



# **MARRI LAXMAN REDDY** **INSTITUTE OF TECHNOLOGY AND MANAGEMENT**

(AN AUTONOMOUS INSTITUTION)

(Approved by AICTE, New Delhi & Affiliated to JNTUH, Hyderabad)

Accredited by NBA and NAAC with 'A' Grade & Recognized Under Section 2(f) & 12(B) of the UGC act, 1956

## **DEPARTMENT MECHANICAL ENGINEERING**

# **PRODUCTION TECHNOLOGY** **LAB MANUAL**



<b>SUBJECT NAME</b>	<b>Production Technology Lab</b>
<b>SUBJECT CODE</b>	<b>2040375</b>
<b>COURSE-BRANCH</b>	<b>B. Tech - Mechanical Engineering</b>
<b>YEAR-SEMESTER</b>	<b>II - II</b>
<b>ACADEMIC YEAR</b>	<b>2021-2022</b>
<b>REGULATION</b>	<b>MLRS-R20</b>

# **MARRI LAXAMAN REDDY**

## **INSTITUTE OF TECHNOLOGY AND MANAGEMENT**

## **MISSION AND VISION OF THE INSTITUTE:**

### **Our Vision:**

To establish as an ideal academic institution in the service of the nation the world and the humanity by graduating talented engineers to be ethically strong globally competent by conducting high quality research, developing breakthrough technologies and disseminating and preserving technical knowledge.

### **Our Mission:**

To fulfill the promised vision through the following strategic characteristics and aspirations:

- Contemporary and rigorous educational experiences that develop the engineers and managers;
- An atmosphere that facilitates personal commitment to the educational success of students in an environment that values diversity and community;
- Prudent and accountable resource management;
- Undergraduate programs that integrate global awareness, communication skills and team building across the curriculum;
- Leadership and service to meet society's needs;
- Education and research partnerships with colleges, universities, and industries to graduate education and training that prepares students for interdisciplinary engineering research and advanced problem solving;
- Highly successful alumni who contribute to the profession in the global society.

## **Vision and Mission statements of the Department of Mechanical Engineering:**

### **Vision Statement:**

“The Mechanical Engineering Department strives immense success in the field of education, research and development by nurturing the budding minds of young engineers inventing sets of new designs and new products which may be envisaged as the modalities to bring about a green future for humanity”

### **Mission Statement:**

1. Equipping the students with manifold technical knowledge to make them efficient and independent thinkers and designers in national and international arena.
2. Encouraging students and faculties to be creative and to develop analytical abilities and efficiency in applying theories into practice, to develop and disseminate new knowledge.

3. Pursuing collaborative work in research and development organizations, industrial enterprises, Research and academic institutions of national and international, to introduce new knowledge and methods in engineering teaching and research in order to orient young minds towards industrial development.

### **PROGRAM EDUCATIONAL OBJECTIVE**

**PEO 1:** Graduates shall have knowledge and skills to succeed as Mechanical engineer's for their career development.

**PEO 2:** Graduates will explore in research.

**PEO 3:** Mechanical Graduates shall have the ability to design products with various interdisciplinary skills

**PEO 4:** Graduates will serve the society with their professional skills

## **PROGRAM OUTCOMES**

- A.** Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals and an engineering specialization for the solution of complex engineering problems.
- B.** Problem Analysis: Identify, formulate, research, review the available literature and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural science and engineering sciences.
- C.** Design and development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specific needs with appropriate considerations for public health safety and cultural, societal and environmental considerations.
- D.** Conduct investigations of complex problems: Use research based knowledge and research methods including design of experiments, analysis and interpretation of data and synthesis of the information to provide valid conclusions.
- E.** Modern tool usage: Create, select and apply appropriate techniques, resources and modern engineering and IT tools including predictions and modeling to complex engineering activities with an understanding of the limitations.
- F.** The Engineer and society: Apply reasoning, informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practices.
- G.** Environment and sustainability: Understand the impact of the professional engineering solutions in society and environmental context and demonstrate the knowledge of and need for sustainable development.
- H.** Ethics: Apply ethical principles and commitment to professional ethics, responsibilities and norms of the engineering practice.
- I.** Individual and team work: Function effectively as an individual and as a member or leader in diverse teams and in multi disciplinary settings.
- J.** Communication: Communicate effectively on complex engineering activities with the engineering community and with the society at large, such as being able to comprehend, write effective reports, design documentation, make effective presentations, give and receive clear instructions.
- K.** Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
- L.** Life – long learning: Recognize the need and have the preparation, ability to engage in independent and life – long learning in the broadest context of technological change.

## **PROGRAMME SPECIFIC OUTCOMES:**

**PS01:** Students acquire necessary technical skills in mechanical engineering that make them employable graduate.

**PSO2:** An ability to impart technological inputs towards development of society by becoming an entrepreneur.

**COURSE OBJECTIVES:**

1. To understand the basic principles of fluid mechanics.
2. To identify various types of flows.
3. To understand boundary layer concepts and flow through pipes.
4. To evaluate the performance of hydraulic turbines.
5. To understand the functioning and characteristic curves of pumps.

**COURSE OUTCOMES:**

- ME 375.1      Understanding the properties of moulding sands and pattern making.
- ME 375.2      Fabricate joints using gas welding and arc welding.
- ME 375.3      Evaluate the quality of welded joints.
- ME 375.4      Understanding the various metal forming process like stamping, drawing etc.
- ME 375.5      Basic idea of press working tools.
- ME 375.6      Perform moulding studies on plastics and their products.

## INSTRUCTIONS TO THE STUDENTS

1. Every student should obtain a copy of the laboratory manual
2. It is important that all students arrive at each session on time.
3. Dress code: Students must come to the laboratory wearing:
  - Trousers.
  - half-sleeve tops.
  - Leather shoes.
  - Half pants, loosely hanging garments and slippers are not allowed.
4. Students should come with thorough preparation for the experiment to be conducted.
5. Students will not be permitted to attend the laboratory unless they bring the practical record fully completed in all respects pertaining to the experiment conducted in the previous class.
6. Experiment should be started only after the staff-in-charge has checked the experimental setup.
7. All the calculations should be made in the observation book. Specimen calculations for one set of readings have to be shown in the practical record.
8. Wherever graphs are to be drawn, A-4 size graphs only should be used and the same should be firmly attached to the practical record.
9. Practical record and observation should be neatly maintained.
10. They should obtain the signature of the staff-in-charge in the observation book after completing each experiment.
11. Theory regarding each experiment should be written in the practical record before procedure in your own words.

## **LABORATORY SAFETY PRECAUTIONS**

1. Laboratory uniform, shoes & safety glasses are compulsory in the lab.
2. Do not touch anything with which you are not completely familiar. Carelessness may not only break the valuable equipment in the lab but may also cause serious injury to you and others in the lab.
3. Please follow instructions precisely as instructed by your supervisor. Do not start the experiment unless your setup is verified & approved by your supervisor.
4. Do not leave the experiments unattended while in progress.
5. Do not crowd around the equipment's & run inside the laboratory.
6. During experiments material may fail and disperse, please wear safety glasses and maintain a safe distance from the experiment.
7. If any part of the equipment fails while being used, report it immediately to your supervisor. Never try to fix the problem yourself because you could further damage the equipment and harm yourself and others in the lab.
8. Keep the work area clear of all materials except those needed for your work and cleanup after your work.

## **LIST OF EXPERIMENTS:**

- 1.** Preparation of green sand by using sand Muller to measure permeability of green sand specimen by using permeability meter and to measure compatibility of green sand specimen.
- 2.** To measure the hardness of green sand specimen by using hardness tester (before heating and after heating) and to measure the shear strength and compression strength of green sand.
- 3.** Preparation of wooden pattern (stepped pulley) by using wood turning lathe machine.
- 4.** Preparation of mould cavity by using dumbbell & stepped pulley pattern.
- 5.** Melting of aluminum and casting in the prepared mould cavity.
- 6.** Arc Welding –Butt joint & Lap joint.
- 7.** Spot welding –Lap joint & Plasma welding, Plasma cutting.
- 8.** Gas Welding & Brazing.
- 9.** MIG Welding & TIG Welding.
- 10.** Preparation of blanking component by using fly press, extruded part by using hydraulic press, lever by using power press.
- 11.** Preparation of key chain by using Injection moulding machine.
- 12.** Preparation of bottle by using Blow moulding machine.



## **EXPERIMENT NO: 1**

### **Preparation of Green Sand by Using Sand Muller**

#### **Objective:**

To prepare the sample batches of green sand in the Sand Muller.

#### **Outcomes:**

Students will be able to:

- Understand the term Green sand and its composition
- Able to demonstrate various skills of sand preparation.

#### **Scope of the Experiment:**

Sand mullers are exclusively used in foundry Industry to knead the working sand, for the purpose of distributing the ingredients (additives) into a homogenous mixture which result in a production of sound dimensionally accurate castings

#### **Theory:**

The objective of sand mulling is to achieve a uniform distribution of sand grains, since this affects permeability and surface fineness. Uniformly mixed sand gives high flow ability. The grain size distribution also influences strength properties of bonded mixtures.

#### **Material Required:**

- Moulding sand
- Bentonite powder
- Water.

#### **Description of Apparatus:**

The equipment consists of two rollers in model VLM 5 and one roller in model VLM 2 and a plough. The mixing is carried out by rotating the above mechanism in the pan .A separate door is provided for discharging the sand.

#### **Procedure:**

- Switch the instrument add weighed dried sand in the pan gradually from one side
- Add measure quantity of binding material. Add the required quantity of water
- The Muller performs the blending action on the sand while mixing to achieve maximum plasticity the plough directs the sand under the Muller with mixing to achieve maximum plasticity the plough.

- This ensures rapid and through blending of the sand, the moulding sand is discharge by Opening bottom discharge door Rotating plough removes the material from the pan easily and quickly.
- Switch off the instrument clean pan; plough and roller close the door.

### Precautions:

1. Add the correct proportions of all the constituents of Green Sand.
2. Don't add the water in the beginning of the mulling action.
3. Clean the apparatus and close the discharging door after using the instrument

### Result:

**Model Equipment: figure 1.a, b, c showing a sand rammer equipment**



Figure 1.a

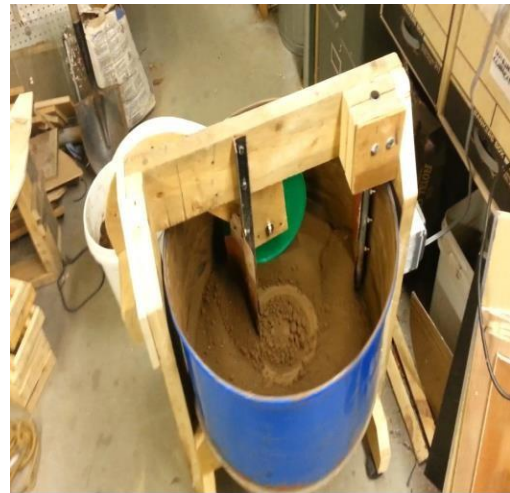


Figure 1.b

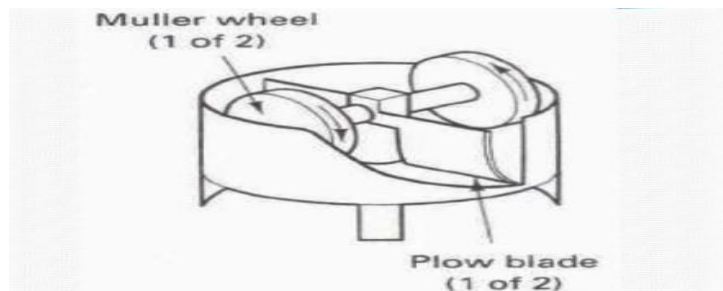


Figure 1.c

## 1(a) SAND RAMMER

### Objective:

To prepare standard samples under identical condition for checking important physical properties of foundry sand.

### Outcomes:

Student will be able to

- Prepare the green sand
- Make the samples for testing the sand properties

### Scope:

Moulding sand must have good strength otherwise it may lead to collapse of mould. It must be retained when the molten metal enters the mould (bond strength) and it should be able to retain its shape when the pattern is removed and movement of the mould.

### Theory:

Good moulding sand must possess the following properties. The properties are determined by the amount of clay, moisture content and by the shape and size of the silica grain in the sand.

- ❖ **Permeability:** It is the ability of sand to allow the gasses to escape from the mould.
- ❖ **Cohesiveness or strength:** This is the ability of sand particles to stick together. Insufficient strength may lead to a collapse in the mould or its partial destruction during conveying turning over or closing.
- ❖ **Adhesiveness:** The sand particles must be capable of adhering to another body, i.e, they should cling to the sides of the moulding boxes.
- ❖ **Plasticity:** It is the property to retain its shape when the pressure of the pattern is removed.
- ❖ **Refractoriness:** The sand must be capable of withstanding the high temperature of the molten metal without fusing.
- ❖ **Binding:** Binder allows sand to flow to take up pattern shape.
- ❖ **Chemical resistivity:** Moulding sand should not chemically react or combine with molten metal so that it can be used again and again.
- ❖ **Flowability:** It is the ability of sand to take up the desired shape.

**Materials used:** Base sand, clay, water,

## Apparatus:

Sand rammer, frame, plunger, lifting cam, calibrated sliding weight and ramming cam and specimen tube.

## Description:

This instrument consists of frame, ramming plunger calibrated sliding weight, lifting cam and ramming cam. The standard supply with instrument includes standard specimen tube one pedestal cup and one stripper.

## Pre-setting:

1. Secure sand rammer on sturdy plat form. It is advisable to mount the rammer on special base block model VSB to assure uniformly in ramming irrespective of platform used.
2. Clean and lubricate moving parts of the instruments lubricate the moving part to minimize wear lift the plunger by lifting cam.

## Procedure:

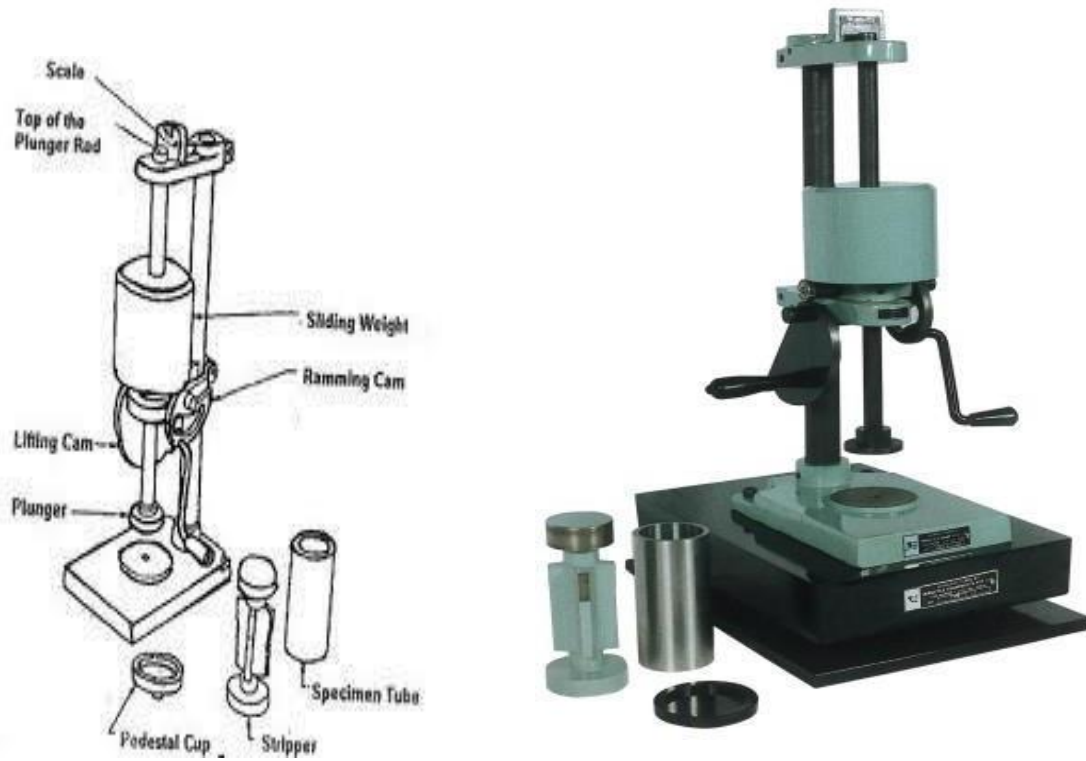
- Place the specimen tube in the pedestal cup; take approximately 150 grams of sand. Place the specimen tube with pedestal cap on base tube filler model VTF.
- Transfer the weighed sand in the specimen tube through the funnel of the filler lift .The plunger by using lifting cam. Take out specimen tube along with pedestal cap at bottom and carefully insert it under plunger of the rammer.
- Make sure that the boss on pedestal cap is located in hole on the rammer base the plunger by operating the lifting cam and allow plunger to enter the tube .turn ramming cam handle and allow weight to fall on stand in tube.
- repeat this for 3 times to get rammed sand specimen the top of the plunger rod will level with center to clearance line 0 on scale when height of test specimen will be exactly 50mm.
- However if top of plunger rod may level within upper tolerance line and lower tolerance the height of test specimen will be within prescribed and acceptable limits.
- Lift the plunger by means of lifting cam take out specimen tube with specimen.
- For removing the specimen from tube place the tube with rammed sample inverted over the stripper and pull tube slowly down wards. The specimen will slide out of tube and rest on stripper.

## Precautions:

1. Always keep rammer plunger in lifted condition with help of lifting cam when hot in use do not turn ramming cam handle and allow weight to fall unless a sample is being rammed.
2. Clean and lubricate all moving parts of rammer clean specimen tube before operation of specimen.

**Result:**

**Model Equipment:**



**Figure 1.d showing parts of sand rammer**

## 1(b) COMPACTABILITY TEST

### Objective:

To find the compactability of moulding sand.

### Outcomes:

Student will be able to

- Understand the term compactability
- Test the property by using the prescribed apparatus.

### Theory:

Compatibility test is carried out to know how molding sand will withstand repeated cycles of heating and cooling during casting operations. According to the theory, sand compactability is directly proportional to the amount of moisture present in the sand.

Scope:

The compactability of the moulding sand must be low enough to avoid oversized castings (due to mold wall movement), shrinks, blows, pin holes, super voids, poor finish, expansion defects, gas and rough surfaces, shakeout problems and high ramming resistance. This test is used to determine the percentage of moisture in the molding sand

### Material Required:

Green Sand, specimen tube, knife.

### Description of Apparatus:

Consists of a special specimen tube, knife and sand compactability scale.



Compact ability should ideally lie in the range 36-42

## Procedure:

- Place the special specimen tube in the pedestal cup, supplied with compactability accessory.
- Insert the tube with the cup on the base of the tube filler model VTF (supplied at extra cost) pour the sand in the tube through the funnel till sand over flows.
- Remove the specimen tube with cup. Scrape out the excess sand with knife provided.
- Place the filled tube under the rammer plunger.
- Bring the plunger gently down by operating the lifting cam and allow it to rest on the sand.
- By operating ramming cam gives three drops. Lift the plunger by operating lifting cam.
- Remove the tube from the rammer. Insert the compactability scale vertically in such a way so that the zero of the mark touches the surface of the specimen.
- Read the division coinciding with the edge of the specimen tube. The reading gives direct value of percentage compactability of the sand.

## Result:

The compactability of green sand specimen is \_\_\_\_\_

## 1 (c) PERMEABILITY TEST

### Objective:

To find the effect of water content, clay content on green permeability of foundry sand.

### Outcomes:

Student will be able to

- Understand the term permeability
- Test the property by using the prescribed apparatus.

### Theory:

Permeability is a property of foundry sand with respect to how well the sand can vent, i.e. how well gases pass through the sand. And in other words, permeability is the property by which we can know the ability of material to transmit fluid/gases

A higher permeability can reduce the porosity of the mold, but a lower permeability can result in a better surface finish. Permeability is determined by the size and shape of the sand grains

- Molten metals always contain certain amount of dissolved gases, which are evolved when the metal starts freezing.
- When molten metal comes in contact with moist sand, generates steam or water vapor.
- Gases and water vapor are released in the mould cavity by the molten metal and sand. If they do not find opportunity to escape completely through the mould, they will get entrapped and form gas holes or pores in the casting. The sand must therefore be sufficiently porous to allow the gases and water vapor to escape out. This property of sand is referred to as permeability.
- Permeability is one of the most important properties affecting the characteristic of moulds which depends upon the grain size, grain shape, grain distribution, binder content, moisture level and degree of compactness.
- Permeability is a physical property of the physical sand mixture, which allows gases to pass through it easily.
- The AFS (American Foundry Men Society) definition of permeability is “the number obtained by passing 2000cc of air through a standard specimen under a pressure of 10 gm. /cm<sup>2</sup> for a given time in minutes”.
- The permeability number PN can be found out by the equation

$$PN = \frac{VH}{PAT}$$



Where

- ✓ V = Volume of air passing through the specimen, 2000cc
- ✓ H = Height of the specimen = 50.8 mm (standard value)
- ✓ P = Pressure as read from the manometer in gm/cm<sup>2</sup>
- ✓ A = Area of the specimen =  $\pi d^2/4$
- ✓ Where d = 50.8 mm (standard value)
- ✓ T = time in minutes for 2000 cc of air passed through the sand specimen

### Material Required:

Base sand, clay and water

### Description of Apparatus:

Permeability meter has a cylindrical water tank in which an air tank is floating. By properly opening the valve, air from the air tank can be made to flow through the sand specimen and a back pressure is setup. The pressure of this air is obtained with the water manometer. The meter also contains the chart, which directly gives the PN depending on pressure

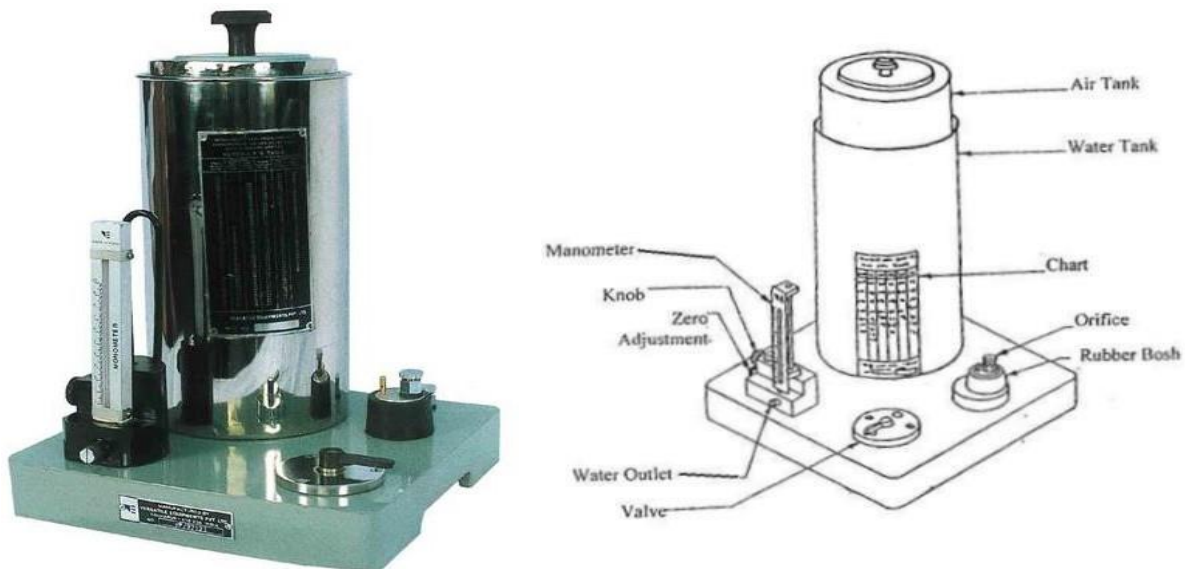


Figure 1.e Describes the parts of the Permieability Tester

### Procedure:

- Conduct the experiment in two parts. In the first case vary water percent keeping clay percent constant. In the second case vary clay percent and keep water percent constant.
- Take weighed proportions of sand dry mix them together for 3 minutes. Then add required proportions of water and wet mix for another 2 minutes, to get a homogeneous and mixture. Take the total weight of the mixture between 150-200 grams. The correct weight has to be determined by trial and error method. 3. Fill the sand mixture into the

specimen tube and ram thrice using sand rammer. Use the tolerance limit provided at the top end of the rammer for checking the specimen size. If the top end of the rammer is within the tolerance limit, the correct specimen is obtained. If it lies below the limit, increase the weight of sand mixture and prepare a new specimen. The specimen conforming to within limits represent the standard specimen required.

- Now the prepared standard specimen is having a dia.50.8mm and height 50.8mm.
- Place the standard specimen along with the tube in the inverted position on the rubber seal or on the mercury cup (specimen in the top position in the manometer reading).
- Operate the valve and start the stop watch simultaneously. When the zero mark on the inverted jar just touches the top of water tank, note down the manometer reading.
- Note down the time required to pass 2000cc of air through the specimen. Calculate the permeability number by using the formula given.

### **Direct scale reading:**

The permeability can also be determined by making use of the graduated marker provided near the manometer.

### **Procedure to be followed:**

- Coincide the graduations on the transparent scale with the meniscus of the manometer liquid.
- Note the reading of the scale.
- This reading represents the permeability number of the sand.

### **Precautions:**

- It is advisable to remove water from water tank by using siphoning attachment provided with the instrument.
- Instrument should be away from electricity.
- Keep air tank clean.
- Do not use metallic piece to clean the orifice. Always use blown air to clean orifices.
- Ensure positive sealing of the specimen tube on rubber sealing boss.
- For removal of the water tank completely from manometer, use zero- adjustment valve.

### **Result:**

### Innovative questions:

1. To determine the composition of green sand
2. Examine the properties of molding sand
3. To find the compactability of green sand
4. Preparation of green sand and to test its permeability

### Boom's Taxonomy Questions:

S No	Question	Level
1	Discuss the various properties of green sand	3
2	Determine the permeability of Green sand	2
3	Explain the procedure to conduct the compactibility test	3
4	What is the composition of green sand	2
5	State the importance of ramming	1

### Viva Questions:

1. What the composition of loam sand\_\_\_\_\_
2. What is the percentage of composition of green sand to mix in sand Muller is\_\_\_\_\_
3. The percentage of water is mixed for green sand is \_\_\_\_\_
4. \_\_\_\_\_ is helpful to mix the sand in sand Muller machine.
5. \_\_\_\_\_type of sand comes out after the mixture of green sand.
6. \_\_\_\_\_Process deals with the preparation of mould sand.
7. To avoid difficulties in making of mold's sand should be cooled to\_\_\_\_\_temperature.
8. What should be accuracy of automatic moisture control for manufacturing sands\_\_\_\_\_
9. \_\_\_\_\_muller is used in mechanized foundries
10. \_\_\_\_\_process deals with mixing the moulding sand elements
11. How much time is taken by sand, for sand preparation in terms of muller time\_\_\_\_\_
12. \_\_\_\_\_are provided for forced cooling of sand after muller operation
13. \_\_\_\_\_process deals with the amount of moisture to be added
14. Green sand composition is \_\_\_\_\_
15. Amount of clay content in loam sand is \_\_\_\_\_
16. Green sand mould contains\_\_\_\_\_strength?
17. Hardness of green sand mould can be increased by decrease in \_\_\_\_\_
18. Green sand is heated to \_\_\_\_\_temperature to convert it into dry sand?
19. Weight of the rammer\_\_\_\_\_
20. \_\_\_\_\_Degrees of rotation gives rammer to make specimen.
21. When will the specimen gets in the required shape of\_\_\_\_\_length.

22. What will be the diameter of specimen is \_\_\_\_\_
23. When tight ramming of the specimen is done it gives rise to\_\_\_\_\_
24. \_\_\_\_\_, \_\_\_\_\_, \_\_\_\_\_, \_\_\_\_\_ are the tools required for making specimen.
25. \_\_\_\_\_ is the protection of specimen to hold the specimen tub.
26. What types of gases are sucked inside the bonding of specimen is\_\_\_\_\_
27. \_\_\_\_\_ Sand is used for making of green sand.
28. How many strokes are applied for ramming\_\_\_\_\_
29. What is absolute permeability number\_\_\_\_\_
30. What is permeability?

## Applications:

### Applications of Casting:

- Transportation vehicles
- Turbine vanes
- Power generators
- Railway crossings
- Agricultural parts
- Aircraft jet engine parts
- Sanitary fittings
- Communication, Construction and Atomic Energy applications, etc..

## Experiment No 2

### (a) Mold's Hardness Tester

#### Objective:

To find the given green mould hardness of sand mould.

#### Outcome:

Students will be able:

- To understand the concept of “hardness”
- To determine the hardness number of green sand

#### Theory:

Mould and core hardness can be found out by the hardness – tester which is based on the same principle as Brinell hardness tester. A steel ball of 50 mm diameter weighing 237 gm. is pressed on the mould surface. The depth of penetration of steel ball will give the hardness of mould surface on the direct reading dial. This hardness test is useful in finding out the mould uniformity

The following are the moulding hardness numbers for Moulding sand (1 number = 1/100 mm) Soft rammed moulds = 100 Medium rammed moulds = 125 Hard rammed mould = 175

#### Apparatus and Material required:

Mould hardness tester, Green sand.

#### Description of Apparatus:

Equipment is used to measure **Mould Hardness** number of Green Sand **Mould**. Consists of dial indicator and special geometry plunger to read **hardness** of Green **Mould** from 0 to 100 Nos. The tip of the instrument is special in shape and made from alloy steel. The hardness tester is supplied in wooden carry box.

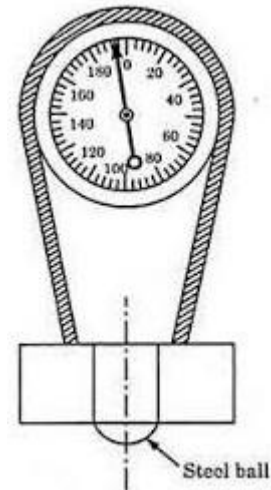


Figure shows, Mould hardness tester

### Testing For Correctness:

- Confirm the movement of the dial indicator and tip by pressing tightly.
- The needle should come to zero position when released.
- Test the instrument on optically flat surface by gently pressing vertically to touch the bottom ring of the tester.
- The needle will show one complete round with zero readings.

### Procedure:

- Apply the instrument vertically, placing the tip of the mould surface of which the hardness is to be measured.
- Gently press on the surface until the surface of the bottom ring contacts the mould surface throughout the periphery.
- The depth of penetration of the tip into the mould indicates the green hardness which is indicates on the dial directly.
- The specimen is put into HOT AIR OVEN and it is heated about 100 °c
- Then measure the hardness of the specimen or mould by the hardness tester

### Precautions:

- Keep the instrument clean and away from dust .ensure that all sticking sand is removed from the instrument before and after every test.
- Don't tamper with setting and calibration

### Result:

The green hardness of the specimen is: \_\_\_\_\_

After heating to 100 °c the hardness is: \_\_\_\_\_

## 2(b) Universal Strength Machine Pendulum

### Objective:

To determine compression strength and shear strength of the foundry sand.

### Outcomes:

Student will be able:

- To understand the bonding or adhesiveness power of various bonding materials in green sand, using compression test.
- To calculate the compression strength and shear strength of foundry sand

### Theory:

- Periodic tests are necessary to check the quality of foundry sand and compression strength test is one among them.
- The constituents of moulding sand are silica sand, clay, water and other special additives.
- Clay imparts the necessary bonding strength to the moulding sand when it is mixed with water etc. bentonite.
- Compression test determines the bonding or adhesiveness power of various bonding materials in green sand.
- The green compressive strength of foundry sand is the maximum compression strength a mixture is capable of developing when it is in most condition.

### Apparatus and Material required:

Universal Strength Machine Pendulum and foundry sand

### Description of Apparatus:

The machine has pendulum, main body, pusher arm, scale, wheel, magnetic rider and a pair of compression pads.



## Pre Setting:

- Remove the bolt located at the left side of machine. Keep the instrument on the plane steady table. Rotate the wheel anticlockwise to take the pusher arm back till it stops.
- While testing green strength, compression pads are inserted in the bottom location and for dry strength the compression pads are inserted in the top location. Ensure that the magnetic rider is resting against pusher plate.

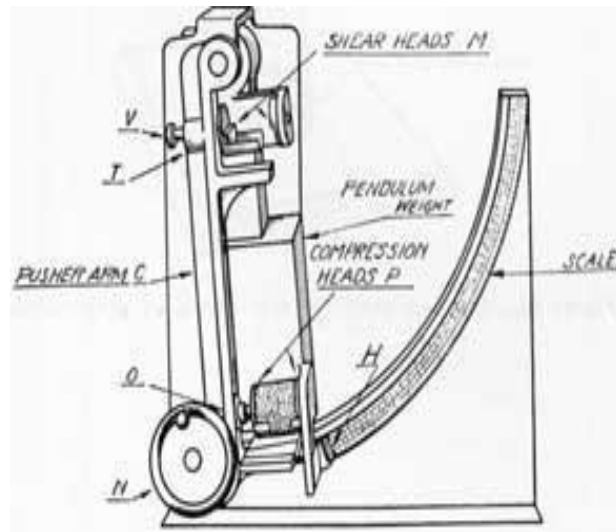


Figure shows; Universal Strength Pendulum

## Procedure:

- Standard compression specimen, under test is held in between compression pads, by left hand, so that plane surface of the specimen touches against the pads. It is essential to have the same specimen of correct length of 50 mm.
- Rotate the wheel in clockwise direction uniformly at the rate so as to obtain a green compression reading of 500 gms cm<sup>2</sup>. Keep the hand wheel until the specimen breaks.
- Immediately after breaking of the specimen, the pendulum with the pusher plate drops slightly down whereas the maximum effective compression strength is indicated on the scale by lower edge of the magnetic rider.
- Read the scale according to the location being used i.e., for bottom location read on "green compression scale" and for top location read on "dry compression scale". Rotate the wheel anticlockwise to take the pusher arm to its original position.
- Remove compression pads. Insert shear pads (For green sand at lower location and for dry sand plane surface of the specimen touches at upper location).

- Place the cylindrical (50mm dia and 50mm length) specimen in between the pads so that plane surface of the specimen touches against the pads.
- Rotate the wheel in clock wise direction uniformly until the specimen breaks.
- Read the scale according to location upper, lower on shear scale directly.

### Result:

- The compression strength is: \_\_\_\_\_
- The shear strength is: \_\_\_\_\_

### Innovative Questions:

1. Find the green compression strength of the given specimen at different percentage of clay and water
2. Determine the green shear strength of the given specimen for different percentage of clay & moisture
3. Find the core hardness & mould hardness.

### Blooms Taxonomy Questions:

S No	Question	Level
1	Differentiate core hardness and mould hardness.	2
2	Compare green strength to dry strength of foundry sand	3
3	Evaluate the compression strength with varying % of moisture content.	4
4	Determine the green shear strength of the given specimen for different percentage of clay.	3
5	What are the constituents in moulding sand?	1

### Viva Questions:

1. At \_\_\_\_\_ temperature the specimen is heated.
2. \_\_\_\_\_ Type of heating is effected for specimen.
3. \_\_\_\_\_ Equipment is used for testing hardness.
4. \_\_\_\_\_ is the wet of the pendulum which is going to lift the specimen for apply load.
5. What is the purpose of hardness test?
6. What is the meaning of zero indicates on scale?
7. What is the meaning of hundred indicates on scale?
8. Define hardness?
9. Define strength?

10. Write types of strength test conducted on moulding sand?
11. Why we are conducting shear strength test?
12. Define cohesiveness?
13. How green strength of moulding sand is reduced?
14. Which type of additives are used for increase dry strength?
15. Why we are conducting hardness test?
16. Define Adhesiveness?
17. Define Refractoriness?
18. What is the meaning of flow ability in moulding sand?
19. What is a core?
20. What is the function of core?

## Applications:

### Applications of Casting

- Bearings for machines
- Pipes
- Liners for IC engines
- Rings and other annular components

## Experiment No 3

### Wood Turning Lathe

#### Objective:

To prepare a pattern from the given dimensions in the drawing

#### Outcome:

Students will be able:

- To Classify Pattern, Pattern Materials
- To make a pattern, providing proper allowances.

#### Theory:

##### Pattern:

Pattern is a replica of the object to be cast, used to prepare the cavity into which molten material will be poured during the casting process.

##### Pattern Materials:

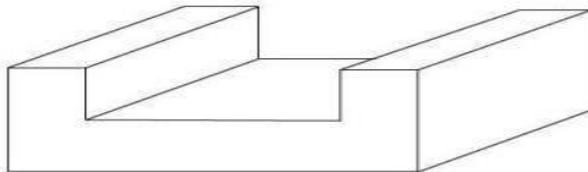
Typically, materials used for pattern making are wood, metal or plastics. Wax and Plaster of Paris are also used, but only for specialized applications. Sugar pine is the most commonly used material for patterns, primarily because it is soft, light, and easy to work.

##### Pattern Types:

##### ❖ Single Piece Pattern:

As the name denotes a single piece that means it has only 1 section, and inside this, the shape of the pattern is made.

##### Single Piece pattern

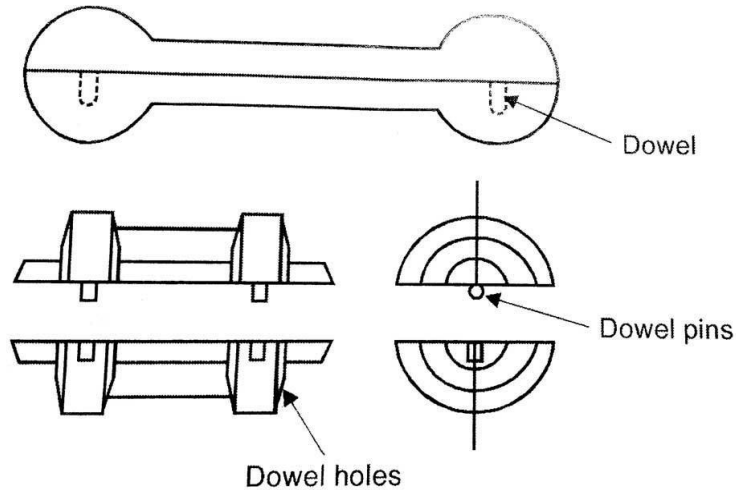


**It is made in one piece, usually from wood, and is used for castings**

❖ **Split Pattern:**

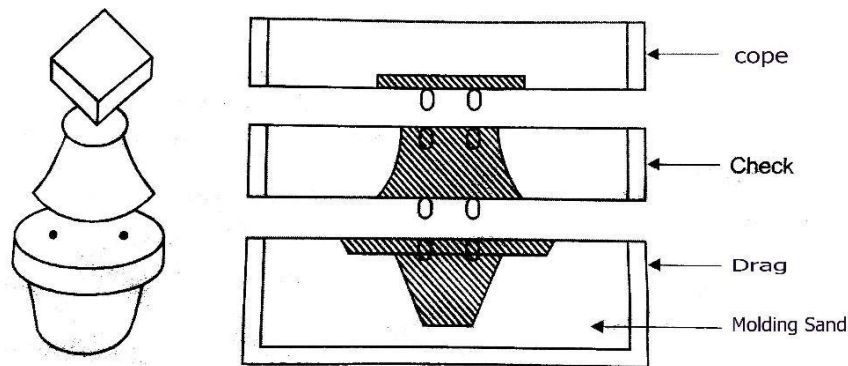
It has two sections and this two-section is connected by pin named dwell pin to attach the two-portion.

When we joined the two-block the joining surface is called parting surface.



❖ **Multi piece Pattern:**

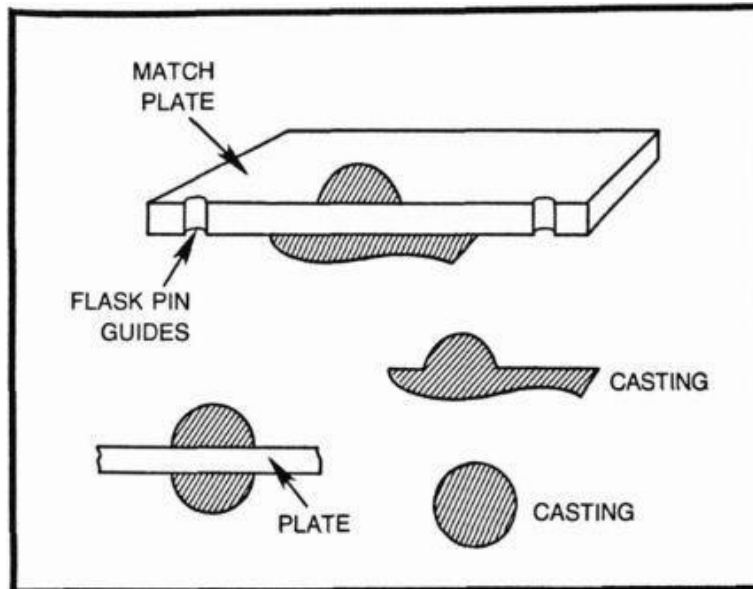
A multi piece pattern is made by more than two pieces, the upper one is called the cope, middle one is called cheek, and the bottom one is named the drag portion.



❖ **Match Plate Pattern:**

In match Plate Pattern, the cope and drag section of the split pattern are mounted on the opposite of metal or wood plate.

This type of pattern is divided into two sections along the parting line formed by the metal or wood plate.

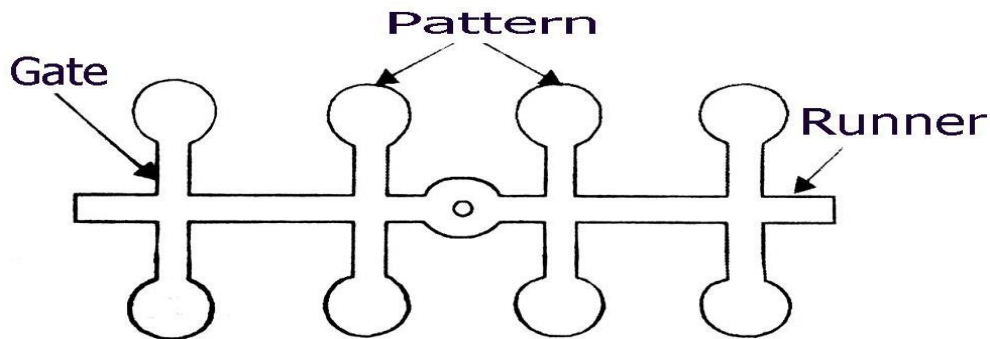


❖ **Gated Pattern:**

A gated pattern consists of:

1. *Gates*
2. *Runner*
3. *Riser*

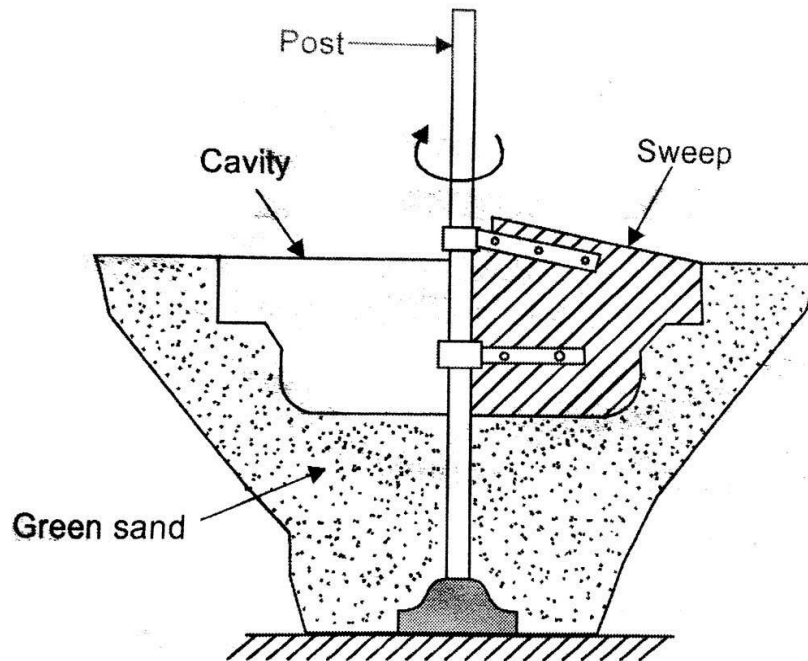
In this type of pattern, the molten metal pours through the runner and then it passes through the several gates and then finally to the pattern.



❖ **Sweep Pattern:**

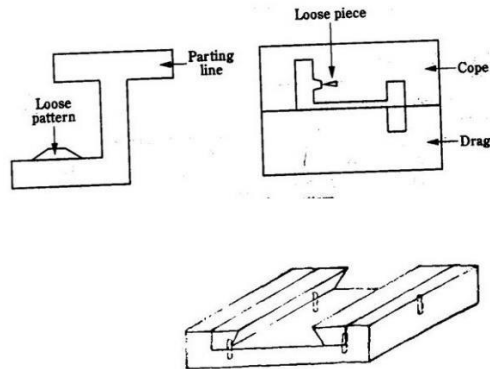
Sweep Pattern is designed for the half shape of the casting products, it is consisted of a mold cavity, rotating spindle, and sweep pattern.

Its edges are contour corresponding to the outer shape and size of the casting.



❖ **Loose Piece Pattern:**

This type of pattern is used when a pattern has projecting parts that lie below or above the main parting line in a mold. That means when some parts of the product have a little outer or inner edge than to casting those part we use loose piece patterns.

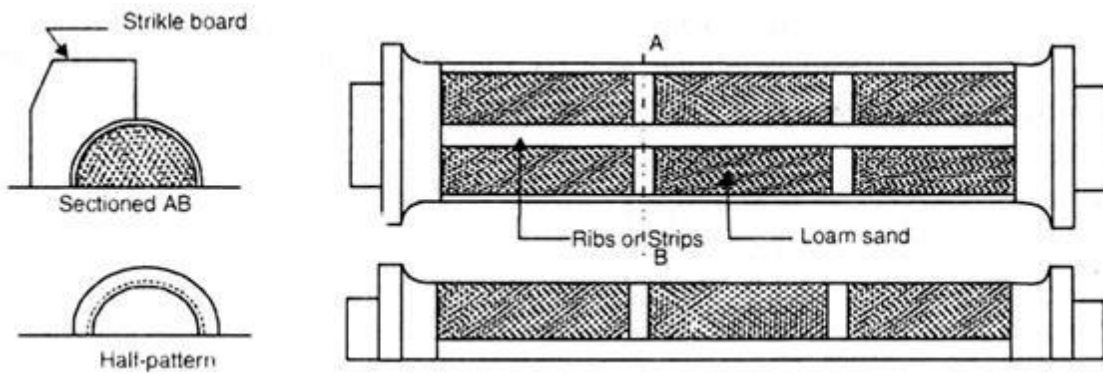


❖ **Skeleton Pattern:**

It is generally used for casting very huge parts

This type of pattern is Not totally solid, it looks like a rib cage. Where we make only the outer or inner surface structure. Shell Pattern:

This type of pattern is generally made of metals and fitted on a plate. It is like a split pattern, one half of the pattern is placed in the upper part of the plate and another one is fitted on the bottom of the plate.

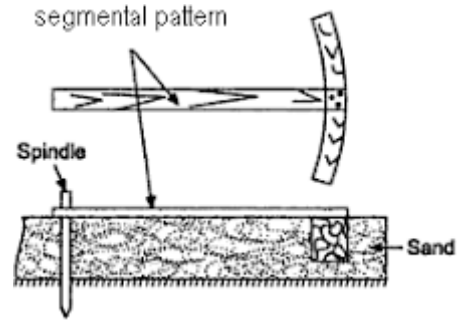


❖ **Segmental Pattern:**

It is used when we need to cast a large circular ring shape product.

The final product is completed on a few repeated steps using this pattern, 1st we mold it in one place then we rotated the pattern to the next portion and again the molding is done.





## Pattern Allowances:

There are 5-types of allowance we are considering when designing a pattern and those are:

- *Contraction Allowances*
- *Draft Allowances*
- *Finishing or Machining allowance*
- *Shake allowance*
- *Distortion allowance*

### ❖ **Contraction allowance / Shrinkage allowance:**

As we know after cooling in the room temperature all the metals shrink, that's why we need to consider contraction allowances.

The contraction allowance depends on:

- *The type of casting method used.*
- *The type of material used for casting.*

It can be also divided into two types:

### **Liquid Shrinkage**

When the metal is in the liquid stage, the liquid shrinkage occurred. to encounter the shrinkage we generally provide a riser that supplied the extra molten metal to the cavity.

### **Solid Shrinkage**

- It's occurred when the metal is in the solid stage, to encounter this situation we can provide the shrinkage allowances.

❖ **Draft allowance:**

- When the casting is done, due to the removal of the pattern sometimes the edges of the casting break, to overcome this situation sometimes we provide a taper for easy removal of the pattern from the mold.
- Generally, a 1-3 degree draft is provided with the outer surface of the pattern to overcome this brokerage.

❖ **Finishing or machining allowance:**

- After casting we need to do some machining operations, may grinding, or surface finishing operation, these all operations are metal removal operation, so we need to keep the size of the pattern little bigger than the actual size so that after removal of some material, it will perfectly be shaped.

❖ **Shake allowance:**

- This is a negative allowance, used for easy removal of the pattern,
- Sometime within the pattern due to cooling of the metal stress is generated to overcome this situation we need to distort the pattern in the opposite direction.
- After casting we need to do some machining operations, may grinding, or surface finishing operation, these all operations are metal removal operation, so we need to keep the size of the pattern little bigger than the actual size so that after removal of some material, it will perfectly be shaped.
- This is a negative allowance, used for easy removal of the pattern

❖ **Distortion allowance:**

Sometime within the pattern due to cooling of the metal stress is generated to overcome this situation we need to distort the pattern in the opposite direction.

### **Apparatus and Material required:**

Wood Turning lathe and Wooden Blocks.

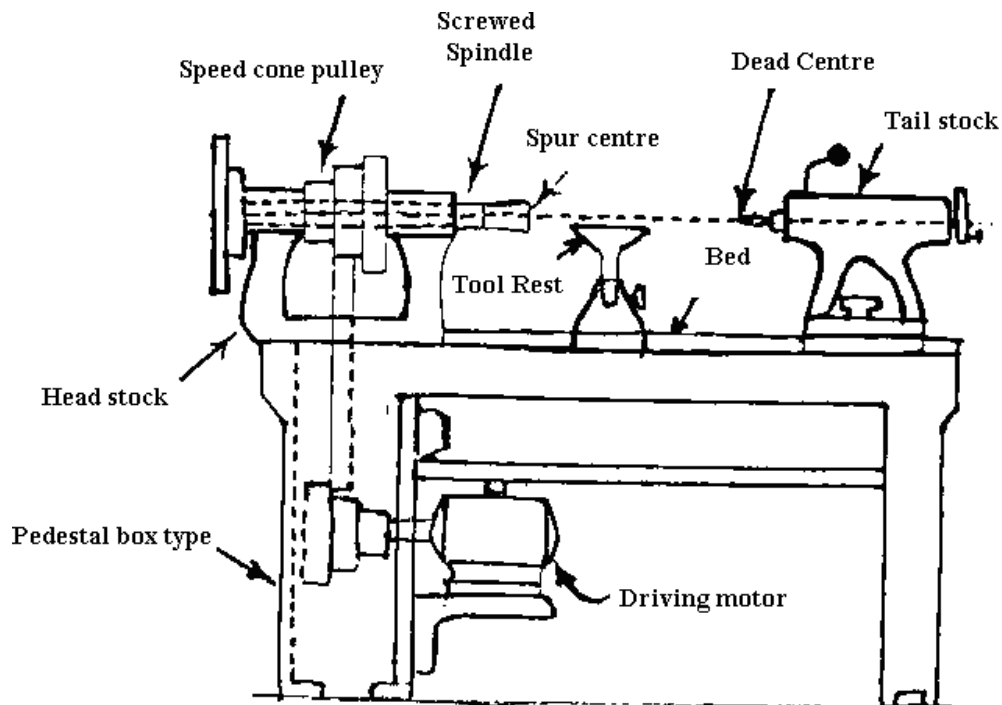
## Description of Apparatus:

### Wood-turning lathe

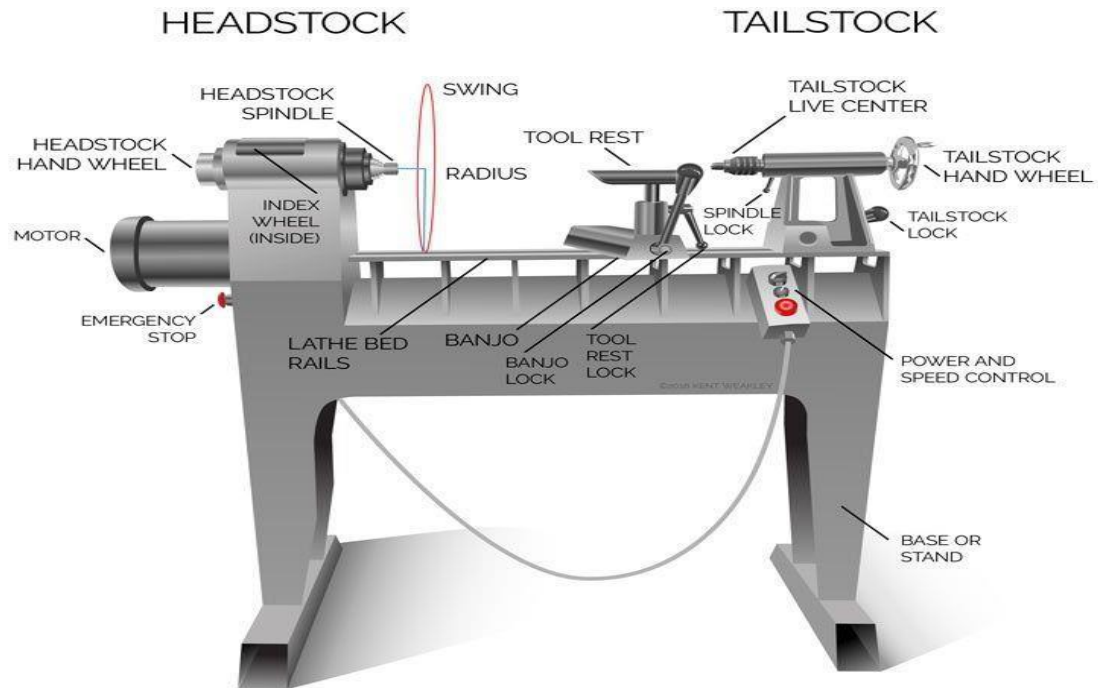
It is one of the oldest types of wood-working machines which still justifies its existence in the modern workshop. It essentially consists of a cast iron bed, a head stock, tail stock, tool rest, live and dead centers and a speed control device. The whole unit is mounted on a wooden or metal frame. The drive in all modern lathes is individual and is contained in the frame, the motor being mounted on a base inside the frame. A cone pulley on the head stock spindle is connected by a belt to a similar cone pulley on the motor shaft. The bed carries horizontal ways at its top on which the tail stock and the tool rest move. They can be clamped at any desired place along these ways. Some very costly designs incorporate a variable speed motor in their head stock. The work piece is either clamped between two centers, the live center on the head stock spindle and the dead center in the tail stock, or on a face plate. The operation done in the former case is known as turning between centers, whereas in the latter case it is known as turning on a faceplate.

The size of the lathe is designated by

- The maximum length of the job that can be turned between centers, and
- The swing, i.e., the maximum diameter of the work piece that can be turned. A typical design of such a lathe is shown in figure 2.1.



**Wood Turning Lathe Machine**

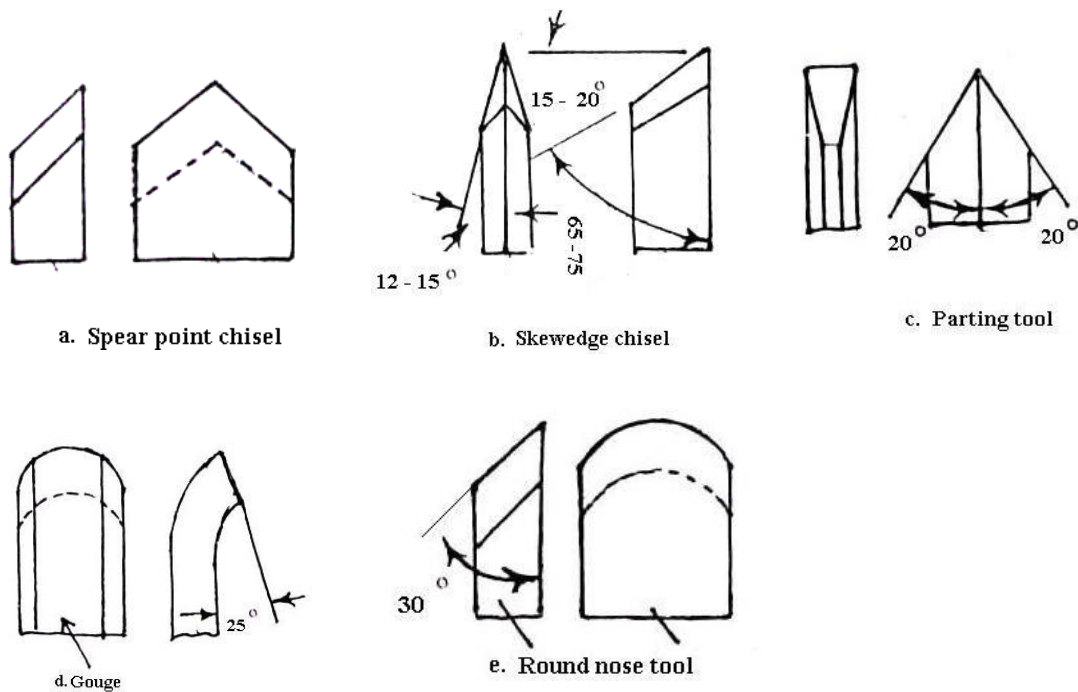


Woodturning tools: Turning tools are generally made from two different types of steel, Carbon steel and High speed steel (HSS). Comparing the two types, high speed steel tools maintain their edge longer, requiring less frequent sharpening. The harder the type of high speed steel used, the longer the edge will maintain sharpness. Unlike other edged woodworking tools, woodturning tools require more frequent sharpening, and the sharpening process requires either skill of the craftsman, or one of the many available sharpening jigs. To maintain a clean cut, the sharpness of the tools edge must be maintained.

**Types:**

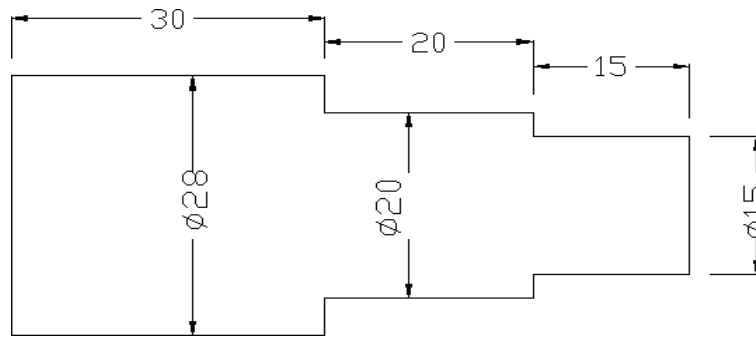
- roughing gouge - a wide fluted gouge used to initially round a wooden spindle, and to roughly shape it
- spindle gouge or detail gouge - a shallow fluted gouge used to create details on spindles, including beads and coves
- bowl gouge - a deep fluted gouge used to turn the outside and inside of bowls and vessels
- skew chisel - a wide, steeply pointed chisel used to smooth flat spindles, cut beads, and add details

- parting tool - a pointed tool used to separate (part off) work from the lathe, and to create a straight edge separating large and small diameter sections - wide parting tools are used to create evenly sized spindle sections
- hollowing tool - many different types of tools used to cut out the deep sections of steep bowls and hollow vessels
- scraper - a tool that scrapes the wood fibers instead of cutting - these are used to smooth off wooden items cut with other tools, and to shape items that are not possible or difficult to shape with gouges
- bowl saver - a tool used to core out the inside part of a bowl, allowing the waste piece to be used to create a smaller bowl
- Auger - a drill bit used to drill a hole partway or all the way through a wooden item. For cutting the hole for a lamp cord, or as the first step when hollowing out a bowl or vessel
- chatter tool - a flexible scraper used to add decorative chatter marks to turned items
- there are also several tool types for special purposes, as well as tools that are a combination design of the above tools, i.e. skew/chisel combinations, thread cutting tools, ring cutting tools, medium fluted gouges, etc

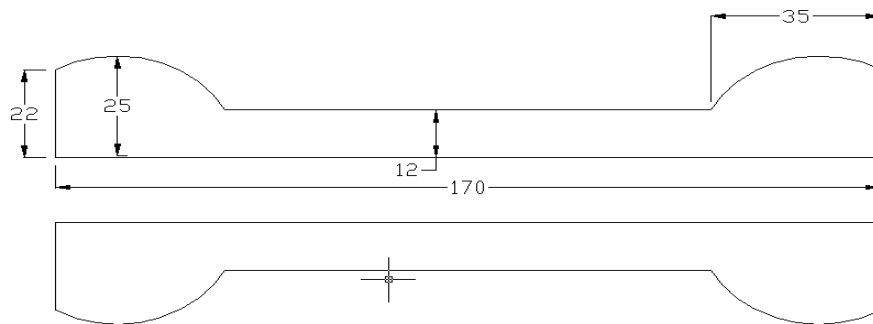


## Wood turning Tools

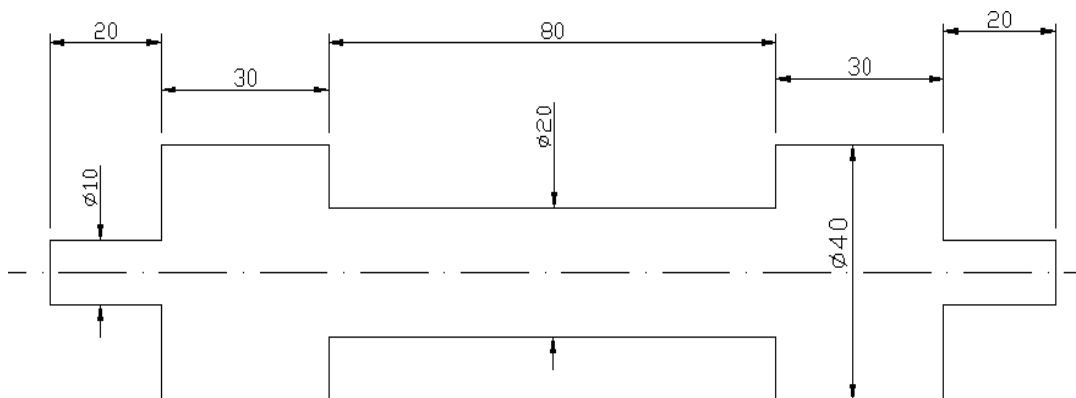
The following models as to be produced using wood turning lathe:



**Single Piece Pattern**



**Split piece pattern**



**Split piece pattern**

### Precautions:

- Make sure the machine is turned off and clean before leaving the workspace.
- Always remove the chuck wrench after use, avoid horseplay, and keep floor area clean.
- Use care when cleaning the lathe, the cutting tools are sharp, the chips are sharp, and the work piece may be sharp.

### Result:

The\_\_\_\_\_Pattern is prepared of wood on Wood Turning Lathe machine.

### Innovative Questions:

1. What allowances need to be considered, if the pattern need to be made with Wax?
2. State few products made of casting using split piece pattern.
3. Why wood is preferred over other materials to make patterns?

### Blooms Taxonomy Questions:

S No	Question	Level
1	Differentiate multi piece pattern and split piece pattern	2
2	Compare skeleton to dry gate pattern.	3
3	What are the allowance to be provided to a pattern make of wax?	2
4	Mention few castings made of single piece pattern.	1
5	State few pattern materials.	2

### Viva Questions:

1. What is the use of draft allowance?
2. What is the material used for making of master piece pattern?
3. Where we use wax pattern?
4. Distortion allowance is used in\_\_\_\_\_
5. What is the another name of rapping allowance\_\_\_\_\_
6. How the pattern is differ from the casting?
7. What are expandable patterns?
8. Why expandable patterns are used?
9. State the applications of gated patterns.
10. Explain wood as a pattern material?
11. How moisture in mould sand does affects a wooden pattern?

12. List the pattern allowances and explain their significant.
13. What are the common allowances that are provided on pattern?
14. Why and how Pattern allowances are provided?
15. Indicate shrinkage allowance value for some of the common metals.
16. What is pattern?
17. Define casting?
18. Write types of patterns?
19. What are the materials used for making of patterns?
20. What are the main parts of Wood turning machine?
21. Name the list of tools used for making of patterns?
22. Write types of allowances provided on pattern?
23. How liquid shrinkage is compensated?
24. How solid shrinkage is compensated?
25. Why machining allowance is provided on the pattern?
26. What is the name of rapping allowance?
27. Name the distinct methods of turning wood.
28. What are the applications of parting tool?
29. Why we are using Scraper?
30. How a wooden lathe is designated?

## **Applications:**

### **Single Piece Pattern**

1. Soil Tamper
2. Stuffing Box
3. Gland of Steam Engines

### **Two Piece or Split Pattern**

1. Spindles
2. Steam valve bodies
3. AK-47 Rifle Stock

### **Multi Piece Pattern**

1. Lap Joint
2. Dowel Joint



### 3. Mitre Joint

#### **Match Plate Pattern**

1. Generally used for small casting such as piston rings of I.C engines and rotor hub.

#### **Gated Pattern**

1. Used for small castings such as corner bracket.

#### **Skeleton pattern**

1. Large castings such as turbines, water pipes, L-bends etc.

#### **Sweep pattern**

1. Symmetrical shapes such as wheels, rims, large kettles of cast irons & bell shapes

#### **Pattern with loose pieces**

1. Pattern having projections or hanging parts.
2. Rotor hub.
3. Axle pin.

#### **Cope and drag pattern**

1. Flange pipe.
2. Water Jacket of JCB head.
3. Hose pipe coupling head.

#### **Follow board pattern**

1. It is used for casting master patterns for many applications.

#### **Segmental pattern**

1. Used for circular work like rings, gears, wheels, rims, pulleys etc.

## Experiment No 4

### Preparation of Mould Cavity using Stepped Pulley Pattern

#### Objective:

To prepare a mould cavity for a given pattern.

#### Outcome:

Students will be able:

- To prepare green sand in proper composition
- To make a mould cavity using the equipment and tools required

#### Theory:

##### Sand casting:

Sand casting, also known as sand molded casting, is a metal casting process characterized by using sand as the mold material. The term "sand casting" can also refer to an object produced via the sand casting process. Sand castings are produced in specialized factories called foundries. Over 60% of all metal castings are produced via sand casting process

##### Mould cavity:

When the pattern is withdrawn, its imprint provides the **mould cavity**. This **cavity** is filled with metal to become the **casting**. - If the **casting** is to be hollow, additional patterns called 'cores', are used to form these **cavities**. Cores are placed into a **mould cavity** to form the interior surfaces of **castings**.

##### Casting Terminology:

**Flask:** A moulding flask is one, which holds the sand mould intact. Depending upon the position of the flask in the mould structure it is referred to by various names such as drag, cope and cheek. It is made up of wood for temporary applications or more generally of metal for long term use.

**Drag:** Lower moulding flask.

**Cope:** Upper moulding flask.

**Cheek:** Intermediate moulding flask used in three piece moulding.

**Pattern:** Pattern is a replica of the final object to be made with some modifications. The mould cavity is made with the help of the pattern.

**Parting line:** This is the dividing line between the two moulding flasks that makes up the sand mould. In split pattern it is also the dividing line between the two halves of the pattern.

**Bottom board:** This is a board normally made of wood which is used at the start of the mould making. The pattern is first kept on the bottom board, sand is poured on it and then the ramming is done in the drag.

**Facing sand:** It is specially prepared sand which is placed around the pattern which has superior properties with regard to refractoriness, permeability, etc. This will ensure better surface on the castings. This is always fresh sand mixture.

**Coal dust:** The small amount of carbonaceous material sprinkled on the inner surface of the moulding cavity to give better surface finish to the castings.

**Moulding sand:** It is a mixture of silica, clay and moisture in appropriate proportions to get the desired results and it surrounds the pattern facing sand while making the mould. The moulding sand is the mixture.

**Backing sand:** It is what constitutes most of the refractory material found in the mould. This is made up of used and burnt sand.

**Core:** It is used for making hollow cavities in castings.

**Pouring basin:** A small funnel shaped cavity at the top of the mould into which the molten metal is poured.

**Sprue:** The passage through which the molten metal from the pouring basin reaches the mould cavity. In many cases it controls the flow of metal into the mould.

**Runner:** The passageways in the parting plane through which molten metal flow is regulated before they reach the mould cavity through the in-gates.

**In-gate:** The actual entry point through which molten metal enters mould cavity.

**Chaplet:** Chaplets are used to support cores inside the mould cavity to take care of weight of core and also to overcome the metallostatic forces. The weight of core is supported when the core is placed in the mould cavity when the molten metal is poured into mould cavity, the metallostatic forces try to push the core upwards and displace it. The chaplets do not permit this displacement.

**Riser:** It is a reservoir of molten metal provided in the casting so that hot metal can flow into the casting when there is a reduction in volume of metal due to solidification. The riser must remain molten for longer time than the casting part. The riser, if properly designed, will avoid formation of shrinkage cavities.

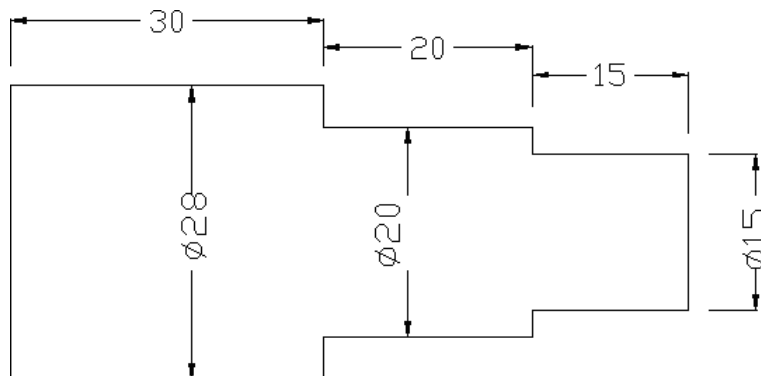
**Chill:** Chills are metallic objects, which are placed in the mould to increase the cooling rate of molten metal at certain locations of mould cavity to ensure directional solidification (solidification of casting towards riser).

**Pattern Material: Wood**

**Pattern Type:**

❖ **Single Piece Pattern:**

As the name denotes a single piece that means it has only 1 section, and inside this, the shape of the pattern is made.

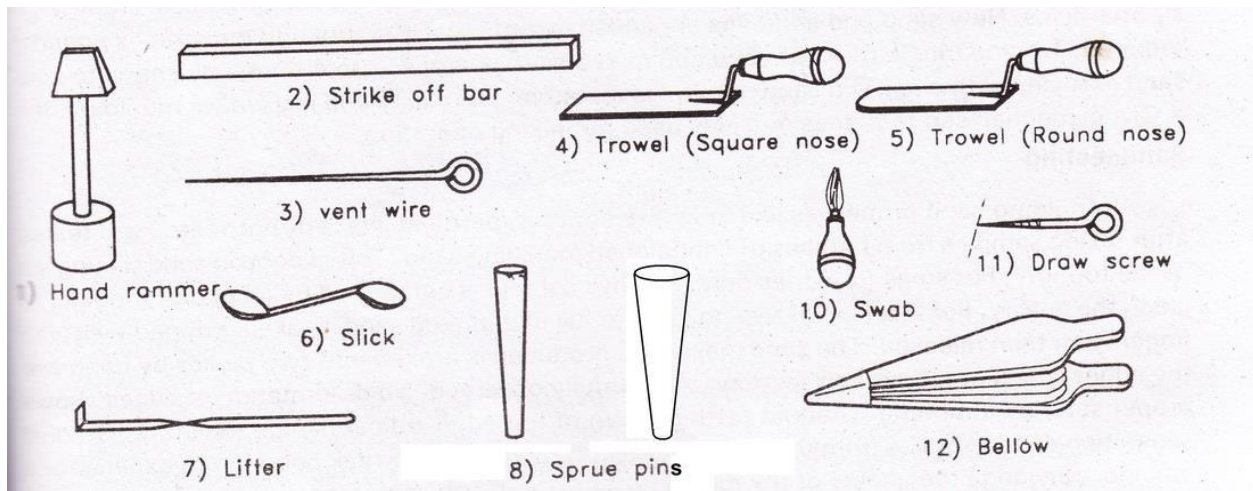


**Material and Equipment required:**

Moulding sand, facing sand, Backing sand, Parting sand, Core, Pattern, Cope box, Drag box and Bottom board

**Tools required:**

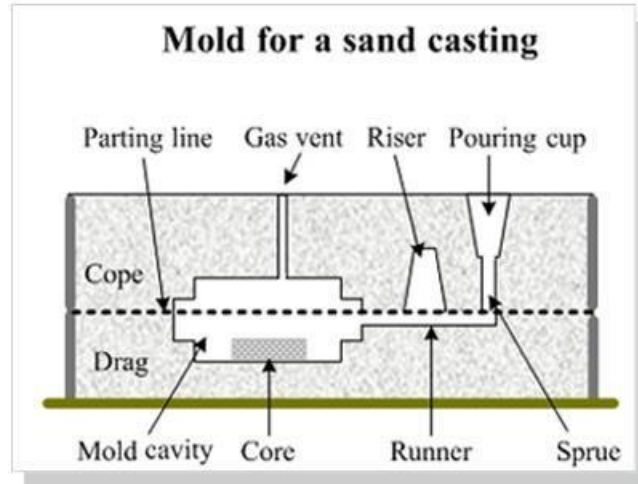
Sprue, Riser, Chaplets, Gate cutter, Towel, Vent rod, Slick and Bellow



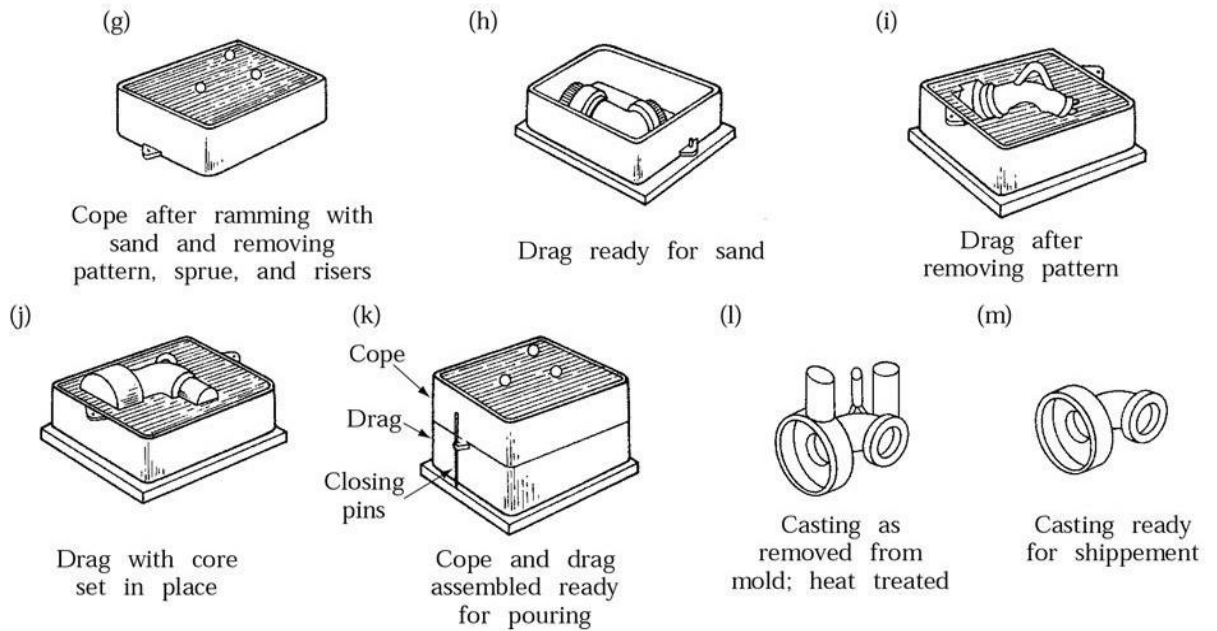
### Procedure:

- First a bottom board is placed either on the moulding platform or on the floor, making the surface even. Follow board is placed on the bottom board to support the weak section of the bracket pattern.
- The drag-moulding flask is kept upside down on the bottom board along with the drag part of the pattern at the center of the flask on the follow board.
- Dry facing sand is sprinkled over the board and pattern to provide a non-sticky layer.
- Freshly prepared moulding sand of requisite quality is now poured into the drag and on the pattern to a thickness of 30 to 50 mm.
- Rest of the drag flask is completely filled with the backup sand and uniformly rammed to compact the sand.
- After the ramming is over, the excess sand in the flask is completely scraped using a flat bar to the level of the flask edges.
- Now with a vent wire, which is a wire of 1 to 2 mm diameter with a pointed end, vent holes are made in the drag to the full depth of the flask as well as to the pattern to facilitate the removal of gases during casting solidification. This completes the preparation of the drag.
- Now finished drag flask is rolled over to the bottom board exposing the pattern. Then follow board is removed.

- Using a slick, the edges of sand around the pattern is repaired and cope half of the pattern is placed over the drag pattern, aligning it with the help of dowel pins.
- The cope flasks on top of the drag is located aligning again with the help of the pins of the drag box.
- Dry parting sand is sprinkled all over the drag surface and on the pattern.
- Sprue of the gating system for making the sprue passage is located at a small distance of about 50 mm from the pattern. The sprue base, runners and in-gates are also located as shown risers are also placed. Freshly prepared facing sand is poured around the pattern. The moulding sand is then poured in the cope box. The sand is adequately rammed, excess sand is scraped and vent holes are made all over in the cope as in the drag.
- The sprue and the riser are carefully withdrawn from the flask.
- Later the pouring basin is cut near the top of the sprue.
- The cope is separated from the drag and any loose sand on the cope and drag interface is blown off with the help of the bellows.
- Now the cope and the drag pattern halves are withdrawn by using the draw spikes and rapping the pattern all around to slightly enlarge the mould cavity so that the mould walls are not spoiled by withdrawing pattern.
- The runners and the gates are to be removed or to be cut in the mould carefully without spoiling the mould.
- Any excess or loose sand found in the runners and mould cavity is blown away using the bellows.
- Now the facing paste is applied all over the mould cavity and the runners, which would give the finished casting a good surface, finish.
- The cope is placed back on the drag taking care of the alignment of the two by means of the pins.
- The mould is ready for pouring molten metal.
- The liquid metal is allowed to cool and to become solid, which is the casting, desired.



## Steps in Sand Casting



### Precautions:

1. There should be enough clearance between the pattern and the walls of the flask.
2. The ramming of sand should be done properly so as not to compact it too hard, which makes the escape of gases difficult.

## Result:

The mould cavity has been prepared for the given pattern.

## Innovative Questions:

4. What is the importance of **cores** in mould cavity?
5. Why do we use runner and riser?
6. How to determine the mould hardness?
7. The vent holes are made in moulding flask, why?

## Blooms Taxonomy Questions:

S No	Question	Level
1	Differentiate facing sand and parting sand	3
2	Compare green strength to dry strength of foundry sand	2
3	State the importance of runner and riser	1
4	Determine the importance of clearance between the pattern and the walls of the flask.	3
5	What are the constituents in moulding sand?	2

## Viva Questions:

1. How mold cavity is prepared?
2. What is the intermittent part of the mold flask?
3. What is the use of molding sand?
4. Write types of molding sand?
5. Why moisture is added to the molding sand?
6. Write name of the tools used for making of the mold cavity?
7. Write some name of the additives used in molding sand?
8. Write properties of the molding sand?
9. Why core is used in mold cavity?
10. Why chaplets are used in mold cavity?
11. Explain the term gate in casting?
12. What is register ring?
13. Where sprue bush is used for?



14. What is core?
15. What do you mean by impression?
16. What is maximum daylight?
17. What is short capacity or injection capacity?
18. Mention the application of sprue?
19. Examples of thermosetting materials?
20. Write about HDPE
21. What is the use of parting line\_\_\_\_\_?
22. Riser is used for \_\_\_\_\_
23. Name the top mould flask is\_\_\_\_\_
24. Name the bottom mould flask is\_\_\_\_\_
25. Venting rod is used for\_\_\_\_\_
26. Name material which sprayed inside mould cavity to get a better finish?
27. Where will be cheek used?
28. What is the Purpose of chaplets in mould cavity?
29. At what temperature aluminum will melt\_\_\_\_\_
30. Name different types of furnaces used in the lab for melting aluminum?

### **Applications:**

Applications of casting process

- Transport:  
Automobile, aerospace, railways and shipping
- Heavy Equipment:  
Construction, farming and mining
- Machine Tools:  
Machining, casting, plastics molding, forging, extrusion and forming
- Plant Machinery;  
Chemical, petroleum, paper, sugar, textile, steel and thermal plants
- Defense:  
Vehicles, artillery, munitions, storage and supporting equipment

## Experiment No 5

### Melting Of Aluminum-Casting Practice

#### Objective:

To melt the Aluminum scrap or ingot in the Furnace and pour the molten metal into the prepared mould cavity

#### Outcome:

Students will be able:

- To prepare mould cavity using given pattern
- Familiarize with foundry tools and procedures
- To make a sound casting

#### Theory:

##### Introduction to Foundry:

Foundry is a process of shaping the metal components in their molten stage. It is also called as metal casting. The shape and size of the metal casting is obtained depends on the shape and size of the cavity produced in sand mould by using wooden/ metal pattern.

##### Steps in foundry process

The Foundry process involves three steps.

- (a) Making the required pattern
- (b) Moulding process to produce the cavity in sand using pattern.
- (c) Pouring the molten metal into the cavity to get casting.

##### Practical application

1. Casting is the cheapest and most direct way of producing the shape of the component
2. Casting is best suited to work where components required is in low quantity.
3. Complicated shapes having internal openings and complex section variation can be produced quickly and cheaply by casting since liquid metal can flow into any form/ shape.

Example:

- ✓ Outer casing of all automobile engines.
- ✓ Electric motor housing
- ✓ Bench vice, Irrigation pumps etc.

4. Heavy equipment such as machine beds of lathe, milling machine, shaping, drilling planning machine etc. can be cast/easily

5. Casting is best suited for composite components

Example.1. steel screw threads in zinc die casting

All conductors into slot in iron armature for electric motor.

### **Aluminum:**

Aluminum has various typical characteristics, which make it one of the most important engineering metals.

Some of its outstanding features are:

- Lightness;
- High electrical conductivity;
- High thermal conductivity;
- High resistances to corrosion;
- Affinity for oxygen;
- Easy cast ability and ability to take good finish.

In pure form, aluminum is a weak material, greatly prone to oxidation, and not readily cast able. Its strength and other mechanical properties, as well as cast ability, can be considerably improved by suitable alloying treatment.

In order to melt aluminum here we are using crucible furnace

### **Crucible Furnace**

A crucible furnace is very convenient for small foundries where the operation is intermittent and a variety of alloys are handled in small quantities. The metal to be melted is put in a heated crucible, which act as a melting pot. The crucible is made of clay and graphite by moulding these materials into a standard shape, and it is produced in sizes from number 1 to 400. The crucible number represents its approximate melting capacity in kg. Of copper. The capacity of a crucible for other metals may be determined by multiplying with the ratio of densities. The fuel used for heating the metal may be coke, oil or gas.

The procedure for preparing aluminum ingots for casting must to be carried out carefully. Outlined below are the stages involved in heating and charging a crucible and then pouring the molten aluminum.

1. **Preheating**
2. **Charging with aluminum**
3. **Adding flux**
4. **Adding a degassing tablet**

- ❖ **Preheating:** The crucible is first preheated. This removes any moisture from the furnace and crucible. Usually the gas is turned half on in order to avoid rapid heating. The aluminum ingots to be used are placed on top of the furnace so that they warm up.
- ❖ **Charging with aluminum:** once the crucible and furnace have been preheated the lid/top is pulled to one side with a steel hook. Aluminum ingots are then placed into the crucible with steel tongs. All steel tools such as tongs are pre-warmed. The gas pressure is turned up to full.
- ❖ **Adding flux:** As the aluminum begins to melt a small amount of 'flux' is sprinkled over the aluminum. A spoon can be used to sprinkle the flux powder. The flux prevents oxidization (oxygen entering the molten aluminum). If oxygen enters the molten aluminum, when it is poured into the mould the final casting can have bubbles, which can ruin the finish of the cast shape.
- ❖ **Adding a degassing tablet:** When the aluminum has melted fully and is approximately 700 degrees centigrade the gas is turned off and a degassing tablet is added. This removes any impurities, in the form of gas. It is important that a good extraction system is used to remove the fumes caused by the tablet. . The degassing tablet causes a lot of fumes, which can be a problem in an enclosed workshop.
- ❖ **Crucible lifted out of furnace:** The top of the furnace is pulled back using a steel hook. This allows special lifting tongs to be placed around the crucible, which can then be lifted up and away from the furnace. The crucible is set to rest in a bed of sand, which surrounds the furnace. The crucible should never be allowed to rest directly on the cold concrete floor as this could cause an explosion.
- ❖ **Pouring the aluminum:** The ladle is then lifted which raises the crucible from the furnace. Great care is needed as the molten aluminum is at a very high temperature.. The aluminum is poured into the runner and when the cavity is full it rises up the riser. The flow of aluminum should be constant, if there is even a short break in pouring the cast aluminum it may cool and the cast may be imperfect.

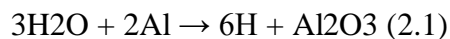
## Material and Equipment required:

Furnace, crucible, Al ingot, tongs, prepared mould cavity.

## Procedure:

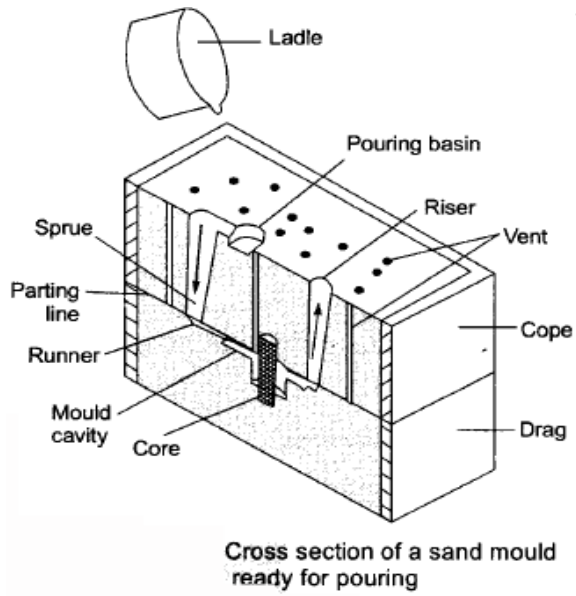
The charge materials and chemicals should be free from the moisture and oil corrosion powders should be preheated before charging. The calculation of charge should be done considering the melting loss of each element in the melting furnace for the final desired analysis.

1. The furnace crucible should be clean and red hot for charging.
2. Aluminum alloys are get readily oxidized and form dross. Using proper covering top with flux and chemicals to reduce this. Different property chemicals are available for different alloys.
3. Melting should be done under steady conditions without agitation is stirring to reduce the gas pickup.
4. Once melting is complete using solid chemicals like Hexachloroethane which involves chlorine by purging with Nitrogen and Argon gas is done to remove the dissolved hydrogen. Hydrogen is evolved from the moisture.



Hydrogen is absorbed liquid metal causes serious porosity in casting during solidification. Degassing should be done in the temperature range of 730°C to 750°C.

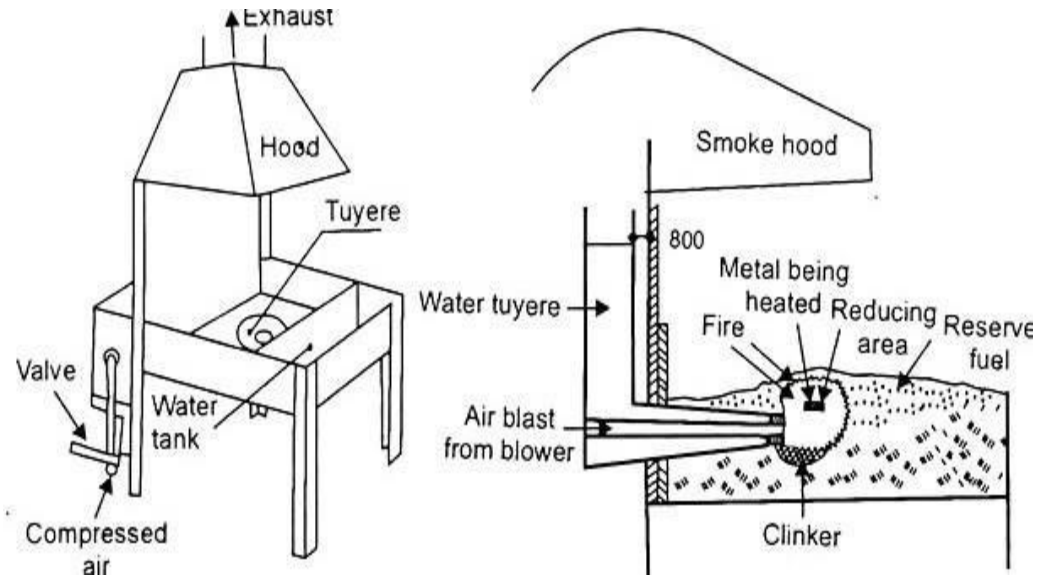
5. Liquid metal after degassing is treated with sodium containing chemicals to improve mechanical properties.
6. Liquid metals once ready should not be super-heated, agitated or kept long in the furnace which will cause drossing and gas pick up. Dross should be skimmed properly before pouring.
7. Alloys containing magnesium should be melted carefully as it is highly reacting. Special fluxes and chemicals like sulphur are used to inhibit the re-activity and prevent spontaneous ignition, melting loss and dross.



**Crucible for melting aluminum**



**Types of tongs used in foundry**



**Furnace used to melt aluminum**

### Precautions:

- There should be enough clearance between the pattern and the walls of the flask.
- The ramming sand should be done properly so as to not compact it too hard, which makes the escape of gasses difficult.
- The furnace crucible should be clean and red hot for charging.
- Charge material should be from oil, moisture etc.
- Melting must be done under steady conditions to reduce gas pickup.

### Result:

Aluminum is melted and casted in the mould cavity.

### Innovative Questions:

1. What is the importance of **cores** in mould cavity?
2. Why do we use runner and riser?
3. How to determine the mould hardness?
4. The vent holes are made in moulding flask, why?

## Blooms Taxonomy Questions:

S No	Question	Level
1	Why degassing tablets are used in melted metal?	3
2	Compare electrical heating and fossil fuel burning	2
3	Which type of metals are used crucible furnace for melting?	2
4	Difference between facing, baking and moulding sand	2
5	What is a ladle?	1

## Viva Questions:

1. What is the melting point of the aluminum?
2. What is the melting point of the Grey cast iron?
3. Write types of furnaces used in foundries?
4. Why degassing tablets are used in melted metal?
5. Why flux is added in melted metal of aluminum?
6. Write some nonferrous metals?
7. Write some defects occurred in casting?
8. Write elements of gating system?
9. Write types of risers?
10. What is the function of riser?
11. What is the directional solidification?
12. What is die casting?
13. What is the function of runner?
14. Strainer is used for\_\_\_\_\_
15. How slag is reduced in molten metal
16. Write types of electric furnaces
17. Shank ladle is used for carrying\_\_\_\_\_to\_\_\_\_\_kg of molten metal.
18. State the functions of ladles.
19. State the common types of ladles used in foundry.
20. What is the meaning of tapping in furnace practice?



21. What is a ladle?
22. What are different zones in cupola?
23. Which type of metals are used crucible furnace for melting?
24. What is the significance of pouring temperature for melting of metals?
25. Which type of material is used for making of crucible?
26. What are the requirements of melting a furnace?
27. What is chill?
28. Explain the solidification of an alloy?
29. What is the function of splash core?
30. What are the types of top pouring ladles?

## Applications:

### Applications of Casting:

- Transportation vehicles
- Turbine vanes
- Power generators
- Railway crossings
- Agricultural parts
- Aircraft jet engine parts
- Sanitary fittings
- Communication, Construction and Atomic Energy applications, etc..

### Centrifugal casting

1. Typical parts made by this process are pipes, boilers, pressure vessels flywheels, cylinder liners and other parts that are axi-symmetric. It is notably used to cast cylinder liners and sleeve valves for piston engines, parts which could not be reliably manufactured otherwise.

### Investment casting

1. It is used in the aerospace and power generation industries to produce turbine blades with complex shapes or cooling systems

## Experiment No 6

### Arc Welding

#### Objective:

To study the effect of Arc current on weld strength and heat affected zone in Arc welding.

#### Outcome:

Students will be able:

- To understand Welding and its process
- To calculate Weld Strength
- To understand the effect of heat affected zone on weldment.

#### Theory:

##### Introduction to welding:

Welding is an operation whereby two or more parts are united by means of heat or pressure or both. It is usually used on metals and thermoplastics but can also be used on wood

The parts that are joined are known as a parent material. The material added to help form the joint is called filler or consumable. The form of these materials may see them referred to as parent plate or pipe, filler wire, consumable electrode (for arc welding), etc.

Consumables are usually chosen to be similar in composition to the parent material, thus forming a homogenous weld, but there are occasions, such as when welding brittle cast irons, when a filler with a very different composition and, therefore, properties is used. These welds are called heterogeneous.

The completed welded joint may be referred to as a weldment.

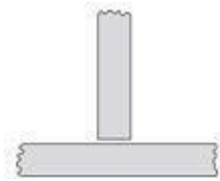
### Common Joint Configurations

#### Butt Joint



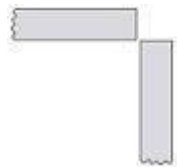
A connection between the ends or edges of two parts making an angle to one another of 135-180° inclusive in the region of the joint.

## T Joint



A connection between the end or edge of one part and the face of the other part, the parts making an angle to one another of more than  $5^\circ$  up to and including  $90^\circ$  in the region of the joint.

## Corner Joint



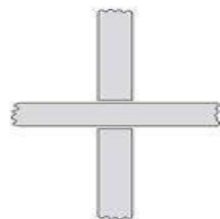
A connection between the ends or edges of two parts making an angle to one another of more than  $30^\circ$  but less than  $135^\circ$  in the region of the joint.

## Edge Joint



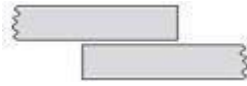
A connection between the edges of two parts making an angle to one another of  $0^\circ$  to  $30^\circ$  inclusive in the region of the joint.

## Cruciform Joint



A connection in which two flat plates or two bars are welded to another flat plate at right angles and on the same axis.

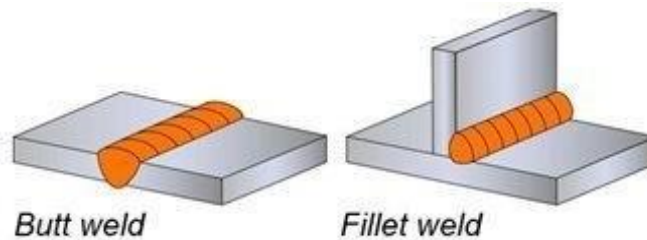
## Lap Joint



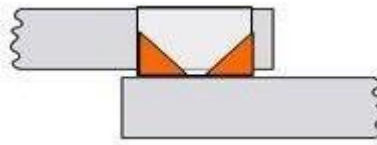
A connection between two overlapping parts making an angle to one another of  $0-5^\circ$  inclusive in the region of the weld or welds.

## Types of Welding Joints

### ❖ Welds Based on Configuration

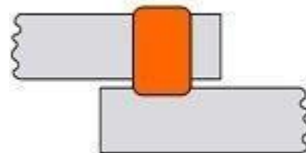


## Slot weld



Joint between two overlapping components made by depositing a fillet weld around the periphery of a hole in one component so as to join it to the surface of the other component exposed through the hole.

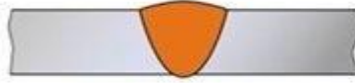
## Plug weld



Weld made by filling a hole in one component of a work piece with filler metal so as to join it to the surface of an overlapping component exposed through the hole (the hole can be circular or oval).

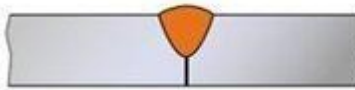
## ❖ Based on Penetration

### Full penetration weld



Welded joint where the weld metal fully penetrates the joint with complete root fusion. In US the preferred term is complete joint penetration weld (CJP, see AWS D1.1).

### Partial penetration weld



Weld in which the fusion penetration is intentionally less than full penetration. In the US the preferred term is partial joint penetration weld (PJP).

## ❖ Welds Based on Accessibility

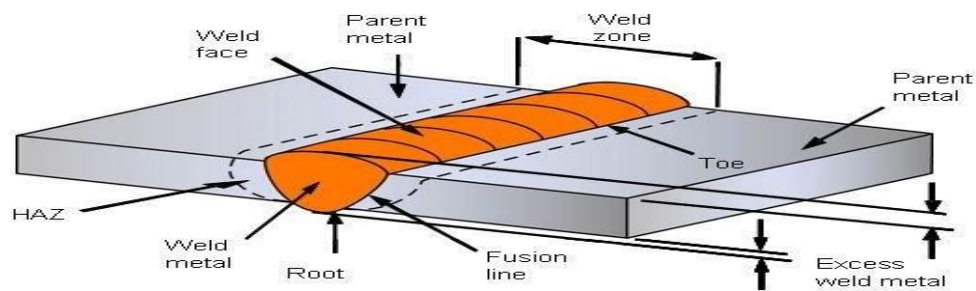


*Single side weld*

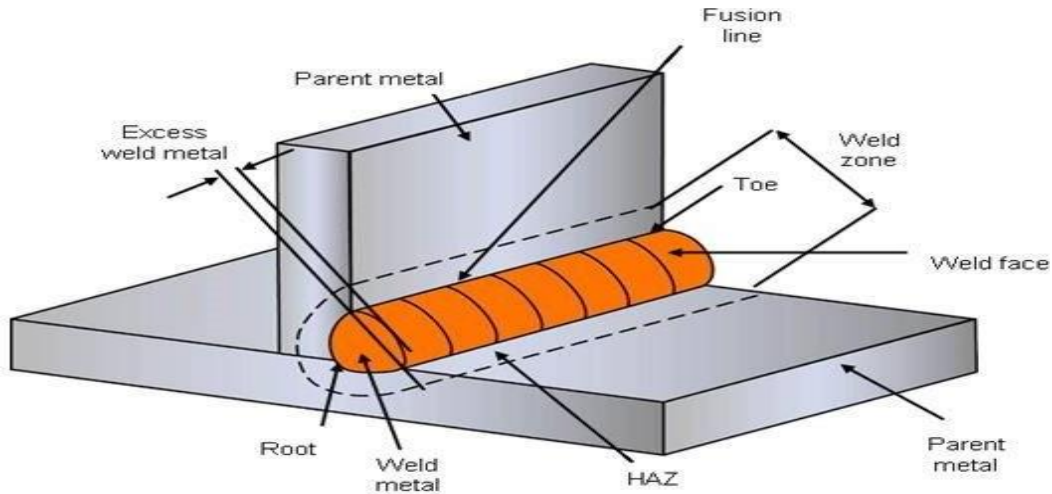


*Double side weld*

## ❖ Features of Completed Welds



**Butt weld**

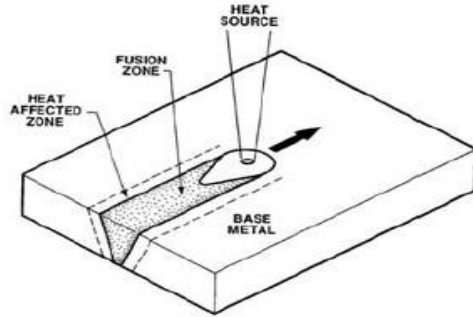


### Fillet weld

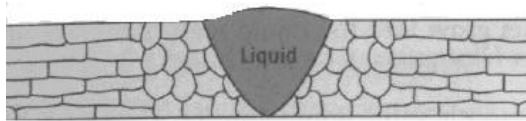
- ✓ **Parent Metal:** Metal to be joined or surfaced by welding, braze welding or brazing.
- ✓ **Filler Metal:** Metal added during welding, braze welding, brazing or surfacing.
- ✓ **Weld Metal:** All metal melted during the making of a weld and retained in the weld.

### Heat Affected Zone (HAZ)

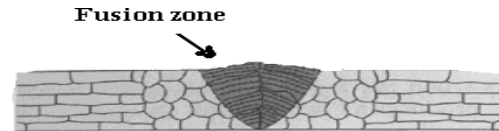
The portion of the base metal that was Not melted during brazing, cutting, or welding, but whose microstructure and mechanical properties were altered by the heat. The grain structure in the fusion zone may be fine and coarse, equi-axial or dendritic, depending on type and volume of weld metal and the rate of cooling. Most electrode and filler rod compositions tend to produce fine equiaxed grains, but the volume of weld metal and variations in cooling rate can easily defeat these objectives. The grain structure in the fusion zone may be fine and coarse, equi-axial or dendritic, depending on type and volume of weld metal and the rate of cooling. Most electrode and filler rod compositions tend to produce fine equiaxed grains, but the volume of weld metal and variations in cooling rate can easily defeat these objectives.



a. Initial prepared joint



b. Weld at maximum temperature ,  
joint filled with filler material



c. Weld after solidification

### A schematic diagram of fusion zone and solidification of weld during arc welding

The pools of molten metal created by fusion welding are prone to all the problems and defects associated with the metal casting, such as gas porosity, inclusions, blowholes, cracks and shrinkage. Since the amount of molten metal is usually small compared to the total mass of the work piece, rapid solidification and rapid cooling of the solidified metal are quite common. Associated with these conditions may be the entrapment of dissolved gases, chemical segregation, grain-size variation, grain shape problems and orientation effects.

Adjacent to the fusion zone, and wholly within the base material, is the ever present and generally undesirable heat affected zone (HAZ). In this region the parent metal is not melted but is subjected to elevated temperatures for a brief period of time. Since the temperature and its duration, vary widely with location, fusion welding might be more approximately described as 'a casting and abnormal, widely varying heat treatment'. The adjacent metal may well experience sufficient heat to bring about structure and property changes, such as phase transformations, recrystallization, grain growth, and precipitation or precipitate coarsening, embrittlement, or even cracking. The variation in thermal history produces a variety of microstructures and a range of properties. In

steels, the structures can range from hard, brittle martensite all the way through coarse pearlite and ferrite. Because of the altered structure, the HAZ may no longer possess the desirable properties of the parent metal, and since it was not molten, it cannot assume the properties of the solidified weld metal. Consequently this is often the weakest area in the as-welded joint. Except where there are obvious defects in the weld deposit, most welding failures originate in the heat-affected zone. The HAZ terminates where the base metal has experienced too little heat to be affected or altered by the welding process. Thermal characteristics can well be understood by knowing the rate of heat input during various welding processes.

Low rate of heat input (slow heating) tends to produce high total heat content within the metal, slow cooling rates and large heat-affected zones. The heat from the welding process and subsequent re-cooling causes this change in the area surrounding the weld. The extent and magnitude of property change depends primarily on the base material, the weld filler metal, and the amount and concentration of heat input by the welding process. The thermal diffusivity of the base material plays a large role, if the diffusivity is high, the material cooling rate is high and the HAZ is relatively small. Alternatively, a low diffusivity leads to slower cooling and a larger HAZ. The amount of heat inputted by the welding process plays an important role as well, as processes like oxy-fuel welding use high heat input and increase the size of the HAZ. Processes like laser beam welding give a highly concentrated, limited amount of heat, resulting in a small HAZ. Arc welding falls between these two extremes, with the individual processes varying somewhat in heat input.

## **Energy Sources**

**Different processes are determined by the energy source used, with a variety of different techniques available.**

Until the end of the 19th century, forge welding was the only method used, but later processes, such as arc welding, have since been developed. Modern methods use gas flame, electric arc, lasers, electron beam, friction and even ultrasound to join materials.

Care needs to be taken with these processes as they can lead to burns, electric shock, damaged vision, exposure to radiation or inhaling of poisonous welding fumes and gases.

## **Different Types of Welding Methods**



There are a variety of different processes with their own techniques and applications for industry, these include:

## **Arc**

This category includes a number of common manual, semi-automatic and automatic processes. These include metal inert gas (MIG) welding, stick welding, tungsten inert gas (TIG) welding, gas welding, metal active gas (MAG) welding, flux cored arc welding (FCAW), gas metal arc welding (GMAW), submerged arc welding (SAW), shielded metal arc welding (SMAW) and plasma arc welding.

These techniques usually use a filler material and are primarily used for joining metals including stainless steel, aluminum, nickel and copper alloys, cobalt and titanium. Arc welding processes are widely used across industries such as oil and gas, power, aerospace, automotive, and more.

## **Friction**

Friction welding techniques join materials using mechanical friction. This can be performed in a variety of ways on different welding materials including steel, aluminum or even wood.

The mechanical friction generates heat which softens the materials which mix to create a bond as they cool. The manner in which the joining occurs is dependent on the exact process used, for example, friction stir welding (FSW), friction stir spot welding (FSSW), linear friction welding (LFW) and rotary friction welding (RFW).

Friction welding doesn't require the use of filler metals, flux or shielding gas.

Friction is frequently used in aerospace applications as it is ideal for joining otherwise 'non-weldable' light-weight aluminum alloys.

Friction processes are used across industry and are also being explored as a method to bond wood without the use of adhesives or nails.

## **Electron Beam**

This fusion joining process uses a beam of high velocity electrons to join materials. The kinetic energy of the electrons transforms into heat upon impact with the work pieces causing the materials to melt together.

Electron beam welding (EBW) is performed in a vacuum (with the use of a vacuum chamber) to prevent the beam from dissipating.

There are many common applications for EBW, as can be used to join thick sections. This means it can be applied across a number of industries from aerospace to nuclear power and automotive to rail.

## **Laser**

Used to join thermoplastics or pieces of metal, this process uses a laser to provide a concentrated heat ideal for barrow, deep welds and high joining rates. Being easily automated, the high welding speed at which this process can be performed makes it perfect for high volume applications, such as within the automotive industry.

Laser beam welding can be performed in air rather than in a vacuum such as with electron beam joining.

## **Resistance**

This is a fast process which is commonly used in the automotive industry. This process can be split into two types, resistance spot welding and resistance seam welding.

Spot welding uses heat delivered between two electrodes which is applied to a small area as the work pieces are clamped together.

Seam welding is similar to spot welding except it replaces the electrodes with rotating wheels to deliver a continuous leak-free weld.

## **Material and Tools required:**

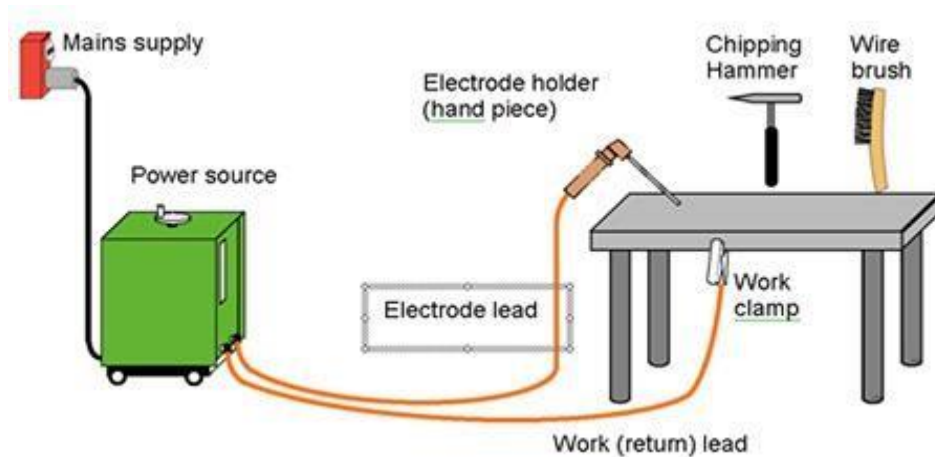
M.S Plates of 100 mm X 50 mm X 5 mm (2 no.), D.C Welding machine, Bench vice

Hack saw, chipping hammer, wire brush, safety goggles, hand gloves, face shield, files.

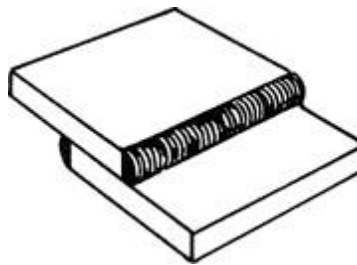
## **Description of Equipment:**

**Direct current (DC** or "*continuous current*") is the continuous flow of electricity through a conductor such as a wire from high to low potential. In direct current, the electric charges flow always in the same direction, which distinguishes it from alternating current (AC). DC is commonly found in many low-voltage applications, especially where these are powered by batteries, which can produce only DC. Most automotive applications use DC although the generator is an AC device which uses a rectifier to produce DC. Most electronic circuits require a DC power supply. Although DC stands for "*Direct Current*", DC is generically used to refer to constant polarity voltages.

In **DC arc welding** a rectifier or a generator can be used to supply the required DC power. In the rectifier type, the power supply is first stepped down by means of a transformer to the required voltage and then silicon controlled rectifiers (SCR) are used to convert AC to DC. These rectifiers are very compact, highly reliable and high efficiency. The other type is a DC generator, which is driven by either an induction motor running on AC or oil engine. This combination is less efficient, more expensive and noisy in operation.



**Fig: Shows Arc Welding Set up**



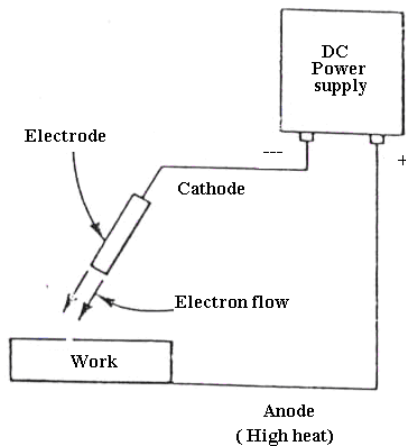
**Fig: Shows Lap Joint**

DC current welding may be

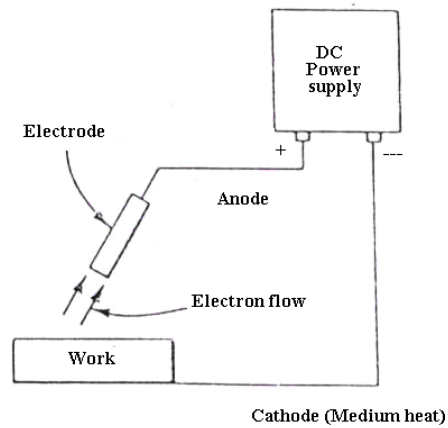
1. Straight polarity (DCEN)
2. Reverse polarity (DCEP)

DC Arc welding set up is shown in the Fig.(3) The work piece is kept on a metallic table to which the ground lead of the secondary windings of the welding transformer is connected. The other lead of the secondary is connected to an electrode holder. Into which the electrode is gripped. When the electrode is brought into the contact with the work the welding takes place.

In **straight polarity** the negative terminal of the DC welding machine is connected to the electrode and work piece to positive terminal. Here the electrons flow from the electrode moves with high velocity towards work piece and produces large amount of heat (nearly 6000°C) when bombarded with the work piece. It produces a narrow deep weld. Since, the heat is concentrated on the work the welding process is more rapid and there is less distortion of the base metal i.e., straight polarity produces better welds. The size of the straight polarity electrode diameter is less than reverse polarity because more amount of heat is concentrated on the work by moving electrons from the electrode. Straight polarity is Not having cleaning power as much as reverse polarity. It is suitable for thicker materials because high penetration of heat into work piece takes place.



**Fig: Straight Polarity or Direct Current**



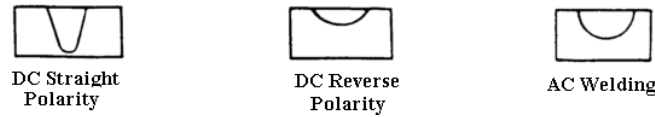
**Fig: Reverse Polarity Direct Current**

**Electrode Negative (DCEN)**

**Electrode Positive (DCEP)**

In **reverse polarity** the negative terminal of the DC welding machine is connected to work piece and positive terminal to the work piece. Here the electrons flow from the work piece to the electrode, thus causing a great concentration of heat at the electrode. Because of this intense heat, the electrode tends to melt off, therefore reverse polarity requires larger diameter electrode than straight polarity. Reverse polarity forms a wide and shallow weld and rarely used. It has excellent cleaning power that results from the action of positively charged ions. When these ions strike the

metal they pierce the oxide film and form a path for the welding current to follow. This same cleaning action occurs in reverse polarity often alternating current welding cycle. It is suitable for thin materials because low penetration of heat into work piece takes place.



**Fig: Comparison of penetration contours**

### Procedure:

- Given two M.S plates, one of the plates is filed at an angle 45 degree at the surface to be joined.
- The electrodes is to be fixed at the holder.
- The connections to be given such that electrode is negative and work piece is positive.
- Now the welding is done carefully for half-length of pates.
- The work piece is to be cut in to two halves by power hacksaws.
- The beds are polished etched with Hydrochloric acid and studied under the microscope whose magnification factor X10 for observing heat affected zone.
- By gripping the beads between jaws of tensile testing machine, load is applied until the work piece breaks and the reading is to be noted.
- The same procedure is repeated for the remaining half which is welded by the reversed polarity and the results are to be compared.

### Precautions:

- Edge penetration should be done very carefully
- Before welding ensure that the surfaces are extremely clean.
- While Welding always use face shield or goggles.

### Result:

**The observation are recorded in tabular column and plotted for analysis**

Sl. No.	DISTANCE FROM CENTRE OF WELD	HARDNESS
1.		
2.		
3.		

**Innovative Questions:**

1. When should we use straight and reversed polarity?
2. What is the effect of polarity on weld strength and HAZ?
3. Differentiate straight and reverse polarity.
4. What is the function of the electrodes?

**Blooms Taxonomy Questions:**

S No	Question	Level
1	Define Weld Bead.	
2	How do you classify weld positions?	
3	Which type of arc welding gives more depth of penetration?	
4	Difference lap and butt joint	
5	What is the effect of polarity on weld strength and HAZ?	

**Viva Questions:**

1. What is reverse polarity?
2. What is the effect of polarity on weld strength?
3. What is the effect of weld current on HAZ?
4. Define duty cycle?
5. What is the function of the SCR in D.C. Welding setup?
6. Write types of welding techniques?
7. Write types of arc welding methods?
8. Write some defects occurred in welding joints?

9. Write types of polarities?
10. What is the function of the electrodes?
11. Write advantages of coatings given on the electrode?
12. What is Weld Bead?
13. What is basic terminology of weld bead?
14. What are the reasons for arc blow?
15. Which type of power supply used in arc welding?
16. What is straight polarity?
17. How much temperature is generated in arc welding?
18. How do you specify a electrode?
19. What is tack welding?
20. Why a electrode should be coated?
21. Where we using consumable electrodes?
22. Where we using non-consumable electrodes?
23. What are the applications of SAW?
24. State the advantages of SAW.
25. What is reverse polarity?
26. Which type of arc welding gives more depth of penetration?
27. What are the types of welds?
28. What are the types of weld joints?
29. How do you classify weld positions?
30. What are the types of welding techniques?

## **Applications:**

### **Submerged Arc Welding (SAW) Applications**

widely used in heavy steel plate fabrication work.

welding of structural shapes.

longitudinal seam of larger diameter pipe.

manufacture of machine components for all types of heavy industry.

manufacture of vessels.  
pressure and storage tanks.

### **Carbon Arc Welding Applications**

The carbon arc process is used as a heat source for brazing and for repairing iron castings. It can also be used in some applications for depositing wear resistant materials on surfaces. Graphite electrodes for welding have been largely superseded by tungsten (in GTAW and PAW).

### **Gas Tungsten Arc Welding Applications**

GTAW is applicable to nearly all metals in a wide range of stock thicknesses. It can also be used for joining various combinations of dissimilar metals. Its most common applications are for aluminum and stainless steel.

### **Shielded Metal Arc Welding (SMAW) Applications**

Used for steels, stainless steels, cast irons, and certain nonferrous alloys  
Not used or rarely used for aluminum and its alloys, copper alloys, and titanium

### **Thermit Welding (TW) Applications**

Joining of railroad rails  
Repair of cracks in large steel castings and Forgings.  
Weld surface is often smooth enough that no finishing is required



## Experiment No 7

### Spot welding-Effect of current on Weld Strength

#### Objective:

To study the effect of the weld current on weld strength in spot welding (Lap Joint).

#### Outcome:

Students will be able:

- To understand concept of Resistance Welding and its process
- To calculate Weld Strength

#### Theory:

It is a solid state welding process which the work pieces to the welded arc forced together by apply a compressive load. Current is passed through the contact area. In this welding at low voltage (100 V) very high current (15000A) is passed through the joint for a short time(25sec). This high amperage heats the joining due to the contact resistance at the joint. The pressure on the joint is continuously maintain and the metal welds together under this pressure. The heat generated in the resistance welding can be expressed as

$$H = I^2RT$$

Where,

H= Total heat generated in the work in Joules (J) Common Joint

I= Electric current

T= Time for which the Electric current is passing through the joint

R= the resistance of the joint in ohms

K= A constant to account for the heat losses from the welded joint

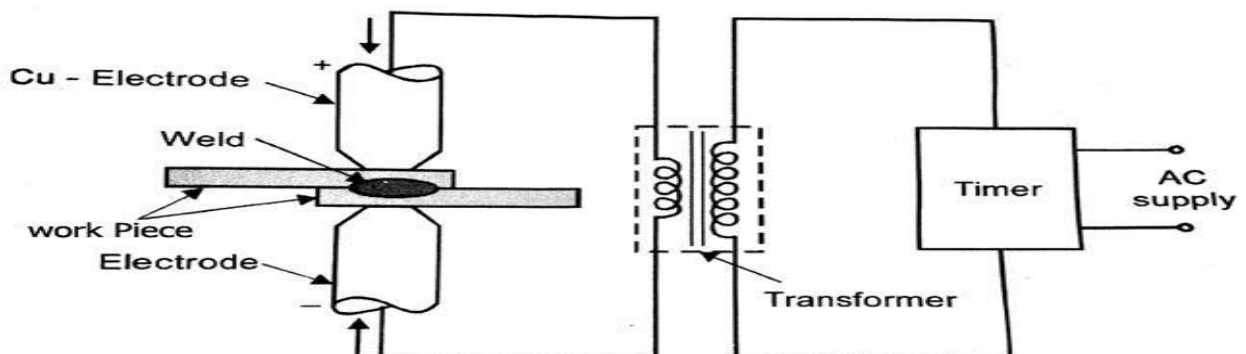
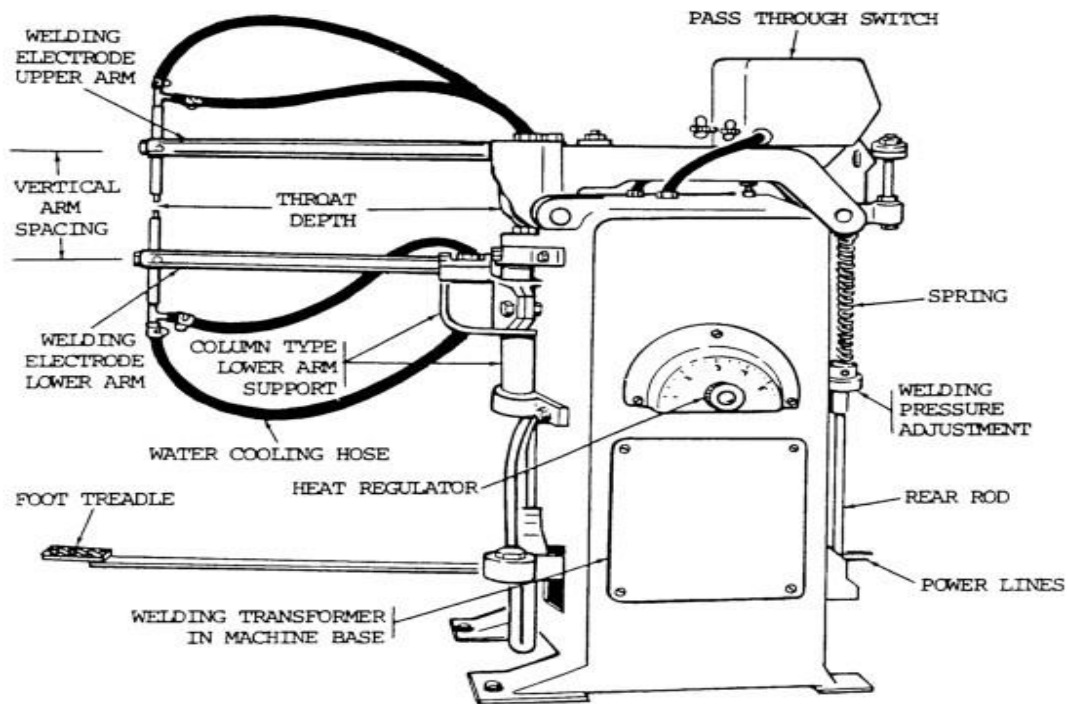


Fig: Spot Welding Process

The main requirement of this process is low voltage and high current power supply. This is obtained by means of step down transformer with a provision to have the different tapping on the primary side, as required depending on the thickness and the properties of the work pieces to be weld. The secondary winding's are to be connected to the electrodes which are made up of copper which have less resistance. The time of electric supply needs to be closely controlled so that the heat released is just enough to make the joint and sub sequence fusion takes place to the force on the joint. The force required can be provided either mechanically, hydraulically or pneumatically. To precisely control the time, sophisticated electronic timers are available.

Spot welding machine consist of two electrodes out of which one is fixed. The other electrode fixed to rocker arm for transmitting the mechanical forces from pneumatic cylinder. This is simplest type of arrangement. The other possibility is that a pneumatic or hydraulic cylinder being connected to the electrode without any rocker arm. a resistance welding consist of sequence of events that takes place. These events are the squeeze time required for the electrode to align and clamp the two work piece together under them and provide necessary electric contact. The weld time is the time of the current is flow through work pieces till they are heated to the melting temperature of the work piece to be welded. The hold time is the time when the pressure is maintained on the molten metal without the electric current. During this time these pieces are expected to be forge welded because the application of the pressure. The off time is the time during which, the pressure on the electrode is taken of so that the plates can be positioned for the next spot.



Resistance spot welding machine and accessories.

## Material and Tools required:

Two GI Sheet sheets of 150x50x1 (2 no.), Spot Welding machine, wire brush, safety goggles, hand gloves, face shield, files.

## Description of Equipment:

Figure shows spot welding set up. It is a resistance welding process which the work pieces to be welded are forced together by apply a compressive load. Current is pass through the contact area. In this welding at low voltage (100 V) very high current (15000A) is passed through the joint for a very short time (25 sec). This high amperage heats the joining due to the contact resistance at the joint. The pressure on the joint is continuously maintained and the metal welds together under this pressure.



**Figure shows Spot welding machine**

## Procedure:

1. Two sheets of 150x50x1 mm are taken and are lap welded by setting in the current knob at position 1, 2, 3, 4.
2. The welded joints are tested for shearing in tensile testing machine.
3. The shear stress to be calculated by using the formula

$$\text{Shear stress} = \frac{\text{Load}}{\text{Nuggetarea}}$$

(Nugget area = area of the tip of the electrode) After calculating the shear stresses at different current values the results are tabulated.

**Precautions:**

1. The weld time for all the welds to be constant.
2. Ensure the overlap the sheets to be proper.

**Result:**

**The observation are recorded in tabular column and plotted for analysis**

S.No.	Current knob position	Nugget area (mm <sup>2</sup> )	Shear Load (N)	Shear Strength

**Innovative Questions:**

1. Where the maximum heat produced in resistance welding?
2. What is the melting point of sheet material?
3. Write types of resistance welding methods?
4. What are the properties of electrode material of flash butt welding?

**Blooms Taxonomy Questions:**

S No	Question	Level
1	Define Nugget	1
2	State the type of electrode used n spot welding	2
3	What is off time?	1
4	Write any applications of spot welding?	2
5	Can we make t joint using spot welding machine.	3

## Viva Questions:

1. What is the principle of resistance welding?
2. What is the maximum thickness of the sheets that can be spot-welded?
3. What is meant by nugget?
4. Explain squeeze time?
5. Write any two applications of spot welding?
6. Which type of electrodes are used in spot welding?
7. What is the melting point of sheet material?
8. Write types of resistance welding methods?
9. What are the properties of electrode material?
10. Which type of current is used in spot welding?
11. What is the maximum weld time?
12. What is the maximum heat utilization in resistance welding?
13. What is Shunting?
14. What is Resistance Projection welding?
15. What is Resistance Seam welding?
16. \_\_\_\_\_type of electrodes are used in projection welding
17. What is the significance of hold time?
18. Which type of electrode is used in seam welding?
19. \_\_\_\_\_welding is used extensively for sheet metal work.
20. Spot welding is used for fabrication of\_\_\_\_\_parts.
21. How does Spot welding differ from roll spot welding?
22. What are the main factors to be considered in resistance welding?
23. Resistance welding requires\_\_\_\_\_Voltage and\_\_\_\_\_current.
24. Where the maximum heat produced in resistance welding?
25. What are the applications of flash butt welding?
26. Explain weld time?
27. Explain hold time?
28. Explain off time?
29. Where we using rotating electrodes?
30. Write the classification of spot welding

## Applications:

1. It has applications in automobile and aircraft industries.
2. Spot welding of two 125 mm thick steel plates has been done satisfactorily as a replacement for riveting.
3. Containers and boxes frequently are spot welded.

## Experiment No 7(a)

### Plasma Welding

#### Objective:

To join two given work pieces using plasma arc welding and Brazing and cut the given plate into two parts using plasma cutting.

#### Outcome:

Students will be able:

- To understand concept of Plasma Welding and its process
- To make a butt joint using Plasma Welding

#### Theory:

The PAW (Plasma Arc Welding), which is a cutting method, was discovered in the year 1953 by “Robert Merrell Gage” and recognized in the year 1957. This procedure was unique as it can perform accuracy cutting on both thin and thick metal. This kind of welding is also competent for spray covering hard metal on new metals. This welding process is used in the welding industries for bringing superior control towards the arc welding method in minor current ranges. At present, plasma holds unique benefits and is used across the industry by generating a superior control level & accuracy for generating high worth joins in miniature applications to give a long life for high production supplies.

The PAW (Plasma arc welding) method is related to GTAW (gas tungsten arc welding). This arc can be formed among the metal as well as an electrode. The major difference among the PAW and GTAW is that in PAW, the welder is capable in placing the electrode in the torch’s body; so this will allow the PAW to be divided from the protecting gas.

Afterward, the plasma is fed throughout a nozzle which will compress the arc to force the plasma away at high speed as well as temperature. The plasma arc method utilizes a non-consumable tungsten electrode & an arc can be formed by strengthening the plasma throughout a bore nozzle. This arc welding can be productively applied to every metal that can be connected with the help of the gas tungsten arc welding technique.

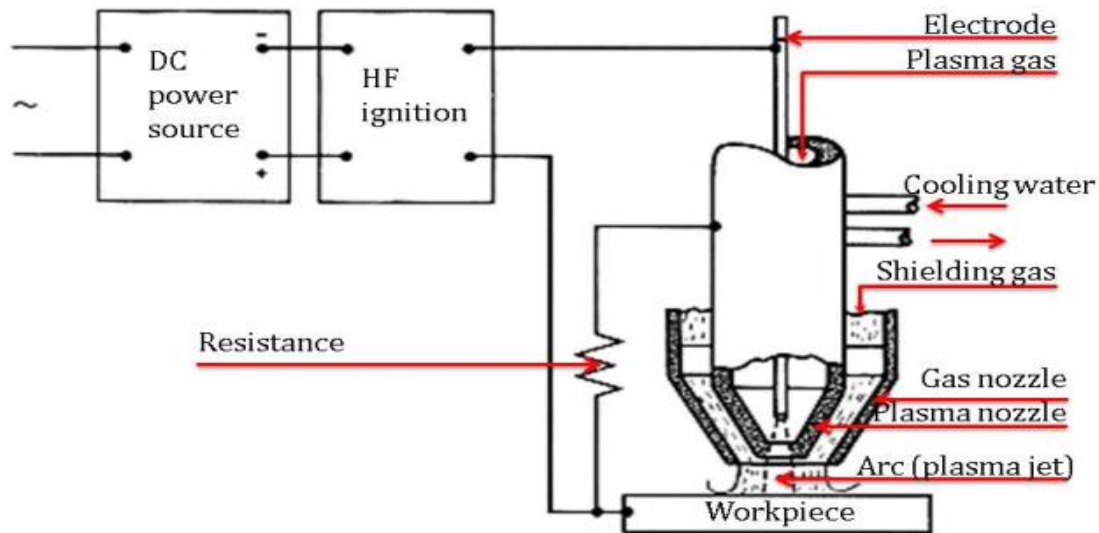
#### Material and Tools required:

M.S flat 50x50x10mm-3 No’s Plasma Welding machine, wire brush, safety goggles, hand gloves, face shield, files.

## Description of Equipment:

The equipment used in the PAW includes the following.

- The power supply used in the PAW is a DC power source, and the suitable voltage for this type of welding is 70 volts otherwise above.
- The typical welding parameters are voltage, current, and gas flow rate. These parameter values can be ranges like the current is 500A, voltage is 30V to 250V, the speed of cutting is: 0.1 to 7.5 m/min, the thickness of the plate is up to 200mm, required power is 2KW to 200KW, the rate of material removal is 150 cm<sup>3</sup>/min, and plasma velocity is 500m/sec
- Current limiting resistors, as well as a high-frequency generator, are used for arc ignition.
- The plasma torch includes an electrode as well as water-cooling arrangement, and these are used to save the nozzle & the electrode's lifespan from dissolving due to the extreme heat generated while welding.
- The fixture is necessary to avoid atmospheric pollution from the molten metal beneath bead.
- Shielding gas is used for protecting the arc region from the atmosphere

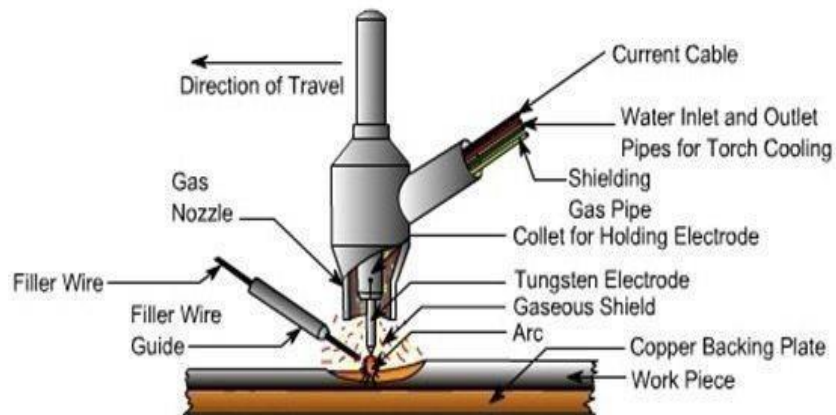
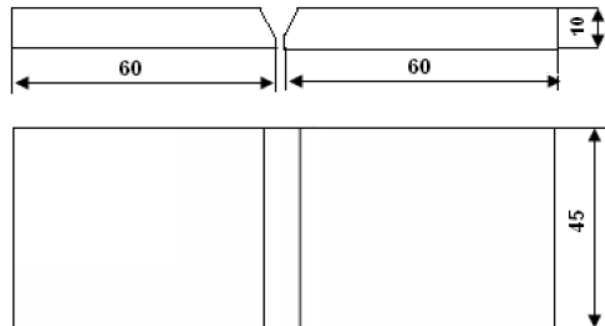


**Plasma Arc Welding**

## Procedure:

- The edge of the given material as prepared to the required V- Shaping using grinding machine.
- The is set to the required permanent (welding)
- Place the two work pieces on the table with required position as shown in figure.
- The work pieces are kept in the required position and tack welding is performed on the work pieces.

- First run of welding is done to fill the gap and penetration of the weldment by holding the electrode at about 700 and filler rod at 300 and move the electrode to the other end uniformly.
- Second run of welding is done with proper weaving and uniform movement to that a uniform weld bead will be obtained.
- The scale formed is chipped with chipping hammer.
- Filing is done to remove any spatter around the weld
- The machine is set to the required parameters (for cutting)



**PLASMA ARC WELDING**



## Experiment No 7(b)

### Plasma Cutting

#### Objective:

To make a plate into two pieces by using cutting machine.

#### Outcome:

Students will be able:

- To understand concept of Plasma Cutting and its process
- To cut the given sheet into two halves using Plasma Cutting machine

#### Theory:

**Plasma cutting** is a process that cuts through electrically conductive materials by means of an accelerated jet of hot plasma. Typical materials cut with a plasma torch include steel, stainless steel, aluminum, brass and copper, although other conductive metals may be cut as well. Plasma cutting is often used in fabrication shops, automotive repair and restoration, industrial construction, and salvage and scrapping operations. Due to the high speed and precision cuts combined with low cost, plasma cutting sees widespread use from large-scale industrial CNC applications down to small hobbyist shops.

#### Material and Tools required:

Plasma cutting Machine, torch, earth wire, table, MS plates, tongs, gosses, goggles, air Compressor.

#### Description of Equipment:

In simplest terms, plasma cutting is a process that uses a high velocity jet of ionized gas that is delivered from a constricting orifice. The high velocity ionized gas that is delivered from a constricting orifice. The high velocity ionized gas that is plasma, conducts electricity from the torch of the plasma cutter to the work piece. The plasma heats the work piece melting the material.

Plasma arc welding (paw) in an arc welding process similar to gas tungsten arc welding(GTAW).The electric arc is formed between an electrode (which is usually but not always made of sintered tungsten)and the work piece.

Plasma gases: The most commonly used plasma gases today are air, oxygen, nitrogen, and organ hydrogen. Air is the most versatile plasma gas: it produces good cut quality and speed on mild steel, stainless and aluminum.

Plasma is a hot ionized gas consisting of approximately equal numbers of positively charged ions and negatively charged electrons. The characteristics of plasma are significantly different from those of ordinary natural gases so that plasma are considered a distinct” forth state of matter.



**Plasma Cutting Machine**

### **Precautions:**

1. Must wear goggles for the safety of eyes.
2. Beware of sparks by using grousers and shoes.
3. Do not increase the set pressure of compressor at a time
4. Use tongue after completion of the cutting operation.

### **Innovative Questions:**

1. How plasma is different from welding?
2. What is the use of transferred type torch?
3. What are the applications of plasma arc cutting?
4. Write advantages of coatings given on the electrode?

### Blooms Taxonomy Questions:

S No	Question	Level
1	Define principle of plasma welding	1
2	State the type of electrode used in plasma cutting	2
3	What is consumable electrode?	1
4	Differentiate plasma welding and cutting.	3
5	Write advantages of coatings given on the electrode?	3

### Viva Questions:

1. Define Plasma
2. What is the pressure capacity of an air compressor?
3. What is function of torch?
4. Which is application of plasma gas welding?
5. How much temp generated in plasma welding?
6. How plasma is different from welding?
7. What is plasma?
8. Write types of polarities?
9. What is the use of transferred type torch?
10. What is the use of non-transferred type torch?
11. Which type of polarity generally used in this welding?
12. What is the material of electrode used in plasma welding?
13. What are the advantages of plasma welding?
14. What are the limitations of plasma welding?
15. How much temperature obtained in this process?
16. What are the applications of plasma welding?
17. What are the advantages of plasma arc cutting?
18. What are the limitations of plasma arc cutting?
19. How much temperature obtained in this process?
20. What are the applications of plasma arc cutting?
21. Write types of arc welding methods?
22. Write some defects occurred in welding joints?
23. Write types of polarities?
24. What is the function of the electrodes?
25. Write advantages of coatings given on the electrode?
26. What is Weld Bead?
27. What is basic terminology of weld bead?
28. What are the reasons for arc blow?
29. Which type of power supply used in arc welding?
30. How much temperature is generated in arc welding?

## **Applications:**

Plasma Arc Welding

Tube mill application

Welding of stainless steel tubes

For melting high melting point metal

## Experiment No 8

### Gas Welding

#### Objective:

To make a lap joint with given M.S. sheets using gas welding.

#### Outcome:

Students will be able:

- To understand concept of Gas Welding and its process
- To make a lap joint using Gas Welding

#### Theory:

Gas welding is one of the most important ones because of its scope of application. Gas welding is one of the oldest forms of heat-based welding and remains the go-to option for many industries.

The reason why this welding technique has a great fanfare is because of its ease of use and low-cost nature. Carrying out a welding process with gas welding is relatively easy and does Not necessarily require expert welders.

When a fuel such as Acetylene is used, the flame can reach up to temperatures of 3100°C. This temperature is lower than what we get from an arc welding machine, but the advantages such as cost savings in the form of simple equipment and labor make gas welding the best choice for repair and construction work.

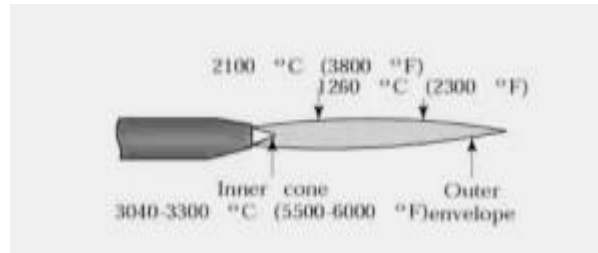
#### **There are two systems of oxygen –acetylene welding.**

- 1) High pressure systems: In this method both of oxygen and acetylene are derived for use from high pressure cylinders.
- 2) Low pressure systems: in this system is taken as usual from high pressure cylinder but acetylene is generated by the action of water on carbide (usually calcium carbide) in a low pressure acetylene generator.

#### **Types of gas welding flames**

Gas welding which is also known as oxyacetylene or oxy-fuel welding uses three controlled flames to carry out any type of operation. These flames are:

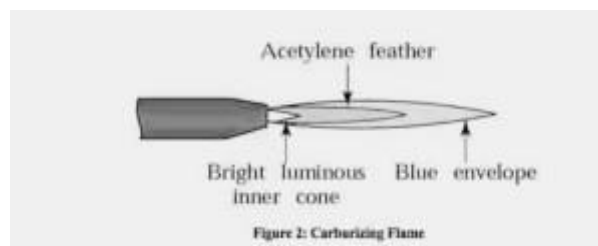
## ❖ Neutral flame



In this gas welding flame, oxygen and acetylene are released at one-to-one ratio. That is, equal amount of oxygen and acetylene is released. It absorbs additional oxygen from air as it provides complete combustion. Neutral flame is fine, clear, and well defined. It is generally preferred for welding. It produces a luminous cone indicating completion of the flame.

Neutral flame is used to weld both ferrous and nonferrous metals such as, mild steel, cast iron, copper, stainless steel, aluminum, etc. welder are expected to adjust to neutral before any other flame. The flame is indicated from its inner cone consisting a luminous cone that is bluish white. It is also known from its surrounding showing a light blue flame sheath or envelope. Neutral flame, which is also known as balanced flame is achieved by releasing excess acetylene. A flame with feather extension of inner cone is produce, increasing the oxygen valve will produce the flame. Immediately oxygen gas, the acetylene flame feather disappears and neutral flame remains. The inner core tip temperature is approximately 585-degree Fahrenheit, whilst, end of its outer sheath or envelope temperature drops to approximately 2300-degree Fahrenheit.

## ❖ Carburizing flame



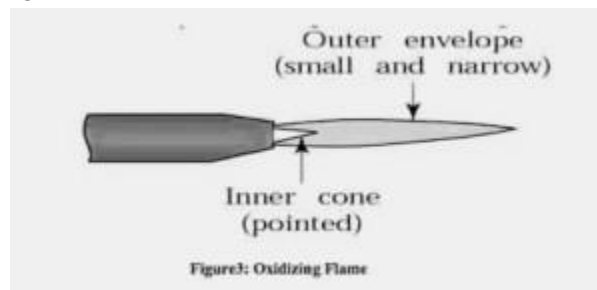
In this oxyacetylene flame, excess acetylene is supply. It inner core has a feather edge extending beyond it, this white feather is also known as acetylene feather. This acetylene is 2x if it's twice as long as the inner cone, helping to know the amount of acetylene supply. Carburizing flame may add carbon to the welded metal of one volume. It is performed by adjusting to neutral flame before increasing the acetylene valve. The inner core will change showing acetylene streamer or "feather" at its end. Level of carburization flame is determined from the length of the streamer. The streamer should not be more than half length of the inner core.

Carburizing flame is clearly recognized by three flame zones;

1. A clearly defined bluish white inner cone
2. White immediately cone indicating amount of excess acetylene
3. A light blue outer flare envelope.

This flare burns with a coarse rushing sound. The inner cone tips temperature is approximately 3700-degree Fahrenheit. If a carburizing flame is used for welding, carbon absorb from the flame, causing metals to boil. This metal is Not clear as it boils, obtain high carbon steel, becomes brittle and subject to cracking.

### ❖ Oxidizing flame



This is the third oxyacetylene flame. It is obtained when oxygen is slightly more than one volume, mixed with one volume of acetylene. Just as it is done in carburizing flame, the torch is adjusted to a neutral flame. Oxygen valve will then be increase until the inner core is shortened to about one-tenth of its original length. The flame tends to be slightly purple and inner cone is pointed if the flame is properly adjusted. This flame is also known by its clear hissing sound.

The temperature of oxidizing flame is approximately 6300-degree Fahrenheit at its inner core tip. It is used to weld metals such as, zinc, copper, manganese steel and cast iron. Applying this flame to steel causes its molten metal to form and spark off, indicating excess oxygen is supply to the steel. It is not used for welding steel because it causes it to be porous, oxidized, and brittle.

Gas welding is all about heating the ends of the materials to a point that they melt and fuse. To achieve this feat, the welder must have a piece of equipment that can create high-temperature flames.

Gas welding ticks this box using the combination of oxygen and highly flammable gas. Most commonly, oxygen is mixed with gases like acetylene, hydrogen, gasoline, propylene, butane, and others.

## **Application of gas welding**

Gas welding is used in a variety of industries. Here is a list of some of the most common applications of gas welding.

***Repair works:*** One of the most common applications of gas welding is for repair works.

***Fabrication of sheet metal:*** Thin to medium sheet metals are easily weld using gas welding.

***Aircraft industry:*** Oxy-Acetylene welding is used in joining various aircraft parts.

***Automotive industry:*** Used to weld parts of the frame and the chassis.

***Joining High carbon Steel:*** Gas welding is very effective in melting high carbon steel

## **Material and Tools required:**

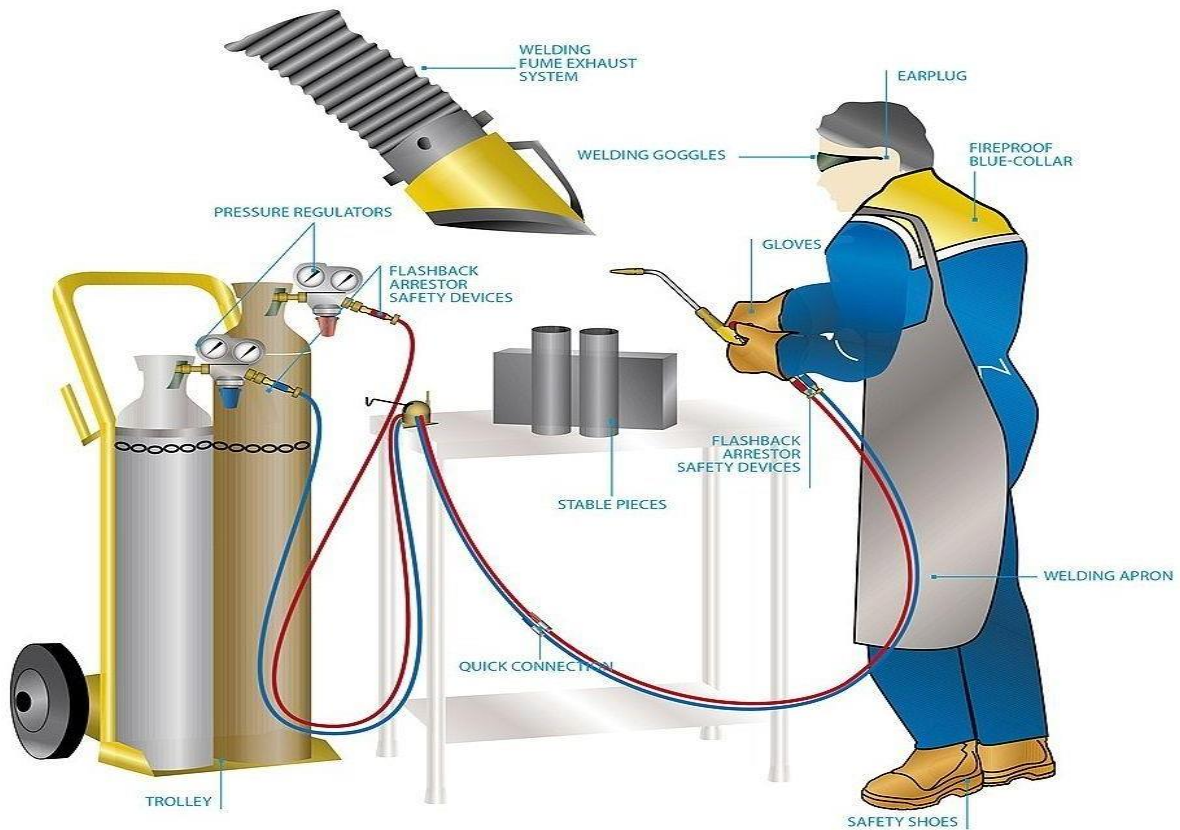
M.S flat 50x50x10mm-3 No's Gas Welding machine, wire brush, safety goggles, chipping hammer, hand gloves, face shield, files.

## **Description of Equipment:**

The equipment used in the Gas Welding includes the following.

- *Cylinders*
- *Oxygen cylinders*
- *Acetylene cylinders*
- *Pressure regulator*
- *Torches*
- *Goggles*
- *Gloves*





## Cylinders:

Oxygen and acetylene are stored under pressure in a steel cylinder. They are seized by the amount of oxygen or acetylene that they hold. Cylinders should always be secured and used in the upright position. When a cylinder is not being used the valve cap should always be in place.

## Oxygen Cylinders:

These cylinders are made of steel and are usually painted green. They contain compressed oxygen at pressures that can be as high as 2200 PSI.

All cylinders have valves and are fitted with a screw-on steel cap that protects the cylinder valve when the cylinder is not in use.

## Acetylene Cylinders:

These cylinders contain acetylene under pressure are painted black made of steel and have cylinder valves. The cylinders contain porous filler material, which is fitted with acetone that allows the acetylene to be safely contained in the cylinder at 250 PSI

Acetylene should never be used at a pressure that exceeds 15 PSI as it becomes highly unstable which depending upon the condition could cause it to decompose and explode.

**Pressure Regulator:**

Both oxygen and fuel gases are filled in the cylinder at high pressure.

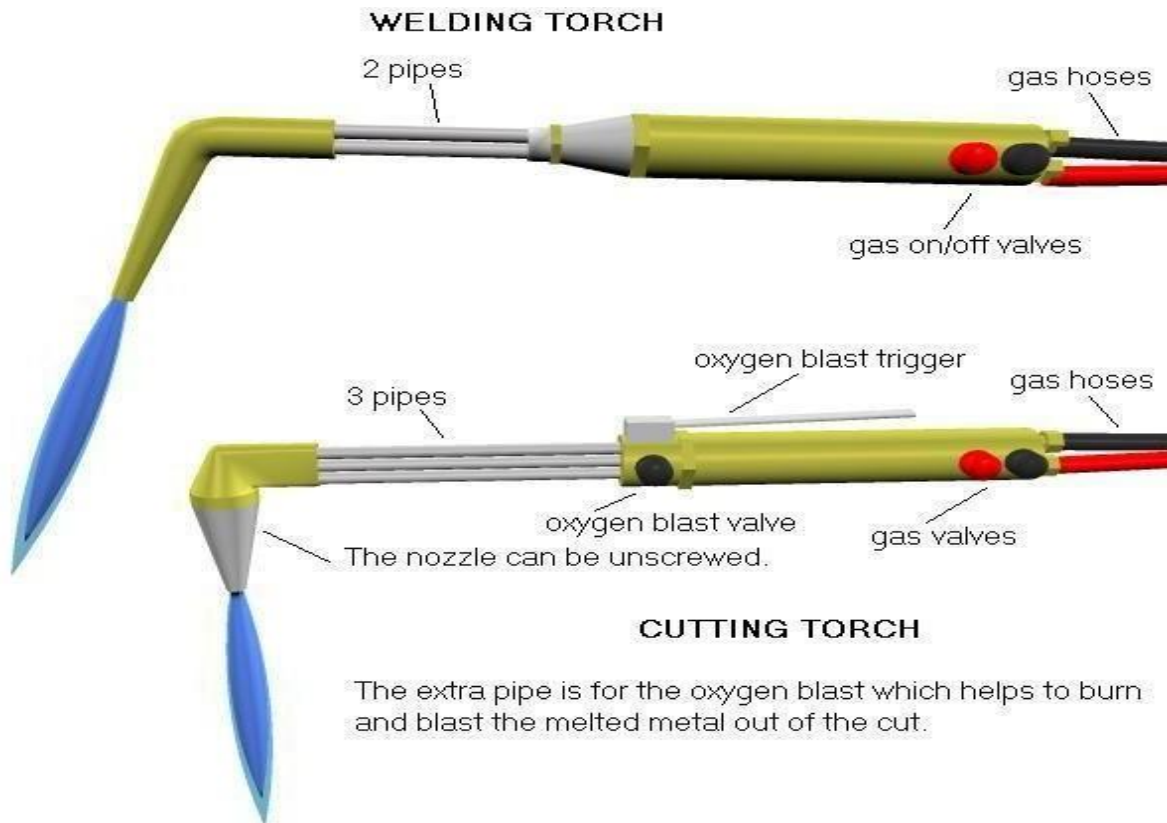
These gases cannot use at this high pressure for welding works, so a pressure regulator is used between the flow.

It supplies oxygen at a pressure of about 70 – 130 Kn/m<sup>2</sup> and gas at 7 – 103 Kn/m<sup>2</sup> to the welding torch.

**Torches:**

The torch assembly consists of the handle Oxygen and fuel gas valves and the mixing chamber.

Welding tips or cutting attachment with the handles can be used, for welding, heating and cutting operations. Oxygen and fuel gas flow through tubes inside the handle which blend in the mixing chamber or tip. It is at the tip that the mixed gas is ignited.



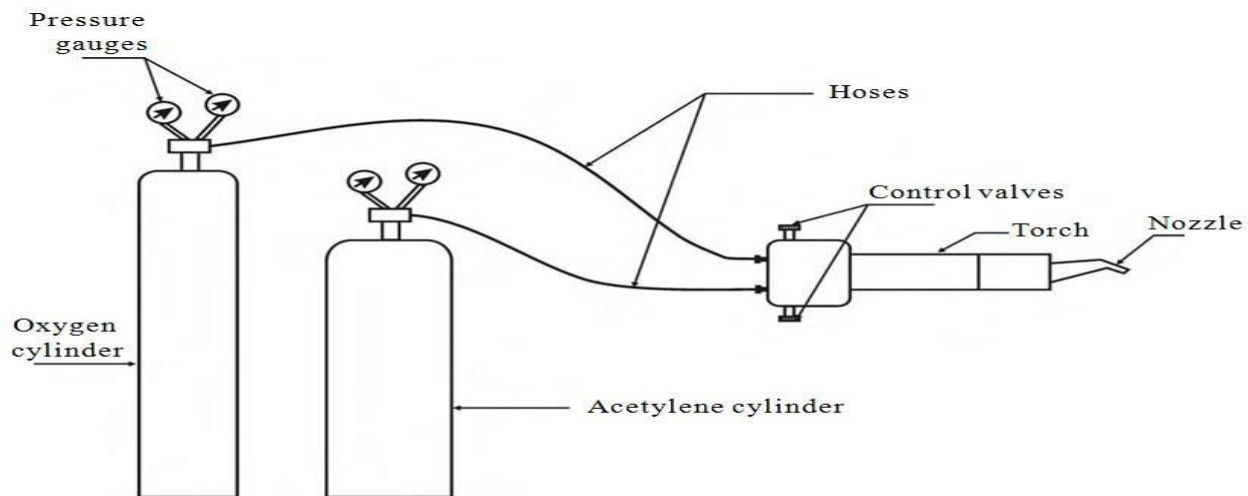
## Goggles and Gloves:

These two Goggles and Gloves are used for safety purposes.

Goggles protect eyes and Gloves protect the hand from radiation and flame of fire.

## Procedure:

- Prepare the work pikes to be welded and place them in proper position on the welding table.
- Wear goggles gloves and apron.
- Select the filler rod of recommended size.
- Do not allow the hose to become excessively worn.
- Do not remove the spanner used for operating valve. Always to kept it with the cylinders.
- Secure the cylinders in use, against galling which may knock –off the valve.
- To test the leakage in a valve or hose, use soap water but not a lighted match.



Gas Welding

## Precautions:

- Inspect equipment for leaks at all connections using approved leak-test solution.
- Inspect hoses for leaks and worn places.
- Replace bad hoses.
- Protect hoses and cylinders from sparks, flames and hot metal.
- Use a flint lighter to ignite the flame.
- Infrared radiation is a cause of retinal burning and cataracts. Protect your eyes with safety glasses

### Innovative Questions:

1. What metals are welded using Carburizing Flame?
2. What are the different gases used in Welding?
3. What are the applications of Gas Welding?
4. Write a brief note on types of flames?

### Blooms Taxonomy Questions:

S No	Question	Level
1	State the principle used in Gas welding	2
2	List out the types of flames used in Gas Welding.	3
3	What is Neutral Flame?	1
4	Differentiate Gas Welding and Brazing.	4
5	Write advantages of gas Welding over arc welding?	2

### Viva Questions:

1. Gas welding is also known as \_\_\_\_\_
2. In which flame the ratio of oxygen is deficient?
3. \_\_\_\_\_ Flame is harmful to steel?
4. For brazing, soldering and flame hardening \_\_\_\_\_ flame is used?
5. The inner core of the flame has \_\_\_\_\_ temperature?
6. The chemical formula of acetylene is \_\_\_\_\_
7. The oxy acetylene gas welding is a type of \_\_\_\_\_ reaction?
8. \_\_\_\_\_ is a condition in gas welding, when the pure methane gas is used as fuel gas instead of acetylene.
9. What is the flame temperature of city gas?
10. What is the flame temperature of water gas?
11. What is the flame temperature of acetylene?
12. Which weld procedure is safe to perform in wet conditions?
13. What temperature of heat is produced in an electric arc furnace?
14. Distance between center of arc and tip of electrode is called as?
15. What is the average length of an arc?
16. Which type of electrode is designed for quick melting?
17. What is the flame temperature of methane?
18. Which joint has the high corrosion resistance?
19. \_\_\_\_\_ Rays are produced during welding?
20. In fusion welding, penetration is the ratio of \_\_\_\_\_
21. Oxidizing flame will be used for welding \_\_\_\_\_ materials?
22. The temperature at which brazing can be done?

23. \_\_\_\_\_ material is used as electrode in brazing operation.
24. Name the three types of flames in gas welding?
25. \_\_\_\_\_ flame is used for welding brass material.
26. \_\_\_\_\_ flame is used to for welding lead material.
27. \_\_\_\_\_ material is used in preparing nozzle of gas welding equipment.
28. The inner cone of the flame has \_\_\_\_\_ temperature.
29. The oxy acetylene gas welding is a type of \_\_\_\_\_ reaction.
30. \_\_\_\_\_ type of join is a not fillet weld.

### Applications:

1. The aerospace industry is one of the primary users of gas tungsten arc welding.
2. Many industries use GTAW for welding thin work pieces, especially nonferrous metals.
3. It is used extensively in the manufacture of space vehicles, and is also frequently employed to weld Small-diameter, thin-wall tubing such as those used in the bicycl industry.

### Brazing Applications

- Fabrications of Bridges, Electric and Transmission Towers.
- Manufacturing of Automobile bodies.
- Building of Ships and Aircrafts.
- Manufacturing of Boiler, Pressure Vessels, Storage Tanks, Pipelines
- Manufacturing of Steel Furniture, Window and Door Frames,
- Window Grills, etc

### Hydrogen brazing

1. It can be applied to a multitude of materials such as stainless steel, copper and some nickel based alloys.
2. Titanium alloys cannot be brazed in a hydrogen atmosphere.
3. Hydrogen brazing reduces surface oxides at the faying surfaces, resulting in a clean, high integrity braze joint that improves the service characteristics of the finished part.

## Experiment No 9 (a)

### MIG (Metal Inert Gas Welding)

#### Objective:

To study metal inert gas welding or shielded arc welding

#### Outcome:

Students will be able:

- To understand concept of MIG Welding and its process.
- To differentiate TIG and MIG Welding.

#### Theory:

Metal Inert Gas (MIG) welding is an arc welding process that uses a continuous solid wire electrode heated and fed into the weld pool from a welding gun. The two base materials are melted together forming a join. The gun feeds a shielding gas alongside the electrode helping protect the weld pool from airborne contaminants.

Metal Inert Gas (MIG) welding was first patented in the USA in 1949 for welding aluminium. The arc and weld pool formed using a bare wire electrode was protected by helium gas, readily available at that time. From about 1952, the process became popular in the UK for welding aluminium using argon as the shielding gas, and for carbon steels using CO<sub>2</sub>. CO<sub>2</sub> and argon-CO<sub>2</sub> mixtures are known as metal active gas (MAG) processes. MIG is an attractive alternative to MMA, offering high deposition rates and high productivity.

#### Process Characteristics

MIG/MAG welding is a versatile technique suitable for both thin sheet and thick section components. An arc is struck between the end of a wire electrode and the workpiece, melting both of them to form a weld pool. The wire serves as both heat source (via the arc at the wire tip) and filler metal for the welding joint. The wire is fed through a copper contact tube (contact tip) which conducts welding current into the wire. The weld pool is protected from the surrounding atmosphere by a shielding gas fed through a nozzle surrounding the wire. Shielding gas selection depends on the material being welded and the application. The wire is fed from a reel by a motor drive, and the welder moves the welding torch along the joint line. Wires may be solid (simple drawn wires), or cored (composites formed from a metal sheath with a powdered flux or metal filling). Consumables are generally competitively priced compared with those for other processes. The process offers high productivity, as the wire is continuously fed.

Manual MIG/MAG welding is often referred as a semi-automatic process, as the wire feed rate and arc length are controlled by the power source, but the travel speed and wire position are under manual control. The process can also be mechanized when all the process parameters are not directly controlled by a welder, but might still require manual adjustment during welding. When no manual intervention is needed during welding, the process can be referred to as automatic.

The process usually operates with the wire positively charged and connected to a power source delivering a constant voltage. Selection of wire diameter (usually between 0.6 and 1.6mm) and wire feed speed determine the welding current, as the burn-off rate of the wire will form an equilibrium with the feed speed.

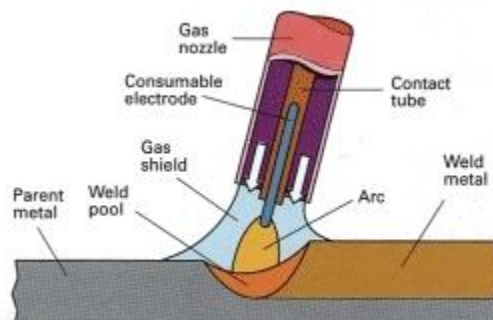
#### Metal Transfer Mode

The manner, or mode, in which the metal transfers from the electrode to the weld pool largely determines the operating features of the process. There are three principal metal transfer modes:

- Short circuiting/ Dip
- Droplet / spray
- Pulsed

Short-circuiting and pulsed metal transfer are used for low current operation while spray metal transfer is only used with high welding currents. In short-circuiting or 'dip' transfer, the molten metal forming on the tip of the wire is transferred by the wire dipping into the weld pool. This is achieved by setting a low voltage; for a 1.2mm diameter wire, arc voltage varies from about 17V (100A) to 22V (200A). Care in setting the voltage and the inductance in relation to the wire feed speed is essential to minimize spatter. Inductance is used to control the surge in current which occurs when the wire dips into the weld pool.

For droplet or spray transfer, a much higher voltage is necessary to ensure that the wire does not make contact i.e. short-circuit, with the weld pool; for a 1.2mm diameter wire, the arc voltage varies from approximately 27V (250A) to 35V (400A). The molten metal at the tip of the wire transfers to the weld pool in the form of a spray of small droplets (about the diameter of the wire and smaller). However, there is a minimum current level, threshold, below which droplets are not forcibly projected across the arc. If an open arc technique is attempted much below the threshold current level, the low arc forces would be insufficient to prevent large droplets forming at the tip of the wire. These droplets would transfer erratically across the arc under normal gravitational forces. The pulsed mode was developed as a means of stabilizing the open arc at low current levels i.e. below the threshold level, to avoid short-circuiting and spatter. Metal transfer is achieved by applying pulses of current, each pulse having sufficient force to detach a droplet. Synergic pulsed MIG refers to a special type of controller which enables the power source to be tuned (pulse parameters) for the wire composition and diameter, and the pulse frequency to be set according to the wire feed speed.



## Shielding Gas

In addition to general shielding of the arc and the weld pool, the shielding gas performs a number of important functions:

- forms the arc plasma
- stabilizes the arc roots on the material surface
- ensures smooth transfer of molten droplets from the wire to the weld pool

Thus, the shielding gas will have a substantial effect on the stability of the arc and metal transfer and the behavior of the weld pool, in particular, its penetration. General purpose shielding gases for MIG welding are mixtures of argon, oxygen and CO<sub>2</sub>, and special gas mixtures may contain helium. The gases which are normally used for the various materials are:

Steels:

- CO<sub>2</sub>
- argon +2 to 5% oxygen
- argon +5 to 25% CO<sub>2</sub>

Non-ferrous (e.g. Aluminium, copper or nickel alloys):

- argon
- argon / helium

Argon based gases, compared with CO<sub>2</sub>, are generally more tolerant to parameter settings and generate lower spatter levels with the dip transfer mode. However, there is a greater risk of lack of fusion defects because these gases are colder. As CO<sub>2</sub> cannot be used in the open arc (pulsed or spray transfer) modes due to high back-plasma forces, argon based gases containing oxygen or CO<sub>2</sub> are normally employed.

### Applications

MIG/MAG is widely used in most industry sectors and accounts for more than 50% of all weld metal deposited. Compared to MMA, MIG/MAG has the advantage in terms of flexibility, deposition rates and suitability for mechanization. However, it should be noted that while MIG/MAG is ideal for 'squirting' metal, a high degree of manipulative skill is demanded of the MIG welder.

## Material and Tools required:

MIG Welding Set up.



## Description of Equipment:

The MIG process is a versatile welding technique which is suitable for both thin sheet and thick section components. It is capable of high productivity but the quality of welds can be called into question. To achieve satisfactory welds, welders must have a good knowledge of equipment requirements and should also recognize fully the importance of setting up and maintaining component parts correctly.

In MIG the arc is formed between the end of a small diameter wire electrode fed from a spool, and the work piece. Main equipment components are:

- power source
- wire feed system
- conduit
- gun

The arc and weld pool are protected from the atmosphere by a gas shield. This enables bare wire to be used without a flux coating (required by MMA). However, the absence of flux to 'mop up' surface oxide places greater demand on the welder to ensure that the joint area is cleaned immediately before welding. This can be done using either a wire brush for relatively clean parts, or a hand grinder to remove rust and scale. The other essential piece of equipment is a wire cutter to trim the end of the electrode wire.

### Power source

MIG is operated usually with a DC power source. The source is termed a flat, or constant voltage, characteristic power source, which refers to the voltage/welding current relationship. In MIG, welding current is determined by wire feed speed, and arc length is determined by power source voltage level (open circuit voltage). Wire burn-off rate is automatically adjusted for any slight variation in the gun to work piece distance, wire feed speed, or current pick-up in the contact tip. For example, if the arc momentarily shortens, arc voltage will decrease and welding current will be momentarily increased to burn back the wire and maintain pre-set arc length. The reverse will occur to counteract a momentary lengthening of the arc.

There is a wide range of power sources available, mode of metal transfer can be:

- dip
- spray
- pulsed

A low welding current is used for thin-section material, or welding in the vertical position. The molten metal is transferred to the work piece by the wire dipping into the weld pool. As welding parameters will vary from around 100A \ 17V to 200A \ 22V (for a 1.2mm diameter wire), power sourceS Normally have a current rating of up to 350A. Circuit inductance is used to control the

surge in current when the wire dips into the weld pool (this is the main cause of spatter). Modern electronic power sources automatically set the inductance to give a smooth arc and metal transfer.

In spray metal transfer, metal transfers as a spray of fine droplets without the wire touching the weld pool. The welding current level needed to maintain the non-short-circuiting arc must be above a minimum threshold level; the arc voltage is higher to ensure that the wire tip does not touch the weld pool. Typical welding parameters for a 1.2mm diameter wire are within 250A \ 28V to 400A \ 35V. For high deposition rates the power source must have a much higher current capacity: up to 500A.

The pulsed mode provides a means of achieving a spray type metal transfer at current levels below threshold level. High current pulses between about 25 and 200Hz are used to detach droplets as an alternative to dip transfer. As control of the arc and metal transfer requires careful setting of pulse and background parameters, a more sophisticated power source is required. Synergic pulsed MIG power sources, which are advanced transistor-controlled power sources, are preprogrammed so that the correct pulse parameters are delivered automatically as the welder varies wire feed speed.

Welding current and arc voltage ranges for selected wire diameters operating with dip and spray metal transfer:

Wire diameter (mm)	Dip transfer		Spray transfer	
	Current (A)	Voltage (V)	Current (A)	Voltage (V)
0.6	30 - 80	15 - 18		
0.8	45 - 180	16 - 21	150 - 250	25 - 33
1.0	70 - 180	17 - 22	230 - 300	26 - 35
1.2	100 - 200	17 - 22	250 - 400	27 - 35
1.6	120 - 200	18 - 22	250 - 500	30 - 40

### Wire feed system

The performance of the wire feed system can be crucial to the stability and reproducibility of MIG welding. As the system must be capable of feeding the wire smoothly, attention should be paid to the feed rolls and liners. There are three types of feeding systems:

- pinch rolls
- push-pull
- spool on gun

The conventional wire feeding system normally has a set of rolls where one is grooved and the other has a flat surface. Roll pressure must not be too high otherwise the wire will deform and cause poor current pick up in the contact tip. With copper coated wires, too high a roll pressure or use of knurled rolls increases the risk of flaking of the coating (resulting in copper build up in the

contact tip). For feeding soft wires such as aluminium dual-drive systems should be used to avoid deforming the soft wire.

Small diameter aluminium wires, 1 mm and smaller, are more reliably fed using a push-pull system. Here, a second set of rolls is located in the welding gun - this greatly assists in drawing the wire through the conduit. The disadvantage of this system is increased size of gun. Small wires can also be fed using a small spool mounted directly on the gun. The disadvantages with this are increased size, awkwardness of the gun, and higher wire cost.

## **Conduit**

The conduit can measure up to 5m in length, and to facilitate feeding, should be kept as short and straight as possible. (For longer lengths of conduit, an intermediate push-pull system can be inserted). It has an internal liner made either of spirally-wound steel for hard wires (steel, stainless steel, titanium, nickel) or PTFE for soft wires (aluminium, copper).

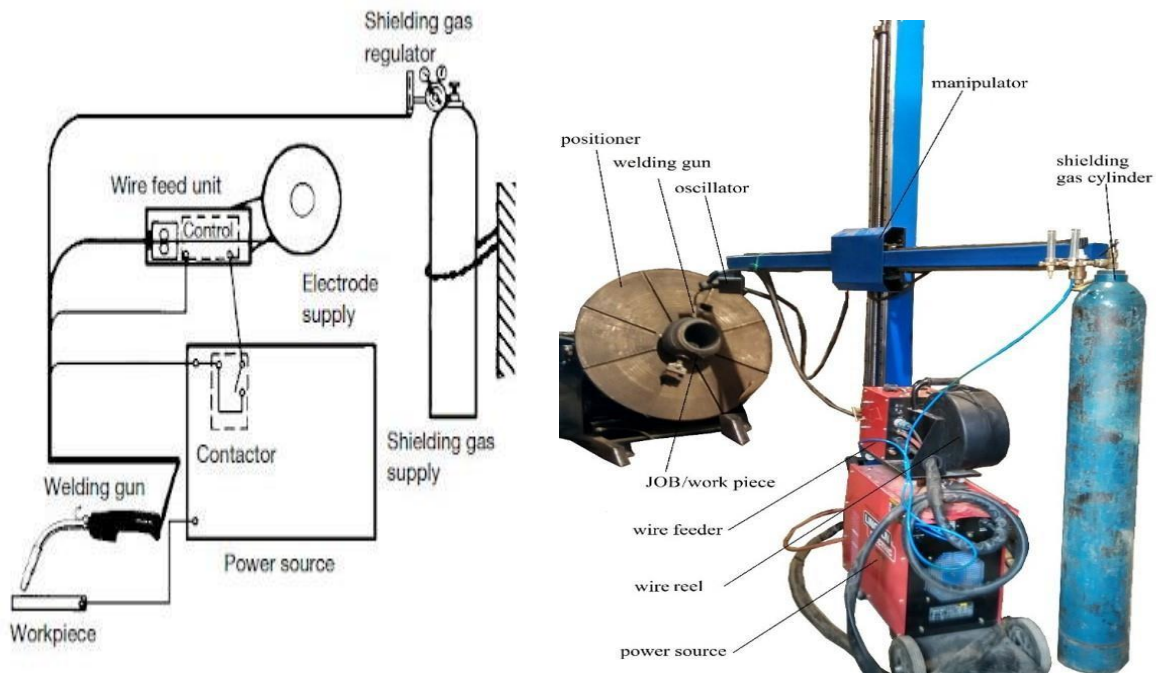
## **Gun**

In addition to directing the wire to the joint, the welding gun fulfils two important functions - it transfers the welding current to the wire and provides the gas for shielding the arc and weld pool.

There are two types of welding guns: 'air' cooled and water cooled. The 'air' cooled guns rely on the shielding gas passing through the body to cool the nozzle and have a limited current-carrying capacity. These are suited to light duty work. Although 'air' cooled guns are available with current ratings up to 500A, water cooled guns are preferred for high current levels, especially at high duty cycles.

Welding current is transferred to the wire through the contact tip whose bore is slightly greater than the wire diameter. The contact tip bore diameter for a 1.2mm diameter wire is between 1.4 and 1.5mm. As too large a bore diameter affects current pick up, tips must be inspected regularly and changed as soon as excessive wear is noted. Copper alloy (chromium and zirconium additions) contact tips, harder than pure copper, have a longer life, especially when using spray and pulsed modes.

Gas flow rate is set according to nozzle diameter and gun to work piece distance, but is typically between 10 and 30 l/min. The nozzle must be cleaned regularly to prevent excessive spatter build-up which creates porosity. Anti-spatter spray can be particularly effective in automatic and robotic welding to limit the amount of spatter adhering to the nozzle.



**Figure shows : Parts of MIG Welding Machine**

### **Precautions:**

- Insulate yourself from work and the ground
- Do not touch electrical parts.
- Keep all panels and covers securely in place
- Keep your head out of the fumes
- Ventilate area , or use breathing device
- Do not weld near flammable material
- Watch for fire : keep extinguisher nearby
- Wear welding helmets with correct shade of filter
- Wear correct eye, ear and body protection.
- Allow cooling period before touching welled metal

## Experiment No 9 (b)

### Tungsten Inert Gas (TIG) Welding

#### Objective:

To prepare a V – Butt Joint Using TIG Welding.

#### Outcome:

Students will be able to:

- To understand the concept and process in TIG Welding
- To Prepare the V butt joint using TIG Welding

#### Theory:

Tungsten Inert Gas (TIG) welding, also known as Gas Tungsten Arc Welding (GTAW) is an arc welding process that produces the weld with a non-consumable tungsten electrode.

Tungsten inert gas (TIG) welding became an overnight success in the 1940s for joining magnesium and aluminium. Using an inert gas shield instead of a slag to protect the weld pool, the process was a highly attractive replacement for gas and manual metal arc welding. TIG has played a major role in the acceptance of aluminium for high quality welding and structural applications.

#### Process characteristics

In the TIG welding process the arc is formed between a pointed tungsten electrode and the work piece in an inert atmosphere of argon or helium. The small intense arc provided by the pointed electrode is ideal for high quality and precision welding. Because the electrode is not consumed during welding, the TIG welder does not have to balance the heat input from the arc as the metal is deposited from the melting electrode. When filler metal is required, it must be added separately to the weld pool.

#### Power source

TIG welding must be operated with a drooping, constant current power source - either DC or AC. A constant current power source is essential to avoid excessively high currents being drawn when the electrode is short-circuited on to the work piece surface. This could happen either deliberately during arc starting or inadvertently during welding. If, as in MIG welding, a flat characteristic power source is used, any contact with the work piece surface would damage the electrode tip or fuse the electrode to the work piece surface. In DC, because arc heat is distributed approximately one-third at the cathode (negative) and two-thirds at the anode (positive), the electrode is always negative polarity to prevent overheating and melting. However, the alternative power source connection of DC electrode positive polarity has the advantage in that when the cathode is on the work piece, the surface is cleaned of oxide contamination. For this reason, AC is used when welding materials with a tenacious surface oxide film, such as aluminium.

## Arc starting

The welding arc can be started by scratching the surface, forming a short-circuit. It is only when the short-circuit is broken that the main welding current will flow. However, there is a risk that the electrode may stick to the surface and cause a tungsten inclusion in the weld. This risk can be minimized using the 'lift arc' technique where the short-circuit is formed at a very low current level. The most common way of starting the TIG arc is to use HF (High Frequency). HF consists of high voltage sparks of several thousand volts which last for a few microseconds. The HF sparks will cause the electrode – work piece gap to break down or ionize. Once an electron/ion cloud is formed, current can flow from the power source.

*Note: As HF generates abnormally high electromagnetic emission (EM), welders should be aware that its use can cause interference especially in electronic equipment. As EM emission can be airborne, like radio waves, or transmitted along power cables, care must be taken to avoid interference with control systems and instruments in the vicinity of welding.*

HF is also important in stabilizing the AC arc; in AC, electrode polarity is reversed at a frequency of about 50 times per second, causing the arc to be extinguished at each polarity change. To ensure that the arc is reignited at each reversal of polarity, HF sparks are generated across the electrode/work piece gap to coincide with the beginning of each half-cycle.

## Electrodes

Electrodes for DC welding are normally pure tungsten with 1 to 4% thoria to improve arc ignition. Alternative additives are lanthanum oxide and cerium oxide which are claimed to give superior performance (arc starting and lower electrode consumption). It is important to select the correct electrode diameter and tip angle for the level of welding current. As a rule, the lower the current the smaller the electrode diameter and tip angle. In AC welding, as the electrode will be operating at a much higher temperature, tungsten with a zirconia addition is used to reduce electrode erosion. It should be noted that because of the large amount of heat generated at the electrode, it is difficult to maintain a pointed tip and the end of the electrode assumes a spherical or 'ball' profile.

## Shielding gas

Shielding gas is selected according to the material being welded. The following guidelines may help:

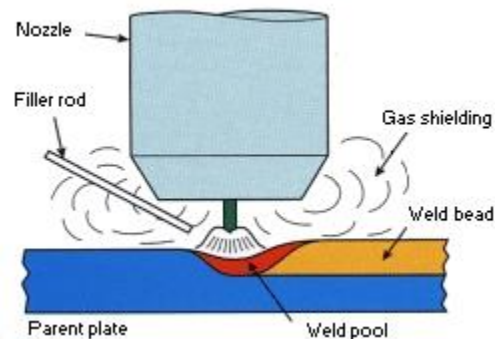
- Argon - the most commonly-used shielding gas which can be used for welding a wide range of materials including steels, stainless steel, aluminium and titanium.
- Argon + 2 to 5% H<sub>2</sub> - the addition of hydrogen to argon will make the gas slightly reducing, assisting the production of cleaner-looking welds without surface oxidation. As the arc is hotter and more constricted, it permits higher welding speeds. Disadvantages include risk of hydrogen cracking in carbon steels and weld metal porosity in aluminium alloys.
- Helium and helium/argon mixtures - adding helium to argon will raise the temperature of the arc. This promotes higher welding speeds and deeper weld penetration. Disadvantages

of using helium or a helium/argon mixture s the high cost of gas and difficulty in starting the arc.

### Applications

TIG welding is applied in all industrial sectors but is especially suitable for high quality welding. In manual welding, the relatively small arc is ideal for thin sheet material or controlled penetration (in the root run of pipe welds). Because deposition rate can be quite low (using a separate filler rod) MMA or MIG may be preferable for thicker material and for fill passes in thick-wall pipe welds.

TIG welding is also widely applied in mechanized systems either autogenously or with filler wire. However, several 'off the shelf' systems are available for orbital welding of pipes, used in the manufacture of chemical plant or boilers. The systems require no manipulative skill, but the operator must be well trained. Because the welder has less control over arc and weld pool behavior, careful attention must be paid to edge preparation (machined rather than hand-prepared), joint fit-up and control of welding parameters.



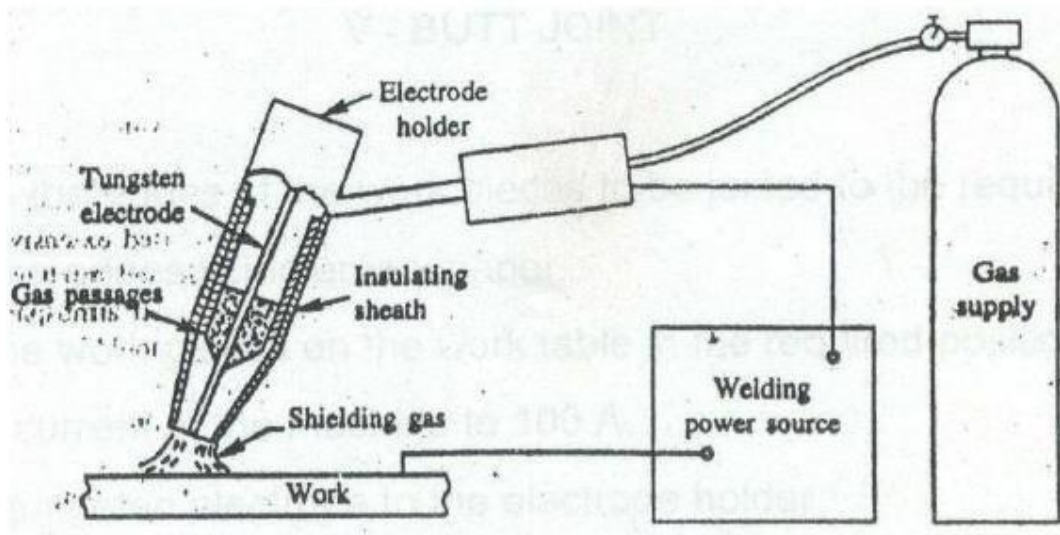
### Material and Equipment Required:

MS flat 50 x 60 X 10 mm<sup>3</sup> ---2 No's Tong, Chipping Hammer, goggles Tungsten Electrode, Ceramic Nozzle and Filler rod.

### Description of Equipment:

Tungsten inert gas (TIG) welding is as inert gas shielded arc welding process using non consumable electrode. The electrode may also contain 1 to 2% thoria mixed along with core tungsten or tungsten with 0.15 to 0.4% zirconia. The pure tungsten electrodes are less expensive but will carry less current. The thoriated tungsten electrodes carry high currents and are more desirable because they can strike and maintain stable arc with relative ease. The zirconia added tungsten electrodes are better than pure tungsten but inferior to thoriated tungsten electrodes.

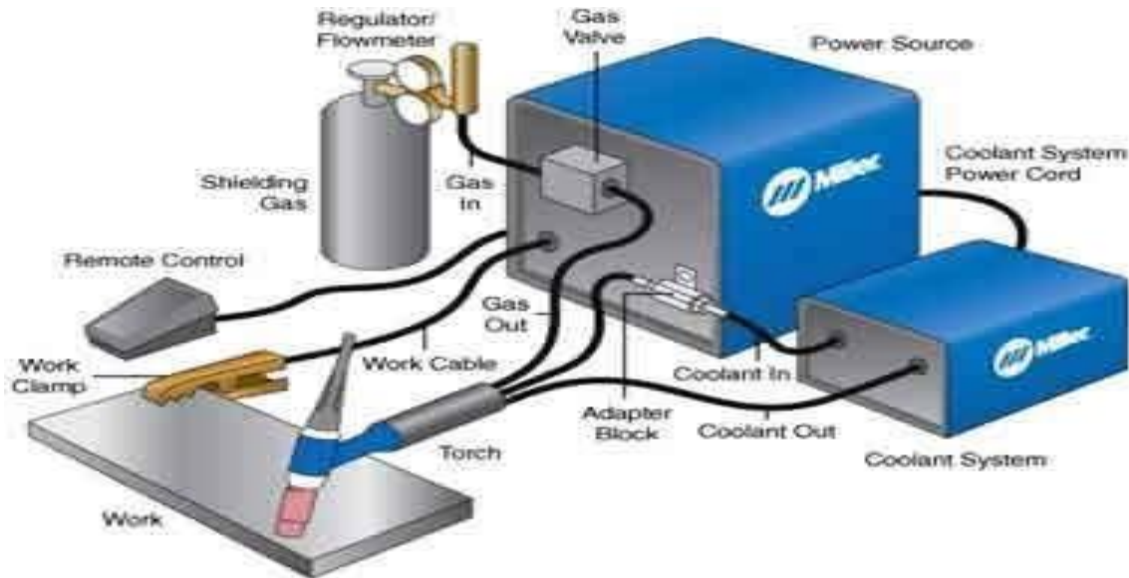
A typical TIG welding setup is shown in fig.



It consists of a welding torch at the center of which is the tungsten electrode. The inert gas is supplied to the welding zone through the annular path surrounding the tungsten electrode to effectively displace the atmosphere around the weld puddle. The TIG welding process can be used for the joining of a number of materials though the most common ones are aluminium, magnesium and stainless steel.

The power sources used are always the constant current type. Both DC and AC power supplies can be used for TIG welding. When DC is used, the electrode can be negative (DCEN) or positive (DCEP). With DCEP is normally used for welding thin metals whereas from deeper penetration welds DCEN is used. An Ac arc welding is likely to give rise to a higher penetration than that of DCEP.





**Parts of TIG Welding Set up**

**Procedure:**

- Prepare the edges of the work pieces to be joined to the required V shape.
- Finish the edges using emery paper.
- Place the work pieces on the work table in the required position.
- Set the current of the machine to 100 A.
- Fix the tungsten electrode to the electrode holder.
- Required size of the nozzle is selected and it is fixed to the torch.
- Adjust the inert gas flow rate to the required rate.
- Select the filler rod (same as base metals) of required diameter.
- Touch the electrode to the work, so that current flow will be established and then separated by a small distance and the arc will be generated.
- First tack weld is done on the work pieces.
- Move the electrode slowly along the length of the joint with the filler rod, so that the filler metal will be deposited in the joint.
- Repeat the operation for the second pass, so that required amount of filler metal will be deposited on the work pieces

**Precautions:**

- Never look at the arc with the naked eye. Always use a shield while welding.
- Always wear the safety hand gloves, apron and leather shoes.
- Ensure proper insulation of the cables and check for openings.
- Select the parameters of the machine properly based on the metals to be welded.
- Set these parameters properly before performing the operation.
- Inflammable and combustible materials are removed from the vicinity of welding operations.

### Innovative Questions:

5. What metals are welded using MIG Welding?
6. What are the different gases used in MIG Welding?
7. State few applications of Metal Inert Gas Welding?
8. Write a brief note on types of wire feed system?

### Blooms Taxonomy Questions:

S No	Question	Level
1	State the principle used in MIG welding	2
2	List out the types of wire feed system used in MIG Welding.	3
3	What is conduit?	1
4	Differentiate MIG and TIG.	4
5	Write advantages of MIG over TIG welding?	5

### Viva Questions:

1. A flame with an excess of acetylene is called \_\_\_\_\_
2. The oxidizing flame is used for welding\_\_\_\_and \_\_\_\_\_
3. Oxygen is stored in a cylinder at\_\_\_\_\_pressure then the acetylene
4. The principle of fusion welding is similar to a \_\_\_\_\_
5. Oxy acetylene flame produces\_\_\_\_\_temperature
6. What is the purpose of mains cable?
7. What inert gas is used in TIG welding?
8. What holds the gas cylinder in place?
9. What dour the trigger on welding gun do?
10. What is the electrode used in TIG welding?
11. Square wave refers to \_\_\_\_\_
12. Name the common materials used for TIG welding
13. What is the purpose of inert shield gas?
14. What is plasma welding?
15. What is a filler metal?
16. Define welding pool?
17. Applications of MIG welding?
18. What is welding torch?

19. What is the purpose of nozzle?
20. What is reverse polarity?
21. \_\_\_\_\_polarity is used in MIG welding.
22. \_\_\_\_\_welding is used to weld sheet metals in automobile and air craft industry.
23. The voltage used in resistance welding is generally kept between\_\_\_\_\_volts
24. The heat generated (H) in resistance welding is expressed by\_\_\_\_\_
25. Purpose of shield gas in TIG welding is?
26. Name the welding in which dissimilar metals can be welded?
27. Write the application of TIG welding?
28. For TIG welding\_\_\_\_\_amp of current has to be supplied.
29. The nozzle used for TIG welding is made of\_\_\_\_\_material.
30. \_\_\_\_\_% of thoria is mixed with tungsten.

## Applications:

### Applications of TIG welding in manufacturing:

TIG is most commonly used to weld thin sections of stainless steel and non ferrous metals such as aluminum, magnesium, and copper alloys.

1. The aerospace industry is one of the primary users of gas tungsten arc welding,
  - TIG in aerospace industry:
  - Aerospace industry uses lite metals (Aluminum and its alloy) thin sheet and need high quality welding. So TIG is more suitable for it.
2. It is also frequently employed to weld small-diameter, thin-wall tubing such as those used in the bicycle industry.
  - Bicycle industry:
  - In Bicycle industry, TIG is frequently employed to weld small-diameter and thin-wall tubing welding.
3. TIG is often used in piping of various sizes.
  - Others industry:
  - Tig welding also used for others industrial purposes. Such as for various piping, Joining thin material in automobile industry.

### Applications of MIG welding in manufacturing:

1. Automotive repair.
  - repairs can be carried out on a number of different vehicles whether they be large, small, light, or heavy.

- capable of providing a strong weld even down to 0.5mm.

## 2. Rebuilding equipment.

- to repair, especially to dismantle and reassemble with new parts. Example: to rebuild an old car.
- When it comes to fixing broken parts in the field, there are three steps to master:
  1. Cutting and removal of the failed component.
  2. Preparation of the new joint/part.
  3. Welding and cleanup.
- worn parts can be repaired by using MIG welding in a variety of coatings (stainless steel, bronze, nickel, aluminum or hard surfacing) and in a range of hardness, for a fraction of the cost of purchasing a new part.

## 3. Overlay of wear resistant coating.

- 1. Coatings for Soft Bearing Surfaces
- 2. Coatings for Hard Bearing Surfaces
- 3. Coatings for Resistance to Abrasion
- 4. Coatings for Resistance to Fretting and Surface Fatigue
- 5. Coatings for Resistance to Erosion
- 6. Coatings for Low Friction and Non-stick Properties

## 4. Welding pipes.

- It is more economical to use a track based robotic welding system than it is to actually man the assembly line.
- Special welding equipment will be needed.
- Four Reasons to Choose Automated Pipe Welding with Robots:
  1. New Technologies
  2. Flexibility
  3. Weld Quality
  4. Productivity

## 5. It can even be used to reinforce the surface of a worn out railroad track.

- it can even be used to reinforce the surface of a worn out railroad track.
- It can be difficult to join metals of different types, but by choosing the right filler wire you can actually achieve it over time.

## Experiment No 10 (a)

### Fly Press

#### Objective:

To make a component (blank) using Fly Press.

#### Outcome:

Students will be able:

- To understand concept of blanking
- To make component using the equipment.

#### Theory:

A Fly Press is a machine tool used to shape sheet metal by deforming it or cutting it with punches and dies. The punch is usually the top (male) tool and the die (female) bottom tool. It can frequently be used to punch holes in sheet metal in one operation, rather than by cutting the hole by slower drilling / milling operations. If used for piercing holes in sheet metal work, the fly press tool itself consists of a punch and clearance die, into which it just fits. This type of set up is known as open tooling as the punch and die are separate from each other. This machine is to work with the help of dies by using the cutting dies and pressing dies. As it is to make blanking and deep drawing operations it is very use full in many industries like small scale and medium scale industries. These types of machine are also used for automated generating machine in heavy scale industries. These types of operations are made for making caps and covers for bottles

#### Description:

The fly presses are purely manually controlled with the operator positioning the work piece against some defined side and ends tops and on conventional fly presses swinging a handle to provide the punching force. On our fly presses we have had them converted with 9 tons hydraulic rams. These hydraulic ram packs enable the operator to be more consistent with the force used in the work cycle (helpful when forming is required, e.g. countersink forms) and it reduces operator fatigue when a large batch of sheet metal work might be needed.

fly presses are used for a variety of sheet metal work operations in our factories including coining, pressing in large anchor rivet bushes and studs, pressings with small press tools, punching various sized holes in sheet metal and extrusions, forming hooks, pressing small joggles, piercing spring stainless steel, corner notching, corner radiusing, stamping in part numbers / logos and adding hole modifications to existing sheet metal work.



**Figure Shows: Fly Press**

**Material and Tools required:**

Fly press machine, sniper Dies steel rule MS sheet, GI sheet marker Vernier calipers.

**Working Principle:**

Sudden impact force is to be applied on the work piece.

## Experiment no 10 (b)

### Study of Progressive Die

#### Objective:

To study a progressive tool and perform blanking and piercing operations. To determine the punching force and blanking force theoretically and compare the same with obtained readings.

#### Outcomes:

Student will be able

- To differentiate various types of dies
- To understand the concept of blanking and piercing
- To determine punching force and blanking force

#### Theory:

##### **SHEET METAL WORKING OR PRESS WORKING OF SHEET METAL**

Press working may be defined as a chip less manufacturing process by which various components are made from sheet metal. This process is also termed as cold stamping. *The main features of a press are:* A frame which supports a ram or a slide and a bed, a source of mechanism for operating the ram in line with and normal to the bed. The ram is equipped with suitable punch and a die block is attached to the bed. A stamping is produced by the down ward stroke of the ram when the punch moves towards and into the die block. The punch and die block assembly is generally termed as a "die set" or simply as a "die". Press working operations are usually done at room temperature. In this process, the wall thickness of the parts remains almost constant and differs only slightly from the thickness of the initial sheet metal. The initial material in cold press working is: low carbon steels, ductile alloy steels, copper and its alloys, aluminium and its alloys, as well as other ductile materials from 10<sup>th</sup> of a mm to about 6 or 8 mm thick.

*Elastic recovery or spring back.* In metal working processes, the total deformation imparted to a work piece will be the sum of elastic deformation and plastic deformation. We also know the elastic deformation is recoverable whereas plastic deformation is permanent. So, at the end of a metal working operation, when the pressure of metal is released, there is an elastic recovery by the material and the total deformation gets reduced a little. This phenomenon is called as "spring back". This

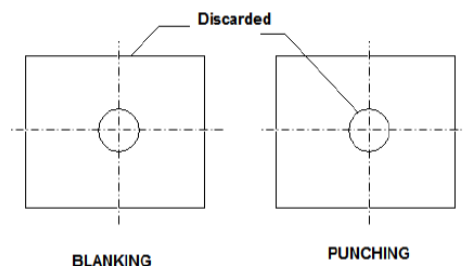
phenomenon is of more importance in cold working operations, especially in forming operations such as bending etc. Spring back depends upon the yield point strength of a metal. The higher the yield point strength of a metal, the greater the spring back. The amount of spring back for a forming operation is difficult to predict and cut- and try methods are most satisfactory to account for it. To compensate for spring back, the cold deformation must always be carried beyond the desired limit by an amount equal to the spring back.

Press operation: The sheet metal operations done on a press may be grouped into two categories, cutting operations and forming operations.

In **cutting** operations, the work piece is stressed beyond its ultimate strength. The stresses caused in the metal by the applied forces will be shearing stresses. In **forming** operations, the stresses are below the ultimate strength of the metal. In this operation, there is No cutting of the metal but only the contour of the work piece is changed to get the desired product. The cutting operations include: blanking, punching, notching, perforating, trimming, shaving, slitting and lancing etc. The forming operations include: bending, drawing, redrawing and squeezing. The stresses induced in the metal during bending and drawing operations are tensile and compressive and during the squeezing operations these are compressive.

Blanking: Blanking is the operation of cutting a flat plate from sheet metal. The article punched out is called the „blank“ and is the required product of the operation. The hole and metal left behind is discarded as waste. It is usually the first step of series of operations.

Punching: It is a cutting operation by which various shaped holes are made in sheet metal Punching is similar to blanking except that in punching, the hole is the desired product, the material punched out to form the hole being waste.



Perforating: This is a process by which multiple holes which are very small and close together are cut in flat work material.



**Trimming:** This operation consists of cutting unwanted excess material from the periphery of a previously formed component.

**Shaving:** The edges of a blanked part are generally rough, uneven and UN square. Accurate dimensions of the part are obtained by removing a thin strip of metal along the edges.

**Slitting:** It refers to the operation of making incomplete holes in a work piece. **Lancing:** This is a cutting operation in which a hole is partially cut and then one side is bent down to form a sort of tab or louver. Since no metal is actually removed, there will be no scrap.

**Bending:** In this operation, the material in the form of flat sheet or strip is uniformly strained around a linear axis which lies in the neutral plane and perpendicular to the lengthwise direction of the sheet metal.

**Drawing:** This is a process of forming a flat work piece into a hollow shape by means of a punch which causes the blank to flow into a die cavity.

### **TYPES OF DIES:**

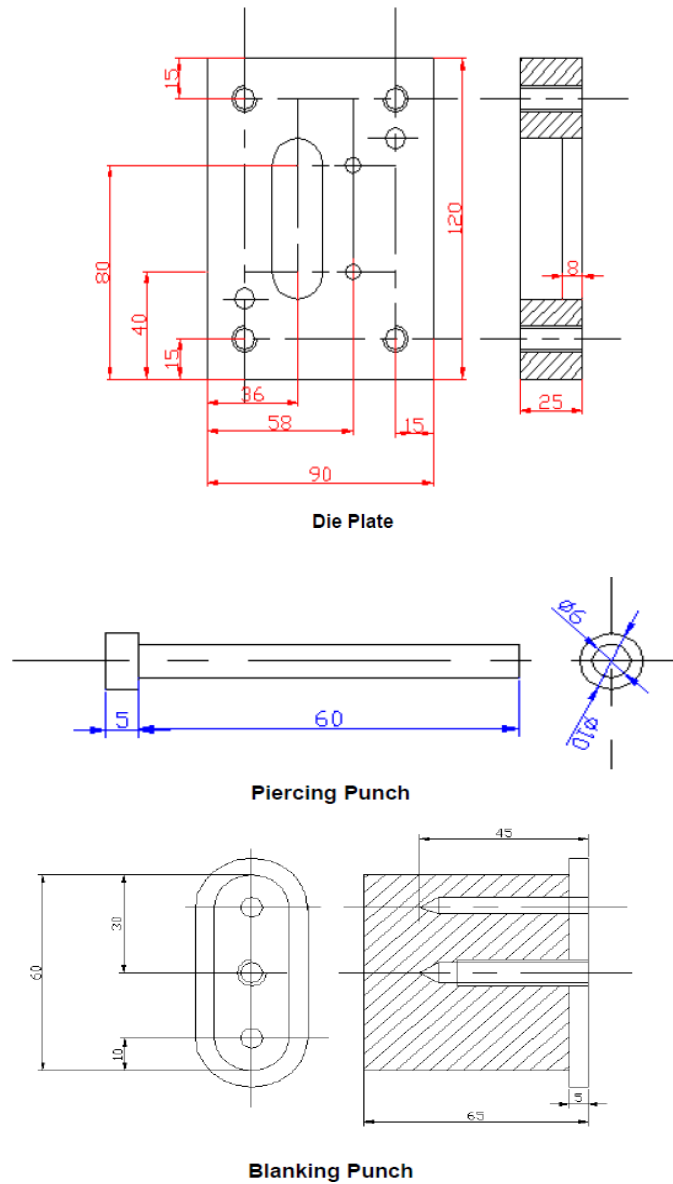
The dies may be classified according to the type of press operation and according to the method of operation.

*Types of press operation:* According to this criterion, the dies may be classified as: cutting dies and forming dies.

**Cutting dies:** The dies are used to cut the metal. They utilize the cutting or shearing action. The common cutting dies are: blanking dies, piercing dies, perforating dies, notching, trimming, shaving dies etc.

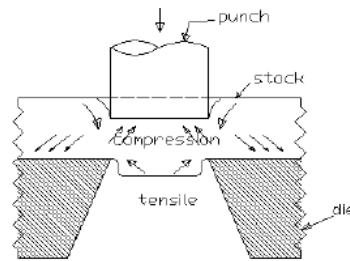
**Forming dies:** These dies change the appearance of the blank without removing any stock. These dies include bending dies, drawing dies, squeezing dies etc.. *Method of operation:* According to this criterion, the dies may be classified as: single operation dies or simple dies, compound dies, combination dies, transfer dies, progressive dies and multiple dies.

## Study of Progressive Die:



A progressive or follow on die has a series of stations. At each station an operation is performed on the work piece during a stroke of the press. Between strokes the piece in the metal strip is transferred to the next station. A finished work piece is made at each stroke of the press. A progressive die is shown in fig. while the piercing punch blanks out a portion of the metal in which two holes had been pierced at a previous station Thus after the stroke two holes will be punched each stroke of the press produces a required finished component.

## Principle of metal cutting:

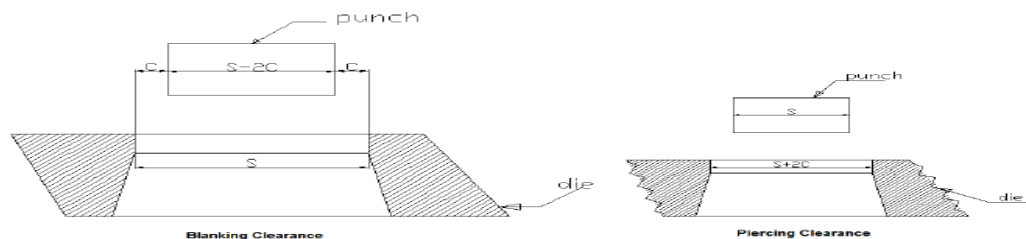


Stresses in Die Cutting

The cutting of sheet metal in the press work is a shearing process. The punch is of the same shape as of the die opening except that it is smaller on the each side by an amount known as „clearance“. As the punch touches the material and travels downward, it pushes the material into the die opening. The material is subjected to both tensile and compressive stresses as shown in fig (a).

Stresses will be highest at the edges of punch and die and the material will start cracking there. The various steps in the rupture or fracture of material can be written as stressing the material beyond the elastic limits; plastic deformation reduction in area fracturing starts in the reduced area and becomes complete. If the clearance between punch and die is correct, the cracks starting from the punch and die edges will meet and the rupture is complete as shown in fig (b). If the clearance is too large or too small the cracks do not meet and ragged edge results due to the material being dragged and torn through the die.

*Clearance:* The die opening must be sufficiently larger than the punch to permit a clean fracture of the metal. This difference in dimensions between the mating members of a die set is called „clearance“. This clearance is applied in the following manner:



„C“ is the amount of clearance per side of the die opening.

- ✓ When the hole has to be held to size, i.e. the hole in sheet metal is to be accurate, and slug is to be discarded the punch is made to the size of hole and the die opening size is obtained by adding clearance to the punch size shown in fig (a).
- ✓ In blanking operation where the slug or blank is desired part and has to be held to size the die opening size equals the blank size and the punch size is obtained by subtracting the clearance from the die opening size shown in fig (b).

The clearance is a function of the kind, thickness and temper of the work material harder materials requiring clearance than soft materials, the exception being aluminium. The usual clearances per side of the die, for various materials,

are given below in terms of the stock thickness, t:

For brass & soft steel,	c=5% of t	For mild steel,	c=6% of t
For hard steel,	c=7% of t	For Aluminium	c=10% of t

The total clearance between punch and die size will be twice these figs these clearances are for blanking and piercing operations.

The clearance may also be determined with the help of the following equation:  $c=0.0032t \times \sqrt{\pi_s}$

Where  $\zeta_s$  is the shear strength of the material in N/mm<sup>2</sup>.

*Cutting forces:* In cutting operation as the punch in its downward movement enters the material it need not penetrate the thickness of the stock in order to affect complete rupture of the part. The distance which the punch enters in to the work material to cause rupture to take place is called “penetration” and is usually given as percentage of the stock thickness. The % penetration depends on the material being cut and also on the stock thickness. When a hard and strong material is being cut very little penetration of the punch is necessary to cause fracture. With softer the penetration will be greater. The percentage penetration is also depends upon the stock thickness, being smaller for thinner sheets.

The max force  $F_{max}$  in newtons needed to cut a material is equal to :

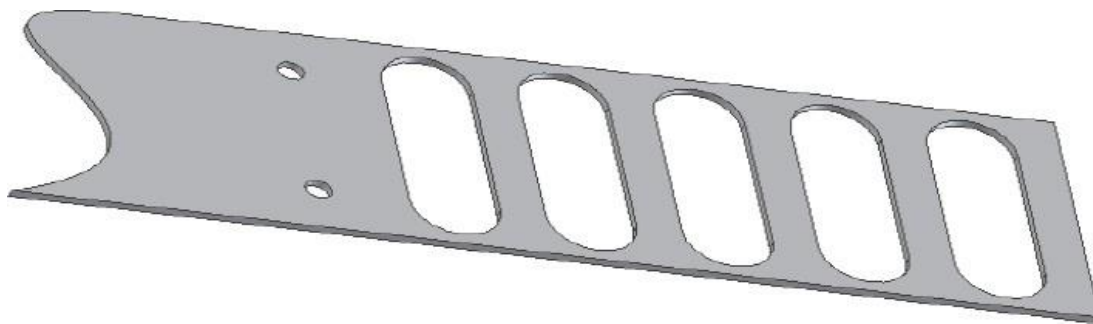
For a circular blank of diameter D mm and of thickness t mm the maximum cutting force will be given as:

$$F_{\max} = \pi D t \zeta_s = P t \zeta_s.$$

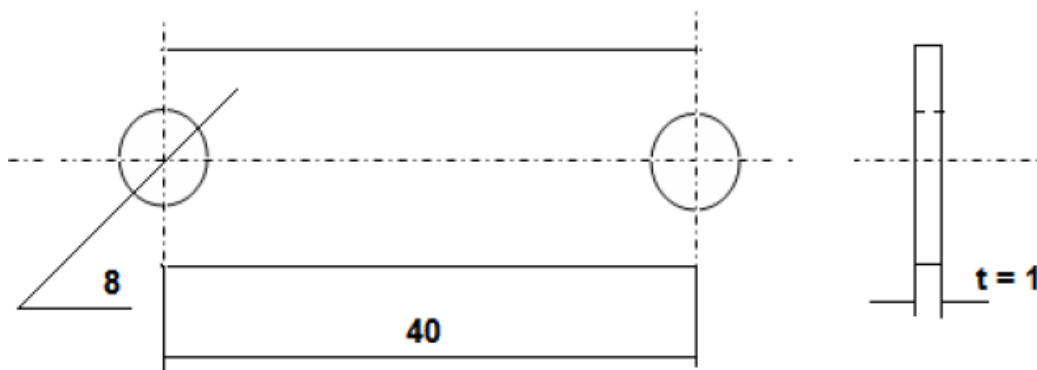
Where P is the perimeter of the section to be blanked

For rectangular blanks the length L and width b it is

$$F_{\max} = 2(L+b) t \zeta_s.$$



**Component to be produced**



### Procedure:

- Fix the punch to the ram of the press.
- Fix the die on the bed of the machine using clamps, bolts and nuts.
- Place the blank of required size between the die and punch.
- Apply pressure hydraulically on the blank through the punch so that piercing will take place at the first station.
- Note down the reading of the pressure gauge which directly gives the force required

to perform the piercing operation.

- Move the blank in forward direction until it touches the stopper on the die.
- Again apply pressure hydraulically on the blank so that piercing punch blanks out a portion of the metal in which already two holes had been pierced. At the same time piercing operation takes place at the first station.
- Note down the reading of the pressure gauge which directly gives the force required to perform the piercing and blanking operations.
- Difference of the two readings gives the force required to perform blanking operation.
- Compare the values with the theoretically obtained values.
- The process may be repeated to produce the components in mass production.

### Precautions:

- The die should be properly clamped to the bed of the machine and it is Not disturbed during the process.
- The punch is properly fixed to the ram of the machine.
- The load should be applied uniformly on the blank.
- The ram should be fed slowly towards the die and make sure that it is properly in line with the die

### Observation and Calculation:

Piercing Force  $(F_p)$  =

Blanking & Piercing Force  $(F_{bp})$  =

Blanking Force  $(F_b = F_p - F_{bp})$  =

Maximum force needed to cut material is  $F_{max} = P \cdot t \cdot \zeta_s$

Where P is the Perimeter of the blank

t is the thickness of the blank

$\zeta_s$  is the shear strength of the material

### Result:

## Experiment No 10 (b)

### Study of Compound Die

#### Objective:

To study a Compound tool and perform blanking and piercing operations. To determine the punching force and blanking force theoretically and compare the same with obtained readings

#### Outcomes:

Student will be able

- To differentiate various types of dies
- To understand the concept of blanking and piercing
- To determine punching force and blanking force

#### Theory:

Press working may be defined as a chip less manufacturing process by which various components are made from sheet metal. This process is also termed as cold stamping. The process has got the following advantages:

Small weight of fabricated parts.

- ✓ High productivity of labor.
- ✓ High efficiency of technique as regards the fabrication of items of diversified shapes, both simple and complex, such as washers, bushings, retainers, of ball bearings, tanks and car bodies etc.
- ✓ The parts obtained by cold sheet metal working are distinguished for their size accuracy. In many cases, they require no subsequent machining and are delivered to the assembly shop.

**PRESSES:** These are classified in various ways:

- ✓ Source of power.
- ✓ Method of actuation of the rams
- ✓ Number of slides
- ✓ Type of frame

- ✓ The type of work for which the press has been designed.

**Source of power:** Two kinds of sources of power for applying force to the ram are mechanical and hydraulic.

In **Mechanical Presses**, the energy of flywheel is utilized which is transmitted to the work piece by gears, cranks, eccentrics or levers. The flywheel rotates freely on the crankshaft and is driven from an electric motor through gears or V belts. The motor runs continuously and stores energy in the fly wheel. When the operator presses a foot treadle or actuates a button, the clutch gets engaged and the fly wheel is connected to the crank shaft. The crankshaft starts rotating and the stored up energy in the flywheel is transmitted to its ram on its downward stroke .The clutch to engage and disengage the flywheel to the driveshaft can be: a jaw clutch, an air operated clutch or an electromagnetic clutch. In manually operated mechanical presses, the clutch is engaged after each cycle. But in automatic presses in which the metal strip is fed to the die automatically, there is No need of single stroke clutch disengaging mechanism and the ram moves up and down continuously.

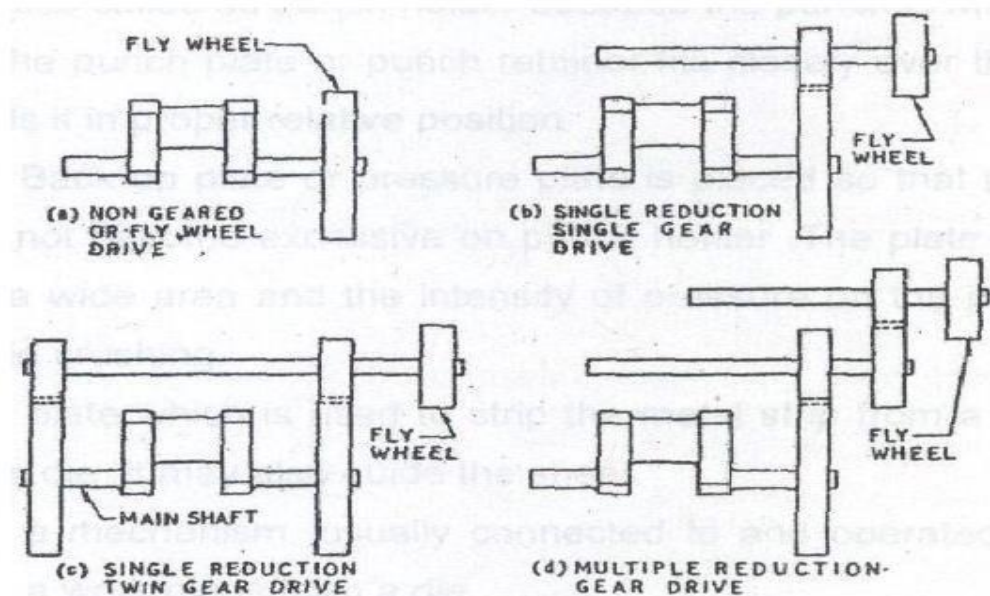


Fig. . Types of Mechanical Press Drives.



These presses can be classified as plain and geared. In the first design, the flywheel is mounted directly on the driveshaft .On a geared press, the flywheel is carried on an auxiliary shaft which is connected to the main shaft through one or more gear reductions, depending upon size and energy needed. In this arrangement, the flywheel stores considerably more energy than the plain drive as its speed is higher than main drive shaft.

In **hydraulic press**, the ram is actuated by oil pressure on a piston in a cylinder. Mechanical presses have following advantages over the hydraulic press:

- ✓ Run faster
- ✓ Lower maintenance cost
- ✓ Lower capital cost.

**Advantages of Hydraulic presses are:**

- More versatile and more easy to operate.
- Tonnage adjustable from zero to maximum.
- Constant pressure is maintained throughout the stroke.
- Force and speed can be adjusted throughout the stroke.
- More powerful than Mechanical presses.
- Safe as it will stop at pressure setting.

The main disadvantage of Hydraulic press is that it is slower than a Mechanical press.

A press is rated in tones of force, t is able to apply without undue strain . To keep the deflections small, it is a usual practice to choose a press rated 50 to 100% higher than the force required for an operation.

**Press selection:** The factors which should be considered while selecting a press for a given job are: the overall work size, the stock thickness and material, kind of operation to be performed, power required and speed of operation.

For punching, blanking and trimming operations, usually the crank or eccentric type mechanical press is used. This is due to their small working strokes and high production rates. In these

operations, there is sudden release of load at the end of cutting stroke. This sudden release of load is Not advisable in Hydraulic

presses. So, Hydraulic presses are not preferred for these operations .If however these are inevitable, and then some damping devices are incorporated in press design. For coining and other squeezing operations, which require very large forces, knuckle joint mechanical press is ideally suited. Hydraulic presses, which are slower and more powerful, can also be used for these operations. Hydraulic presses are also better adapted to pressing, forming and operations, which are basically slower processes.

### Press Working Terminology:

A simple cutting die used for punching and blanking operations is shown in fig. the following are the main components of die and press.

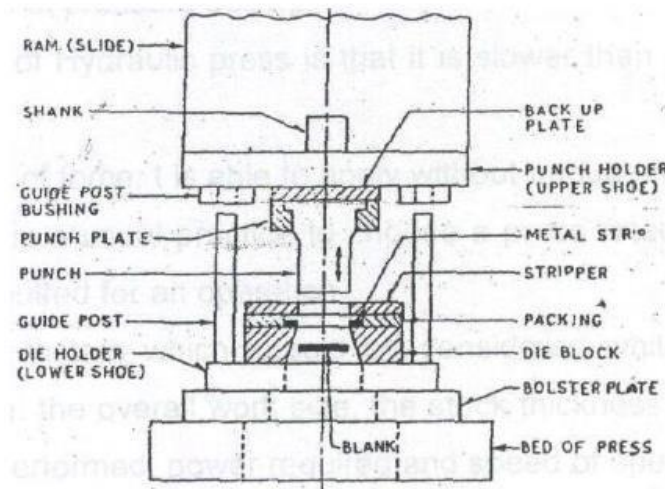


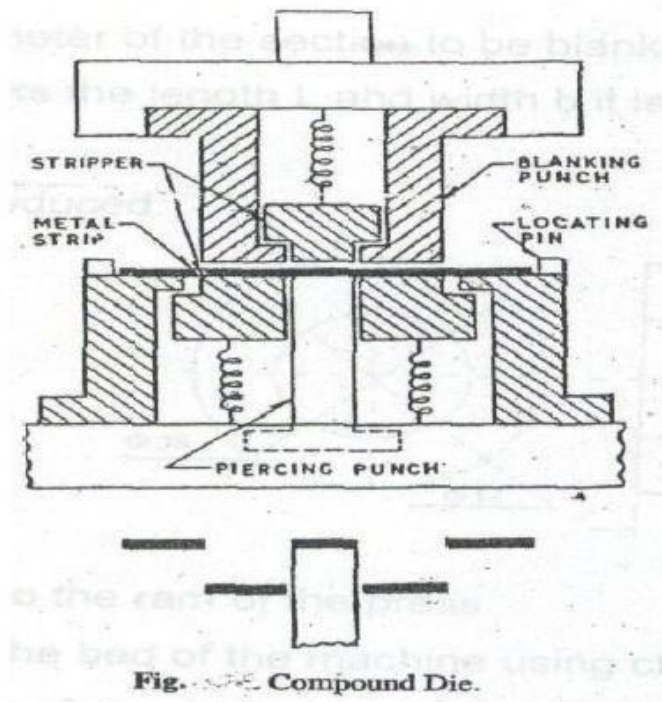
Fig. 17. A simple Cutting Die.

- Bed: The bed is the lower part of a press frame that serves as a table to which a bolster plate is mounted.
- Bolster Plate: This is a thick plate secured to the press bed, which is used for locating and supporting the die assembly. It is usually 5 to 12.5 cm thick.
- Die set: It is unit assembly which incorporates a lower and upper shoe, two or more guide

posts and guide post bushings.

- Die: The die may be defined as the female part of a complete tool for producing work in a press. It is also referred to a complete tool consisting of a pair of mating members for producing work in a press.
- Die Block: It is a block or a plate which contains a die cavity.
- Lower Shoe: The lower shoe of a die set is generally mounted on the bolster plate of a press. The die block is mounted on the lower shoe. Also, the guide posts are mounted in it. It is also called as die holder.
- Punch: This is the male component of the die assembly, which is directly or indirectly moved by and fastened to the press ram or slide.
- Upper shoe: This is the upper part of the die set which contains guide post bushings. It is also called as punch holder because the punch is mounted on it. Punch plate: The punch plate or punch retainer fits closely over the body of the punch and holds it in proper relative position.
- Back up plate: Back up plate or pressure plate is placed so that the intensity of pressure does not become excessive on punch holder. The plate distributes the pressure over a wide area and the intensity of pressure on the punch holder is reduced to avoid crushing.
- Stripper: It is a plate which is used to strip the metal strip from a cutting or non cutting punch or die. It may also guide the sheet.
- Knockout: It is a mechanism, usually connected to and operated by the press ram, for freeing a work piece from a die.
- Pitman: It is a connecting rod which is used to transmit motion from the main drive shaft to the press slide.
- Shut height: It is the distance from top of the bed to the bottom of the slide, with its stroke down and adjustment up.
- Stroke: The stroke of a press is the distance of ram movement from its up position to its down position. It is equal to twice the crankshaft throw or eccentric drives but is variable on the hydraulic press.

## STUDY OF COMPOUND DIE:



In these dies two or more operations may be performed at one station. Such dies are considered as cutting tools since only cutting operations are carried out. Compound dies are more accurate and economical in mass production as compared to single operation dies.

**Cutting forces:** In cutting operation as the punch in its downward movement enters the material it need not penetrate the thickness of the stock in order to affect complete rupture of the part. The distance which the punch enters in to the work material to cause rupture to take place is called “penetration” and is usually given as percentage of the stock thickness. The % penetration depends on the material being cut and also on the stock thickness. When a hard and strong material is being cut very little penetration of the punch is necessary to cause fracture. With softer the penetration will be greater. The percentage penetration is also depends upon the stock thickness, being smaller for thinner sheets.

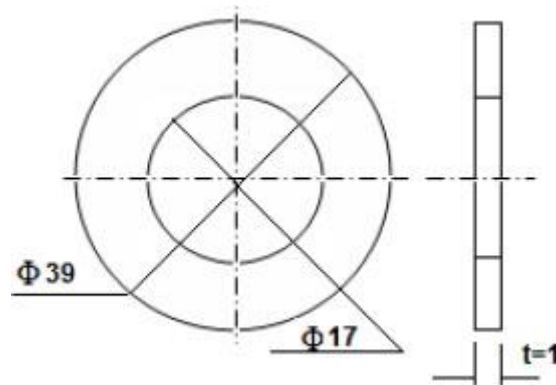
The max force  $F_{\max}$  in newtons needed to cut a material is equal to the area to be sheared times the shearing strength,  $T_s$  in  $N/mm^2$  for the material. For a circular blank of diameter  $D$  mm and of thickness  $t$  mm the cutting force will be given as:  $F_{\max} = \pi D t \zeta_s = P t \zeta_s$ .

Where P is the perimeter of the section to be blanked

For rectangular blanks the length L and width b it is  $F_{\max} = 2(L+b) t \zeta_s$ .

### Procedure:

- Fix the punch to the ram of the press.
- Fix the die on the bed of the machine using clamps, bolts and nuts.
- Place the blank of required size between the die and punch.
- Apply pressure hydraulically on the blank through the punch so that blanking and piercing will take place at one station.
- Note down the reading of the pressure gauge which directly gives the force required to perform both blanking and piercing operations.
- Compare the value with the theoretically obtained value.
- The process may be repeated to produce the components in mass production.



### Precautions:

- Fix the punch to the ram of the press.
- Fix the die on the bed of the machine using clamps, bolts and nuts.
- Place the blank of required size between the die and punch.
- Apply pressure hydraulically on the blank through the punch so that blanking and piercing will take place at one station.
- Note down the reading of the pressure gauge which directly gives the force required to perform both blanking and piercing operations.
- Compare the value with the theoretically obtained value.
- The process may be repeated to produce the components in mass production.

### Observation and Calculation:

Force required to perform blanking and piercing operations = Maximum force

needed to cut material is  $F_{\max} = P \cdot t \cdot \zeta_s$  Where P is the Perimeter of

the blankt is the thickness of the blank

$\zeta_s$  is the shear strength of the material

In these dies two or more operations may be performed at one station. Such dies are considered as cutting tools since only cutting operations are carried out. Compound dies are more accurate and economical in mass production as compared to single operation dies.

**Cutting forces:** In cutting operation as the punch in its downward movement enters the material it need not penetrate the thickness of the stock in order to affect complete rupture of the part. The distance which the punch enters in to the work material to cause rupture to take place is called “penetration” and is usually given as percentage of the stock thickness. The % penetration depends on the material being cut and also on the stock thickness. When a hard and strong material is being cut very little penetration of the punch is necessary to cause fracture. With softer the penetration will be greater. The percentage penetration is also depends upon the stock thickness, being smaller for thinner sheets.

The max force  $F_{\max}$  in newtons needed to cut a material is equal to the area to be sheared times the shearing strength,  $T_s$  in  $N/mm^2$  for the material. For a circular blank of diameter D mm and of thickness t mm the cutting force will be given as:  $F_{\max} = \pi D t \zeta_s = P t \zeta_s$ .

Where P is the perimeter of the section to be blanked

For rectangular blanks the length L and width b it is  $F_{\max} = 2(L+b) t \zeta_s$ .

**Result:**

## Experiment No 10 (d)

### Drawing and Bending

#### Objective:

- To Determine the Blank Size, Drawing Force and Blank Holding Force for Producing a symmetrical cup of circular cross section using a Draw Tool and Perform Drawing Operation.
- To perform Bending Operation

#### Outcomes:

Student will be able

- To determine the Blank Size, Drawing Force and Blank Holding Force for Producing a symmetrical cup of circular cross section
- To understand the concept of blanking and piercing
- To perform the bending operation

#### Theory:

##### Drawing:

Drawing operation is the process of forming a flat piece of material into a hollow shape by means of a punch which causes the blank to flow into the die cavity. The depth of draw may be shallow, moderate or deep. If the depth of the formed cup is up to half of its diameter, the process is called "Shallow drawing". If the depth of the formed cup exceeds the diameter it is termed as "Deep drawing". Parts of various geometries and sizes are made by drawing operation, two extreme examples being bottle caps and automobile panels.

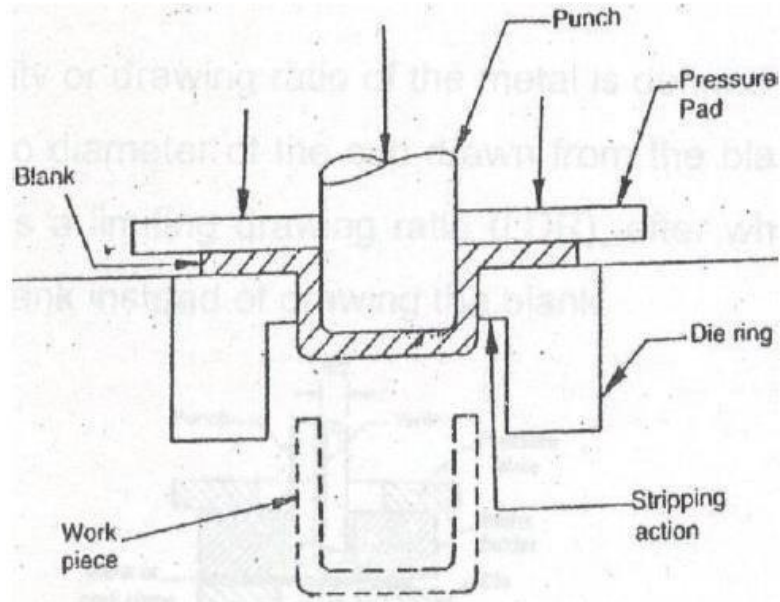


Fig. 4.86. Deep Drawing Operation.

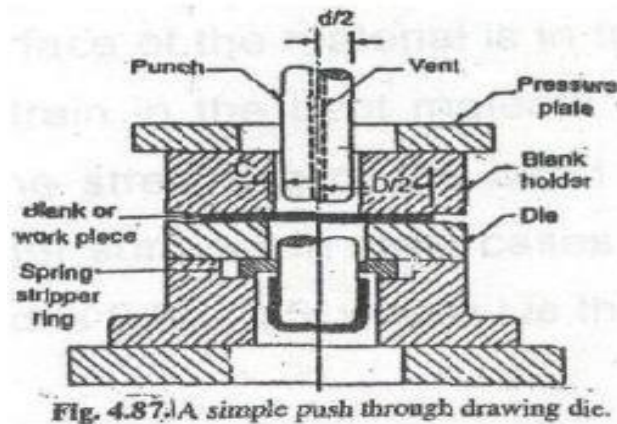
As the drawing progress i.e. as the punch forces the blank into die cavity, the blank diameter decreases and causes the blank to become thicker at its outer portions. This is due to the circumferential compressive stress to which the material element in the outer portions is subjected. If this stress becomes excessive the outer portions of the blank will have the tendency to buckle or wrinkle. To avoid this, a pressure pad or blank holder is provided. The holding down of pressure is obtained by means of springs, rubber pad, compressed air cylinder or the auxiliary ram on a double action press.

The portion of the blank between the die wall and punch is subjected to nearly purely tension and tends to stretch and becomes thinner. The portion of the formed cup which wraps around the punch radius is under tension in the presence of bending. This part becomes the thinnest portion of the cup. This action is termed as 'necking' and in the presence of unsatisfactory drawing operation, is usually the first place to fracture. The outer portions of the blank under the blank holder become thicker during the operation. When these portions are drawn into the die cavity, 'ironing' of this section will occur if the clearance between the punch die is Not enough to accommodate this increased thickness of the work piece. This ironing is useful if uniform thickness of the product is desired after the drawing operation.



### Deep Durability:

Deep drawability or drawing ratio of the metal is defined as the ratio of the max blank diameter to diameter of the cup drawn from the blank, i.e.  $D/d$ . For a given material there is a limiting drawing ratio (LDR), after which the punch will pierce a hole in the blank instead of drawing the blank.



This ratio depends upon many factors, such as material, amount of friction present etc. The usual range of the max drawing ratio is 1.6 to 2.3.

A simple push through drawing die is shown. The drawing punch should be properly vented with drilled passages. Venting serves double purpose it eliminates suction which would hold the cup on the punch and damage the cup when it is stripped from the punch. Secondly, venting provides passages for lubricants. Many presses used for the deep drawing operations are hydraulically operated and these presses have an additional hydraulic cylinder and piston for the additional slide.

Product applications of deep drawing process are: cups, shells, automotive bodies, gas tanks, household hard ware etc.

### Redrawing:

In deep drawing the percentage reduction in one draw is defined as: % reduction =  $\frac{D-d}{D} \times 100$

Now  $D/d = 1.6$  to  $2.3$ ,  $d/D = 0.435$  to  $0.625 = 0.5$  (average) the average reduction in deep drawing =

$$[1-d/D] \times 100 = 50\%$$

To make tall cups of smaller diameter it is necessary to use successive drawing operations. Reducing the drawn cup to the smaller diameter and increased height is known as "redrawing".

**BENDING:**

Bending is the metal working process by which a straight length is transformed in to the curved length. It is a very common forming process for changing sheet and plate into channels, drums, tanks etc. During the bending operation, the outer surface of the material is in tension and the inside surface is in compression. The strain in the bent material increases with decrease in the radius of curvature. The stretching of the bend causes the neutral axis of the section towards the inner surface. In most cases the distance of the neutral axis to the inside of the bend is  $0.3t - 0.5t$  where  $t$  is the thickness of the part.

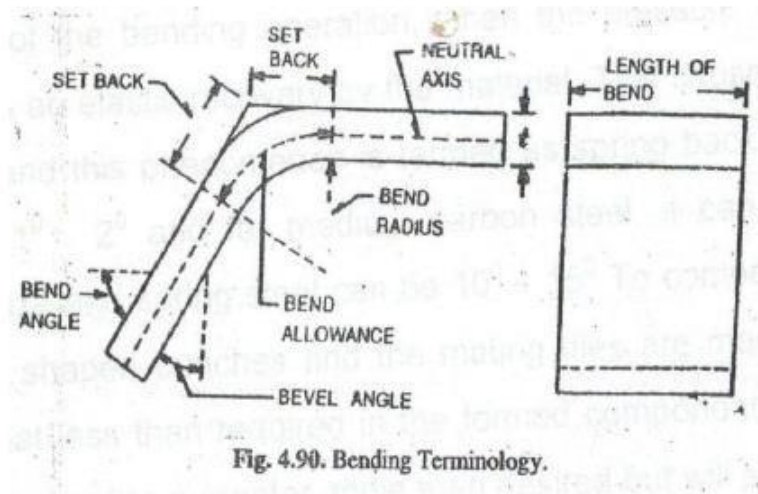


Fig: Bending terminology

**Bending Methods:**

The three bending methods commonly used are V-bending, edge bending, and U bending

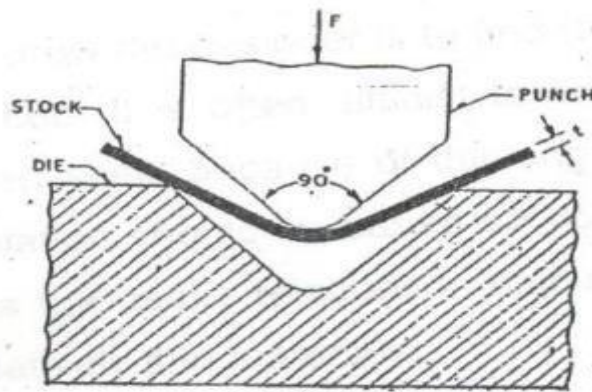


Fig. 4.91. V-Bending.

### V-Bending:

In V bending, a wedge shaped punch forces a metal sheet or strip in to a wedge shaped die cavity .The bend angle may be acute,  $90^0$  or obtuse. As the punch descends the contact forces at the die corner produces a sufficiently large bending moment at punch corner to cause the necessary deformation.

To maintain the deformation to be plane - strain, the side creep of the part during its bending is prevented or reduced by incorporating a spring loaded knurled pin in the die. The friction between pin and the part will achieve this. Plane strain conditions will also be established in the center of the sheet if its width is more than 10 time its thickness.

### Spring Back:

At the end of the bending operation, when the pressure on the metal is released, there is an elastic recovery by the material. This causes a decrease in the bend angle and this phenomenon is termed as spring back For low carbon steel it can be  $1^0 - 2^0$  and for medium carbon steel, it can be  $3^0 - 4^0$  for phosphorus bronze and spring steel can be  $10^0 - 15^0$  To compensate for spring back the wedge shaped punches and the mating dies are made with included angles some what less than required in the formed component. Due to this the component will be bent to a greater angle than desired but will spring back to the desired angle for other types of bending the part is over bent by an angle equal to the spring back angle by having the face of the punch undercut or relieved.

### Blank Size:

One of the first jobs of the draw die designer is to find the size of the blank to be used for making a given cup. It is often difficult to find a blank of exact size required for making a given shell, because

of thinning and thickening of sheet during drawing. The calculation should be based on volume, surface area or by layout. The following gives the useful relations in calculating the blank diameter for cylindrical shells for relatively thin materials.

$D = \sqrt{d^2 + 4dh}$	When $d \geq 20r$
$D = \sqrt{d^2 + 4dh + 0.5r}$	When $15r \leq d \leq 20r$
$D = \sqrt{d^2 + 4dh + r}$	When $10r \leq d \leq 15r$
$D = \sqrt{(d + 2r)^2 + 4d(h + r) + 2r(d + 0.5r)}$	When $d < 10r$

Where  $r$  = corner radius on the punch, mm  $h$  = height of the shell, mm

$d$  = outer diameter of the shell, mm  $D$  = blank diameter, mm

**Drawing Force:**

The drawing force depends on the cup material, its dimensions and the configuration. The drawing force can empirically be calculated using the following equation for cylindrical shells.

—

Where  $P$  = drawing force, N  
 $t$  = thickness of the blank material, mm  
 $s$  = yield strength of the metal, Mpa

$C$  = constant to cover friction and bending. Its value is between 0.6 and 0.7

### **Blank Holding Force:**

The blank holding pressure required depends on the wrinkling tendency of the cup, which is difficult to determine and hence it is obtained more by trial and error. The maximum limit is generally one-third of the drawing force.

### **Material and Equipment Required:**

Aluminium sheet of required size and MS round bar of 25mm diameter. Hydraulic Press, Draw tool and Inclinometer.

### **Procedure:**

#### **Drawing Operation:**

- Fix the punch to the ram of the press.
- Fix the die on the bed of the machine using clamps, bolts and nuts.
- Calculate the required blank size and place the same between the punch and die block.
- Apply the hydraulic pressure on the punch through ram so that the punch slowly descends on the blank and forces it take the cup shape formed by the end of the punch, by the it reaches the bottom of the die.
- When the cup reaches the counter bored portion of the die, the top edge of the cup formed around the punch expands slightly due to spring back.
- Observe the reading of the pressure gauge which directly gives the force required to perform the operation.
- Calculate the drawing force required, to perform the operation using above relations.
- Compare the two readings
- Then move the punch in the return direction so that the cup will be
- Stripped by counter bored portion.

#### **Bending Operation:**

- Fix the wedge shaped punch to the ram of the press.
- Fix the wedge shaped die cavity on the bed of the press using clamps, bolts and nuts.
- Place the MS round bar between the punch and die.
- Apply pressure on the bar by moving the ram in downward direction through the punch.
- As the punch descends, the contact forces at the die corner produce a sufficiently large bending movement at the punch corner to cause the necessary deformation.
- Then the bar will take the shape of die cavity.
- Measure the included angle of the bar using inclinometer and repeat the process until the included angle reaches  $90^{\circ}$ .

### Precautions:

- The die should be properly clamped to the bed of the machine and it is Not disturbed during the process.
- The punch is properly fixed to the ram of the machine.
- The load should be applied uniformly on the bar.
- The bar should be held properly on the die block.

### Observation and Calculation:

1.  $r$  = corner radius on the punch = mm  
 $h$  = height of the shell = mm  
 $d$  = outer diameter of the shell = mm  
 $d/r$  =  
  
then  $D$  = blank diameter = mm
2. Drawing Force = N
3. Blank Holding Force = N

### Result:

### Innovative Questions:

9. What metals are considered for deep drawig?
10. Define blanking and piercing?
11. State the use of tear drop punch.
12. Differentiate punching and blanking?

### Blooms Taxonomy Questions:

S No	Question	Level
1	Define die clearance	2
2	What is blanking operation	3
3	State the use of stop collar	4
4	Differentiate blanking and piercing.	4
5	What are flyweights?	2

## Viva Questions:

1. What is a Die?
2. Which type of m/l are used for manufacturing of Die?
3. Write types of Dies?
4. Write types of operation performed on Die?
5. Write the parts of a Die?
6. What is the function of Stripper plate?
7. Write the types of press tools?
8. In a blanking operation , the clearance is provided on\_\_\_\_\_
9. In a piercing operation the clearance is provided on\_\_\_\_\_
10. Spring back effect is found in\_\_\_\_\_operation
11. In deep drawing the diameter of the specimen should\_\_\_\_\_than length
12. In shallow drawing the diameter of the specimen should\_\_\_\_\_than length
13. What is blanking operation?
14. What is the use of stop collar?
15. Define friction coupling?
16. Fly press is operated by \_\_\_\_\_
17. Purpose of flywheel?
18. \_\_\_\_\_Screw is used in screw press?
19. What are flyweights?
20. Define piercing?
21. Types of presses?
22. What is the use of teardrop punch?
23. What is a die?
24. Define die clearance?
25. What is the use of shear angle in case of piercing?
26. Types of Operations of fly wheel?
27. Name the operation to be performed in order to produce bottle caps?
28. Name the operation to be performed in order to produce glasses?
29. If the dia of the spicemen is greater than height of the spicimen then it is called as – drawing
30. If the dia of the spicemen is less than height of the spicimen then it is called as \_\_\_drawing

## Applications:

### Sheet Metal Applications

Sheet metal is widely used for numerous industrial and non-industrial applications including:

- **Aircraft:** Fuselages, wings, body panels, trim parts, etc.
- **Automotive:** body panels, bumpers, doors, chassis, trim parts, brackets etc.

- **Construction:** roofing, home building and structural applications.
- **Other applications:** appliances, food and beverage containers, boilers, kitchen equipment, office equipment etc.



## Experiment No 11

### Injection Molding

#### Objective:

To make a component (college emblem) by injection molding equipment.

#### Outcome:

Students will be able:

- To understand concept molding and its types
- To differentiate injection and blow molding.
- To make component using the equipment.

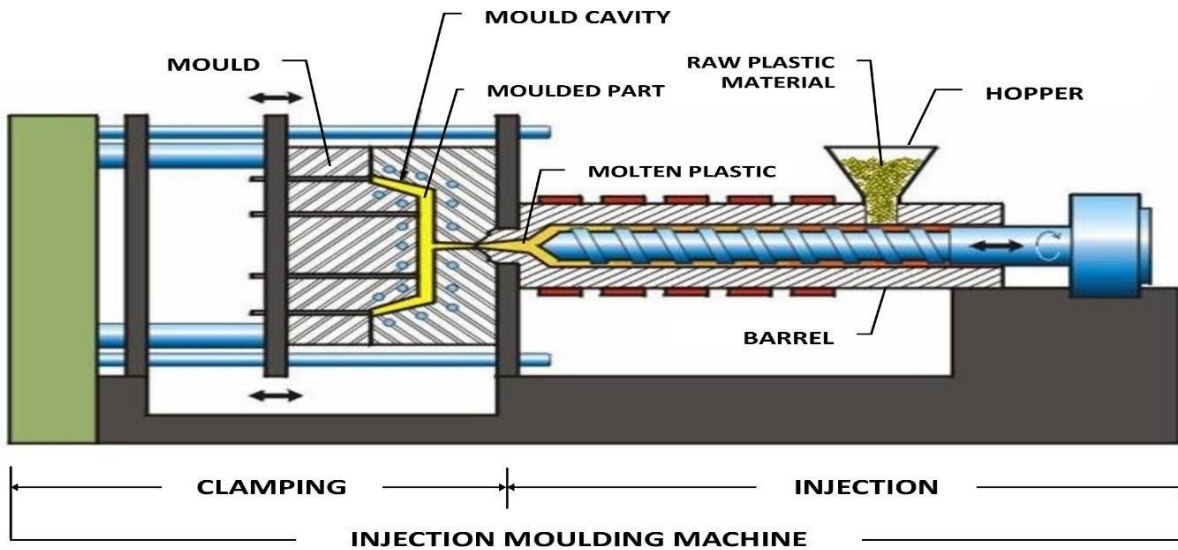
#### Theory:

Injection moulding is the process used for forming thermoplastic materials. The basic process involves six major steps in the moulding cycle.

- ✓ The hopper is loaded granules of plastic materials.
- ✓ Heat is applied to the plastic until it becomes soft to flow
- ✓ The softened plastic is forced through the nozzle into the mould cavity.
- ✓ When cool the halves of mould are separated.
- ✓ The part is ejected from the mould.
- ✓ Gates connecting the product to the runner system are removed.

For injection moulding two most important units are required along with raw material. One is injection moulding machine and the other is injection moulding tool. Commonly named as mould.

Injection moulding machines are made in many sizes. These are rated according to size by the amount of material, which can be injected in one cycle. The re two basic units to an injection moulding machine, one for injecting the heated plastic and one for opening and closing the mould. The first unit includes a feeding hopper, heated injection cylinder and an injection plunger or screw system. The second unit comprises a hydraulic operated moving pattern and a stationary plate on which the halves of mould are mounted. Injection moulding machine are available in horizontal or vertical models. Injection moulds are used in injection moulding consist of two halves, one is stationary and another is movable. The stationary half is directly connected to the stationary pattern directly and is in direct contact with the nozzle of the mould is secured to the movable half of the mould and usually contains the ejector mechanism. There are many possible mould designs, includes multiple piece mould for complicated parts.



**Figure shows: Injection Moulding Machine**



**Figure Shows: Products produced from Injection Moulding**

**Material and Tools required:**

Injection Moulding, plastic Granules.

## Description of Equipment:

Injection moulding is usually employed for thermo plastic materials, which are soft, end by heating and then re-harden during cooling. The moulding material (thermoplastic) is fully polymerized before pouring into the mould since they undergo only a physical change during injection moulding. In injection moulding the material is heated to the soften state and then the soft material is injected into the mould and then allowed to cool to harden there by the desired article is obtained.

Fig.1.1 shows the injection moulding method for thermo plastic material. The mould, is used, consists of two parts one is movable and other is stationary. The stationary part is fixed to the end of the cylinder while the movable part is opened or locked and to the stationary part. A device called torpedo helps in spreading the moulding material uniformly around the walls of the cylinder thereby ensures uniform heat distribution. Heating unit temperatures usually ranges from 150° C to 300°C and injection pressure ranges from 30 Kg/cm<sup>2</sup> to 40 Kg/cm<sup>2</sup>.and clamping pressure ranges from 45Kg/cm<sup>2</sup> to 50 Kg/cm<sup>2</sup>.

The advantage of injection moulding is that mass production is possible which offset the higher capital cost.



### **Poly propylene plastic granules used in Injection Molding**

#### Procedure:

- The moulding material in the form of granules is fed through the hopper to the cylinder where it gets softened.
- Now mould is to be closed tightly and plunger is to be moved forward by applying pressure to push and inject the soften material through the nozzle into the mould.
- The mould is allowed to cool and hardened.
- After hardening the plunger to be returned backwards.
- Now mould is to be opened to eject the plastic article.

### Precautions:

- Allow sufficient time to harden the material before the object is removed from the mould.
- Keep the heat unit temperature ranges from 150°C to 300°C.
- Ensure that the injection pressure is to be between 100 N/mm<sup>2</sup> to 150 N/mm<sup>2</sup>.

### Innovative Questions:

13. What plastics are moulded in Injection Moulding?
14. What are the Advantages in Injection Moulding?
15. State few applications of Injection Moulding?
16. Differentiate Injection and Blow Moulding?

### Blooms Taxonomy Questions:

S No	Question	Level
1	State the principle used in Injection Moulding	2
2	List out the types of Plastics used Injection Moulding	5
3	What plastics are recyclable?	3
4	Differentiate Injection and Blow Moulding	2
5	Write advantages of Injection over Blow Moulding	3

### Viva Questions:

1. What are the advantages of injection moulding?
2. State the difference between thermoplastics and thermosetting plastics.
3. Write the applications of injection moulding.
4. Can we use injection moulding for thermosetting plastics?
5. What is the main constituent of the plastics?
6. Write types of plastic materials?
7. What are the advantages of plastic materials?
8. What are the limitations of the plastic materials?
9. Write parts of injection moulding machine?
10. What is the melting point of the plastic?
11. \_\_\_\_\_ moulding is suitable for the thermosetting plastics
12. The material used to prepare a die is \_\_\_\_\_
13. Types of plastic moulding are \_\_\_\_\_, \_\_\_\_\_, \_\_\_\_\_.
14. Define plastic?

15. What is polymerization?
16. How are plastics extruded?
17. What kind of substances are added to plastic resins?
18. State the purpose of adding substances?
19. What are the advantages of plastics over other materials?
20. How is injection moulding done?
21. What are the limitations of injection moulding?
22. What are the steps involved in injection moulding?
23. Select suitable raw material for any common plastic components.
24. Select suitable manufacturing process for any common plastic components.
25. State the advantages of plastics compared to metals as engineering materials.
26. State the limitations of plastics compared to metals as engineering materials.
27. Give the examples of thermosetting plastics.
28. Give the examples of thermoplastics.
29. What is calendaring?
30. What is thermoforming?

### Applications:

1. It is used in making parts of complex threads. Intricate shapes such as thin walled parts can be produced.
2. Typical parts such as cups, containers, tool handles, toys, knobs and plumbing fittings can be produced.
3. Electrical and communication components such as telephone receivers can be produced.

#### Materials produced by injection moulding

- Bottle caps.
- Automotive parts.
- Toys.
- Pocket comb.
- Musical instruments and parts.
- Storage container.
- Mechanical parts.

## Experiment No 12

### Blow Moulding

#### Objective:

To make a component (bottle) using blow molding equipment.

#### Outcome:

Students will be able:

- To understand concept molding and its types
- To differentiate injection and blow molding.
- To make component using the equipment.

#### Theory:

The process principle comes from the idea of glassblowing. Enoch Ferngren and William Kopitke produced a blow molding machine and sold it to Hartford Empire Company in 1938. This was the beginning of the commercial blow molding process. During the 1940s the variety and number of products was still very limited and therefore blow molding did not take off until later. Once the variety and production rates went up the number of products created soon followed.

The technical mechanisms needed to produce hollow bodied work pieces using the blowing technique were established very early on. Because glass is very breakable, after the introduction of plastic, plastic was being used to replace glass in some cases. The first mass production of plastic bottles was done in America in 1939. Germany started using this technology a little bit later, but is currently one of the leading manufacturers of blow molding machines.

In the United States soft drink industry, the number of plastic containers went from zero in 1977 to ten billion pieces in 1999. Today, an even greater number of products are blown and it is expected to keep increasing.

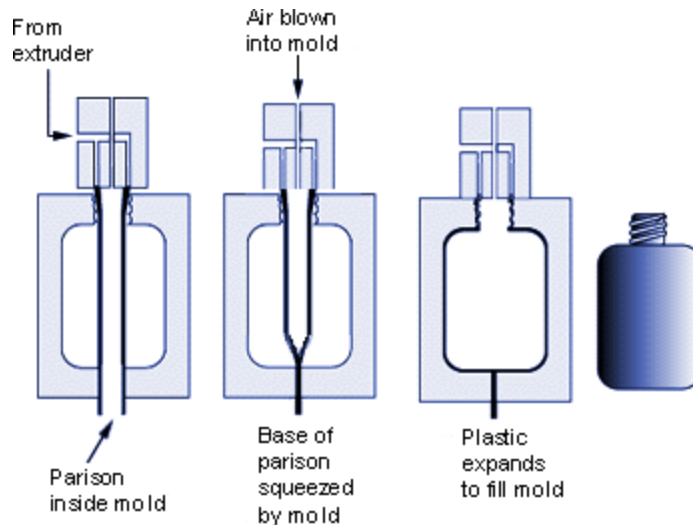
For amorphous metals, also known as bulk metallic glasses, blow molding has been recently demonstrated under pressures and temperatures comparable to plastic blow molding

Blow molding is a manufacturing process that is used to create hollow plastic parts by inflating a heated plastic tube until it fills a mold and forms the desired shape. The raw material in this process is a thermoplastic in the form of small pellets or granules, which is first melted and formed into a hollow tube, called the parison. There are various ways of forming the parison, as explained below. The parison is then clamped between two mold halves and inflated by pressurized air until it conforms to the inner shape of the mold cavity. Typical pressures are 25 to 150 psi, far less than for injection molding. Lastly, after the part has cooled, the mold halves are separated and the part is ejected.

Parts made from blow molding are plastic, hollow, and thin-walled, such as bottles and containers that are available in a variety of shapes and sizes. Small products may include bottles for water, liquid soap, shampoo, motor oil, and milk, while larger containers include plastic drums, tubs, and

storage tanks. Blow molded parts can be formed from a variety of thermoplastic materials, including the following:

- ✓ Low Density Polyethylene (LDPE)
- ✓ High Density Polyethylene (HDPE)
- ✓ Polyethylene Terephthalate (PET)
- ✓ Polypropylene (PP)



### **Material and Tools required:**

Blow Moulding machine, plastic Granules.

### **Description of Equipment:**

Blow moulding is a manufacturing method used in the plastics and polymers industries to create hollow but strong containers. A typical blow moulding machine set-up uses an extruded plastic pre form and compressed air to fill the chamber of a divided moulding. The two halves of the moulding separate and the finished container are released.

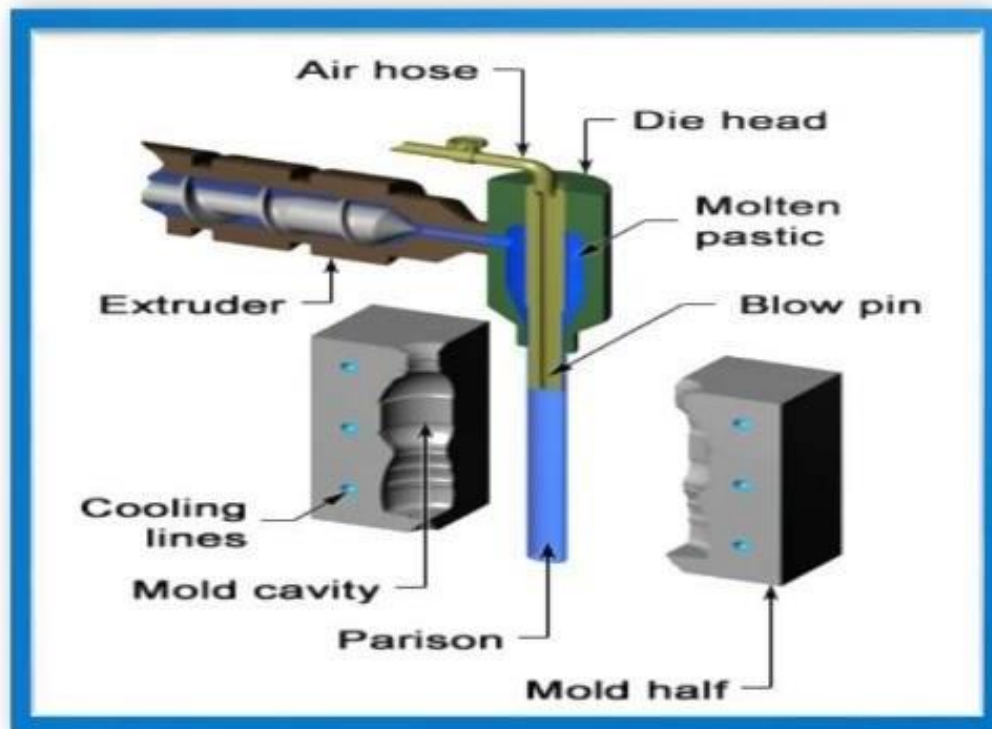
Plastics are actually chains of polymers held together by a strong but fluid bond. The polymer chains in a plastic bottle form in two directions, creating a very strong webbing effect. The plastic itself can be stretched out without sacrificing strength. Blow moulding experts takes advantage of this property to make thin but strong containers.

Blow moulding a bottle requires a preformed piece called a parison. This parison is usually extruded from a plastic injection moulding placed very close to the blow moulding machinery. The

warm parison looks like an upside-down plastic test tube, with a preformed collar and threads for the cap at the bottom. The parison is mechanically loaded onto a stand and two sides of a bottle-shaped metal mould come together around it.

Before the parison cools down, the hot air under pressure (of 3 kg/cm<sup>2</sup> to 4 kg/cm<sup>2</sup>) is blown into the parison, which causes the tube to expand to the walls of the cavity. Because the stretching is performed evenly, the plastic remains uniformly thin and strong. The bottle assumes the shape of the moulding and is dropped out of the blow moulding machine as the two moulding halves separate. A new parison is extruded and the entire blow moulding process begins again. The actual manufacture of a bottle takes only a few seconds.

## COMPONENTS FOR BLOW MOLDING:







**Plastic granules used for blow moulding**



**Products made of blow moulding**

### **Procedure:**

- Set the die in position. Adjust the guide rod nuts to shut height. Align the tapered face of the die for sealing the parison while blowing. Also check for free opening and closing of the die.
- Ensure the required die height.
- Set the injection, release and blow pressure by rotating the regulator knob to suit the requirement of moulding the container.
- Set the required timings to the timer for top middle heater. Set the temperature by adjusting automatic temperature controller to control the bottom heater.
- Required quantity of poly propylene granules fed through the hopper into the cylinder.
- Allow sufficient time to stabilize.
- When the temperature reached, operate the hand lever valve.
- Extrude the parison to the required length and close the two die halves then release the injection pressure.
- Operate the hand lever and blow the air, so that parison to form the shape of container as designed in the die.
- The mould is allowed to cool and hardened.
- Open the die and take the container out of the die.
- Now the machine is ready for next cycle.

### **Precautions:**

- Don't open the die while blowing the air into the container.
- Don't run the machine without the required pressure of air.

- Don't inject, unless plastic material reached the required plasticizing temperature
- Allow sufficient time to harden the material before the object is removed from the mould.
- Keep the bottom heater unit temperature at 350 °C
- Ensure that the release pressure at 2 kg/cm<sup>2</sup>, injection pressure at 4 kg/cm<sup>2</sup> and blowing pressure in the range of 3 kg/cm<sup>2</sup> to 4 kg/cm<sup>2</sup>

### Result:

Bottle produced using blow moulding machine.

### Innovative Questions:

17. What plastics are moulded in Blow Moulding?
18. What are the Advantages of Blow Moulding?
19. State few applications of blow Moulding?
20. Differentiate Injection and Blow Moulding?

### Blooms Taxonomy Questions:

S No	Question	Level
1	State the principle used in Blow Moulding	3
2	List out the types of Plastics used Blow Moulding	4
3	What plastics are recyclable?	2
4	Differentiate Injection and Blow Moulding	5
5	Give the examples of thermoplastics.	3

### Viva Questions:

1. What are the advantages of blow moulding?
2. Write the difference between thermoplastics and thermosetting plastics?
3. Write the applications of blow moulding?
4. What is multilayer blow moulding?
5. What is parison?
6. What is multilayer blow moulding?
7. Which type of parts are produced by using blow moulding?
8. Write parts of blow moulding machine?
9. How much of temperature has to be maintained in the machine?
10. How much of air flow should be in cavity?
11. How much pressure is required for preparing the given bottle\_\_\_\_\_
12. What is the temperature required for melting the plastic\_\_\_\_\_

13. Thermostat is used to \_\_\_\_\_ the temperature
14. If pressure is more what happens to hollow parts \_\_\_\_\_
15. How to regulate the air pressure?
16. Select suitable raw material for any common plastic components.
17. Select suitable manufacturing process for any common plastic components.
18. State the advantages of plastics compared to metals as engineering materials.
19. State the limitations of plastics compared to metals as engineering materials.
20. Give the examples of thermosetting plastics.
21. Give the examples of thermoplastics.
22. What is calendaring?
23. What is thermoforming?
24. What is direct blow moulding?
25. What is indirect blow moulding?
26. What happens when pressure is higher in the process?
27. What is the advantage of higher pressure in blow moulding?
28. Where parison is placed in mould?
29. When we open the die in process?
30. What type of materials are used for making of blow moulding dies?

## Applications:

### Blow moulding Applications:

1. It is used in making plastic bottles and toys.
2. The hollow containers are produced by this process.
3. The multiplayer blow moulding is used in cosmetics and pharmaceutical industries.
  - Milk bottles
  - Pharmaceutical bottles
  - Antifreeze bottles
  - Polypropylene bottles
  - Coliseum seats
  - One-piece chair
  - Ice chests and coolers
  - Double-wall player case
  - Garbage cans
  - Drums
  - Fuel tanks

## ADVANTAGES , DISADVANTAGES AND APPLICATIONS

Process	Advantages	Disadvantages	Examples
Sand	Wide range of metals, sizes, shapes, low cost	poor finish, wide tolerance	engine blocks, cylinder heads
Shell mold	better accuracy, finish, higher production rate	limited part size	connecting rods, gear housings
Expendable pattern	Wide range of metals, sizes, shapes	patterns have low strength	cylinder heads, brake components
Plaster mold	complex shapes, good surface finish	non-ferrous metals, low production rate	prototypes of mechanical parts
Ceramic mold	complex shapes, high accuracy, good finish	small sizes	impellers, injection mold tooling
Investment	complex shapes, excellent finish	small parts, expensive	jewellery
Permanent mold	good finish, low porosity, high production rate	Costly mold, simpler shapes only	gears, gear housings
Die	Excellent dimensional accuracy, high production rate	costly dies, small parts, non-ferrous metals	precision gears, camera bodies, car wheels
Centrifugal	Large cylindrical parts, good quality	Expensive, limited shapes	pipes, boilers, flywheels

## Beyond the lab experiment

### **New Welding Technology Trends for 2022 and beyond**



As technology advances, it often brings additional benefits such as less time wastage, greater productivity, lower costs, improved quality, shorter project timelines, and better finishes. Now in the first half of 2022, predictions for the year are being revealed in the welding industry, including education, professional innovation, and technology. Many benefits are there to be had, but they're often only leveraged by those with an inclination towards innovation. Many will say “don't fix what isn't broken”, but these are the ones who get left behind.

Equipped with this knowledge, here is some insight into the welding technology trends which have already thrived in 2021 as well as a look ahead at what technology appears best placed to

dominate the future.

## **Advanced Arc Welding**

Professional welders know that arc welding is simply the process of using an electric current to fuse two metals together. Heat is generated to melt a filler metal that creates the arc and a successful metallurgic bond. The process involves the use of two or three different metals, giving it great strength, which is why it's critical to aerospace and automotive engineering. Additionally, advanced arc welding is well known for being corrosion resistant, making it perfect for chemical, nuclear, and toxic welding operations.

## **Augmented Reality (AR) and Virtual Reality (VR)**

Welcome to the new generation of welding. Budding welders are now able to leverage augmented reality for training purposes, making the whole experience more visual, attractive, and educational. AR welding also reduces the cost of consumables, moderates risk, and allows educators to train more new welders simultaneously. It's no wonder it's being used to help fill the welding skill gap

While it is a common misconception that AR and VR are the same, there are some important distinctions between VR Welding and AR Welding. Virtual Reality brings the user to a 100% computer-generated world and provides an environment where one can pretend to weld. The experience is similar to that of a video game. Augmented Reality allows the user to enter a real environment, touch and feel a real-life item and “augment” that item into a new shape, realistically changing its appearance.

In the case of Welding, AR allows a welding student to take a plastic-based piece and interact with it while it behaves as a Carbon Steel, Stainless Steel, Aluminum piece would when it is welded. Also, Augmented Reality welding is the closest to reality experience, allowing welding trainees to see and to feel a real-world welding environment using real welding equipment, such as a real welding mask and real welding torches, enhancing the experience and learning

process.

## **Robotic Welding**

Is it possible to talk about future technologies without discussing robotics? Of course not. When the term ‘robotic welding’ is used, it is not talking about a blowtorch used by one of Tesla’s recently announced humanoid robots, but rather the need for Industry 4.0 technology advancement. Industry 4.0, or the 4th industrial revolution, is about changing the way manufacturing production is automated through the use of smart technologies to create a more resilient supply chain and a circular economy.

With the use of machine learning, computer vision, sensors, robotics, cloud computing, and the 5G network, the bar has been raised completely regarding the capability of programmed welding. Advanced technologies, as well as the growth of the Internet of Things (IoT), will see interconnectivity and smart technologies on scales that are yet to be fathomed. For the welding industry, this means better data, flexible manufacturing, near-perfect quality, and more accurate reporting and documentation.

Robotics has been linked to welding for some time now, and Global Robotic Welding is already expected to be valued in \$10B by 2026, with manufacturing industrial robots experiencing an 80% growth.

## **Tailored Welding Training**

Retraining welders is a crucial task for industrial companies that rely on professional, experienced welders for their manufacturing. It is extremely important to keep them up-to-date on the latest trends and as well as to ensure that they understand the advancements relevant to their specific tasks. Companies not only need experienced welders, they need welders who know how to perform specific welds required for their industry and products.

This is critical for companies due to the cost of welding errors both consumable and productivity expenses. New technologies such as Augmented Reality and 3D printing have

tackled this issue directly. It is now possible to replicate specific Welding joints with all their requirements in Augmented Reality, so welders can train on industry-specific tasks before moving on to the real deal.

## **Laser Welding**

Laser Beam welding (LBW) is a style of welding that utilizes a concentrated heat source which creates a narrow, deep weld; it is very penetrative. LBW is an innovative method that eliminates the need for filler materials and allows the materials being welded to have a superior bond. The process allows for conduction, conduction-penetration, and keyhole welds to be performed. Laser welding is also a non-contact process, with the concentrated energy from the laser allowing the metal to heat faster in a pre-programmed route.

Laser welding allows engineering companies greater flexibility with thinner, high-alloy metals due to its accuracy and finish quality, making it perfect for electronics and, even jewelry. There are some challenges and limitations in Laser Welding, however, welding thick metals for example. The amount of energy required in a lab setting is thought to be as much as 100kW, which can weld 50mm in a single pass. However, typically the power generated is much lower. This process requires experienced, trained welders as well as continued research, development, and training.