# LUKHDHIRJI ENGINEERING COLLEGE-MORBI

# MANUFACTURING TECHNOLOGY (3151912)

**2021_22**

## LAB MANUAL

**STUDENT NAME :**____________________________

**ENROLL NO. :**____________________________

**BRANCH :**____________________________

**BATCH :**____________________________

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**Vision:** To deliver quality engineering education for Mechanical Engineers with Professional competency, Human values and Acceptability in the society.

**Mission:**

- To nurture engineers with basic and advance mechanical engineering concepts.
- To impart Techno-Managerial skill in students to meet global engineering challenges.
- To create ethical engineers who can contribute for sustainable development of society.

# LUKHDHIRJI ENGINEERING COLLEGE-MORBI

## Vision of the Institute

To provide quality engineering education and transforming students into professionally competent and socially responsible human beings.

## Mission of the Institute

- To provide a platform for basic and advanced engineering knowledge to meet global challenges
- To impart state-of-art know- how with managerial and technical skills
- To create a sustainable society through ethical and accountable engineering practices

## MECHANICAL ENGINEERING DEPARTMENT

### Vision of the Department

To deliver quality engineering education for Mechanical Engineers with Professional competency, Human values and Acceptability in the society.

### Mission of the Department

- To nurture engineers with basic and advance mechanical engineering concepts
- To impart Techno-Managerial skill in students to meet global engineering challenges
- To create ethical engineers who can contribute for sustainable development of society

### Program Educational Objectives (PEOs)

Mechanical Engineering graduates will be able to,

1. Apply the knowledge of basic science and engineering to analyze and solve problems related to mechanical engineering.
2. Design and develop the new system/process using advanced tools and technologies.
3. Enhance professional practice to meet global challenges with ethical and social responsibility.

### Program Specific Outcomes (PSOs)

1. Students will be able to apply the knowledge of computer aided tools for design and development of products based on engineering principles.
2. Students will be able to manage production of components/systems using conventional and advanced manufacturing methods.

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# CERTIFICATE

This is to certify that Mr. / Ms. _________________________________ Enrollment no. _______________of 5th semester Bachelor of _______ ___________Engineering has completed the term work satisfactorily in Manufacturing Technology (3151912) for the academic year __________as prescribed in the GTU curriculum.

Place:________ Date:________

**Subject faculty** **Head of Department**

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**GENERAL INSTRUCTIONS:**

1. Every student should obtain a copy of Manufacturing Technology Laboratory Manual.

2. Dress Code: Students must come to the laboratory wearing (i) Trousers, (ii) half-sleeve tops and (iii) Leather shoes. Half pants, loosely hanging garments and slippers are not allowed.

3. To avoid injury, the student must take the permission of the laboratory staff before handling any machine.

4. Students must ensure that their work areas are clean and dry to avoid slipping.

5. A leather apron will be issued to each student during Welding Exercise. Students not wearing the apron will not be permitted to work in the laboratory. Students are required to clear off all tools and materials from machine/work place.

6. At the end of each experiment, students must clear off all tools and materials from the work area.

7. Each group submits one lab report if the experiment was performed in a group. For individual experiments separate lab reports should be submitted.

8. The Lab report should only contain: (1) Title of the experiment, (ii) Three to four lines stating the objectives, (iii) Name of all equipments/tools used along with a one line description of its use, and (iv) Answer to questions specifically asked in the section "Report the following." The report should be short and sweet.

9. Laboratory report will not be returned. However, student can check their graded report by contacting their respective tutors.

10.Careless handling of machines may result in serious injury.

# List of Experiments

| Sr. No. | Title | Start Date | End Date | Sign | Remark |
|---|---|---|---|---|---|
| 1 | Laboratory Exercise-I Mold making and Casting | | | | |
| 2 | Laboratory Exercise-II Forging | | | | |
| 3 | Laboratory Exercise-III Sheet Metal Forming | | | | |
| 4 | Laboratory Exercise-IV Arc Welding | | | | |
| 5 | Laboratory Exercise-V Gas welding & Brazing | | | | |
| 6 | Laboratory Exercise-VI Study of types of weld joints. | | | | |
| 7 | Laboratory Exercise-VII Study of Investment casting Process | | | | |
| 8 | Laboratory Exercise-VIII Study of Injection moulding process. | | | | |

## LABORATORY EXERCISE I
## MOLD MAKING & CASTING

**Objective**

1. To prepare a pattern for given object for sand casting.
2. To prepare a molasses sand mold from the prepared pattern.
3. To melt and pour iron metal into the mold.

**Equipment and Materials**

Pattern, core box, molding flasks, molding tools, sand muller, riddle, sand, molasses, bentonite, core baking oven, thermocole, melting furnace, fluxes, pouring ladle, pyrometer, hacksaw, file.

**Procedure**

**Core making**

(i) Prepare the core sand
(ii) Assemble (clamp) the core-box after applying some parting sand
(iii) Fill the core box cavity with core sand and ram it
(iv) Make vent holes or insert reinforcing wire as desired
(v) Tap the mold box on all sides to loosen the core from the box, unclamp the core box and carefully transfer the core on to a baking plate or stand.
(vi) Keep the core in the baking oven and bake it for desired length of the time at a predetermined temperature. After baking take the core out of the oven and allow it to cool at room temperature.

**Mold Making**

(i) Place the drag part of the pattern with parting surface down on ground or molding board at the center of the drag (flask).
(ii) Riddle molding sand to a depth of about 2 cm in the drag and pack this sand carefully around the pattern with fingers.
(iii) Heap more molding sand in the drag and ram with rammer carefully.
(iv) Strike off the excess sand using strike bar.
(v) Make vent holes to within 1 cm of the pattern surface in the drag.
(vi) Turn this complete drag and place the cope portion (flask) over it.
(vii) Place the cope half of the pattern over the drag pattern matching the guide pins and apply parting sand over the parting surface. Also place the sprue pin and riser pin in proper positions.
(viii) Complete the cope half by repeating steps (ii) to (v).
(ix) Remove the sprue and riser pins and make a pouring basin. Separate the cope and drag halves, and place them with their parting faces up.
(x) Moisten sand at the copes of the pattern and remove pattern halves carefully using draw spikes.
(xi) Cut gate and runner in the drag. Repair and clean the cavities in the two mold halves.

(xii) Place the core in position, assembled the two mold halves assemble and clamp them together.

**Melting and Pouring**

(i) Melt the metal in the furnace. Use appropriate fluxes at proper stages and measure metal temperature from time to time.

(ii) Pour the molten metal into the pouring ladle at a higher temperature (say 100$^{o}$C higher) than the pouring temperature. As soon as the desired pouring temperature is reached, pour the liquid metal into the mold in a steady stream with ladle close to the pouring basin of the mold. Do not allow any dross or slag to go in.

(iii) Allow sufficient time for the metal to solidify in the mold. Break the mold carefully and remove the casting.

(iv) Cut-off the riser and gating system from the casting and clean it for any sand etc.

(v) Inspect the casting visually and record any surface and dimensional defects observed.

**Report The Following**

1. Sketches of the product made, pattern and core.
2. Composition of molding sand and core sand used.
3. Melting and pouring temperature of the used metal.
4. List the allowances that are generally provided on a pattern.
5. Type, amount and manner of addition of fluxes, if any used.
6. Defects produced in your casting.

## LABORATORY EXERCISE II
## FORGING

### Objective

To manufacture a small object using hot forging technique.
Report the observations during the cold forging of given metal pieces.

### Equipment & materials
Forge hearth, tongs, anvil, sledge, flatter hammer, steel rod.

### Procedure
- Take a steel rod of about 25 mm dia and about 75 mm long.
- Take piece weight before the heating.
- Place it in the hearth and heat it upto 1150ºC (yellow hot).
- Remove it from the hearth and hammer it to square shape
- Grind the head and sharpen the edge
- Weigh the final object.

**Report The Following**

(i) Sketches depicting each major step in processing.
(ii) Give the weight loss during the hot forging in your object.
(iii) Problems associated with heating of steel prior to forging.
(iv) Applications of the open die cold forging.
(v) Precautions to be taken.

## LABORATORY EXERCISE III
## SHEET METAL FORMING

**Objective**

(i) To prepare a sheet metal product (square container).
(ii) Report the various parameters for the various passes during the rolling of the given metal piece.

**Equipment & material**

Mallet, hand shear, bench shear, grooving and riveting tool, metal sheet, soldering equipment.

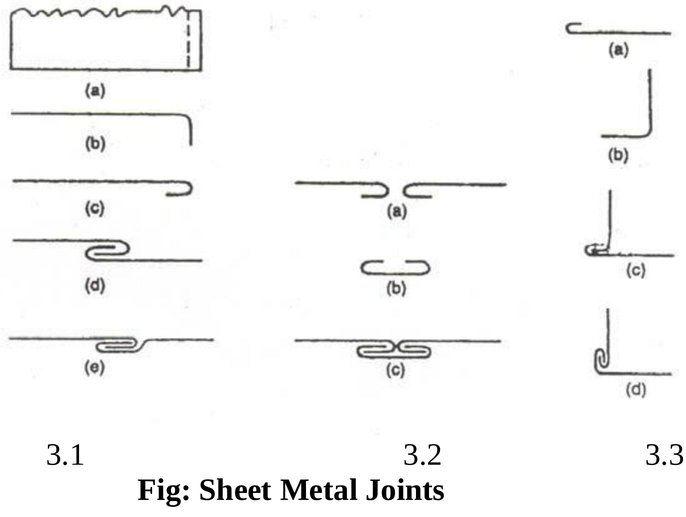
**Demonstration**

Self secured sheet metal joints

(a) Internal grooved joint
- Mark out portions of given sheets near edges to be joined with a marker (Fig. 3.1a)
- Fold the sheets at edges in the portion marked, first at right angles to the plane of the sheet (Fig. 8.1b) and then at 180$^o$ to the plane (Fig.3.1c)
- Insert one folded sheet into the other (Fig. 3.1d)
- Groove the seam using grooving die (Fig. 3.1e)

(b) Double grooved joint
- Fold sheets after making them as per the instructions given (Fig. 3.2a)
- Cut a piece of sheet (called strap) of required width
- Strap width = (4x size of marked edges) + (4 x thickness of sheet)
- Close the edges of the strap slightly as shown in Fig. 3.2(b)
- Slip the strap on the bent edges of the sheets after bringing them together (Fig. 3.2c)

(c) Knocked-up joint
- Fold one sheet and close edges slightly (Fig. 3.3a)
- Bend one sheet to form a right angles band (Fig. 3.3b)
- Slip the second sheet in the folded one (Fig. 3.3c)
- Close the right angled sheet using a mallet (Fig. 3.3d)




3.1 3.2 3.3

**Fig: Sheet Metal Joints**

Procedure for Square Container:

- Cut a sheet of 120 mm x 120 mm, and mark a center of 60 mm x 60 mm to indicate bend lines.
- Mark bending lines of 4 mm and 6 mm on outer edge of square sheet as shown in figure
- Join the diagonals and mark $15^0$ from corners of inner square (60 x 60 mm) …i.e. $7.5^0$ on the either side of the diagonals
- Mark the intersection of $15^0$ line with 10mm outside bending line, mark a $60^0$ to the bending line (for all four corners, or eight times).
- From $60^0$ intersecting line at 4mm from outer edge, now mark $172.5^0$ to bending line (for all four corners, or eight times).
- Now remove the corner portions
    a. i.e. $60^0$ till 6 mm (from inner corner edge towards outside edge),and then
    b. $172.5^0$ for last 4 mm till outer edge.
- Fold the sides of container (try avoiding waviness)
- Seam the edges at all corners and make sure it is leak proof

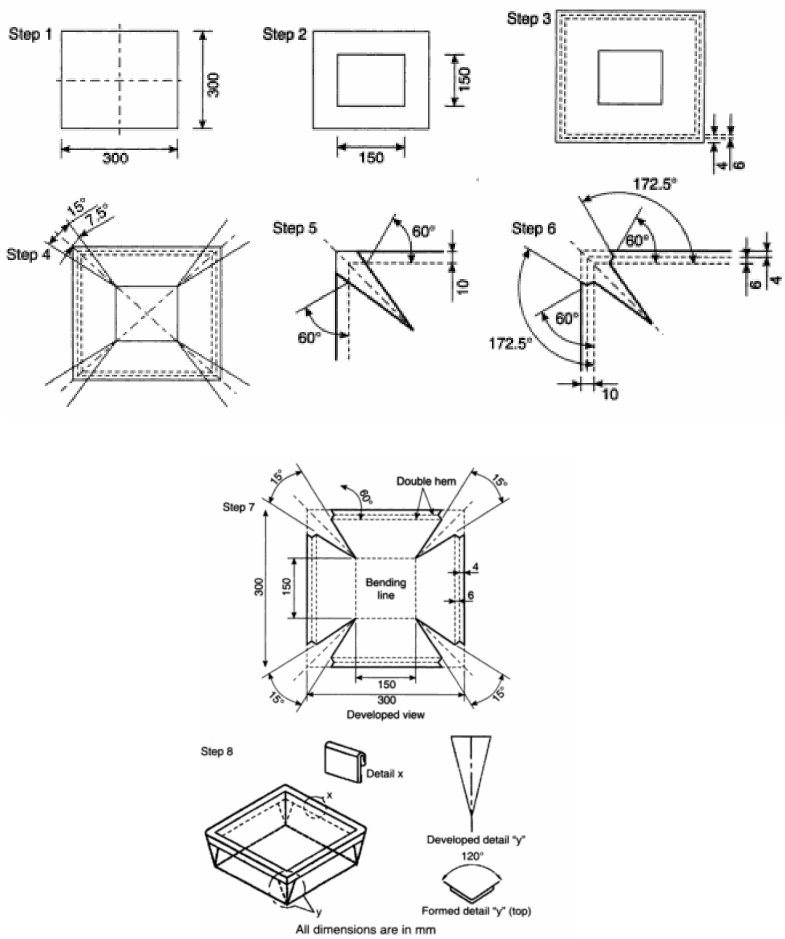


**Fig. 2: Sheet metal forming of square container**

## Report the following

1. Precautions to be taken during sheet metal working
2. Name the processes used in soldering with description.
3. Composition of Solder alloy.
4. Draw the sketches showing the principle of the development of the job as shown in the sheet metal forming demonstration.
5. What are the machines used in the shearing and bending operation

## LABORATORY EXERCISE IV
## ARC WELDING

**Objective**

To prepare a butt joint with mild steel strip using GMAW & MMAW technique.

**Equipment and materials**

Welding unit, consumable mild steel wire, mild steel flats (140 x 25 x 5 mm), protecting gas, Wire Brush, Tongs etc.

**Procedure**

- Clean the mild steel flats to be joined by wire brush
- Arrange the flat pieces properly providing the gap for full penetration for butt joint (gap ½ thicknesses of flats).
- Practice striking of arc, speed and arc length control
- Set the welding current, voltage according to the type of metal to be joined.
- Strike the arc and make tacks at the both ends to hold the metal pieces together during the welding process
- Lay beads along the joint maintaining proper speed and arc length (Speed 100-150 mm/min).
- Clean the welded zone and submit.

**Report the following**

1. Precautions to be taken during various arc welding processes.
2. Advantages of GMAW over MMAW.
3. Difference between consumable and non-consumable arc welding.
4. Limitations of arc welding.
5. What is the procedure of ultrasonic welding?
6. Is there any difference between resistance and ultrasonic welding?

## LABORATORY EXERCISE V
## GAS WELDING & BRAZING

**Objective**

To prepare a butt joint with mild steel strips using brazing technique.

**Equipment & materials**

Gas welding set, brazing wire, gas-welding wire, fluxes, mild steel strips(140 x 25 x 3 mm), wire brush, tongs etc.

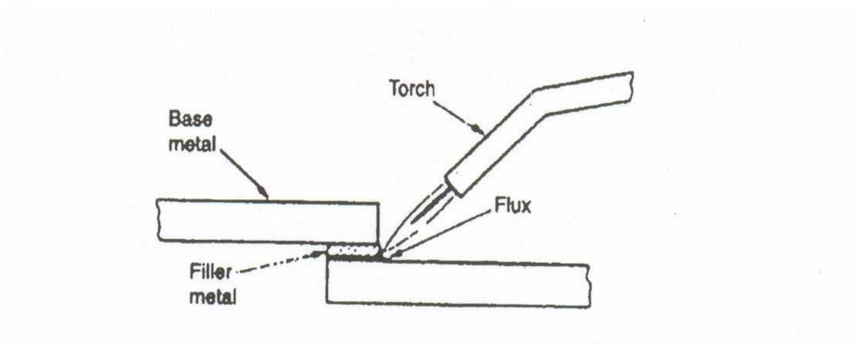



**Fig: Brazing**

**Procedure**

**Brazing**

- Clean the mild steel strip removing the oxide layer and flatten it.
- Keep the metal strip in lap position.
- Tack at the two ends.
- Lay brazing metal at the joint maintaining proper speed and feed.
- Clean the joint and submit

**Gas Welding**

- Clean the mild steel strip removing the oxide layer and flatten it.
- Keep the metal strip in butt position.
- Tack at the two ends.
- Deposit filler metal at the joint maintaining proper speed and feed.
- Clean the joint and submit

**Report the following**

1. Nature of flame used in brazing and gas welding.
2. Composition of the filler rod used in brazing and gas welding.
3. Composition of flux used in brazing and its role.
4. Precautions to be taken during brazing and gas welding.
5. Limitation of gas welding and Brazing

## LABORATORY EXERCISE VI
## STUDY OF TYPES OF WELD JOINTS

**Objective**

To do practice of different types of weld joints.

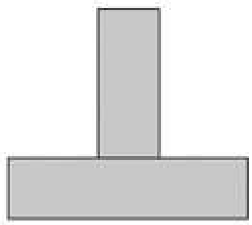
**Introduction**

The first arc welding method was developed in the 19th century, and it has become commercially significant within shipbuilding throughout the 2nd-World War. Nowadays it remains a significant process for the vehicles as well as steel structures fabrication. This is one of the famous welding methods which are used for joining metals in industries. In this type of welding, the joint can be formed by melting the metal with the help of electricity. So due to this reason, it is named as an electric arc. The main benefit of this welding is a high-temperature can be easily developed for welding. A metal joining method in which the joining edges are heated and fused together with or without filler metal to form a permanent (homogeneous) bond is known as welding. or in other words, “Welding is a process of joining two or more pieces of the same or dissimilar materials to achieve complete coalescence. This is the only method of developing monolithic structures and it is often accomplished by the use of heat and/or pressure.

**Types of Welding Joints**

Different jobs need different types of welds. Different types of welding joints are made to stand up to the needs and forces of each individual application. The experts at Cliff’s Welding have been mastering the art of these welds for over 50 years. With professionals that have a wide variety of experience there really is not job too big or too small. Let’s go over the 5 types of weld joints that we use to get the job done right.

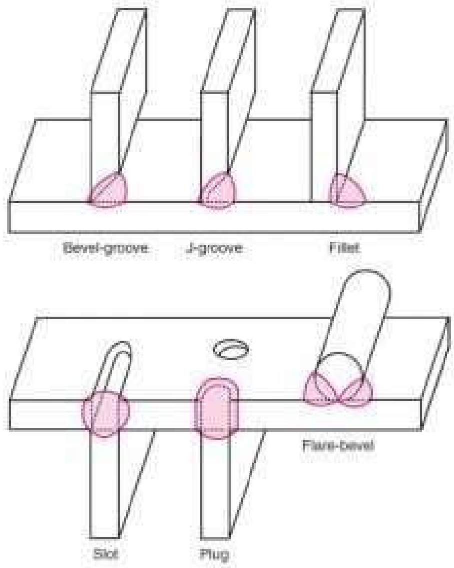
1. **Tee Welding Joint**



Tee Joint

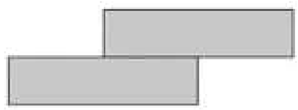
Tee welding joints are formed when two members intersect at a 90° angle which makes the edges come together in the centre of a plate or component. Tee Joints are considered a type of fillet weld, and can also be made when a pipe or tube is welded onto a base plate. Extra care is required to ensure effective penetration into the roof of the weld.

**Welding Styles Used To Create T-Joints**




- Plug weld
- Fillet weld
- Bevel-groove weld
- Slot weld
- Flare-bevel-groove weld
- J-groove weld
- Melt-through weld

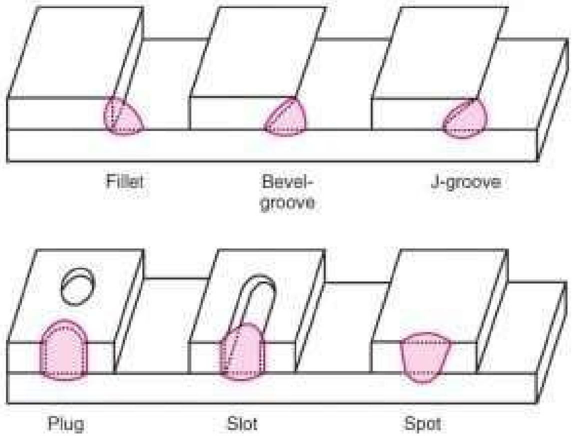
**2. Lap Welding Joint**



**Lap Joint**

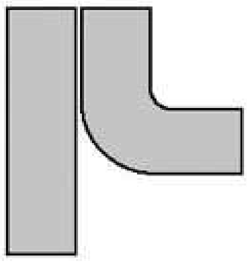
Lap welding joints are used most often to joint two pieces with differing thicknesses together. Also considered a fillet type, the weld can be made on one or both sides. A Lap Joint is formed when 2 pieces are placed in an over lapping pattern on top of each other.

**Welding Styles Used To Create Lap Joints:**




- Slot weld
- Plug weld
- Bevel-groove weld
- Spot weld
- Flare-bevel-groove weld
- J-groove weld

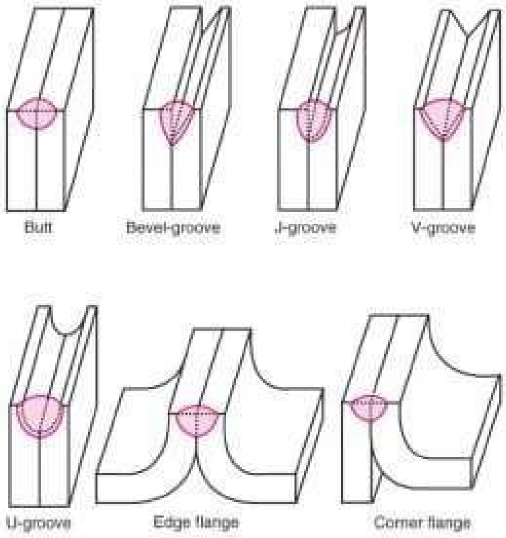
**3. Edge Welding Joint**



**Edge Joint**

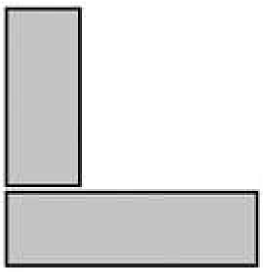
Edge welding Joints are often applied to sheet metal parts that have flanging edges or are placed at a location where a weld must be made to attach to adjacent pieces. Being a groove type weld, Edge Joints, the pieces are set side by side and welded on the same edge. For heavier applications filler metal is added to melt or fuse the edge completely and to reinforce the plate.

**Welding Styles Used To Create Edge Joints:**




- Bevel-groove weld
- Square-groove weld or butt weld
- J-groove weld
- V-groove weld
- Edge-flange weld
- U-groove weld
- Corner-flange weld

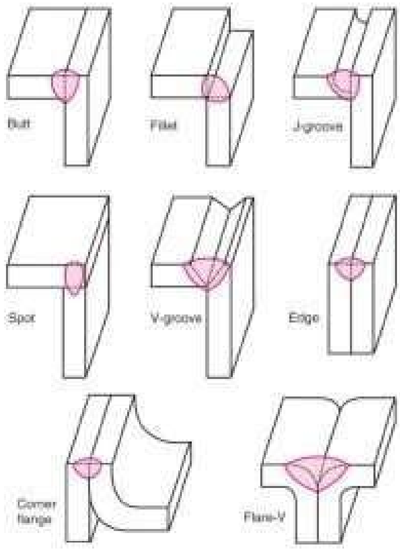
4. **Corner Welding Joint**



**Corner Joint**

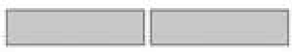
being one of the most popular welds in the sheet metal industry the Corner welding joint is used on the outer edge of the piece. This weld is a type of joint that comes together at right angles between two metal parts to form an L. These are common in the construction of boxes, box frames and similar fabrications.

Welding Styles Used To Create Corner Joints:




- Spot weld
- Fillet weld
- V-groove weld
- Square-groove weld or butt weld
- U-groove weld
- Bevel-groove weld
- Flare-V-groove weld
- J-groove weld
- Corner-flange weld.
- Edge weld

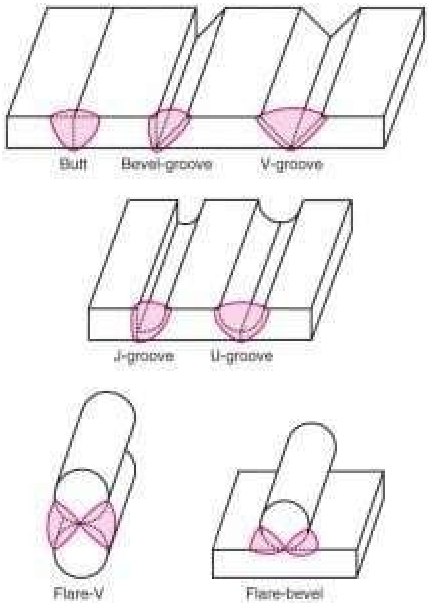
## 5. Butt Welding Joint



Butt Joint

Being the universally accepted method for attaching a pipe to itself it's also used for valves, flanges, fittings, and other equipment. A butt welding joint is also known as a square grove weld. It's the easiest and probably the most common weld there is. It consists of two flat pieces that are side by side parallel. It's a very affordable option.

**Welding Styles Used To Create Butt Joints:**




- Bevel-groove butt weld
- Square-groove butt weld
- V-groove butt weld
- U-groove butt weld
- J-groove butt weld
- Flare-bevel-groove butt weld
- Flare-V-groove butt weld

## 6. Fillet Welded Joints

Fillet Welded Joints are just another terminology for corner, lap, and tee joints. Fillet Welded Joints are the most common type of welding joint and accounts for nearly 75% of joints made with arc welding. You do not need to prepare the edge and this type of joint make it easy to weld piping systems. Butt welds are more expensive than fillet welds. Fillet welds are mostly used in piping systems to join pipe to socket joints.

## LABORATORY EXERCISE VII

## STUDY OF INVESTMENT CASTING PROCESS

**Objective**

Study of Investment casting process.

**Introduction:** Investment casting process is also known as lost-wax process. The term investment refers to a clock or special covering apparel. In investment casting, the clock is a refractory mould which surrounds the pre coated wax pattern. A wax pattern must be made for every casting and gating system also. A wax pattern is invested by liquid mould material which is latter allowed to be set and form a hard layer around the pattern. A mould cavity is then obtained by melting the wax pattern.

The procedural steps in an investment casting process are as follows:

**a. Die making:**

A die for casting the wax pattern is made. These dies can be made by using a metallic master pattern and casting a low melting point alloy around it.

**b. Wax patterns and gating systems:**

Wax patterns and gating systems are produced from the metal dies by injection. Wax is injected into the die at a temperature of 70°C to 80°C and at a pressure of 8 to 150 kg/cm$^2$.

**c. Assembling the wax patterns:**

The wax patterns so made are then attached to wax gates and Sprues already made with the help of heated tool known as hot wire welder. Assembling fixtures are used to minimize the operation time.

**d. Pre coating:**

The wax assembly is dipped into slurry of a refractory coating material. Typical slurry consists of 325 mesh silica flour suspended in ethyl silica solution of suitable viscosity to produce uniform coating.

**e. Investing:**

The coated wax assembly is then invested in the mould. This is done by inverting the wax assembly on a table, surrounding it with a paper lined steel flask and pouring the investment moulding mixture around the pattern. The whole system is then vibrated and then the material settles by gravity and
the mould is then allowed to air-set.

**f. Wax melting:**

The wax is melted out of the hardened mould by heating it in an inverted position at about 200°C. Sometimes, the wax may be reused.

**g. Pouring:**

Prepared moulds are first preheated to a suitable temperature between 540°C to 1 040°C and the metal is gravity poured into the sprue. Air pressure may then be applied to the sprue with force to fill the mould cavity.

**h. Cleaning and inspection:**

After solidification, the casting is vibrated to separate itself from the investment material. The gates, risers, etc. are then chipped off. The castings are then subjected to sand blasting. Then they are inspected through the specified inspection method.


**Steps involved in making investment casting**

**Advantages:**

- Better dimensional accuracy with close tolerances can be achieved.
- Complicated shapes and complex contours can be easily cut.
- Extremely thin sections up to 0.75 mm can be cast.
- Surface finish of the casting is very high.
- Castings are sound and free from defects.

**Limitations:**

- Size of the casting to be made is limited.
- Suitable only for small sized casting.
- Moulds used are single purpose only.
- Cost of investment material is high.
- It is a time-consuming process.

**Applications:**

- Parts for aerospace industry, aircraft engines, frames, fuel systems, etc.
- Parts for food and beverage machinery, computers and data processing equipment, machine tools and accessories.
- Nozzles, buckets, blades, etc. for gas turbines.
- Costume jewellery can be made.

**Report The Following**

1. Enlist ingredients of ceramic slurry used in investment casting process.
2. Why investment casting known as precision casting?
3. Name the common material cast by investment casting process
4. Enlist name of engineering components made by investment casting process.

## LABORATORY EXERCISE VIII
## STUDY OF INJECTION MOULDING PROCESS.

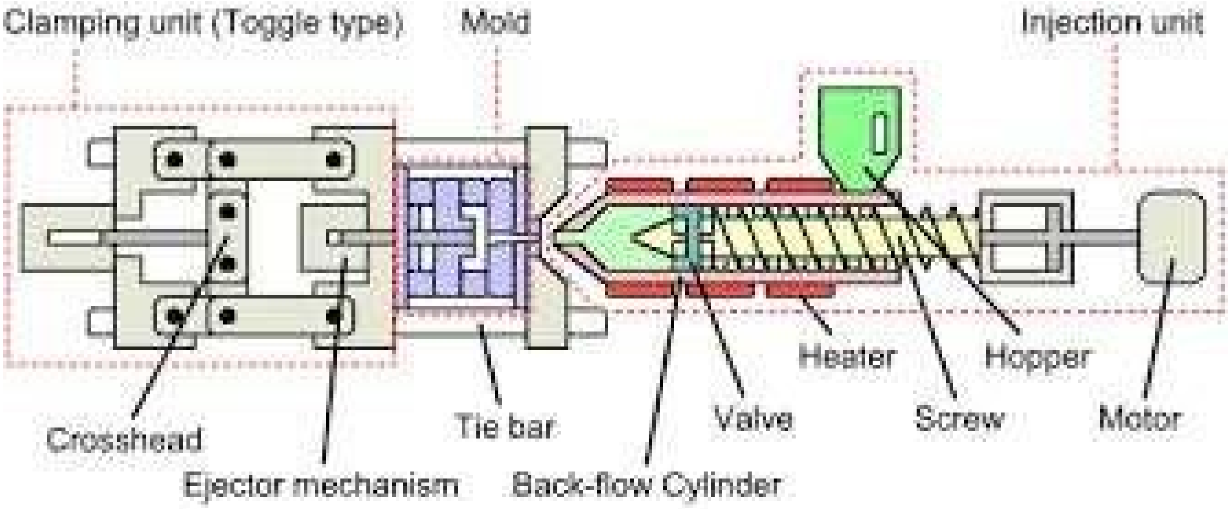
**Objective**

Study of the injection moulding process.

Injection molding is a common processing method for mass producing plastic parts. Plastic granules are heated in a chamber and an exact amount of molten plastic is forced into the mound which is made in two or more sections, held tightly together with a hollow the shape of the finished product inside. Plastic model kits have many parts molded at the one time, the molten plastic being forced from one part to the other through the tiny section which keeps the parts together.

Plastic has, quite literally, become the cornerstone of our society. We make so many things from plastic that it is hard to imagine what our lives would be like if it was never invented. With so many of our everyday products being made of plastic, it is easy to understand why plastic injection molding is such a huge industry.

Approximately 30% of all plastic products are produced using an injection molding process. Of this 30%, a large amount of these products are produced by using custom injection molding technology. Six steps are involved in the injection molding process, after the prototype has been made and approved.




**Injection moulding**

The first step to the injection molding process is the clamping of the mold. This clamping unit is one of three standard parts of the injection machine. They are the mold, the clamping unit and the injection unit. The clamp is what actually holds the mold while the melted plastic is being injected, the mold is held under pressure while the injected plastic is cooling.

Next is the actual injection of the melted plastic. The plastic usually begins this process as pellets that are put into a large hopper. The pellets are then fed to a cylinder; here they are heated until they become molten plastic that is easily forced into the mold. The plastic stays in the mold, where it is being clamped under pressure until it cools.

The next couple of steps consist of the dwelling phase, which is basically making sure that all of the cavities of the mold are filled with the melted plastic. After the dwelling phase, the cooling process begins and continues until the plastic becomes solid inside the form. Finally, the mold is opened and the newly formed plastic part is ejected from its mold. The part is cleaned of any extra plastic from the mold. As with any process, there are advantages and disadvantages associated with plastic injection molding. The advantages outweigh the disadvantages for most companies;

they include being able to keep up high levels of production, being able to replicate a high tolerance level in the products being produced, and lower costs for labor as the bulk of the work is done by machine. Plastic injection molding also has the added benefit of lower scrap costs because the mold is so precisely made. However, the disadvantages can be a deal breaker for smaller companies that would like to utilize plastic injection molding as a way to produce parts. These disadvantages are, that they equipment needed is expensive, therefore, increasing operating cost.

# LUKHDHIRJI ENGINEERING COLLEGE-MORBI

## Vision of the Institute

To provide quality engineering education and transforming students into professionally competent and socially responsible human beings.

## Mission of the Institute

- To provide a platform for basic and advanced engineering knowledge to meet global challenges
- To impart state-of-art know- how with managerial and technical skills
- To create a sustainable society through ethical and accountable engineering practices

## MECHANICAL ENGINEERING DEPARTMENT

### Vision of the Department

To deliver quality engineering education for Mechanical Engineers with Professional competency, Human values and Acceptability in the society.

### Mission of the Department

- To nurture engineers with basic and advance mechanical engineering concepts
- To impart Techno-Managerial skill in students to meet global engineering challenges
- To create ethical engineers who can contribute for sustainable development of society

### Program Educational Objectives (PEOs)

Mechanical Engineering graduates will be able to,

1. Apply the knowledge of basic science and engineering to analyze and solve problems related to mechanical engineering.
2. Design and develop the new system/process using advanced tools and technologies.
3. Enhance professional practice to meet global challenges with ethical and social responsibility.

### Program Specific Outcomes (PSOs)

1. Students will be able to apply the knowledge of computer aided tools for design and development of products based on engineering principles.
2. Students will be able to manage production of components/systems using conventional and advanced manufacturing methods.

**Program Outcomes (POs):**

Engineering Graduates will be able to:

1. Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
2. Problem analysis: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
3. Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
4. 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.
5. Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
6. 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 practice.
7. Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
8. Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
9. Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
10. Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
11. 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.
12. Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.