DEPARTMENT OF

# MECHANICAL ENGINEERING

# *FOUNDRY, FORGING AND WELDING LAB*

As per VTU Syllabus 2018

## (*18MEL38B/48B*)

As per VTU Syllabus CBCS scheme for III Semester

BAPUJI INSTITUTE OF ENGINEERING AND TECHNOLOGY
DAVANGERE- 577 004

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Name : ..................................................

USN : ..................................................

Semester: ............... Batch No.: ......................


Umesh D E/A B Vinayaka Patil Ravikumar H N

Faculty Incharge Instructor



BAPUJI INSTITUTE OF ENGINEERING AND TECHNOLOGY

DAVANGERE- 577 004

## VISION OF THE INSTITUTE

To be center of excellence recognized nationally and internationally, in distinctive areas of engineering education and research, based on a culture of innovation and invention.

## MISSION OF THE INSTITUTE

BIET contributes to the growth and development of its students by imparting a broad based engineering education and empowering them to be successful in their chosen field by inculcating in them positive approach, leadership qualities and ethical values.

## VISION OF THE DEPARTMENT

The department endeavors to be a center of excellence, to provide quality education leading the students to become professional mechanical engineers with ethics, contributing to the society through research, innovation, entrepreneurial and leadership qualities.

## MISSION OF THE DEPARTMENT

1. To impart quality technical education through effective teaching-learning process leading to development of professional skills and attitude to excel in Mechanical Engineering.
2. To interact with institutes of repute, to enhance academic and research activities.
3. To inculcate creative thinking abilities among students and develop entrepreneurial skills.
4. To imbibe ethical, environmental friendly and moral values amongst students through broad based education

# PROGRAM EDUCATIONAL OBJECTIVES (PEO'S)

1. Enable to understand mechanical engineering systems those are technically viable, economically feasible and socially acceptable to enhance quality of life.
2. Apply modern tools and techniques to solve problems in mechanical and allied engineering streams.
3. Communicate effectively using innovative tools, to demonstrate leadership and entrepreneurial skills.
4. Be a professional having ethical attitude with multidisciplinary approach to achieve self and organizational goals.
5. Utilize the best academic environment to create opportunity to cultivate lifelong learning skills needed to succeed in profession.

# PROGRAM SPECIFIC OUTCOMES (PSO'S)

PS01:-Apply the acquired knowledge in design, thermal, manufacturing and interdisciplinary areas for solving industry and socially relevant problems.

PS02:-To enhance the abilities of students by imparting knowledge in emerging technologies to make them confident mechanical engineers.

**B. E. MECHANICAL ENGINEERING**

**Choice Based Credit System (CBCS) and Outcome Based Education (OBE)**

**FOUNDRY, FORGING AND WELDING LAB**

| | | | |
|---|---|---|---|
| Course Code | **18MEL38B/48B** | CIE Marks | 40 |
| Teaching Hours/Week (L:T:P) | 0:2:2 | SEE Marks | 60 |
| Credits | 02 | Exam Hours | 03 |

**Course Learning Objectives:**

To provide an insight into different sand preparation and foundry equipment.

To provide an insight into different forging tools and equipment and arc welding tools and equipment.

To provide training to students to enhance their practical skills in welding, forging and hand moulding.

To practically demonstrate precautions to be taken during casting, hot working and welding operations.

| Sl No | Experiments |
|---|---|
| | **PART A** |
| 1 | **Testing of Molding sand and Core sand:**<br>**Preparation of sand specimens and conduction of the following tests:**<br>1. Compression, Shear and Tensile tests on Universal Sand Testing Machine.<br>2. Permeability test<br>3. Sieve Analysis to find Grain Fineness Number (GFN) of Base Sand<br>4. Clay content determination on Base Sand.<br>**Welding Practice:**<br>Use of Arc welding tools and welding equipment<br>Preparation of welded joints using Arc Welding equipment<br>L-Joint, T-Joint, Butt joint, V-Joint, Lap joints on M.S. flats |
| | **PART B** |
| 2 | **Foundry Practice:**<br>**Use of foundry tools and other equipment for Preparation of molding sand mixture.**<br>**Preparation of green sand molds kept ready for pouring in the following cases:**<br>1. Using two molding boxes (hand cut molds).<br>2. Using patterns (Single piece pattern and Split pattern).<br>3. Incorporating core in the mold (Core boxes).<br>4. Preparation of one casting (Aluminum or cast iron-Demonstration only) |
| | **PART C** |
| 3 | **Forging Operations:**<br>Use of forging tools and other forging equipment.<br>• Calculation of length of the raw material required to prepare the model considering scale loss.<br>• Preparing minimum three forged models involving upsetting, drawing and bending operations. |

**Course Outcomes:** At the end of the course, the student will be able to:

Demonstrate various skills in preparation of molding sand for conducting tensile, shear and compression tests using Universal sand testing machine.

Demonstrate skills in determining permeability, clay content and Grain Fineness Number of base sands.

Demonstrate skills in preparation of forging models involving upsetting, drawing and bending operations.

## DO's

1. Students must always wear uniform and shoes before entering the lab.
2. Proper code of conduct and ethics must be followed in the lab.
3. Windows and doors to be kept open for proper ventilation and air circulation.
4. Note down the specifications of the experimental setup before performing the experiment.
5. Check for the electrical connections and inform if any discrepancy found to the attention of lecturer/lab instructor.
6. Perform the experiment under the supervision/guidance of a lecturer/lab instructor only.
7. After the observations are noted down switch off the electrical connections.
8. In case of fire use fire extinguisher/throw the sand provided in the lab.
9. In case of any physical injuries or emergencies use first aid box provided.
10. Any unsafe conditions prevailing in the lab can be brought to the notice of the lab in charge.

## DONT's

1. Do not operate any experimental setup to its maximum value.
2. Do not touch/ handle the experimental setups/Test Rigs without their prior knowledge,
3. Never overcrowd the experimental setup/Test Rig, Leave sufficient space for the person to operate the equipment's.
4. Never rest your hands on the equipment or on the display board, because it has fragile measurement devices like thermometers, manometers, etc.

## SAFETY MEASURES FOR FOUNDRY, FORGING AND WELDING LAB

1. Work areas are monitored regularly to ensure that good housekeeping practices are being followed and adequate lighting is provided in the working areas.
2. Foundry lab is equipped with safety blankets, automatic emergency showers to extinguish fire.
3. Suitable protective clothing and eye protection such as goggles, should be worn in the laboratory.
4. Use dust mask to avoid dusts from sand, parting dusts and chemicals which are hazardous
5. Floors around furnaces should be slip-resistant, non- combustible material, kept free of obstructions and cleaned regularly.
6. Always use safety glasses, even minor mishaps can cause blindness.
7. Always wear proper clothes such as apron and foot-wears.
8. No person should stand in line with the flying objects during forging.
9. Always use proper tongs to grip and lift objects according to the type of work to avoid slipping of raw material.
10. Always put out the fire in the forge before leaving the forging shop.

# GENERAL INSTRUCTIONS:

## INSTRUCTION TO THE STUDENT:-

All students are

1. Required to be present in the laboratory in time.
2. Informed to note down the tabular column, specifications of the machines, observations and calculations from lab manual before the commencement of each lab.
3. Informed to follow the procedure, which is given in the laboratory manual to conduct respective experiment.
4. Informed to come with the write- up and results of the previous experiment without fail for conducting the next experiment.
5. Informed to conduct each experiment in presence of staff member or lab instructor.
6. Informed to take the tools to conduct each experiment and must return them on completion of that experiment without fail. If students are unable to return the Tools in good, conditions, a suitable penalty will be imposed on them.

## SAFTY PRECAUTIONS:

1. Contact the instructors before starting a machine or the experiment
2. Do not start a machine of which the operation is not known which leads to accidents as well as damage to the machine.
3. Keep your eyes protected from the flying chips during forging operations.
4. Handle machine/tools properly and carefully.
5. Avoid loose clothing and long unbuttoned sleeves while working on a machine.
6. Wear boots or shoes in the laboratory.

## DRESS CODE:

Students must always wear uniform and shoes during his laboratory session.

# Part A:

# TESTING OF
# MOLDING SAND AND CORE SAND

# INTRODUCTION

**FOUNDRY:**

Foundry engineering deals with the process of making casting in moulds prepared by patterns.

The whole process of producing castings may be classified into the following five stages.

1. Pattern making.
2. Molding and core making.
3. Melting and casting.
4. Fettling
5. Testing and inspection.

Except pattern making, all other stages to produce castings are done in the foundry shops.

Pattern is the principle tool used in the casting process. It may defined as a model of any thing, so constructed that it may be used for forming an impression called mould in sand or other suitable material When this mould is filled with the molten metal and metal is allowed to solidify, it forms reproduction of pattern, which is known as casting. The process of making a pattern is known as pattern making.

Almost any article may be cast with proper technique and design, and there is practically no limit to the size and shape of the castings to be produced.

**FOUNDRY AND SAND TEST:-**

Various sand tests are conducted on foundry sands to ascertain its working qualities. The sand tests help to a greater extent in controlling the sand properties which assist in making a good mould and hence to get sound castings.

**MOULD MAKING:-**

Molding is the process of preparing cavities of suitable shapes using patterns. These cavities may be formed by manual operations or machines. The various materials used are sand, plaster, cement and special molding mixtures.

**MOULDING TOOLS AND EQUIPMENTS:-**

A large number of tools and other equipments are used in foundry work. These can be classified in to following categories.

**Hand Tools: -** These are used by moulder in doing molding operation by hand. The common hand tools used in foundry works are as follows.

1. **Shovel: -** It consists of iron pan fitted with wooden handle. It is used for mixing and conditioning the foundry sand by hand and transferring it to the flask.
2. **Hand Ridel:** It consists of a wooden frame, fitted with screen of standard and wire mesh at its bottom. It is used for hand ridding of sand to remove foreign materials from it.
3. **Rammer:** It is a wooden tool used for packing or ramming the sand in to the mould.
4. **Trowel:** It consists of a metal blade fitted with a wooden handle and is employed in order to smooth or sleek over the surfaces of moulds.
5. **Slick:** It is a small double-ended tool having a flat on one end and a spoon on the other end. These are used for repairing and finishing small surfaces of the mould.
6. **Gate Cutter**: It is a small piece of tin plate and is used as a tool for cutting gates and runners in the mould.
7. **Strike Off Bar**: It is flat bar, made up of wood for or grain to strike off the excess sand from top of box after ramming. Its one edge is made beveled and surface perfectly smooth and plane.
8. **Vent Wire:** It is steel rod carrying a pointed edge at one end and wooden handle or bend at other. After ramming and striking off excess sand. It is used to make small holes called vents in sand moulds to allow the gases exit and steam during casting.
9. **Lifters or Cleaners:** They are also finishing tools and are used for repairing and finishing the sand mould after with drawl of pattern. They are used to remove loose sand from mould cavity.
10. **Draw Spike:** It is a pointed steel rod with a loop at one end and is used to rap and draw patterns from the sand.
11. **Molding Boxes:** Sand moulds are prepared in specially constructed molding boxes which will impart the necessary rigidity and strength to the sand in molding.
12. **Containers:** Used for containing in sand moulds and molten metal and also for transforming from one place to other. Sand testing and conditioning equipment: Used to determine the constituents and their composition and properties of molding sand.

**METAL MELTING EQUIPMENT:** It includes various types of melting furnaces.

**FLATTERING AND FINISHING EQUIPMENT:** For finishing of castings after they are taken out of mould.

**SMITHY AND FORGING:**

A blacksmith's work involves heating of a metal stock to a desired temperature; enable it to acquire sufficient plasticity, followed by the operations like hammering, bending and pressing etc., to give it the desired shape. This is known a*s forging.* The above operations can be carried out by hand hammering, by power hammers, by drop stamps or by forging machines.

*Hand Forging,* is the term used for the process when it is done by means of hand tools. Similarly forgoing done with the help of power hammers is known as *Power forging,* when carried out by means of drop hammers or drop stamps as *drop forging,* and when by forging machines as *Machine Forging.* Whatever may be the means of applying pressure for shaping the metal, the primary requirement always is to heat the metal to a definite temperature to convert it to plastic state. This may be done either in open hearth, known as *smith's forge,* or in closed furnaces of bigger capacities. Small jobs are normally heated in the smith's forge and larger jobs in closed furnaces. The *Hand forging* process is employed for relatively small components, machine forging for medium sized and large articles requiring very heavy blows and *drop forging* for mass production of identical parts.

The forging process is very important an is indispensable position among the various manufacturing processes generally adopted in the workshops, since it provides a number of advantages as given below, provided it is carried out.

1. It refines the structure of the metal.
2. It renders the metal stronger by setting the direction of the grains.
3. It effects considerable saving in time, labour and material as compared to the Production of a similar item by cutting from a solid stock and then shaping it.
4. Since the production of articles measuring with reasonable degree of accuracy is possible the machining operations can be avoided in most of the cases. This

Also results in a considerable saving of time and labor.

**FORGING TOOLS AND EQUIPMENTS:**

1. Anvil
2. Swage block
3. Hand Hammers
4. Tongs
5. Chisels
6. Swages
7. Fullers
8. Flatters/
9. Set Hammer
10. Punch & Drift

1. **ANVIL:** The anvil forms a support for blacksmith's work when hammering. The body of the anvil is made of mild steel with a tool steel face welded on the body, but the beak or horn used for bending curves is not steel faced. The round hole in the anvil called pritchel hole is used for bending rods of small diameter, and as a die for hot punching operations. The square or hardie hole is used for holding square shanks of various fittings.
Anvils vary up to about 100 to 150 kg and should stand with the top face about 0.75m from the floor. This height may be attained by resting the anvil on a cast iron or wooden base.

2. **SWAGE BLOCK:** This forge shop tool is used for mainly squaring, sizing, heading, bending and forming operations. It is 0.25m or wider and may be used either flat or edgewise in its stand.

3. **HAND HAMMER:**

Two kinds of hammers are used in hand forging:

1. The hand hammer used by the smith himself, and
2. The sledge hammer used by the striker.

**Hand hammers may be classified as:**

1. Ball peen hammer
2. Straight peen hammer
3. Cross peen hammer.

Hammer heads are made of cast steel, the ends hardened and tempered. The striking face is slightly convex. The weight of a hand hammer varies from about 0.5 to 2 kg while the weight of a sledge hammer varies from 4 to 10 kg.

4. **TONGS:** The work to be forged is generally held with tongs. The tongs generally used for holding work are,

1). Straight-lip fluted tong used for square, circular and hexagonal bar stock.
2). Ring tong used for bolts, rivets and other work of circular section.
3). Flat tong used for holding work of rectangular section.

5. **CHISELS:** Chisels are used for cutting metals and for nicking prior to breaking. They may be hot or cold. The main difference the two is in the edge. The edge of a cold chisel is hardened and tempered with an angle of about 60, while the edge of a hot chisel is 30 and the hardening is not necessary. The edge is made slightly rounded for better cutting action.

6. **SWAGES:** Swages are used for work which has to be reduced and finished to round, square or hexagonal form. These are made with half grooves of dimensions to suit the work being Reduced swages consist the top part having a handle and the bottom part having a square shank which fits in the hard i,e hole in the anvil face.

7. **FULLERS:** Fullers are used to give smoothness and accuracy to articles which have already been shaped by fullers and swages.

8. **SET HAMMER:** It is really a form of flatter. A set hammer is used for finishing comers in shouldered work where the flatter would inconvenient. It is also used for drawing out.

9. **PUNCH AND DRIFT:** A punch is used for making holes in metal part when it is at forging heat, and holes are opened out by driving through a larger tapered punch called a drift.

## EXPERIMENT – 1

### COMPRESSION, SHEAR AND TENSILE TESTS ON UNIVERSAL SAND TESTING MACHINE.

**Aim / Objective:** To determine the compression and shear strengths of a molding sand sample.

**List of Equipments: -** Universal Testing Machine (UTM) with all accessories, Sand Rammer, Sand specimen both wet and dry.

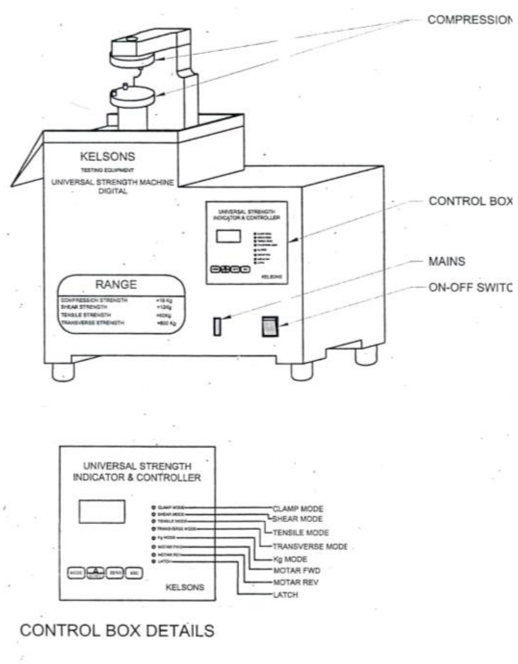
**Attachments:** 1. Tensile strength 2. Shear strength 3. Compressive strength

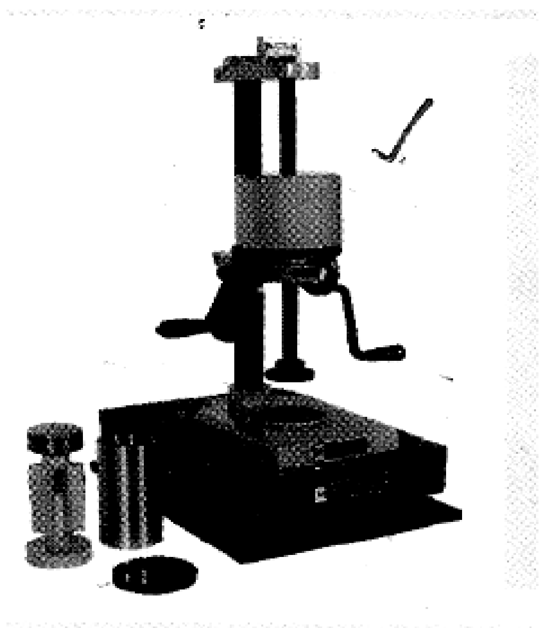
**Specifications of drying oven:**

1. Single Phase, 220V, 10 Amps.
2. Size: 14" X 12" X 12" (Depth)
3. Maximum temperature: 230°C to 300 °C

**Theoretical Background:-**

To find out the holding power ofvm1ous bonding materials in green and dry sand molds, strength tests are performed. The strength test is performed on the horizontal hydraulic press. The most commonly used tests are compression and shear tests. For the sand tests standard cylindrical specimen with 50 mm diameter 50 mm height prepared in a sand rammer is used.



**Universal Testing Machine** **Sand Rammer**

**Procedure:-**

Weigh in 145 to 155 gms of molding sand and prepare few (eight) specimens of the size H=D=50 mm.

For tensile strength**:-**

1. Hold the specimen between the two jaws of the UTM.
2. Rotate the hand wheel slowly till the specimen fractures.
3. Note down the corresponding reading on the gauge.
4. Repeat the above procedure for at least two specimens and take the average reading.

For shear strength**:-**

1. Change the jaws for shear strength.
2. Rotate the hand wheel slowly till the specimen fractures.
3. Repeat the above procedure for at least two specimens and take the average reading.

For compression strength**:-**

Repeat the same procedure as mentioned above by changing the jaws.

For dry strength:-

Heat the specimen in the oven for 2-3 hours and then carry out tests as mentioned above.

**Observations:-**

1. Height of specimen = …….mm
2. Diameter of specimen = ……..mm

**Tabulation:**

| **Sample No.** | **Type of strength** | **Dry/wet state** | **Strength in gms/cm2** | **Strength in kg/cm2** | **Mean strength kg/cm2** |
|---|---|---|---|---|---|
| 1 | **Compressive** | **Wet** | 1) ……..<br>2) ………<br>3) ……… | 1) ……..<br>2) ………<br>3) ……… | |
| 2 | **Shear** | | 1) ……..<br>2) ………<br>3) ……… | 1) ……..<br>2) ………<br>3) ……… | |
| 3 | **Compressive** | **Dry** | 1) ……..<br>2) ………<br>3) ……… | 1) ……..<br>2) ………<br>3) ……… | |
| 4 | **Shear** | | 1) ……..<br>2) ………<br>3) ……… | 1) ……..<br>2) ………<br>3) ……… | |

**Results:-**

| | | |
|---|---|---|
| 1) **Wet strength** --- | Compressive | = ……….. $Kg/cm^2$ |
| | Shear | = ………. $Kg/cm^2$ |
| 2) **Dry strength** --- | Compressive | =………….. $Kg/cm^2$ |
| | Shear | = ………… $Kg/cm^2$ |

## EXPERIMENT – 2

### PERMEABILITY TEST

**Aim / Objective**: To determine the Permeability number of the given sample of moulding sand.

**List of Equipments:**

1) Standard sand specimens,
2) Stopwatch,
3) Permeability meter.

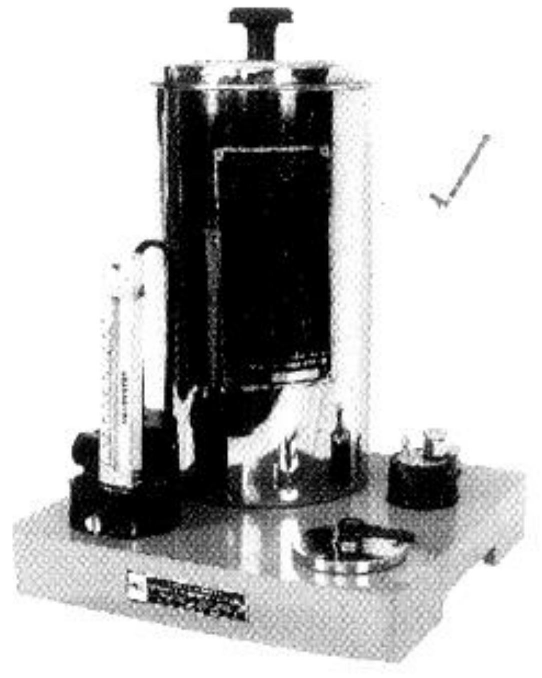
**Theoretical Background:**

Permeability and strength are two of the most essential properties of sand. Although the permeability and strength of sand depend primarily on the size and shape of the sand grains and the clay content, the required values would not be realized unless the correct quantity of water were mixed with the sand and the sand itself were rammed to a particular degree of hardness. If the sand hardness number does not exceed 85, it is observed that the product of the hardness number and the permeability remains a constant. For absolute determination, permeability is tested with an apparatus known as the *'permeability meter'*. Permeability is expressed in terms of the *permeability number,* which is defined as the volume of air in c.c. that will pass per minute through a sand sample of I sq. cm in cross section and I cm high, at a pressure of I gm per sq. cm. Thus,

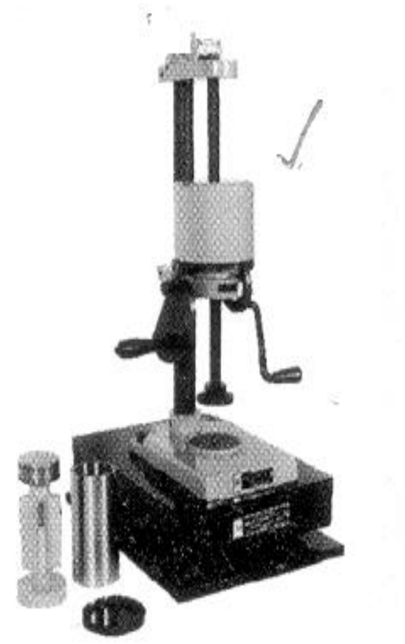
*Permeability Number = v.h / p.a.t*

*Where,* v= *Volume of air in c.c*
*h = Height of the sample in cm*
*p= Pressure of air in gm/sq.cm*
*a= Cross sectional area of the sample in sq.cm*
*t- Time in minutes*

Thus, *permeability* is a condition of porosity and thus is related to the passage of gaseous material through the sand. The permeability of sand is determined by using a standard cylindrical specimen (50mm diameter and 50 mm height) in the permeability tester. The permeability tester consists of a inverted floating bell in which 2000cc of air is trapped, a specimen tube, mercury seal and a water tube manometer. Molten metal alloys contain certain amount of dissolved gases, which are evolved when metal solidifies. Also the molten metal when comes in contact with the moist sand, generates steam and water vapor. If these gases and water vapor do not find passage to escape completely through the mold they will produce gas holes and pores in the casting. Therefore the sand must be sufficiently porous to allow the gases or moisture present in or generated to be removed freely while pouring. This property is known as porosity or permeability. Sands, which are coarse or have round grain, exhibit more permeability. Soft ramming and clay addition in lesser quantities improve permeability. Inadequate permeability causes defects like surfacing blows, gas holes etc.



**Permeability Meter**



**Sand Rammer**

**Procedure**:

1. Prepare a sand specimen using specimen preparation machine (Sand Rammer).
2. Keep the specimen along with the ram tube on the orifice of the permeability meter.
3. Close the air outlet valve by turning the knob of the permeability meter to "0" position and keep the specimen along with the ram tube on the orifice.
4. Open the valve by turning the knob to "P" position and allow inverted bell jar to come down slowly. Air will be pushed through the specimen to atmosphere.
5. Note down the stabilized manometer reading and time taken to pass 2000cc of air.
6. Permeability can be directly read from the calibrated chart by referring to pressure reading of manometer.
7. Repeat the same procedure by replacing the orifice of different diameter.
8. Compare the experimental value of permeability number with the theoretical value.

**Observations:**

1. Size of the specimen, Diameter, (d) = (50mm) 5 cm
2. Volume of air passed, (V) = 2000 $cm^3$
3. Cross-sectional area of specimen (A) = $\pi d^2 /4$
4. Time taken to pass 2000cc of air for 0.5 dia. Orifice = (30min.± 10sec.)
5. Time taken to pass 2000cc of air for Orifice = (20sec ±2sec)
6. Pressure reading for 0.5 dia. Orifice = ……….gm / $cm^2$
7. Pressure reading for 0.5 dia. Orifice = ……….gm / $cm^2$

Direct reading from chart

**Tabulation:**

| SL. No. | Diameter of orifice (mm) | Time (Minutes) | Manometer Reading | Permeability No. |
|---|---|---|---|---|
| 1 | 0.5 | 30min.± 10sec. | | |
| 2 | 1.5 | 20sec ±2sec. | | |

**Formulae required:**
Permeability Number (Theoretical value) = (v x h) /( p x a x t)

**Results:**

1. Calculated value of permeability number for 0.5 dia. Orifice. (Theoretical value) = 48
2. Permeability number from chart (Experimental value) = 47
1. Calculated value of permeability number for 1.5 dia. Orifice. (Theoretical value) = 55
2. Permeability number from chart (Experimental value) = 56

## EXPERIMENT – 3

### SIEVE ANALYSIS TO FIND GRAIN FINENESS NUMBER (GFN) OF BASE SAND

**Aim / Objective:** To find Grain Fineness Number (GFN) of the given sand sample.

**List of Equipments**:

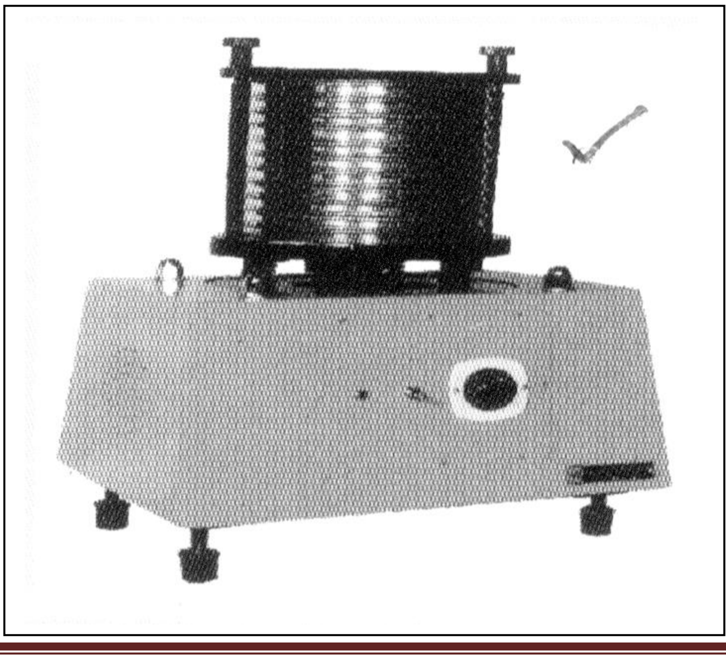
1. Sieve shaker
2. Digital weight balance
3. Standard set of 11 sieves.

**Theoretical Background**:

The grain size of sand is expressed by a number called *'grain fineness number'*. The fineness number is a concept that can be used for comparing fineness of different sands. A given grain fineness number corresponds to a standard sieve of 280 mm diameter which has the identical number of meshes in it. To determine this number for a given sand sample, it is customary to use a standard sieve set, which contains several sieves one above the other, having a varying but known number of meshes. The coarsest sieve is placed at the top and the finest at the bottom. The percentage collected in each sieve is multiplied by its own multiplying number- a given constant, one for each sieve- and all the products are added to arrive at the total product. Thus,

*A = Total product /* total *sum of percentages collected in each sieve.*

This number is a convenient means of describing the relative fineness of sands, most foundry sands being from about 40 to 220 in average fineness. Most sand properties, however, depend on the size distribution as well as average size. The sieve test makes possible the evaluation of both factors.



**Procedure:**

1. Weigh 100 gm of dry sand and place the sand on the upper most sieves.
2. Start the shaker and shake for it 5 minutes. Timer on the machine can be used for this I purpose.
3. Loosen the belt, when the machine stops and remove the sieve one by one. Then carefully transfer the contents to different papers and weigh the sand in each paper.
4. A.F.S No. or G.F.N is calculated using the standard formula indicated below.

**5.6 Observations:**

(i). Weight of sand sample taken = 100 gm.
(ii). Time allotted for shaking =10 minutes

**Tabulation:**

| **Order of sieve** | **Sieve opening No. (in microns)** | **Sand left in each sieve (in gms)** | **Residue sand % (A)** | **Multiplier (B)** | **Product D=A x B** |
|---|---|---|---|---|---|
| 1 | 1700 | | | 5 | |
| 2 | 850 | | | 10 | |
| 3 | 600 | | | 20 | |
| 4 | 425 | | | 30 | |
| 5 | 300 | | | 40 | |
| 6 | 212 | | | 50 | |
| 7 | 150 | | | 70 | |
| 8 | 106 | | | 100 | |
| 9 | 75 | | | 140 | |
| 10 | 53 | | | 200 | |
| | Sieve pan | | | 300 | |

∑ **D=**

**Specimen Calculations:**

American foundry society number Or Grain Fineness No. = {∑ D=(AxB)}

**Result:**

A.F.S No. or GFN of given sample = …………

Note:-

Higher the A.F.S. No. or GFN, better will be the surface finish of the castings

## EXPERIMENT – 4

### CLAY CONTENT TEST

**Aim / Objective: -** To determine the clay content of the given sample of molding sand.

**List of Equipments**:-

Physical/digital balance, molding sand sample, Distilled water, NaOH solution, Quick Dryer.

**Theoretical Background:-**

Clay is the binding material in foundry sand. It influences the strength, permeability and preparation of sand. The method of determining the clay content of moulding sands consists of agitating the sand in water so as to separate the clay from the sand particles and then removing the clay which remains suspended in water. The material which fails to settle within a period of 5 minutes in distilled water at room temperature is designated as a clay substance. The equipment necessary for determining the percentage of clay in moulding sands consists of a drying oven, a balance and weights and a sand washer.

**Procedure:**

1. Weigh the drying pan first with 50 gms ($W_1$) of wet molding sand.
2. Place the sample in the wash bottle and fill it with 1000 ml of distilled water & NaOH solution.
3. Mount the wash bottle below the stirrer and start the switch. Agitate the moisture for 5 minutes. Allow the sand particles to settle and remove the murky water from the wash bottle.
4. Again fill the wash bottle with fresh water and repeat step 3 till we get clean water after the stirring.
5. Remove the sand and dry under the infrared lamp. Weigh the dry sample ($W_2$). The difference between the two weights gives the clay content of the sample.

**Observations:**

1. Initial weight of the molding sand, (W1) = ………gms
2. Quantity of water = 1000 ml
3. Quantity of alkaline solution = 10 ml
4. Final weight of dry molding sand, (W2) =………..gms

**Tabulation:**

| Sample No. | Weight of Sand | | % of Clay Content |
|---|---|---|---|
| | Initial ($W_1$) | Final ($W_2$) | |
| | | | |
| | | | |

**General instructions:**

1. Mix the molding sand properly before the sample is weighed.
2. Check the seal of the washed bottle after clamping to the rapid stirrer

Desired clay content in molding sand:

1) Lean or weak sand = 2 to 10% clay
2) Moderately strong sand = 10 to 20% clay
3) Strong sand = 30% clay

**Preparation of Alkaline solution:**

- For 500ml of water we have to add 30gms of NaOH and stir it.
- After that make it 1000 ml by adding water.
- For each and every wash add 10ml of prepared alkaline solution.

**Formulae required:**

$$\text{Percentage of clay content} = \frac{W_1 - W_2}{W_1} \times 100$$

**Specimen Calculations:**

$$\text{Percentage of clay content} = \frac{W_1 - W_2}{W_1} \times 100$$

**Results:**

The Percentage of clay content present in the given sample of molding sand was found to be…………. %

**EXPERIMENT – 5**

# RAPID MOISTURE TEST

**MACHINE CONTAINS:**

1. Balance
2. Absorbent compound
3. Spoon
4. Moisture meter
5. Wooden case
6. Rubber washer

**PRE- SETTING**

Open the case. Check entire equipment thoroughly, to its seat providing at left side. While tightening the wing nuts see the level and body of the tester from inside by brush.

**OPERATING INSTRUCTIONS**

Keep the case on the plane platform. Set the balance bracket. Place the balance lever, pan seat and pan in their proper position. Weigh the sample accurately by matching the edge lines bracket and lever. Unclamp the cap of the tester. Transfer the sample in the cap. Take one spoonful of absorbent compound and transfer into the body of the tester. Hold the body horizontally and place the cap in position and tighten the cap with screw. Shake the instrument vigorously. Immediately the pointer of the gauge moves. Observe the reading when pointer stops further movements. This will give the percentage of moisture in the sample directly.

**PRECAUTION:**

- Clean the instrument after use.
- Do not keep the absorbent compound exposed to atmosphere.

## EXPERIMENT – 6

### MOULD AND CORE HARDNESS TEST

**Aim / Objective**: To determine the hardness of the mould and core.

**List of Equipments:**

1. Mould hardness tester,
2. Core hardness tester,
3. Molding box filled with rammed sand.

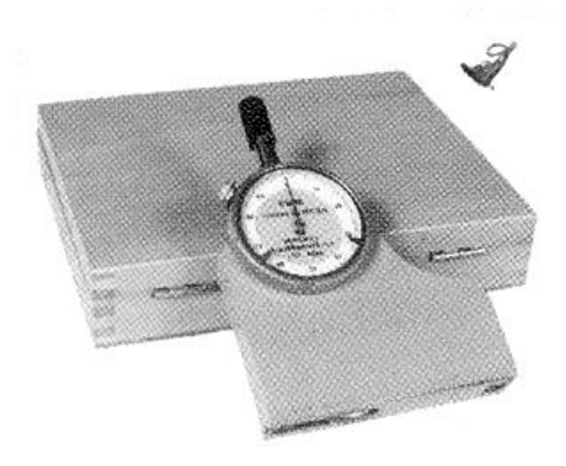
**Theoretical Background:**

The purpose of conducting this test is to determine how hard a mould has been rammed. The tester operates on the same principle as a Brinell hardness into the surface of the mould and the depth of penetration is indicated on the dial of the tester in hundredth of a millimeter. The tester resembles a dial indicator. It has a spring loaded plunger with a ball end. The common mould hardness is in the range of 80 to 95 for machine molding.

Desired hardness values:

1) Soft rammed moulds = 1 to 25
2) Medium rammed moulds = 25 to 50
3) Hard rammed moulds = up to 100

**Mould Hardness Tester**



**Core Hardness Tester**

**Procedure**:

1. Prepare the mould with the help of molding box, pattern and the molding sand.
2. Prepare a core using core sand mixture.
3. Press the mould hardness tester against the mould at the ball end and note down the reading shown on the dial indicator.
4. Take two more readings by the tester keeping it at different places of the mould.
5. Press the core hardness tester against the core and note down the reading.
6. Take two more readings by the tester keeping it at different places of the core.

**Tabulation:**

| Sl.No. | Description | Tester Reading in 1/100 mm | Average |
|---|---|---|---|
| **1** | **Mould sand** | **1)**<br>**2)**<br>**3)** | |
| **2** | **Core sand** | **1)**<br>**2)**<br>**3)** | |

**Results**:

1. Mould hardness of the given mould is found to be…………….
2. Core hardness of the given core is found to be…………

# WELDING PRACTICE:

Welding is the process of joining two pieces of metals by the application of heat and with or without the application of pressure and filler material. Welding produces a permanent fastening.

**Uses of welding:**

Welding is used in making bridges and buildings. The large and small pressure vessels and tanks are usually welded. The automobile, aircraft, railway and shop building industries use large amounts of welding. Machine bases, frames, brackets, bearing supports are often designed as weldments.

**Classification of welding processes:**

Welding processes may be divided into two types:

1. Plastic welding or pressure welding, and 2. Fusion welding or non-pressure welding.

**Plastic welding:** In this type of welding the metal pieces to be joined are heated to a plastic state and then joined together by the application of external pressure without the addition of filler material. Forge welding, resistance welding, and thermit welding with pressure are examples of this class.

**Fusion welding:** In fusion welding the metal pieces are heated to molten state at the joint and allowed to solidify without the application of pressure. A filler material is used during the welding process. Gas welding, Arc welding and Thermit welding without pressure are examples of this class.

**Arc Welding:**

Air a poor conductor and it offers great resistance to the flow of electricity. The resistance of the air between two conductors to the current creates great amount of heat. Arc welding is a process in which coalescence is obtained by heat produced form an electric arc obtained between work and an electrode. The electrode or filler metal is heated to a liquid state and deposited in to the joint to the weld. Contact is first made between the electrode and the work to create electric circuit sand then by separating the conductors, an arc is formed. The electrical energy is converted into intense heat in the arc, which attains a temperature around $5500^0$C.

**Electric circuit:** The welding circuit consists of an AC or DC welding machine, cables, electrode holder, electrode and the work pieces to be welded. The welding machine furnishes the electricity; The AC welding machine (transformer) illustrated in fig. 1 takes the incoming electricity, usually 220V or 440V, and generates a low voltage (10V to 50V), and high amperage (50A to 300A) electric current. This altered electricity then flows to the electrode through the electrode cable and the electrode holder. The electricity flow easily through the electrode and leaps the air gap between the tip of the electrode and the work piece being welded. The distance across the gap is about equal to the diameter of the electrode. The current then flows through the workpiece being welded to a metal table. A ground cable clamped to the metal table carries the current back to the arc welding machine to complete the circuit. Usually AC welding is preferred for ferrous metals.

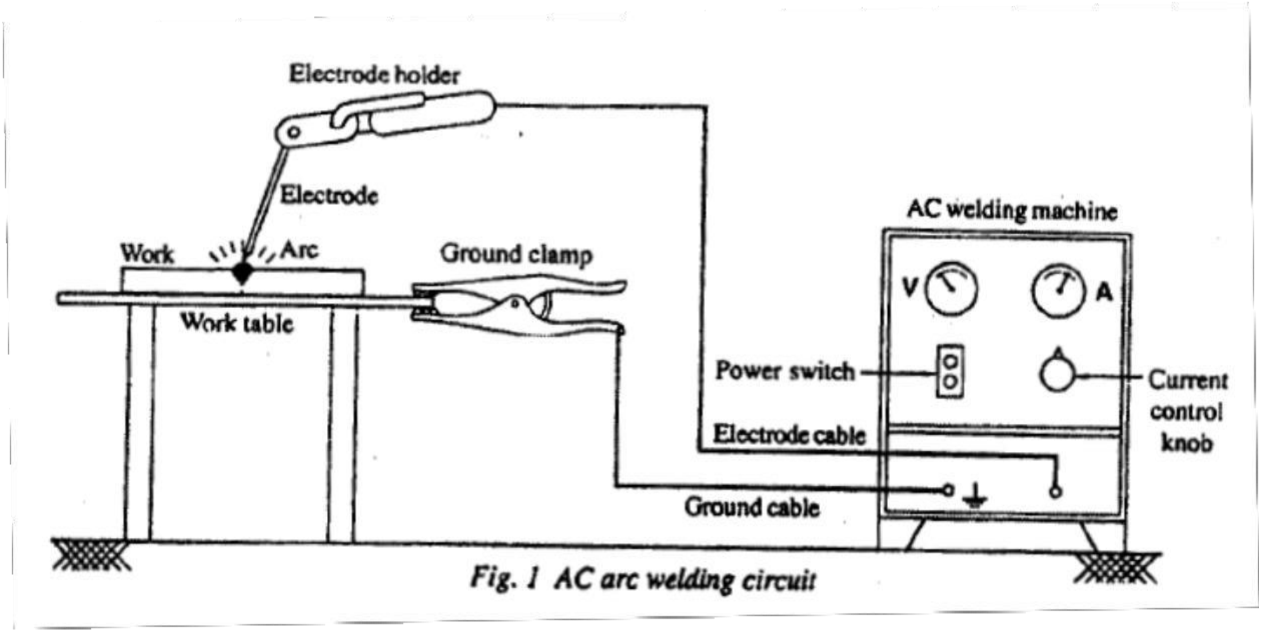
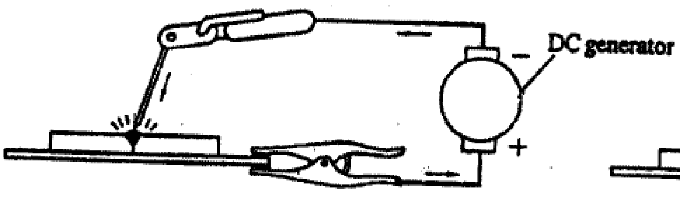
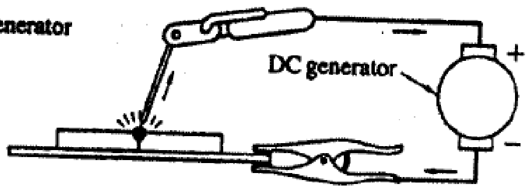



Fig. 1 AC arc welding circuit

**Polarity in DC welding:** A direct current welding machine may be either a motor-generator type or rectifier type. An internal combustion engine or a AC electric motor may drive the generator type welding machine. Direct current has a positive and a negative pole. When the electrode is connected negative terminal, the polarity called negative or straight polarity (refer fig. 2), when connected to positive terminal, the polarity is called positive or reverse (refer fig.3), straight polarity deposits heavier amount of filler, and reverse polarity produces deeper penetration. Usually DC welding is preferred when welding non-ferrous metals. A disadvantage of the DC welding is that we may sometimes get arc blow. Arc blow causes bread in the evenness of the bead, leading to a weak weld. It also causes excessive splatter. Arc blow is a phenomenon caused by a magnetic disturbance close to the arc when welding with DC current.




.

Fig.2 Straight polarity

Fig. 3 Reverse polarity

**Arc length:** The passage of current through air is seen as electric arc. The arc gap between the electrode and the base metal is called the arc length. If the arc gap is too small, it creates a cold weld and may cause the electrode to stick to the base metal. Tool large an air gap creates too hot an arc and causes the weld puddle to splatter. If the arc length is about the diameter of the electrode, the arc will produce a steady frying noise it creates a good weld.

**Electrodes:**

Electrode is the filler metal in the form of a wire or rod, either bare coated through which current is conducted between the electrode holder and the arc. Bare electrodes have limited use for welding wrought iron and low or medium carbon steel. They are used as filler metals various welding operations. The coated electrodes are the most important ones used in commercial welding. Electrodes area coated with materials that include silicate binders, oxides, carbonates, fluorides, metal alloys and cellulose.

The coating, perform the following functions:

1. Provide a protective atmosphere
2. Provide slag to protect the molten metal
3. Stabilize the arc
4. Add alloying elements to the weld metal
5. Perform metallurgical refining operations
6. Reduce spatter of weld metal
7. Increase deposition efficiency
8. Influence the depth of arc penetration
9. Slow down the cooling rate of the weld

Electrodes are identified by numbers and letters or by color code. Typical coated electrode dimensions are 150mm – 460mm long and l.5mm – 8mm in diameter.

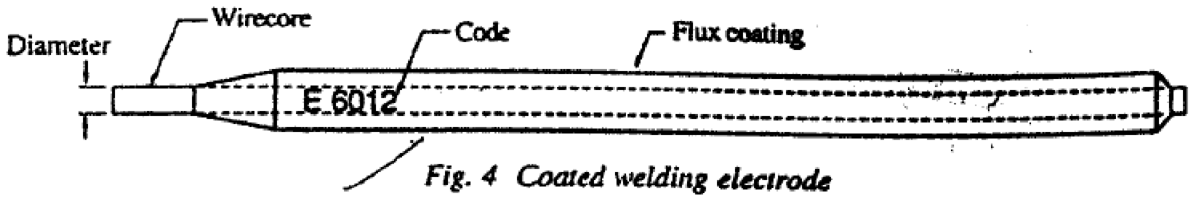



*Fig. 4 Coated welding electrode*

**Shielded metal arc welding:** It is one of the oldest, simplest, and most versatile joining processes. The electric arc is generated by touching the tip of a coated electrode against the workpiece and then withdrawing it quickly to a distance sufficient to maintain the arc. The generated melts a portion of the tip of the electrode, its coating, and the base metal in the immediate area of the arc. The voltage produces pressure in the electric arc. The effect of this pressure on the molten base metal in the puddle is to dig out metal. This piled-up metal from the crater forms ripple ridges to create the weld bead. The electrode coating deoxidizes and provides a shielding gas in the weld area to protect it from oxygen in the environment.

The electrode coating also covers the weld metal with a protective slag coating that prevents oxidation of surface metal during cooling. The deposited slag must be removed after each weld bead by a chipping hammer a1d a wire brush. Unless, removed completely. The solidified slag can cause severe corrosion of the weld area and lead to failure of the weld.

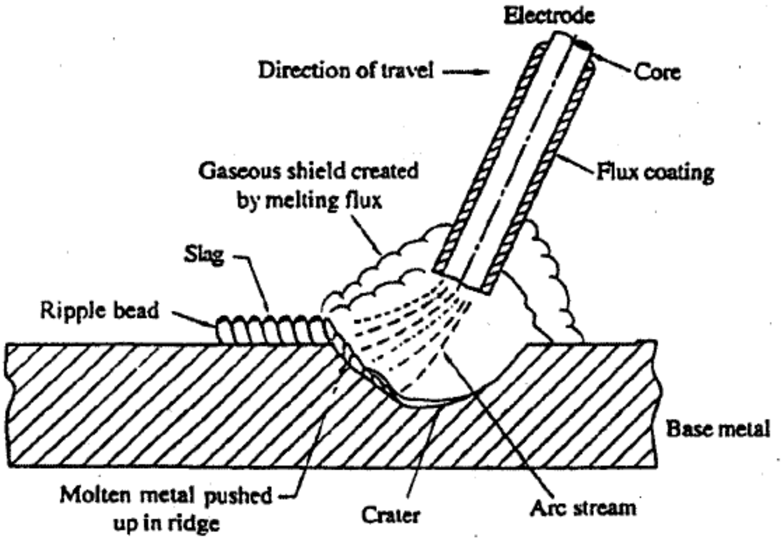



Fig. 5 Shielded metal arc welding

Shielded metal arc welding is commonly used in general constructions, ship building and pipe lines as well as for maintenance work, since the equipment is portable and can be easily maintained.

**Advantages and disadvantages of arc welding**

**Advantages:**

A properly made weld can be stronger than the part on which it is used.

1. It is a Permanent joint.
2. No holes are needed as in the case of bolted and riveted joints.
3. No patterns such as those used in casting are needed'
4. The equipment is inexpensive
5. The equipment is Portable.
6. The process allows considerable freedom in design.

**Disadvantages:**

1. A good welding job requires skilled operator.
2. Fixtures are often needed to hold parts in position for welding.
3. Each part of weldments must be cut to size and shape before it can be welded.
4. Presence of residual stresses and distortion in the welded joints.

**Welding machines:**

The electric current for the welding arc is generally provided by the welding machine. The following are the most commonly used welding machines.

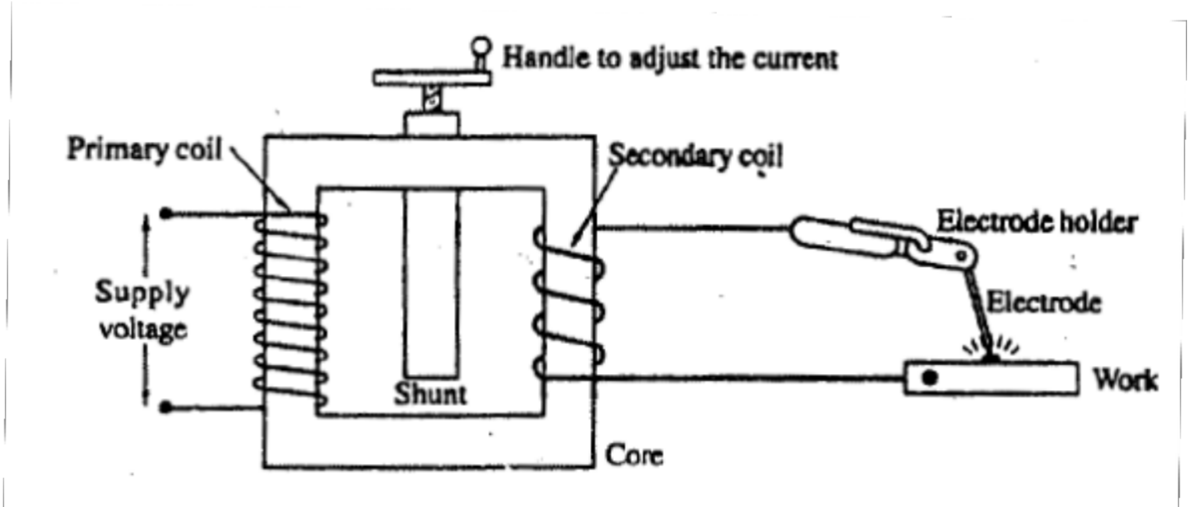



*Fig. 6 AC welding machine*

**AC transformer welding machine:** Fig.6 illustrates transformer type AC welding machine. The function of the transformer is to step down the voltage and to generate high amperage current required for welding. It consists of a square block-shaped core, a primary coil, which carries the input current, and a secondary coil which is connected to the electrode holder. A movable shunt between the two coils controls the secondary coil current (welding current).

**Advantages:**

1. Less initial and less maintenance cost.
2. Free from arc blow

**Disadvantages:**

1. Not suitable for welding non-ferrous metals and metals with thin sections.
2. Needs safety precautions.

**DC motor-generator welding machines:** The motor-generator welding machine shown in fig.7 consists of an AC motor, a DC generator, and an exciter built on a single shaft. The AC current the power line drives the electric motor, which in turn drives the generator, which provides the direct current for welding. A gasoline or diesel internal combustion engine can also drive the DC generator.

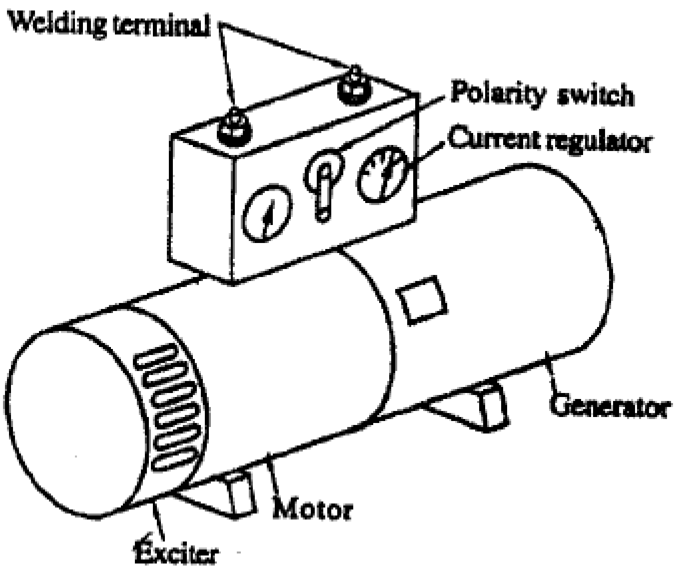



Fig. 7 DC motor-generator welding machines

**Advantages:**

1. It can be used to weld ferrous and non-ferrous metals.
2. It ensures safe working and can be used in all positions
3. Accurate current setting is possible.
4. It can be used to weld with all types of electrodes.

**Disadvantages:**

1. High initial and maintenance cost.
2. Occurrence of arc blow causes excessive splatter.

**DC Transformer-rectifier welding machine:** It is the transformer type with a built in rectifier. The rectifier converts the alternating current to direct current for welding.

**Welding machine accessories**

**Electrode holder:** A metal electrode holder is a mechanical device used for holding the electrode. It conveys electric current from the welding cable to the electrode, and it has an insulated handle to protect the operator's hand from heat. The jaws of the holder have several grooves that are used for positioning the electrode at different angles. (refer fig. 8).

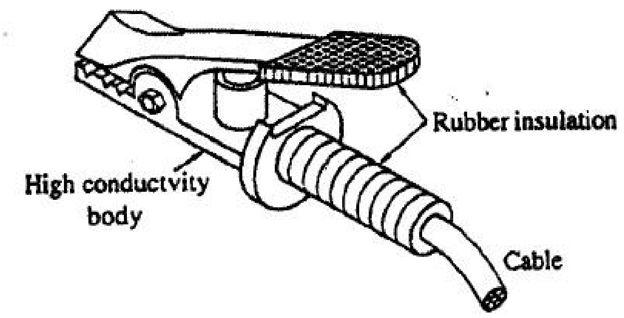



Fig. 8 Electrode holder

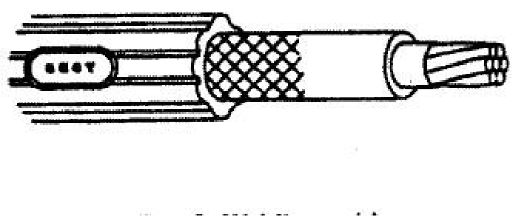
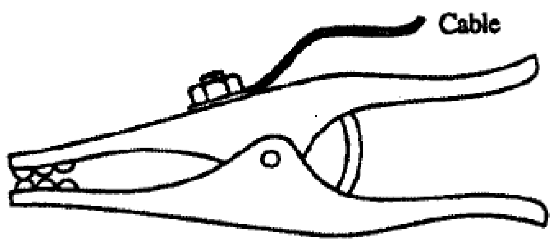


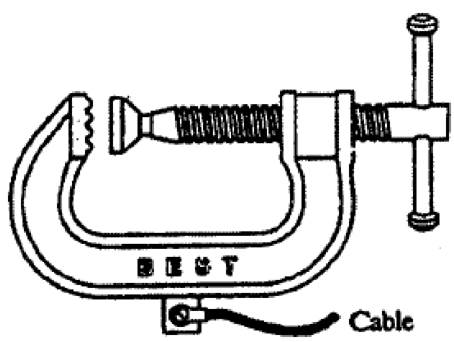
Fig.9 Welding cable

**Welding cables:** Welding cables are flexible, rubber-covered copper cables of a large enough size to carry the necessary current from the welding machine to the work and to the electrode holder without overheating (refer fig. 9).

**Ground clamps:** Ground clamps are used to connect the work and the welding cable. A clip type and a C-clamp type ground are shown in fig. 10.




(a) Clip type




(b) C-clamp type

Fig.10 Ground clamps

**Hand tools**

**Tongs:** Tongs are used to hold and to turn the workpiece during welding. Tongs are made of mild steel and are available in various shapes for holding different cross sections. A flat tong to hold flat plates and bars is shown in fig. 11.

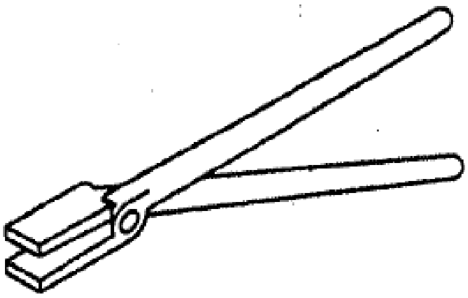


Fig. 1l Flat tong

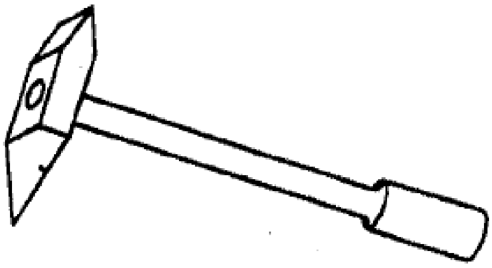


Fig.12 Chipping hammer

**Chipping hammer:** A chipping hammer made of medium carbon steel is shown in fig.12. One end of the hammer is pointed and the other end is like that of a chisel. It is used to remove the slag form the weldment.

**Wire brush:** A wire brush made of steel wires embedded in wood is shown in fig.l3. It is used to clean the surface of the base metal before welding and to remove small particles of slag from the weld bead.

Fig. 13 Wire brush

**SAFETY**

The flame from the arc and the molten pools of metal give off tremendous heat, glare, and radiation. The operator's eyes, hands, and body must be protected.

**Gloves:** Hands working so close to arc and molten metal are vulnerable to radiation burns and splattered metal, Gloves as shown in fig. 14 protect the hands of the operator. Gloves are made of leather or asbestos.

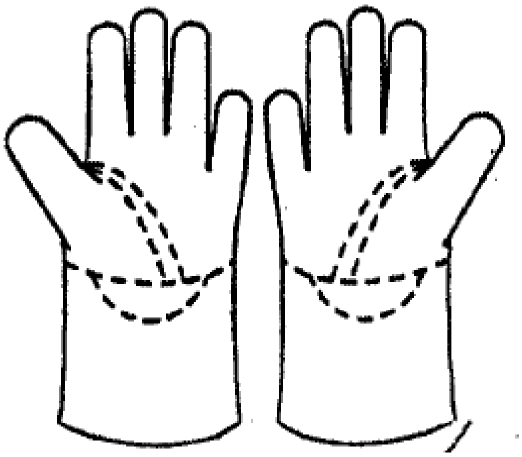


Fig.14 gloves

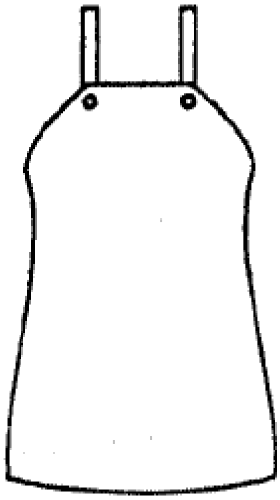


Fig. 15 Apron

**Protective clothing:** Flying particles of hot metal will penetrate the ordinary cloth and cause sunburn. Therefore, the operator must protect himself with fire-resistance aprons, and sleeves eliminate this hazard.

**High-top shoes:** A welder must wear high-top shoes during welding. The feet and legs can be protected by the use of loggings and spats.

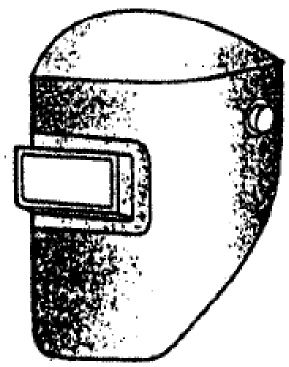


Fig. 16 Head shield

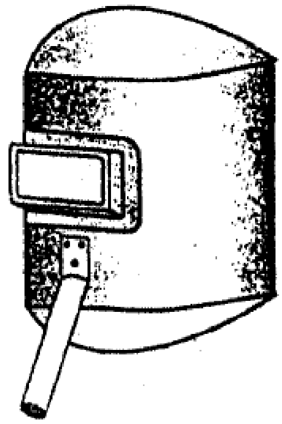


Fig. 17 Hand shield

**Head shields:** The light caused by an electric arc contains two kinds of invisible rays namely the ultraviolet rays and infrared rays. Repeated exposure to the electric are is painful to the eyes. The head shield shown infig.16 protects the operator not only against the harmful light rays but also against the hot splattered metal. It is also called hood or helmet. The head shield is usually made of fiber board. The head shield encloses the entire face, neck, and half of the top of the head. A rectangular opening level with the welder's eyes is covered with shaded filter glass and an outside layer of plain glass to protect the filter from splatter. The hand shield shown in fig. 17 has a handle so that the operator may hold the shield in front of his face.

Welded joints are permanent in nature and the component parts once connected together cannot be separated or disassembled without breaking the weld metal or connected parts. There are five basic forms of welded joints: butt weld, lap weld, edge weld, corner weld, and T - weld.

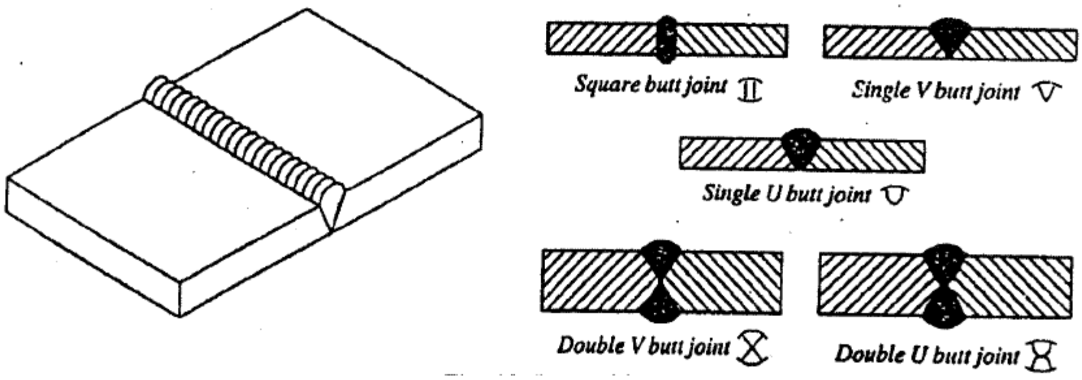



Fig. l8 Butt welds

**Butt weld:** Butt welds are joints connecting the ends or edges of parts located in one plane. Before welding, the edges of the butts should be specially prepared. The forms and dimensions of the edge preparation depend on the thickness of the plates to be joined. The edges of the plates may be unleveled for thin plates, leveled on one side only, or on both sides. The shape of the space thus obtained for depositing weld metal maybe single or double V, or single or double U as showninfig.18. The symbolic representations of joints are also shown in the figure.

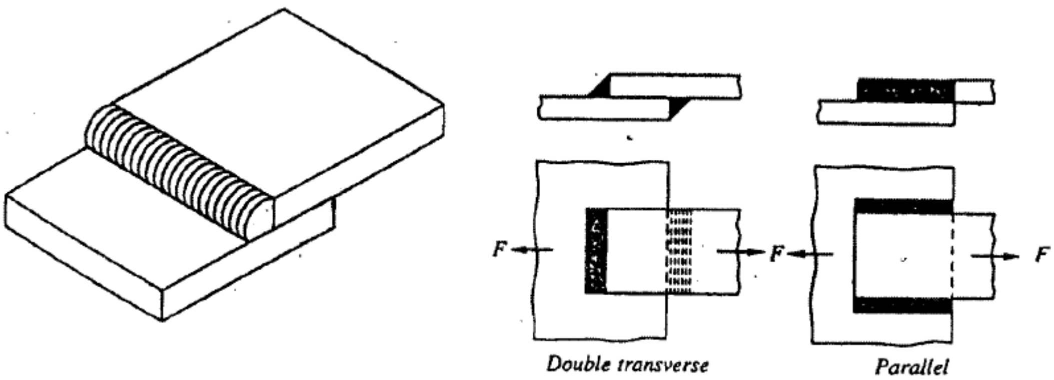



Fig. l9 Lap welds

**Lap weld:** The plates to be joined are made to overlap with each other for certain distance. The right angle recesses so formed along the width of the plates are filled with weld metal. The cross section of the fillet is approximately triangular. Various forms of lap joints are shown in fig. 19.

**Edge weld:** In an edge weld metal is deposited along the edges of plates as shown in fig.20. This type of weld is used to join two parallel plates and is not recommended for plates thicker than 6mm.

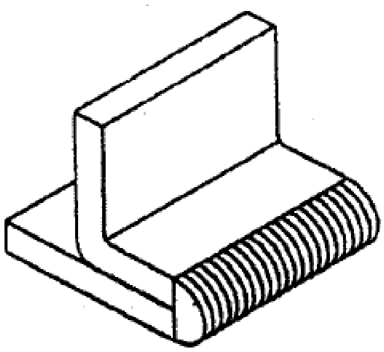


Fig.20 Edge joint

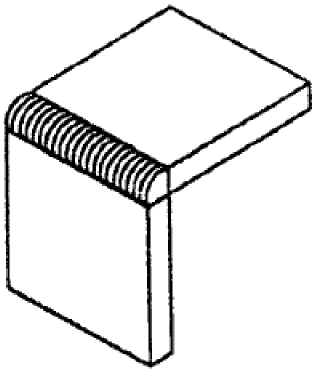


Fig.21 Corner joint

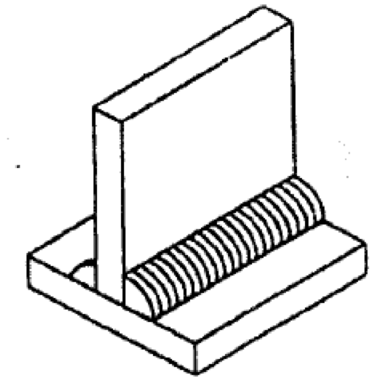


Fig.22 T-joint

**Corner weld:** It is used to join the edges of two plates whose surfaces are at an angle of approximately 90degree to each other (refer fig.21). Welding can be done on one or both sides, depending upon the position and type of corner joint used. Corner weld is commonly used in construction of boxes, tanks, frames, etc.

**T-weld:** The T-weld is used to weld two plates whose surfaces are at approximately right angles to each other (refer fig.22). The plate to be joined to form a T may leveled on one side, on both sides may not be leveled at all.

**Edge Preparation:** The edges of the plate to be welded must be properly squared, leveled, or grooved in the form of V, U, or J shape. Beveling of the edges may be done by any suitable means such as machining, flame cutting, grinding, filing or by chipping, The edge preparation will improve penetration. The proportions of grooves for butt joints are shown in fig.23.

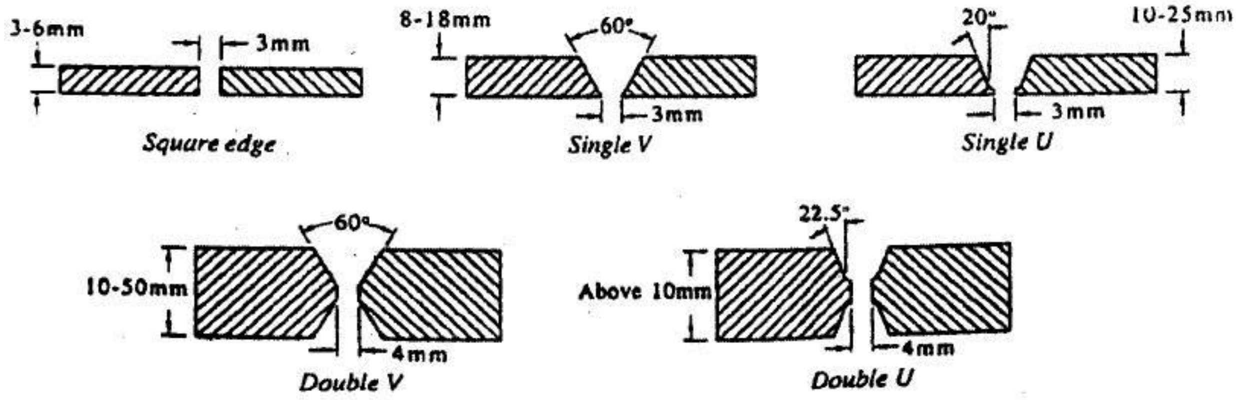



Fig. 23 Edge preparation of butt joint

**Angle of electrode:** The electrode angle should not be greater than 20 Degree toward the direction of travel. The rate of travel of the arc changes with the thickness of the metal being welded, the amount of current, and the size and shape of the weld, or bead desired.

**Weaving:** Weaving accomplished by oscillating the electrode back and forth, cross ways in the direction of travel, and at the same time moving the electrode forward to advance the bead, weaving is used to float out slag, deposit a wider bead, secure good penetration, allow gas to escape, and to avoid porosity, the commonly used weaving patterns are shown in fig.21.

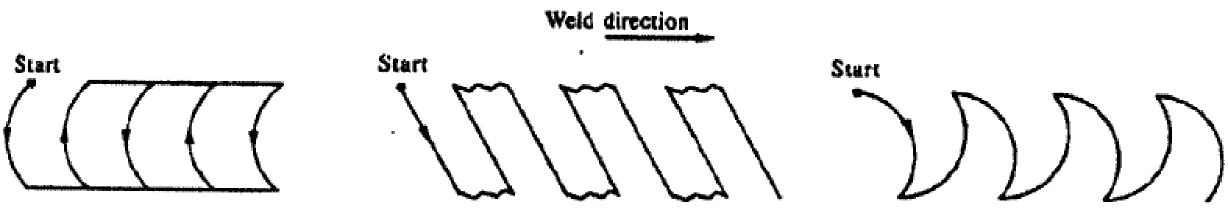



Fig.24 Weaving patterns

**Defects in welds:** The principal defects of welded joints are as follows:

**Cracks:** Cracks in the weld may arise from localized stresses set up by uneven heating and cooling, presence of high percentage of sulphur and carbon in the base metal.

**Porosity:** Porosity is a group of small voids, and they occur mainly due to the entrapped gases.

**Poor fusion:** It is the lack of thorough and complete union between the metal deposited by the electrodes and parent metal.

**Inclusion:** The presence of non-metallic substances in the metal is called inclusion. **Undercut:** In undercut, a groove gets formed in the base metal along the sides of the weld bead. The reasons for under cutting are non-uniform feed of the welding rod, improper position of electrode, or excessive heating.

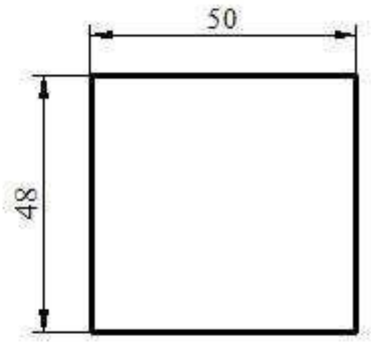
**Spatter:** Spatter are the small metal particles which are thrown out of the arc during welding and gets deposited on the base metal around the weld bead along its length.

**Hints on welding**

1. Adequate ventilation in the work area is a must
2. The welding machine must be well ground.
3. The ground cable must have a firm grip,
4. Keep the floor and work area dry.
5. Select the correct electrode for the given job
6. Wear head shield, gloves and heavy clothing.
7. Stand on a dry wooden plate or on rubber mat.

# 4. WELDING MODELS
## MODEL 1

**Aim:** To Prepare and weld L-Joint of the given two specimens as per dimensions shown in figure below.


All dimensions are in mm

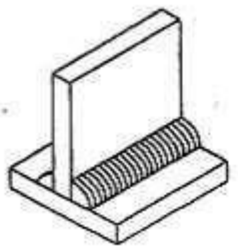
**Tools:** Apron, Work Piece, Welding machine, Electrode, Clamps, Hand gloves, Hand Shield, Tongs, Chipping hammer, Wire brush.

**Procedure:**

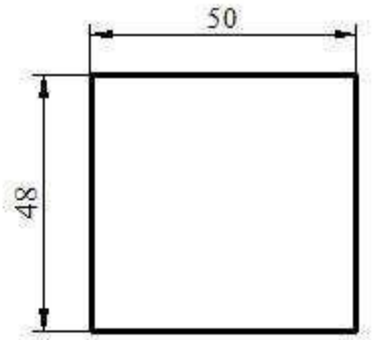
1. Brush the given steel plate free form dirt and scale.
2. Lay the plate on the welding table.
3. Attach the ground lead securely to the welding table.
4. Set the welding machine amperage at120 to 140A.
5. Fit the electrode in to the electrode holder.
6. Turn on the welding machine.
7. Touch the plate with the electrode to close the electric circuit.
8. Raise the electrode immediately to about 6mm above the plate
9. Lower to normal arc length (Frying sound indicates the correct (arc length). Note that the electrode must be fed downward at constant rate dip the correct arc length.
10. Move the arc forward at a constant rate to form the bead.
11. Repeat the arc movement on the opposite side.
12. Make series of beads on the plate, until a smooth and uniform weld is obtained.

# MODEL 2

**Aim:** To Prepare and weld T-Joint of the given two specimens as per dimensions shown in figure below.



WELDING MODEL 4
T Joint




All dimensions are in mm

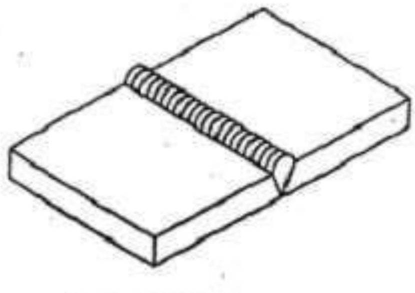
**Tools:** Apron, Work Piece, Welding machine, Electrode, Clamps, Hand gloves, Hand Shield, Tongs, Chipping hammer, Wire brush.

**Procedure:**

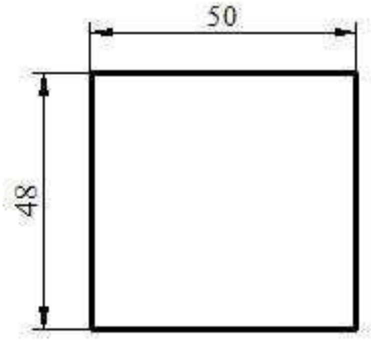
1. Brush the given steel plate free form dirt and scale.
2. Lay the plate on the welding table.
3. Attach the ground lead securely to the welding table.
4. Set the welding machine amperage at120 to 140A.
5. Fit the electrode in to the electrode holder.
6. Turn on the welding machine.
7. Touch the plate with the electrode to close the electric circuit.
8. Raise the electrode immediately to about 6mm above the plate
9. Lower to normal arc length (Frying sound indicates the correct (arc length). Note that the electrode must be fed downward at constant rate dip the correct arc length.
10. Move the arc forward at a constant rate to form the bead.
11. Repeat the arc movement on the opposite side.
12. Make series of beads on the plate, until a smooth and uniform weld is obtained.

## MODEL 3

**Aim:** To Prepare and weld Butt joint of the given two specimens as per dimensions shown in figure below.



WELDING MODEL 1
Butt Joint




All dimensions are in mm

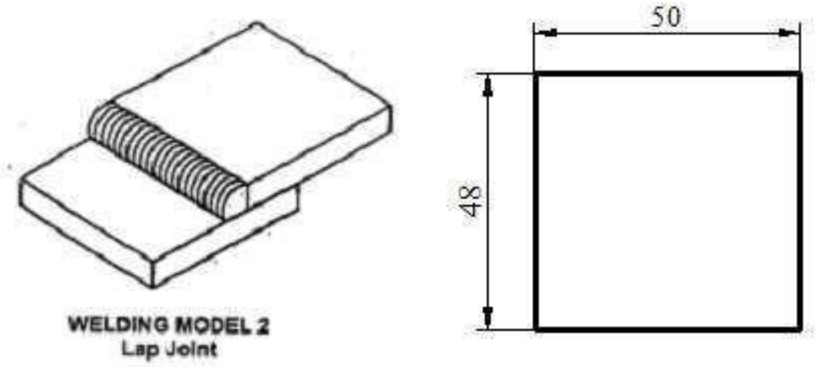
**Tools:** Apron, Work Piece, Welding machine, Electrode, Clamps, Hand gloves, Hand Shield, Tongs, Chipping hammer, Wire brush.

**Procedure:**

1. Brush the given steel plate free form dirt and scale.
2. Lay the plate on the welding table.
3. Attach the ground lead securely to the welding table.
4. Set the welding machine amperage at120 to 140A.
5. Fit the electrode in to the electrode holder.
6. Turn on the welding machine.
7. Touch the plate with the electrode to close the electric circuit.
8. Raise the electrode immediately to about 6mm above the plate
9. Lower to normal arc length (Frying sound indicates the correct (arc length). Note that the electrode must be fed downward at constant rate dip the correct arc length.
10. Move the arc forward at a constant rate to form the bead.
11. Repeat the arc movement on the opposite side.
12. Make series of beads on the plate, until a smooth and uniform weld is obtained.

# MODEL 4

**Aim:** To Prepare and weld Lap joint of the given two specimens as per dimensions shown in figure below.




All dimensions are in mm

**Tools:** Apron, Work Piece, Welding machine, Electrode, Clamps, Hand gloves, Hand Shield, Tongs, Chipping hammer, Wire brush.

**Procedure:**

1. Brush the given steel plate free form dirt and scale.
2. Lay the plate on the welding table.
3. Attach the ground lead securely to the welding table.
4. Set the welding machine amperage at120 to 140A.
5. Fit the electrode in to the electrode holder.
6. Turn on the welding machine.
7. Touch the plate with the electrode to close the electric circuit.
8. Raise the electrode immediately to about 6mm above the plate
9. Lower to normal arc length (Frying sound indicates the correct (arc length). Note that the electrode must be fed downward at constant rate dip the correct arc length.
10. Move the arc forward at a constant rate to form the bead.
11. Repeat the arc movement on the opposite side.
12. Make series of beads on the plate, until a smooth and uniform weld is obtained.

# Part B:

# FOUNDRY PRACTICE

## EXPERIMENT – 7

### MOULD MAKING USING SINGLE PIECE PATTERN

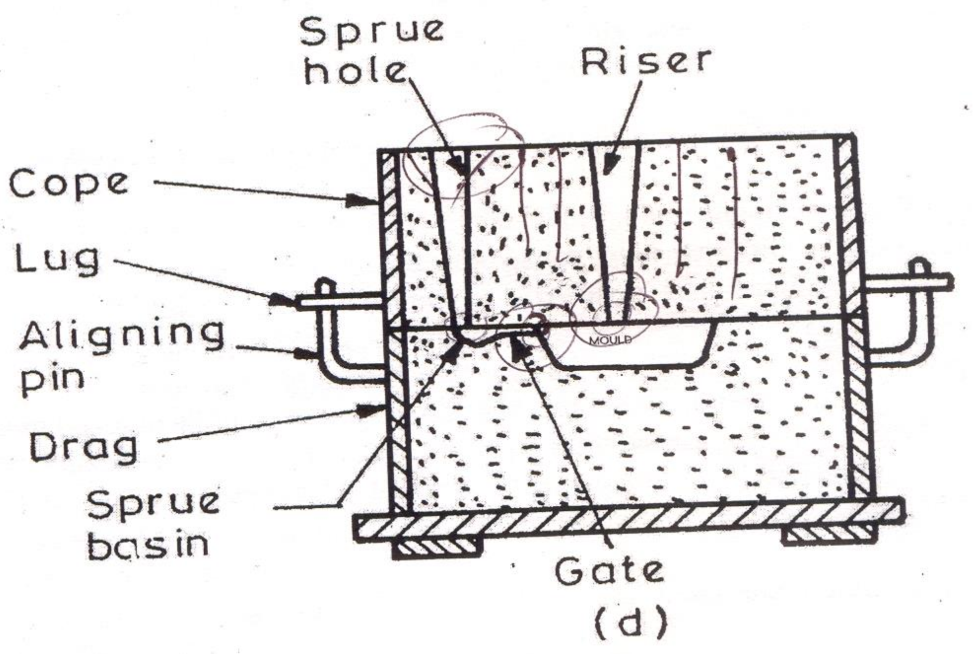
**Aim / Objective:** To make the mould in green sand using single piece pattern and molding boxes.

**List of Equipments**:

1. Cope and drag boxes,
2. Pattern,
3. Hand molding tools etc.

**Theoretical Background:**

Molding is the process of preparing cavities in sand or metal, of suitable shapes using patterns. Sand moulds are prepared with natural molding sands or with mixtures of silica sand, binding clay and water. These materials are thoroughly mixed in proper proportions which will give the desired properties for the class of work being done. Molten metal is poured in to the mould cavity and allowed to solidify. After the solidification casting is taken out by breaking the sand mould.




**Single Piece Pattern**

**Procedure:**

5. Take a pair of cope and drag boxes, single piece pattern and the required tools.
6. Place the drag upside down and keep the pattern at center. Fill the box with molding sand and ram uniformly around the pattern layer by layer using hand rammer.
7. Invert the drag and place the cope above it.
8. Spray the parting sand graphite powder at the parting surface. Keep the sprue and risers pins in position and fill the cope with sand and ram uniformly.
9. Takeout sprue and riser pins and cut the pouring basin.
10. Lift the cope and keep it aside to remove the pattern from drag carefully.
11. Cut the gate using gate cutter to connect sprue and mold cavity. Using blower, clean the loose sand particles present in the mold.
12. Assemble the cope and drag and make vent holes around the mould cavity with the help of vent rod.
13. Keep the mould ready for pouring the molten metal.

**Results:**

Single piece pattern mould is simple and easy to make. This is suitable for small and plain jobs.

## EXPERIMENT – 8

### MOULD MAKING USING SPLIT PATTERN

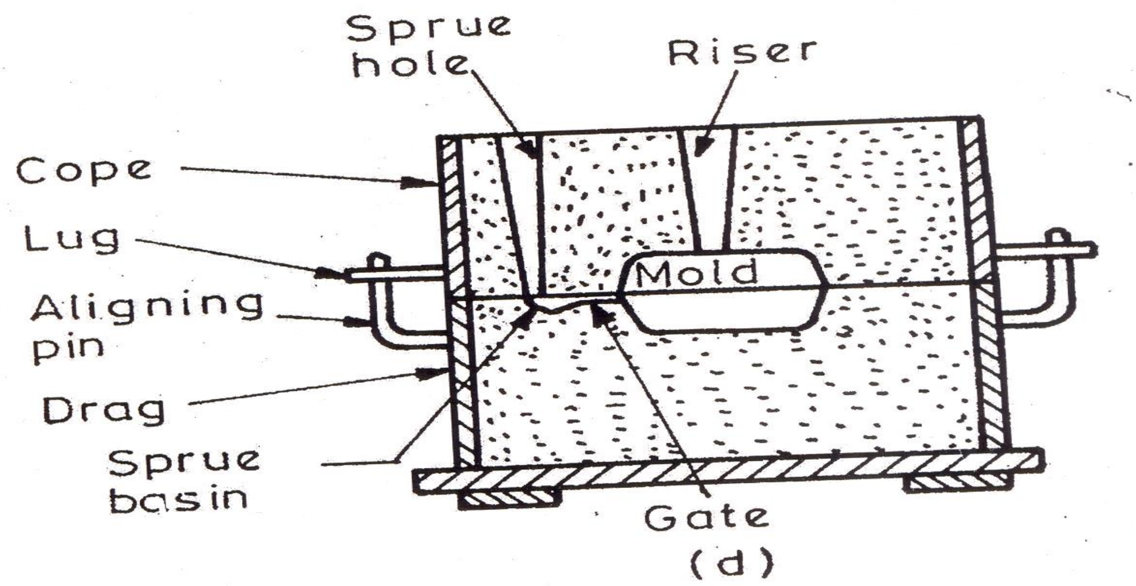
**Aim / Objective:** To make the mould in green sand using split or two-piece pattern and the molding boxes.

**List of Equipments:**

1. Cope and drag boxes
2. Two piece pattern
3. Hand molding tools
4. Hand blower
5. Graphite powder etc

**Theoretical Background:**

Molding is the process of preparing cavities in sand or metal, of suitable shapes using patterns. Sand moulds are prepared with natural molding sands or with mixtures of silica sand, binding clay and water. These materials are thoroughly mixed in proper proportions which will give the desired properties for the class of work being done. Molten metal is poured in to the mould cavity and allowed to solidify. After the solidification casting is taken out by breaking the sand mould.




**Split Pattern**

**Procedure:**

1. Take a pair of cope and drag boxes, split pattern and the required tools.
2. Place the drag upside down and keep one half of the pattern at center. Fill the box with molding sand and ram uniformly around the pattern layer by layer using hand rammer.
3. Invert the drag and place the other half of the split pattern on the previous one.
4. Keep the cope above the drag and spray the parting sandI graphite powder at the parting surface.
5. Keep the sprue and riser pins in position and fill the cope with sand and ram uniformly.
6. Take out sprue and riser pins and cut the pouring basin.
7. Lift the cope and keep it aside to remove the pattern from drag carefully.
8. Cut the gate using gate cutter to connect sprue and mold cavity. Using blower, clean the loose sand particles present in the mold.
9. Assemble the cope and drag and make vent holes around the mould cavity with the help of vent rod.
10. Keep the mould ready for pouring the molten metal.

**Results**: Split pattern mould is found to be suitable for complex patterns but care should be taken for proper alignment

## EXPERIMENT – 9

### PREPARATION OF A CASTING USING MATCH PLATE PATTERN

**Aim / Objective:** To make the mould in green sand using split or two-piece pattern and the molding boxes.

**List of Equipments**:

1. Cope and drag boxes
2. Match plate pattern,
3. Hand molding tools,
4. Hand blower,
5. Graphite powder etc

**Theoretical Background:**

Molding is the process of preparing cavities in sand or metal, of suitable shapes using patterns. Sand moulds are prepared with natural molding sands or with mixtures of silica sand, binding clay and water. These materials are thoroughly mixed in proper proportions which will give the desired properties for the class of work being done. Molten metal is poured in to the mould cavity and allowed to solidify. After the solidification casting is taken out by breaking the sand mould.

**Procedure:**

1. Take a pair of cope and drag boxes, match plate pattern and the required tools.
2. Keeps the pattern in between the two molding boxes.
3. Fill the drag which is at the top with the sand and ram uniformly using hand rammer.
4. Place the drag upside down and keep the cope above it.
5. Spray the parting sand graphite powder at the parting surface.
6. Keep the sprue and risers pins in position and fill the cope with sand and ram uniformly.
7. Take out sprue and riser pins and cut the pouring basin.
8. Lift the cope and keep it aside to remove the pattern from drag carefully.
9. Cut the gate using gate cutter to connect sprue and mold cavity. Using blower, clean the loose sand particles present in the mold.
10. Assemble the cope and drag and make vent holes around the mould cavity with the help of vent rod.
11. Pour the molten metal in to the mould cavity through sprue basin until it rises up in the riser.
12. Allow the molten metal to solidify.
13. After solidification of the metal, break the mould and take out the casting.

**Results:** Split pattern mould is found to be suitable for complex patterns but care should be taken for proper alignment.

# Part C

# FORGING MODELS

## EXPERIMENT – 10

### FORGING JOB 1

**Aim / Objective:** To convert a given round mild steel bar to square cross section nail as shown in the figure.

**List of Equipments:** Anvil, Tongs, hammer, Open-hearth furnace, Bench vice etc

**Theoretical Background:**
Forging is mainly a hot working operation where the metal is heated and then a force is applied to manipulate the metal in such away that, the required final shape is obtained. The processes working above the recrystallization temperature are termed as hot working processes whereas those below are termed as cold working processes. Under the action of heat and force, when the atoms reach a certain higher energy level, the new crystals start forming which is termed as hot working.

The main advantages of hot working are,

1. As the material is above the recrystallisation temperature, any amount of working can be imparted since there is no strain hardening-taking place.
2. At a high temperature, the material would have higher amount of ductility and therefore, there is no limit on the amount of hot working that can be done on a material.
3. Since the shear stress gets reduced at higher temperatures, the hot working requires much less force to achieve the necessary deformation.

It is possible to continuously reform the grains in metal working and if the temperature and rate of working are properly controlled, a very favorable grain size could be achieved giving rise to better mechanical properties.

**SCHEMATIC DIAGRAM OF JOB:**

**Procedure:**

1. Cut the given circular mild steel bar to the required length using shearing machine. The round bar is to be heated above the recrystallisation temperature, in the open-hearth furnace.
2. Then drawing-out operation is carried out by keeping the job on anvil and applying the force by hammer, to increase the length of the job by decreasing the diameter to the required dimension.
3. In between the operations the work piece is heated to maintain it at the recrystallisation temperature.
4. Bending operation is done to a particular length by keeping the work piece on the anvil and also by applying the force by hammer.
5. The tip of the job is made into circular shape to a particular length.
6. Check the dimensions of the job after each operation.
7. Make the surface of the job smooth using flattener.
8. Finally, the finished component is cooled by placing it in the water

**Note:**

1. All dimensions are in millimeters
2. Remove all burrs / sharp edges

**Formulae required**: As per the drawing, the required length has to be calculated

## EXPERIMENT – 11

### FORGING JOB 2

**Aim / Objective:** To convert a given round mild steel bar to a pointed hook as shown in figure.

**List of Equipments:** Tongs, Anvil, Hammer, Mild steel bar, Open-hearth furnace.

**Theoretical Background:-**

Forging is the mainly a hot working operation where the metal is heated and then a force is applied to manipulate the metal in such away that the required final shape is obtained. The processes working above the recrystallisation temperature are termed as hot working processes whereas those below are termed as cold working processes. Under the action of heat and force, when the atoms reach a certain higher energy level, the new crystals start forming which is termed as hot working.

The advantages of hot working are,

1. As the material is above the recrystallisation temperature, any amount of working can be imparted since there is no strain hardening taking place.

2. At a high temperature, the material would have higher amount of ductility and therefore there is no limit on the amount of hot working that can be done on a material.

3. Since the shear stress gets reduced at higher temperatures, the hot working requires much less force to achieve the necessary deformation.

It is possible to continuously reform the grains in metalworking and if the temperature and rate of working are properly controlled, a very favorable grain size could be achieved giving rise to better mechanical properties.

**SCHEMATIC DIAGRAM OF JOB:**

**Procedure**:

1. Calculate the length of the MS bar required for forging into final shape by selecting the available diameter of the bar.
2. Cut the round bar to the calculated length.
3. Metal bar is heated above the recrystallisation temperature in the open-hearth furnace. This can be ensured by the red-hot condition of the work piece.
4. Then heated metal bar is decreased in cross section by increasing the length by keeping on the anvil and applying the force by a hammer.
5. Then the bending operation is carried out by placing the heated metal bar on the horn of the anvil and force is applied so that circular bend is obtained with the desired diameter.
6. In between the operations the metal bar is heated in the open-hearth furnace to maintain the work piece at the recrystallisation temperature.

**Note:**

1. All dimensions are in millimeters
2. Remove all burrs / sharp edges

**Formulae required**: As per the drawing, the required length has to be calculated

## EXPERIMENT – 12

### FORGING JOB 3

**Aim / Objective:** To produce Hexagonal bolt head by using the mild steel bar.

**List of Equipments**: Anvil, tongs, Hammer, Swage Block, Scale etc

**Theoretical Background:**
Forging is the mainly a hot working operation where the metal is heated and then a force is applied to manipulate the metal in such away that the required final shape is obtained. The processes working above the recrystallisation temperature are termed as hot working processes whereas those below are termed as cold working processes. Under the action of heat and force, when the atoms reach a certain higher energy level, the new crystals start forming which is termed as hot working.

The main advantages of hot working are,

1. As the material is above the recrystallisation temperature, any amount of working can be imparted since there is no strain hardening-taking place.
2. At a high temperature, the material would have higher amount of ductility and therefore there is no limit on the amount of hot working that can be done on a material.
3. Since the shear stress gets reduced at higher temperatures, the hot working requires much less force to achieve the necessary deformation.

It is possible to continuously reform the grains in metalworking and if the temperature and rate of working are properly controlled, a very favorable grain size could be achieved giving rise to better mechanical properties.

**SCHEMATIC DIAGRAM OF JOB:**

**Procedure**:

1. Calculate the length of the MS bar required for forging into final shape by selecting the available diameter of the bar.
2. Cut the round bar to the calculated length.
3. Metal bar is heated above the recrystallisation temperature in the open-hearth furnace. This can be ensured by the red-hot condition of the work piece.
4. Fullering is carried out i.e., increase in cross sectional area by decreasing the length at one end of the work piece.
5. Now the work piece is heated at the one end where bolt head is to be made and is placed in a hole provided in the anvil and then by applying the force.
6. Circular face is produced by keeping the work piece in the swage block and applying the force.
7. Hexagonal head is produced on the circular face by applying force alternately.
8. Finally the finished component is cooled by placing it in the water bath.

**Note:**

1. All dimensions are in millimeters
2. Remove all burrs / sharp edges

**Formulae required**: As per the drawing, the required length has to be calculated

# Part D:

# ASSIGNMENTS

## ASSIGNMENT-1

**Q1.** Sketch and explain the following tools.

Anvil, Swage block, Hammers, Tongs, Chisels, Swages, Fullers, Flatters, Set hammers, Punch, Drift

1. ANVIL

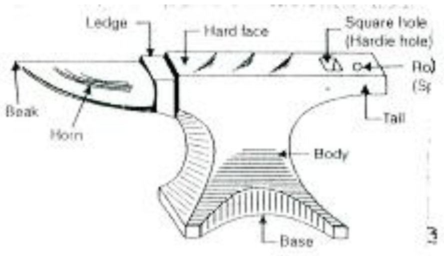



Fig: ANVIL

1. The anvil forms a support for blacksmith's work when hammering.
2. The body of the anvil is made of mild steel with a tool steel face welded on the body, but the beak or horn used for bending curves is not steel faced.
3. The round hole in the anvil is called stud hole which is used for
   a) Bending rods of small diameter
   b) As a die for hot punching operation.
4. The square hole is called hardie hole which is used for holding square shanks of various fittings
5. Anvils vary up to about 100kg to 150kg and should stand with the top face about 0.75 meter from the floor.

2. SWAGE BLOCK

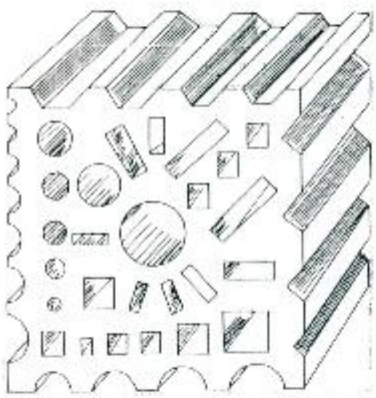


Fig: SWAGE BLOCK

1. Swage block, is generally made of cast iron and has round, square, rectangular and half-round grooves
2. In addition to their, it is provided with holes which are useful for holding bars while bending and knocking up heads.

3. It is used for mainly squaring, sizing, heading, bending and forming operations.
4. It is 0.25m or more wide and may be used either feat or edge wire in its stand.

3. HAMMERS

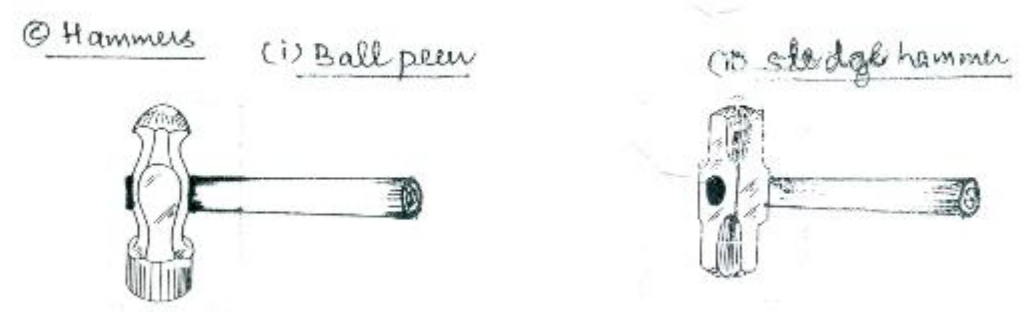



Fig: HAMMERS

The hammers commonly used in hand forging are:-

a) Hand hammer and
b) Sledge hammer.

**Hand hammers** are generally ball peen hammers. They usually have a slightly convex striking face and should have a mass from 1 to 1.5 kg. The hammer heads should be of cast steel, the ends are hardened and tempered.

**Sledge hammers** are used by the smith's helper or striker. The mass of the sledge hammer various from 4 to 6 kg for ordinary work and 8 to 10 kg for heavy work. The draft is about 1m long and it is mostly made of wood.

4. TONGS

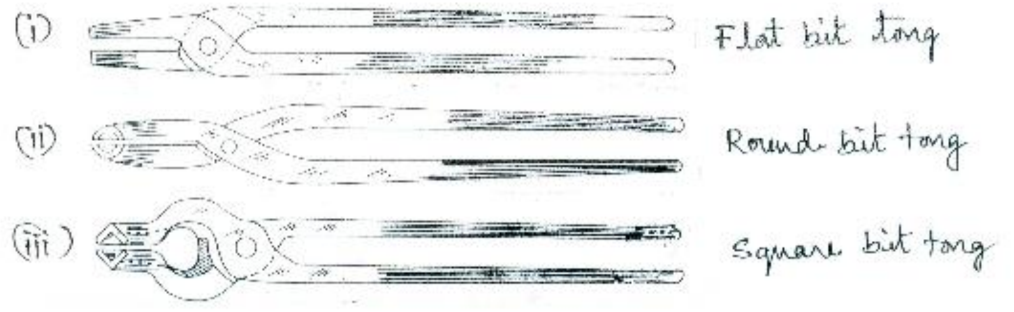



Fig: TONGS

Tongs are used for handle the work while forging. These are made of mild steel and sizes vary from 40cm to 60cm in length and 0.6cm to 5.5cm opening.

a) **Feat tong: -** used for holding work of rectangular section.
b) **Round tong: -** used for holding a round rod.
c) **Square tong: -** used for holding a square rod.
d) **Pick up tong** :- used for pickup the heated rods from the hearth

5. CHISELS

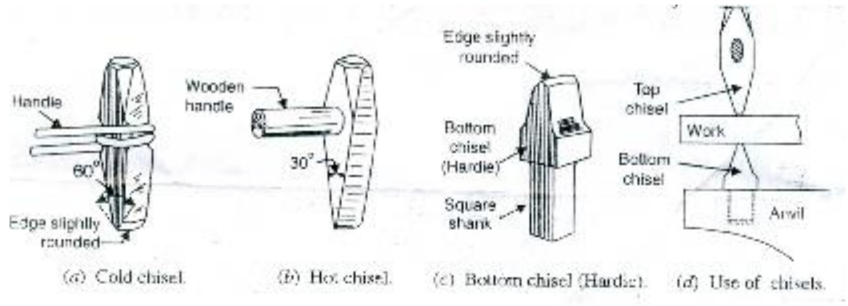



Fig: CHISELS

Chisels are used for cutting metals and for necking prior to breaking. They may be cold or hot depending upon whether the metal to be cut is cold or hot. The main difference between the two chisels is in the edge.

Cold chisels are made of tool steel with a cutting angle about $60^0$ and its edge is hardened and tempered. The handle of their chisels is usually formed on an iron rod bent around a fullered recess made in the body of the chisel the edge of the chisel should not be quite straight but slightly rounded. Hot chisel is made of low can be steel and has a cutting angle of 300 the hardening of the edge is not necessary or the hot metal would soften it. This type of chisel is fitted with wooden shafts.

6. SWAGES

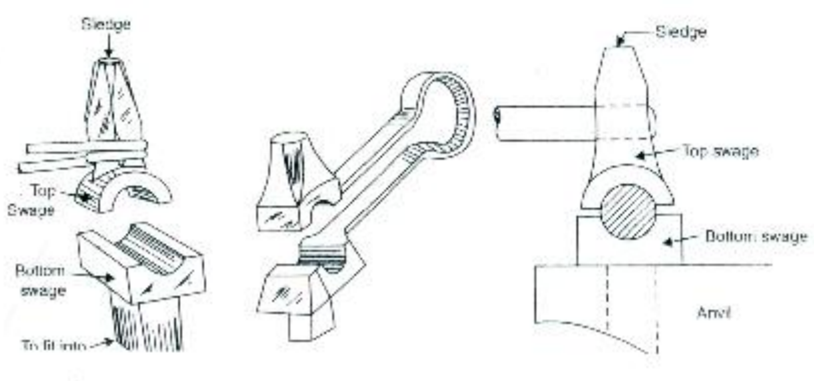



Fig: SWAGES

1. The swages are used for work which has to be reduced and finished to round or hexagonal form.
2. These are made with half grooves of dimensions to suit the work being reduced.
3. The swages may be in separate top and bottom halves or the two halves may be connected by strip of spring steel.

7. FULLERS: Fullers are used for necking down a piece of work.
   1. It is mainly used to reduce the metal while making shoulders.
   2. They are made of tool steel.

3. The fullers are made in pairs the top fuller is held by the striker, while the bottom fuller is fitted into the hardie hole of the anvil.

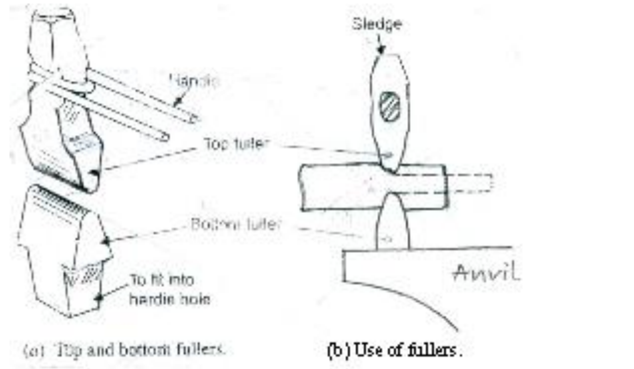



Fig: FULLERS

8. FLATTERS

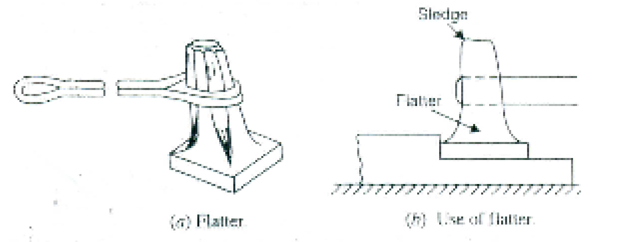



Fig: FLATTERS

1. The flatter is used for finishing flat surfaces and are made with a perfectly flat face.
2. It gives smoothness and accuracy to articles which have already been finished by swages and fullers.
3. The size is about 7.5cm square or round.
4. It is made of tool steel.

9. SET HAMEER

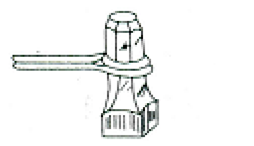


Fig. 14.11. Set hammer.

1. The set hammer is similar to flatter, but is a smaller tool. It is made up of forged steel and is hardened.
2. It is generally available in 4cm square size.
3. It is used to set down shoulders or smooth out fuller marks near the shoulders before the blacksmith finished with the flatter.

10. PUNCHES

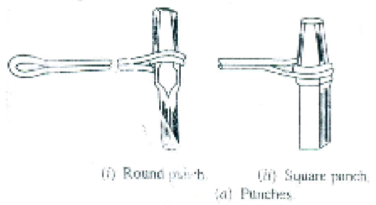
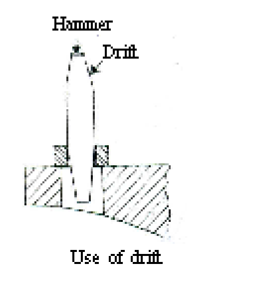



Fig: PUNCHES

1. These are used for making holes when the metal is at forging heat.
2. These are made in various shapes and sizes such as square round oval etc.
3. It is made of tool steel, hardened and tempered.

11. DRIFT




1. The drift is used to finish the size of the punched holes.
2. They are made taper and bulging in the centre.
3. These are made in various shapes and sizes.
4. These are also made of tool steel, hardened and tempered.

**Q2.** Define blacks smithy or hand forging.

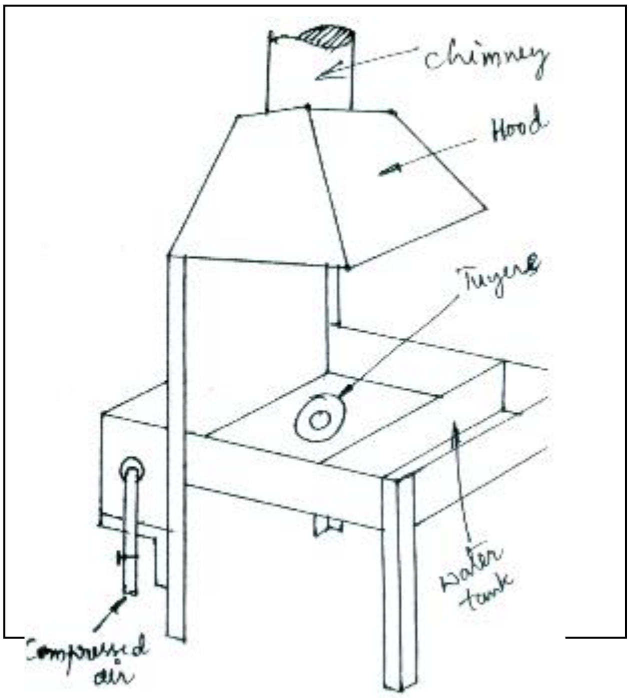
Black smithy or hand forging is defined as one of the ancient method of manufacturing articles by heating a metal stock till it acquires sufficient plasticity, followed by hammering, bending, pressing etc. till the desired shape the article is attained.

**Q3.** What are the advantages of forging?

The following are the advantages of forging

a. Strength and toughness is high.
b. Strength to weight ratio is high.
c. Internal defects are eliminated.
d. Forged parts need less or no machining.

**Q4**. Explain with a line diagram Forge or hearth.




A smith's forge or hearth is used to heat the metal to be shaped.

1. Hearths are used for heating small jobs to be forged by hand.
2. Gas, oil, or coal firing may be used for the purpose.
3. The required air for the fire is supplied under pressure in the hearth.
4. The blowers may either be hand operated or power driver.
5. In power driver type, the amount of air supply is controlled by values near the forge.
6. The hood (shown in fig) collects gases of combustion and sends through a chimney.

**Q5.** What are the different fuels used in forging work?

Fuels used in forging work are: - Coal, charcoal, coke, anthracite, petroleum etc.

**Q6.** Give the forging temperature of the following.
Aluminium, Mild steel, Stainless steel, Copper, High carbon steel and alloy steel, Medium carbon steel, Wrought iron.

| **Metal** | **Forging temperature** |
|---|---|
| Aluminium | $350^0$C to $500^0$ C |
| Mild steel | $750^0$ C to $1300^0$ C |
| Stainless steel | $1350^0$ C |
| Copper | $950^0$ C |
| High carbon steel | $800^0$ C to $1150^0$ C |
| Medium carbon steel | $750^0$ C to $1250^0$ C |
| Wrought iron | $900^0$ C to $1300^0$ C |

## ASSIGNMENT-2

**Q1.** Name any 5 smithy operations and explain then briefly.

The five smithy operations are Upsetting, Drawing down, Setting down, Punching, Bending.

1. UPSETTING

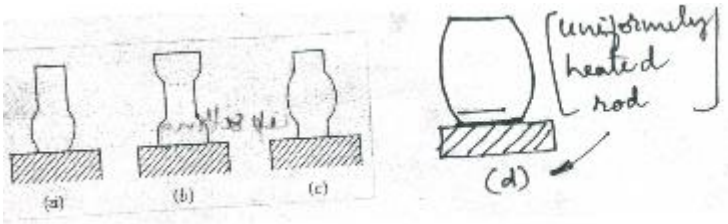



Fig: UPSETTING

It is the process of increasing the cross section of a bar at the expense of its length.

1. In this process, the work is heated to the required temperature and then the heavy blow is given by hand hammer. The swelling of work takes place at the heating portion.
2. The position and nature of upsetting depends upon the heating and upon the type of blow delivered.
3. The increase in lateral swelling will be greatest at the parts where the metal is hottest.
4. Figure (a) (b) and (c) shows the effect of heavy blow, when the heating is done at one end, at both ends, and at the centre respectively.

2. DRAWING DOWN OR SWAGING

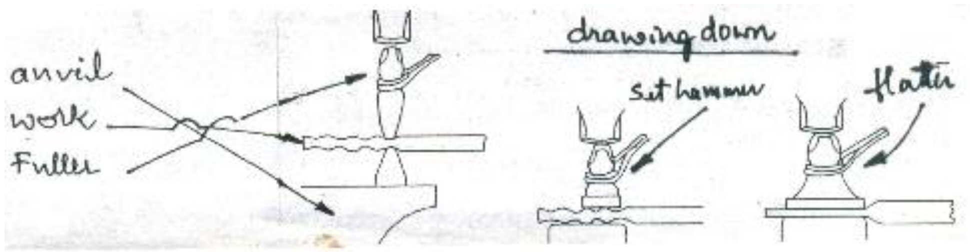


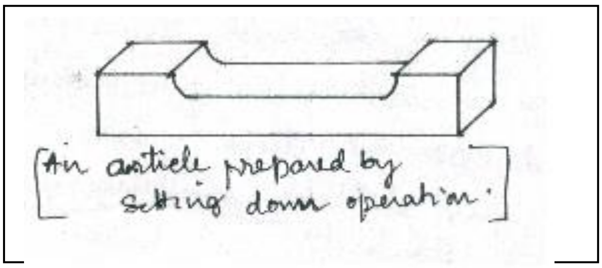

Fig: DRAWING DOWN OR SWAGING

It is the process of reducing the cross-section of a bar and increasing its length.

1. First of all, the hammering is done with a straight peen hammer by keeping the work at the edge or beak of the anvil.
2. The bar is turned through $90^0$ if the thickness in both directions is to be reduced. Pair of fullers are also used for their process.
3. Now the curved top of the work is leveled off with a set hammer, and finally finished with a flatter.

**<u>Note:-</u>** When a round bar is to be drawn down a considerable amount, it is first brought to a square by the above method, and then squared up again. It is then reduced to octagonal shape by taking off the corners and finally rounded and finished between swages.

3. SETTING DOWN



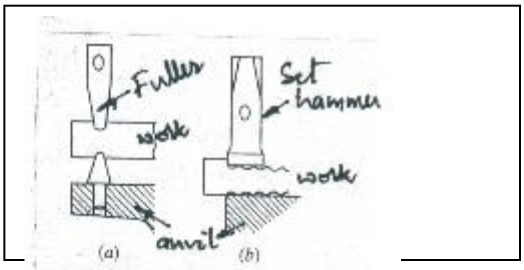




Fig. 14.16. Setting down operation.

It is a process of local thinning down affected by the set hammer. The work is usually fullered at the place where the setting down commences.
Fig shows the process of setting down both ends of a bar by using the top and bottom fuller.

4. PUNCHING

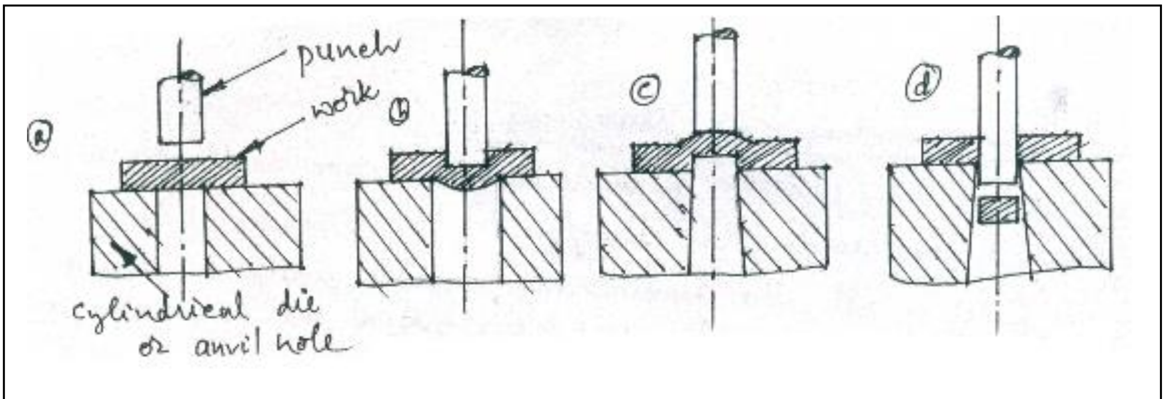


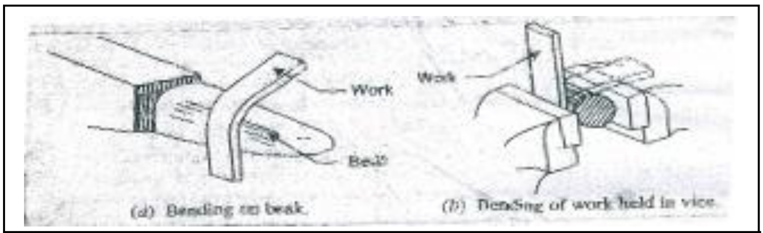

Fig: PUNCHING

It is the process of producing holes by forcing the punch through the work. The work may be placed over the pritchel hole of the anvil, over a cylindrical die, over a hole of correct size in the swage block.

1. The work is heated to nearly welding heat (while heat) and then laid flat on anvil.
2. The punch is now driven about half a way through one side.
3. The work is then turned over and the punch is again completely driven through the other side to give a clean cut hole on both sides.

5. BENDING:
    1. It is an important operation in forging and is very frequently used. The bends may be either sharp cornered angle bends or they may be composed more gradual curve.

2. A little consideration will show that when the metal is bent the layers of metal on the inside are shortened and those on the outside are stretched. This causes a bulging of the sides at the inside, and a radius on the outside of the bend.
3. The gradual bends may be made by using the beak of the anvil or the metal may be bent round a bar of the correct radius held in a nice. Some type of bending fixture should be used to save time and to produce better and uniform bends.



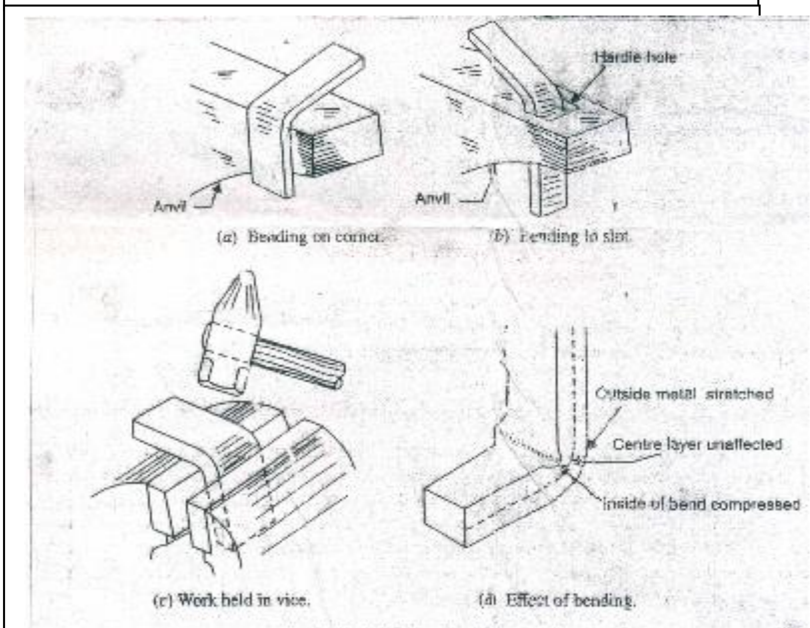
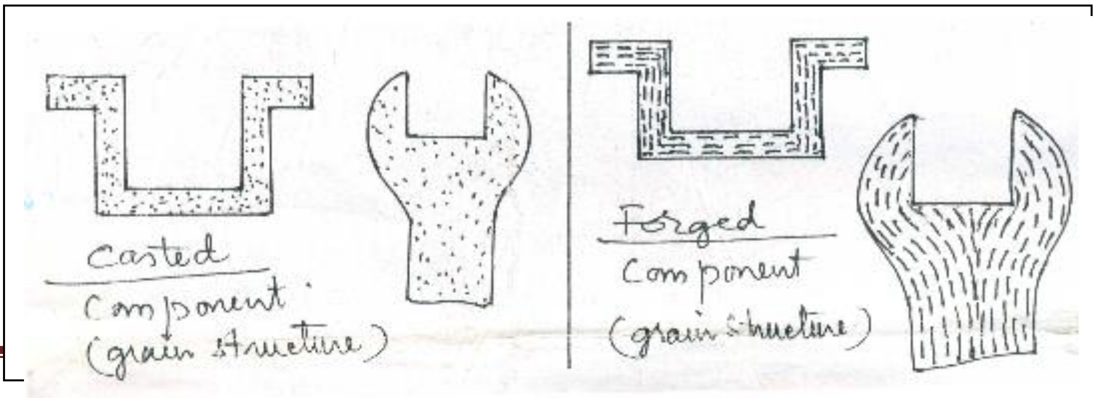




Fig. 14.18. Methods of making angle bends.

**Q2**. Write short note on one difference between casting and forged component



The basic rule of obtaining a forged and casted component is that in a forged component the grains are arranged radially thus increasing the resistance to shock. A casted component has a symmetrically aligned grain arrangement and is thus weaker as compared to forged component.

**Q3.** What is the purpose of heat treatment of steel forged parts?
The purpose of heat treatment of steel forged parts is:-

1. To eliminate residual stresses that generate in steel during forging and cooling
2. To homogenize the structure of forged model
3. To improve strength hardness and other mechanical properties.

## ASSIGNMENT-3

**Q1.** Define the following terms

Foundry, Mould, Moulding, Core, Casting, Casting process, Pattern, Sand

1. **Foundry: -** is a place where moulds and castings are prepared.
2. **Mould: -** Mould is a cavity of required shape made out of sand, with or without using a pattern.
3. **Molding: -** It is a process of making a cavity of desired shape out of sand by means of a pattern. (Some time we can also prepare moulds without using pattern e.g. preparing moulds by scooping or cutting)
4. **Casting: -** It is the final product we get after the solidification of molten metal, which has been poured into the mould cavity of desired shape and size.
5. **Casting process: -** It is the process of pouring the molten metal into a mould of desired shape and size, and allowing it to solidify
6. **Pattern: -** A pattern may be defined as a model or replica of desired casting made up of wood, metal, plaster of Paris, or plastics etc.
7. **Core: -** Core is a sand body used to form the hollow portions or cavities of desired shape and size in a casting
8. **Sand: -** Sand is defined as the granular particles resulting from the breakdown of rocks.

**Q2.** Name the sand commonly used for molding

Commonly used sand for moulding is silica sand the silica sand is found in nature on the bottoms and banks of rivers, lakes and larger bodies of water.

**Q3.** Name the ingredients of good moulding sand.

A good moulding sand contains the following ingredients.

Silica sand ($SiO_2$)-80.8%, Alumina ($Al2O_3$)-14.9%, Iron oxide ($Fe_2O_3$)-1.3%,
Combined water-2.5%, Other inert materials-1.5%.

**Q4.** What is sand binder?

Any material added to the sand, (or provided by nature in the sand) which imparts cohesiveness to it is called a sand binder (eg water, clay, bentonite etc)

**Q5.** What are functions of a binder?

The binder holds the sand grains together impart strength, resistance to breakage and degree of collapsibility.

**Q6.** What is a sand additive?

A sand additive is materials which do not promote binding action, but it improves surface finish of the moulds, aids in cleaning of castings and prevents burning on sand.

e.g., Sea coal or pulverized bituminous coal, wood flour, silica flour.etc.

**Q7.** What are the properties of good moulding sand?

The following are the properties of good moulding sand

1. **Porosity or permeability**: - It is that property of sand, which permits the steam and other gases to pass through the sand mould.
2. **Plasticity: -** It is that property of sand due to which it flows to all portions of the moulding box and acquires a pre-determined shape under ramming pressure and retain this shape when the pressure is removed.
3. **Adhesiveness: -** It is that property of the sand, due to which it adhere or cling to the sides of the moulding box.
4. **Cohesiveness:-** It is that property of sand due to which sand grains stick together during ramming
5. **Green strength:-** It is the strength of sand in its green or moist state, due to which a would will retain its shape and will not distort or collapse even after the pattern is removed from the moulding box.
6. **Dry strength:-** It is the strength of the sand that has been dried or baked, due to which sand withstand the erosive pressure or forces of the molten metal.
7. **Refractoriness:-** It is that property of moulding sand which enables it to resist high temperature of the molten metal with breaking down or fusing.
8. **Flow ability:-** It is that property of moulding sand due to which it behaves like a fluid, so that, when rammed, it flows to all portions of a mould and distribute the ramming pressure evenly.
9. **Collapsibility: -** It is that property of the sand, due to which the sand mould collapses automatically after the solidification of the casting, in order to allow free contraction of the metal.

**Q8.** Name and explain foundry hand tools

The hand tools commonly employed in preparing the mould in foundry are as fallows.

1. Shovel 2. Riddle 3. Rammer 4. Vent wire 5. Slick 6. Lifter 7. Swab 8. Bellow 9. Trowel 10. Gate cutter 11. Draw spike and screw 12. Strike off bar 13. Sprue cutter 14. Mallet 15. Gaggers 16. Clamps 17. Pouring weight 18. Rapping plate 19. Spirit level.

1. **Shovel:** A shovel, as shown in Fig. 11.1, consists of a square pan fitted with a wooden handle. It is used for mixing and for moving the sand from one place to another in the foundry.

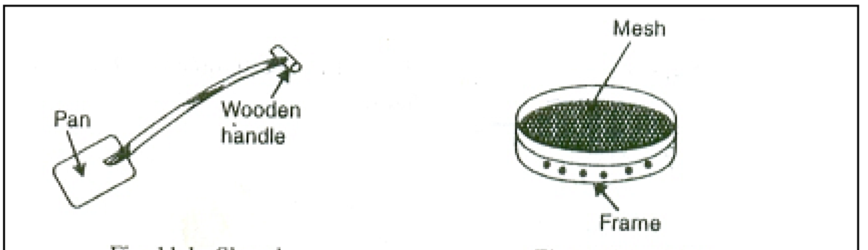
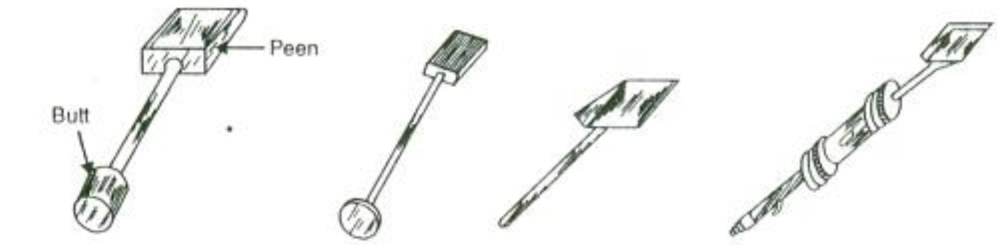


Fig. 11.1. Shovel. Fig. 11.2. Riddle.

2. **Riddle**: A riddle, as shown in Fig. 11.2, has a standard wire mesh fixed into a circular or square wooden frame. It is used for cleaning the moulding 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.
3. **Rammer**: A hand rammer, as shown in Fig. 11.3 (a), is made of wood or metal. It has a wedge shaped construction at one end (called peen) and the cylindrical shape at the other end (called butt). It is a short rammer and is used for packing and ramming the sand for bench moulding. The floor rammer, as shown in Fig. 11.3(b), is similar in construction, but have long handles. It is used for floor moulding or for ramming large moulds. The pen rammer, as shown in Fig. 11.3(c), has a wedge shaped end and is used for setting into corners and pockets of the mould. The pneumatic rammers, as shown in Fig. 11.3(d) are automatic rammers operated by compressed air. They have long or short shafts according to the requirements with peen or flat ends. It is used in large moulds saving considerable labour and time.



(*a*) Hand rammer. (*b*) Floor rammer. (*c*) Peen rammer. (*d*) Pneumatic rammer.

Fig. 11.3. Types of rammer.

4. **Vent wire**: A vent wire, as shown in Fig. 11.4, is similar to a knitting needle. It has a pointed edge at one end and a handle at the other end. It is used to pierce holes in the rammed sand to provide artificial vents which permit the easy escape of steam and gases generated by the hot metal in contact with the sand.

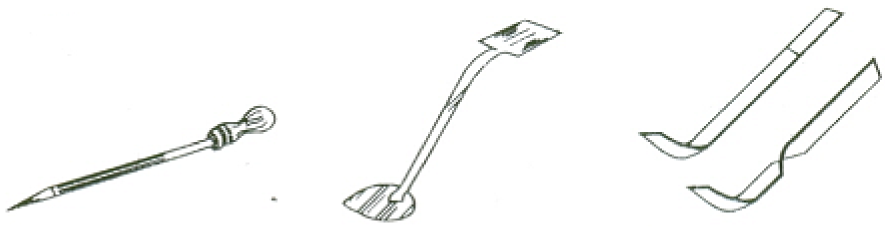


Fig. 11.4. Vent wire. Fig. 11.5. Slick. Fig. 11.6. Lifter.

5. **Slick**: A slick, as shown in Fig. 11.5, is a small double ended tool having a flat on one end and a spoon on the other. This tool is also made in a variety of other shapes and is used for repairing and finishing the mould surfaces after the pattern is withdrawn.

6. **Lifter**: A lifter, as shown in Fig. 11.6, is made of thin sections of steel of various width and lengths with one end bent at right angles. It is used for smoothing and cleaning out depressions in the mould.
7. **Swab:** A simple swab, as shown in Fig. 11.7(a), is a small brush having long hemp fibres.


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

Fig. 11.7. Swabs.

Fig. 11.8. Bellow.

A bulb swab, as shown in Fig. 11.7(b), has a rubber bulb to hold the water and and a soft hair brush at the open end. It is used for moistening the sand around the edge before the pattern is removed.

8. **Bellow:** The hand operated bellow, as shown in Fig. 11.8, is used to blow loose particles of sand from the cavities and surface of the mould.
9. **Trowel:** The trowels, as shown in Fig. 11.9, consist of a metal blade with a wooden handle. The small trowels of various shapes are used for finishing and repairing mould cavities as well as for smoothing over the parting surface of the mould. The usual trowel is rectangular in shape and has either a round or a square end.

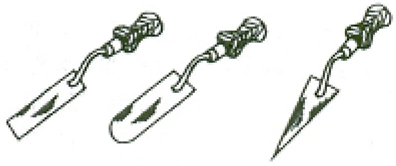
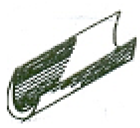
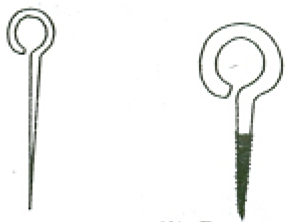


Fig. 11.9. Trowels.

10. **Gate cutter:** A gate cutter, as shown in Fig. 11.10, is a U-shaped piece of thin sheet. It is used for cutting a shallow trough in the mould to act as a passage for the hot metal.





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

11. **Draw spike and screw:** A draw spike, as shown in Fig. 11.11(a), is a pointed steel rod, with a loop at one end. It is driven into a wooden pattern to hold it when the sand is withdrawn. The draw screw, as shown in Fig. 11.11(b), is similar in shape but threaded on the end to engage metal patterns.
12. **Strike-off-bar:** A strike-off-bar, as shown in Fig. 11.12, is a straight bar of wood or steel usually of rectangular cross-section. It is used to strickle or strike off excess sand to provide a level and smooth surface.


Fig. 11.12. Strike-off-bar.


Fig. 11.13. Sprue cutter.


Fig. 11.14. Mallet.

13. **Sprue cutter:** A sprue cutter (also called a runner peg), as shown in Fig. 11.13, is a tapered wooden peg. It is forced into the top part of the mould (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.
14. **Mallet:** A raw hide mallet, as shown in Fig. 11.14, is used to loosen the pattern in the mould so that it can be withdrawn easily.


Fig. 11.15. Gaggers.

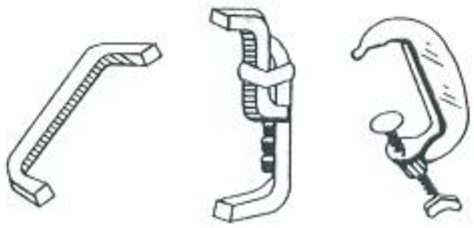


Fig. 11.16. Clamps.

15. **Gaggers:** the gaggers (also called lifters), as shown in Fig. 11.15, are iron rods bent at one end or both ends. It is used for reinforcement of sand in the top part of a moulding box and to support hanging bodies of sand. The length of the gaggers vary from 125 mm to 600 mm and they are coated with clay wash to cause the sand to adhere to them.
16. **Clamps:** The clamps, as shown in Fig. 11.16, are used for holding the cope and drag of the mould so that the cope should not rise when the molten metal is poured into the mould.
17. **Pouring weight:** It is simply a cast iron plate with a cross-shaped opening casting in it to give considerable liberty in placing the runner in the mould. It is used on the top of the mould for giving a weight to prevent the pressure of the molten metal forcing the mould apart, causing run out.

18. **Rapping plate:** A rapping plate (also called lifting plate) is made of sheet and are firmly fixed to the top of the pattern by screws or bolts. It is used for lifting and rapping large patterns. These are available in different shapes, as shown in Fig. 11.17.

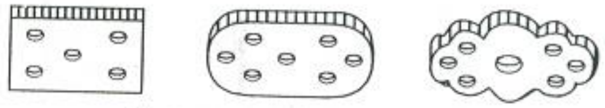


Fig. 11.17. Rapping plates.

Fig. 11.18. Spirit level.

19. **Spirit level:** A spirit level, as shown in Fig. 11.18, consists of an air bubble in a curved glass tube protected by a wooden or metal flame. It is used by the moulder to ensure that his bed of sand, moulding box or moulding machine table is horizontal.

**Q9.** Explain moulding boxes.

The sand moulds are prepared in a specially constructed boxes called flasks, which are open at the top and bottom. They are made in two parts, held in alignment by dowel pins. The top part is called the cope and the lower part as drag. If the flask is made in three parts, the intermediate part is called a cheek.

These flasks can be made of either wood or metals. Though the wood is the cheapest material and flasks can be made quickly, but they have the disadvantage of wearing out rapidly and are destroyed by the contact with hot metal. The metal flasks of steel, cast iron, magnesium or aluminium alloys are widely used in production work because of their rigidity. Following two types of flasks are widely used in foundry:

1. **Box type flask:** The box type flask (also known as tight or permanent flask), as shown in Fig. 11.19, is used for small and medium-sized castings.

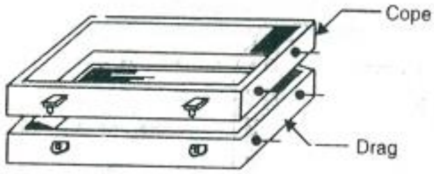



Fig. 11.19. Box type of flask.

Fig. 11.20. Snap flask.

These flasks should not be removed till the pouring of molten metal is completed. Hence a number of tight flasks are required for any one moulding sets up, one for each mould being processed. These flasks are generally made of steel.

2. **Snap flask:** The snap flask, as shown in Fig. 11.20, is often used in the production of small casting and in machine moulding. These flasks are fitted with a hinge at one corner and a fastener at the corner diagonally opposite. After the mould has been made, it is carried to the

position where it is to be cast and the snap flask is removed to be used for the following moulds. Since one flask is employed for many moulds, therefore, there is a considerable economy.

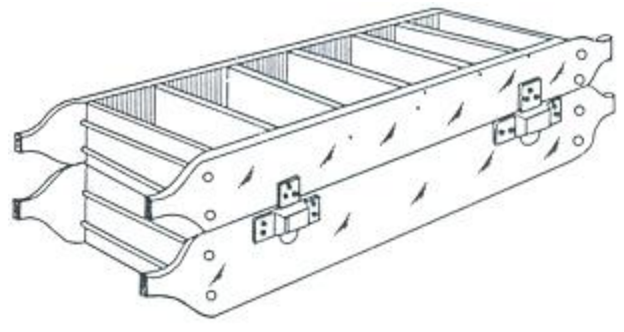


Fig. 11.21. Typical wooden moulding box.

A typical wooden moulding box is shown in Fig. 11.21. The side timbers are continued beyond the ends of the box to form two handles at each end. The sides are held together by strong cross timbers, reinforced with bolts. The crossbars prevent the sand from falling out when the top part of the box (i.e., cope) has been rammed up and is lifted away from the bottom part of the box (i.e., drag).

A moulding board and a bottom board complete the flask. The moulding board is a smooth board on which the flask and patterns are placed when the mould is started. It should be perfectly flat and well reinforced with cleats on the bottom. When the mould is turned over, the function of this board is ended and the mould is placed on a similar board called bottom board which acts as a support until it is poured.

**Q10.** Explain the process of making a green sand mould by turn over method

The procedure of making green sand mould using a split pattern and turn over method is discussed in the following steps:

1. First of all, a flat board, known as moulding board, is placed on the floor with the lower half of the pattern placed in position.
2. The bottom half of the moulding box or flask known as drag, is placed on the moulding board, as shown in Fig. 12.2(a). The moulding box should be of such a size that it accommodates the pattern easily and some space is left around it for ramming the sand.
3. The tempered moulding sand is riddled on the pattern. The sand is pressed around the pattern with fingers.
4. The sand is then rammed in the drag by means of a hand rammer. It should be lightly rammed over the pattern and more heavily away from the pattern. In ramming the sand around the sides of the flask, the peen end of the rammer should be used first and then additional sand is placed into the drag as the sand is packed down. The inside area of the drag is then packed down with butt end of the rammer. It may be noted that if the sand is not sufficiently rammed, it will not hold together when handled or

when the molten iron strikes it. On the other hand, if it is rammed too hard, it will not permit the steam and gas to escape when the molten iron comes into the mould.

5. After ramming, the excess sand is leveled off with a strike-off bar.
6. A vent wire is thrust into the sand in a number of places to reach the pattern so that small vent holes are made to escape of the gases when molten metal is poured.
7. A loose sand is now sprinkled over the mould and a bottom board is clamped in position, as shown in Fig. 12.2(b).
8. The drag is now rolled over and the moulding board is removed, exposing the pattern.
9. The surface of the sand is first smoothed over with a trowel and then covered with a dry parting sand. This is done to prevent the sand in the cope(upper part of moulding box) from sticking to the sand in the drag when the mould is separated to remove the pattern.
10. The top half pattern is now fixed in position with a cope on the drag, as shown in Fig. 12.2(d).
11. The facing sand is riddled over the pattern and the sprue and riser pegs fixed in position, the cope is filled with green sand. The operations of filling, ramming and venting of the cope is similar to that of drag.
12. The sprue and riser pegs are withdrawn; the top part lifted from the drag and rolled over to horizontal position.
13. Any loose sand is brushed from the faces of the mould and the joints smoothed.
14. Water from a swab is sprinkled on the sand around the pattern so that the edges of the mould hold firmly when the pattern is withdrawn.
15. A draw spike is driven into the patterns and rapped lightly in all directions in order to loosen the pattern. The patterns from both parts of the mould are withdrawn by lifting up the draw spike.
16. A small passage known as gate must be cut from the mould at the bottom of the sprue opening which is made like a funnel to facilitate pouring of molten metal.
17. The centre core is now fixed in the print left by the pattern in the drag.
18. The mould surfaces may be sprayed, swabbed or dusted with a prepared coating material containing silica flour and graphite. The composition of the coating material depends upon the type of material being cast. This coating material improves the surface finish of the casting and reduce possible surface defects.
19. The top part is rolled back, carefully lowered into position on the drag, and clamped or weighted. The mould is now ready for pouring, as shown in Fig. 12.2(h).

the draw spike.

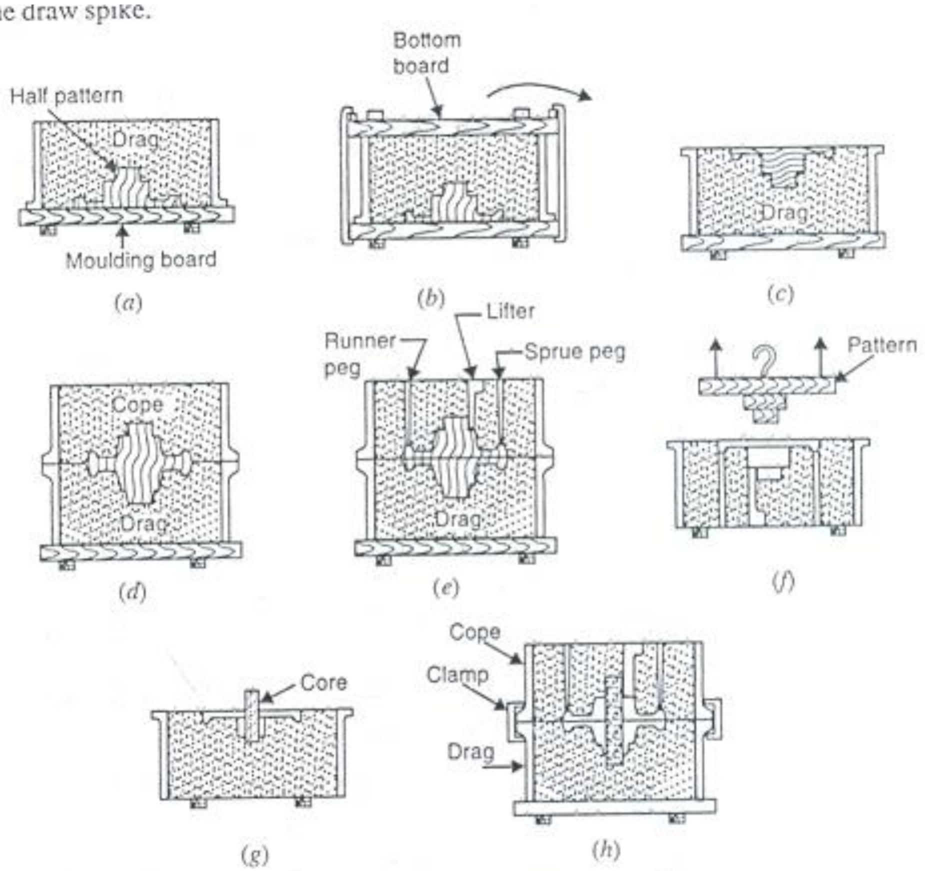



Fig. 12.2. Turn over method of green sand moulding.