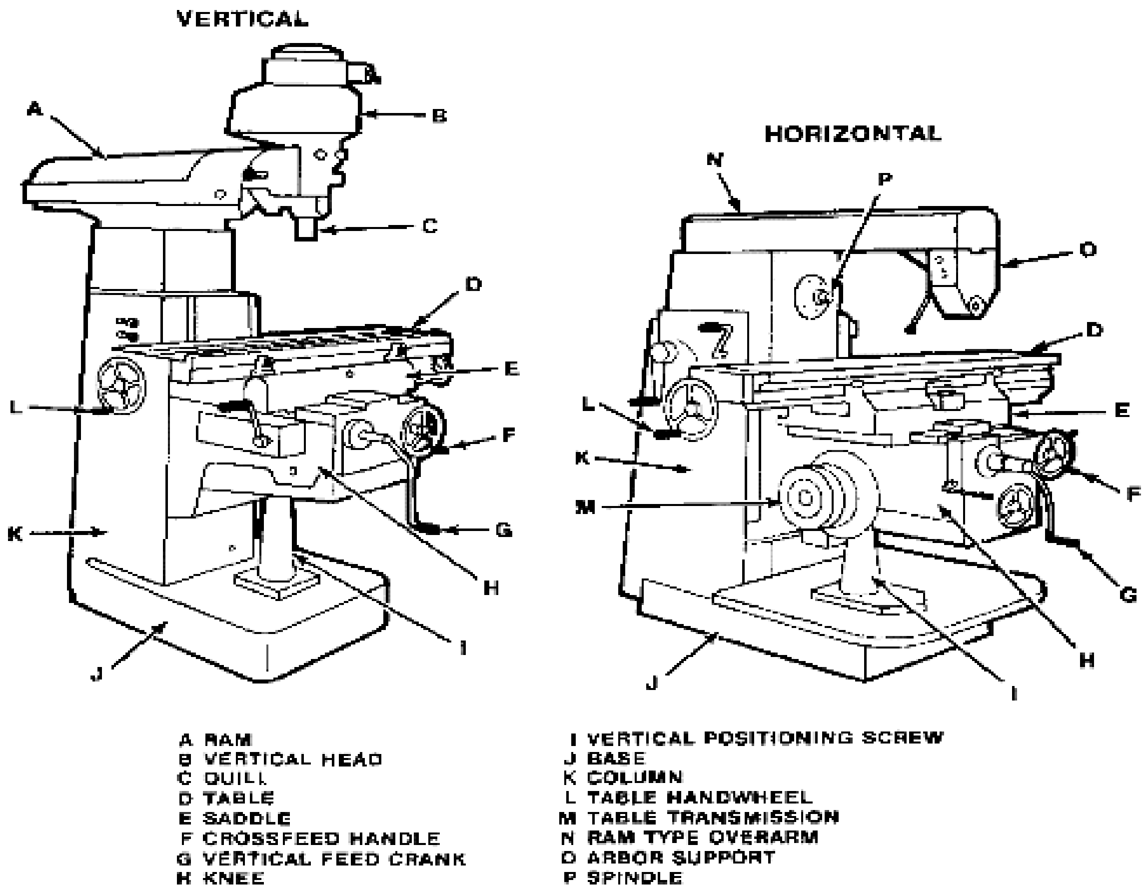
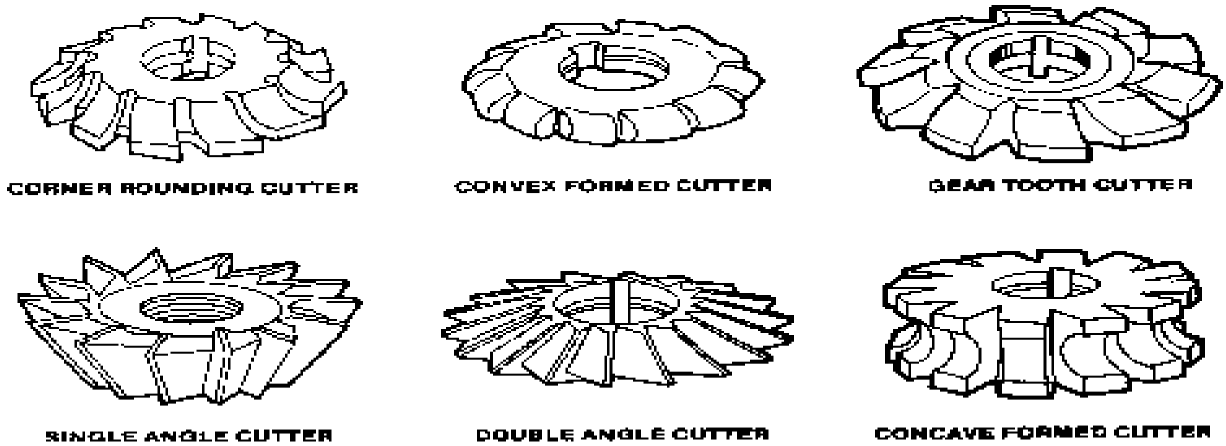


Figure 28 : Vertical & Horizontal Milling Machine

In a knee & column type milling machine, five types of movement can be found. The longitudinal traverse hand wheel moves the worktable to the left & right, the cross traverse hand wheel moves the work table in & out. The vertical crank moves the knee, saddle & worktable up & down. The swivel plate gives the angular movement and spindle gives the rotary movement.

Types of milling cutter:

A milling cutter is a multiple point cutting tool that is used on a milling machine. They are available in many types, forms, diameters and widths.



Milling operations:

There are different types of milling operations such as, slab milling, face milling, end milling etc.

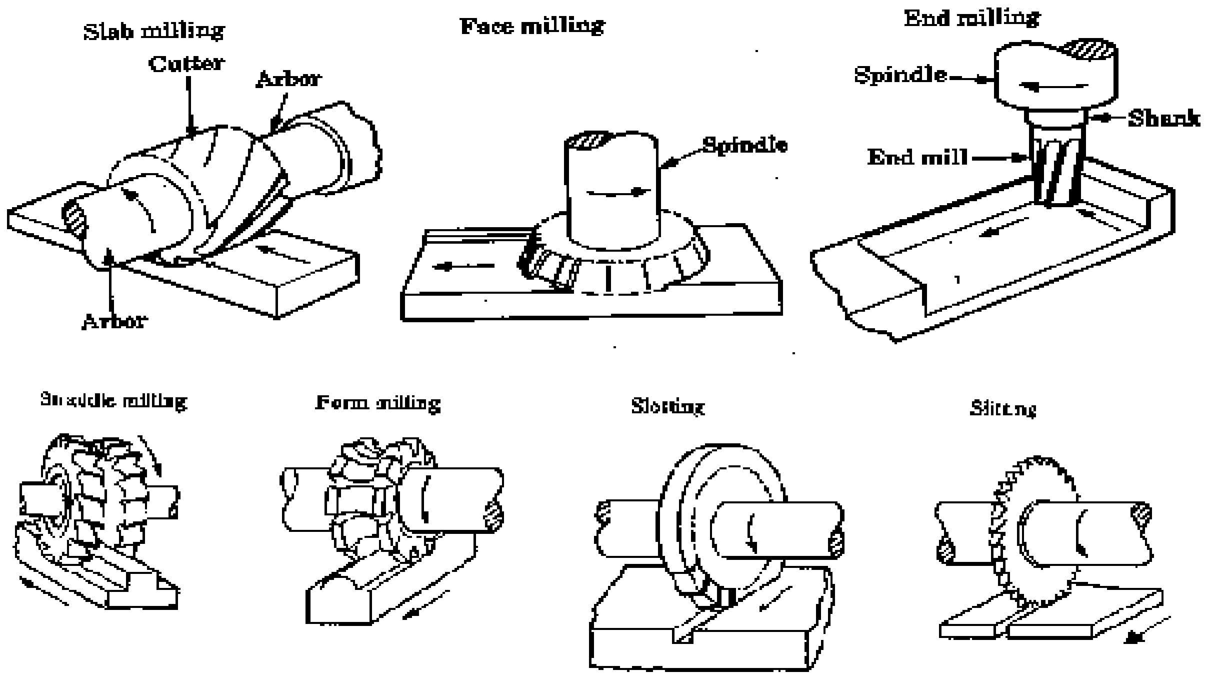


Figure 29: Various types of milling operation

Dividing head:

A dividing table is a tool that is used to divide a circle into equal divisions. Dividing heads are employed in operations on knee type milling machines for

- Setting work piece at the required angle to the table of the machine
- Turning the work piece through a predetermined angle
- Dividing circle into the required number of parts (indexing)
- Continuous rotation of work piece in milling helical grooves

There are plain dividing heads, optical dividing heads and universal dividing heads. Universal dividing heads are used for simple indexing, differential indexing and cutting helical grooves.

Assignments:

1. What is the difference between the machining procedure in lathe and milling machine?
2. What are the possible motions in a horizontal milling machine?
3. How many kinds of Milling Machine are available?
4. What are the principal parts of the plain knee & column milling machine?
5. How many types of Indexing?
6. What is a milling machine attachment?
7. What is a rotary attachment?
8. What is up milling & down milling?

Experiment 09

Study of Shaper Machine

Objectives:

- To introduce with shaper machine
- To study & operate shaper machine
- Be familiar with bull-gear mechanism

Theory:

The process of shaping is among the oldest single point machining processes that use a straight-line cutting motion with a single point cutting tool to generate a flat surface. In shaping, the work piece is fed at right angles to the cutting motion between successive strokes of the tool. The cutting tool reciprocates over the work piece to remove metal by digging deep into it. The work piece remains rigidly clamped on the table. Cutting motion takes place only in the forward stroke. The tool is held in the clapper box which prevents the cutting edge from being damaged on the return stroke of the tool.

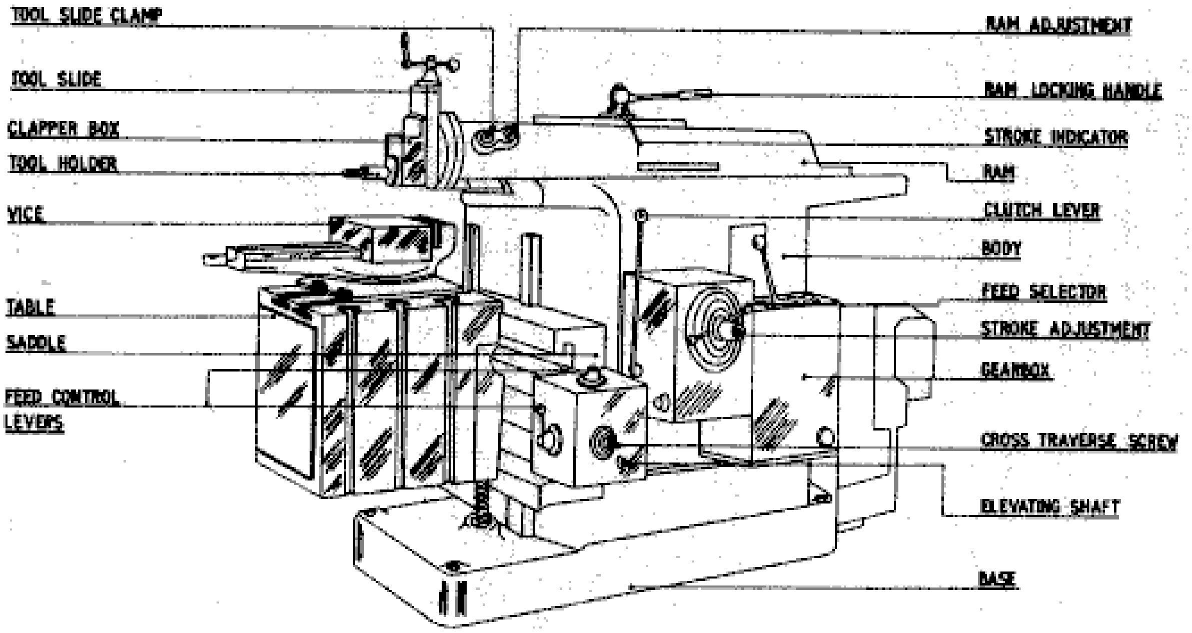


Figure 30: Different parts of shaper machine

The shaping machine is a versatile machine able to produce flat surfaces, grooves, T-Slots, dovetails, and may be used to produce curved surfaces. The size of components that may be machined is normally limited by the length of the stroke of the shaping machine which can vary up to a maximum of about 1500mm. The shaping machine is not generally used as a production tool because of its slow cutting speed and the unproductive return stroke.

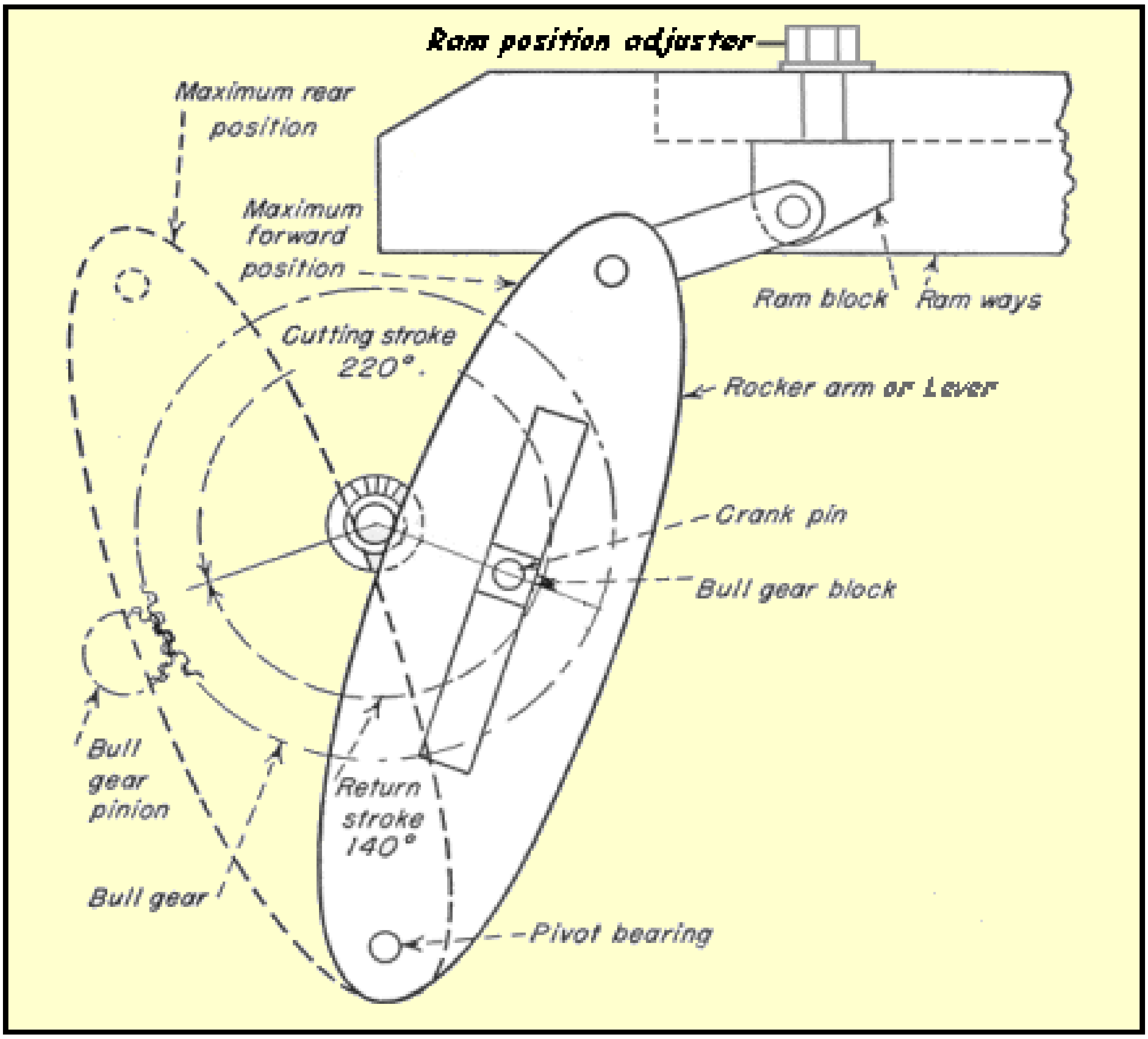


Figure 31: Bull gear mechanism

Assignments:

1. What is clapper box? Why it is used?
2. What is bull gear mechanism? Why it is used?
3. what are the principal parts of the shaper machine?
4. What is the main different between shaper & planer machine?
5. How much clearance should there be between the work in the vice & the ram?

Experiment 10

Manufacturing a Job using Bench, Drilling Machine and Grinding Machine

Objectives:

- To introduce with bench, drilling machine & grinding machine
- To use various hand tools and machines to produce an assigned job

Theory:

In manufacturing it is probable that more holes are produced than any other shape and a large proportion of these are made by drilling. The basic work and tool motions are required for drilling; relative rotation between the work piece and the tool, with relative longitudinal feeding.

The common name for the machine tool used for drilling is the drill press. Drill press consists of a base, a column that supports a power head, a spindle and a worktable.

Figure 32: Drill press

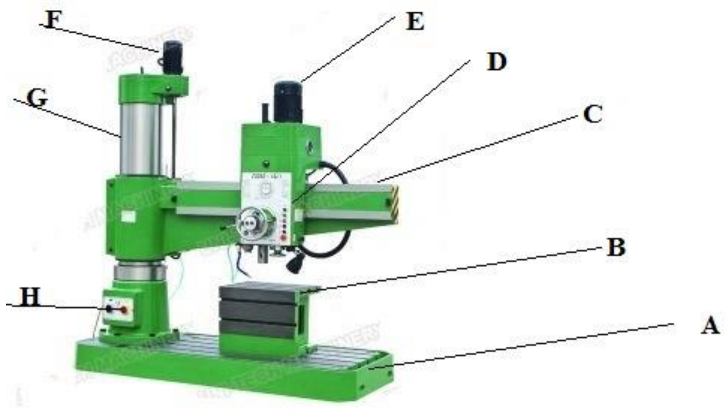


Figure 33: Radial Drill Machine

A= Bass
B=Table
C=Arm
D=Drill Head
E=Drill Head Motor
F=Lead Screw Motor
G=Column
H=Main Switch

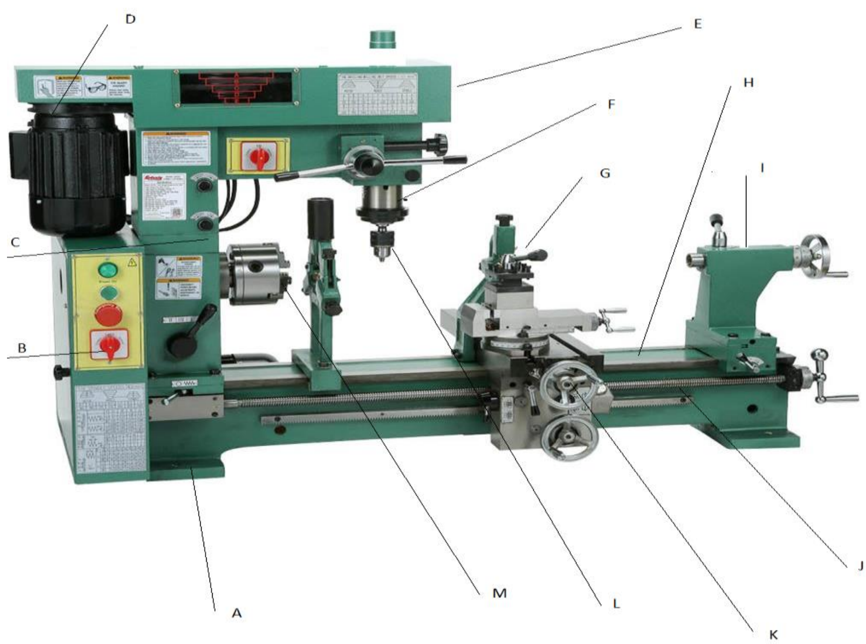


Figure 34: Different Parts of Drill and Lathe Machine

Abrasive machining is the basic process in which chips are formed by very small cutting edge that is integral parts of the abrasive particle. Grinding is one of the abrasive machining processes and it is done using grinding machine. Each abrasive grain in a grinding wheel is a cutting tool. Each has sharp cutting edge which cutoff tiny particles from the metal being ground. Grinding machines are precision machine tools. They machine metal parts to very close tolerances. Grinding machines are available for grinding flat surfaces, external & cylindrical surfaces, tapered surfaces and irregular surfaces.

Assignment:

1. What operations are used to manufacture the assigned part in this experiment? Write down the name of operations with schematic figures sequentially
2. What will happen to a drill if the operating speed is too fast.
3. What is the tap drill size?
4. When the cutting speed known , how can you calculate the RPM ?