EXPERIMENT NO.: 1.1 Preparation of a Simple job (Wooden Book Stand) by Marking, Cutting, Planning and Finishing as per the Given Drawing/Sketch.

Practical Significance

This experiment develops basic carpentry skills such as measuring, marking, cutting, planing, drilling, assembling, and finishing. It helps students understand the proper use of carpentry tools and promotes safe working practices while producing a useful wooden book stand.

Relevant Program Outcomes (POs)

PO-1 Basic and Discipline Specific Knowledge
PO-2 Problem Analysis
PO-3 Design/Devel opment of Solutions
PO-4 Engineering Tools
PO-5 Engineering Practices for Society, Sustainability and Environment
PO-7 Lifelong Learning

Related Course Outcome(s)

CO	Statement	PO							PSO	
CO1	Undertake wood working operations economically and safely.	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO3
		3	2	2	3	1	-	2		

Laboratory Session Outcomes

After completing this experiment, the student will be able to:
LSO 1.1 Use relevant wood working tools and instruments as per given job.
LSO 1.2 Undertake wood working operations like marking, cutting, plaining and finishing etc.
LSO 1.3 Prepare given wooden joints as per given sketch / drawing.

Practical Skills to be developed.

- Measuring and marking
- Sawing
- Planing
- Chiselling (if required)
- Drilling
- Sanding

- Assembly
- Surface finishing
- Safe handling of carpentry tools.

Minimum Theoretical Background

A book stand is a simple utility product manufactured from wooden pieces joined together using screws, nails or adhesive. The experiment involves sequential operations including measuring, marking, cutting, planing, drilling, assembling and finishing. Proper selection and use of carpentry tools ensure dimensional accuracy and good workmanship.

Circuit Diagram/Layout/Experimental Setup

Base Plate, Back Support, Front Stop, Side Supports, Hinged Support (if applicable)
Material: Seasoned Softwood/Plywood
Typical Dimensions
Height: 200 mm
Width: 300 mm
Base: 300 × 180 mm
Thickness: 12–18 mm

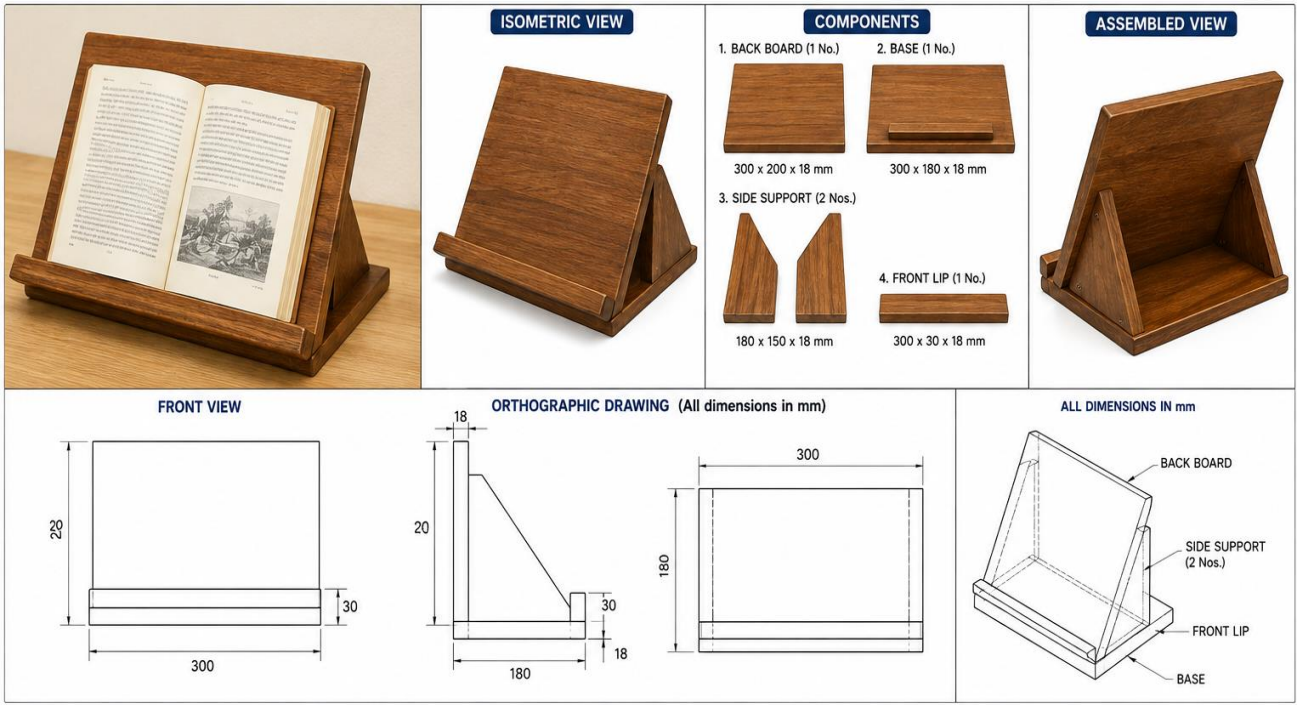


Fig.1. wooden book stand

Resources Required

Material: Softwood/Plywood (12–18 mm thick), Wood screws/Nails, Wood adhesive, Sand paper

Tools & Equipment: Steel Rule, Try Square, Marking Gauge, Pencil, Hand Saw, Jack Plane, Chisel, Wooden Mallet, Bench Vice, Hand Drill, Screw Driver, File**.**

PPE: Apron, Safety Shoes, Safety Goggles

Precautions

1. Wear PPE before starting work.
2. Check all tools before use.
3. Hold the workpiece firmly in the vice.
4. Cut away from the body.
5. Plane along the grain.
6. Keep cutting tools sharp.
7. Remove wood chips using a brush.
8. Do not leave tools on the workbench.
9. Maintain cleanliness.
10. Return all tools after completion.

Procedure

1. Study the given drawing.
2. Select suitable wooden stock.
3. Measure and mark all dimensions.
4. Cut the wooden pieces using a hand saw.
5. Plane surfaces to obtain the required dimensions.
6. Prepare joints if required.
7. Drill holes for screws where necessary.
8. Assemble the components using adhesive and screws.
9. Check dimensions and squareness.
10. Finish the surface using sand paper.
11. Inspect the completed book stand.

Observations and Calculations

Observation Table

Sl. No.	Parameter	Specified	Measured
1	Overall Height	250 mm	_____

Sl. No.	Parameter	Specified	Measured
2	Overall Width	300 mm	_____
3	Base Length	300 mm	_____
4	Base Width	200 mm	_____
5	Material Thickness	12 mm	_____
6	Surface Finish	Smooth	_____
7	Squareness	Yes/No	_____
8	Workmanship	Good/Fair/Poor	_____

Results

A simple wooden book stand was successfully prepared according to the given drawing using marking, cutting, planing and finishing operations.

Interpretation of Results.

- Dimensions are within permissible tolerance.
- Surfaces are smooth and properly finished.
- Components are correctly assembled.
- Book stand is stable and functional.
- Good workmanship indicates correct use of carpentry tools.

Conclusions and Recommendations

Conclusion
The experiment successfully demonstrated the preparation of a simple wooden book stand using standard carpentry operations while following safe workshop practices.

Recommendations

- Ensure accurate marking before cutting.
- Use sharp tools for better finish.
- Plane along the grain direction.
- Check dimensions frequently.
- Apply finishing carefully to improve appearance.

Practical Related Questions

1. Why is seasoning of wood necessary?
2. Name any five carpentry tools.
3. What is the function of a try square?
4. Why is planing performed?
5. What is the difference between softwood and hardwood?

6. Why should wood be clamped before cutting?
7. Which tool is used for drilling holes in wood?
8. What is the purpose of sand paper?
9. State two safety precautions in carpentry.
10. List two applications of a wooden book stand.

References / Suggestions for Further Reading

1. P. N. Rao, *Manufacturing Technology*, Vol. I, McGraw-Hill.
2. S. K. Hajra Choudhury, *Workshop Technology*, Vol. I, Media Promoters.
3. B. S. Raghuwanshi, *Workshop Technology*, Dhanpat Rai Publications.
4. SBTE Bihar Mechanical Engineering Workshop Practice Manual.
5. BIS Standards for Carpentry Tools and Timber.

Assessment Scheme (Combined Process and Product Rubrics)

A. Process Assessment Rubrics (20 Marks)

Assessment Criteria	Weightage	Level 4 – Excellent	Level 3 – Good	Level 2 – Satisfactory	Level 1 – Needs Improvement
1. Drawing Interpretation and Planning	**4**	**4 Marks** – Correctly interprets the drawing/sketch, identifies dimensions and plans the complete sequence of operations independently.	**3 Marks** – Correctly interprets the drawing with minor guidance and plans most operations correctly.	**2 Marks** – Requires guidance to understand the drawing and sequence of operations.	**1 Mark** – Unable to interpret the drawing correctly or plan the work.
2. Selection and Safe Use of Tools	**4**	**4 Marks** – Selects appropriate tools independently and uses them correctly and safely throughout the experiment.	**3 Marks** – Selects suitable tools with minor errors in handling or safety.	**2 Marks** – Requires assistance in selecting or using tools safely.	**1 Mark** – Selects inappropriate tools or handles them unsafely.

Assessment Criteria	Weightage	Level 4 – Excellent	Level 3 – Good	Level 2 – Satisfactory	Level 1 – Needs Improvement
3. Execution of Marking, Cutting, Planing and Finishing	**6**	**6 Marks** – Performs all operations accurately, systematically and confidently with excellent workmanship.	**4.5 Marks** – Performs all operations with minor procedural or workmanship errors.	**3 Marks** – Completes the work with frequent guidance and noticeable errors.	**1.5 Marks** – Unable to perform operations correctly or complete the work satisfactorily.
4. Safety Practices and Housekeeping	**3**	**3 Marks** – Consistently follows safety rules, uses PPE correctly and maintains a clean workplace.	**2.25 Marks** – Follows safety practices with occasional reminders.	**1.5 Marks** – Requires frequent reminders to follow safety practices and maintain housekeeping.	**0.75 Mark** – Frequently ignores safety practices and workplace cleanliness.
5. Work Discipline and Time Management	**3**	**3 Marks** – Completes the job within the allotted time and demonstrates excellent discipline and work ethics.	**2.25 Marks** – Completes the work with minor delay while maintaining acceptable discipline.	**1.5 Marks** – Requires additional time and supervision to complete the work.	**0.75 Mark** – Fails to complete the work within the allotted time and requires continuous supervision.

B. Product Assessment Rubrics (10 Marks)

Assessment Criteria	Weightage	Level 4 – Excellent	Level 3 – Good	Level 2 – Satisfactory	Level 1 – Needs Improvement
1. Dimensional Accuracy	**4**	**4 Marks** – All dimensions are within the specified tolerance and conform to the drawing.	**3 Marks** – Minor dimensional deviations that do not affect functionality.	**2 Marks** – Noticeable dimensional errors requiring correction.	**1 Mark** – Significant dimensional errors; job does not conform to the drawing.

Assessment Criteria	Weightage	Level 4 – Excellent	Level 3 – Good	Level 2 – Satisfactory	Level 1 – Needs Improvement
2. Surface Finish	**3**	**3 Marks** – Surface is smooth, uniform and free from tool marks, splinters and defects.	**2.25 Marks** – Good surface finish with minor tool marks or roughness.	**1.5 Marks** – Acceptable finish with noticeable roughness or uneven planing.	**0.75 Mark** – Poor surface finish with major defects or improper planing.
3. Overall Appearance and Quality	**3**	**3 Marks** – Job is neat, square, properly finished and demonstrates excellent workmanship.	**2.25 Marks** – Job is neat with minor imperfections in appearance.	**1.5 Marks** – Job is complete but has visible defects affecting appearance.	**0.75 Mark** – Job is poorly finished, defective or incomplete.

EXPERIMENT NO.: 1.2 Preparation of Any Two Wooden Joints out of following Safely as per the Given Drawing Using Suitable Hand Tools (Mortise Joint, Dovetail Joint, Half Lap Joint, Cross Joint, Tenon Joint or Bridle Joint)

Practical Significance

Wooden joints are essential in woodworking for assembling two or more wooden members without compromising strength, alignment, and appearance. They are widely used in furniture manufacturing, doors, windows, wooden frames, patterns, and structural assemblies. This experiment develops students' skills in reading engineering drawings, accurate marking, cutting, chiselling, fitting, and finishing while emphasizing safe workshop practices.

Relevant Program Outcomes (POs)

PO-1 Basic and Discipline Specific Knowledge
PO-2 Problem Analysis
PO-3 Design/Devel opment of Solutions
PO-4 Engineering Tools
PO-5 Engineering Practices for Society, Sustainability and Environment
PO-7 Lifelong Learning

Related Course Outcome(s)

CO	Statement	PO							PSO	
CO1	Undertake wood working operations economically and safely.	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2
		3	2	2	3	1	-	2		

Laboratory Session Outcomes

After completing this experiment, the student will be able to:
LSO 1.1 Use relevant wood working tools and instruments as per given job.
LSO 1.2 Undertake wood working operations like marking, cutting, plaining and finishing etc.
LSO 1.3 Prepare given wooden joints as per given sketch / drawing.

Practical Skills

Students will develop the ability to:
- Read workshop drawings.
- Measure and mark accurately.

- Perform sawing and chiseling operations.
- Plane wooden surfaces.
- Assemble mating parts.
- Check dimensional accuracy and fit.
- Produce neat finished joints.

Minimum Theoretical Background

A wooden joint is the connection formed between two or more wooden members to obtain strength, rigidity, and accurate alignment.

Common Wooden Joints

Joint	**Application**
Mortise and Tenon Joint	Door and window frames
Dovetail Joint	Drawers and boxes
Half Lap Joint	Frames and partitions
Cross Joint	Wooden grids and partitions
Bridle Joint	Frames and furniture
Tenon Joint	Structural wooden assemblies

Basic Operations: Measuring, Marking, Sawing, Chiselling, Planing, Trial fitting Finishing

Circuit Diagram/Layout/Experimental Setup

Suggested Job Specifications

Woodworking Bench, Bench Vice, Wooden Pieces, Measuring and Marking Tools, Hand Saw, Chisels, Jack Plane, Wooden Mallet, Sandpaper

(Students should draw a neat labelled sketch of the selected wooden joint and the woodworking bench setup.)

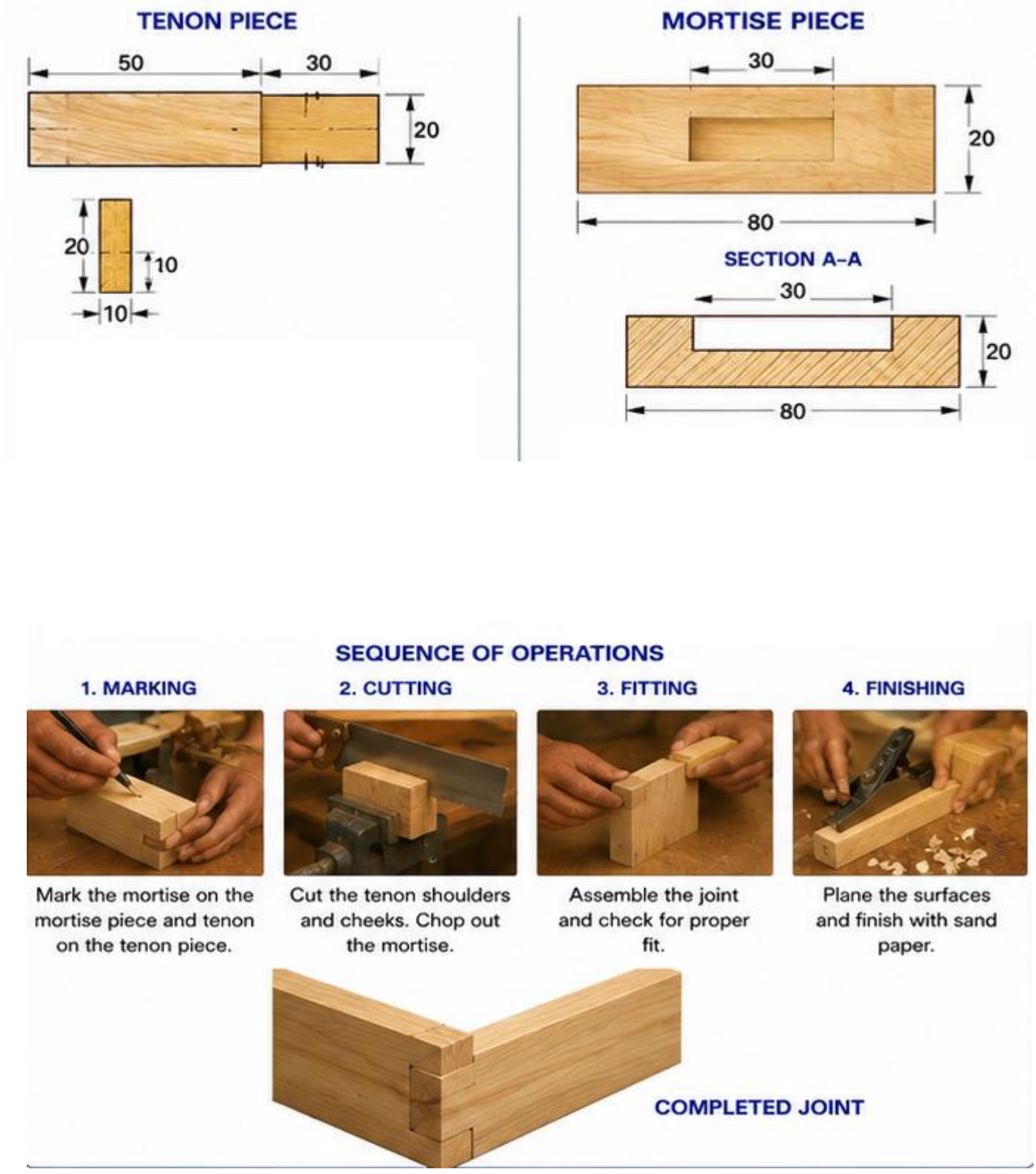


Fig. 2. Tenon and mortoise Joint

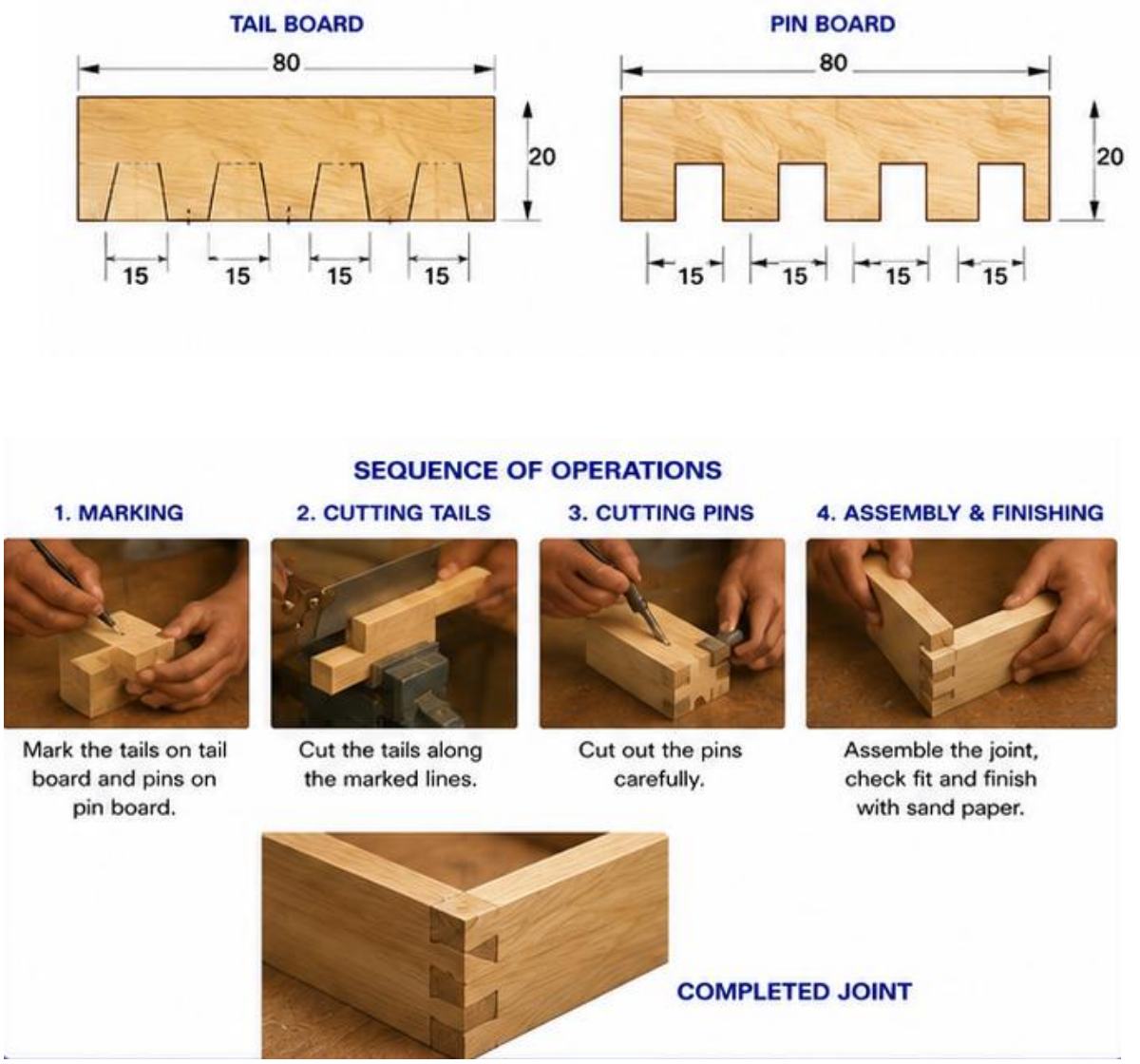


Fig. 3. Dovetail joint

Resources Required

Material: Softwood pieces (Pine/Deodar or equivalent)

Tools: Steel Rule, Try Square, Marking Gauge, Pencil, Hand Saw, Jack Plane, Firmer, Chisel, Wooden Mallet, Bench Vice, Sandpaper

Safety Equipment: Safety Goggles, Apron, Dust Mask

Precautions

1. Wear safety goggles and apron.
2. Clamp the work securely before cutting.

3. Use sharp and undamaged tools.
4. Keep hands away from cutting edges.
5. Mark dimensions carefully before sawing.
6. Remove wood gradually while chiselling.
7. Check the fit frequently during assembly.
8. Clean the workplace after completion.

Procedure

1. Study the given drawing of the selected wooden joints.
2. Select suitable wooden pieces.
3. Measure and mark dimensions accurately.
4. Secure the workpiece in the vice.
5. Cut along the marked lines using a hand saw.
6. Remove waste material using chisels.
7. Plane the surfaces to obtain accurate dimensions.
8. Assemble the mating parts without forcing.
9. Check alignment and fitting.
10. Finish the joint using sandpaper.
11. Repeat the same procedure for the second wooden joint.
12. Inspect both finished joints.

Observations and Calculations

Observation Table

Parameter	**Joint 1**	**Joint 2**
Type of Joint		
Length (mm)		
Width (mm)		
Thickness (mm)		
Fit (Loose/Tight/Correct)		
Surface Finish		
Alignment		

Dimensional Error

Error=|Specified Dimension−Measured Dimension|

Results

Two wooden joints were successfully prepared according to the given drawing using appropriate woodworking tools while maintaining acceptable dimensional accuracy, proper fitting, and satisfactory surface finish.

Interpretation of Results

- Correct marking improved dimensional accuracy.
- Proper sawing and chiselling ensured good fitting.
- Smooth planing enhanced the surface finish.
- Accurate alignment resulted in strong joints.
- Minor gaps indicate errors in marking or cutting.

Conclusions and Recommendations

Conclusion

The experiment demonstrated the correct method of preparing wooden joints using standard woodworking tools. Students developed skills in measuring, marking, cutting, chiselling, fitting, and finishing while following safe workshop practices.

Recommendations

- Verify all dimensions before cutting.
- Use sharp chisels for accurate fitting.
- Avoid excessive force during assembly.
- Plane along the wood grain.
- Check fitting frequently to avoid over-cutting.
- Maintain cleanliness and proper tool storage.

Practical Related Questions

1. Define a wooden joint.
2. State the purpose of a mortise and tenon joint.
3. List the applications of a dovetail joint.
4. Differentiate between a half lap joint and a cross joint.
5. Explain the function of a marking gauge.
6. Why is trial fitting important?
7. State the purpose of a chisel.
8. List the woodworking operations involved in joint preparation.
9. Mention four safety precautions followed during woodworking.
10. Explain the importance of dimensional accuracy in wooden joints.

References / Suggestions for Further Reading

1. Hajra Choudhury, S. K**.,** Elements of Workshop Technology, Vol. I, Media Promoters & Publishers.
2. P. N. Rao, Manufacturing Technology, McGraw Hill Education.
3. B. S. Raghuwanshi, Workshop Technology, Dhanpat Rai Publications.
4. Government Polytechnic Workshop Practice Manual.
5. BIS Workshop Safety Guidelines.
6. All images are AI generated

Assessment Scheme (Combined Process and Product Rubrics)

A. Process Assessment Rubrics (20 Marks)

Assessment Criteria	**Weightage**	**Level 4 – Excellent**	**Level 3 – Good**	**Level 2 – Satisfactory**	**Level 1 – Needs Improvement**
1. Drawing Interpretation and Work Planning	**4**	**4 Marks** – Correctly interprets the drawing, identifies dimensions and plans the sequence of operations independently.	**3 Marks** – Interprets the drawing correctly with minor guidance and plans most operations appropriately.	**2 Marks** – Requires guidance to understand the drawing and sequence of operations.	**1 Mark** – Unable to interpret the drawing or plan the work correctly.
2. Selection and Safe Use of Hand Tools	**4**	**4 Marks** – Selects appropriate hand tools independently and uses them correctly, safely and efficiently throughout the work.	**3 Marks** – Selects suitable tools with minor errors in handling or safety.	**2 Marks** – Requires assistance in tool selection or safe handling.	**1 Mark** – Selects inappropriate tools or uses them unsafely.

Assessment Criteria	Weightage	Level 4 – Excellent	Level 3 – Good	Level 2 – Satisfactory	Level 1 – Needs Improvement
3. Joint Preparation Procedure	**6**	**6 Marks** – Performs marking, cutting, chiselling, fitting and assembly systematically with excellent workmanship and minimal errors.	**4.5 Marks** – Completes all operations with minor procedural or workmanship errors.	**3 Marks** – Completes operations with frequent guidance and noticeable errors.	**1.5 Marks** – Unable to perform operations correctly or complete the joints satisfactorily.
4. Safety Practices and Housekeeping	**3**	**3 Marks** – Consistently follows safety rules, uses PPE correctly and maintains a clean and organized workplace.	**2.25 Marks** – Follows safety practices with occasional reminders.	**1.5 Marks** – Requires frequent reminders regarding safety and housekeeping.	**0.75 Mark** – Frequently neglects safety practices and workplace cleanliness.
5. Work Discipline and Time Management	**3**	**3 Marks** – Completes both joints within the allotted time while maintaining excellent discipline and work ethics.	**2.25 Marks** – Completes work with minor delay and minimal supervision.	**1.5 Marks** – Requires additional time and supervision.	**0.75 Mark** – Fails to complete the assigned work within the allotted time.

B. Product Assessment Rubrics (10 Marks)

Assessment Criteria	Weightage	Level 4 – Excellent	Level 3 – Good	Level 2 – Satisfactory	Level 1 – Needs Improvement
1. Dimensional Accuracy of Joints	**4**	**4 Marks** – Both joints conform to the drawing with dimensions within the specified tolerance.	**3 Marks** – Minor dimensional deviations that do not affect assembly or function.	**2 Marks** – Noticeable dimensional errors affecting fit.	**1 Mark** – Significant dimensional errors; joints do not conform to the drawing.
2. Fit and Finish of Joints	**3**	**3 Marks** – Joints fit accurately with smooth surfaces, clean edges and no visible gaps or defects.	**2.25 Marks** – Good fit with minor gaps or tool marks.	**1.5 Marks** – Acceptable fit with noticeable gaps or rough surfaces.	**0.75 Mark** – Poor fit, rough finish or defective joints.
3. Overall Quality and Workmanship	**3**	**3 Marks** – Both joints are neat, properly assembled, well finished and demonstrate excellent craftsmanship.	**2.25 Marks** – Good overall appearance with minor imperfections.	**1.5 Marks** – Functional joints with visible workmanship defects.	**0.75 Mark** – Poor workmanship, incomplete or defective joints.

EXPERIMENT NO.: 2.1 Select Different Fitting Tools, Equipment, Machines and Measuring Instruments for preparation of a Simple Fitting Job (Square of 50 mm × 50 mm or Square of 40 mm × 40 mm with Ø5 mm Hole at Centre).

Practical Significance

Selection of appropriate fitting tools, equipment, machines, and measuring instruments is a fundamental skill in mechanical workshop practice. Proper selection ensures safe working, dimensional accuracy, improved productivity, reduced material wastage, and quality workmanship. This experiment develops students' ability to identify and select suitable resources for various fitting operations based on the job requirement.

Relevant Program Outcomes (POs)

PO-1 Basic and Discipline Specific Knowledge
PO-2 Problem Analysis
PO-3 Design/Devel opment of Solutions
PO-4 Engineering Tools
PO-5 Engineering Practices for Society, Sustainability and Environment
PO-7 Lifelong Learning

Related Course Outcome(s)

CO	Statement	PO							PSO	
CO2	Carryout fitting and turning operations properly in a given situation.	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO3
		3	2	2	3	2	-	2		

Laboratory Session Outcomes

After completing this experiment, the student will be able to:

LSO 2.1 Prepare list of relevant tools, equipment, machines and measuring instruments used in fitting shop as per given situation

Practical Skills

1. Students will develop the ability to:
2. Identify fitting tools and equipment.
3. Select suitable measuring instruments.
4. Match tools with workshop operations.
5. Inspect tools for serviceability.
6. Apply safety practices while handling tools.
7. Organize tools systematically.

Minimum Theoretical Background

Fitting is the process of assembling, shaping, finishing, and adjusting metal parts using hand tools and machines to obtain the required dimensions and fit.

Classification of Fitting Resources

Holding Tools: Bench Vice, Hand Vice, C-Clamp, Machine Vice

Marking Tools: Surface Plate, Scriber, Surface Gauge, Divider, Centre Punch, Try Square

Cutting Tools: Hacksaw, Cold Chisel, Snips

Finishing Tools: Files (Flat, Round, Half-round, Square, Triangular)

Striking Tools: Ball Peen Hammer, Mallet

Measuring Instruments: Steel Rule, Vernier Caliper, Outside Micrometer,

Inside Caliper, Feeler Gauge, Try Square

Machines Used in Fitting Shop: Bench Grinder, Drilling Machine, Power,

Hacksaw, Pedestal Grinder

Circuit Diagram/Layout/Experimental Setup

Arrange the following on a fitting workbench: Bench Vice, Set of Files, Hacksaw Chisels, Hammers, Vernier Caliper, Micrometer, Steel Rule, Try Square, Surface Plate, Drilling Machine, Bench Grinder

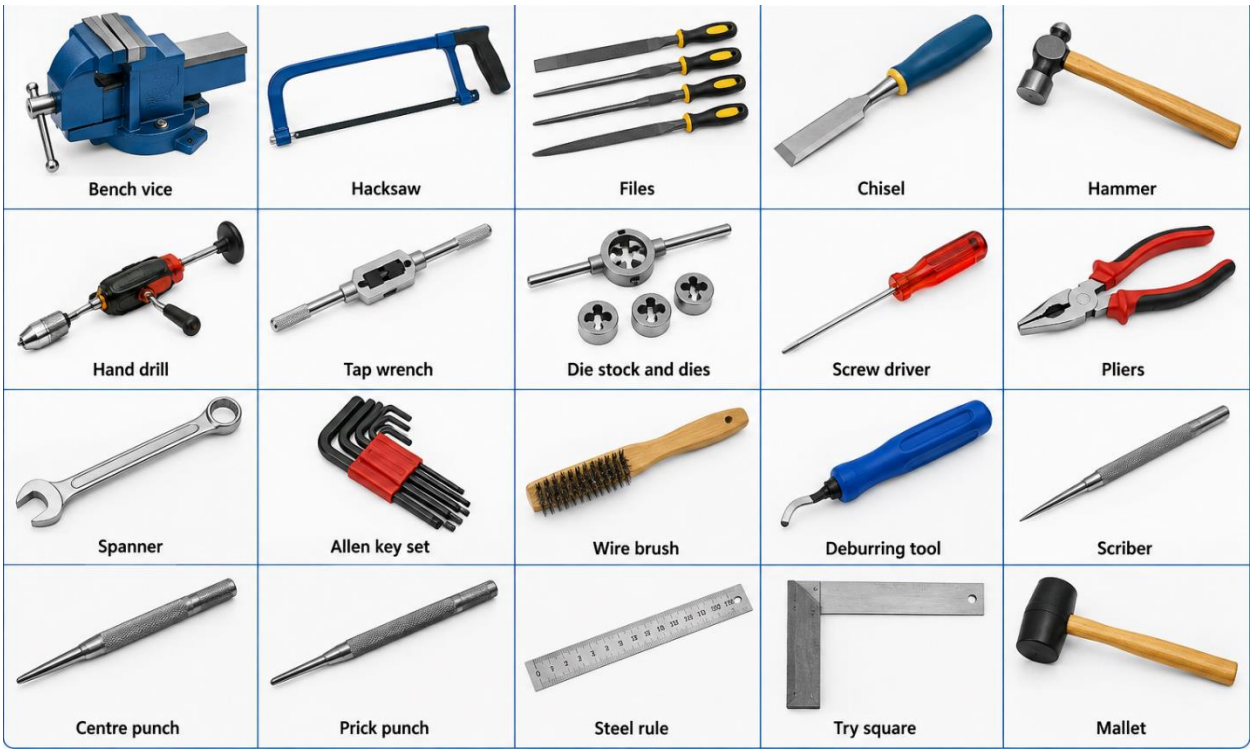


Fig.4. Fitting tools



Fig.5. Fitting Equipments

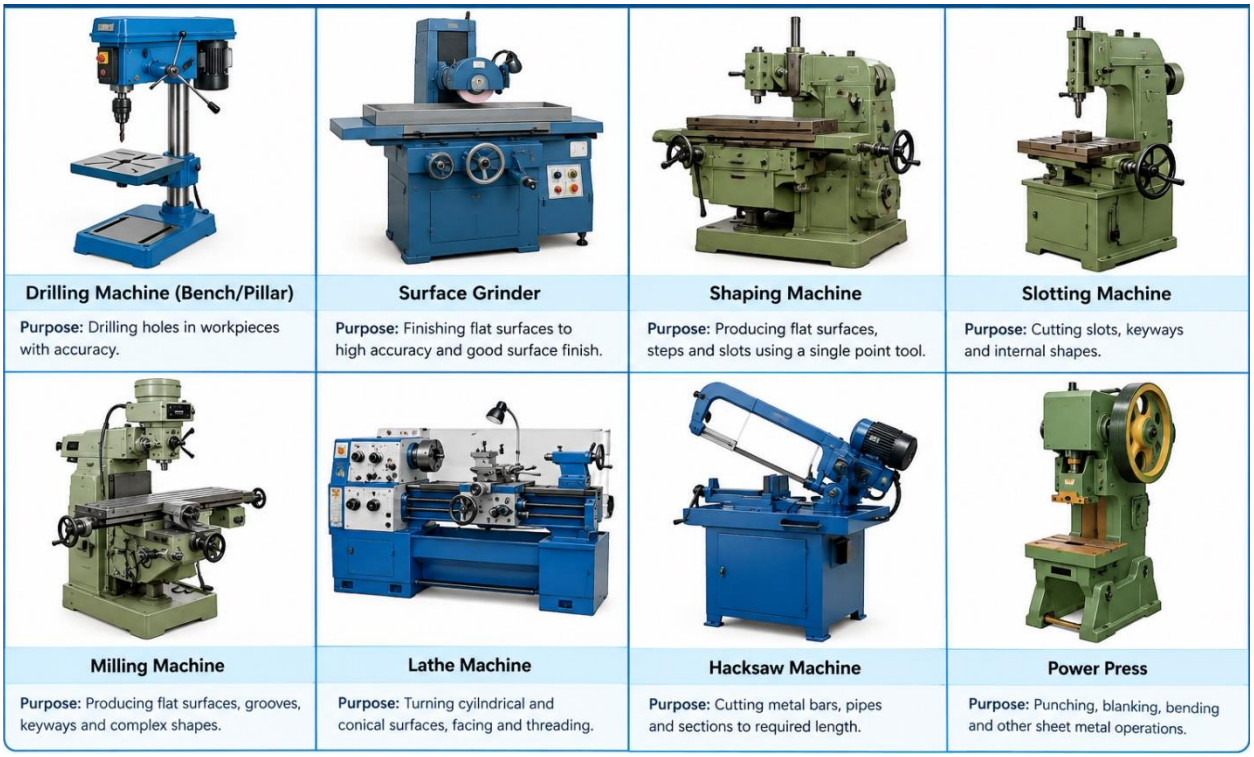


Fig.6. Fitting machines



Fig.7. Fitting Equipments

Resources Required

Equipment: Fitting Bench, Bench Vice, Drilling Machine, Bench Grinder.

Tools: Hacksaw, Files, Chisels, Ball Peen Hammer, Centre Punch, Scriber, Divider, Try Square

Measuring Instruments: Steel Rule, Vernier Caliper, Micrometer, Feeler Gauge

Safety Equipment: Safety Goggles, Apron, Safety Shoes, Gloves

Precautions

1. Wear appropriate personal protective equipment (PPE).
2. Inspect tools before use.
3. Use only the correct tool for the intended operation.
4. Handle measuring instruments carefully.
5. Return tools to their designated locations after use.
6. Avoid using damaged or worn-out tools.
7. Maintain cleanliness of the workbench.
8. Follow all workshop safety rules.

Procedure

1. Study the given workshop situation or job requirement.
2. Identify the operations to be performed (e.g., marking, cutting, filing, drilling, measuring).
3. Select suitable hand tools for each operation.
4. Select the required measuring instruments based on the desired accuracy.
5. Select appropriate machines, if required.
6. Justify the selection of each tool and instrument.
7. Demonstrate the correct method of handling the selected tools.
8. Record the selected tools and their applications in the observation table.
9. Return all tools to their proper places after completion.

Observations and Calculations

Observation Table

Sl. No.	Workshop Operation	Selected Tool/Equipment	Selected Measuring Instrument	Reason for Selection
1	Marking			
2	Cutting			
3	Filing			
4	Drilling			
5	Measuring			
6	Inspection			

Note: No numerical calculations are required. Assessment is based on the correctness and justification of the selected tools and instruments.

Results

Suitable fitting tools, equipment, machines, and measuring instruments were correctly selected for the given workshop situation in accordance with the required operations and standard workshop practices.

Interpretation of Results

Appropriate selection of tools improved efficiency and accuracy.
Suitable measuring instruments ensured reliable dimensional inspection.
Correct selection of machines reduced manual effort.
Improper tool selection may lead to poor workmanship, damage to the workpiece, and unsafe working conditions.

Conclusions and Recommendations

Conclusion

The experiment enabled students to identify and select appropriate fitting tools, equipment, machines, and measuring instruments for different workshop operations. Proper selection contributes to improved productivity, dimensional accuracy, and workplace safety.

Recommendations

- Select tools according to the operation and material.
- Choose measuring instruments based on the required precision.
- Inspect tools regularly for wear and damage.
- Handle measuring instruments carefully to maintain accuracy.
- Store tools properly after use.
- Always follow workshop safety procedures.

Practical Related Questions

1. Classify fitting tools into holding, marking, cutting, and finishing tools.
2. State the function of a bench vice.
3. Explain the purpose of a try square.
4. Select a suitable tool for cutting a metal bar.
5. Which measuring instrument is used for measuring an outside diameter accurately?
6. State the application of a Vernier caliper.
7. Why should damaged tools not be used?
8. Differentiate between a file and a hacksaw.
9. List the machines commonly used in a fitting shop.
10. Explain the importance of selecting the correct measuring instrument.

References / Suggestions for Further Reading

1. S. K. Hajra Choudhury, Elements of Workshop Technology, Vol. I, Media Promoters & Publishers.
2. P. N. Rao, Manufacturing Technology, McGraw Hill Education.
3. B. S. Raghuwanshi, Workshop Technology, Dhanpat Rai Publications.
4. Government Polytechnic Workshop Practice Manual.
5. BIS Workshop Safety Guidelines.
6. NIMI, Engineering Workshop Practice.
7. All images are AI generated

Assessment Scheme (Combined Process and Product Rubrics)

A. Process Assessment Rubrics (20 Marks)

Assessment Criteria	Weightage	Level 4 – Excellent	Level 3 – Good	Level 2 – Satisfactory	Level 1 – Needs Improvement
1. Identification and Interpretation of Workshop Requirement	**4**	**4 Marks** – Correctly identifies the workshop task and selects the appropriate category of tools, equipment, machines and measuring	**3 Marks** – Correctly identifies most requirements with minor guidance.	**2 Marks** – Identifies requirements with frequent guidance.	**1 Mark** – Unable to identify the workshop requirement correctly.

Assessment Criteria	Weightage	Level 4 – Excellent	Level 3 – Good	Level 2 – Satisfactory	Level 1 – Needs Improvement
		instruments independently.			
2. Selection of Tools, Equipment and Measuring Instruments	**5**	**5 Marks** – Selects all appropriate tools, equipment and measuring instruments suitable for the given workshop situation without assistance.	**3.75 Marks** – Selects most items correctly with minor errors.	**2.5 Marks** – Selects some appropriate items but requires guidance.	**1.25 Marks** – Incorrect selection of most tools and instruments.
3. Demonstration of Proper Handling and Usage	**5**	**5 Marks** – Demonstrates correct handling, operating method and purpose of all selected tools and	**3.75 Marks** – Demonstrates correct handling with minor errors.	**2.5 Marks** – Requires guidance for proper handling and usage.	**1.25 Marks** – Unable to demonstrate correct handling or usage.

Assessment Criteria	Weightage	Level 4 – Excellent	Level 3 – Good	Level 2 – Satisfactory	Level 1 – Needs Improvement
		instruments confidently.			
4. Safety Practices and Housekeeping	**3**	**3 Marks** – Consistently follows safety practices, handles tools safely and maintains an organized workplace.	**2.25 Marks** – Follows safety practices with occasional reminders.	**1.5 Marks** – Requires frequent reminders regarding safety and housekeeping.	**0.75 Mark** – Frequently ignores safety rules and workplace cleanliness.
5. Work Discipline and Communication	**3**	**3 Marks** – Completes the activity within the allotted time, communicates technical information clearly and demonstrates profession	**2.25 Marks** – Completes the activity with minor delay and communicates adequately.	**1.5 Marks** – Requires supervision for completing the activity and communication.	**0.75 Mark** – Incomplete activity with poor communication and discipline.

Assessment Criteria	Weightage	Level 4 – Excellent	Level 3 – Good	Level 2 – Satisfactory	Level 1 – Needs Improvement
		al behaviour.			

B. Product Assessment Rubrics (10 Marks)

Assessment Criteria	Weightage	Level 4 – Excellent	Level 3 – Good	Level 2 – Satisfactory	Level 1 – Needs Improvement
1. Accuracy of Tool and Instrument Selection	**4**	**4 Marks** – All selected tools, equipment, machines and measuring instruments are fully appropriate for the assigned workshop task.	**3 Marks** – Minor errors in selection without affecting task suitability.	**2 Marks** – Several inappropriate selections requiring correction.	**1 Mark** – Most selected items are inappropriate.
2. Justification of Selection	**3**	**3 Marks** – Clearly explains the purpose, application and selection criteria for each selected item.	**2.25 Marks** – Explains most selections correctly with minor omissions.	**1.5 Marks** – Provides partial explanation with noticeable gaps.	**0.75 Mark** – Unable to justify the selections satisfactorily.
3. Overall Accuracy and Presentation	**3**	**3 Marks** – Selection sheet, observations	**2.25 Marks** – Good presentation	**1.5 Marks** – Acceptable presentation	**0.75 Mark** – Poor presentation, incomplete or

Assessment Criteria	Weightage	Level 4 – Excellent	Level 3 – Good	Level 2 – Satisfactory	Level 1 – Needs Improvement
		and presentation are complete, neat, accurate and well organized.	with minor errors.	with noticeable mistakes.	inaccurate work.

EXPERIMENT NO.: 2.3 Preparation of a Simple Fitting Job (Square of 50 mm × 50 mm or Square of 40 mm × 40 mm with Ø5 mm Hole at Centre) by Marking, Filing, Punching, Drilling and Finishing as per the Given Drawing/Sketch.

Practical Significance

Fitting is one of the most important basic manufacturing processes used for producing accurate components by manual operations. It develops precision, workmanship, and the ability to produce components within specified tolerances. This experiment provides practical exposure to measuring, marking, filing, centre punching, drilling, and finishing operations, which are essential skills for manufacturing, maintenance, repair, and assembly work in mechanical industries.

Relevant Program Outcomes (POs)

PO-1 Basic and Discipline Specific Knowledge
PO-2 Problem Analysis
PO-3 Design/Devel opment of Solutions
PO-4 Engineering Tools
PO-5 Engineering Practices for Society, Sustainability and Environment
PO-7 Lifelong Learning

Related Course Outcome(s)

CO	Statement	PO							PSO	
CO2	Carryout fitting and turning operations properly in a given situation.	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO3
		3	2	2	3	2	-	2		

Laboratory Session Outcomes

After completing this experiment, the student will be able to:
LSO 2.1 Prepare list of relevant tools, equipment, machines and measuring instruments used in fitting shop as per given situation.
LSO 2.2 Perform marking, cutting, filing, punching, drilling, and finishing operations as per given fitting job safely.
LSO 2.3 Select relevant single point cutting tool and associated parameters for a given turning job.
LSO 2.4 Undertake turning operations economically and safely in a given situation

Practical Skills

- Students will be able to:
- Measure dimensions accurately.
- Perform marking using layout tools.
- Use files correctly to obtain accurate dimensions.
- Perform centre punching.
- Drill holes using a bench drilling machine.
- Finish and inspect the workpiece.
- Maintain workshop safety and housekeeping.

Minimum Theoretical Background

Fitting is the process of removing small amounts of material manually to obtain accurate dimensions and proper fit between mating parts.
Operations Performed: Measuring, Marking, Centre Punching, Filing , Drilling, Deburring, Finishing, Inspection.

Tools Used

Tool	**Application**
Steel Rule	Measurement
Scriber	Marking
Try Square	Checking squareness
Divider	Marking circles and centre
Centre Punch	Locating drill position
Ball Peen Hammer	Punching
Bench Vice	Holding workpiece
Flat File	Filing
Bench Drilling Machine	Drilling
Vernier Caliper	Dimensional inspection

Circuit Diagram/Layout/Experimental Setup

Experimental Setup

Fitting Bench with Bench Vice, Surface Plate, Marking Tools, Bench Drilling Machine, Measuring Instruments, Files, Mild Steel Flat Workpiece

(Students should draw a neat labelled layout of the fitting bench and drilling machine showing the arrangement of tools.)

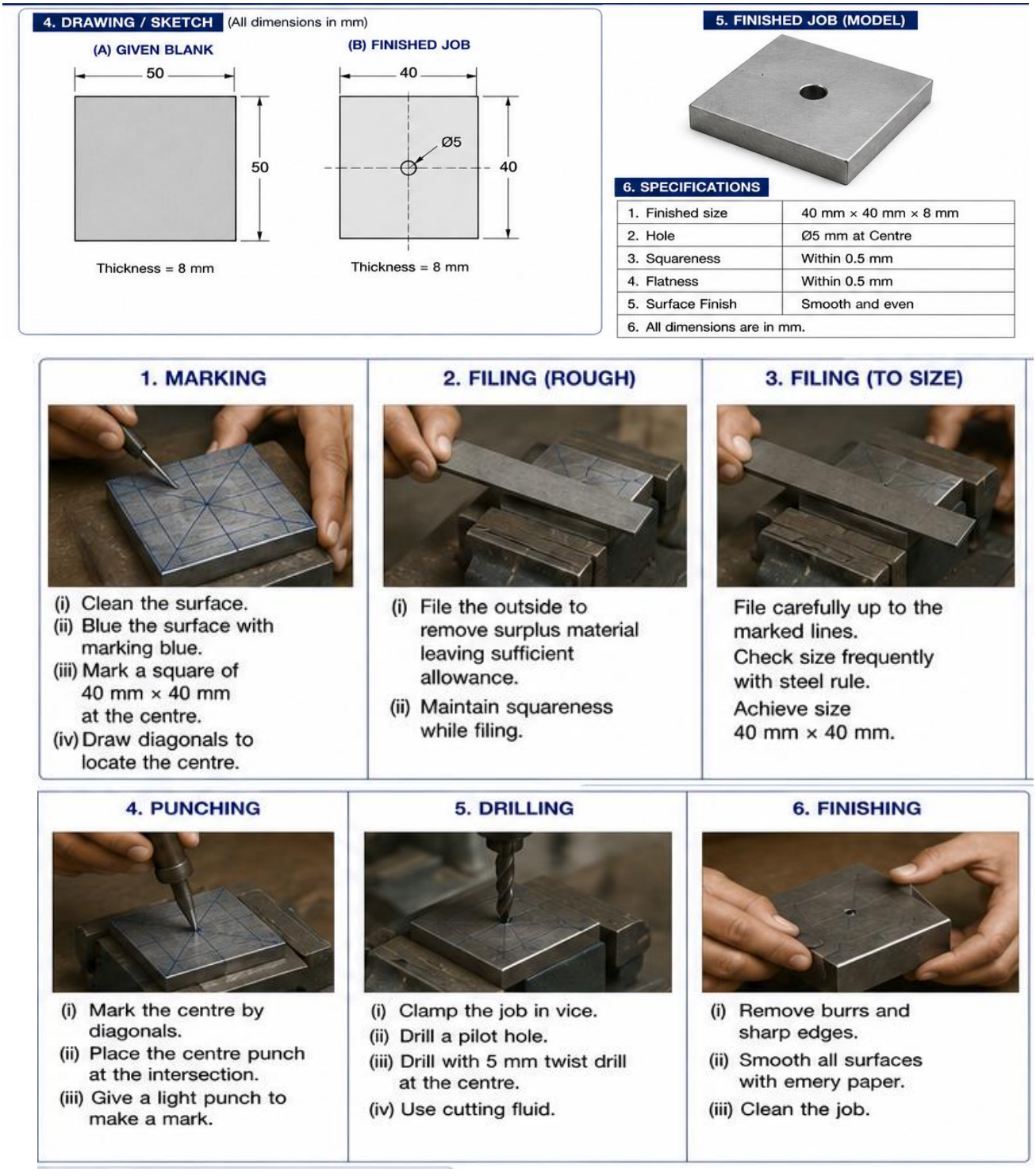


Fig. 8. Fitting Job (Square of 50 mm × 50 mm or Square of 40 mm × 40 mm with Ø5 mm Hole at Centre)

Resources Required

Material: Mild Steel Flat (approximately 60 mm × 60 mm × 6 mm)

Tools: Steel Rule, Scriber, Try Square, Divider, Centre Punch, Ball Peen Hammer, Flat File, Bench Vice.

Machines: Bench Drilling Machine

Measuring Instruments: Vernier Caliper, Steel Rule, Try Square.

Consumables: Cutting Fluid, Emery Paper.

Safety Equipment: Safety Goggles, Apron, Safety Shoes.

Precautions

1. Wear safety goggles during drilling and filing.
2. Clamp the workpiece securely in the vice.
3. Ensure accurate marking before filing.
4. Punch the centre before drilling.
5. Select the correct drill bit.
6. Apply cutting fluid during drilling when required.
7. Remove burrs after drilling.
8. Keep fingers away from rotating drill bits.
9. Clean the workplace after completion.
10. Return all tools to their designated locations.

Procedure

1. Study the given drawing/sketch carefully.
2. Select the raw material of suitable size.
3. Measure and mark the required dimensions using a steel rule, scriber, and try square.
4. Mark the centre position for the hole using a divider.
5. Make a centre punch mark at the drilling location.
6. Clamp the workpiece in the bench vice.
7. File all four sides until the required dimensions are achieved.
8. Check dimensions periodically using a Vernier caliper and try square.
9. Clamp the workpiece on the drilling machine table.
10. Drill a Ø5 mm hole at the centre.
11. Remove burrs and finish the component using emery paper.
12. Inspect the finished job for dimensional accuracy, squareness, hole location, and surface finish.

Observations and Calculations

Observation Table

Parameter	Specified Value	Measured Value	Error
Length (mm)	50 / 40		
Width (mm)	50 / 40		
Thickness (mm)			
Hole Diameter (mm)	5		
Hole Centre Position	As per drawing		
Squareness	90°		
Surface Finish	Smooth		

Calculation

Dimensional Error

Error = |Specified Dimension−Measured Dimension|

Results

A simple fitting job was successfully prepared according to the given drawing by performing marking, filing, centre punching, drilling, and finishing operations while maintaining acceptable dimensional accuracy and surface finish.

Interpretation of Results

- Accurate marking resulted in proper dimensions.
- Correct filing produced flat and square surfaces.
- Proper centre punching ensured accurate drill positioning.
- Drilling produced a hole of the required diameter.
- Good workmanship resulted in satisfactory dimensional accuracy and surface finish.

Conclusions and Recommendations

Conclusion

The experiment demonstrated the complete procedure for producing a simple fitting job using standard fitting tools and machines. Students developed practical skills in marking, filing, punching, drilling, finishing, and inspection while following safe workshop practices.

Recommendations

- Verify all dimensions before starting filing.
- File uniformly and check dimensions frequently.
- Ensure correct centre punching before drilling.
- Use sharp cutting tools and drill bits.
- Remove burrs after drilling.
- Maintain cleanliness and proper storage of tools.
- Follow all workshop safety rules.

Practical Related Questions

1. Define fitting.
2. List the operations involved in preparing a fitting job.
3. State the purpose of centre punching.
4. Why is filing carried out before drilling?
5. Name different types of files used in fitting work.
6. State the purpose of a bench vice.
7. Which measuring instrument is suitable for measuring the hole diameter?
8. Explain the function of a try square.
9. Why should burrs be removed after drilling?
10. State five safety precautions to be followed in a fitting shop.

References / Suggestions for Further Reading

1. S. K. Hajra Choudhury, Elements of Workshop Technology, Vol. I, Media Promoters & Publishers.
2. P. N. Rao, Manufacturing Technology, McGraw Hill Education.
3. B. S. Raghuwanshi**,** Workshop Technology, Dhanpat Rai Publications.
4. NIMI, Engineering Workshop Practice.
5. Government Polytechnic Workshop Practice Manual.
6. BIS Workshop Safety Guidelines.
7. All images are AI generated

Assessment Scheme (Combined Process and Product Rubrics)

A. Process Assessment Rubrics (20 Marks)

Assessment Criteria	Weightage	Level 4 – Excellent	Level 3 – Good	Level 2 – Satisfactory	Level 1 – Needs Improvement
1. Drawing Interpretatio	**4**	**4 Marks** – Correctly	**3 Marks** – Correctly	**2 Marks** – Requires	**1 Mark** – Unable to

Assessment Criteria	Weightage	Level 4 – Excellent	Level 3 – Good	Level 2 – Satisfactory	Level 1 – Needs Improvement
n and Work Planning		interprets the drawing/sketch, identifies dimensions and plans the sequence of marking, filing, punching, drilling and finishing independently.	interprets the drawing with minor guidance and plans most operations correctly.	guidance to understand the drawing and sequence of operations.	interpret the drawing or plan the work correctly.
2. Selection and Safe Use of Tools and Measuring Instruments	**4**	**4 Marks** – Selects and uses appropriate fitting tools, drilling machine and measuring instruments correctly and safely throughout the work.	**3 Marks** – Selects suitable tools with minor errors in handling or measurement.	**2 Marks** – Requires assistance in tool selection, measurement or safe handling.	**1 Mark** – Uses inappropriate tools or follows unsafe practices.
3. Execution of Marking, Filing, Punching, Drilling and Finishing	**6**	**6 Marks** – Performs all operations systematically with correct technique, sequence and excellent workmanship.	**4.5 Marks** – Performs all operations with minor procedural or workmanship errors.	**3 Marks** – Completes operations with frequent guidance and noticeable errors.	**1.5 Marks** – Unable to perform operations correctly or complete the job satisfactorily.

Assessment Criteria	Weightage	Level 4 – Excellent	Level 3 – Good	Level 2 – Satisfactory	Level 1 – Needs Improvement
4. Safety Practices and Housekeeping	**3**	**3 Marks** – Consistently follows safety rules, uses PPE correctly and maintains a clean and organized workplace.	**2.25 Marks** – Follows safety practices with occasional reminders.	**1.5 Marks** – Requires frequent reminders regarding safety and housekeeping.	**0.75 Mark** – Frequently ignores safety practices and workplace cleanliness.
5. Work Discipline and Time Management	**3**	**3 Marks** – Completes the job within the allotted time with excellent discipline and professional work habits.	**2.25 Marks** – Completes the work with minor delay and minimal supervision.	**1.5 Marks** – Requires additional time and supervision.	**0.75 Mark** – Fails to complete the work within the allotted time.

B. Product Assessment Rubrics (10 Marks)

Assessment Criteria	Weightage	Level 4 – Excellent	Level 3 – Good	Level 2 – Satisfactory	Level 1 – Needs Improvement
1. Dimensional Accuracy and Hole Location	**4**	**4 Marks** – Overall dimensions and Ø5 mm hole location conform to the drawing within the	**3 Marks** – Minor dimensional or hole location deviation that does not affect the job quality.	**2 Marks** – Noticeable dimensional or hole location errors requiring correction.	**1 Mark** – Significant dimensional or hole location errors; job does not conform to the drawing.

Assessment Criteria	Weightage	Level 4 – Excellent	Level 3 – Good	Level 2 – Satisfactory	Level 1 – Needs Improvement
		specified tolerance.			
2. Surface Finish and Edge Quality	**3**	**3 Marks** – Surfaces are smooth and flat, edges are square and burr-free, and the drilled hole is properly finished.	**2.25 Marks** – Good finish with minor roughness or small burrs.	**1.5 Marks** – Acceptable finish with noticeable roughness or burrs.	**0.75 Mark** – Poor finish with major roughness, burrs or edge defects.
3. Overall Quality and Workmanship	**3**	**3 Marks** – Job is neat, complete, accurately finished and demonstrates excellent workmanship.	**2.25 Marks** – Good workmanship with minor imperfections.	**1.5 Marks** – Functional job with visible workmanship defects.	**0.75 Mark** – Poor workmanship, incomplete or defective job.

EXPERIMENT NO.: 2.4 Preparation of Step Turning / Taper Turning Job as per the Given Sketch/Drawing Using Centre Lathe

Practical Significance

Step turning and taper turning are fundamental lathe operations used in the manufacturing of machine shafts, stepped pins, spindles, arbors, bushes, pulleys, and automotive components. This experiment enables students to interpret engineering drawings, select suitable machining parameters, perform turning operations accurately, and inspect the finished component using precision measuring instruments. The practical develops machining skills, dimensional accuracy, safety awareness, and quality-conscious work habits required in manufacturing industries.

Relevant Program Outcomes (POs)

PO-1 Basic and Discipline Specific Knowledge
PO-2 Problem Analysis
PO-3 Design/Devel opment of Solutions
PO-4 Engineering Tools
PO-5 Engineering Practices for Society, Sustainability and Environment
PO-7 Lifelong Learning

Related Course Outcome(s)

CO	Statement	PO							PSO	
CO2	Carryout fitting and turning operations properly in a given situation.	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO3
		3	2	2	3	2	-	2		

Laboratory Session Outcomes

After completing this experiment, the student will be able to:
LSO 2.1 Prepare list of relevant tools, equipment, machines and measuring instruments used in fitting shop as per given situation.
LSO 2.2 Perform marking, cutting, filing, punching, drilling, and finishing operations as per given fitting job safely.
LSO 2.3 Select relevant single point cutting tool and associated parameters for a given turning job.
LSO 2.4 Undertake turning operations economically and safely in a given situation

Practical Skills

The student will be able to:

- Read engineering drawings.
- Perform machine setup.
- Hold workpiece correctly in a chuck or between centres.
- Operate a centre lathe safely.
- Produce step turning and taper turning.
- Measure diameters and lengths using Vernier caliper and micrometer.
- Maintain dimensional accuracy and surface finish.

Minimum Theoretical Background.

Step Turning

Step turning is the operation of producing different diameters on a cylindrical workpiece to obtain stepped portions.

Applications

1. Stepped shafts
2. Gear shafts
3. Machine spindles
4. Bearing seats

Taper Turning

Taper turning is the operation of producing a conical surface by gradually reducing the diameter over a specified length.

Methods of Taper Turning

- Swivelling compound rest
- Tailstock set-over
- Taper turning attachment
- Form tool method

Formula

$$\text{Taper} = \frac{(D-d)}{L}$$

Where

- D = Larger diameter
- d = Smaller diameter

- L = Length of taper

Cutting Parameters (Mild Steel)

Parameter	Recommended Value
Cutting speed	25–35 m/min
Feed	0.15–0.30 mm/rev
Rough depth of cut	1–2 mm
Finish depth of cut	0.2–0.5 mm

Circuit Diagram / Layout / Experimental Setup

Machine: Centre lathe, Three-jaw chuck, Mild steel workpiece, Single-point cutting tool, Tool post, Tailstock, Vernier caliper, Outside micrometer, Steel rule, Cutting fluid

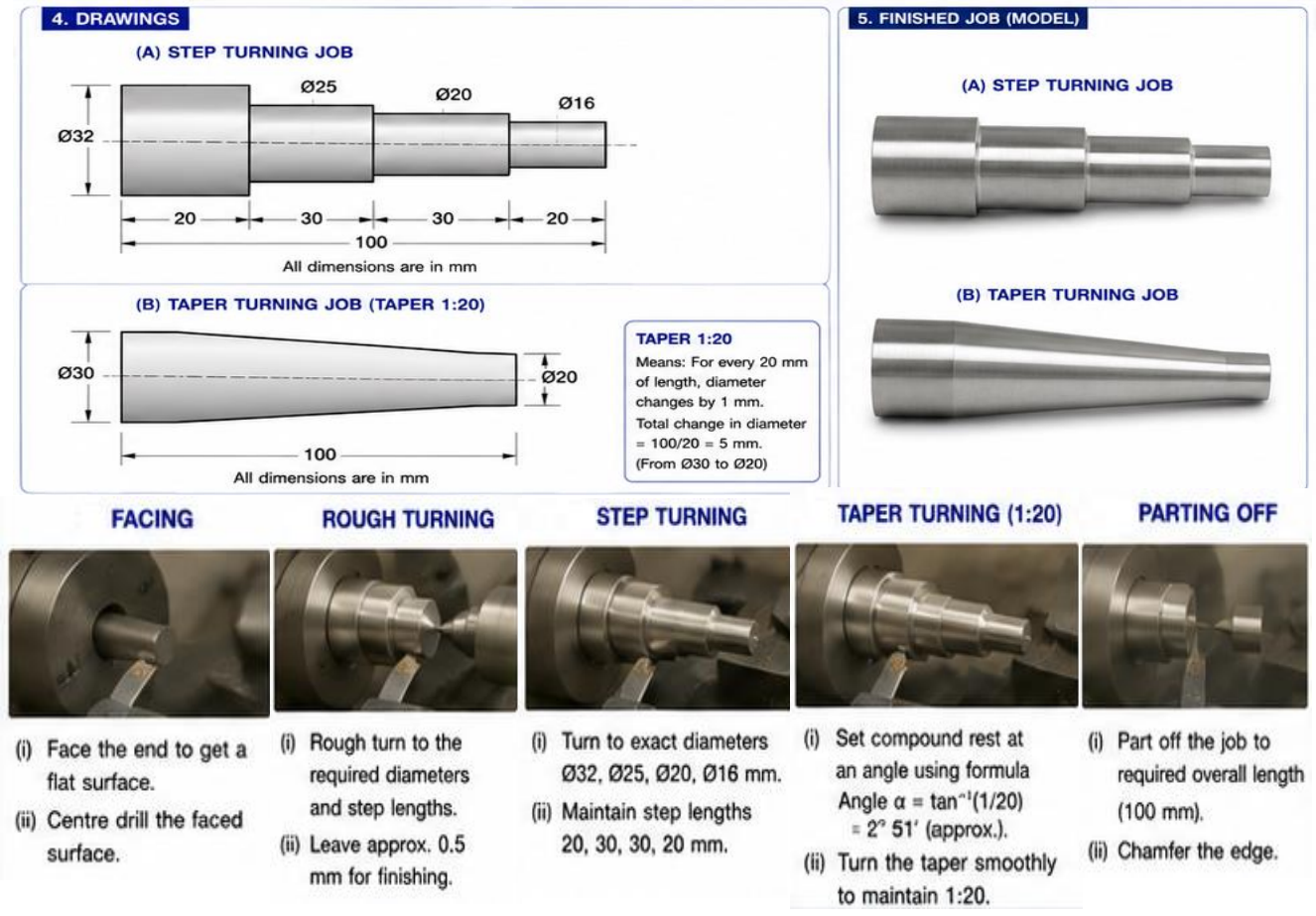


Fig. 9. Lathe Operations (facing, turning, step turning, taper turning, parting off)

Resources Required

Sl. No.	Resource	Specification	Qty.
1	Centre Lathe	Medium duty	1
2	Mild Steel Rod	As per drawing	1
3	Single Point Cutting Tool	HSS/Carbide	1
4	Vernier Caliper	0–150 mm	1
5	Outside Micrometer	0–25 mm	1
6	Steel Rule	300 mm	1
7	Cutting Fluid	Suitable grade	As required

Precautions

1. Wear safety goggles and apron.
2. Clamp the workpiece securely.
3. Remove the chuck key immediately after tightening.
4. Set the cutting tool exactly at centre height.
5. Check machine settings before machining.
6. Use cutting fluid whenever required.
7. Never measure the workpiece while rotating.
8. Remove chips with a brush only.
9. Stop the machine before changing speed or tool.
10. Keep the workplace clean after completion.

Procedure

1. Study the given drawing carefully.
2. Select the required mild steel workpiece.
3. Mount the workpiece in the chuck or between centres.
4. Fix the cutting tool at centre height.
5. Set spindle speed and feed.
6. Face the workpiece.
7. Mark the required lengths.
8. Perform rough turning.
9. Machine the required step diameters or taper.
10. Take finishing cuts.
11. Measure all dimensions.
12. Compare dimensions with the drawing.
13. Deburr and clean the finished component.

Observations and Calculations

Machine Data

Particular	Observation
Machine Used	
Material	
Tool Material	
Speed (rpm)	
Feed (mm/rev)	
Depth of Cut (mm)	

Step Turning Measurements

Dimension	Specified (mm)	Measured (mm)	Error (mm)
Diameter D1			
Diameter D2			
Diameter D3			
Length L1			
Length L2			
Overall Length			

Taper Turning Measurements

Parameter	Specified	Measured
Large Diameter		
Small Diameter		
Length of Taper		
Calculated Taper		
Actual Taper		

Results

The given step turning / taper turning job was successfully prepared according to the given sketch/drawing.
The measured dimensions were found to be within / not within the specified tolerance.

Interpretation of Results

1. The finished component satisfies the drawing requirements when measured dimensions are within tolerance.
2. Proper machine setup, correct cutting parameters, and accurate measurement improve dimensional accuracy.
3. Surface finish depends on tool geometry, cutting speed, feed, and finishing cuts.

Conclusions and Recommendations

Conclusion

The experiment successfully demonstrated the preparation of a step turning/taper turning job using a centre lathe. The practical enhanced machining skills, dimensional inspection techniques, and adherence to safe machining practices.

Recommendations

1. Use sharp cutting tools.
2. Select appropriate machining parameters.
3. Verify dimensions after every machining stage.
4. Maintain machine cleanliness.
5. Follow all safety instructions.

Practical Related Questions

1. Define step turning.
2. Define taper turning.
3. State four methods of taper turning.
4. Write the taper formula.
5. Name the measuring instrument used for outside diameter measurement.
6. Why is the cutting tool set at centre height?
7. What is the function of the tailstock?
8. State four applications of taper turning.
9. Why is cutting fluid used?
10. State five safety precautions during lathe operation.

References / Suggestions for Further Reading

1. P. N. Rao, Manufacturing Technology – Metal Cutting and Machine Tools.
2. HMT Ltd., Machine Tools Handbook.
3. B. S. Raghuwanshi, Workshop Technology.
4. S. K. Hajra Choudhury, Elements of Workshop Technology (Vol. II).
5. SBTE Bihar Diploma Curriculum – Manufacturing Engineering Laboratory.

6. Relevant BIS Standards for Machine Shop Practice.
7. All images are AI generated

Assessment Scheme (Combined Process and Product Rubrics)

A. Process Assessment Rubric (20 Marks)

Assessment Criteria	Weightage	Level 4 – Excellent	Level 3 – Good	Level 2 – Satisfactory	Level 1 – Needs Improvement
1. Drawing Interpretation and Job Setting	**4**	**4 Marks** – Correctly interprets the drawing, selects raw material, mounts the job accurately and aligns the cutting tool independently.	**3 Marks** – Interprets the drawing and sets the job with minor guidance or minor alignment errors.	**2 Marks** – Requires frequent guidance for job setting and tool alignment.	**1 Mark** – Unable to interpret the drawing or set the job correctly.
2. Selection of Cutting Tool, Speed, Feed and Depth of Cut	**4**	**4 Marks** – Selects appropriate cutting tool and machining parameters correctly and independently.	**3 Marks** – Selects suitable parameters with minor errors.	**2 Marks** – Requires guidance in selecting tool or machining parameters.	**1 Mark** – Incorrect selection of tool or machining parameters.
3. Machining Procedure (Facing, Turning, Step/Taper Turning and Measurement)	**6**	**6 Marks** – Performs all machining operations systematically with correct sequence, accurate measurements and excellent machining practice.	**4.5 Marks** – Completes all operations with minor procedural or measurement errors.	**3 Marks** – Completes operations with frequent guidance and noticeable errors.	**1.5 Marks** – Unable to complete machining operations satisfactorily.
4. Safety Practices and Housekeeping	**3**	**3 Marks** – Consistently follows all lathe safety practices,	**2.25 Marks** – Follows safety practices with	**1.5 Marks** – Requires frequent reminders regarding	**0.75 Mark** – Frequently ignores safety rules and housekeeping.

Assessment Criteria	Weightage	Level 4 – Excellent	Level 3 – Good	Level 2 – Satisfactory	Level 1 – Needs Improvement
		uses PPE correctly and maintains a clean workplace.	occasional reminders.	safety and housekeeping.	
5. Work Discipline and Time Management	**3**	**3 Marks** – Completes the job within the allotted time while demonstrating excellent discipline and machine handling.	**2.25 Marks** – Completes the work with minor delay.	**1.5 Marks** – Requires additional time and supervision.	**0.75 Mark** – Fails to complete the job within the allotted time.

B. Product Assessment Rubric (10 Marks)

Assessment Criteria	Weightage	Level 4 – Excellent	Level 3 – Good	Level 2 – Satisfactory	Level 1 – Needs Improvement
1. Dimensional Accuracy (Diameter, Length and Taper/Steps)	**4**	**4 Marks** – All dimensions, step lengths or taper dimensions conform to the drawing within the specified tolerance.	**3 Marks** – Minor dimensional deviations without affecting functionality.	**2 Marks** – Noticeable dimensional errors requiring correction.	**1 Mark** – Significant dimensional errors; job does not conform to the drawing.
2. Surface Finish and Geometrical Accuracy	**3**	**3 Marks** – Smooth surface finish with accurate shoulders, taper profile and burr-free edges.	**2.25 Marks** – Good finish with minor tool marks or slight geometrical deviation.	**1.5 Marks** – Acceptable finish with noticeable roughness or minor defects.	**0.75 Mark** – Poor finish with major roughness or geometrical inaccuracies.

Assessment Criteria	Weightage	Level 4 – Excellent	Level 3 – Good	Level 2 – Satisfactory	Level 1 – Needs Improvement
3. Overall Quality and Workmanship	**3**	**3 Marks** – Job is neat, complete, accurately machined and demonstrates excellent workmanship.	**2.25 Marks** – Good workmanship with minor imperfections.	**1.5 Marks** – Functional job with visible workmanship defects.	**0.75 Mark** – Poor workmanship, incomplete or defective job.

EXPERIMENT NO.: 3.1 Preparation of a Simple Job (T-Section) by Using a Suitable Joining Process as per the Given Sketch/Drawing.

Practical Significance

This experiment enables students to learn the fundamentals of metal joining by fabricating a simple T-section joint using a suitable joining process (Arc Welding/MIG Welding/TIG Welding/Gas Welding as specified). It develops practical skills in joint preparation, alignment, welding, inspection, and finishing while emphasizing safe workshop practices. The experiment is widely applicable in the fabrication of frames, machine structures, gates, railings, supports, and structural components used in mechanical engineering industries.

Relevant Program Outcomes (POs)

PO-1 Basic and Discipline Specific Knowledge
PO-2 Problem Analysis
PO-3 Design/Development of Solutions
PO-4 Engineering Tools
PO-5 Engineering Practices for Society, Sustainability and Environment
PO-7 Lifelong Learning

Related Course Outcome(s)

CO	**Statement**	**PO**							**PSO**	
CO3	Perform various joining operations using welding, brazing, and soldering methods.	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO3
		3	2	2	3	1	-	1		

Laboratory Session Outcomes

After completing this experiment, the student will be able to:
LSO 3.1 Select suitable joining process in a given situation.
LSO 3.2 Use Personal Protective Equipment in welding shop.
LSO 3.3 Perform gas welding operations in a given situation to prepare joint safely.
LSO 3.4 Prepare given welding joint safely using arc welding in a given situation.
LSO 3.5 Carryout soldering / brazing operation(s) as per given job.

Practical Skills

- Measuring and marking
- Cutting metal pieces
- Edge preparation
- Joint alignment
- Tack welding
- Welding operation
- Slag removal
- Weld cleaning and finishing
- Visual inspection
- Safe handling of welding equipment

Minimum Theoretical Background

A T-joint is formed when one metal plate is positioned perpendicular to another, forming the shape of the letter 'T'. It is one of the most common joints used in fabrication work. Depending on the process specified, the joint may be prepared using Shielded Metal Arc Welding (SMAW), Gas Welding, MIG Welding, or TIG Welding.
A good welded T-joint should have Proper fusion, Uniform bead appearance, Adequate penetration, Minimum distortion, No cracks, porosity, undercut, or slag inclusion, Proper electrode selection, current setting, welding speed, and electrode angle significantly influence weld quality.

Circuit Diagram/Layout/Experimental Setup

Job Specification

Material: Mild Steel Flat
Typical Dimensions
Base Plate: 100 × 50 × 6 mm
Vertical Plate: 100 × 50 × 6 mm
Joint Type: T-Joint (90°)
Joining Process: Shielded Metal Arc Welding (SMAW) *(or as specified by instructor)*
Equipment Layout
Welding Machine
Electrode Holder
Earth Clamp
Welding Table
Workpiece
Welding Screen
PPE

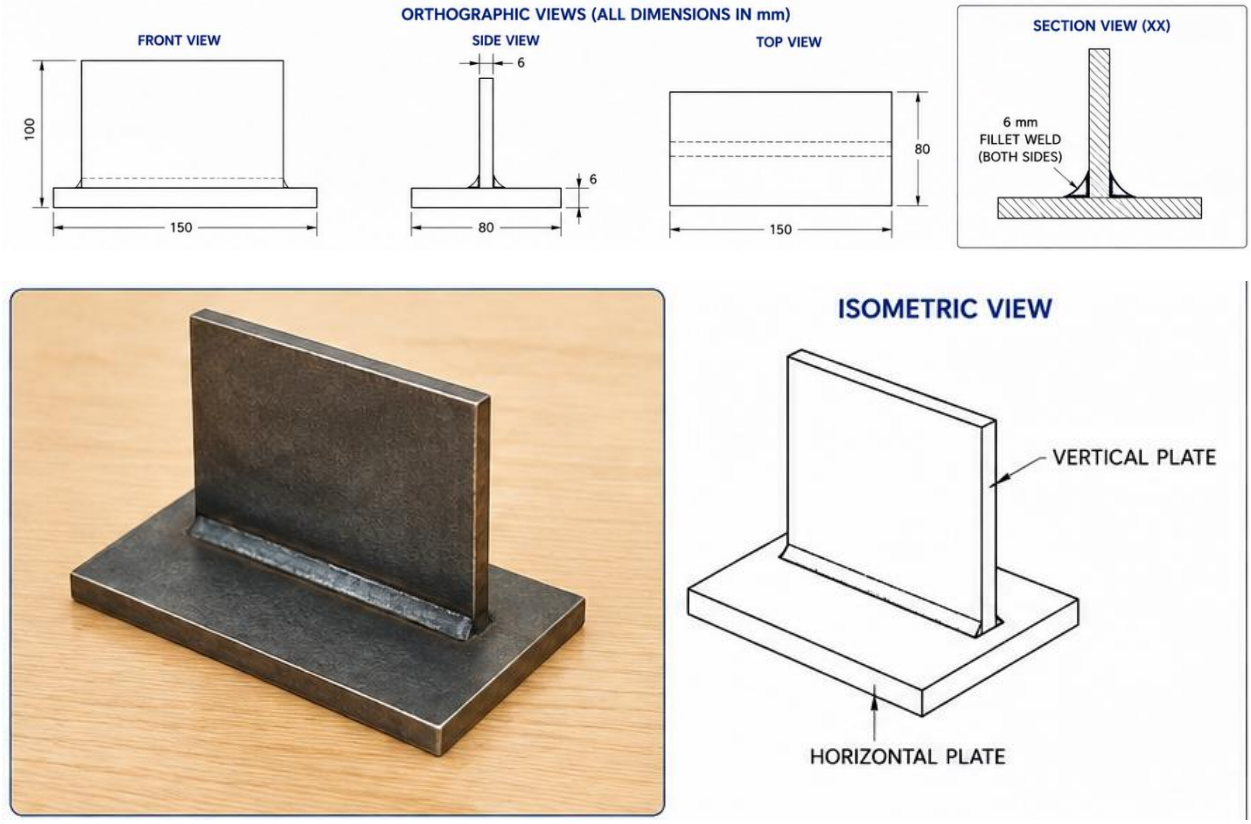


Fig. 10. Mild steel T- section.

Resources Required

Material: Mild Steel Flats, Welding Electrodes (E6013 or equivalent)

Machines: Arc Welding Machine

Tools: Chipping Hammer Wire Brush Steel Rule Try Square C-Clamp Bench Vice.

Angle Grinder (if required)

Measuring Instruments: Steel Rule Vernier Caliper Try Square.

PPE: Welding Helmet, Leather Gloves, Apron, Safety Shoes, Safety Goggles

Precautions

1. Wear complete PPE before welding.
2. Ensure proper earthing of the welding machine.
3. Use recommended welding current.

4. Clean the workpieces before welding.
5. Clamp the workpieces firmly.
6. Maintain proper arc length.
7. Do not touch hot metal immediately after welding.
8. Remove slag carefully.
9. Keep flammable materials away.
10. Switch off the machine after completion.

Procedure

1. Study the given sketch.
2. Select mild steel flats of required dimensions.
3. Mark and cut the workpieces.
4. Clean the surfaces thoroughly.
5. Arrange the plates at 90° to form a T-joint.
6. Clamp the workpieces securely.
7. Set suitable welding current.
8. Perform tack welding.
9. Complete the welding on both sides.
10. Allow the joint to cool.
11. Remove slag using a chipping hammer.
12. Clean the weld bead with a wire brush.
13. Inspect the weld visually.
14. Measure dimensions and finish the job.

Observations and Calculations.

Observation Table

Sl. No.	**Parameter**	**Specified**	**Observed**
1	Base Plate Length	100 mm	_____
2	Vertical Plate Length	100 mm	_____
3	Joint Angle	90°	_____
4	Weld Bead Uniformity	Uniform	_____
5	Penetration	Good	_____
6	Surface Finish	Smooth	_____
7	Visual Defects	Nil	_____
8	Overall Workmanship	Good	_____

Results

A T-section joint was successfully prepared using the specified joining process according to the given drawing while maintaining dimensional accuracy and good weld quality.

Interpretation of Results

- Weld bead is continuous and uniform.
- Joint angle is maintained at 90°.
- Proper fusion and penetration are achieved.
- No visible defects are observed.
- The fabricated joint satisfies the given specifications.

Conclusions and Recommendations

Conclusion

The T-section joint was successfully fabricated using the selected welding process by following standard workshop practices and safety procedures.

Recommendations

- Maintain a uniform arc length.
- Use proper welding current.
- Clean workpieces before welding.
- Remove slag after each pass.
- Inspect the weld before final finishing.
- Practice proper electrode manipulation for better bead appearance.

Practical Related Questions

1. What is a T-joint?
2. Name different welding joints.
3. Why is tack welding necessary?
4. What is arc length?
5. State the function of welding flux.
6. Name two welding defects.
7. What is weld penetration?
8. Why is slag removed after welding?
9. List five welding safety precautions.
10. Give two industrial applications of T-joints.

References / Suggestions for Further Reading.

1. P. N. Rao, Manufacturing Technology, Vol. II, McGraw-Hill.
2. S. K. Hajra Choudhury, Workshop Technology, Vol. II, Media Promoters.
3. O. P. Khanna, Welding Technology, Dhanpat Rai Publications.
4. BIS Standards for Arc Welding.
5. SBTE Bihar Mechanical Engineering Workshop Practice Manual.
6. All images are AI generated

Assessment Scheme (Combined Process and Product Rubrics)

A. Process Assessment Rubric (20 Marks)

Assessment Criteria	Weightage	Level 4 – Excellent	Level 3 – Good	Level 2 – Satisfactory	Level 1 – Needs Improvement
1. Drawing Interpretation and Job Preparation	**4**	**4 Marks** – Correctly interprets the drawing, identifies joint type, prepares the workpieces and plans the joining sequence independently.	**3 Marks** – Interprets the drawing correctly with minor guidance and prepares the workpieces with minor errors.	**2 Marks** – Requires guidance to interpret the drawing and prepare the workpieces.	**1 Mark** – Unable to interpret the drawing or prepare the workpieces correctly.
2. Selection and Safe Use of Tools, Equipment and Consumables	**4**	**4 Marks** – Selects suitable tools, equipment, filler material/electrode and PPE correctly; handles them safely throughout the work.	**3 Marks** – Selects appropriate tools and consumables with minor errors or occasional reminders on safety.	**2 Marks** – Requires guidance in selecting tools, consumables or using PPE.	**1 Mark** – Incorrect selection of tools/consumables or unsafe handling practices.

Assessment Criteria	Weightage	Level 4 – Excellent	Level 3 – Good	Level 2 – Satisfactory	Level 1 – Needs Improvement
3. Execution of the Joining Process	**6**	**6 Marks** – Performs edge preparation, alignment, clamping and joining systematically using correct process parameters and technique.	**4.5 Marks** – Performs all operations with minor procedural or alignment errors.	**3 Marks** – Completes the joining process with frequent guidance and noticeable errors.	**1.5 Marks** – Unable to perform the joining process satisfactorily or complete the job.
4. Safety Practices and Housekeeping	**3**	**3 Marks** – Consistently follows safety Rules, uses PPE correctly and maintains a clean and organized work area.	**2.25 Marks** – Follows safety practices with occasional reminders.	**1.5 Marks** – Requires frequent reminders regarding safety and housekeeping.	**0.75 Mark** – Frequently ignores safety rules and workplace cleanliness.
5. Work Discipline and Time Management	**3**	**3 Marks** – Completes the job within the allotted time while demonstrating excellent discipline and teamwork.	**2.25 Marks** – Completes the work with minor delay and minimal supervision.	**1.5 Marks** – Requires additional time and supervision.	**0.75 Mark** – Fails to complete the assigned job within the allotted time.

B. Product Assessment Rubric (10 Marks)

Assessment Criteria	Weightage	Level 4 – Excellent	Level 3 – Good	Level 2 – Satisfactory	Level 1 – Needs Improvement
1. Joint Accuracy and Dimensional Conformity	**4**	**4 Marks** – Joint dimensions, alignment and assembly conform to the given drawing with negligible deviation.	**3 Marks** – Minor dimensional or alignment deviations that do not affect the joint.	**2 Marks** – Noticeable dimensional or alignment errors affecting appearance or fit.	**1 Mark** – Significant dimensional or alignment errors; job does not conform to the drawing.
2. Joint Quality and Surface Finish	**3**	**3 Marks** – Joint is clean, uniform and free from visible defects such as excessive spatter, undercut, porosity, excess solder/braze or loose rivets, as applicable.	**2.25 Marks** – Good joint quality with minor visible defects.	**1.5 Marks** – Acceptable joint with noticeable defects but remains functional.	**0.75 Mark** – Poor joint quality with major visible defects or incomplete joining.
3. Overall Workmanship and Functionality	**3**	**3 Marks** – Job is neat, complete, structurally sound and demonstrates excellent workmanship.	**2.25 Marks** – Good workmanship with minor imperfections.	**1.5 Marks** – Functional job with visible workmanship defects.	**0.75 Mark** – Poor workmanship, incomplete or weak joint.

EXPERIMENT NO.: 3.2 Preparation of a Butt Joint / Lap Joint Using Gas Welding as per the Given Sketch/Drawing Safely.

Practical Significance

Gas welding is a fusion welding process widely used for joining thin and medium-thickness metal sections in fabrication, maintenance, automobile body repair, pipelines, sheet metal work, and light engineering industries. This experiment enables students to prepare butt and lap joints according to the given drawing, understand flame adjustment, operate gas welding equipment safely, and produce sound welded joints with acceptable quality.

Relevant Program Outcomes (POs)

PO-1 Basic and Discipline Specific Knowledge
PO-2 Problem Analysis
PO-3 Design/Development of Solutions
PO-4 Engineering Tools
PO-5 Engineering Practices for Society, Sustainability and Environment
PO-7 Lifelong Learning.

Related Course Outcome(s)

CO	Statement	PO							PSO	
CO3	Perform various joining operations using welding, brazing, and soldering methods.	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO3
		3	2	2	3	1	-	1		

Laboratory Session Outcomes

After completing this experiment, the student will be able to:
LSO 3.1 Select suitable joining process in a given situation.
LSO 3.2 Use Personal Protective Equipment in welding shop.
LSO 3.3 Perform gas welding operations in a given situation to prepare joint safely.
LSO 3.4 Prepare given welding joint safely using arc welding in a given situation.
LSO 3.5 Carryout soldering / brazing operation(s) as per given job.

Practical Skills

The student will be able to:

- Read engineering drawings.
- Identify gas welding equipment.
- Set regulator pressures safely.
- Adjust neutral, carburizing, and oxidizing flames.
- Perform tack welding and final welding.
- Produce a sound butt or lap joint.
- Inspect weld quality visually.

Minimum Theoretical Background

Gas Welding Gas welding is a fusion welding process in which heat is produced by the combustion of oxygen and acetylene gases. The heat melts the base metals and filler rod (if required), forming a permanent joint after solidification.

Principle A high-temperature flame (approximately 3200°C) produced by burning oxygen and acetylene melts the edges of the workpieces and filler rod to form a welded joint.

Types of Oxy-Acetylene Flames

Neutral Flame
Equal oxygen and acetylene.
Most commonly used.
Suitable for mild steel.
Carburizing Flame
Excess acetylene.
Used for high-carbon steel and aluminium.
Oxidizing Flame
Excess oxygen.
Used for brass and bronze.

Types of Weld Joints

a) Butt Joint
b) Lap Joint
c) Tee Joint
d) Corner Joint
e) Edge Joint

Applications

1. Automobile body repair
2. Sheet metal fabrication
3. Pipe welding
4. Maintenance work
5. Light fabrication
6. Bicycle and furniture manufacturing

Circuit Diagram / Layout / Experimental Setup

The setup consists of: Oxygen cylinder, Acetylene cylinder, Pressure regulators, Flashback arrestors, Gas hoses, Welding torch (blowpipe), Filler rod, Flux (if required), Welding table, Fire extinguisher, PPE (goggles, gloves, apron, shoes)

(Students should draw a labelled diagram showing the oxygen cylinder, acetylene cylinder, regulators, hoses, welding torch, workpiece, and filler rod.)

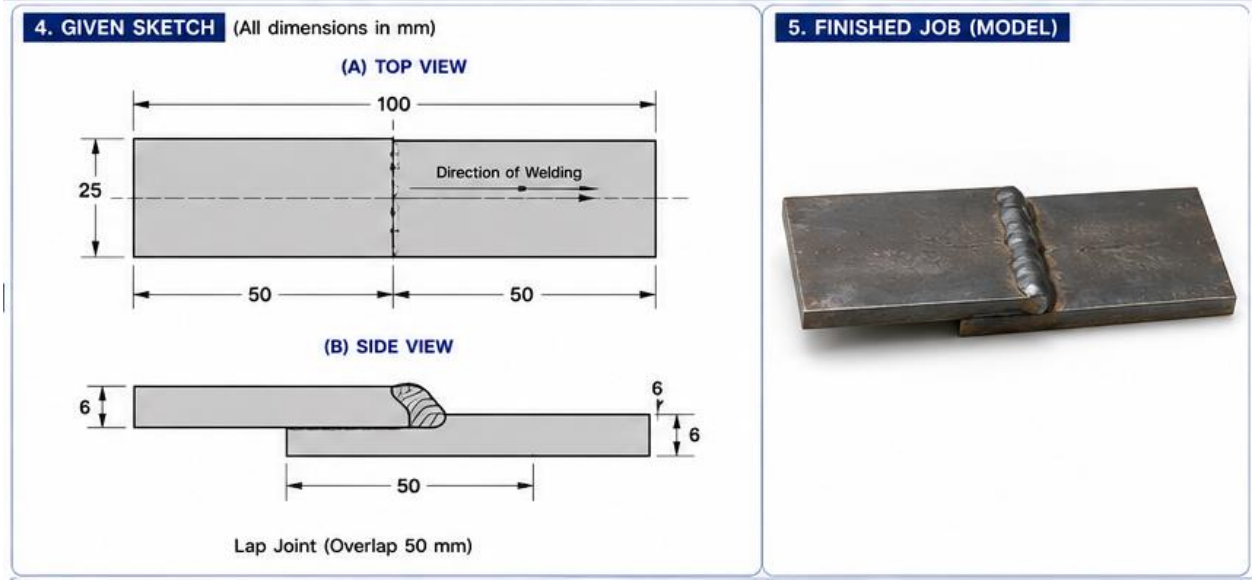


Fig. 11. Gas welded lap Joint

Resources Required

Sl. No.	Item	Specification	Quantity
1	Gas welding set	Standard	1
2	Oxygen cylinder	Industrial grade	1
3	Acetylene cylinder	Industrial grade	1
4	Gas welding torch	Suitable nozzle	1
5	Mild steel plates	As per drawing	2

Sl. No.	Item	Specification	Quantity
6	Filler rod	Suitable grade	As required
7	Spark lighter	Standard	1
8	Welding goggles	Standard	1
9	Leather gloves	Standard	1 Pair
10	Wire brush	Standard	1
11	Steel rule	300 mm	1
12	Fire extinguisher	CO_2/DCP	1

Precautions

1. Wear welding goggles, gloves, apron, and safety shoes.
2. Inspect cylinders, regulators, hoses, and torch before use.
3. Ensure all gas connections are leak-free.
4. Use a spark lighter to ignite the torch; never use matches or a cigarette lighter.
5. Adjust the required flame before welding.
6. Keep cylinders in the upright position.
7. Keep combustible materials away from the work area.
8. Never use oil or grease on oxygen cylinder fittings.
9. Handle hot workpieces using pliers or tongs.
10. Close acetylene and oxygen valves properly after completion.
11. Ensure adequate ventilation during welding.
12. Keep a fire extinguisher readily available.

Procedure

1. Study the given sketch/drawing.
2. Select suitable mild steel plates.
3. Clean the edges to be joined.
4. Prepare the joint (butt or lap) according to the drawing.
5. Clamp the workpieces properly.
6. Connect the gas welding equipment.
7. Open the cylinder valves carefully.
8. Adjust regulator pressures.
9. Ignite the torch using a spark lighter.
10. Adjust a neutral flame.
11. Tack weld the plates to maintain alignment.
12. Perform gas welding along the joint using filler rod.
13. Allow the joint to cool naturally.
14. Clean the weld bead using a wire brush.
15. Inspect the weld visually.
16. Shut down the equipment safely.

Observations and Calculations

Welding Details

Particular	Observation
Joint Type	
Material	
Plate Thickness	
Filler Rod Used	
Flame Type	
Welding Position	

Machine Parameters

Parameter	Observation
Oxygen Pressure	
Acetylene Pressure	
Nozzle Size	
Welding Speed	

Weld Inspection

Inspection Parameter	Observation
Joint Alignment	
Uniformity of Weld Bead	
Penetration	
Surface Finish	
Visible Defects	

Results

The butt joint / lap joint was successfully prepared using the gas welding process according to the given sketch/drawing while following safe operating practices. The welded joint was found to be acceptable / requires improvement based on visual inspection.

Interpretation of Results

- A good gas-welded joint exhibits proper fusion, uniform bead profile, smooth appearance, and adequate penetration.
- Weld quality depends on flame adjustment, travel speed, edge preparation, filler rod manipulation, and operator skill.

- Improper flame or welding speed may produce defects such as porosity, undercut, excessive reinforcement, or lack of fusion.

Conclusions and Recommendations

Conclusion

The experiment demonstrated the preparation of a butt joint or lap joint using gas welding. Students developed practical skills in equipment setup, flame adjustment, welding operation, inspection, and safe handling of gas welding equipment.

Recommendations

- Always use a neutral flame for welding mild steel.
- Maintain proper torch angle and travel speed.
- Keep joint surfaces clean before welding.
- Inspect gas leakage before ignition.
- Follow standard gas welding safety procedures throughout the experiment.

Practical Related Questions

1. Define gas welding.
2. State the principle of gas welding.
3. Name the gases used in oxy-acetylene welding.
4. List the three types of oxy-acetylene flames.
5. Which flame is commonly used for welding mild steel?
6. Differentiate between a butt joint and a lap joint.
7. State four applications of gas welding.
8. Why is a filler rod used in gas welding?
9. What are four common welding defects?
10. State six safety precautions to be followed during gas welding.

References / Suggestions for Further Reading

1. O. P. Khanna, A Textbook of Welding Technology.
2. S. K. Hajra Choudhury, Elements of Workshop Technology (Vol. II).
3. P. N. Rao, Manufacturing Technology.
4. B. S. Raghuwanshi, Workshop Technology.
5. SBTE Bihar Diploma Curriculum – Manufacturing Engineering Laboratory.
6. IS 817: Code of Practice for Training and Testing of Metal Arc Welders.
7. Relevant BIS standards for gas welding and safety practices.
8. All images are AI generated

Assessment Scheme (Combined Process and Product Rubrics)

A. Process Assessment Rubric (20 Marks)

Assessment Criteria	Weightage	Level 4 – Excellent	Level 3 – Good	Level 2 – Satisfactory	Level 1 – Needs Improvement
1. Drawing Interpretation and Joint Preparation	**4**	**4 Marks** – Correctly interprets the drawing, prepares workpieces, edge preparation and joint alignment independently.	**3 Marks** – Correctly prepares the joint with minor guidance or alignment errors.	**2 Marks** – Requires frequent guidance in joint preparation and alignment.	**1 Mark** – Unable to prepare or align the joint correctly.
2. Equipment Setup and Flame Adjustment	**4**	**4 Marks** – Correctly inspects equipment, sets regulators, adjusts gas pressures and obtains the required flame safely and independently.	**3 Marks** – Performs setup with minor errors or occasional guidance.	**2 Marks** – Requires frequent guidance during setup and flame adjustment.	**1 Mark** – Incorrect equipment setup or unsafe flame adjustment.
3. Welding Technique and Process Execution	**6**	**6 Marks** – Maintains correct torch angle, travel speed, filler rod manipulation and produces a uniform weld bead	**4.5 Marks** – Performs welding with minor variations in technique or bead uniformity.	**3 Marks** – Completes welding with frequent guidance and noticeable procedural errors.	**1.5 Marks** – Unable to complete the weld satisfactorily or demonstrates incorrect welding technique.

Assessment Criteria	Weightage	Level 4 – Excellent	Level 3 – Good	Level 2 – Satisfactory	Level 1 – Needs Improvement
		throughout the joint.			
4. Safety Practices and Housekeeping	**3**	**3 Marks** – Consistently follows gas welding safety procedures, uses PPE correctly and maintains a clean work area.	**2.25 Marks** – Follows safety practices with occasional reminders.	**1.5 Marks** – Requires frequent reminders regarding safety and housekeeping.	**0.75 Mark** – Frequently ignores safety practices or workplace cleanliness.
5. Work Discipline and Time Management	**3**	**3 Marks** – Completes the welding job within the allotted time with excellent discipline and proper shutdown procedure.	**2.25 Marks** – Completes the work with minor delay and minimal supervision.	**1.5 Marks** – Requires additional time and supervision.	**0.75 Mark** – Fails to complete the welding job within the allotted time.

B. Product Assessment Rubric (10 Marks)

Assessment Criteria	Weightage	Level 4 – Excellent	Level 3 – Good	Level 2 – Satisfactory	Level 1 – Needs Improvement
1. Joint Accuracy and Alignment	**4**	**4 Marks** – Butt/Lap joint dimensions and	**3 Marks** – Minor alignment or dimensional deviation	**2 Marks** – Noticeable alignment or dimensional errors	**1 Mark** – Significant misalignment or incorrect

Assessment Criteria	Weightage	Level 4 – Excellent	Level 3 – Good	Level 2 – Satisfactory	Level 1 – Needs Improvement
		alignment conform to the drawing with proper root gap (where applicable).	without affecting the joint.	affecting appearance.	joint dimensions.
2. Weld Bead Quality and Surface Finish	**3**	**3 Marks** – Uniform weld bead with good fusion, smooth appearance and free from visible defects such as excessive spatter, undercut or porosity.	**2.25 Marks** – Good weld bead with minor visible defects.	**1.5 Marks** – Acceptable weld with noticeable irregularities or defects.	**0.75 Mark** – Poor weld bead with major defects or incomplete fusion.
3. Overall Workmanship and Joint Strength	**3**	**3 Marks** – Joint is neat, complete, structurally sound and demonstrates excellent workmanship.	**2.25 Marks** – Good workmanship with minor imperfections.	**1.5 Marks** – Functional joint with visible workmanship defects.	**0.75 Mark** – Weak, incomplete or poorly finished joint.

EXPERIMENT NO.: 3.3 Preparation of a Butt Joint / Lap Joint by Shielded Metal Arc Welding (SMAW) Using Suitable Welding Parameters as per the Given Sketch/Drawing Economically and Safely.

Practical Significance

Shielded Metal Arc Welding (SMAW), commonly known as arc welding, is one of the most widely used fusion welding processes in fabrication, construction, automobile, shipbuilding, pipeline, and maintenance industries. It is suitable for joining ferrous metals of various thicknesses and is economical due to its simple equipment and portability. This experiment enables students to prepare butt and lap joints according to the given sketch/drawing by selecting appropriate welding parameters, producing sound welds, minimizing material wastage, and following safe welding practices.

Relevant Program Outcomes (POs)

PO-1 Basic and Discipline Specific Knowledge
PO-2 Problem Analysis
PO-3 Design/Development of Solutions
PO-4 Engineering Tools
PO-5 Engineering Practices for Society, Sustainability and Environment
PO-7 Lifelong Learning

Related Course Outcome(s)

CO	**Statement**	**PO**							**PSO**	
CO3	Perform various joining operations using welding, brazing, and soldering methods.	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO3
		3	2	2	3	1	-	1		

Laboratory Session Outcomes

After completing this experiment, the student will be able to:
LSO 3.1 Select suitable joining process in a given situation.
LSO 3.2 Use Personal Protective Equipment in welding shop.
LSO 3.3 Perform gas welding operations in a given situation to prepare joint safely.
LSO 3.4 Prepare given welding joint safely using arc welding in a given situation.
LSO 3.5 Carryout soldering / brazing operation(s) as per given job. .

Practical Skills

The student will be able to:

- Read engineering drawings.
- Select suitable welding electrodes.
- Set welding current according to electrode size.
- Prepare and align workpieces.
- Strike and maintain a stable arc.
- Deposit uniform weld beads.
- Inspect welded joints visually.
- Practice safe and economical welding.

Minimum Theoretical Background

Shielded Metal Arc Welding (SMAW)

Shielded Metal Arc Welding is a fusion welding process in which heat is generated by an electric arc struck between a consumable coated electrode and the workpiece. The electrode coating produces shielding gases and slag that protect the molten weld metal from atmospheric contamination

Principle - When electric current flows through the electrode and workpiece, an electric arc is produced. The heat generated by the arc melts the base metal and electrode to form a permanent joint after solidification.

Main Components of SMAW Equipment

Welding power source (AC/DC)
Electrode holder
Welding electrode
Welding cables
Earth clamp
Welding table
Chipping hammer
Wire brush
Personal Protective Equipment (PPE)

Common Types of Weld Joints

a) Butt Joint
b) Lap Joint
c) Tee Joint
d) Corner Joint
e) Edge Joint

Welding Parameters

Parameter	Typical Range
Electrode Diameter	2.5–3.15 mm
Welding Current	70–130 A (depending on electrode size)
Arc Length	Approximately equal to electrode diameter
Electrode Angle	70°–80° to the workpiece
Travel Speed	Uniform and consistent

Economic Welding Practices

1. Select the correct electrode diameter.
2. Use the recommended welding current.
3. Minimize electrode wastage.
4. Reduce excessive weld reinforcement.
5. Avoid unnecessary grinding and rework.
6. Prevent welding defects through proper technique.

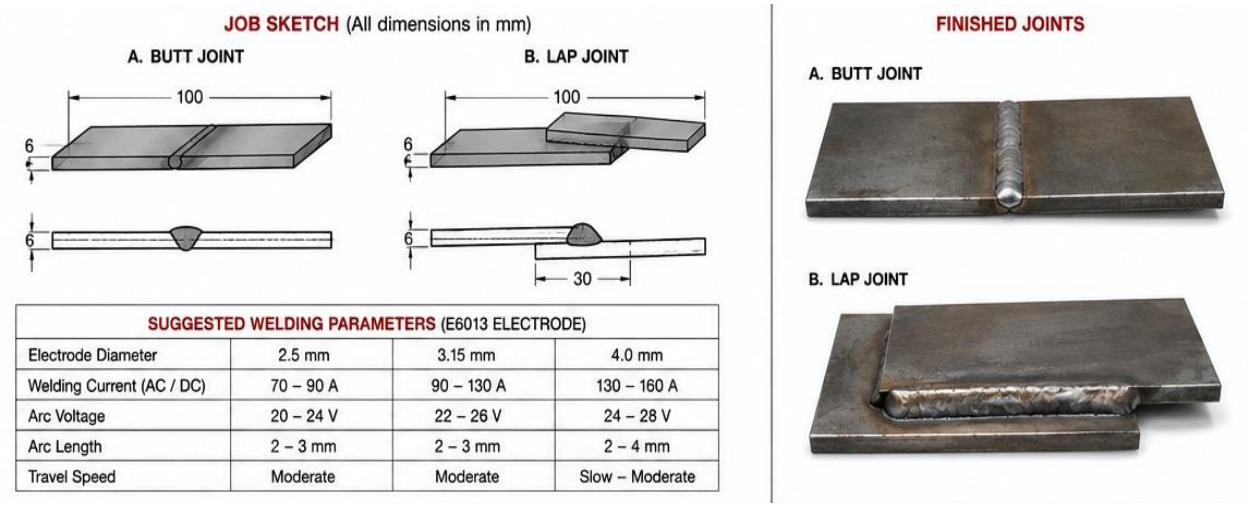
Applications

1. Structural fabrication
2. Bridges
3. Pipelines
4. Machine frames
5. Pressure vessels
6. General repair and maintenance

Circuit Diagram / Layout / Experimental Setup

Experimental Setup

The setup consists of:
Arc welding machine (AC/DC)
Electrode holder
Welding electrode
Earth clamp
Mild steel plates
Welding table
Chipping hammer
Wire brush
PPE (helmet, gloves, apron, safety shoes)
(Students should draw a labelled setup showing the welding machine, power cables, electrode holder, workpiece, earth clamp, and welding table.)



SUGGESTED WELDING PARAMETERS (E6013 ELECTRODE)			
Electrode Diameter	2.5 mm	3.15 mm	4.0 mm
Welding Current (AC / DC)	70 – 90 A	90 – 130 A	130 – 160 A
Arc Voltage	20 – 24 V	22 – 26 V	24 – 28 V
Arc Length	2 – 3 mm	2 – 3 mm	2 – 4 mm
Travel Speed	Moderate	Moderate	Slow – Moderate

Fig. 12. Arc welded lap Joint

Resources Required

Sl. No.	Item	Specification	Quantity
1	Arc Welding Machine	AC/DC	1
2	Mild Steel Plates	As per drawing	2
3	Welding Electrodes	E6013, 2.5 mm/3.15 mm	As required
4	Electrode Holder	Standard	1
5	Earth Clamp	Standard	1
6	Chipping Hammer	Standard	1
7	Wire Brush	Standard	1
8	Welding Helmet	Standard	1
9	Leather Gloves	Standard	1 Pair
10	Steel Rule	300 mm	1

Precautions

1. Wear a welding helmet, gloves, apron, and safety shoes.
2. Check all electrical connections before switching on the machine.
3. Ensure proper earthing of the welding machine.
4. Select the correct welding current according to electrode size.
5. Hold the electrode firmly in the electrode holder.
6. Maintain the proper arc length during welding.
7. Keep combustible materials away from the welding area.
8. Do not touch live electrical parts.

9. Remove slag only after the weld has cooled sufficiently.
10. Switch off the welding machine after completing the work.
11. Maintain good ventilation in the welding area.
12. Keep the workplace clean and dry.

Procedure

1. Study the given sketch/drawing.
2. Select suitable mild steel plates.
3. Clean the joint edges to remove rust, oil, and dirt.
4. Prepare the butt or lap joint according to the drawing.
5. Clamp the workpieces securely.
6. Select the appropriate electrode and welding current.
7. Connect the earth clamp properly.
8. Wear the required PPE.
9. Strike the arc and maintain the proper arc length.
10. Deposit the weld bead uniformly along the joint.
11. Remove slag using a chipping hammer and wire brush.
12. Inspect the weld bead visually.
13. Compare the finished joint with the drawing.
14. Switch off the welding machine and clean the workplace.

Observations and Calculations

Welding Details

Particular	**Observation**
Joint Type	
Base Material	
Plate Thickness	
Electrode Type	
Electrode Diameter	
Welding Position	

Welding Parameters

Parameter	**Observation**
Current (A)	
Voltage (V)	
Arc Length	
Travel Speed	
Number of Passes	

Weld Inspection

Inspection Parameter	Observation
Joint Alignment	
Uniformity of Weld Bead	
Penetration	
Surface Finish	
Visible Defects	

Results

The butt joint / lap joint was successfully prepared by Shielded Metal Arc Welding (SMAW) using suitable welding parameters according to the given sketch/drawing. The welded joint was found to be acceptable / requires improvement based on visual inspection.

Interpretation of Results

- A sound welded joint exhibits proper fusion, uniform bead profile, adequate penetration, and freedom from visible defects such as cracks, porosity, slag inclusion, undercut, and lack of fusion.
- Proper electrode selection, welding current, arc length, and travel speed significantly influence weld quality and economy.

Conclusions and Recommendations

Conclusion

The experiment demonstrated the preparation of butt and lap joints using Shielded Metal Arc Welding (SMAW). Students acquired practical skills in selecting welding parameters, producing sound welded joints, reducing material wastage, and following safe welding practices.

Recommendations

- Select the appropriate electrode for the base metal.
- Maintain the recommended welding current and arc length.
- Keep the workpieces clean before welding.
- Avoid excessive reinforcement and unnecessary grinding.
- Follow all electrical and welding safety precautions.
- Inspect the weld after slag removal before accepting the job.

Practical Related Questions

1. Define Shielded Metal Arc Welding (SMAW).

2. State the principle of arc welding.
3. What is the function of electrode coating?
4. Differentiate between a butt joint and a lap joint.
5. How does welding current affect weld quality?
6. State four common welding defects.
7. What is arc length, and why is it important?
8. Why is slag removed after welding?
9. List four economic practices in arc welding.
10. State six safety precautions to be followed during arc welding.

References / Suggestions for Further Reading

1. O. P. Khanna, A Textbook of Welding Technology.
2. S. K. Hajra Choudhury, Elements of Workshop Technology (Vol. II).
3. P. N. Rao, Manufacturing Technology.
4. B. S. Raghuwanshi, Workshop Technology.
5. SBTE Bihar Diploma Curriculum – Manufacturing Engineering Laboratory.
6. IS 817: Code of Practice for Training and Testing of Metal Arc Welders.
7. Relevant BIS standards for arc welding practices and safety.
8. All images are AI generated

Assessment Scheme (Combined Process and Product Rubrics)

A. Process Assessment Rubric (20 Marks)

Assessment Criteria	Weightage	Level 4 – Excellent	Level 3 – Good	Level 2 – Satisfactory	Level 1 – Needs Improvement
1. Drawing Interpretation and Joint Preparation	**4**	**4 Marks** – Correctly interprets the drawing, prepares edges, aligns and clamps the workpieces accurately before welding.	**3 Marks** – Correctly prepares the joint with minor guidance or alignment errors.	**2 Marks** – Requires guidance in edge preparation and alignment.	**1 Mark** – Unable to prepare or align the joint correctly.
2. Selection of Electrode, Welding	**4**	**4 Marks** – Selects suitable	**3 Marks** – Selects appropriate	**2 Marks** – Requires guidance in	**1 Mark** – Incorrect parameter

Assessment Criteria	Weightage	Level 4 – Excellent	Level 3 – Good	Level 2 – Satisfactory	Level 1 – Needs Improvement
Parameters and Equipment Setup		electrode, polarity, welding current and sets up the welding machine correctly and independently.	parameters with minor errors or occasional guidance.	selecting electrode or welding parameters.	selection or improper machine setup.
3. Welding Technique and Process Execution	**6**	**6 Marks** – Maintains proper arc length, electrode angle, travel speed and bead sequence, producing a uniform weld with minimum electrode wastage.	**4.5 Marks** – – Performs welding with minor variations in technique or bead uniformity.	**3 Marks** – Completes welding with frequent guidance and noticeable procedural errors.	**1.5 Marks** – Unable to perform the welding process satisfactorily or complete the joint.
4. Safety Practices and Economy of Consumables	**3**	**3 Marks** – Consistently follows welding safety rules, uses PPE correctly and utilizes electrodes and electrical power efficiently with minimal wastage.	**2.25 Marks** – – Follows safety practices with occasional reminders and minor consumable wastage.	**1.5 Marks** – Requires frequent reminders for safety and economical use of consumables.	**0.75 Mark** – Ignores safety practices or wastes electrodes and materials excessively.
5. Work Discipline and Time Management	**3**	**3 Marks** – Completes the welding job within the allotted time with excellent	**2.25 Marks** – – Completes the work with minor delay.	**1.5 Marks** – Requires additional time and supervision.	**0.75 Mark** – Fails to complete the work within the allotted time.

Assessment Criteria	Weightage	Level 4 – Excellent	Level 3 – Good	Level 2 – Satisfactory	Level 1 – Needs Improvement
		discipline and proper shutdown procedure.			

B. Product Assessment Rubric (10 Marks)

Assessment Criteria	Weightage	Level 4 – Excellent	Level 3 – Good	Level 2 – Satisfactory	Level 1 – Needs Improvement
1. Joint Accuracy and Alignment	**4**	**4 Marks** – Butt/Lap joint dimensions and alignment conform to the drawing with proper fit-up and uniform bead placement.	**3 Marks** – Minor alignment or dimensional deviation without affecting joint quality.	**2 Marks** – Noticeable alignment or dimensional errors affecting appearance.	**1 Mark** – Significant misalignment or incorrect joint dimensions.
2. Weld Bead Quality and Surface Finish	**3**	**3 Marks** – Uniform weld bead with good fusion, proper penetration (visual), smooth appearance and free from visible defects such as slag inclusion, undercut, overlap or excessive spatter.	**2.25 Marks** – Good weld bead with minor visible defects.	**1.5 Marks** – Acceptable weld with noticeable irregularities or surface defects.	**0.75 Mark** – Poor weld bead with major defects or incomplete fusion.
3. Overall Workmanship	**3**	**3 Marks** – Joint is neat, complete,	**2.25 Marks** – Good workmanship	**1.5 Marks** – Functional joint with	**0.75 Mark** – Weak, incomplete or

Assessment Criteria	Weightage	Level 4 – Excellent	Level 3 – Good	Level 2 – Satisfactory	Level 1 – Needs Improvement
and Joint Integrity		structurally sound and demonstrates excellent workmanship.	with minor imperfections.	visible workmanship defects.	poorly finished joint.

EXPERIMENT NO.: 3.4 Preparation of a Simple Job (Lap Joint of Mild Steel Plate) Using Soldering/Brazing Operations as per the Given Drawing

Practical Significance

This experiment provides hands-on experience in joining two mild steel plates using soldering or brazing, which are widely used for joining thin metallic components where high-strength fusion welding is not required (soldering) or where moderate-strength permanent joints are desired (brazing). Students learn surface preparation, flux application, heating techniques, filler metal selection, joint inspection, and safe working practices. The experiment develops accuracy, workmanship, and an understanding of capillary action in metal joining.

Relevant Program Outcomes (POs)
PO-1 Basic and Discipline Specific Knowledge
PO-2 Problem Analysis
PO-3 Design/Development of Solutions
PO-4 Engineering Tools
PO-5 Engineering Practices for Society, Sustainability and Environment
PO-7 Lifelong Learning

Related Course Outcome(s)

CO	Statement	PO							PSO	
CO3	Perform various joining operations using welding, brazing, and soldering methods.	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO3
		3	2	2	3	1	-	1		

Laboratory Session Outcomes

After completing this experiment, the student will be able to:

LSO 3.1 Select suitable joining process in a given situation.
LSO 3.2 Use Personal Protective Equipment in welding shop.
LSO 3.3 Perform gas welding operations in a given situation to prepare joint safely.
LSO 3.4 Prepare given welding joint safely using arc welding in a given situation.
LSO 3.5 Carryout soldering / brazing operation(s) as per given job.

Practical Skills

- Measuring and marking
- Surface cleaning
- Edge preparation
- Flux application
- Heating technique
- Soldering/Brazing operation
- Joint inspection
- Cleaning and finishing
- Safe handling of heating equipment.

Minimum Theoetical Background

Soldering is a metal joining process in which a filler metal having a melting temperature below 450°C is melted to join two metallic components without melting the base metal.
Brazing is a joining process in which a filler metal having a melting temperature above 450°C but below the melting point of the base metal is used. The filler metal flows into the joint by capillary action, producing a stronger joint than soldering.
A lap joint is formed when one plate overlaps another plate and both are joined over the overlapping region.
The quality of a soldered/brazed joint depends upon:
Proper surface cleaning
Correct overlap
Suitable flux
Uniform heating
Proper filler metal flow
Adequate cooling

VII. Circuit Diagram/Layout/Experimental Setup

Job Specification
Material: Mild Steel Plate
Typical Dimensions
Plate Size: 50 × 15 × 3 mm (2 Nos.)
Lap Length: 15 mm
Joint Type
Lap Joint
Joining Process
Soft Soldering or
Brazing (as specified by the instructor)

Experimental Setup



Fig. 13. Brazed mild steel lap joint

Resources Required

Material: Mild Steel Plates (2 Nos.), Flux (Zinc Chloride/Borax), Solder Wire or Brazing Rod, Emery Paper

Equipment: Soldering Iron or Gas Torch, Bench Vice

Tools: Steel Rule, Try Square, File, Wire Brush, Tongs, Hammer

Measuring Instruments: Steel Rule, Vernier Caliper

PPE: Safety Goggles, Leather Gloves, Apron, Safety Shoes

Precautions

1. Wear appropriate PPE throughout the experiment.
2. Clean the plate surfaces thoroughly before joining.
3. Apply flux uniformly over the joint area.
4. Heat the joint uniformly without overheating.
5. Do not overheat the solder or brazing filler.
6. Hold the workpiece securely using a vice.
7. Avoid direct contact with hot metal.
8. Work in a well-ventilated area.
9. Keep flammable materials away from the heating source.
10. Allow the joint to cool naturally before inspection.

Procedure

1. Study the given drawing carefully.
2. Select two mild steel plates of the specified dimensions.
3. Mark the required overlap length.
4. Clean the joining surfaces using emery paper and a wire brush.
5. Clamp the plates to form the lap joint.
6. Apply suitable flux to the overlapping area.
7. Heat the joint uniformly using the appropriate heating source.
8. Apply solder or brazing filler to the heated joint.
9. Allow the filler metal to flow completely through the lap.
10. Remove the heat source and allow the joint to cool naturally.
11. Clean residual flux using a wire brush.
12. Inspect the completed joint for proper bonding and finish.

Observations and Calculations

Observation Table

Sl. No.	Parameter	Specified	Observed
1	Plate Length	100 mm	_____
2	Plate Width	25 mm	_____
3	Plate Thickness	3 mm	_____
4	Lap Length	25 mm	_____
5	Joint Alignment	Proper	_____
6	Filler Metal Flow	Uniform	_____
7	Surface Finish	Good	_____
8	Visual Defects	Nil	_____

Results

A simple lap joint of mild steel plates was successfully prepared using soldering/brazing as per the given drawing, producing a neat and properly bonded joint.

Interpretation of Results

- The joint exhibits proper adhesion of the filler metal.
- Filler metal has flowed uniformly throughout the overlap.
- The joint is free from visible defects such as voids, cracks, or incomplete bonding.
- Proper heating and flux application resulted in a sound joint.
- The finished job meets the specified dimensions and workmanship requirements.

Conclusions and Recommendations

Conclusion

The lap joint was successfully fabricated using the soldering/brazing process by following the correct sequence of surface preparation, flux application, heating, filler metal application, and finishing while maintaining workshop safety.

Recommendations

1. Clean the surfaces thoroughly before joining.
2. Apply flux uniformly.
3. Maintain proper overlap.
4. Avoid overheating during the joining process.
5. Allow natural cooling for improved joint quality.
6. Inspect the joint visually before use.

Practical Related Questions

1. Define soldering and brazing.
2. Differentiate between soldering and brazing.
3. What is a lap joint?
4. What is the purpose of flux?
5. Name two commonly used soldering fluxes.
6. What is capillary action in brazing?
7. Name two brazing filler metals.
8. State four safety precautions during soldering/brazing.
9. List two industrial applications of brazing.
10. Why is surface cleaning essential before soldering or brazing?

References / Suggestions for Further Reading

1. P. N. Rao, Manufacturing Technology, Vol. II, McGraw-Hill Education.
2. S. K. Hajra Choudhury, Workshop Technology, Vol. II, Media Promoters & Publishers.
3. O. P. Khanna, Welding Technology, Dhanpat Rai Publications.
4. AWS Brazing Handbook, American Welding Society.
5. SBTE Bihar Mechanical Engineering Workshop Practice Manual.

Assessment Scheme (Combined Process and Product Rubrics)

A. Process Assessment Rubric (20 Marks)

Assessment Criteria	Weightage	Level 4 – Excellent	Level 3 – Good	Level 2 – Satisfactory	Level 1 – Needs Improvement
1. Drawing Interpretation and Joint Preparation	**4**	**4 Marks** – Correctly interprets the drawing, prepares the workpieces, cleans joint surfaces and plans the sequence of soldering/brazing independently.	**3 Marks** – Interprets the drawing correctly with minor guidance and prepares the joint with minor errors.	**2 Marks** – Requires guidance to interpret the drawing and prepare the joint surfaces.	**1 Mark** – Unable to interpret the drawing or prepare the joint correctly.
2. Selection and Safe Use of Tools,	**4**	**4 Marks** – Selects appropriate	**3 Marks** – Selects suitable	**2 Marks** – Requires guidance in	**1 Mark** – Incorrect selection of

Assessment Criteria	Weightage	Level 4 – Excellent	Level 3 – Good	Level 2 – Satisfactory	Level 1 – Needs Improvement
Equipment and Consumables		solder/brazing filler, flux, heating equipment and tools correctly; handles them safely throughout the operation.	materials and tools with minor errors or occasional reminders on safety.	selecting filler, flux or equipment.	consumables or unsafe handling practices.
3. Execution of Soldering/Brazing Operation	**6**	**6 Marks** – Performs heating, flux application and filler deposition systematically, producing proper wetting and bonding with minimal material wastage.	**4.5 Marks** – Completes the operation with minor procedural errors or slight overheating/ underheating.	**3 Marks** – Completes the operation with frequent guidance and noticeable procedural errors.	**1.5 Marks** – Unable to perform the operation satisfactorily or complete the joint.
4. Safety Practices and Housekeeping	**3**	**3 Marks** – Consistently follows safety rules, uses PPE correctly, handles hot components safely and maintains a clean workplace.	**2.25 Marks** – Follows safety practices with occasional reminders.	**1.5 Marks** – Requires frequent reminders regarding safety and housekeeping.	**0.75 Mark** – Frequently ignores safety practices and workplace cleanliness.
5. Work Discipline and Time Management	**3**	**3 Marks** – Completes the job within the allotted time with excellent discipline and proper shutdown of equipment.	**2.25 Marks** – Completes the work with minor delay and minimal supervision.	**1.5 Marks** – Requires additional time and supervision.	**0.75 Mark** – Fails to complete the work within the allotted time.

B. Product Assessment Rubric (10 Marks)

Assessment Criteria	Weightage	Level 4 – Excellent	Level 3 – Good	Level 2 – Satisfactory	Level 1 – Needs Improvement
1. Joint Accuracy and Dimensional Conformity	**4**	**4 Marks** – Joint dimensions, alignment and assembly conform to the given drawing with proper fit and clearance.	**3 Marks** – Minor dimensional or alignment deviations that do not affect functionality.	**2 Marks** – Noticeable dimensional or alignment errors affecting fit or appearance.	**1 Mark** – Significant dimensional or alignment errors; job does not conform to the drawing.
2. Joint Quality and Surface Finish	**3**	**3 Marks** – Joint is clean, well bonded, uniformly filled and free from visible defects such as excess filler, voids or burnt flux residues.	**2.25 Marks** – Good joint quality with minor surface defects or excess filler.	**1.5 Marks** – Acceptable joint with noticeable surface defects or uneven filler distribution.	**0.75 Mark** – Poor joint quality with incomplete bonding or major visible defects.
3. Overall Workmanship and Functionality	**3**	**3 Marks** – Job is neat, complete, mechanically sound and demonstrates excellent workmanship.	**2.25 Marks** – Good workmanship with minor imperfections.	**1.5 Marks** – Functional job with visible workmanship defects.	**0.75 Mark** – Poor workmanship, weak or incomplete joint.

EXPERIMENT NO.: 4.1 Prepare One Sheet Metal Funnel Using Cutting, Bending, Edging and Joining Operations as per Given Drawing.

Practical Significance

This experiment develops basic sheet metal fabrication skills through measuring, marking, cutting, bending, edging and joining operations. The preparation of a funnel provides practical understanding of pattern development and the fabrication of a useful sheet metal product. It also develops accuracy, proper tool selection, safe working habits and quality inspection skills.

Relevant Program Outcomes (POs)

PO-1 Basic and Discipline Specific Knowledge
PO-2 Problem Analysis
PO-3 Design/Development of Solutions
PO-4 Engineering Tools
PO-5 Engineering Practices for Society, Sustainability and Environment
PO-6 Project Management
PO-7 Lifelong Learning

Related Course Outcome(s)

CO	**Statement**	**PO**							**PSO**	
CO4	Perform various sheet metal operations as per given sketch/ drawing.	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO3
		3	1	1	3	1	1	1		

Laboratory Session Outcomes

After completing this experiment, the student will be able to:
LSO 4.1 Select suitable sheet metal tools, machinery / equipment for given used as per requirements.
LSO 4.2 Select suitable sheet metal operations in a given situation.
LSO 4.3 Perform relevant sheet metal operations such as shearing, bending, drawing, squeezing, snipping, riveting, grooving etc.to prepare utility jobs safely as given sketch/ drawing.

Practical Skills

- Measuring and marking
- Pattern development
- Sheet metal cutting
- Bending and forming
- Edge preparation and edging
- Seaming/soldering
- Filing and finishing
- Dimensional inspection
- Safe handling of sheet metal tools

Minimum Theoretical Background

A sheet metal funnel is a conical or frustum-shaped product used for transferring liquids, powders or small materials from a larger opening into a smaller opening.The funnel can be fabricated from GI sheet, aluminium sheet or mild steel sheet. The basic operations involved are:

1. **Marking** – transferring the developed pattern onto the sheet.
2. **Cutting** – cutting the sheet according to the developed pattern.
3. **Bending/Forming** – forming the sheet into the required conical shape.
4. **Edging** – preparing or strengthening the edges.
5. **Joining** – joining the overlapping edges by seaming, riveting or soldering.
6. **Finishing** – removing sharp edges and burrs.

A typical funnel consists of a conical body and a cylindrical outlet/spout.

Circuit Diagram/Layout/Experimental Setup

Suggested Job Dimensions

Material: GI Sheet

Thickness: 0.8–1.0 mm

Component	**Specification**
Funnel top diameter	Ø200 mm
Funnel height	150 mm
Outlet/spout diameter	Ø50 mm
Spout length	50 mm
Sheet thickness	0.8–1.0 mm

Joining: Seaming/Soldering as specified by the instructor.

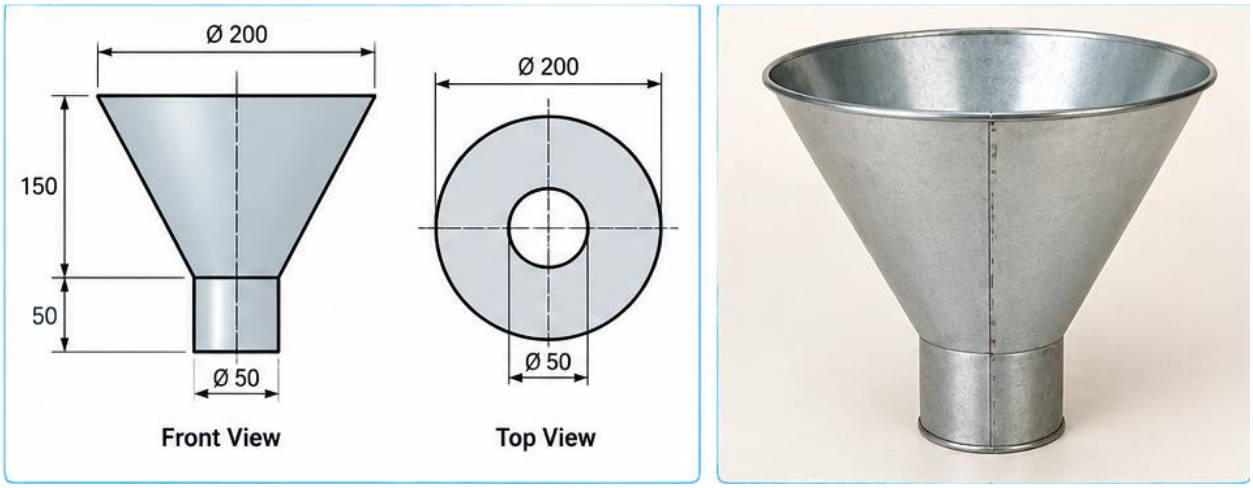




Fig. 14.GI sheet Funnel

Suggested Drawing

The drawing should show:

- Conical funnel body
- Cylindrical spout
- Developed pattern of conical body
- Seam allowance
- Edge allowance
- Dimensions and joining locations

Resources Required

Material

- GI sheet, approximately 0.8–1.0 mm thick
- Solder and flux, if soldering is used

Tools and Equipment: Steel rule, Try square, Scriber, Divider, Snips, Hand shears, Wooden mallet, Stakes, Bench vice, Files, Pliers, Seamers, Soldering iron/gas torch, if required

Measuring Instruments: Steel rule, Vernier caliper, Divider

PPE: Safety goggles, Safety shoes, Apron, Protective gloves

Precautions

1. Wear appropriate PPE throughout the experiment.
2. Handle sheet metal carefully because its edges may be sharp.
3. Use the correct type of snips for cutting.
4. Secure the sheet properly before cutting or bending.
5. Do not use excessive force while bending the sheet.
6. Remove sharp edges and burrs after cutting.
7. Keep hands away from cutting edges.
8. If soldering is used, work in a properly ventilated area.
9. Do not touch hot soldering equipment or freshly heated work.
10. Keep the workplace clean and return tools after use.

Procedure

1. Study the given drawing and identify all dimensions.
2. Select GI sheet of the specified thickness.
3. Clean the sheet surface.
4. Develop the pattern of the conical funnel body.
5. Add suitable seam and edge allowances.

6. Mark the developed pattern on the sheet using a scriber.
7. Cut the pattern carefully using suitable snips.
8. Remove burrs and sharp edges using a file.
9. Form the cut sheet into a conical shape using suitable forming tools.
10. Bring the edges together and provide the required seam.
11. Prepare the cylindrical spout according to the drawing.
12. Roll and join the spout.
13. Join the spout to the funnel body.
14. Perform edging on the required rim.
15. Solder the joints if soldering is specified.
16. Check the overall dimensions and alignment.
17. Remove excess solder, burrs and sharp edges.
18. Clean and finish the completed funnel.

Observations and Calculations

Observation Table

Sl. No.	Parameter	Specification	Actual Observation
1	Material	GI Sheet	_____
2	Sheet thickness	0.8–1.0 mm	_____
3	Top diameter	Ø120 mm	_____
4	Funnel height	100 mm	_____
5	Outlet diameter	Ø20 mm	_____
6	Spout length	50 mm	_____
7	Joint type	Seam/Soldered	_____
8	Edge finish	Smooth	_____

Calculations

For a conical funnel, the slant height can be determined by:

$L = h_2 + (R - r)2$

Where:

- h = height of funnel
- R = radius of large end
- r = radius of small end
- L = slant height

The developed pattern is marked by considering the required seam and edge allowances.

Results

A sheet metal funnel was successfully prepared by performing cutting, bending, edging and joining operations according to the given drawing.

Interpretation of Results

- The funnel body was formed to the required conical shape.
- The spout was properly aligned with the funnel body.
- The joining operation produced a continuous and secure joint.
- The rim was properly edged and finished.
- The final dimensions were within the specified limits.
- No significant sharp edges or visible defects were observed.

Conclusions and Recommendations

Conclusion

The sheet metal funnel was successfully fabricated using suitable cutting, bending, edging and joining operations**.** The experiment provided practical experience in pattern development, sheet metal forming and joining.

Recommendations

- Provide adequate allowance during pattern development.
- Use sharp and suitable snips for accurate cutting.
- Avoid excessive hammering during forming.
- Ensure proper alignment before joining.
- Remove all burrs and sharp edges.
- Inspect the final product before submission.

Practical Related Questions

1. What is sheet metal work?
2. What is the purpose of a funnel?
3. Why is pattern development required in sheet metal work?
4. Name four sheet metal cutting tools.
5. What is the function of snips?
6. What is edging?
7. Why are allowances provided in sheet metal patterns?
8. Name two methods of joining sheet metal.
9. Why are sharp edges removed after cutting?
10. State any four safety precautions for sheet metal work.

References / Suggestions for Further Reading

1. S. K. Hajra Choudhury**,** Workshop Technology, Vol. I.
2. B. S. Raghuwanshi, A Course in Workshop Technology, Vol. I.
3. P. N. Rao, Manufacturing Technology, Vol. I.
4. Standard workshop technology manuals covering sheet metal operations.
5. All images are AI generated

Assessment Scheme (Combined Process and Product Rubrics)

A. Process Assessment Rubric (20 Marks)

Assessment Criteria	Weightage	Level 4 – Excellent	Level 3 – Good	Level 2 – Satisfactory	Level 1 – Needs Improvement
1. Drawing Interpretation and Layout Marking	**4**	**4 Marks** – Correctly interprets the drawing, prepares the development/ layout and completes marking accurately without assistance.	**3 Marks** – Interprets the drawing correctly with minor marking errors or minor guidance.	**2 Marks** – Requires guidance for layout preparation and marking.	**1 Mark** – Unable to interpret the drawing or prepare the layout correctly.
2. Selection and Safe Use of Sheet Metal Tools	**4**	**4 Marks** – Selects appropriate hand tools, measuring instruments and joining tools; uses them correctly and safely throughout the work.	**3 Marks** – Selects suitable tools with minor handling or safety errors.	**2 Marks** – Requires guidance in tool selection or safe handling.	**1 Mark** – Uses inappropriate tools or follows unsafe practices.
3. Execution of Cutting,	**6**	**6 Marks** – Performs all	**4.5 Marks** – Performs all	**3 Marks** – Completes	**1.5 Marks** – Unable to

Assessment Criteria	Weightage	Level 4 – Excellent	Level 3 – Good	Level 2 – Satisfactory	Level 1 – Needs Improvement
Bending, Edging and Joining Operations		operations systematically with correct sequence, accurate workmanship and minimal material wastage.	operations with minor procedural or workmanship errors.	operations with frequent guidance and noticeable errors.	complete the job satisfactorily or demonstrates incorrect procedures.
4. Safety Practices and Housekeeping	**3**	**3 Marks** – Consistently follows safety practices, uses PPE correctly, handles sharp sheet edges safely and maintains a clean workplace.	**2.25 Marks** – Follows safety practices with occasional reminders.	**1.5 Marks** – Requires frequent reminders regarding safety and housekeeping.	**0.75 Mark** – Frequently ignores safety rules and workplace cleanliness.
5. Work Discipline and Time Management	**3**	**3 Marks** – Completes the sheet metal job within the allotted time with excellent discipline and proper use of materials.	**2.25 Marks** – Completes the work with minor delay and minimal supervision.	**1.5 Marks** – Requires additional time and supervision.	**0.75 Mark** – Fails to complete the assigned job within the allotted time.

B. Product Assessment Rubric (10 Marks)

Assessment Criteria	Weightage	Level 4 – Excellent	Level 3 – Good	Level 2 – Satisfactory	Level 1 – Needs Improvement
1. Dimensional Accuracy and Shape	**4**	**4 Marks** – All dimensions, bend angles and overall shape conform to the	**3 Marks** – Minor dimensional or bend angle deviations	**2 Marks** – Noticeable dimensional or shape	**1 Mark** – Significant dimensional or shape errors; job does not

Assessment Criteria	Weightage	Level 4 – Excellent	Level 3 – Good	Level 2 – Satisfactory	Level 1 – Needs Improvement
		given drawing within the specified tolerance.	that do not affect functionality.	errors affecting fit or appearance.	conform to the drawing.
2. Edge Finish and Joint Quality	**3**	**3 Marks** – Edges are smooth, burr-free, bends are uniform and joints (seam/rivet/fold) are neat and secure.	**2.25 Marks** – Good finish with minor burrs, uneven bends or slight joint imperfections.	**1.5 Marks** – Acceptable finish with noticeable burrs or joint defects.	**0.75 Mark** – Poor edge finish, defective bends or weak/incomplete joints.
3. Overall Workmanship and Appearance	**3**	**3 Marks** – Job is neat, complete, clean and demonstrates excellent craftsmanship with proper symmetry.	**2.25 Marks** – Good workmanship with minor imperfections.	**1.5 Marks** – Functional job with visible workmanship defects.	**0.75 Mark** – Poor workmanship, incomplete or defective job.

EXPERIMENT NO.: 4.2 Preparation of a Sheet Metal Rectangular Tray of Dimensions 300 mm × 100 mm × 50 mm.

Practical Significance

A rectangular tray is a common sheet metal product manufactured using marking, cutting, notching, bending, edging, and joining operations. Such products are widely used in workshops, industries, electrical panels, storage systems, food processing equipment, laboratories, and packaging applications. This experiment develops students' skills in reading engineering drawings, preparing development layouts, performing sheet metal operations accurately, minimizing material wastage, and producing a finished product with good dimensional accuracy and workmanship.

Relevant Program Outcomes (POs)

PO-1 Basic and Discipline Specific Knowledge
PO-2 Problem Analysis
PO-3 Design/Development of Solutions
PO-4 Engineering Tools
PO-5 Engineering Practices for Society, Sustainability and Environment
PO-6 Project Management
PO-7 Lifelong Learning

Related Course Outcome(s)

CO	Statement	PO							PSO	
CO4	Perform various sheet metal operations as per given sketch/ drawing.	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO3
		3	1	1	3	1	1	1		

Laboratory Session Outcomes

After completing this experiment, the student will be able to:
LSO 4.1 Select suitable sheet metal tools, machinery / equipment for given used as per requirements.
LSO 4.2 Select suitable sheet metal operations in a given situation.
LSO 4.3 Perform relevant sheet metal operations such as shearing, bending, drawing, squeezing, snipping, riveting, grooving etc.to prepare utility jobs safely as given sketch/ drawing.

Practical Skills

- The student will be able to:
- Read engineering drawings.
- Prepare sheet metal development.
- Perform accurate marking and cutting.
- Carry out notching and bending operations.
- Finish edges safely.
- Inspect dimensions using measuring instruments.
- Minimize material wastage.

Minimum Theoretical Background

Sheet Metal Work

Sheet metal work involves converting thin metal sheets into useful products by operations such as marking, cutting, bending, notching, edging, hemming, seaming, riveting, and soldering.

Development of a Rectangular Tray

Development is the flat pattern prepared before fabrication.

For a tray of:

Length (L) = 300 mm

Width (W) = 100 mm

Height (H) = 50 mm

Approximate blank size (without hemming allowance):

Length = 300 + 2 × 50 = 400 mm

Width = 100 + 2 × 50 = 200 mm

Additional allowance may be provided for edging or hemming as specified in the drawing.

Operations Involved

a) Measuring
b) Marking
c) Cutting
d) Corner Notching
e) Bending
f) Edging (if required)
g) Finishing

Sheet Metal Tools Used

a) Steel rule
b) Scriber
c) Divider
d) Try square
e) Prick punch

f) Hand snips
g) Ball peen hammer
h) Wooden mallet
i) Folding bars
j) Stakes
k) Bench vice

Applications

1. Tool trays
2. Component storage trays
3. Electrical panel trays
4. Laboratory trays
5. Packaging trays
6. Industrial material handling

Circuit Diagram / Layout / Experimental Setup

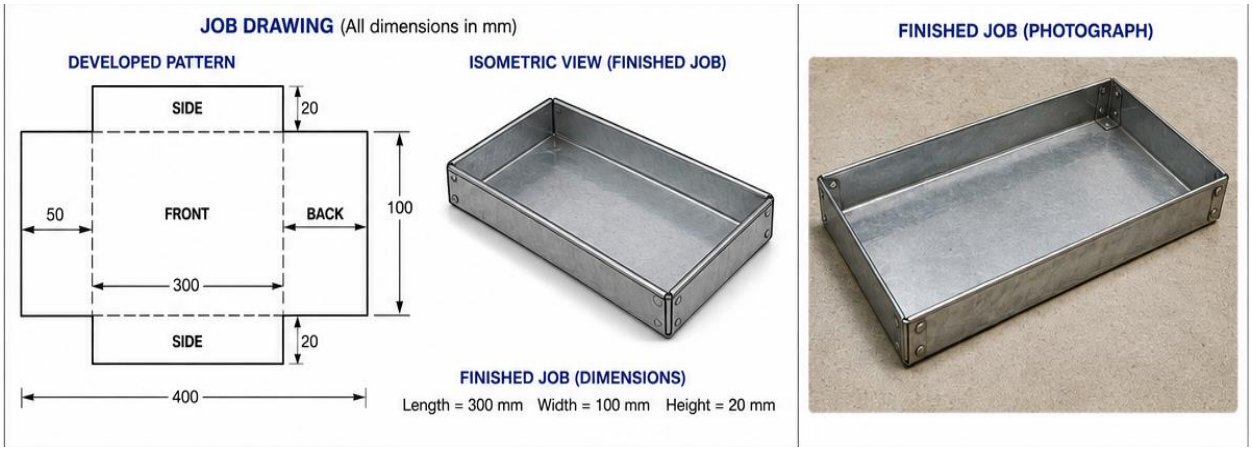
Development/Layout

Students should draw the development of the tray showing:
Bottom: 300 × 100 mm
Four side flanges: 50 mm
Corner notches
Bending lines
Edging allowance (if provided)

Experimental Setup

The setup consists of:

Sheet metal workbench
GI sheet
Measuring and marking tools
Cutting tools
Folding bars
Stakes
Wooden mallet
PPE



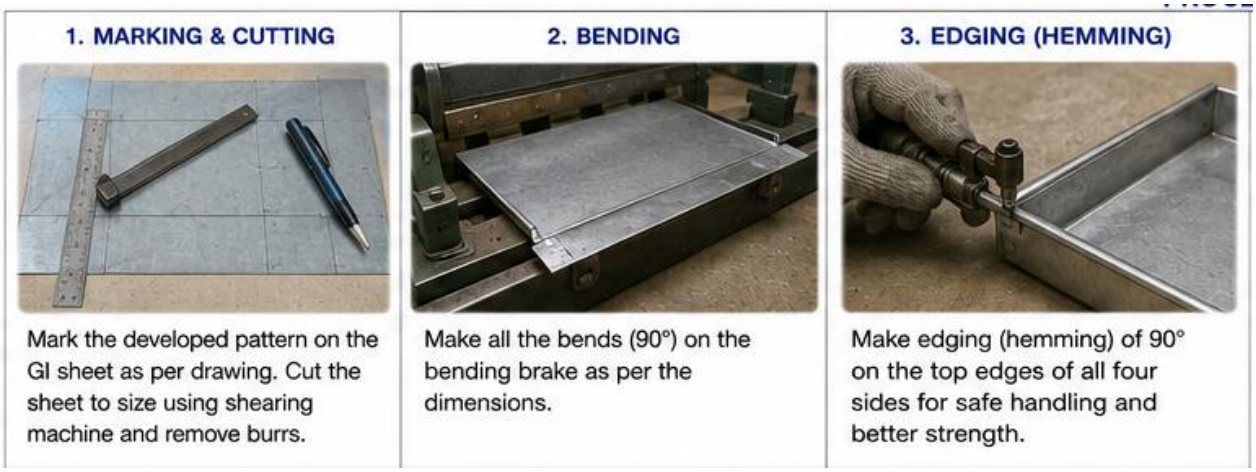




Fig. 15. Rectangular tray made up of GI sheet

Resources Required

Sl. No.	Item	Specification	Quantity
1	GI Sheet	22–24 SWG	1
2	Steel Rule	300 mm	1
3	Scriber	Standard	1
4	Divider	Standard	1
5	Try Square	Standard	1
6	Prick Punch	Standard	1
7	Hand Snips	Straight Cut	1
8	Wooden Mallet	Standard	1
9	Ball Peen Hammer	Standard	1
10	Folding Bar	Standard	1
11	Stake	Standard	1
12	Bench Vice	Standard	1
13	Safety Gloves	Standard	1 Pair
14	Safety Goggles	Standard	1

Precautions

1. Wear safety gloves and goggles.
2. Handle sheet metal carefully to avoid injury from sharp edges.
3. Verify dimensions before cutting.
4. Cut accurately along the marked lines.
5. Remove burrs before bending.
6. Perform bending gradually to avoid cracks.
7. Use wooden mallets to avoid surface damage.
8. Maintain proper alignment during bending.
9. Avoid excessive force during folding.
10. Keep the workplace clean after completion.

Procedure

1. Study the given drawing.
2. Calculate the blank size.
3. Prepare the development/layout.
4. Mark all dimensions accurately on the GI sheet.
5. Mark corner notches.
6. Cut the blank using hand snips.
7. Remove burrs from the edges.
8. Cut the corner notches carefully.
9. Bend all four sides along the bending lines.
10. Perform edging or hemming if required.

11. Check the squareness of the tray.
12. Measure the final dimensions.
13. Finish sharp edges.
14. Clean the work area.

Observations and Calculations

Material Details

Particular	**Observation**
Material	
Sheet Thickness	
Blank Size	
Finished Tray Size	

Dimensional Inspection

Dimension	**Specified (mm)**	**Measured (mm)**
Length	300	
Width	100	
Height	50	

Material Utilization

Parameter	**Observation**
Blank Area	
Finished Area	
Material Wastage	
Time Taken	

Inspection

Parameter	**Observation**
Cutting Quality	
Corner Notches	
Bending Accuracy	
Edge Finish	
Overall Appearance	

Results

A rectangular sheet metal tray of dimensions 300 mm × 100 mm × 50 mm was successfully prepared using marking, cutting, notching, bending, and edging operations. The finished tray was found to be acceptable / requires improvement based on dimensional inspection and workmanship.

Interpretation of Results

- The finished tray meets the specified dimensions when the measured values are within permissible limits.
- Accurate marking and cutting improve dimensional accuracy.
- Proper bending sequence and corner notching ensure correct tray geometry.
- Material utilization depends upon efficient layout planning and controlled cutting.

Conclusions and Recommendations

Conclusion

The experiment successfully demonstrated the fabrication of a rectangular sheet metal tray using fundamental sheet metal operations. Students acquired practical skills in layout preparation, cutting, notching, bending, finishing, and inspection.

Recommendations

- Verify dimensions before cutting.
- Prepare an accurate development layout.
- Perform corner notching carefully.
- Bend uniformly using suitable tools.
- Minimize material wastage.
- Follow all workshop safety practices.

Practical Related Questions

1. Define sheet metal work.
2. What is sheet metal development?
3. Why are corner notches provided?
4. State the purpose of edging.
5. List five sheet metal hand tools.
6. Differentiate between bending and folding.
7. Why is burr removal necessary?
8. State four applications of rectangular trays.
9. Explain the importance of layout planning.
10. List six safety precautions followed during sheet metal work.

References / Suggestions for Further Reading

1. S. K. Hajra Choudhury, Elements of Workshop Technology (Vol. I).
2. B. S. Raghuwanshi, Workshop Technology.
3. P. N. Rao, Manufacturing Technology.
4. K. C. John, Workshop Technology.
5. SBTE Bihar Diploma Curriculum – Manufacturing Engineering Laboratory.
6. Relevant BIS standards for sheet metal work and workshop safety.
7. All images are AI generated

Assessment Scheme (Combined Process and Product Rubrics)

A. Process Assessment Rubric (20 Marks)

Assessment Criteria	Weightage	Level 4 – Excellent	Level 3 – Good	Level 2 – Satisfactory	Level 1 – Needs Improvement
1. Drawing Interpretation and Development/Layout Preparation	**4**	**4 Marks** – Correctly interprets the drawing, prepares the development with accurate bend allowance and completes marking independently.	**3 Marks** – Correctly interprets the drawing with minor errors in development or marking.	**2 Marks** – Requires guidance in preparing the development and layout.	**1 Mark** – Unable to prepare the development /layout correctly.
2. Selection and Safe Use of Tools and Equipment	**4**	**4 Marks** – Selects and uses appropriate sheet metal tools, measuring instruments and equipment correctly and safely	**3 Marks** – Selects suitable tools with minor handling or safety errors.	**2 Marks** – Requires guidance in tool selection or safe handling.	**1 Mark** – Incorrect tool selection or unsafe work practices.

Assessment Criteria	Weightage	Level 4 – Excellent	Level 3 – Good	Level 2 – Satisfactory	Level 1 – Needs Improvement
		throughout the work.			
3. Execution of Cutting, Bending, Edging and Joining Operations	**6**	**6 Marks** – Performs all operations in the correct sequence with excellent accuracy, proper technique and minimum material wastage.	**4.5 Marks** – Performs all operations with minor procedural or workmanship errors.	**3 Marks** – Completes operations with frequent guidance and noticeable errors.	**1.5 Marks** – Unable to complete the tray satisfactorily or demonstrates incorrect procedures.
4. Safety Practices and Housekeeping	**3**	**3 Marks** – Consistently follows safety rules, uses PPE correctly, handles sharp sheet edges safely and maintains a clean workplace.	**2.25 Marks** – Follows safety practices with occasional reminders.	**1.5 Marks** – Requires frequent reminders regarding safety and housekeeping.	**0.75 Mark** – Frequently ignores safety practices and workplace cleanliness.

Assessment Criteria	Weightage	Level 4 – Excellent	Level 3 – Good	Level 2 – Satisfactory	Level 1 – Needs Improvement
5. Work Discipline and Time Management	**3**	**3 Marks** – Completes the tray within the allotted time with excellent discipline and efficient material utilization.	**2.25 Marks** – Completes the work with minor delay and minimal supervision.	**1.5 Marks** – Requires additional time and supervision.	**0.75 Mark** – Fails to complete the tray within the allotted time.

B. Product Assessment Rubric (10 Marks)

Assessment Criteria	Weightage	Level 4 – Excellent	Level 3 – Good	Level 2 – Satisfactory	Level 1 – Needs Improvement
1. Dimensional Accuracy	**4**	**4 Marks** – Tray dimensions (300 mm × 100 mm × 50 mm), bend angles and squareness conform to the drawing within the specified tolerance.	**3 Marks** – Minor dimensional or bend angle deviations that do not affect functionality.	**2 Marks** – Noticeable dimensional or squareness errors affecting appearance or fit.	**1 Mark** – Significant dimensional errors; tray does not conform to the drawing.

Assessment Criteria	Weightage	Level 4 – Excellent	Level 3 – Good	Level 2 – Satisfactory	Level 1 – Needs Improvement
2. Edge Finish and Joint Quality	**3**	**3 Marks** – Edges are smooth and burr-free, bends are uniform and joints (locked seam/riveted/folded, as applicable) are neat and secure.	**2.25 Marks** – Good finish with minor burrs or slight joint imperfections.	**1.5 Marks** – Acceptable finish with noticeable burrs or uneven joints.	**0.75 Mark** – Poor edge finish, defective bends or weak/incomplete joints.
3. Overall Workmanship and Appearance	**3**	**3 Marks** – Tray is neat, clean, symmetrical and demonstrates excellent workmanship with proper rigidity.	**2.25 Marks** – Good workmanship with minor imperfections.	**1.5 Marks** – Functional tray with visible workmanship defects.	**0.75 Mark** – Poor workmanship, incomplete or defective tray.

EXPERIMENT NO.: 4.3 Prepare a Watering Can Job of Sheet Metal Using Suitable Sheet Metal Tools and Operations.

Practical Significance

This experiment develops practical skills in sheet metal fabrication through measuring, marking, cutting, bending, rolling, edging, seaming and joining operations. The fabrication of a watering can helps students understand pattern development, selection and use of sheet metal tools, assembly of different components, and quality inspection of a functional utility product.

Relevant Program Outcomes (POs)

PO-1 Basic and Discipline Specific Knowledge
PO-2 Problem Analysis
PO-3 Design/Development of Solutions
PO-4 Engineering Tools
PO-5 Engineering Practices for Society, Sustainability and Environment
PO-6 Project Management
PO-7 Lifelong Learning

Related Course Outcome(s)

CO	Statement	PO							PSO	
CO4	Perform various sheet metal operations as per given sketch/ drawing.	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO3
		3	1	1	3	1	1	1		

Laboratory Session Outcomes

After completing this experiment, the student will be able to:

LSO 4.1 Select suitable sheet metal tools, machinery / equipment for given used as per requirements.

LSO 4.2 Select suitable sheet metal operations in a given situation.

LSO 4.3 Perform relevant sheet metal operations such as shearing, bending, drawing, squeezing, snipping, riveting, grooving etc.to prepare utility jobs safely as given sketch/ drawing.

Practical Skills

- Measuring and marking

- Pattern development
- Sheet metal cutting
- Bending and forming
- Rolling
- Edging
- Seaming and joining
- Soldering, if specified
- Component assembly
- Leak testing
- Finishing and inspection

Minimum Theoretical Background

A watering can is a sheet metal utility product used for watering plants and gardens. It generally consists of a cylindrical or rectangular body, base, handle, spout, rose and lid/opening**.** The fabrication involves several basic sheet metal operations:

Marking: Transferring dimensions from the drawing onto the sheet.

Cutting: Separating the required blanks using snips or shears.

Bending: Forming the sheet into the required shape.

Rolling: Producing cylindrical or curved components.

Edging: Strengthening or finishing the edges.

Seaming: Joining sheet edges mechanically.

Soldering: Producing a leak-resistant joint where required.

Finishing: Removing burrs, sharp edges and excess joining material.

Accurate pattern development and proper allowance are important for obtaining the required final dimensions

Circuit Diagram/Layout/Experimental Setup

Suggested Job Specifications

Material: GI Sheet, **Thickness:** 0.8–1.0 mm
Components: Main cylindrical body, Circular base, Handle, Spout, Rose/sprinkler head, Lid/opening

Joining: Seaming, riveting or soldering as specified by the instructor.

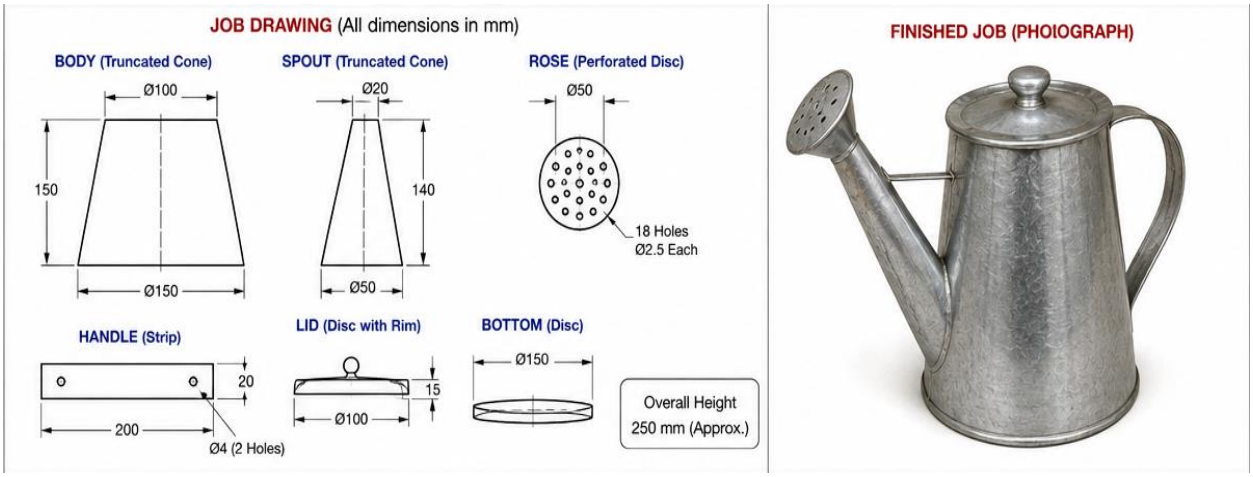






Fig. 16. Watering can

Resources Required

Material: GI sheet, 0.8–1.0 mm thick, Solder and flux, if required, Rivets, if required, Emery paper

Sheet Metal Tools: Steel rule, Try square, Scriber, Divider, Snips, Hand shears, Pliers, Seamers Stakes, Wooden mallet, Files

Equipment: Bench vice, Sheet bending/forming tools, Soldering iron or suitable heating equipment, if required

Measuring Instruments: Steel rule, Vernier caliper, Divider

PPE: Safety goggles, Safety shoes, Apron, Protective gloves

Precautions

1. Wear appropriate PPE throughout the experiment.
2. Handle sheet metal carefully because cut edges may be sharp.
3. Use suitable snips for cutting the sheet.
4. Secure the sheet properly during cutting and forming.
5. Do not use excessive force while bending or forming.
6. Remove burrs and sharp edges immediately after cutting.
7. Maintain proper alignment during assembly.
8. If soldering is used, provide adequate ventilation.
9. Do not touch hot soldering equipment or heated components.
10. Keep the workplace clean and dry.
11. Check the watering can for leakage after fabrication.
12. Return all tools to their designated places after completion.

Procedure

1. Study the given drawing and note all dimensions.
2. Select GI sheet of the specified thickness.
3. Clean the sheet surface.
4. Develop the patterns for the body, base, handle, spout and rose.
5. Provide suitable seam, joint and bending allowances.
6. Mark all patterns accurately on the sheet using a scriber.
7. Cut the marked blanks using suitable snips or shears.
8. Remove burrs and sharp edges using a file.
9. Roll and form the body into the required cylindrical shape.
10. Join the longitudinal seam of the body.
11. Prepare and attach the circular base.
12. Develop, cut and form the spout.
13. Join the spout to the body at the required position.
14. Prepare the rose and attach it to the end of the spout.

15. Prepare and bend the handle according to the drawing.
16. Attach the handle securely to the body.
17. Perform edging and finishing operations.
18. Solder or seal the joints where required.
19. Check the dimensions and alignment of all components.
20. Fill the watering can with water and perform a leak test.
21. Remove burrs, excess solder and other surface imperfections.
22. Clean and finish the completed job.

Observations and Calculations

Observation Table

Sl. No.	**Parameter**	**Specification**	**Actual Observation**
1	Material	GI Sheet	_____
2	Sheet thickness	0.8–1.0 mm	_____
3	Body height	180 mm	_____
4	Body diameter	150 mm	_____
5	Spout length	250 mm	_____
6	Spout diameter	35–40 mm	_____
7	Handle height	100 mm	_____
8	Handle width	250 mm	_____
9	Rose diameter	45–50 mm	_____
10	Leakage	Nil	_____
11	Surface finish	Smooth	_____

Calculations

For a cylindrical body:

Developed length = πD + seam allowance

Where:

- D = required body diameter
- Seam allowance = allowance provided for joining.

For a circular base:

Blank diameter=D+2(edge allowance)

The actual allowances should be taken according to the given drawing and selected joining method**.**

Results

A sheet metal watering can was successfully fabricated using suitable sheet metal tools and operations such as marking, cutting, bending, rolling, edging and joining as per the given drawing.

The completed watering can was found to be dimensionally satisfactory and free from leakage during the final inspection.

Interpretation of Results

- The body was formed to the required cylindrical shape.
- The spout was properly aligned with the body.
- The handle was securely attached.
- The rose was properly fitted to the spout.
- The joints were adequately sealed.
- The finished product satisfied the specified dimensional requirements.
- No leakage was observed during the water test.
- The product demonstrated acceptable workmanship and surface finish.

Conclusions and Recommendations

Conclusion

The watering can was successfully prepared from GI sheet using suitable cutting, bending, rolling, edging and joining operations. The experiment provided practical knowledge of pattern development, component fabrication, assembly and inspection of a sheet metal utility product.

Recommendations

1. Take accurate measurements before developing patterns.
2. Provide appropriate seam and edge allowances.
3. Use sharp and suitable cutting tools.
4. Maintain proper alignment during assembly.
5. Ensure leak-proof joining of the body and spout.
6. Remove all sharp edges before final inspection.
7. Perform a water leakage test before accepting the finished product.

Practical Related Questions

1. What is sheet metal work?
2. What is the purpose of a watering can?

3. Name the main components of a watering can.
4. Name four sheet metal cutting tools.
5. What is the purpose of pattern development?
6. Why are seam allowances provided?
7. What is edging?
8. What is the purpose of rolling in sheet metal work?
9. Name two methods of joining sheet metal.
10. Why is leak testing necessary for a watering can?
11. What is the function of a rose in a watering can?
12. State four safety precautions for sheet metal work.

References / Suggestions for Further Reading

1. S. K. Hajra Choudhury, Workshop Technology, Vol. I, Media Promoters & Publishers.
2. B. S. Raghuwanshi, A Course in Workshop Technology, Vol. I.
3. P. N. Rao, Manufacturing Technology, Vol. I, McGraw-Hill Education.
4. Standard workshop technology textbooks covering sheet metal fabrication.
5. All images are AI generated

Assessment Scheme (Combined Process and Product Rubrics)

A. Process Assessment Rubric (10 Marks)

Assessment Criteria	Weightage	Level 4 – Excellent	Level 3 – Good	Level 2 – Satisfactory	Level 1 – Needs Improvement
1. Drawing Interpretation and Layout Preparation	**4**	**4 Marks** – Correctly interprets the drawing, prepares the development/layout accurately and completes marking independently.	**3 Marks** – Correctly interprets the drawing with minor errors in layout or marking.	**2 Marks** – Requires guidance in preparing the layout and marking.	**1 Mark** – Unable to interpret the drawing or prepare the layout correctly.
2. Selection and Safe Use of Sheet Metal Tools	**4**	**4 Marks** – Selects appropriate sheet metal tools,	**3 Marks** – Selects suitable tools with minor	**2 Marks** – Requires guidance in selecting or	**1 Mark** – Incorrect tool selection or unsafe

Assessment Criteria	Weightage	Level 4 – Excellent	Level 3 – Good	Level 2 – Satisfactory	Level 1 – Needs Improvement
and Equipment		measuring instruments and equipment; uses them correctly and safely throughout the work.	handling or safety errors.	handling tools safely.	handling practices.
3. Execution of Cutting, Bending, Forming and Joining Operations	**6**	**6 Marks** – Performs all operations systematically using the correct sequence and techniques with minimum material wastage.	**4.5 Marks** – Completes all operations with minor procedural or workmanship errors.	**3 Marks** – Completes the operations with frequent guidance and noticeable errors.	**1.5 Marks** – Unable to complete the utility job satisfactorily or demonstrates incorrect procedures.
4. Safety Practices and Housekeeping	**3**	**3 Marks** – Consistently follows safety rules, uses PPE correctly, handles sharp sheet edges safely and maintains a clean workplace.	**2.25 Marks** – Follows safety practices with occasional reminders.	**1.5 Marks** – Requires frequent reminders regarding safety and housekeeping.	**0.75 Mark** – Frequently ignores safety practices and workplace cleanliness.
5. Work Discipline and Time Management	**3**	**3 Marks** – Completes the utility job within the allotted time with excellent discipline and efficient utilization of material.	**2.25 Marks** – Completes the work with minor delay and minimal supervision.	**1.5 Marks** – Requires additional time and supervision.	**0.75 Mark** – Fails to complete the assigned job within the allotted time.

B. Product Assessment Rubric (10 Marks)

Assessment Criteria	Weightage	Level 4 – Excellent	Level 3 – Good	Level 2 – Satisfactory	Level 1 – Needs Improvement
1. Dimensional Accuracy and Shape	**4**	**4 Marks** – Dimensions, shape and geometry conform to the given drawing/specifications with proper symmetry and fit.	**3 Marks** – Minor dimensional or shape deviations without affecting usability.	**2 Marks** – Noticeable dimensional or shape errors affecting appearance or function.	**1 Mark** – Significant dimensional or shape errors; job does not conform to the drawing/specifications.
2. Edge Finish, Forming and Joint Quality	**3**	**3 Marks** – Edges are smooth and burr-free, bends/formed surfaces are uniform and joints (if any) are neat, secure and properly finished.	**2.25 Marks** – Good finish with minor burrs, uneven bends or slight joint imperfections.	**1.5 Marks** – Acceptable finish with noticeable burrs, forming defects or joint irregularities.	**0.75 Mark** – Poor edge finish, defective forming or weak/incomplete joints.

Assessment Criteria	Weightage	Level 4 – Excellent	Level 3 – Good	Level 2 – Satisfactory	Level 1 – Needs Improvement
3. Overall Workmanship and Utility	**3**	**3 Marks** – Job is neat, complete, aesthetically finished, structurally sound and fully functional for its intended use.	**2.25 Marks** – Good workmanship with minor imperfections; utility is not affected.	**1.5 Marks** – Functional job with visible workmanship defects.	**0.75 Mark** – Poor workmanship, incomplete job or limited functionality.

EXPERIMENT NO.: 5.1 Selection of Various Blacksmithy Tools, Equipment, Machines, and Measuring Instruments for preparation of an S-Shaped Hook from a Mild Steel Rod

Practical Significance

Blacksmithy is one of the oldest metal forming processes used to manufacture and repair agricultural implements, hand tools, machine parts, fasteners, and structural components. Proper selection of blacksmithy tools, equipment, machines, and measuring instruments is essential for safe working, improved productivity, quality workmanship, and economical use of resources. This experiment develops the ability to identify and select suitable blacksmithy tools and equipment according to the given forging operation or job requirement.

Relevant Program Outcomes (POs)

PO-1 Basic and Discipline Specific Knowledge
PO-2 Problem Analysis
PO-3 Design/Development of Solutions
PO-4 Engineering Tools
PO-5 Engineering Practices for Society, Sustainability and Environment
PO-7 Lifelong Learning.

Related Course Outcome(s)

CO	Statement	PO							PSO	
CO5	Undertake black smithy operations safely.	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO3
		3	3	2	3	1	-	1		

Laboratory Session Outcomes

After completing this experiment, the student will be able to:
LSO 5.1 Select suitable black smithy tools and operations to complete jobs as per requirements.
LSO 5.2 Perform various operations safely to prepare given black smithy job(s).
LSO 5.3 Follow safety procedures and use personal safety equipment during black smithy.

Practical Skills
The student will be able to:
Identify blacksmithy hand tools.

Identify forging machines and equipment.
Select suitable measuring instruments.
Select tools according to the given situation.
Follow safe handling practices.
Organize workplace efficiently.

Minimum Theoretical Background

Blacksmithy
Blacksmithy is the process of shaping heated metal by applying compressive forces using hand tools or power hammers.

Classification of Blacksmithy Tools
A. Holding Tools: Tongs, Ring tongs, Flat-jaw tongs, Hollow-bit tongs, Square-jaw tongs
Function: Hold hot metal during forging.
B. Striking Tools: Ball Peen Hammer, Cross Peen Hammer, Straight Peen Hammer, Sledge Hammer
Function: Apply forging force.
C. Supporting Tools: Anvil, Swage Block
Function: Support the workpiece during forging.
D. Cutting Tools: Hot Chisel, Cold Chisel, Hardy Tool
Function: Cut hot or cold metal.
E. Finishing Tools: Fuller, Flatter, Set Hammer, Swages, Punch, Drift
Function: Produce grooves, smooth surfaces, enlarge holes, and finish forged components.

Forging Equipment
a) Forge Furnace
b) Blower
c) Anvil
d) Leg Vice
e) Water Trough
f) Power Hammer (where available)

Measuring Instruments
a) Steel Rule
b) Vernier Caliper
c) Outside Caliper
d) Inside Caliper
e) Try Square
f) Bevel Protractor
g) Divider

Selection Criteria
1. Selection depends on:
2. Type of forging operation

3. Shape of the workpiece
4. Size of material
5. Temperature of metal
6. Accuracy required
7. Safety considerations

Applications

1. Blacksmithy tools are used in:
2. Agricultural tool manufacturing
3. Machine repair workshops
4. Fabrication industries
5. Automobile workshops
6. Forging industries
7. Maintenance workshops

Circuit Diagram / Layout / Experimental Setup

Experimental Setup

The setup consists of:

- Forge furnace
- Anvil
- Leg vice
- Various hammers
- Various tongs
- Chisels
- Fullers
- Flatters
- Punches
- Measuring instruments
- Safety equipment

(Students should draw a labelled layout of a blacksmithy shop showing the forge furnace, blower, anvil, vice, water trough, tool rack, and work area.)



Fig.17. black smithy equipments



Fig. 18. black smithy tools



Fig. 19. black smithy tools



Fig. 20. black smithy measuring and marking instruments

Resources Required

Sl. No.	Item	Specification	Quantity
1	Forge Furnace	Standard	1
2	Anvil	Standard	1
3	Blower	Manual/Electric	1
4	Leg Vice	Standard	1
5	Hammers	Different types	1 Set
6	Tongs	Different types	1 Set
7	Chisels	Hot & Cold	1 Set
8	Fullers and Flatters	Standard	1 Set
9	Punches and Drifts	Standard	1 Set
10	Steel Rule	300 mm	1
11	Vernier Caliper	0–150 mm	1
12	Try Square	Standard	1

Precautions

1. Wear safety goggles, gloves, apron, and safety shoes.
2. Handle hot metal only with suitable tongs.
3. Check tools before use.
4. Keep the work area clean and organized.
5. Do not strike damaged tools.
6. Place hot metal only at designated locations.
7. Use the correct tool for each forging operation.
8. Maintain proper posture while using hammers.
9. Allow heated tools to cool safely.
10. Follow instructor's safety instructions at all times.

Procedure

1. Observe the tools, equipment, and measuring instruments available in the blacksmithy shop.
2. Identify each tool and record its name.
3. Classify the tools according to their functions.
4. Study different forging situations provided by the instructor.
5. Select suitable tools and equipment for each situation.
6. Select appropriate measuring instruments for inspection.
7. Record the purpose of each selected tool.
8. Discuss the selection with the instructor.
9. Complete the observation sheet.
10. Clean and arrange the tools after completion.

Observations and Calculations

Identification of Tools

Sl. No.	Tool Name	Category	Function
1			
2			
3			
4			
5			

Selection of Tools for Given Situations

Situation	Selected Tool(s)	Reason for Selection
Holding hot round bar		
Cutting heated metal		
Punching a hole		
Flattening surface		
Making groove		
Measuring forged job		

Measuring Instruments Used

Instrument	Purpose
Steel Rule	
Vernier Caliper	
Try Square	
Outside Caliper	

Results

The various black smithy tools, equipment, machines, and measuring instruments were successfully identified and selected according to the given forging situations. Appropriate tools were selected based on the operation, workpiece geometry, safety requirements, and accuracy.

Interpretation of Results

- Correct tool selection improves productivity, safety, dimensional accuracy, and surface finish.

- Improper tool selection may lead to poor workmanship, excessive effort, damage to tools, and unsafe working conditions.
- Measuring instruments ensure dimensional accuracy of forged products.

Conclusions and Recommendations

Conclusion

The experiment successfully demonstrated the identification and selection of suitable blacksmithy tools, equipment, machines, and measuring instruments for various forging operations. Students developed the ability to select appropriate resources based on the nature of the job.

Recommendations

- Select tools according to the forging operation.
- Inspect tools before use.
- Use proper PPE while working.
- Handle hot materials safely.
- Store tools properly after use.
- Maintain the blacksmithy shop in a clean and organized condition.

Practical Related Questions

1. Define blacksmithy.
2. What is the function of an anvil?
3. Why are tongs used in forging?
4. Differentiate between a hot chisel and a cold chisel.
5. State the function of a fuller.
6. What is the purpose of a flatter?
7. Name four measuring instruments used in blacksmithy.
8. State four types of forging hammers.
9. Why is proper tool selection important?
10. List six safety precautions followed in a blacksmithy shop.

References / Suggestions for Further Reading

1. S. K. Hajra Choudhury, Elements of Workshop Technology (Vol. I).
2. B. S. Raghuwanshi, Workshop Technology.
3. P. N. Rao, Manufacturing Technology.
4. K. C. John, Workshop Technology.
5. SBTE Bihar Diploma Curriculum – Manufacturing Engineering Laboratory.
6. Relevant BIS standards for forging and workshop safety.
7. All images are AI generated.

Assessment Scheme (Combined Process and Product Rubrics)

A. Process Assessment Rubric (20 Marks)

Assessment Criteria	Weightage	Level 4 – Excellent	Level 3 – Good	Level 2 – Satisfactory	Level 1 – Needs Improvement
1. Interpretation of Given Workshop Situation	**4**	**4 Marks** – Correctly interprets the given blacksmithy operation and independently identifies the required tools, equipment, machines and measuring instruments.	**3 Marks** – Correctly interprets the situation with minor guidance and identifies most of the required items.	**2 Marks** – Requires guidance to understand the workshop situation and identify suitable items.	**1 Mark** – Unable to interpret the situation or identify the required items correctly.
2. Selection and Identification of Tools, Equipment, Machines and Measuring Instruments	**5**	**5 Marks** – Correctly selects and identifies all required tools, equipment, machines and measuring instruments appropriate for the assigned task.	**3.75 Marks** – Correctly selects most items with minor errors.	**2.5 Marks** – Selects some appropriate items but requires frequent guidance.	**1.25 Marks** – Incorrect selection and identification of most items.

Assessment Criteria	Weightage	Level 4 – Excellent	Level 3 – Good	Level 2 – Satisfactory	Level 1 – Needs Improvement
3. Demonstration of Handling and Application	**5**	**5 Marks** – Demonstrates correct handling, purpose and application of all selected tools and equipment confidently and safely.	**3.75 Marks** – Demonstrates handling and application with minor errors.	**2.5 Marks** – Requires guidance while demonstrating handling and application.	**1.25 Marks** – Unable to demonstrate proper handling or application.
4. Safety Practices and Housekeeping	**3**	**3 Marks** – Consistently follows blacksmithy safety practices, uses PPE correctly and maintains a clean and organized work area.	**2.25 Marks** – Follows safety practices with occasional reminders.	**1.5 Marks** – Requires frequent reminders regarding safety and housekeeping.	**0.75 Mark** – Frequently ignores safety rules and workplace cleanliness.
5. Work Discipline and Communication	**3**	**3 Marks** – Completes the activity within the allotted time and explains tool selection and applications clearly using appropriate technical terminology.	**2.25 Marks** – Completes the activity with minor delay and communicates adequately.	**1.5 Marks** – Requires supervision to complete the activity and explain tool applications.	**0.75 Mark** – Incomplete activity with poor communication and work discipline.

B. Product Assessment Rubric (10 Marks)

Note: As this is a **tool selection and identification experiment**, the "product" is the completed observation record and the accuracy of tool selection rather than a fabricated component.

Assessment Criteria	Weightage	Level 4 – Excellent	Level 3 – Good	Level 2 – Satisfactory	Level 1 – Needs Improvement
1. Accuracy of Selection	**4**	**4 Marks** – All selected tools, equipment, machines and measuring instruments are fully appropriate for the given blacksmithy operation.	**3 Marks** – Minor errors in selection without affecting suitability.	**2 Marks** – Several inappropriate selections requiring correction.	**1 Mark** – Most selected items are inappropriate.
2. Justification of Selection	**3**	**3 Marks** – Clearly explains the function, application and reason for selecting each tool, equipment and measuring instrument.	**2.25 Marks** – Explains most selections correctly with minor omissions.	**1.5 Marks** – Provides partial explanation with noticeable gaps.	**0.75 Mark** – Unable to justify the selections satisfactorily.

Assessment Criteria	Weightage	Level 4 – Excellent	Level 3 – Good	Level 2 – Satisfactory	Level 1 – Needs Improvement
3. Documentation and Presentation	**3**	**3 Marks** – Observation sheet, tool identification record and presentation are complete, neat, accurate and well organized.	**2.25 Marks** – Good documentation with minor errors.	**1.5 Marks** – Acceptable documentation with noticeable mistakes.	**0.75 Mark** – Incomplete or poorly organized documentation and presentation.

EXPERIMENT NO.: 5.2 Preparation of an S-Shaped Hook from a Mild Steel Rod (220 mm × Ø6 mm) Using Blacksmithy Operations.

Practical Significance

Blacksmithy is a primary metal forming process in which heated metal is shaped by hammering and bending. An S-shaped hook is a simple forged product used for hanging tools, chains, buckets, ropes, electrical cables, and light loads in workshops, farms, warehouses, and households. This experiment develops students' skills in heating, bending, forming, sizing, and finishing of mild steel using blacksmithy tools and equipment while following safe workshop practices. It also promotes economical use of material and energy during forging.

Relevant Program Outcomes (POs)

PO-1 Basic and Discipline Specific Knowledge
PO-2 Problem Analysis
PO-3 Design/Development of Solutions
PO-4 Engineering Tools
PO-5 Engineering Practices for Society, Sustainability and Environment
PO-7 Lifelong Learning

Related Course Outcome(s)

CO	Statement	PO							PSO	
CO5	Undertake black smithy operations safely.	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO3
		3	3	2	3	1	-	1		

Laboratory Session Outcomes

After completing this experiment, the student will be able to:
LSO 5.1 Select suitable black smithy tools and operations to complete jobs as per requirements.
LSO 5.2 Perform various operations safely to prepare given black smithy job(s).
LSO 5.3 Follow safety procedures and use personal safety equipment during black smithy.

Practical Skills

The student will be able to:
Identify blacksmithy tools and equipment.

Heat mild steel to the correct forging temperature.
Hold hot workpieces safely using tongs.
Perform bending and shaping operations.
Measure the forged component.
Finish the forged job by removing scale and burrs.

Minimum Theoretical Background

Blacksmithy: Blacksmithy is the process of shaping heated metal by applying compressive forces using hand hammers or forging machines.

Forging Temperature for Mild Steel: The recommended forging temperature for mild steel is approximately 900°C to 1250°C. Forging should be stopped when the metal cools below the recommended temperature to avoid cracking.

Operations Used: Heating, Holding, Bending,Shaping, Straightening, Finishing

Tools Used

1. **Heating Equipment:** Forge furnace, Blower
2. **Holding Tools:** Flat-jaw tongs
3. **Supporting Tools:** Anvil
4. **Striking Tools:** Ball peen hammer, Cross peen hammer
5. **Measuring Tools:** Steel rule, Vernier caliper

Applications of S-Hook

1. Hanging workshop tools
2. Supporting electrical cables
3. Holding chains
4. Hanging buckets
5. Agricultural applications
6. Material handling

Circuit Diagram / Layout / Experimental Setup
Experimental Setup

The setup consists of: Forge furnace with blower, Anvil, Flat-jaw tongs, Ball peen hammer, Cross peen hammer, Mild steel rod (220 mm × Ø6 mm), Steel rule, Vernier caliper, Water trough, Wire brush, Personal Protective Equipment (PPE) (Students should draw a labelled layout of the blacksmithy shop showing the forge furnace, blower, anvil, tongs, hammer, and workpiece.)

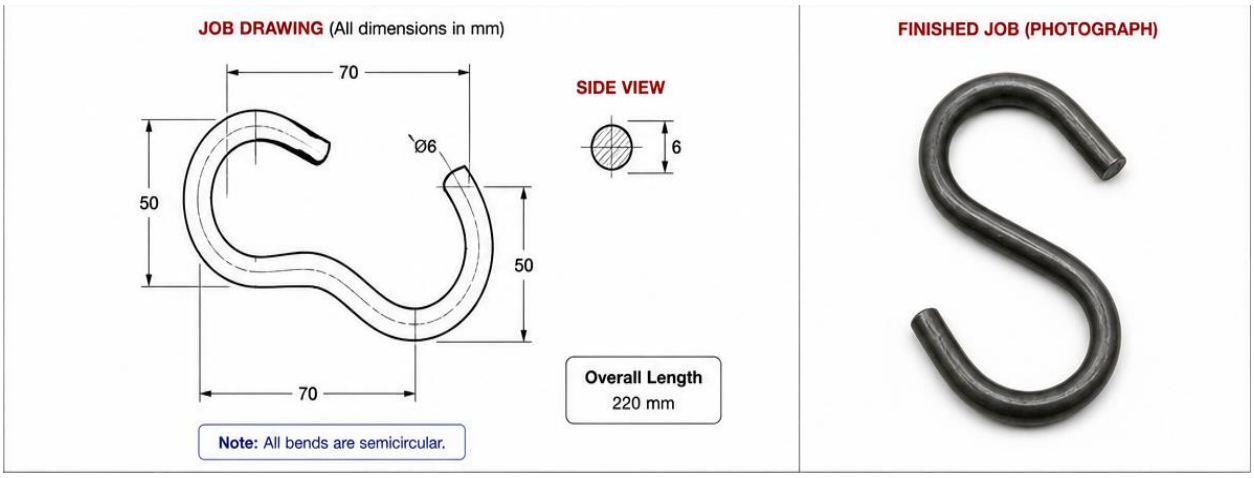






Fig. 21. S-Shaped Hook

Resources Required

Sl. No.	Item	Specification	Quantity
1	Mild Steel Rod	220 mm × Ø6 mm	1
2	Forge Furnace	Standard	1
3	Blower	Manual/Electric	1
4	Anvil	Standard	1
5	Flat-Jaw Tongs	Suitable for Ø6 mm rod	1
6	Ball Peen Hammer	0.5–1 kg	1
7	Cross Peen Hammer	Standard	1
8	Steel Rule	300 mm	1
9	Vernier Caliper	0–150 mm	1
10	Wire Brush	Standard	1
11	Water Trough	Standard	1
12	Safety Goggles	Standard	1
13	Leather Gloves	Standard	1 Pair
14	Leather Apron and Safety Shoes	Standard	1 Set

Precautions

1. Wear safety goggles, gloves, apron, and safety shoes.
2. Handle heated workpieces only with suitable tongs.
3. Heat the workpiece uniformly to the proper forging temperature.
4. Avoid overheating or burning the metal.
5. Strike the workpiece only on the anvil face.
6. Maintain proper grip while hammering.
7. Keep hands away from the striking area.
8. Do not cool the workpiece suddenly unless instructed.
9. Keep the workplace clean and free from obstacles.
10. Return all tools to their proper place after completion.

Procedure

1. Study the given drawing of the S-shaped hook.
2. Collect the required tools and equipment.
3. Cut or select a 220 mm × Ø6 mm mild steel rod.
4. Heat one end of the rod to the forging temperature.
5. Bend the heated end around the horn of the anvil to form the first hook.
6. Reheat the opposite end of the rod.
7. Bend the second end in the opposite direction to form the second hook.
8. Straighten and adjust the shape as required.
9. Remove scale using a wire brush.

10. Allow the hook to cool naturally.
11. Measure the dimensions and compare them with the given drawing.
12. Clean the workplace and arrange the tools.

Observations and Calculations

Material Details

Particular	**Observation**
Material	Mild Steel
Rod Length	220 mm
Rod Diameter	6 mm
Forging Temperature	Approximately 900–1250°C

Dimensional Inspection

Parameter	**Specified**	**Measured**
Rod Length	220 mm	
Rod Diameter	6 mm	
Overall Height of Hook	As per drawing	
Hook Opening (Top)	As per drawing	
Hook Opening (Bottom)	As per drawing	

Tool Selection

Tool	**Purpose**
Forge Furnace	Heating
Anvil	Supporting
Tongs	Holding hot metal
Hammer	Forging and bending
Steel Rule	Measurement

Results

An S-shaped hook was successfully prepared from a 220 mm × Ø6 mm mild steel rod using blacksmithy operations. The finished component conformed within / not within the specified dimensions and exhibited satisfactory workmanship.

Interpretation of Results

Proper heating and uniform hammering produce smooth bends and maintain the required shape.

Correct tool selection and proper forging temperature improve dimensional accuracy and reduce defects.
The quality of the forged hook depends on heating control, bending accuracy, and finishing operations.

Conclusions and Recommendations

Conclusion
The experiment demonstrated the preparation of an S-shaped hook using blacksmithy operations. Students acquired practical skills in heating, bending, shaping, measuring, and finishing forged components while following safe workshop practices.

Recommendations

1. Heat the workpiece uniformly before forging.
2. Use suitable tongs for handling hot metal.
3. Perform bending on the horn of the anvil for smooth curvature.
4. Avoid excessive hammering after the metal cools.
5. Remove scale after forging to improve appearance.
6. Follow all blacksmithy safety rules.

Practical Related Questions

1. Define blacksmithy.
2. What is the forging temperature range of mild steel?
3. Why are tongs used during forging?
4. State the function of an anvil.
5. Why should forging not be continued below the recommended temperature?
6. Name four tools used in blacksmithy.
7. List four applications of an S-shaped hook.
8. What is the purpose of a blower in a forge furnace?
9. Why is scale removed after forging?
10. State six safety precautions followed during blacksmithy operations.

References / Suggestions for Further Reading

1. S. K. Hajra Choudhury, Elements of Workshop Technology (Vol. I).
2. S. Raghuwanshi, Workshop Technology.
3. P. N. Rao, Manufacturing Technology.
4. K. C. John, Workshop Technology.
5. SBTE Bihar Diploma Curriculum – Manufacturing Engineering Laboratory.
6. Relevant BIS standards for forging practices and workshop safety.
7. All images are AI generated.

Assessment Scheme (Combined Process and Product Rubrics)

A. Process Assessment Rubric (10 Marks)

Assessment Criteria	Weightage	Level 4 – Excellent	Level 3 – Good	Level 2 – Satisfactory	Level 1 – Needs Improvement
1. Drawing Interpretation and Job Preparation	**4**	**4 Marks** – Correctly interprets the drawing, selects the MS rod, plans the sequence of heating and forging operations independently.	**3 Marks** – Interprets the drawing correctly with minor guidance and prepares the job with minor errors.	**2 Marks** – Requires guidance in understanding the drawing and planning the operations.	**1 Mark** – Unable to interpret the drawing or prepare the job correctly.
2. Selection and Safe Use of Blacksmithy Tools and Equipment	**4**	**4 Marks** – Selects appropriate forge, anvil, hammer, tongs and measuring instruments; uses them correctly and safely throughout the work.	**3 Marks** – Selects suitable tools with minor handling or safety errors.	**2 Marks** – Requires guidance in tool selection or safe handling.	**1 Mark** – Incorrect tool selection or unsafe handling practices.
3. Execution of Heating and Forging Operations	**6**	**6 Marks** – Performs heating, bending, shaping and finishing operations systematically with correct forging temperature, technique and minimum	**4.5 Marks** – Performs all operations with minor procedural or shaping errors.	**3 Marks** – Completes the operations with frequent guidance and noticeable errors.	**1.5 Marks** – Unable to complete the S-hook satisfactorily or demonstrates incorrect forging procedures.

Assessment Criteria	Weightage	Level 4 – Excellent	Level 3 – Good	Level 2 – Satisfactory	Level 1 – Needs Improvement
		material wastage.			
4. Safety Practices and Housekeeping	**3**	**3 Marks** – Consistently follows blacksmithy safety rules, uses PPE correctly and maintains a clean and organized workplace.	**2.25 Marks** – Follows safety practices with occasional reminders.	**1.5 Marks** – Requires frequent reminders regarding safety and housekeeping.	**0.75 Mark** – Frequently ignores safety practices or workplace cleanliness.
5. Work Discipline and Time Management	**3**	**3 Marks** – Completes the S-hook within the allotted time while demonstrating excellent discipline and efficient material utilization.	**2.25 Marks** – Completes the work with minor delay and minimal supervision.	**1.5 Marks** – Requires additional time and supervision.	**0.75 Mark** – Fails to complete the assigned job within the allotted time.

B. Product Assessment Rubric (10 Marks)

Assessment Criteria	Weightage	Level 4 – Excellent	Level 3 – Good	Level 2 – Satisfactory	Level 1 – Needs Improvement
1. Dimensional Accuracy and Shape	**4**	**4 Marks** – Length, hook radii, symmetry and overall shape conform to the given drawing within	**3 Marks** – Minor dimensional or shape deviations without affecting functionality.	**2 Marks** – Noticeable dimensional or shape errors affecting appearance or usability.	**1 Mark** – Significant dimensional or shape errors; hook does not conform to the drawing.

Assessment Criteria	Weightage	Level 4 – Excellent	Level 3 – Good	Level 2 – Satisfactory	Level 1 – Needs Improvement
		acceptable tolerance.			
2. Surface Finish and Forging Quality	**3**	**3 Marks** – Smooth forged surface with uniform bends, free from excessive scale, cracks or hammer marks.	**2.25 Marks** – Good finish with minor hammer marks or scale.	**1.5 Marks** – Acceptable finish with noticeable surface defects.	**0.75 Mark** – Poor finish with major defects such as uneven bends, excessive scale or deformation.
3. Overall Workmanship and Functionality	**3**	**3 Marks** – S-hook is neat, symmetrical, structurally sound and fully functional with excellent workmanship.	**2.25 Marks** – Good workmanship with minor imperfections; functionality is not affected.	**1.5 Marks** – Functional hook with visible workmanship defects.	**0.75 Mark** – Poor workmanship, incomplete hook or reduced functionality.

EXPERIMENT NO.: 5.3 Preparation of a Garden Trowel, Sickle, or Shovel Using Blacksmithy Operations as per the Instructions Provided by the Instructor.

Note: Each student shall fabricate any one of the following products as assigned by the instructor:
Garden Trowel
Sickle
Shovel (Miniature/Workshop Model)

Practical Significance

Forging is one of the most economical and widely used manufacturing processes for producing agricultural and gardening tools with high strength, toughness, and durability. Garden trowels, sickles, and shovels are commonly manufactured by blacksmithy operations such as heating, drawing out, flattening, bending, upsetting, cutting, and finishing. This experiment develops practical skills in forging, shaping, dimensional control, tool handling, and safe workshop practices. It also familiarizes students with the manufacture of commonly used agricultural implements.

Relevant Program Outcomes (POs)

PO-1 Basic and Discipline Specific Knowledge
PO-2 Problem Analysis
PO-3 Design/Development of Solutions
PO-4 Engineering Tools
PO-5 Engineering Practices for Society, Sustainability and Environment
PO-7 Lifelong Learning

Related Course Outcome(s)

CO	Statement	PO							PSO	
CO5	Undertake black smithy operations safely.	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO3
		3	3	2	3	1	-	1		

Laboratory Session Outcomes

After completing this experiment, the student will be able to:
LSO 5.1 Select suitable black smithy tools and operations to complete jobs as per requirements.
LSO 5.2 Perform various operations safely to prepare given black smithy job(s).

LSO 5.3 Follow safety procedures and use personal safety equipment during black smithy.

Practical Skills

The student will be able to:
Select appropriate blacksmithy tools.
Heat and handle hot metal safely.
Perform drawing out, upsetting, flattening, bending, and cutting operations.
Shape agricultural tools accurately.
Measure forged dimensions.
Finish and inspect forged products.

Minimum Theoretical Background

Blacksmithy
Blacksmithy is a hot metal forming process in which heated metal is shaped by hammering or pressing to obtain the required geometry.

Forging Temperature; For mild steel, the recommended forging temperature is approximately 900°C to 1250°C.

Common Forging Operations
Heating
Drawing Out
Flattening
Upsetting
Bending
Cutting
Punching (if required)
Finishing

Blacksmithy Tools Used

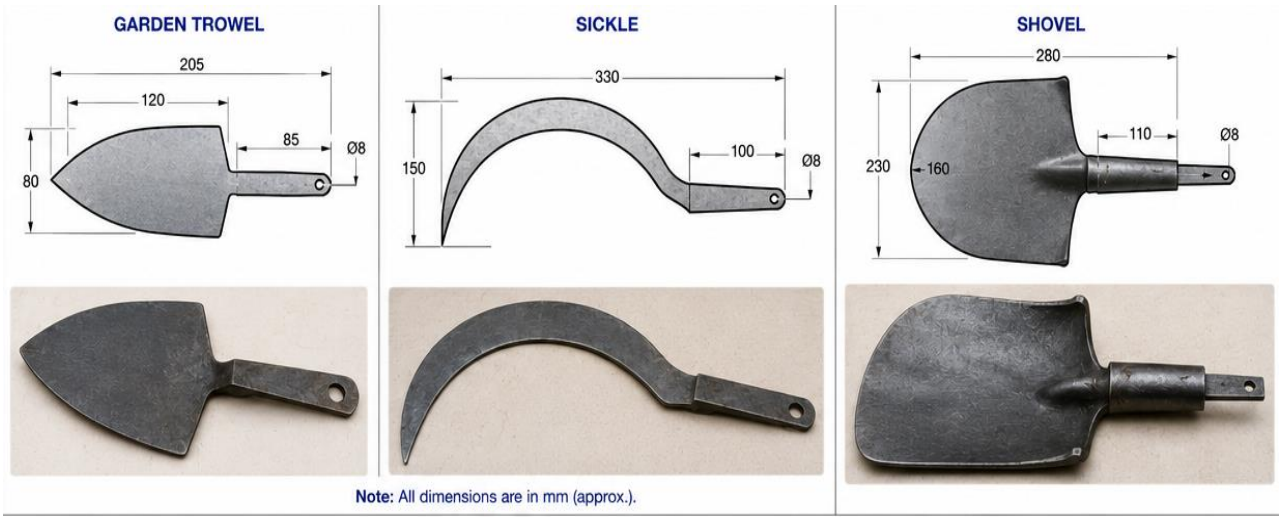
Heating Equipment: Forge furnace, Blower
Holding Tools: Tongs
Supporting Tools: Anvil
Striking Tools: Ball peen hammer, Cross peen hammer, Sledge hammer
Finishing Tools: Fuller, Flatter, set hammer, Chisel
Measuring Instruments: Steel rule, Vernier caliper, Try square
Applications
Garden Trowel: Digging soil, Planting seedlings, Weeding
Sickle: Harvesting crops, cutting grass, Cutting small branches
Shovel: Digging, lifting loose materials, Loading soil and sand.

Circuit Diagram / Layout / Experimental Setup

Experimental Setup

The setup consists of: Forge furnace, Blower, Anvil, Tongs, Hammers, Chisels, Fullers, Flatters, Measuring instruments, Water trough, PPE

(Students should draw a labelled layout of the blacksmithy shop showing the forge furnace, blower, anvil, tool rack, water trough, and workpiece.)



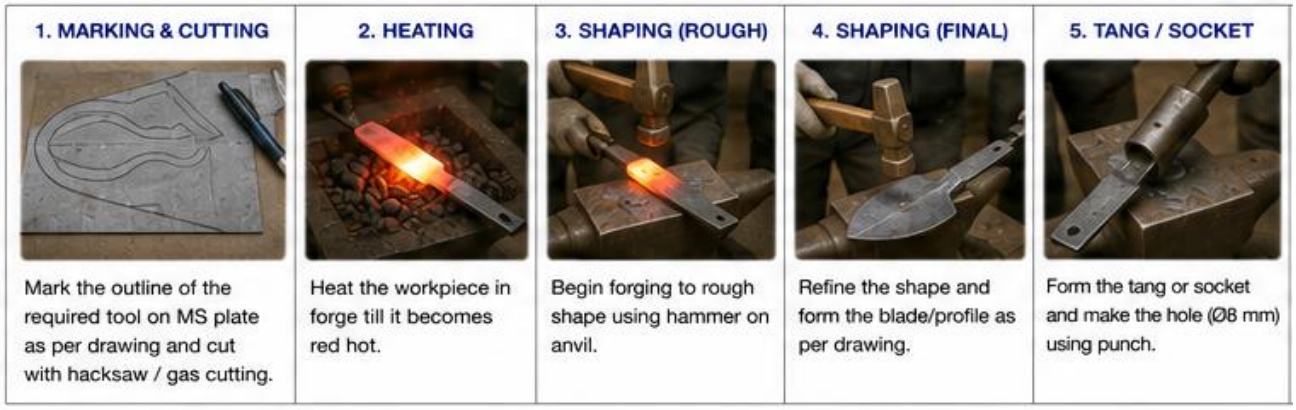




Fig. 22. Garden Trowel, Sickle, or Shovel

Resources Required

Sl. No.	Item	Specification	Quantity
1	Mild Steel Flat/Rod	As per job	1
2	Forge Furnace	Standard	1
3	Blower	Manual/Electric	1
4	Anvil	Standard	1
5	Tongs	Suitable type	1
6	Ball Peen Hammer	0.5–1 kg	1
7	Cross Peen Hammer	Standard	1
8	Fuller	Standard	1
9	Flatter	Standard	1
10	Hot Chisel	Standard	1
11	Steel Rule	300 mm	1
12	Vernier Caliper	0–150 mm	1
13	Wire Brush	Standard	1
14	Water Trough	Standard	1
15	Safety Goggles	Standard	1
16	Leather Gloves	Standard	1 Pair
17	Leather Apron and Safety Shoes	Standard	1 Set

Precautions

1. Wear safety goggles, gloves, apron, and safety shoes.
2. Heat the workpiece uniformly before forging.
3. Use suitable tongs to hold hot metal.
4. Do not overheat the workpiece.
5. Perform forging only within the recommended temperature range.
6. Strike the workpiece only on the anvil face.
7. Keep hands away from the striking area.
8. Remove scale periodically during forging.
9. Maintain proper body posture while hammering.
10. Clean and arrange all tools after completing the experiment.

Procedure

1. Study the instructor's drawing or instructions for the assigned tool.
2. Select the appropriate mild steel stock.
3. Heat the workpiece in the forge furnace to the forging temperature.
4. Draw out or flatten the heated portion as required.
5. Shape the workpiece by bending, flattening, and hammering.
6. Reheat whenever necessary to maintain forging temperature.
7. Trim excess material using a hot chisel, if required.

8. Finish the profile using flatter and hammer.
9. Remove scale with a wire brush.
10. Allow the component to cool under suitable conditions.
11. Measure the finished dimensions using appropriate measuring instruments.
12. Inspect the finished product for workmanship.
13. Clean the work area and return all tools.

Observations and Calculations

Job Details

Particular	**Observation**
Assigned Job	
Material Used	
Initial Stock Size	
Final Dimensions	
Forging Temperature	Approximately 900–1250°C

Tool Selection

Tool	**Purpose**
Forge Furnace	Heating
Anvil	Supporting
Hammer	Forging
Tongs	Holding
Fuller	Drawing
Flatter	Finishing
Steel Rule	Measurement

Dimensional Inspection

Parameter	**Specified**	**Measured**
Length		
Width		
Thickness		
Profile Accuracy		

Visual Inspection

Parameter	Observation
Shape Accuracy	
Surface Finish	
Symmetry	
Scale Formation	
Overall Workmanship	

Results

The assigned forged product (garden trowel / sickle / shovel) was successfully prepared using blacksmithy operations according to the instructor's instructions. The finished component met acceptable / requires improvement standards with respect to dimensions, shape, and workmanship.

Interpretation of Results

- Proper heating and controlled forging produce the desired shape with good mechanical properties.
- Uniform hammering improves dimensional accuracy and surface finish.
- Correct selection of tools and forging sequence minimizes defects and material wastage.
- Frequent reheating within the recommended temperature range prevents cracking during forging.

Conclusions and Recommendations

Conclusion

The experiment demonstrated the fabrication of a garden trowel, sickle, or shovel using blacksmithy operations. Students developed practical skills in heating, drawing out, flattening, bending, shaping, finishing, and inspection while following standard safety practices.

Recommendations

- Heat the workpiece uniformly before forging.
- Reheat whenever the temperature falls below the forging range.
- Use suitable tools for each forging operation.
- Remove scale regularly during forging.
- Avoid excessive hammering on cold metal.
- Follow all blacksmithy safety precautions.

Practical Related Questions

1. Define blacksmithy.
2. What is the recommended forging temperature range for mild steel?
3. Explain the drawing-out operation.
4. What is upsetting in forging?
5. State the function of a flatter.
6. Why is an anvil used in blacksmithy?
7. Name four blacksmithy tools used during forging.
8. List four applications of forged agricultural tools.
9. Why should forging not continue below the recommended temperature?
10. State six safety precautions followed during blacksmithy operations.

References / Suggestions for Further Reading

1. S. K. Hajra Choudhury, Elements of Workshop Technology (Vol. I).
2. B. S. Raghuwanshi, Workshop Technology.
3. P. N. Rao, Manufacturing Technology.
4. K. C. John, Workshop Technology.
5. SBTE Bihar Diploma Curriculum – Manufacturing Engineering Laboratory.
6. Relevant BIS standards for forging practices and workshop safety.
7. All images are AI generated

Assessment Scheme (Combined Process and Product Rubrics)

A. Process Assessment Rubric (20 Marks

Assessment Criteria	Weightage	Level 4 – Excellent	Level 3 – Good	Level 2 – Satisfactory	Level 1 – Needs Improvement
1. Interpretation of Drawing/Instructions and Work Planning	**4**	**4 Marks** – Correctly interprets the instructor's drawing/instructions, selects the material and independently plans the complete sequence of	**3 Marks** – Correctly interprets the instructions with minor guidance and plans most operations appropriately.	**2 Marks** – Requires guidance to understand the instructions and plan the work.	**1 Mark** – Unable to interpret the instructions or plan the work correctly.

Assessment Criteria	Weightage	Level 4 – Excellent	Level 3 – Good	Level 2 – Satisfactory	Level 1 – Needs Improvement
		forging operations.			
2. Selection and Safe Use of Blacksmithy Tools and Equipment	**4**	**4 Marks** – Selects and uses the appropriate forge, anvil, hammer, tongs, chisels, swages and measuring instruments correctly and safely throughout the work.	**3 Marks** – Selects suitable tools and equipment with minor handling or safety errors.	**2 Marks** – Requires guidance in tool selection or safe handling.	**1 Mark** – Incorrect tool selection or unsafe handling practices.
3. Execution of Forging Operations	**6**	**6 Marks** – Performs heating, drawing out, flattening, bending, shaping and finishing systematically with correct forging temperature, proper technique and minimum	**4.5 Marks** – Performs all operations with minor procedural or shaping errors.	**3 Marks** – Completes the operations with frequent guidance and noticeable errors.	**1.5 Marks** – Unable to complete the job satisfactorily or demonstrates incorrect forging procedures.

Assessment Criteria	Weightage	Level 4 – Excellent	Level 3 – Good	Level 2 – Satisfactory	Level 1 – Needs Improvement
		material wastage.			
4. Safety Practices and Housekeeping	**3**	**3 Marks** – Consistently follows blacksmithy safety rules, uses PPE correctly, handles hot workpieces safely and maintains a clean and organized workplace.	**2.25 Marks** – Follows safety practices with occasional reminders.	**1.5 Marks** – Requires frequent reminders regarding safety and housekeeping.	**0.75 Mark** – Frequently ignores safety practices or workplace cleanliness.
5. Work Discipline and Time Management	**3**	**3 Marks** – Completes the assigned job within the allotted time while demonstrating excellent discipline and efficient utilization of material.	**2.25 Marks** – Completes the work with minor delay and minimal supervision.	**1.5 Marks** – Requires additional time and supervision.	**0.75 Mark** – Fails to complete the assigned job within the allotted time.

B. Product Assessment Rubric (10 Marks)

Assessment Criteria	Weightage	Level 4 – Excellent	Level 3 – Good	Level 2 – Satisfactory	Level 1 – Needs Improvement
1. Dimensional Accuracy and Shape	**4**	**4 Marks** – Dimensions, profile, curvature (where applicable) and overall shape conform to the instructor's drawing/instructions within acceptable tolerance.	**3 Marks** – Minor dimensional or shape deviations without affecting functionality.	**2 Marks** – Noticeable dimensional or shape errors affecting appearance or usability.	**1 Mark** – Significant dimensional or shape errors; job does not conform to the instructions.
2. Surface Finish and Forging Quality	**3**	**3 Marks** – Surface is smooth and uniformly forged, free from cracks, excessive scale, folds and deep hammer marks.	**2.25 Marks** – Good finish with minor hammer marks or scale.	**1.5 Marks** – Acceptable finish with noticeable surface defects.	**0.75 Mark** – Poor finish with major forging defects or deformation.
3. Overall Workmanship and Functionality	**3**	**3 Marks** – Job is neat, structurally sound, properly shaped and fully functional with excellent workmanship.	**2.25 Marks** – Good workmanship with minor imperfections; functionality is not affected.	**1.5 Marks** – Functional job with visible workmanship defects.	**0.75 Mark** – Poor workmanship, incomplete job or reduced functionality.

