LENDI INSTITUTE OF ENGINEERING AND TECHNOLOGY

STUDENT MANUAL

MANUFACTURING PROCESSES LAB

B.Tech - Mechanical Engineering

Department of Mechanical Engineering

MANUFACTURING PROCESS

LAB MANUAL

For

MECHANICAL ENGINEERING

DEPARTMENT OF MECHANICAL ENGINEERING

LENDI INSTITUTE OF ENGINEERING AND TECHNOLOGY
An Autonomous Institution
(Approved by A.I.C.T.E & Affiliated to JNTU-GV,
Accredited by NAAC with “A” Grade & NBA)
Jonnada, Denkada(Mandal),Vizianagaram Dist –535005
Phone No. 08922-241111, 24166
E-Mail:lendi_2008@yahoo.comWebsite:www.lendi.org

lendi Institute of Engineering & Technology
An Autonomous Institution
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Via 5th APSP Battalion, Jonnada (V), Denkada (M), NH-3, Vizianagaram Dist - 535005, A.P. Website : www.lendi.org
Ph : 08922-241111, 241666, Cell No : 9490344747, 9490304747,e-mail : lendi_2008@yahoo.com

DEPARTMENTOFMECHANICALENGINEERING

MANUFACTURING PROCESS LAB MANUAL

DEGREE	B.Tech (U.G)
SUBJECTWITH CODE	**MANUFACTURING PROCESS** (R23MEC-PC2205)
REGULATION	R23
PROGRAM	**MECHANICAL ENGINEERING**
YEAR&SEMESTER	II B.TECH II SEM
COURSEAREA/ DOMAIN	MANUFACTURING
CREDITS	1.5

INSTITUTE

VISION

- Producing globally competent and quality technocrats with human values for the holistic needs of industry and society.

MISSION

- Creating an outstanding infrastructure and platform for enhancement of skills, knowledge and behavior of students towards employment and higher studies.

- Providing a healthy environment for research, development and entrepreneurship, to meet the expectations of industry and society.

- Transforming the graduates to contribute to the socio-economic development and welfare of the society through value-based education.

DEPARTMENT OF MECHANICAL ENGINEERING

VISION

Envisions Mechanical Engineers of globally competent and skilled professionals to meet the needs of Industry and society

MISSION

- Providing state of art facilities with inspiring learning environment to develop skill and ethical values of students towards higher studies and employment.
- Creating a conducive environment for technological development, research and entrepreneurship to fulfill the evolving needs of Industry and Society.
- Transforming the graduates to contribute towards wellbeing of society and sustainable development goals turn value based and sustainable engineering education.

PROGRAM EDUCATIONAL OBJECTIVES (PEOs)

PEO1: Graduates Shall have strong knowledge, skills and professional aptitude towards employment, higher studies and research.

PEO2: Graduates shall comprehend latest tools and rapidly changing techniques to analyze, design and develop sustainable systems for real life applications.

PEO3: Graduates shall develop multidisciplinary approach, ethics, good communication, teamwork to became competent technocrats and entrepreneurs.

PROGRAM SPECIFIC OUT COMES (PSOs)

PSO1: Capable of design, develop and implement sustainable mechanical environmental systems.

PSO2: Quality in national and international competitive examinations for successful higher studies and employment.

PROGRAM EDUCATIONAL OBJECTIVES(PEOs)

PEO1: Graduates shall have strong knowledge, skills and attitudes towards employment, higher studies and research.

PEO2: Graduates shall comprehend latest tools and techniques to analyze, design and develop novel systems and products for real life problems.

PEO3: Graduates shall have multidisciplinary approach, professional attitude, ethics, good communication, teamwork and engage in life-long learning to adapt the rapidly changing technologies.

PROGRAM OUTCOMES(POs)

Engineering Graduates will be able to:

PO1: Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

PO2: 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.

PO3: 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.

PO4: 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.

PO5: 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.

PO6: 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.

P07: 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.

PO8: Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

P09: Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

PO10: 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.

PO11: 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.

PO12: 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

PROGRAM SPECIFIC OUTCOMES (PSOs)

PSO1: Capable of design, develop and implement sustainable mechanical and environmental systems.

PSO2: Qualify in national and international competitive examinations for successful higher studies an employment.

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MANUFACTURING PROCESS LAB SYLLABUS

Course Objective:

- Acquire practical knowledge on Metal casting, Welding, Press working and Processing of Plastics

Course Outcomes:

After completion of this lab the student will be able to

1. **Demonstrate** pattern preparation and production of casting with sand casting technique (L3)
2. **Demonstrate** metal forming operations for shaping materials |(L3)
3. **Perform** arc welding, gas welding and brazing operations for joining metals (L3)
4. **Make** the engineering parts with given specifications using 3D printing techniques (L6)
5. **Identify** suitable manufacturing processes for producing components with different materials (L5)

LIST OF EXPERIMENTS

1. Design and making of pattern
   a. Single piece pattern
   b. Split pattern
2. Mould preparation
   a. Straight pipe
   b. Bent pipe
   c. Dumble
3. Gas cutting and welding
4. Manual metal arc welding
   a. Lap joint
   b. Butt joint
5. Injection Molding
6. Blow Molding
7. Simple models using sheet metal operations
8. Study of deep drawing /extrusion operations
9. To make weldments using TIG/MIG welding
10. To weld using Spot welding machine
11. To join using Brazing and Soldering
12. To make simple parts on a 3D printing machine
13. Demonstration of metal casting.

INDEX

16	Demonstration of metal casting.	53	CO1, CO5	PO1, PO2, PO3, PO6, PO7, PO8, PO9, PO10, PO11, PO12.
17	To make simple parts on a 3D printing machine	57	CO4	PO1, PO2, PO3, PO6, PO7, PO8, PO9, PO10, PO12.

COURSEOUTCOMES:

SNO	DESC RIPTI	PO(1..12) MAPPING	PSO(1..2) MAPPING
R23MEC-PC 2205.1	**Demonstrate** pattern preparation and production of casting with sand casting technique (L3)	PO1, PO2, PO3, PO6, PO7, PO8, PO9, PO10, PO11, PO12	PSO1, PSO2
R23MEC-PC 2205.2	**Demonstrate** metal forming operations for shaping materials |(L3)	PO1, PO2, PO3, PO6, PO7, PO8, PO9, PO10, PO12	PSO1, PSO2
R23MEC-PC 2205.3	**Perform** arc welding, gas welding and brazing operations for joining metals (L3)	PO1, PO2, PO3, PO6, PO7, PO8, PO9, PO10, PO11, PO12	PSO1, PSO2
R23MEC-PC 2205.4	**Make** the engineering parts with given specifications using 3D printing techniques (L6)	PO1, PO2, PO3, PO6, PO7, PO8, PO9, PO10, PO12	PSO1
R23MEC-PC 2205.5	**Identify** suitable manufacturing processes for producing components with different materials (L5)	PO1, PO2, PO3, PO6, PO7, PO8, PO9, PO10, PO11, PO12	PSO1, PSO2
COURSEOVERALLPO/PSOMAPPING: PO1, PO2, PO3, PO6, PO7, PO8, PO9, PO10, PO11, PO12, PSO1, PSO2			

COURSE OUT COMES VS Pos MAPPING(DETAILED;HIGH:3;MEDIUM:2;LOW:1**):**

S.NO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO 1	PSO 2
R23MEC-PC 2205.1	3	2	3	-	-	2	2	1	3	2	2	3	3	2
R23MEC-PC 2205.2	3	2	3	-	-	2	2	1	3	2	-	2	3	2
R23MEC-PC 2205.3	3	3	3	-	-	2	2	2	2	3	2	2	3	2
R23MEC-PC 2205.4	3	3	3	-	-	2	2	1	2	3	-	3	2	-
R23MEC-PC 2205.5	3	2	2	-	-	2	1	1	3	3	2	3	3	2
R23MEC-PC 2205*	3	3	3	-	-	2	2	2	3	3	2	2	3	3

*For Entire Course, PO & PSO Mapping

CO vs PO mapping justification

LAB CODE	PO/PSO Mapped	Level of Mapping	JUSTIFICATION
R23MEC-PC 2205.1	PO1	3	Understanding fundamental engineering principles involved in pattern preparation and sand casting.
	PO2	2	Applying problem analysis to choose suitable patterns and mold-making techniques.
	PO3	3	Designing and fabricating patterns for sand casting as part of the manufacturing process.
	PO6	2	Assessing the environmental and safety aspects of foundry processes, such as handling molten metal and reducing material waste.
	PO7	2	Understanding the impact of sustainable manufacturing and resource utilization in casting processes.
	PO8	1	Following ethical practices in material selection and foundry operations.
	PO9	3	Working in teams for mold preparation and casting production tasks.
	PO10	2	Documenting and presenting reports on pattern-making and casting experiments.
	PO11	2	Managing time and resources efficiently while producing quality castings.
	PO12	3	Engaging in lifelong learning by understanding advancements in casting and molding technologies.
	PSO1	3	Gaining the capability to design and implement casting-based mechanical systems.
	PSO2	2	Preparing for competitive exams and higher studies with knowledge of manufacturing techniques.

LAB CODE	PO/PSO Mapped	Level of Mapping	JUSTIFICATION
R23MEC-PC 2205.2	PO1	3	Understanding fundamental engineering concepts related to metal forming operations.
	PO2	2	Applying problem analysis to select appropriate metal forming techniques for different materials.
	PO3	3	Designing and shaping materials using sheet metal operations and extrusion/deep drawing processes.
	PO6	2	Assessing safety and environmental aspects in metal forming, including material wastage and recycling.
	PO7	2	Understanding the impact of sustainable manufacturing in metal shaping techniques.
	PO8	1	Following ethical considerations in material selection and forming processes.
	PO9	3	Working effectively in teams to perform metal forming operations.
	PO10	2	Documenting and presenting reports on metal forming techniques and observations.
	PO12	2	Engaging in lifelong learning by understanding advancements in forming technologies.
	PSO1	3	Gaining the capability to design and implement mechanical systems using forming processes.
	PSO2	2	Preparing for competitive exams and higher studies by understanding different manufacturing processes.

LAB CODE	PO/PSO Mapped	Level of Mapping	JUSTIFICATION
R20MEC-PC3105.3	PO1	3	Understanding fundamental engineering concepts related to arc welding, gas welding, and brazing operations.
	PO2	3	Applying problem analysis to select appropriate welding techniques for different materials and joint configurations.
	PO3	3	Designing and fabricating welded joints using manual metal arc welding (MMAW), TIG/MIG welding, and spot welding.
	PO6	2	Assessing safety and environmental considerations in welding processes, including handling fumes and energy consumption.
	PO7	2	Understanding the impact of sustainable welding practices, such as material optimization and energy-efficient welding methods.
	PO8	2	Following ethical considerations in welding operations, including workplace safety and proper handling of equipment.
	PO9	2	Collaborating effectively in teams to perform different welding and joining operations.
	PO10	3	Documenting and presenting reports on welding techniques, parameters, and observations.
	PO11	2	Applying engineering and management principles to efficiently plan and execute welding projects.
	PO12	2	Engaging in lifelong learning by understanding advancements in welding technologies and automation.
	PSO1	3	Gaining the capability to design and implement mechanical systems involving welded structures.
	PSO2	2	Preparing for competitive exams and higher studies with knowledge of welding processes and joining technologies.

LAB CODE	PO/PSO Mapped	Level of Mapping	JUSTIFICATION
R20MEC-PC3105.4	PO1	3	Understanding fundamental engineering concepts related to 3D printing and additive manufacturing techniques.
	PO2	3	Applying problem analysis to determine suitable 3D printing processes and materials for engineering components.
	PO3	3	Designing and fabricating engineering parts using 3D printing technology with given specifications.
	PO6	2	Assessing safety and environmental concerns related to additive manufacturing, including material usage and waste management.
	PO7	2	Understanding the impact of sustainable manufacturing in reducing material waste and energy consumption through 3D printing.
	PO8	1	Following ethical considerations in the use of 3D printing for engineering applications.
	PO9	2	Collaborating effectively in teams to operate and optimize 3D printing processes.
	PO10	3	Documenting and presenting designs, process parameters, and outcomes of 3D-printed components.
	PO12	3	Engaging in lifelong learning by exploring new advancements in additive manufacturing and digital fabrication.
	PSO1	2	Gaining the capability to design and implement mechanical systems using 3D printing technologies.

LAB CODE	PO/PSO Mapped	Level of Mapping	JUSTIFICATION
R20MEC-PC3105.5	PO1	3	Understanding fundamental manufacturing processes for different materials and their applications.
	PO2	2	Applying problem analysis to select appropriate manufacturing techniques based on material properties.
	PO3	2	Designing components using suitable manufacturing processes, considering material constraints and specifications.
	PO6	2	Assessing safety and environmental concerns in selecting and implementing manufacturing methods.
	PO7	1	Understanding the importance of sustainable production techniques to minimize resource wastage.
	PO8	1	Following ethical considerations in material selection and manufacturing practices.
	PO9	3	Collaborating effectively in teams to analyze, plan, and execute manufacturing tasks.
	PO10	3	Documenting and presenting comparative analyses of different manufacturing methods based on cost, efficiency, and material suitability.
	PO11	2	Applying engineering and management principles to optimize manufacturing efficiency and resource utilization.
	PO12	3	Engaging in lifelong learning by staying updated on emerging manufacturing technologies and advancements.
	PSO1	3	Gaining the capability to design and implement sustainable mechanical systems using modern manufacturing techniques.
	PSO2	2	Preparing for competitive exams and higher studies by acquiring knowledge of various manufacturing processes.

Ex. No:1

Dt: **PREPARATION OF MOLD CAVITY**

AIM: To prepare a mold for a given pattern.

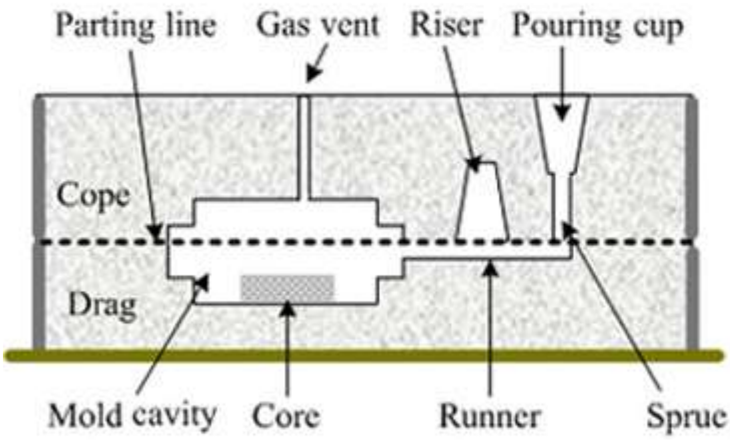
MATERIAL AND EQUIPMENT REQUIRED: Molding sand, Facing sand, Backing sand, Parting sand, Pattern, Cope box, Drag box, Bottom board.

TOOLS REQUIRED: Sprue, Riser, Gate cutter, Trowel, Vent rod, Sleek, Bellow.

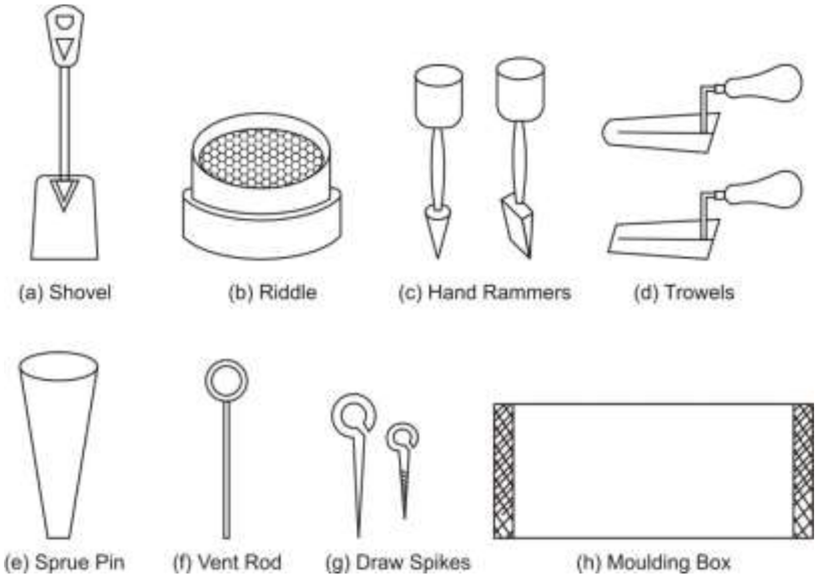
DESCRIPTION:

Preparation of Mold Cavity:

Mold cavity preparation is a crucial step in the casting process, where a cavity is created within a mold to shape molten metal into a desired form. The quality of the final casting largely depends on the accuracy and precision of the mold cavity. This experiment aims to understand the essential steps involved in mold preparation, including pattern making, sand preparation, molding, and cavity finishing.



(A) Mold for a sand casting



(B) Tools used for preparation of a mold

Process of Mold Cavity Preparation

1. Pattern Selection and Preparation:

The first step in mold cavity preparation is selecting an appropriate pattern, which serves as a replica of the final casting. Patterns can be made from wood, metal, plastic, or other materials depending on the complexity and production requirements. The surface of the pattern must be smooth to ensure a good quality mold cavity. If needed, draft angles are provided to facilitate easy removal from the sand.

2. Preparation of Molding Sand:

Molding sand is an essential component for cavity formation. The sand should have good permeability, strength, and cohesiveness. Typically, sand is mixed with binders like clay and water to enhance its properties. Proper conditioning and sieving of the sand help in achieving a uniform texture, which improves the mold quality and reduces casting defects.

3. Mold Making Process:

The molding process involves placing the drag (bottom half of the mold box) on a flat surface. The selected pattern is positioned inside the drag, and fine sand is sprinkled over it to ensure smooth surface finishing. The remaining space is filled with molding sand and compacted to provide adequate strength. Once the drag is ready, the cope (upper part of the mold box) is prepared in a similar manner. Proper compaction prevents defects such as porosity and shrinkage in the casting.

4. Cavity Formation and Gating System:

After compacting the sand, the pattern is carefully removed to create a cavity within the mold. The removal process should be done without disturbing the mold walls to maintain dimensional accuracy. The cavity is then inspected and repaired if any imperfections exist. The gating system, including sprues, runners, and risers, is incorporated to facilitate proper flow of molten metal and avoid defects like turbulence and air entrapment.

5. Mold Finishing and Assembly:

Once the cavity is prepared, a refractory coating may be applied to the inner surface to enhance surface finish and prevent metal penetration. The mold is then dried to remove excess moisture, which helps in reducing steam formation during metal pouring. Finally, the cope and drag are aligned correctly and securely closed to ensure proper assembly before pouring the molten metal.

MOLDING PROCEDURE:

1. First a bottom board is placed either on the molding platform or on the floor, making the surface even.
2. The drag molding flask is kept upside down on the bottom board along with the drag part of the pattern at the Centre of the flask on the board.
3. Dry facing sand is sprinkled over the board and pattern to provide a non-sticky layer.

4. Freshly prepared molding sand of requisite quality is now poured in to the drag and on the pattern to a thickness of 30 to 50 mm.
5. Rest of the drag flask is completely filled with the backup sand and uniformly rammed to compact the sand.
6. 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.
7. Now with a vent wire 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.
8. Now finished drag flask is rolled over to the bottom board exposing the pattern.
9. Using a slick, the edges of sand around the pattern is repaired and cope of the pattern is placed over the drag pattern, aligning it with the help of dowel pins.
10. Dry parting sand is sprinkled all over the drag surface and on the pattern.
11. Sprue of the gating system for making the sprue passage is located at a small distance of about 50mm from the pattern. The sprue base, runners and ingates are also located as shown.
12. The sprue and the riser are carefully withdrawn from the flask.
13. Later the pouring basin is cut near the top of the flask.
14. 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.
15. Now the cope and drag pattern halves are withdrawn by using the draw spikes and rapping the pattern all around to slightly enlarge the mold cavity so that the walls are not spoiled by the withdrawing pattern.
16. The runners and the gates are to be removed or to be cut in the mold carefully without spoiling the mold.
17. The cope is placed back on the drag taking care of the alignment of the two by means of the pins.
18. The mold is ready for pouring molten metal.

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.
3. Pattern should have good surface finish, because finish of the casting depends on the finish of the pattern.

RESULT:

The sand mold is thus made, which is ready for pouring the molten metal.

REVIEW QUESTIONS:

1. What is cope?
2. What is drag?
3. Define sprue?
4. What are the tools used in preparing a mold cavity?
5. Where are the chaplets used?
6. Define riser?
7. What is the necessity of bottom board?
8. Define parting line?
9. What do you mean by chill?

Ex. No:2

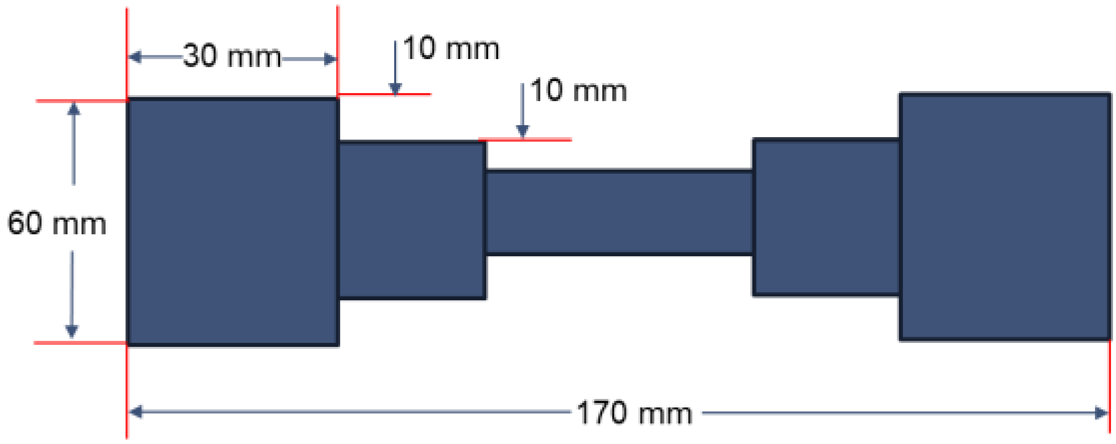
Dt: **MOLD FOR A STEPPED ROD**

AIM: To prepare a mold for a given pattern.

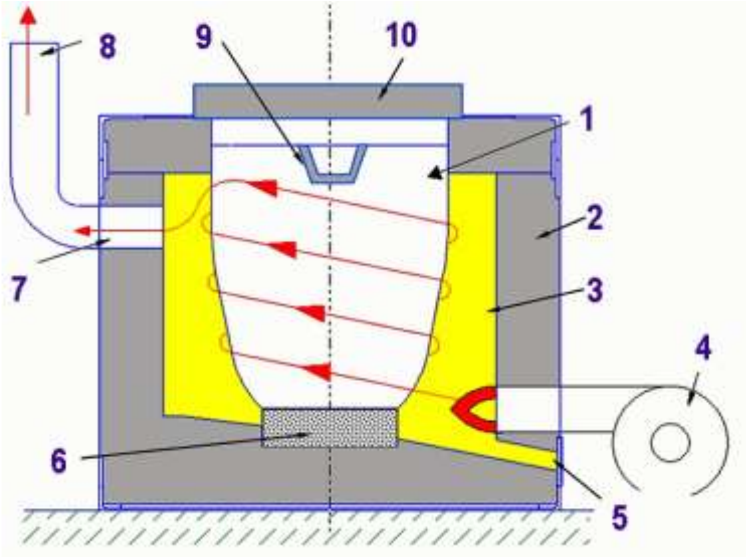
TOOLS REQUIRED: Sand mold, Single piece pattern for Stepped Rod.

DESCRIPTION:

Mold cavity preparation is a crucial step in the casting process, where a cavity is created within a mold to shape molten metal into a desired form. The quality of the final casting largely depends on the accuracy and precision of the mold cavity. This experiment aims to understand the essential steps involved in mold preparation, including pattern making, sand preparation, molding, and cavity finishing, specifically for a stepped rod.



(A) Steeped Rod Pattern



(B) Oil fired furnace

Process of Mold Cavity Preparation for a Stepped Rod

1. Pattern Selection and Preparation:

The first step in mold cavity preparation is selecting an appropriate pattern for the stepped rod. A stepped rod has varying diameters along its length, so the pattern should accurately replicate these dimensions. Patterns can be made from wood, metal, plastic, or other materials depending on the complexity and production requirements. The surface of the pattern must be smooth to ensure a good quality mold cavity. If needed, draft angles are provided to facilitate easy removal from the sand.

2. Preparation of Molding Sand:

Molding sand is an essential component for cavity formation. The sand should have good permeability, strength, and cohesiveness. Typically, sand is mixed with binders like clay and water to enhance its properties. Proper conditioning and sieving of the sand help in achieving a uniform texture, which improves the mold quality and reduces casting defects.

3. Mold Making Process:

The molding process involves placing the drag (bottom half of the mold box) on a flat surface. The selected stepped rod pattern is positioned inside the drag, and fine sand is sprinkled over it to ensure smooth surface finishing. The remaining space is filled with molding sand and compacted to provide adequate strength. Once the drag is ready, the cope (upper part of the mold box) is prepared in a similar manner. Proper compaction prevents defects such as porosity and shrinkage in the casting.

4. Cavity Formation and Gating System:

After compacting the sand, the pattern is carefully removed to create a cavity within the mold. The removal process should be done without disturbing the mold walls to maintain dimensional accuracy. The cavity is then inspected and repaired if any imperfections exist. The gating system, including sprues, runners, and risers, is incorporated to facilitate proper flow of molten metal and avoid defects like turbulence and air entrapment.

5. Mold Finishing and Assembly:

Once the cavity is prepared, a refractory coating may be applied to the inner surface to enhance surface finish and prevent metal penetration. The mold is then dried to remove excess moisture, which helps in reducing steam formation during metal pouring. Finally, the cope and drag are aligned correctly **and securely closed to ensure proper assembly before pouring the molten metal.**

SEUENCE OF OPEARATIONS:

1. The pattern is placed on the molding board.
2. The drag box is placed over the board, after giving it a clay wash inside.
3. Parting sand is sprinkled over the pattern and the molding board.
4. Foundry sand is placed over the pattern, until it is covered to the depth of 20 to 30 mm.

5. Using fingers, sand is packed around the pattern and into the corners of the box.
6. Some more sand is then placed in the box and packed with the rammer, using first, the peen end and then with the butt end.
7. The excess sand from the surface of the drag is removed by striking-off with the strike-off bar.
8. The drag is turned upside down.
9. The loose sand particles are blown-off with the bellows and the surface is smoothed.
10. The cope box is placed in position on top of the drag box, after giving it a clay wash inside. The riser pin is then located on the surface of the pattern.
11. The sprue pin is placed at about 50 to 60 mm from the pattern, but on the opposite of the riser pin.
12. Parting sand is sprinkled on the upper surface.
13. Steps 4 to 7 are repeated, appropriately.
14. Using a vent rod, holes are made to about 10 mm from the pattern.
15. The sprue and riser pins are removed, by carefully drawing them out. A Funnel shaped hole is made at the top of the sprue hole, called pouring basin/cup.
16. The cope is lifted and placed aside on its edge.
17. A draw spike is inserted into the pattern and the edges around the pattern are wetted. Then the pattern is loosened by tapping, and then drawn straight up.
18. The mold is repaired by adding bits of sand, where the mold is found defective.
19. Using a gate cutter, a gate is cut in the drag, from the sprue to the mold.
20. The loose sand particles that are present in the mold are blown-off.

21. The mold is finally closed by replacing the cope on the drag and placing weights on it.

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.
3. Pattern should have good surface finish, because finish of the casting depends on the finish of the pattern.

RESUTS:

The sand mold for a Straight pipe is thus made, which is ready for pouring the molten metal.

REVIEW QUESTIONS:

1. Define casting?
2. What is Shrinkage Allowance?
3. What are the different types of allowances in the casting?
4. What is the purpose of runner and riser and how it will locate?

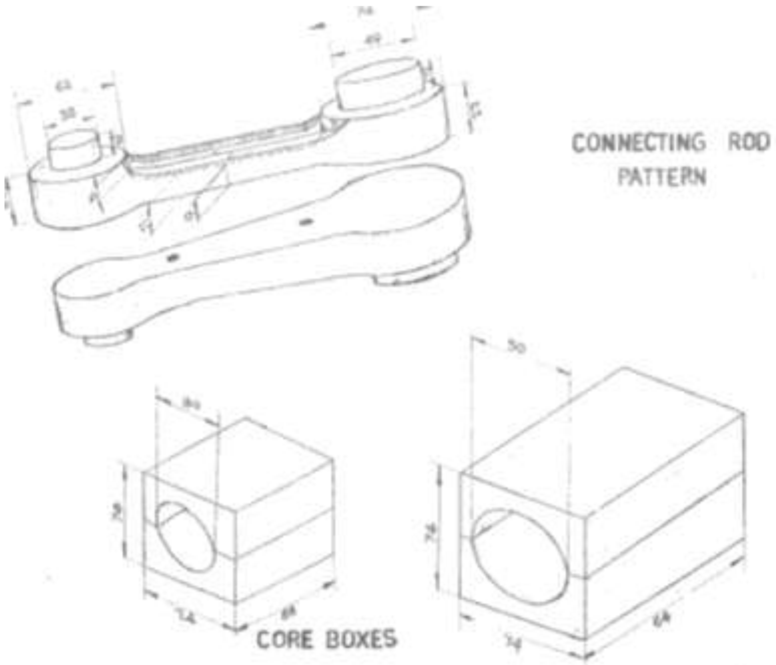
Ex. No:3

Dt: **MOLD FOR A CONNECTING ROD**

AIM: To prepare a sand Mold, using the given double piece pattern for Connecting Rod.

TOOLS REQUIRED: Molding board, drag and cope boxes, molding sand, parting sand, rammer, strike-off bar, bellows riser and sprue pins, gate cutter, vent rod and draw spike

DESCRIPTION:



(A) Mold for connecting Rod

The preparation of a mold for a connecting rod is a critical step in the casting process, where a precisely shaped cavity is created to form the required component. A connecting rod is an essential mechanical element used in internal combustion engines and other machinery to transfer motion from the piston to the crankshaft. Since it experiences high stresses during operation, the mold must be accurately designed to ensure proper casting with minimal defects. This experiment aims to understand the step-by-step procedure for creating a mold for a connecting rod, including pattern making, sand preparation, mold cavity formation, and finishing.

Process of Mold Preparation for a Connecting Rod:

1. Pattern Selection and Preparation:

The first step in mold preparation is the selection and preparation of a pattern that replicates the shape of the connecting rod. The pattern is usually made from wood, metal, or plastic, depending on the required durability and accuracy. It must include allowances for shrinkage, machining, and draft angles to facilitate easy removal from the sand mold.

2. Preparation of Molding Sand:

Molding sand plays a vital role in the quality of the final casting. The sand used should have good permeability, strength, and cohesiveness to withstand the forces during pouring and solidification. Typically, the sand is mixed with binders such as clay and water to improve its properties. The sand mixture is sieved and conditioned to ensure a uniform texture and consistency.

3. Mold Making Process:

The mold is created using a two-part molding box, consisting of the drag (bottom half) and the cope (top half). The process is as follows:

The drag is placed on a flat surface, and parting sand is sprinkled to prevent sticking.

The pattern of the connecting rod is positioned inside the drag.

Molding sand is filled around the pattern and compacted to achieve uniform density and strength.

Once compacted, the drag is flipped, and the cope is placed on top.

Additional sand is added and compacted around the upper part of the pattern in the cope.

The gating system, including sprues, runners, and risers, is designed to allow smooth molten metal flow and prevent defects.

4. Cavity Formation and Gating System:

After compacting the sand, the pattern is carefully removed to create a cavity that will shape the connecting rod. The gating system is refined to ensure proper metal flow and minimize turbulence. The cavity is inspected, and minor imperfections are corrected before proceeding further.

5. Mold Finishing and Assembly:

To improve the surface quality of the cast component, a refractory coating may be applied to the cavity walls. The mold is then dried to eliminate moisture, reducing the risk of defects like steam formation and gas porosity. Finally, the cope and drag are carefully aligned and securely closed, ensuring the cavity remains intact for pouring.

SEQUENCE OF OPERATIONS:

1. One half of the pattern is placed on the molding board with its flat side on the board.
2. The drag box is placed over the board, after giving it a clay wash inside.
3. Parting sand is sprinkled over the pattern and the molding board.
4. Foundry sand is placed over the pattern, until it is covered to the depth of 20 to 30 mm.
5. Using fingers, sand is packed around the pattern and into the corners of the box.
6. Some more sand is then placed in the box and packed with the rammer, using first, the peen end and then with the butt end.
7. The excess sand from the surface of the drag is removed by striking-off with the strike-off bar.
8. The drag is turned upside down.

9. The loose sand particles are blown-off with the bellows and the surface is smoothed.
10. The second half of the pattern is located over the first half, using the dowel pins.
11. The cope box is placed in position on top of the drag box, after giving it a clay wash inside. The riser pin is then located on the surface of the pattern.
12. The sprue pin is placed at about 50 to 60 mm from the pattern, but on the opposite side of the riser pin.
13. Parting sand is sprinkled on the upper surface.
14. Steps 4 to 7 are repeated, appropriately.
15. Using a vent rod, holes are made to about 10 mm from the pattern.
16. The sprue and riser pins are removed, by carefully drawing them out. A Funnel shaped hole is made at the top of the sprue hole, called pouring basin/cup.
17. The cope is lifted and placed aside on its edge.
18. A draw spike is inserted into the pattern and the edges around the pattern are wetted. Then the pattern is loosened by tapping, and then drawn straight up.
19. The mold is repaired by adding bits of sand, where the mold is found defective.
20. Using a gate cutter, a gate is cut in the drag, from the sprue to the mold.
21. The loose sand particles that are present in the mold are blown-off.
22. The mold is finally closed by replacing the cope on the drag and placing weights on it.

RESULT: The sand mold for a Connecting Rod is thus made, which is ready for pouring the molten metal.

Ex. No:4

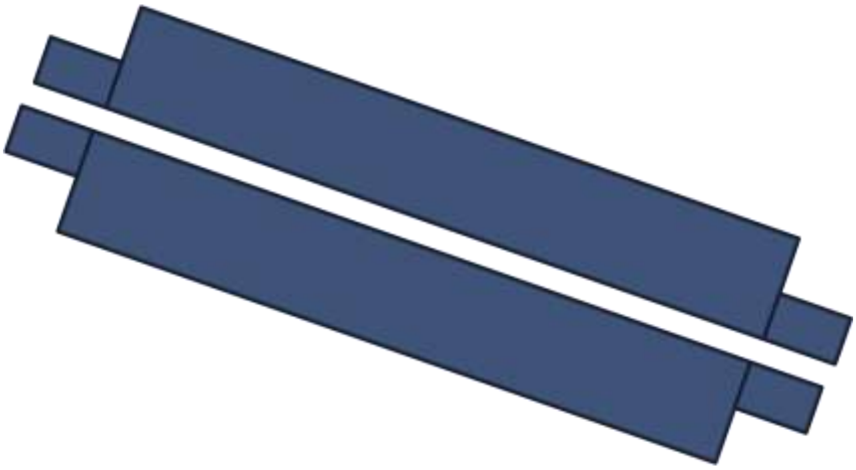
Dt: **MOLD FOR A STRAIGHT PIPE**

AIM: To prepare a sand mold, using the given double piece pattern for Straight Pipe.

TOOLS REQUIRED: Molding board, drag and cope boxes, molding sand, parting sand, rammer, strike-off bar, bellows riser and sprue pins, gate cutter, vent rod and draw spike.

DESCRIPTION:

The preparation of a mold for a straight pipe is an essential step in the casting process, where a precisely shaped cavity is created to form a cylindrical pipe with uniform dimensions. Pipes are widely used in fluid transport systems, structural applications, and mechanical components. Ensuring the accuracy of the mold is crucial for achieving a defect-free casting with good surface finish and mechanical strength. This experiment aims to understand the step-by-step procedure for creating a mold for a straight pipe, including pattern making, sand preparation, mold cavity formation, and finishing.



(A) Mold for straight pipe

Process of Mold Preparation for a Straight Pipe

1. Pattern Selection and Preparation:

The first step in mold preparation is the selection and preparation of a pattern that replicates the shape of the straight pipe. The pattern is typically cylindrical and can be made from wood, metal, or plastic, depending on the required durability and precision. Shrinkage and machining allowances must be considered to ensure accurate final dimensions. Split patterns are often used to facilitate easy removal from the mold.

2. Preparation of Molding Sand:

Molding sand plays a crucial role in determining the quality of the final casting. The sand used should have good permeability, strength, and cohesiveness to withstand the forces during pouring and solidification. Typically, the sand is mixed with binders such as clay and water to enhance its properties. The sand mixture is sieved and conditioned to achieve a uniform texture and consistency.

3. Mold Making Process:

The mold is created using a two-part molding box, consisting of the drag (bottom half) and the cope (top half). The process includes:

Placing the drag on a flat surface and sprinkling parting sand to prevent sticking.

Positioning the cylindrical pattern of the straight pipe inside the drag.

Filling and compacting the molding sand around the pattern to ensure uniform density and strength. Flipping the drag, placing the cope on top, and adding additional sand around the upper half of the pattern.

Designing the gating system, including sprues, runners, and risers, to facilitate smooth molten metal flow and avoid casting defects.

4. Cavity Formation and Gating System:

After compacting the sand, the pattern is carefully removed to create a cavity that will shape the straight pipe. The gating system is refined to ensure proper metal flow and minimize turbulence. The cavity is inspected, and minor imperfections are corrected before proceeding further.

5. Mold Finishing and Assembly:

To improve the surface quality of the cast pipe, a refractory coating may be applied to the cavity walls. The mold is then dried to remove moisture, reducing the risk of defects such as gas porosity and metal penetration. Finally, the cope and drag are aligned correctly and securely closed to ensure the cavity remains intact for pouring.

SEQUENCE OF OPERATIONS:

1. One half of the pattern is placed on the molding board with its flat side on the board.
2. The drag box is placed over the board, after giving it a clay wash inside.
3. Parting sand is sprinkled over the pattern and the molding board.
4. Foundry sand is placed over the pattern, until it is covered to the depth of 20 to 30 mm.
5. Using fingers, sand is packed around the pattern and into the corners of the box.
6. Some more sand is then placed in the box and packed with the rammer, using first, the peen end and then with the butt end.
7. The excess sand from the surface of the drag is removed by striking-off with the strike-off bar.
8. The drag is turned upside down.
9. The loose sand particles are blown-off with the bellows and the surface is smoothed.
10. The second half of the pattern is located over the first half, using the dowel pins.

11. The cope box is placed in position on top of the drag box, after giving it a clay wash inside. The riser pin is then located on the surface of the pattern.
12. The sprue pin is placed at about 50 to 60 mm from the pattern, but on the opposite side of the riser pin.
13. Parting sand is sprinkled on the upper surface.
14. Steps 4 to 7 are repeated, appropriately.
15. Using a vent rod, holes are made to about 10 mm from the pattern.
16. The sprue and riser pins are removed, by carefully drawing them out. A Funnel shaped hole is made at the top of the sprue hole, called pouring basin/cup.
17. The cope is lifted and placed aside on its edge.
18. A draw spike is inserted into the pattern and the edges around the pattern are wetted. Then the pattern is loosened by tapping, and then drawn straight up.
19. The mold is repaired by adding bits of sand, where the mold is found defective.
20. Using a gate cutter, a gate is cut in the drag, from the sprue to the mold.
21. The loose sand particles that are present in the mold are blown-off.
22. The mold is finally closed by replacing the cope on the drag and placing weights on it.

RESULT: The sand mold for a Straight pipe is thus made, which is ready for pouring the molten metal.

Ex. No:5

Dt: **BUTT JOINT WELDING**

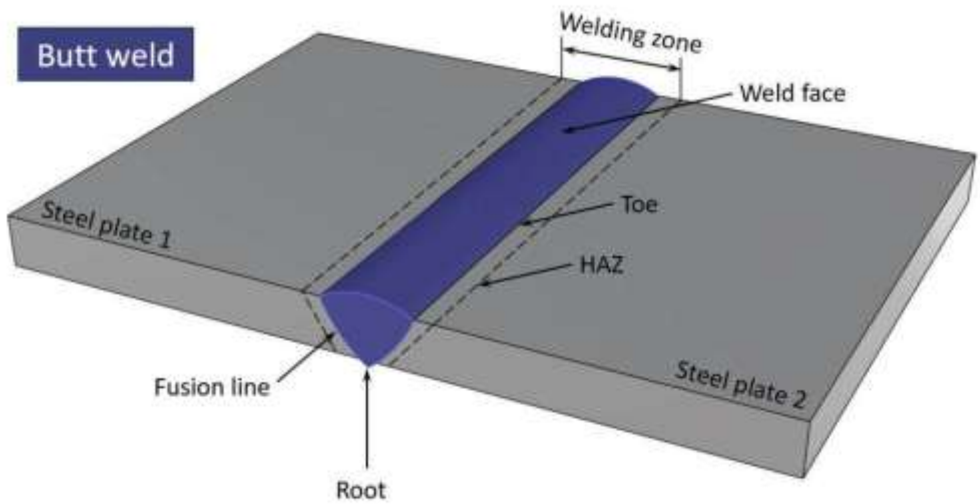
AIM: To make a square butt joint in downward direction.

EQUIPMENT & MATERIAL REQUIRED: A.C welding machine, M.S plates (2 Nos.)

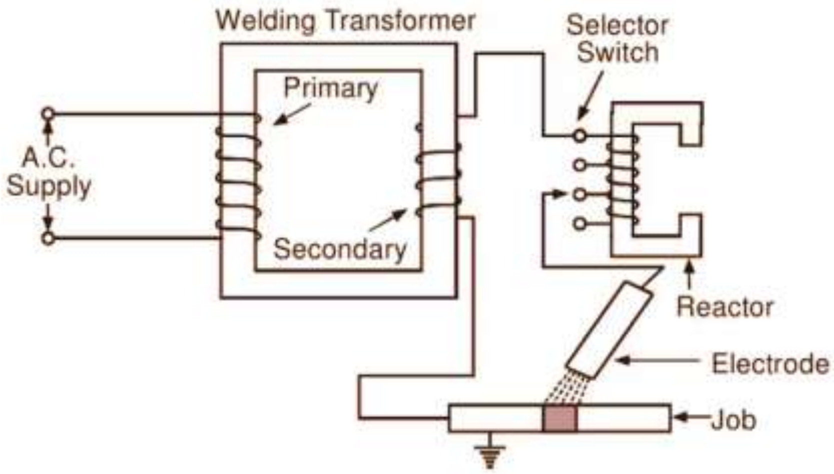
TOOLS REQUIRED: Hack saw, chipping hammer, wire brush, safety goggles, hand gloves, face shield and files.

DESCRIPTION:

Welding is a crucial fabrication process used in various industries, including construction, automotive, and manufacturing. The butt joint welding method is one of the simplest and most commonly used techniques in which two metal pieces are joined along their edges in the same plane. The quality of the weld significantly influences the strength, durability, and overall performance of the final component. This experiment aims to understand the process of butt joint welding, the necessary equipment, and the key parameters that affect weld quality.



(A) Butt joint welding



(B) Welding transformer

Objective:

The objective of this experiment is to study the procedure for performing a butt joint weld, understand the role of welding parameters, and evaluate the strength and quality of the weld.

Materials and Equipment:

- Mild steel plates (or other suitable metal sheets)
- Welding machine (Arc welding, MIG welding, or TIG welding)
- Electrodes or filler material
- Clamps and fixtures
- Measuring tools (vernier calipers, rulers)
- Grinding and cleaning tools (wire brush, grinder)
- Personal protective equipment (gloves, welding helmet, safety goggles, apron)

Process of Butt Joint Welding:

1. Preparation of Metal Pieces:

- Select two metal plates of the required thickness and dimensions.
- Clean the edges of the plates using a grinder or wire brush to remove any dirt, rust, or grease that may affect the weld quality.
- If necessary, provide a slight bevel at the edges to improve weld penetration and strength.

2. Fixture and Alignment:
    - Position the metal pieces edge to edge in a straight line, ensuring proper alignment.
    - Use clamps and fixtures to hold the pieces securely in place, preventing movement during welding.
3. Welding Process:
    - Set up the welding machine according to the metal thickness and electrode type.
    - Select an appropriate welding technique (Arc, MIG, or TIG) based on the requirements.
    - Strike the arc and begin welding along the joint, maintaining a consistent travel speed and electrode angle.
    - Ensure proper heat control to avoid defects such as warping, porosity, or incomplete fusion.
4. Post-Weld Inspection and Finishing:
    - Allow the welded joint to cool naturally to prevent thermal stress.
    - Inspect the weld visually for defects such as cracks, undercuts, or lack of fusion.

- Use a grinder to smoothen the weld if required.
- Conduct a strength test, such as a bend test or tensile test, to evaluate the quality of the weld.

PROCEDURE:

1. The electrode is held in the electrode holder.
2. The two pieces to be welded are filed first and placed such that the two edges are in contact shown in fig, so as to form a Butt joint.
3. The extreme corners of the Butt portion of the weld pieces are tagged.
4. Then the welding is performed by the number of parallel passes by the electrode on the edge of the two weld pieces, and then chipping the extra weld portion by chipping hammer and cooling the Butt joint.
5. Thus the Butt joint operation is performed.

PRECAUTIONS:

1. The process is maintained at a current of 90-130 amperes.
2. Parallel passes are a must.
3. The electrode must be at 2-3 mm from work piece.
4. During the process the electrode is held at 60^o to 70^o to the horizontal.
5. Keeping the cloths safely the welding operation should be done.

RESULT: The Two Metal pieces are connected through Butt joint by ARC welding.

REVIEW QUESTIONS:

1. What are the specific advantages and applications of thermit welding?

2. Describe the electro slag welding process?

3. What do you understand by laser beam welding?

Ex. No:6

Dt: **LAP JOINT WELDING**

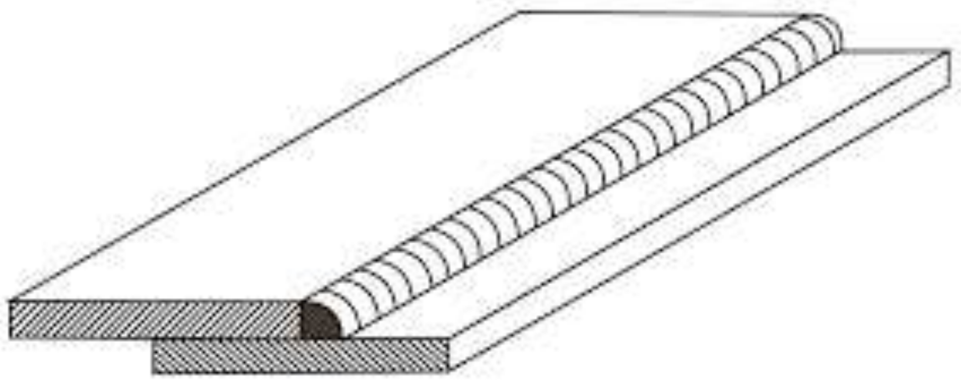
AIM: To make a Lap Joint in downward direction.

EQUIPMENT & MATERIAL REQUIRED: A.C welding machine, M.S plates (2 Nos.)

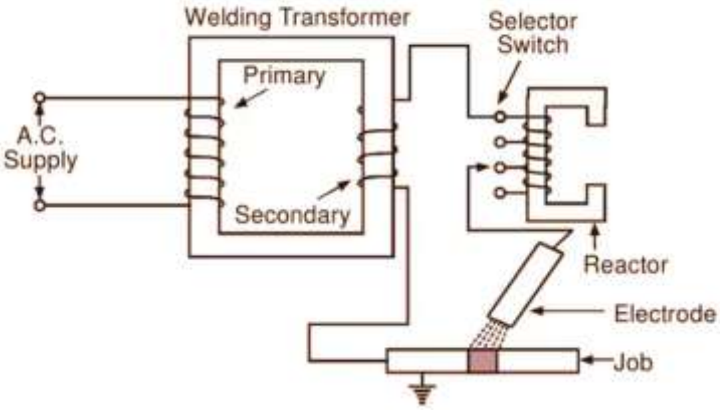
TOOLS REQUIRED: Hack saw, chipping hammer, wire brush, safety goggles, hand gloves, face shield and files.

DESCRIPTION:

Welding is a fundamental fabrication process used across various industries, including automotive, aerospace, and structural engineering. Lap joint welding is a widely used technique where two overlapping metal pieces are welded together. This type of joint is commonly employed in sheet metal work, offering good strength and load-bearing capabilities. The quality of the weld plays a crucial role in ensuring the durability and structural integrity of the welded components. This experiment aims to understand the process of lap joint welding, necessary equipment, and factors affecting weld quality.



(A) Lap joint welding



(B) Welding transformer

Objective:

The objective of this experiment is to study the procedure for performing a lap joint weld, understand the role of welding parameters, and evaluate the strength and quality of the weld.

Materials and Equipment:

- Mild steel plates (or other suitable metal sheets)
- Welding machine (Arc welding, MIG welding, or TIG welding)
- Electrodes or filler material
- Clamps and fixtures
- Measuring tools (vernier calipers, rulers)
- Grinding and cleaning tools (wire brush, grinder)
- Personal protective equipment (gloves, welding helmet, safety goggles, apron)

Process of Lap Joint Welding:

1. Preparation of Metal Pieces:
    - Select two metal plates of the required thickness and dimensions.

- Clean the overlapping surfaces using a grinder or wire brush to remove dirt, rust, or grease that may affect weld quality.
- Ensure proper overlap length to provide sufficient strength to the joint.

2. Fixture and Alignment:
   - Position one metal plate over the other, ensuring a proper overlapping arrangement.
   - Use clamps and fixtures to hold the plates securely in place, preventing movement during welding.
3. Welding Process:
   - Set up the welding machine according to the metal thickness and electrode type.
   - Select an appropriate welding technique (Arc, MIG, or TIG) based on the requirements.
   - Strike the arc and begin welding along the edges of the overlapping plates, maintaining a consistent travel speed and electrode angle.
   - Apply sufficient heat to achieve proper fusion without causing burn-through.
4. Post-Weld Inspection and Finishing:
   - Allow the welded joint to cool naturally to prevent thermal stress.
   - Inspect the weld visually for defects such as cracks, undercuts, or incomplete fusion.
   - Use a grinder to smoothen the weld if required.

- Conduct a strength test, such as a bend test or tensile test, to evaluate the quality of the weld.

PROCEDURE:

1. The electrode is held in the electrode holder.
2. The two pieces to be welded are filed first and placed on over the other as shown in fig, such that the lap joint is formed.
3. The extreme corners of the lapping portion of the weld pieces are tagged.
4. Then the welding is performed by the number of parallel passes by the electrode on the edge of the two weld pieces and then the lapped weld piece is reversed and the same operation is performed, and chipping the extra weld portion by chipping hammer and cooling the lap joint.
5. Thus the lap joint operation is performed.

PRECAUTIONS:

1. The process is maintained at a current of 90-130 amperes.
2. Parallel passes are a must.
3. The electrode must be at 2-3 mm from work piece.
4. During the process the electrode is held at 60^{o} to 70^{o} to the horizontal.
5. Keeping the cloths safely.

RESULT: The Two Metal pieces are connected through Lap joint by ARC welding.

REVIEW QUESTIONS:

1. Distinguish between arc and gas welding processes.

2. Why is it normally necessary to use filler material in welding with tungsten arc? Give reasons.

3.How do you specify an electric arc welding power source?

4.How is an arc obtained in arc welding?

Ex. No:7

Dt: **SPOT WELDING**

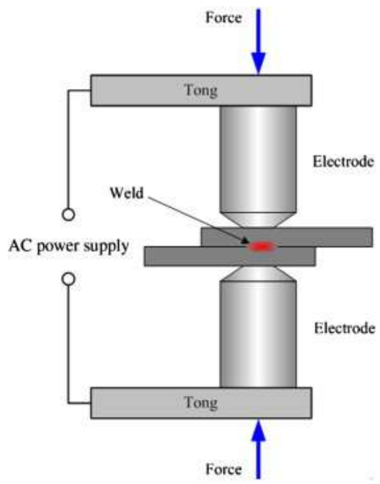
AIM: To Weld the given sheet metal pieces with the help of spot-welding.

EQUIPMENT AND MAERIAL REQUIRED: Spot welding machine (440 V, single phase, 50 cycles fuse rating 15 amps,), GI Sheets.

TOOLS REQUIRED: Wire brush, hand gloves.

DESCRIPTION: Fig shows Spot welding set up. It is a solid state welding process, in which the work pieces to be welded are forced together by apply a compressive load. Current is passed through the contact area.

(A) Spot Welding Machine



(B) Welded thin Pieces

In this welding at low voltage, very high current is passed through the joint for a very short time (25 see). This high amperage heats the Joining due to the contact resistance at the joint. The pressure on the joint is continuously maintained and the metals weld together, under this pressure. The heat generated in the resistance welding can be expressed as

$$H = kI^2 Rt.$$

Where H = the total heat generated in the work, J

I = Electric current, A

T = Time for which the electric current is passing through the joint (seconds)

R = Resistance of the joint.

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

The main requirement of the process is the low voltage and high current power supply. This is obtained, by means of a step-down transformer with a provision to have different tapings on the primary side, as required depending on the thickness and the properties of work pieces to be weld. The secondary windings are 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 subsequence fusion take place to the force on the joint. The force required can be provided either mechanically, by hydraulically and pneumatically. To precisely control the time, sophisticated electronic times are available. Spot welding machine consists of two Electrodes out of which one is fixed. The other electrode is fixed to rocker arm for transmitting mechanical force from a pneumatic cylinder. A resistance welding consists of sequence of events that take place.

These events are:

The squeeze time is the time required for the electrodes to align and clamp the two pieces together under them and provide necessary electrical contact. The weld time is the time of the current flow through work pieces till they are heated to the melting temperature of the workpieces to be welded.

PROCEDURE:

1. Place the sheets between two electrodes, such that the electrode should tough the sheet at the required spot.

2. As the lower electrode arm is stationary, bring the upper electrode in to contact with the sheet by means of spring – loaded foot pedal.
3. By completing the circuit resistance, spot welding will be carried out.

PRECAUTIONS:

1. Proper care should be taken during welding.
2. Ensure the overlap the sheet to be proper.

RESULT: The Two Metal pieces are connected through LAP joint by SPOT welding.

REVIEW 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, weld time and off time?
5. Write any two applications of spot welding

Ex. No:8

Dt: **TIG WELDING PROCESS**

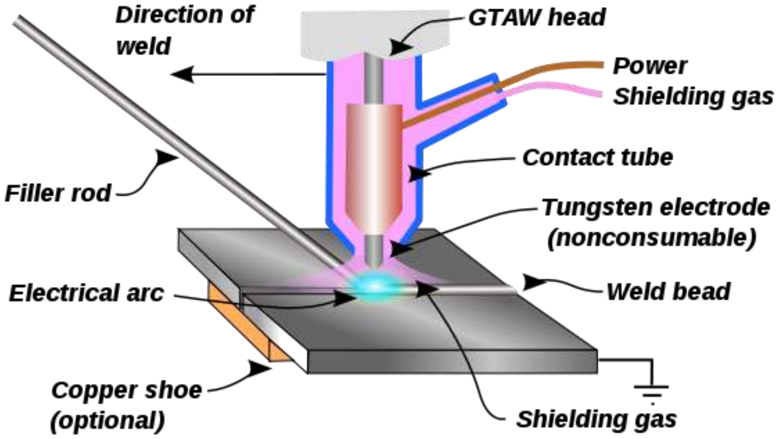
AIM: To learn how to do TIG welding.

EQUIPMENT & MATERIAL REQUIRED: TIG welding machine, M.S plates (2 Nos.)

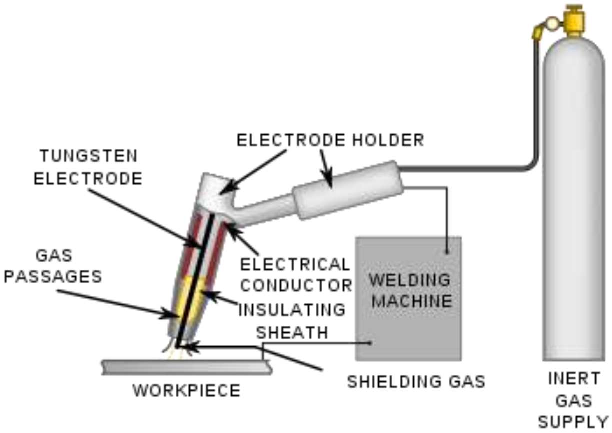
TOOLS REQUIRED: Hack saw, safety goggles, hand gloves, face shield and files.

DESCRIPTION: Tungsten - also called wolfram - is a metal with a fusion point of more than 3300^0 C, which means more than double the fusion point of the metals which are usually welded. Inert Gas is the same thing as inactive gas, which means a type of gas that will not to combine with other elements.

TIG welding is an electric arc welding process in which the fusion energy is produced by an electric arc burning between the work piece and the tungsten electrode. During the welding process the electrode, the arc and the weld pool are protected against the damaging effects of the atmospheric air by an inert shielding gas. By means of a gas nozzle the shielding gas is lead to the welding zone where it replaces the atmospheric air. TIG welding differs from the other arc welding processes by the fact that the electrode is not consumed like the electrodes in other processes such as MIG/MAG and MMA.



(A)Working of TIG Welding



(B) Tig welding equipment

PROCEDURE:

1. Prepare sharp tip for the tungsten electrode on grinding machine.
2. The two pieces to be welded are filed first and placed side by side as shown in fig, such that the butt joint is formed.
3. Adjust the gas flow rate to 2 lit/min.
4. The extreme corners of the butting portion of the weld pieces are tagged.
5. Produce the arc by maintaining4-5mm electrode gap and move the torch by weaving electrode gun, use filler material if required.
6. Thus, the butt joint operation is performed on TIG welding machine.

PRECAUTIONS:

1. The process is maintained at a current of 180-250 amperes.
2. Must use hand glove, face shield.
3. The electrode must be at 4-5 mm from work piece.
4. During the process the electrode gun is held at 60^o to 70^o to the horizontal and filler rod of 35^0-50^0 to the horizontal.
5. Keeping the cloths safely.

RESULT:

Tig welding is performed for given work piece

Ex. No:9

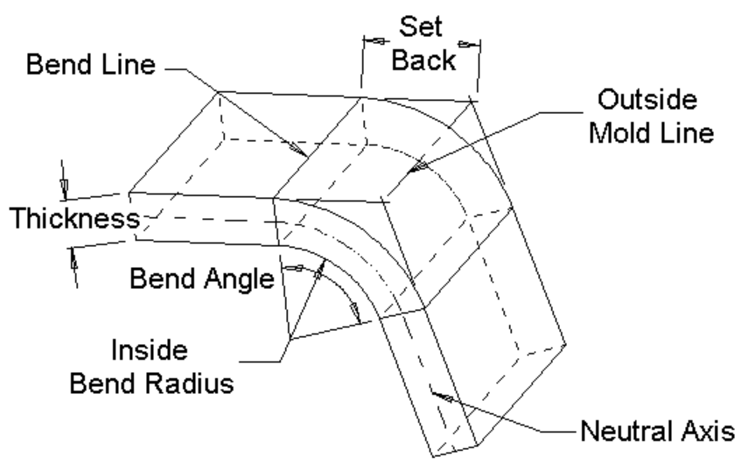
Dt: **SHEET BENDING**

AIM: To bend a given a G I sheet by using hydraulic press.

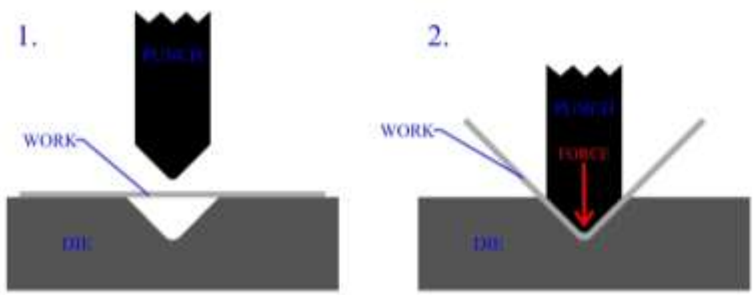
EQUIPMENT, TOOLS&MATERIAL REQUIRIED:

Hydraulic Press working machine (10 tons, stroke 15 cm), Bending die & Punch, spanners, T-bolts, Clamps, G.I Sheets, (0.5 mm or 26 gauge).

DESCRIPTION: Press Tool operation is one of the cheapest and fastest ways of the complete manufacture of a component. Sheet metal is generally considered to be plate with thickness less than about 5 mm. Bending is a process in which the V- punch forces the sheet metal in to a V-die to make a 90^0 bend or 60^0 bend plastically.



(A) Bending process



(B) Bending with help of Die

In this machine hydraulic oil forces the piston in a cylinder, the high pressure oil is supplied from manual operating pump. The pump contains two levers. Lever 1 is used for fast travelling of ram , lever 2 is used to increase the bending force.

PROCEDURE:

1. Punch (Top die) is properly attached with the ram.
2. Bottom die is placed on the worktable, & fixed by means of T- bolts & clamps.
3. Pump the oil by using lever 1 to bring the ram down.
4. The marked sheet is placed on top of V-die.
5. By operating lever 2 increase the pressure on sheet metal to force in to V-groove.
6. Relieve the pressure by operating pressure relief vale manually.
7. Remove work from die carefully.
8. Repeat the operation for number of bends.

PREACUTIONS:

1. Die & punch are to be fixed properly.
2. Before start machine, all parts to be tightened.
3. Do not apply excessive pressure(more than 2Mpa) on cylinder which damages the oil seals.
4. Wear working glove to protect hands from sheet mstal.

RESULT:

Sheet bending operation for given piece is performed

Ex. No:10

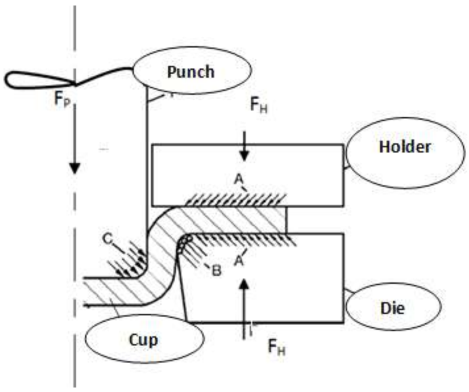
Dt: **DEEP DRAWING**

AIM: To deep draw a given G I circular sheet by using deep drawing die on hydraulic press.

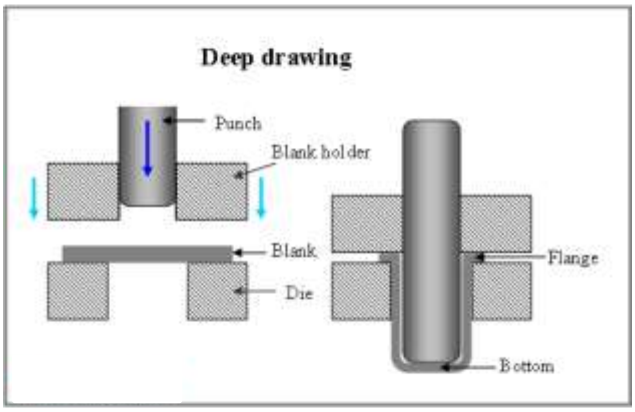
EQUIPMENT, TOOLS&MATERIAL REQUIRIED:

Hydraulic Press working machine (10 tons, stroke 15 cm), Bending die & Punch, spanners, T-bolts, Clamps, G.I blank of 40mm in dia (0.5 mm or 26 gauge).

DESCRIPTION: Press Tool operation is one of the cheapest and fastest ways of the complete manufacture of a component. Sheet metal is generally considered to be plate with thickness less than about 5 mm. Deep drawing is a process in which the circular punch forces the sheet metal blank in to a die to form cup plastically. .



(A) Deep Drawing Process



(B) Deep Drawing with help of Die

In this machine hydraulic oil forces the piston in a cylinder, the high pressure oil is supplied from manual operating pump. The pump contains two levers. Lever 1 is used for fast travelling of ram, lever 2 is used to increase the bending force.

PROCEDURE:

1. Punch (Top die) is properly attached with the ram.
2. Bottom die is placed on the worktable, & fixed by means of T- bolts & clamps.
3. Pump the oil by using lever 1 to bring the ram down.
4. The sheet metal blank is placed in the die.
5. By operating lever 2 increase the pressure on sheet metal bank to force in to circular die.
6. Relieve the pressure by operating pressure relief vale manually.
7. Remove work piece from die carefully.

PREACUTIONS:

1. Die & punch are to be fixed properly.
2. Before start machine, all parts to be tightened.
3. Do not apply excessive pressure(more than 2Mpa) on cylinder which damages the oil seals.
4. Wear working glove to protect hands from sheet metal.

RESULT:

Deep Drawing operation is performed for G.I sheet by Hydraulic press.

Ex. No:11

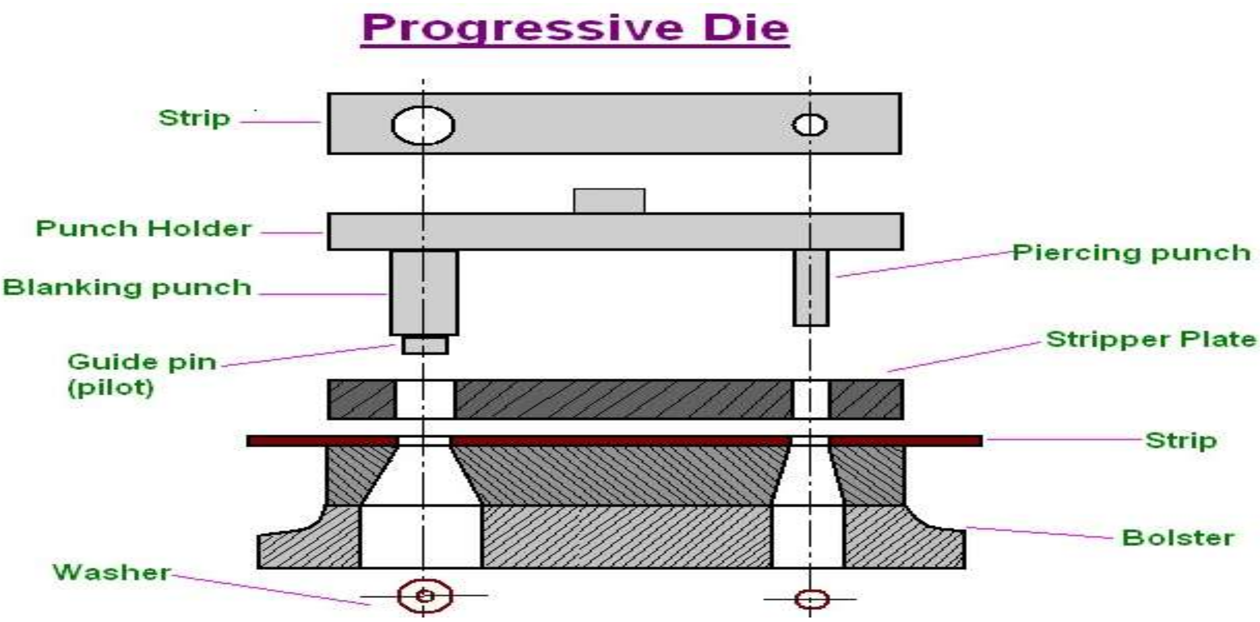
Dt: **PRESS WORKING**

AIM: To make a washer of given dimensions from a G I sheet with progressive die.

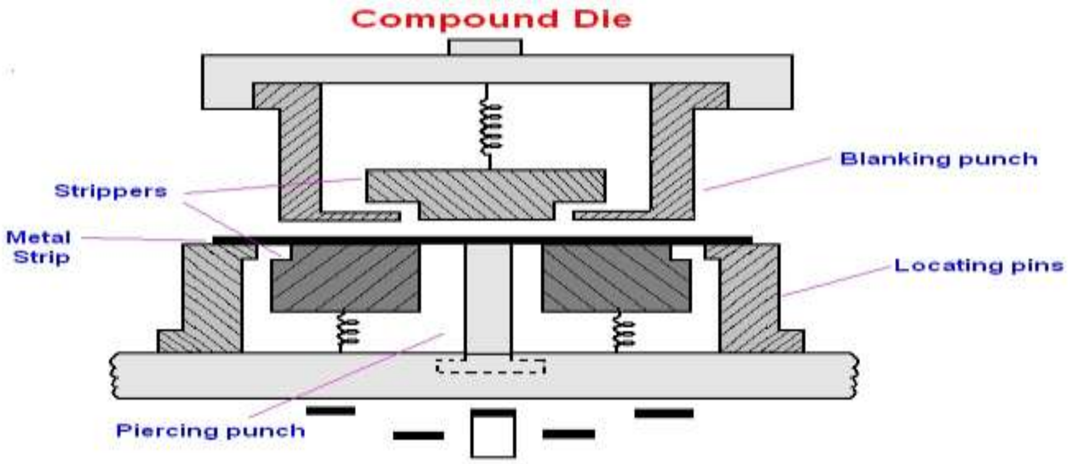
EQUIPMENT, TOOLS&MATERIAL REQUIRIED:

Press working machine (15tons, stroke 1'inch, 1440rpm, 1hp motor, 415v, 3phase), progressive dies, spanners, T-bolts, Clamps, G.I Sheets, (0.5 mm or 26 gauge).

DESCRIPTION: Press Tool operation is one of the cheapest and fastest ways of the complete manufacture of a component. Sheet metal is generally considered to be plate with thickness less than about 5 mm. Blanking is a process in which the punch removes a portion of material from the stock, which is a strip of sheet metal of necessary thickness and width. Punching or Piercing is making holes in a sheet.



(A) Press Working Operation



(B) Press working operation with help of Die

In a progressive die, all the necessary operations are carried at two stations in a single stroke of the ram. During part of the stroke, piercing of holes is done in the stock and up on further travel, the blanking operation is done. The washer is produced by simultaneously blanking & piercing operations. Progressive dies are more accurate and economical in mass production, due to high accuracy in locating work piece wrt work tool.

PROCEDURE:

1. Punch (Top die) is properly attached with the ram.
2. Bottom die is placed on the worktable, & fixed by means of T- bolts & clamps.
3. Power supply is to be given to the motor.
4. The sheet with a width of 28 mm feed into the die.
5. Motion is transmitted from motor shaft to driver pulley and to pinion.
6. Then after motion is transferred from pinion to bull gear.
7. By operating pedal, the motion will be transferred from bull gear to eccentric.
8. Ram moves downward, because of rotation of eccentric.
9. The punch cuts the material & the required washer is obtained.

PREACUTIONS:

1. Die & punch are to be fixed properly.

2. Before start machine, all parts to be tightened.
3. After one stroke, pedal to be released.
4. During feeding Sheet, proper care must be taken.

RESULT:

Washer is prepared by G.I Sheet with help of press working

REVIEW QUESTIONS:

1. Explain different types of dies?

2. Explain the advantages and disadvantages of compound dies over progressive dies?

3. What are the methods that can be used for saving material in construction of die blocks?

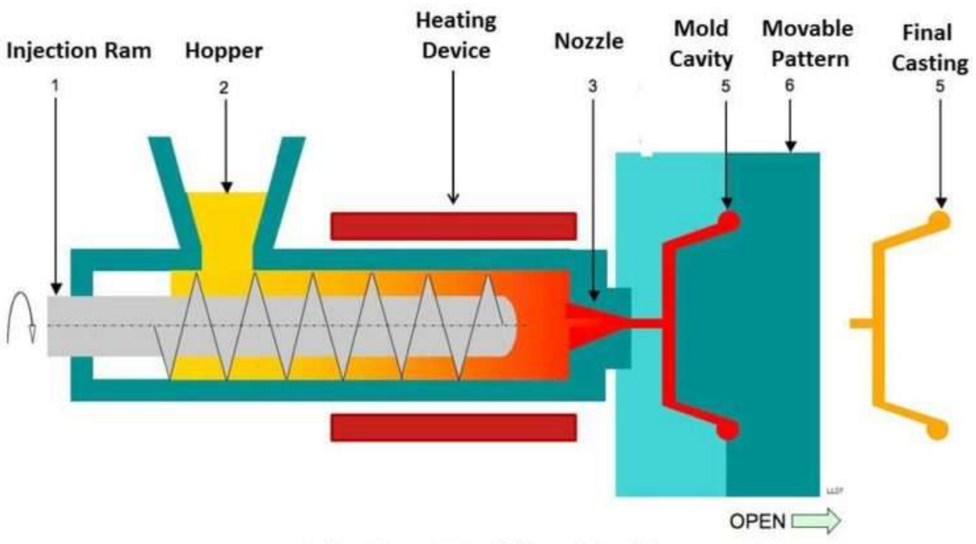
Ex. No:12

Dt: **INJECTION MOULDING**

AIM: To make a component by Injection molding equipment.

EQUIPMENT AND MATERIAL REQUIRED: Injection moulding equipment, thermoplastic material and dies.

DESCRIPTION: Injection moulding is usually employed for thermo plastic materials, which are soften by heating and then reharden during cooling. The moulding material (thermoplastic) is fully polymerized before pouring in to the mould, since the under go 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 in to the mould and then allowed to cool to harden, there by the desired article is obtained. Heating unit temperatures usually ranges from 180 ^{0}C to 280 ^{0}C . The advantage of injection moulding is that mass production is possible, which offset the higher capital cost.



(A) Injection Moulding operation.

PROCEDURE:

1. Die is placed at proper position, under the nozzle hole, on the bed of the Injection moulding machine.

2. The moulding material in the form of granules is fed through the hoper to the Cylinder where it gets softened.
3. By electric means, heat the granules up to molten state.
4. After material reaches to molten state, move the plunger in to the heated chamber, which advances against die cavity.
5. Molten material can pass though nozzle in to the mould cavity and then mould is allowed to cool and hardened.
6. After hardening, the plunger to be returned backward.
7. Now mould is to be opened to eject the plastic article.

PRECAUTIONS:

1. Keep the heat unit temperature ranges from $180^{o}C$ to $280^{0}C$
2. The sprue hole of the die should be placed exactly below the nozzle of feeding Chamber.
3. Injection should be carried out at faster rate
4. Allow sufficient time to harden the materiel before the object is removed from the mould.

RESULT:

The Bottle component is prepared by Injection molding process

REVIEW QUESTIONS:

1. Write the difference between thermoplastics and thermosetting plastics?
2. What are advantages of injection moulding?
3. Write the application of injection moulding?

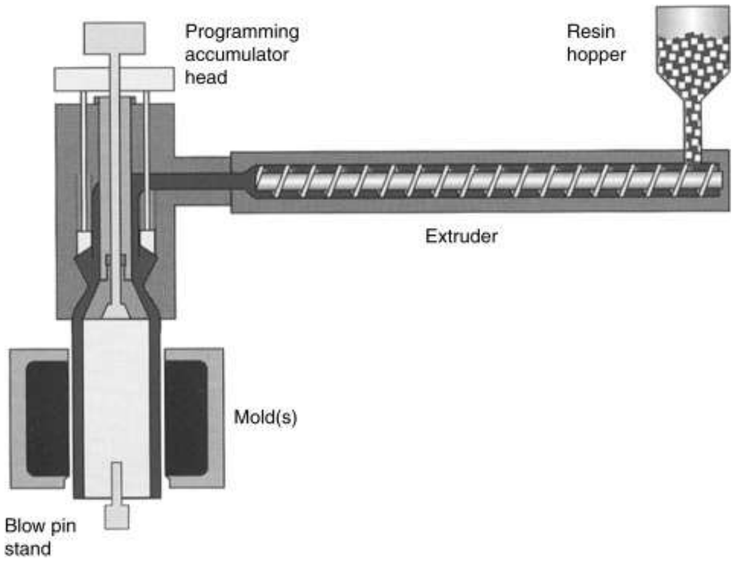
Ex. No:13

Dt: **BLOW MOULDING**

AIM: To make a component by Blow moulding equipment.

EQUIPMENT AND MATERIAL REQUIRED: Blow moulding equipment, thermoplastic material and Dies.

DESCRIPTION: This process is applied to only thermoplastics, which are used for producing hollow objects, such as bottle and floatable objects; by applying are pressures to the sheet material, when it is in heated and in soft pliable condition.



(A) Blow moulding Operation.

PROCEDURE:

1. Die is placed at proper position, under the nozzle hole, on the bed of the blow-moulding machine.
2. The moulding material in the form of granules is fed through the hoper to the cylinder, where it gets softened.
3. By Electric mean, heat the granules up to molten state.
4. A measured amount of material in the form of tube is either injected or extruded in a split cavity die.
5. The split mould is closed around the tube, sealing off the lower end.

6. The air under pressure (4 bar) is blown in to the tube, which causes the tube to expand to the walls of cavity.
7. After hardening, the plunger to be returned backward.
8. Now mould is to be opened to eject the plastic article.

PRECAUTIONS:

1. The sprue hole of the die should be placed exactly below the nozzle of feeding chamber.
2. Nozzle screw is properly tightened to get the required material
3. Keep the heat unit temperature ranges from 180^0c to 280^0c depending on the plastic.

RESULT:

The bottle is prepared by blow molding machine

REVIEW QUESTIONS:

1. What are the advantages of Blow moulding?
2. Write the difference between Injection moulding and Blow moulding?
3. Write the applications of Blow moulding?

Ex. No: 14

Dt: **GAS CUTTING AND WELDING**

AIM:

To perform gas cutting and welding operations using an oxy-acetylene setup.

MATERIAL AND EQUIPMENT REQUIRED:

- Oxygen cylinder
- Acetylene cylinder
- Gas regulators
- Hoses and torch
- Welding rods
- Workpieces (Mild Steel plates)

TOOLS REQUIRED:

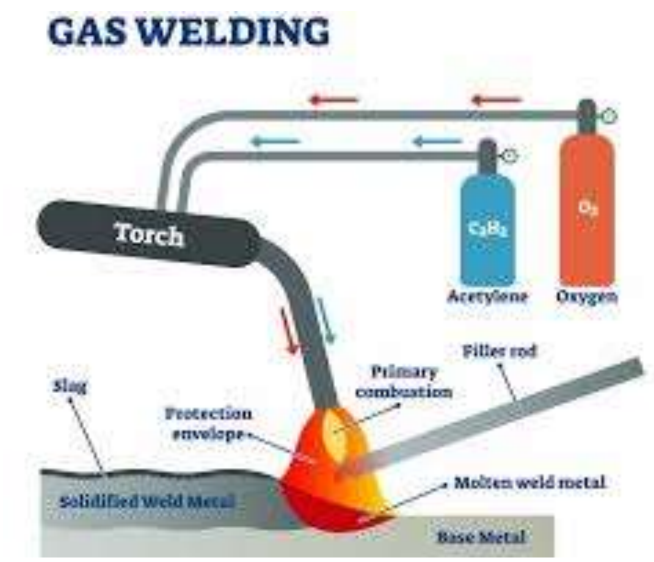
- Welding goggles
- Gloves
- Apron
- Wire brush
- Spark lighter
- Chipping hammer

DESCRIPTION:

Gas cutting and welding are widely used processes in metal fabrication industries, enabling precise cutting and strong joint formation. Gas cutting utilizes a combination of oxygen and fuel gases to generate a high-temperature flame capable of cutting metals, while gas welding (oxy-fuel welding) employs a similar flame to fuse metal pieces together. These techniques are commonly used in construction, repair work, and manufacturing. This experiment aims to understand the process of gas cutting and welding, necessary equipment, and factors affecting the quality of the cut and weld.

Objective:

The objective of this experiment is to study the procedure for performing gas cutting and welding, understand the role of gas mixtures, and evaluate the quality of cuts and welds.



(A) Gas Welding

(B) Gas Welding

Materials and Equipment:

- Mild steel plates (or other suitable metal sheets)

- Oxy-acetylene or oxy-propane gas setup
- Cutting torch and welding torch
- Gas regulators and hoses
- Filler rods (for welding)
- Clamps and fixtures
- Measuring tools (vernier calipers, rulers)
- Grinding and cleaning tools (wire brush, grinder)
- Personal protective equipment (gloves, welding helmet, safety goggles, apron)

Process of Gas Cutting and Welding:

1. Preparation of Metal Pieces:
    - Select the required metal pieces for cutting or welding.
    - Clean the surfaces using a grinder or wire brush to remove dirt, rust, or grease that may affect the process.
2. Gas Cutting Process:
    - Set up the oxy-fuel gas cutting equipment, ensuring proper connections and gas pressure settings.
    - Ignite the cutting torch and adjust the flame for optimal cutting conditions.
    - Move the torch along the marked cutting path while maintaining a steady speed for a smooth cut.
    - Ensure proper heat control to avoid excessive metal oxidation and rough edges.
3. Gas Welding Process:
    - Set up the oxy-acetylene welding equipment, ensuring appropriate gas mixture and pressure settings.
    - Ignite the welding torch and adjust the flame for proper welding conditions.
    - Position the metal pieces to be welded and secure them using clamps.
    - Use a filler rod if required and maintain a steady motion along the joint to ensure proper fusion.
4. Post-Weld Inspection and Finishing:

- Allow the welded joint to cool naturally to prevent thermal stress.
- Inspect the weld and cut surfaces for defects such as cracks, rough edges, or incomplete fusion.
- Use a grinder to smoothen the weld if necessary.
- Conduct a strength test, such as a bend test or tensile test, to evaluate the quality of the weld.

PROCEDURE:

Gas Cutting:

1. Ensure the work area is clean and free from flammable materials.
2. Secure the workpiece properly on the cutting table.
3. Open the oxygen and acetylene cylinder valves carefully.
4. Adjust the gas regulators to obtain the desired pressure for cutting.
5. Use a spark lighter to ignite the oxy-acetylene flame.
6. Adjust the flame to obtain a neutral flame suitable for cutting.
7. Hold the cutting torch at an angle of 60–70° and preheat the metal at the starting point.
8. Once the metal reaches its ignition temperature, press the oxygen lever to begin the cutting process.
9. Move the torch steadily along the cutting line to achieve a smooth cut.
10. After cutting is complete, close the gas valves properly and clean the cut edges with a wire brush.

Gas Welding:

1. Clean the surfaces of the metal pieces to be welded.
2. Secure the workpieces in proper alignment using clamps.
3. Open the oxygen and acetylene cylinder valves and set the appropriate pressure.
4. Ignite the flame using a spark lighter and adjust it to obtain a neutral flame.
5. Position the torch at a suitable angle and start welding by melting the filler rod along the joint.
6. Maintain a steady movement of the torch to ensure a uniform weld bead.
7. After welding, allow the joint to cool gradually to avoid cracks.

8. Close the gas valves and clean the weld bead with a wire brush.

PRECAUTIONS:

1. Always wear protective gear such as goggles, gloves, and an apron.
2. Ensure the gas cylinders are properly secured and leak-free.
3. Do not use excessive oxygen pressure while cutting to avoid metal burning.
4. Maintain a safe distance from the flame and hot metal surfaces.
5. Store gas cylinders in a well-ventilated area, away from direct sunlight or heat sources.

RESULT:

The gas cutting and welding operations were successfully performed, and the required joint was obtained.

REVIEW QUESTIONS:

1. What is oxy-acetylene welding?
2. What are the three types of oxy-acetylene flames?
3. Define neutral flame.
4. What is the purpose of a cutting torch?
5. What is the function of a welding rod?
6. Why is preheating necessary in gas cutting?
7. What are the safety measures to be followed in gas welding?
8. What is the difference between gas welding and arc welding?

Ex. No: 15

Dt:

BRAZING AND SOLDERING

AIM:

To perform brazing and soldering operations to join metal pieces.

MATERIAL AND EQUIPMENT REQUIRED:

- **For Brazing:**
    - Brazing torch
    - Brazing rods (Brass or Silver alloy)
    - Flux (Boron-based or Zinc chloride)
    - Metal workpieces (Mild steel, Copper, or Brass)
- **For Soldering:**
    - Soldering iron
    - Solder wire (Lead-Tin Alloy or Lead-free solder)
    - Flux (Rosin or Acid core)
    - Electrical wires or thin metal sheets

DESCROPTION:

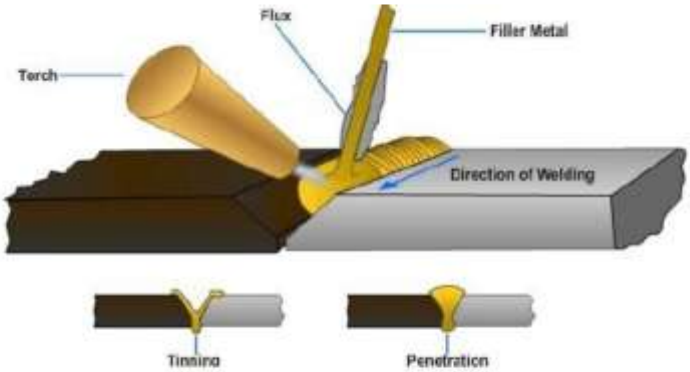
Brazing and soldering are essential joining processes used in metal fabrication, electronics, plumbing, and other industries where strong and reliable joints are required. Brazing involves the use of a filler metal with a melting point above 450°C but below the melting point of the base metals, while soldering uses a filler metal with a melting point below 450°C. Both processes rely on capillary action to distribute the filler metal between closely fitted parts without melting the base metals. This experiment aims to understand the principles of brazing and soldering, necessary equipment, and factors affecting joint quality.

Objective:
The objective of this experiment is to study the procedures for performing brazing and soldering, understand the role of filler metals and fluxes, and evaluate the quality and strength of the joints formed.

Materials and Equipment:

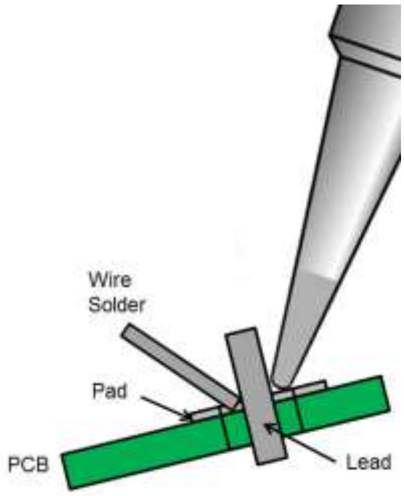
- Copper, brass, or mild steel pieces (for brazing)
- Electronic components or copper pipes (for soldering)

- Brazing torch (oxy-acetylene or propane torch)
- Soldering iron or soldering station
- Brazing rods (silver, brass, or copper-based filler metals)
- Solder wire (tin-lead or lead-free solder)
- Flux (borax-based for brazing, rosin or acid-based for soldering)
- Clamps and fixtures
- Cleaning tools (wire brush, sandpaper)
- Personal protective equipment (gloves, safety goggles, apron)



Braze welding cast iron and nickel alloy using the backhand method.

(A) Brazing



(B)Soldering

Process of Brazing and Soldering:

1. Preparation of Metal Surfaces:

    - Select the appropriate metal pieces to be joined.
    - Clean the surfaces using a wire brush or sandpaper to remove oxidation, dirt, or grease.
    - Apply an appropriate flux to prevent oxidation and promote filler metal flow.

2. Brazing Process:

    - Set up the brazing torch and adjust the flame for optimal heating.
    - Position the metal pieces with a slight gap to allow capillary action.
    - Heat the joint evenly and apply the brazing filler metal, ensuring it flows between the pieces.
    - Allow the joint to cool naturally for proper solidification.

3. Soldering Process:

    - Set up the soldering iron and allow it to reach the correct temperature.
    - Position the electronic components or metal pieces to be soldered.
    - Apply flux and then touch the solder wire to the heated joint, allowing it to flow and bond the parts.
    - Let the soldered joint cool and solidify without disturbance.

4. Post-Joining Inspection and Finishing:

    - Inspect the brazed and soldered joints for defects such as weak bonding, cracks, or insufficient filler material.
    - Clean excess flux residue using a brush or solvent.
    - Conduct strength tests (such as bend or pull tests) to evaluate the quality of the joints.

TOOLS REQUIRED:

- Wire brush
- Files
- Tongs
- Flux brush
- Wet sponge (for cleaning the soldering iron tip)
- Clamps or fixtures

PROCEDURE:

Brazing Process:

1. Clean the metal surfaces to be joined using a wire brush or sandpaper to remove oxides and dirt.
2. Apply flux to the joint area to prevent oxidation and improve bonding.
3. Secure the workpieces in proper alignment using clamps.
4. Ignite the brazing torch and adjust the flame to a neutral setting.
5. Heat the joint area uniformly until it reaches the brazing temperature (above 450°C).
6. Touch the brazing rod to the joint; the molten filler metal will flow and fill the gap by capillary action.
7. Remove the torch and allow the joint to cool naturally.
8. Clean the joint using a wire brush to remove flux residues.

Soldering Process:

1. Clean the surfaces to be joined using a file or wire brush.
2. Apply flux to the joint area to improve adhesion.
3. Heat the soldering iron to the required temperature (around 250–350°C).
4. Place the soldering iron tip at the joint and allow it to heat the surfaces.
5. Touch the solder wire to the heated joint; it will melt and flow into the gap.
6. Remove the soldering iron and let the joint cool naturally.
7. Wipe the joint with a damp cloth to remove excess flux residue.

PRECAUTIONS:

1. Always wear safety goggles and heat-resistant gloves.
2. Ensure proper ventilation to avoid inhalation of flux fumes.
3. Avoid overheating, as it can weaken the joint.
4. Use the correct type of flux and filler metal for the specific application.
5. Keep the soldering iron tip clean for efficient heat transfer.

RESULT:

The brazing and soldering operations were successfully performed, and strong metal joints were obtained.

REVIEW QUESTIONS:

1. What is the difference between brazing and soldering?
2. What is the role of flux in brazing and soldering?
3. Define capillary action in brazing.
4. What is the melting point range of solder?
5. Why is flux necessary in soldering?
6. What safety measures should be taken while performing brazing?
7. How is the strength of a soldered joint compared to a brazed joint?
8. What is the purpose of a soldering iron?

Ex. No: 16

Dt:

DEMONSTRATION OF METAL CASTING

AIM:

To demonstrate the process of metal casting by preparing a sand mold and pouring molten metal to form a casting.

MATERIAL AND EQUIPMENT REQUIRED:

- Molten metal (Aluminum, Cast Iron, or Brass)
- Moulding sand (Green sand or Dry sand)
- Facing sand, Backing sand, Parting sand
- Cope and Drag (Moulding box)
- Bottom board
- Crucible furnace

TOOLS REQUIRED:

- Pattern
- Sprue, Riser, Gate cutter
- Trowel
- Vent rod
- Bellows
- Ladle
- Draw spike
- Clamps

DESCRIPTION:

Metal casting is a fundamental manufacturing process used to shape molten metal into desired forms by pouring it into a mould cavity and allowing it to solidify. This process is widely used in industries such as automotive, aerospace, and construction for producing complex metal parts. The quality of the final casting depends on factors such as mould design, metal composition, pouring technique, and cooling rate. This experiment aims to demonstrate the key steps involved in metal casting and provide an understanding of the principles governing the process.

Objective:
The objective of this experiment is to study the metal casting process, understand the role of mould preparation, melting, pouring, and solidification, and evaluate the quality of the final casting.

Materials and Equipment:

- Pattern for mould formation
- Moulding sand (with binders)
- Moulding box (cope and drag)
- Foundry tools (rammer, sprue cutter, trowel, strike-off bar)
- Molten metal (aluminum, brass, or cast iron)
- Crucible and furnace
- Tongs and ladle for handling molten metal
- Personal protective equipment (gloves, safety goggles, apron)

Process of Metal Casting:

1. Pattern Preparation and Mould Making:
    - Select an appropriate pattern based on the desired shape of the casting.
    - Place the pattern inside the drag (bottom moulding box) and fill it with fine moulding sand.
    - Compact the sand around the pattern using a rammer to ensure strength.
    - Repeat the process for the cope (upper moulding box) and create a gating system (sprue, runners, and risers) for molten metal flow.
    - Carefully remove the pattern, ensuring that the mould cavity remains intact.
2. Metal Melting and Pouring:
    - Heat the selected metal in a crucible until it reaches its melting point.
    - Skim off impurities or slag to ensure clean metal for casting.
    - Carefully pour the molten metal into the mould cavity through the sprue.
    - Allow the metal to fill the cavity and settle without turbulence to prevent defects.
3. Solidification and Cooling:

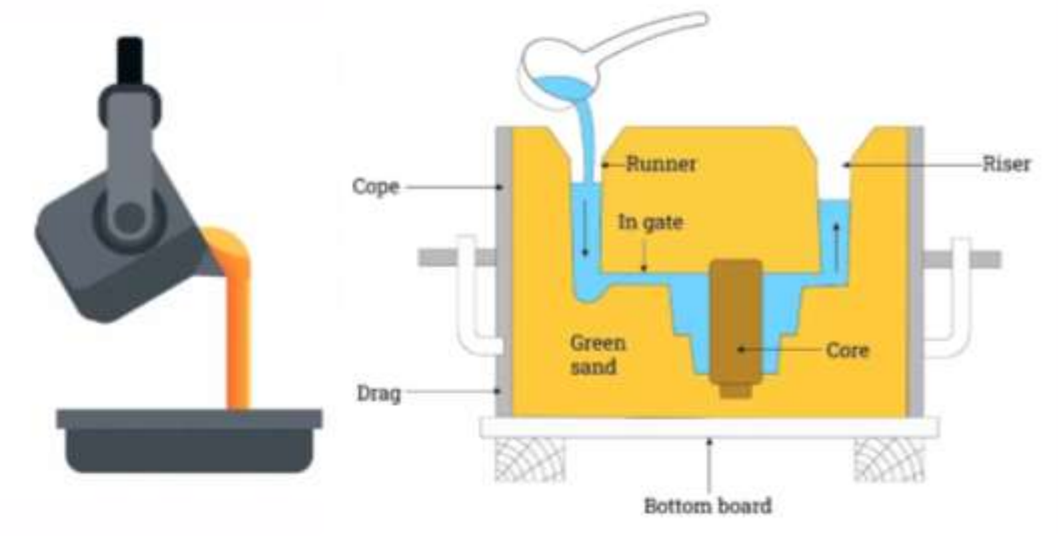
- Let the metal solidify within the mould at a controlled rate.
- Avoid premature disturbance to prevent shrinkage defects or cracks.

4. Casting Removal and Finishing:

- Once cooled, break open the mould to retrieve the solidified casting.
- Remove excess material such as sprues and risers using cutting or grinding tools.
- Conduct surface finishing operations like machining or polishing to improve appearance and dimensional accuracy.

5. Inspection and Testing:

- Visually inspect the casting for surface defects such as cracks, porosity, or misruns.
- Perform non-destructive tests (NDT) or mechanical tests to evaluate structural integrity.



(A) Metal Casting

PROCEDURE:

Step 1: Pattern Preparation

1. Select a suitable pattern with allowances for shrinkage and machining.
2. Clean and apply parting sand on the pattern to prevent sticking.

Step 2: Mould Preparation

3. Place the bottom board on the molding platform.
4. Position the drag flask on the bottom board and place the pattern at the center.
5. Sprinkle dry parting sand over the pattern for easy removal.
6. Fill the drag flask with molding sand and ram it uniformly.
7. Level the surface and make vent holes using a vent rod.
8. Flip the drag flask, place the cope flask on top, and align with dowel pins.
9. Repeat the molding process for the cope flask and create the gating system (sprue, riser, runner, and ingates).
10. Carefully remove the pattern and clean the mold cavity.

Step 3: Metal Pouring

11. Heat the metal in a crucible furnace until it reaches its pouring temperature.
12. Skim off impurities and slag before pouring.
13. Pour the molten metal into the mold cavity through the sprue using a ladle.

Step 4: Solidification and Removal

15. Allow the metal to cool and solidify inside the mold.
16. Break open the sand mold and remove the casting carefully.
17. Trim excess metal, clean the casting, and inspect for defects.

PRECAUTIONS:

1. Ensure the work area is free from moisture to prevent steam explosions.
2. Wear protective gloves, goggles, and heat-resistant clothing.
3. Maintain proper ventilation to prevent inhalation of fumes.
4. Handle molten metal carefully to avoid burns and splashes.
5. Ensure proper gating and riser design to avoid casting defects.

RESULT:

The metal casting process was successfully demonstrated, and the required casting was obtained.

Ex. No: 17

Dt: **TO MAKE SIMPLE PARTS ON A 3D PRINTING MACHINE**

AIM:

To design and fabricate a simple 3D object using a 3D printing machine.

MATERIAL AND EQUIPMENT REQUIRED:

- 3D Printer (FDM, SLA, or SLS)
- Filament material (PLA, ABS, PETG) or resin for SLA printing
- 3D modeling software (Tinkercad, Fusion 360, SolidWorks, etc.)
- Slicing software (Cura, PrusaSlicer, etc.)

TOOLS REQUIRED:

- Spatula (for part removal)
- Sandpaper or file (for finishing)
- Isopropyl alcohol (for cleaning, if resin printing)
- Nozzle cleaning tool (for maintenance)

DESCRIPTION:

3D printing, also known as additive manufacturing, is a process of creating three-dimensional objects by layering material based on a digital model. This technology is widely used in industries such as automotive, healthcare, aerospace, and product prototyping. The quality of a 3D-printed part depends on factors like material selection, print settings, and design optimization. This experiment aims to demonstrate the step-by-step process of making simple parts using a 3D printing machine.

Objective:
The objective of this experiment is to understand the process of designing, slicing, and printing a simple 3D part while evaluating the factors that affect print quality and accuracy.

Materials and Equipment:

- 3D printer (Fused Deposition Modeling (FDM) or Stereolithography (SLA))
- Filament material (PLA, ABS, PETG, or resin for SLA)
- Computer with 3D modeling software (Tinkercad, Fusion 360, or SolidWorks)
- Slicing software (Cura, PrusaSlicer, or Simplify3D)
- SD card or USB for file transfer
- Personal protective equipment (gloves, safety glasses if required)

Process of 3D Printing a Simple Part:

1. Designing the 3D Model:

   - Use 3D modeling software to create a simple part, ensuring proper dimensions and structural integrity.
   - Export the design in STL (Stereolithography) format for compatibility with slicing software.

2. Slicing and Preparing the File:

   - Import the STL file into slicing software.
   - Adjust print settings such as layer height, infill percentage, support structures, and print speed.
   - Generate G-code, which is the machine-readable format for the 3D printer.
   - Save the G-code file onto an SD card or USB drive for printing.

3. 3D Printing Process:

   - Load the selected filament material into the 3D printer.
   - Level the print bed to ensure proper adhesion.
   - Insert the SD card or USB and start the print job.

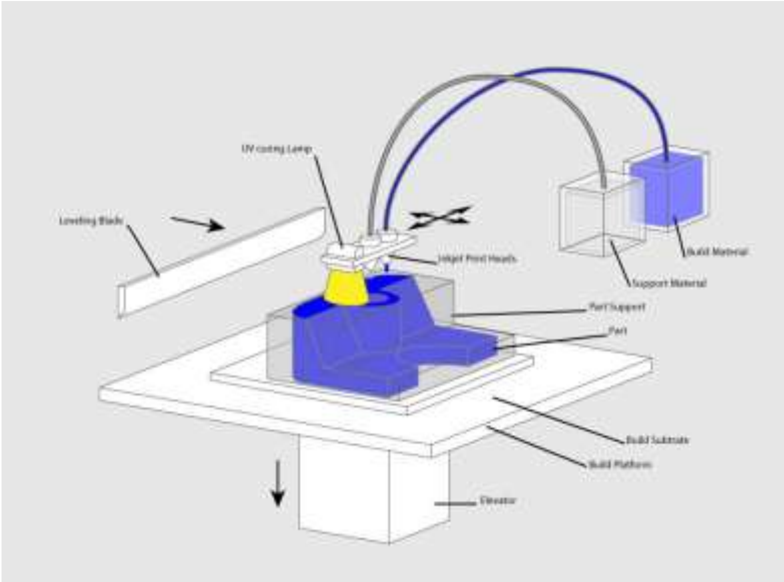
   - Monitor the first few layers to ensure proper extrusion and bed adhesion.

4. Post-Processing and Inspection:

   - Once printing is complete, carefully remove the part from the print bed.
   - Remove any support structures if necessary.
   - Use sanding, painting, or acetone smoothing (for ABS) to improve the surface finish.
   - Inspect the printed part for defects such as warping, layer separation, or under-extrusion.

5. Testing and Evaluation:

   - Measure the printed part dimensions and compare them with the original design.
   - Perform functional testing if applicable.
   - Adjust print settings for future prints based on observations.



(A) Schematic Layout of 3D Printer

PROCEDURE:

Step 1: Designing the 3D Model

1. Open a 3D modeling software and create a simple part (e.g., a cube, keychain, or small mechanical component).
2. Ensure the dimensions are appropriate for the 3D printer's build volume.
3. Save the design file in **STL** or **OBJ** format.

Step 2: Preparing the Model for Printing

4. Open the slicing software (e.g., Cura) and import the STL file.
5. Set print parameters such as layer height, infill density, print speed, and support structures if needed.
6. Generate the **G-code** file and save it onto a USB drive or SD card.

Step 3: Setting Up the 3D Printer

7. Load the required filament into the printer's extruder (for FDM) or fill the resin tank (for SLA).
8. Level the print bed to ensure proper adhesion.
9. Insert the SD card/USB drive and select the G-code file for printing.

Step 4: Printing Process

10. Start the 3D printing process and monitor the initial layers to ensure proper adhesion.
11. Allow the printer to complete the object; this may take minutes to hours depending on the complexity.
12. Once finished, remove the part carefully using a spatula.

Step 5: Post-Processing

13. Remove any support structures if present.
14. Sand the printed part for a smoother finish.
15. If needed, apply paint or surface treatment for enhanced appearance.

PRECAUTIONS:

1. Ensure the print bed is properly leveled for successful printing.
2. Use proper ventilation when printing with materials like ABS to avoid harmful fumes.
3. Keep hands away from the heated nozzle and print bed during operation.
4. Handle resin and chemicals with gloves and wash hands after use.
5. Store filament in a dry place to prevent moisture absorption.

RESULT:

A simple 3D-printed part was successfully fabricated using a 3D printing machine.

REVIEW QUESTIONS:

2. What is 3D printing?
3. What are the different types of 3D printing technologies?
4. What is the role of slicing software in 3D printing?
5. Define infill density in 3D printing.
6. What are common defects in 3D printing, and how can they be avoided?
7. What materials can be used in FDM and SLA printing?
8. Why is bed leveling important in 3D printing?
9. What are the post-processing techniques in 3D printing?

Manufacturing Process

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LAB MANUAL

DEPARTMENT OF MECHANICAL ENGINEERING


Do's:

- Wear appropriate safety gear (gloves, goggles, and aprons).
- Ensure proper machine guarding before operation.
- Keep the workspace clean and free of obstructions.
- Report any spills, accidents, or damaged equipment immediately to the lab supervisor.


Don'ts:

- Do not operate machines without prior training.
- Avoid wearing loose clothing or [illegible]es near rotating machinery.
- Never leave a running machine unattended.