



RQF LEVEL 4



MATFO401
MANUFACTURING
TECHNOLOGY

Forging
Operation

TRAINER'S MANUAL

October, 2024



FORGING OPERATION



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ACRONYMS

BOM: Bill of Materials

IC: Indicative Content

ICT: Information and Communication Technology

LO: Learning outcome

PPE: Personal Protective Equipment

RQF: Rwanda Qualification Framework

RTB: Rwanda TVET Board

SMAW: Shielded Metal Arc Welding

TeM: Trainee Manual

TrM: Trainer Manual

TVET: Technical and Vocational Education and Training

INTRODUCTION

This trainer's manual includes all the methodologies required to effectively deliver the module titled "**Forging Operation.**" Students enrolled in this module will engage in practical activities designed to develop and enhance their competencies.

The development of this training manual followed the Competency-Based Training and Assessment (CBT/A) approach, offering ample practical opportunities that mirror real-life situations.

The trainer's manual is organized into Learning Outcomes, which is broken down into indicative content that includes both theoretical and practical activities. It provides detailed information on the key competencies required for each learning outcome, along with the objectives to be achieved.

As a trainer, you will begin by asking questions related to the activities to encourage critical thinking and guide trainees toward real-world applications in the labor market. The manual also outlines essential information such as learning hours, didactic materials, and suggested methodologies.

This manual outlines the procedures and methodologies for guiding trainees through various activities as detailed in their respective trainee manuals.

The activities included in this training manual are designed to offer students opportunities for both individual and group work. Upon completing all activities, you will assist trainees in conducting a formative assessment known as the end learning outcome assessment. Ensure that trainees review the key reading and the points to remember section.

MODULE CODE AND TITLE: MATFO401, FORGING OPERATION

Learning Outcome 1: Prepare the work place for forging operations.

Learning Outcome 2: Carry out cold forging.

Learning Outcome 3: Carry out hot forging.

Learning Outcome 4: Perform forging finishing activities.

Learning Outcome 1: Prepare the Work Place for Forging Operations.



Indicative contents

- 1.1 Introduction to forging operations
- 1.2 Organizing workplace
- 1.3 Selecting materials used in forging
- 1.4 Selecting tools used in forging
- 1.5 Selecting Forging Equipment
- 1.6 Applying safety measures at workplace

Key Competencies for Learning Outcome 1 : Prepare the Work Place for Forging operation

Knowledge	Skills	Attitudes
• Description of forging operations • Organisation of workplace • Description of materials selected in forging • Identification of tool and equipment selected in forging • Description of safety measures at workplace.	• Cleaning and finishing materials used in forging. • Applying safety measures at workplace.	• Having self-control • Paying attention to the materials during finishing • Being organized while cleaning the workplace. • Working as a team member while Applying safety measures at the workplace • Working on time



Duration: 10 hrs

Learning outcome 1 objectives:



By the end of the learning outcome, the trainees will be able to:

1. Describe correctly forging operations as used in manufacturing
2. Organize properly the workplace used for forging operation
3. Describe correctly materials selected in forging operation at workplace
4. Identify correctly tools and equipment selected in forging operation
5. Describe appropriately safety measures at the workplace.
6. Clean and finish effectively workpiece used in forging operation
7. Apply effectively safety measures for forging operation at workplace.



Resources

Equipment	Tools	Materials
• Vacuum • Air Compressor • Air Blower • Anvil • Swaging Block • Angle Grinder • Shearing Machine • Power Saw Machine • Plasma Cutter • Blacksmith's Hearth • Pressing Machine • Furnace • Swage Block • Firefighting equipment	• Brushes • Clamp • Tong • Chisel • Hammer • Hacksaw • File • Punches • Tape Measure • Vernier Calliper • Micrometer	• Soap water • Disinfectant • Steels • Aluminium • Stainless Steel • Copper • Lead • Zinc



Advance Preparation:

Before delivering this learning outcome, you are recommended to:

- Have a sample of videos and photos, which present forging activities.
- Avail safety equipment related to forging work activities.
- Avail materials, tools, and equipment required in forging operation



Indicative content 1.1: Introduction to Forging Operations



Duration: 2 hrs.



Theoretical Activity 1.1.1: Description of forging operations



Notes to the trainer:

- Avail workshop or classroom for a better understanding of forging operations.
- Avail some pictures and/or figures and videos to be used while introducing forging operations



Key steps:

While delivering this activity, pass through the following steps:

Step 1: Introduce the topic of the session and ask trainees to answer the following questions:

- What do you understand by the term forging, hot forging, cold forging, forge furnace, recrystallization temperature, Die and heat treatment as used in forging operation?
- What are the advantages and disadvantages of forging, cold forging and hot forging
- What are the categories of forging used in forging operation

Step 2: Engage trainees in presentation of their finding

Step 3: Provide expert view on presentations of the groups.

Step 4: Ask trainees to read the key reading 1.1.1, in trainee manual

Step 5: Ask trainees to perform the task provided in application of learning 1.1



Points to Remember

- Always control temperature, pressure, and deformation speed to avoid defects like cracks or distortion.
- Remember to Follow proper safety protocols, wear protective gear, and ensure equipment guards are in place.
- Practically, always remember that Forging is better suited for simpler shapes and designs compared to other manufacturing processes like casting



Application of learning 1.1.

Ask your trainees to Visit any metal forging workplace located in your surrounding area and identify the following activities performed on:

- a) forging
- b) Hot forging
- c) Cold and hot forging

Checklist

S/N	Criteria	Indicators	Score		Comments
			Yes (1)	Yes (0)	
1	The activities of forging operation are correctly enumerated at workplace.	Hot forging activities are identified			
		Cold forging activities are identified			



Indicative content 1.2: Organizing Workplace



Duration : 1 hr



Theoretical Activity 1.2.1: Organization of workplace in forging operations.



Notes to the trainer:

- Trainer may have arranged a workshop to identify the hazards.
- Trainer is also recommended to prepare workshop safety signs and symbols.



Key steps:

- Step 1:** Introduce the activities and ask trainees to answer the following questions:
- What do you understand by job hazard analysis? Give some example of job hazards
 - What are the importance of organizing the workplace?
- Step 2:** Ask trainees to write the findings on the paper, flip chart blackboard or whiteboard
- Step 3:** Facilitate to trainees to present their findings and choose the correct answers
- Step 4:** Provide the expert view and clarify ideas by using didactic materials
- Step 5:** Address any question or concerns
- Step 6:** Ask trainees to read key reading 1.2.1 in trainee manual.
- Step 7:** Ask trainees to perform the task provided in application of learning 1.2.



Points to Remember

- Workplace organization plays a critical role in enhancing productivity, reducing stress, and fostering collaboration.
- Remember that Effective workplace organization should focus on both physical space and digital tools.



Practical Activity 1.2.2: Applying 5s in organizing the workplace



Notes to the trainer

- Trainer may have arranged a workshop to identify the hazards.
- Trainer is also recommended to organize workshop using 5S.



Key steps:

- Step 1:** Introduce the activities and ask trainees to go in manufacturing workshop and Apply of 5s to organizing the workplace for forging.
- Step 2:** Explain the task and provide clear work instructions (PPE, Time allocated)
- Step 3:** Demonstrate how to apply of 5s to organize the workplace for forging. While demonstrating; explain the procedure
- Step 4:** Ask to trainees to apply of 5s to organize the workplace for forging shear and provide additional clarification where necessary
- Step 5:** Evaluate whether the activity of applying 5s to organize the workplace for forging is effectively done
- Step 6:** Ask trainees to read the key reading 1.2.2 in trainee manual.
- Step 7:** Ask trainees to perform the task provided in application of learning 2.2



Points to Remember

- While performing application of 5S take into consideration sort, set in order, shine, standardize and sustain this will concern to work in good condition of forging workplace



Application of learning 1.2.

Ask your trainees implement the 5S methodology to streamline operations, improve safety, and enhance overall productivity, towards forging industry which is facing issues with workspace clutter, inefficient tool storage, inconsistent cleanliness, and maintenance problems.

Checklist

S/N	Criteria	Indicator	Yes (1)	No (0)	Comments
1.	5S are effectively applied to organize workplace for forging.	1.1 Sort is applied			
		1.2 Set in Order is applied			
		1.3 Shine is applied			
		1.4 Standardize is applied			
		1.5 Sustainability is applied			



Indicative content 1.3: Selecting Materials used in Forging



Duration : 1 hr



Theoretical Activity 1.3.1: Description of materials selected in forging operation



Notes to the trainer:

Trainer may:

Use short questions to identify the selection metal materials used in forging operation activities

Use some videos or pictures to explain more about the selection metal materials used in forging operation activities.



Key steps:

- Step 1:** Introduce the activities and ask trainees to answer the following questions:
- What do you understand ferrous and nonferrous metals used in forging operation? And how are they classified?
 - What are the properties that the metal possess?
- Step 2:** Ask trainees to write the findings on the paper, flip chart blackboard or whiteboard
- Step 3:** Facilitate to trainees to present their findings and choose the correct answers
- Step 4:** provide the expert view and clarify ideas by using didactic materials
- Step 5:** Address any question or concerns
- Step 6:** Ask trainees to read key reading 1.3.1 in trainee manual.



Points to Remember

- Selecting the right material for forging operations is crucial for ensuring the quality, performance, and cost-effectiveness of forged components.
- Remember that The material selection depends on the desired mechanical properties, the specific application, and the forging process itself



Practical Activity 1.3.2: Cleaning and finishing materials used in forging.



Notes to the trainer

- ✓ While delivering this content, the trainer may use appropriate PPEs for proper protection of trainees
- ✓ While delivering this content, the trainer may use safety sign and symbols appropriately for forging operation
- ✓ Use some videos or pictures to explain more about on the uses of PPEs, Safety sign and symbols in forging operations.



Key steps:

- Step 1:** Introduce the activities and ask trainees to go in manufacturing workshop and clean materials selected in forging operation.
- Step 2:** Explain the task and provide clear work instructions (PPE, Time allocated)
- Step 3:** Demonstrate how to clean materials selected in forging operation. While demonstrating; explain the procedure
- Step 4:** Ask to trainees to clean materials selected in forging operation and provide additional clarification where necessary
- Step 5:** Evaluate whether the activity of cleaning materials selected in forging operation is effectively done
- Step 6:** Ask trainees to read the key reading 1.3.2 in trainee manual.
- Step 7:** Ask trainees to perform the task provided in application of learning 1.3



Points to Remember

- You should always use cleaning and finishing materials to remove contaminants, to prepare the surfaces and to enhance the appearance, surface quality, and dimensional accuracy of the products



Application of learning 1.3.

Ask your trainees to apply cleaning and finishing process to ensure the workspace is safe, efficient, and ready for the next production to your nearest school/company which has recently completed a large production run of metal components.

Checklist

S/N	Criteria	Indicator of checklist	Yes (1)	No (0)	Comments
1.	Materials are used efficiently to clean the workspace	Solvents are used			
		Cleaning Agents are used			
		Degreasers are used			
		Abrasive Materials are used			
2.	materials are correctly used to finish the workspace	Buffing Materials are used			
		Abrasive Materials are used			
		Coatings are used			
		Plating are used			



Indicative content 1.4: Selecting of Tools used in Forging



Duration : 2 hrs



Theoretical Activity 1.4.1: Identification of tools used in forging operation



Notes to the trainer:

- Trainer may:
 - ✓ Use short questions on the selection of tools used in forging operations
 - ✓ Use some videos or pictures to explain more about selection of tools used in forging operation.



Key steps:

While delivering this activity, pass through the following steps:

- Step 1:** Introduce the activities and ask trainees to answer the following questions:
- Enumerate cleaning, cutting, forging, marking, holding and finishing tools used in forging.
- Step 2:** Ask trainees to write the findings on the paper, flip chart blackboard or whiteboard
- Step 3:** Facilitate to trainees to present their findings and choose the correct answers
- Step 4:** provide the expert view and clarify ideas by using didactic materials
- Step 5:** Address any question or concerns
- Step 6:** Ask trainees to read key reading 1.4.1 in trainee manual.



Points to Remember

- While selecting tools used in forging activities take into consideration cleaning, cutting, forging, marking, measuring, holding and finishing as tools used to perform forging operations activities.



Practical Activity 1.4.2: Selecting tools used in forging operation



Notes to the trainer

- ✓ While delivering this content, the trainer may use appropriate PPEs for proper protection of trainees
- ✓ While delivering this content, the trainer may use images and videos of the tools used in forging operation as didactic materials



Key steps:

Step 1. Introduce the activities and ask trainees to go in manufacturing workshop and select the tools used in forging operation according to their use.

Step 2. Explain the task and provide clear work instructions (PPE, Time allocated)

Step 3. Demonstrate how to select the tools used in forging operation. While demonstrating; explain the selection criteria

Step 4. Ask to trainees to select the tools used in forging operation and provide additional clarification where necessary

Step 5. Evaluate whether the activity of selecting tools used in forging operation is effectively done

Step 6. Ask trainees to read the key reading 1.4.2 in trainee manual.

Step 7. Ask trainees to perform the task provided in application of learning 1.4



Points to Remember

- During selection of the tools for forging, keep in mind that The tool material must be harder than the workpiece material and The tool shape should complement the desired workpiece shape



Application of learning 1.4.

Suppose that the company has recently hosted internees near your school whose job includes selecting forging tools in manufacturing workshop. Request your trainees to attend and select tools for forging operation.

Checklist

S/ N	Criteria	Indicators	Score		Comments
			Yes (1)	Yes (0)	
1	Tools are selected effectively according to forging operation	Cleaning tools are selected			
		Cutting tools are selected			
		Forging tools are selected			
		Marking tools are selected,			
		Measuring tools are selected			
		Holding and finishing tools are selected			



Indicative content 1.5: Selection of Forging Equipment



Duration : 2 hrs



Theoretical Activity 1.5.1: Identification of equipment used in forging operation



Notes to the trainer:

- Trainer may use short questions on the selection of equipment used in forging operations activities,
- Use some videos or pictures to explain more about on the selection of tools used in forging operation activities.



Key steps:

- Step 1:** Introduce the activities and ask trainees to answer the following questions:
- What do you understand on the following terms of equipment: cutting, forging, Handling, Cleaning, and Firefighting used in forging operations activities?
 - With explanation, give example of the equipment used for section of cutting, forging, Handling, Cleaning, and Firefighting in forging operations activities?
- Step 2:** Ask trainees to write the findings on the paper, flip chart blackboard or whiteboard
- Step 3:** Facilitate to trainees to present their findings and choose the correct answers
- Step 4:** provide the expert view and clarify ideas by using didactic materials
- Step 5:** Address any question or concerns
- Step 6:** Ask trainees to read key reading 1.5.1 in trainee manual.



Points to Remember

- Consider cutting, forging, Handling, Cleaning, and Firefighting as equipment for forging operations and ensure that you understand the uses that can help you to do the work safely. Otherwise, you are at high risk of getting serious injuries



Practical Activity 1.5.2: Selecting forging equipment



Notes to the trainer

- ✓ While delivering this content, the trainer may use appropriate PPEs for proper protection of trainees
- ✓ While delivering this content, the trainer may use images and videos of the equipment used in forging operation as didactic materials



Key steps:

Step 1. Introduce the activities and ask trainees to go in manufacturing workshop and select the equipment used in forging operation according to their use.

Step 2. Explain the task and provide clear work instructions (PPE, Time allocated)

Step 3. Demonstrate how to select the equipment used in forging operation. While demonstrating; explain the selection criteria

Step 4. Ask to trainees to select the equipment used in forging operation and provide additional clarification where necessary

Step 5. Evaluate whether the activity of selecting equipment used in forging operation is effectively done

Step 6. Ask trainees to read the key reading 1.5.2 in trainee manual.

Step 7. Ask trainees to perform the task provided in application of learning 1.5



Points to Remember

- When selecting the equipment for forging, make sure that it can handle the size and weight of the work piece, check if it provides enough force for the forging process and check if it offers automation features for efficiency



Application of learning 1.5.

Ask your trainees to visit the workshop/industrial manufacturing company near the school and select appropriate forging equipment based on material properties, product complexity, and production volume.

Checklist

S/N	Criteria	Indicators	Score		Comments
			Yes (1)	Yes (0)	
1	Forging equipment are appropriately selected based on material properties, product complexity, and production volume	Cutting equipment are selected			
		Handling equipment are selected			
		Cleaning equipment are selected			
		Forging equipment are selected			
		Firefighting equipment are selected			



Indicative content 1.6: Applying Safety Measures at Workplace



Duration : 2 hrs



Theoretical Activity 1.6.1: Description of safety measures at workplace



Notes to the trainer:

- Trainer may use short questions on the identify the causes of hazard and ways of hazard control used in forging operations
- Use some videos or pictures to explain more about Workplace Hazards in forging operations.



Key steps:

- Step 1:** Introduce the activities and ask trainees to answer the following questions:
- i. Explain types and causes of hazards
 - ii. What are the ways of hazard control?
- Step 2:** Ask trainees to write the findings on the paper, flip chart blackboard or whiteboard
- Step 3:** Facilitate to trainees to present their findings and choose the correct answers
- Step 4:** provide the expert view and clarify ideas by using didactic materials
- Step 5:** Address any question or concerns
- Step 6:** Ask trainees to read key reading 1.6.1 in trainee manual.



Points to Remember

- Always keep in mind that safety measures reduce accidents, protect employee health, and ensure compliance with safety standards, ultimately fostering a productive and secure working environment.



Practical Activity 1.6.2: Applying safety measures at workplace



Notes to the trainer

- ✓ While delivering this content, the trainer may use appropriate PPEs for proper protection of trainees
- ✓ While delivering this content, the trainer may use safety sign and symbols appropriately for forging operation
- ✓ Use some videos or pictures to explain more about on the uses of PPEs, Safety sign and symbols in forging operations.



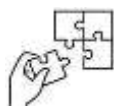
Key steps:

- Step 1:** Introduce the activities and ask trainees to go in manufacturing workshop and wear PPEs and setting Safety Signs and Symbols in forging workshop.
- Step 2:** Explain the task and provide clear work instructions (PPE, Time allocated)
- Step 3:** Demonstrate how the PPEs are worn and how control the hazards in forging workshop. While demonstrating; explain the safety signs and symbols and provide additional clarification where necessary
- Step 4:** Evaluate whether the activity of PPEs and Safety Signs and Symbols in forging workshop is effectively done.
- Step 5:** Ask trainees to read the key reading 1.6.2 in trainee manual.
- Step 6:** Ask trainees to perform the task provided in application of learning.1.6



Points to Remember

- you should always apply safety measures to prevent injuries, illnesses, and fatalities in the workplace
- Many safety measures are required by law. Non-compliance can result in fines and other penalties.



Application of learning 1.6

Organise a study visit to forging workplace located in your surrounding area and request your trainees to apply strategies for hazards prevention by enhancing safety measures and by integrating personal protective equipment (PPE) with clear safety signs and symbols to address the specific hazards associated with forging processes,

Checklist

S/N	Criteria	Indicator	Yes (1)	No (0)	Comments
1.	Personnel protective equipment used in forging workshop are correctly selected.	Safety glasses are worn			
		Helmet is worn			
		Safety shoes are worn			
		Gloves are worn			
		Overall are worn			
		Ear plugs are worn			
2	Safety Signs and Symbols are placed in good position	Warning Signs used			
		Mandatory Signs are used			
		Prohibition Signs are used			



Learning outcome 1 end assessment

Written assessment

1. The following table contains the key terms used in forging. Match the column A. Forging key terms to their correct meaning in column B and write the letter corresponding to the right question in Answer column

Answers	Column A (Forging key terms)	Column B (meaning)
A.....	A. Forging	1. A process that involves heating and cooling metals to change their properties.
B.....	B. Forge	2. Heating device used to heat metal to the required temperature for forging.
C.....	C. Heat treatment	3. A workspace or facility equipped with the necessary tools and equipment for conducting forging operations
D.....	D. Furnace	4. A deformation process in which the work piece is compressed between two dies, using either impact load or hydraulic load (or gradual load) to deform it.

Answers

- A. Forging → 4
B. Forge → 3
C. Heat treatment → 2
D. Furnace → 1

2. Read carefully the following questions related to forging operation and answers by **True** for the correct statement or **False** for the incorrect statement
- a) Mandatory signs indicate actions or behaviours that are required in the workplace, such as wearing PPE, using safety harnesses, or using hand protection. **T**
 - b) Types of clothing used for body protection include conventional and disposable overalls, boiler suits, aprons, and high-visibility clothing **T**
 - c) Lack of training led to sufficient knowledge or training on safe work practices and equipment operation. **F**
 - d) Prohibition signs indicate actions that are not allowed or restricted in the workplace, such as no smoking, no entry, or no open flames. **T**

3. Read carefully the following sentences and Complete the empty spaces using the following words of 5S to make them meaningful. (**Sustain, set in order, shine, standardize, sort**)
- a) Implement a culture of continuous improvement and regular inspection to ensure that the organized workplace is maintained over time
 - b) Regularly clean and maintain the workplace, including machinery, tools, and work surfaces. This helps prevent dirt, debris, or contaminants from affecting the forging process.
 - c) Develop standard operating procedures (SOPs) for organizing the workplace, including guidelines for tool placement, cleaning schedules, and maintenance routines.
 - d) Arrange tools, equipment, and materials in a logical and ergonomic manner. Clearly label storage areas and provide designated locations for each item.
 - e) Remove unnecessary items, tools, or equipment from the workplace to reduce clutter and improve accessibility.

Answers/

- ✓ Sustain: Implement a culture of continuous improvement and regular inspection to ensure that the organized workplace is maintained over time.
 - ✓ Set in Order: Arrange tools, equipment, and materials in a logical and ergonomic manner. Clearly label storage areas and provide designated locations for each item.
 - ✓ Shine: Regularly clean and maintain the workplace, including machinery, tools, and work surfaces. This helps prevent dirt, debris, or contaminants from affecting the forging process.
 - ✓ Sort: Remove unnecessary items, tools, or equipment from the workplace to reduce clutter and improve accessibility.
 - ✓ Standardize: Develop standard operating procedures (SOPs) for organizing the workplace, including guidelines for tool placement, cleaning schedules, and maintenance routines.
4. Read carefully the following statement related to forging operation and Encircle the correct answer
- I. the following is the function of the correspondence except
 - a) Wire brushes are used to remove loose debris, scale, or rust from the surface of the materials.
 - b) Brushes Different types of brushes, such as nylon brushes or abrasive brushes, can be used for cleaning purposes.
 - c) chisel are handheld tools with a sharp cutting edge used for cutting or shaping the workpiece by striking it with a hammer or mallet

- d) tongs are gripping tools used to hold and manipulate the hot metal workpiece during forging
- e) Swage blocks are multi-purpose tools with the same shaped hole and recesses. They are used to support and shape the workpiece during forging
- f) Hot Forging: is a forging process carried out at elevated temperatures, typically below the recrystallization temperature of the metal

Answers E, F

- II. The list below are the holding tools applied on the work piece **Except;**
 - a) Vises
 - b) tongs
 - c) clamps
 - d) Buffing Wheels
 - e) holding fixture

Answer, d

- III. The list below are the finishing tools applied on the work piece **Except;**
 - a) Files
 - b) Sandpaper
 - c) Bench dogs
 - d) wire brushes
 - e) scraper

Answer, c

Practical assessment

During industrial attachment program, there is a task of forging a custom hook from a steel bar. Ask your trainees to select appropriate tools, materials, and equipment that required to forge a custom hook from a steel bar. Also ask them to identify necessary safety measures required for handling hot metal.

Checklist

S/N	Criteria	Indicator	Yes (1)	No (0)	Comments
1.	Materials are correctly selected	ferrous materials are selected			
		non-ferrous materials are selected			
		properties of metals are considered during selection			
2	Tools are correctly selected	Cleaning tools are selected			
		Cutting Tools are selected			
		Forging tools are selected			
		Marking tools are selected			
		Measuring Tools are selected			
		Holding Tools are selected			
		Finishing tools are selected			
3	Equipment are correctly selected	Cutting equipment are selected			
		forging equipment are selected			
		handling equipment are selected			
		cleaning equipment are selected			
		firefighting equipment are selected			
4	Safety measures are properly applied	appropriate PPES are selected			
		safety sign and symbols are identified			
		workplace hazards are identified			



Further information to the trainer

Altan, T., Ngaile, G., & Shen, G. (2005). *Cold and hot forging: Fundamentals and applications*. ASM International.

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Learning Outcome 2: Carry out Cold Forging



Indicative contents

2.1: Cutting Workpiece

2.2: Clamping the Workpiece

2.3: Heating the Workpiece

2.4: Applying Cold forging on the Workpiece

Key Competencies for Learning Outcome 2 : Carry out Cold Forging

Knowledge	Skills	Attitudes
• Description of cutting, clamping, and heating techniques • Description of heat treatment processes applied in forging Operation	• Cutting the work piece • Clamping the work piece for forging operation • Heating the work piece for forging • Forming the work piece through cold forging • Collecting forging defects in forged parts	• Having precision while measuring and cutting metals • Paying attention to the heated metals during cold forging operation • Being organized while cutting and clamping the metals • Working as a team member while performing cold forging operation



Duration: 20 hrs

Learning outcome 2 objectives:



By the end of the learning outcome, the trainees will be able to:

1. Describe clearly the cutting, clamping, and heating techniques applied in cold forging operation
2. Describe clearly heat treatment processes as applied in forging Operation
3. Cut properly the workpiece according to the citing techniques
4. Clamp properly the work piece for forging operation techniques
5. Heat effectively the work piece as per metal heating techniques
6. Form properly the work piece as per cold forging techniques
7. Collect properly the forging defects according to cold forging techniques



Resources

Equipment	Tools	Materials
• Cutting Equipment • Forging Equipment • Personal Protective Equipment • Clamping equipment • Handling equipment • Cleaning equipment • Firefighting equipment • Heating equipment	• Cleaning tools • Cutting Tools • Forging tools • Marking tools • Measuring Tools • Holding Tools • Finishing tools	• Soap water • Disinfectant • Steels • Aluminium • Stainless Steel • Copper • Lead • Zinc

Advance Preparation:

Before delivering this learning outcome, you are recommended to:

- Have a tutorial videos related to cold forging operations.
- Avail safety equipment related to cold forging operations.

- Make sure there is metals for cold forging application.



Indicative content 2.1: Cutting Workpiece



Duration : 5 hrs



Practical Activity 2.1.1: Cutting metals using hacksaw, snip, and shear



Notes to the trainer

- ✓ While delivering this session, trainer may use individualized work during practical works
- ✓ Trainer may use tutorial video for metal cutting using hacksaw, snip, and shear as didactic materials



Key steps:

While delivering this activity, pass through the following steps:

Step 1: Introduce the activities and ask trainees to go in manufacturing workshop and perform metal cutting by using hacksaw, snip, and shear.

Step 2: Explain the task and provide clear work instructions (PPE, Time allocated)

Step 3: Demonstrate metal cutting operation by using hacksaw, snip, and shear. While demonstrating; explain the procedure

Step 4: Ask to trainees to perform metal cutting using hacksaw, snip, and shear. Monitor the activity and provide additional clarification where necessary

Step 5: Evaluate whether the activity of metal cutting by using hacksaw, snip, and shear is effectively done

Step 6: Ask trainees to read the key reading 2.1.1 in trainee manual.

Step7: Ask trainees to perform the task provided in application of learning 2.1



Points to Remember

- While cutting metals using hacksaw, snip and shear make sure that the safety precautions are applied.
- Pay attention to the dimensions requested for metal cutting.



Practical Activity 2.1.2: Cutting metals using Plasma, Angle Grinder, Punch, and power saw

Notes to the trainer

- ✓ While delivering this session, trainer may use individualized work during practical works
- ✓ Trainer may use tutorial video for metal cutting using Plasma, Angle Grinder, Punch, and power saw as didactic materials



Key steps:

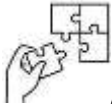
While delivering this activity, pass through the following steps:

- Step 1:** Introduce the activities and ask trainees to go in manufacturing workshop and perform metal cutting by using plasma, angle grinder, punch, and power saw.
- Step 2:** Explain the task and provide clear work instructions (PPE, Time allocated)
- Step 3:** Demonstrate metal cutting operation by using plasma, angle grinder, punch, and power saw. While demonstrating; explain the procedure
- Step 4:** Ask to trainees to perform metal cutting using plasma, angle grinder, punch, and power saw. Monitor the activity and provide additional clarification where necessary
- Step 5:** Evaluate whether the activity of metal cutting by using plasma, angle grinder, punch, and power saw is effectively done
- Step 6:** Ask trainees to read the key reading 2.1.2 in trainee manual.
- Step 7:** Ask trainees to perform the task provided in application of learning.



Points to Remember

- While cutting metals using plasma, angle grinder, punch, and power saw make sure that the safety precautions are applied.
- Pay attention to the dimensions requested for metal cutting.
- Power tool adjustment should always consider power supply system.



Application of learning 2.1

Suppose that you are willing to produce kitchen axe from mild steel. Request your trainees to go in manufacturing workshop and cut the work piece of 500 mmx140mmx4mm using appropriate cutting technique.

Checklist

Criteria	Indicator	Scores		Comment
		Yes(1)	No(0)	
Metal cutting is properly done/performed	Metals is selected			
	Dimesnions are respected			
	Cutting tool is operated			
	Appropriate cutting technique is performed			



Indicative content 2.2: Clamping the Workpiece



Duration : 5 hrs



Theoretical Activity 2.2.1: Description of Clamping the workpiece



Notes to the trainer:

- ✓ While delivering this session, trainer may use individualized work during practical works
- ✓ Trainer may use tutorial video for metal clamping as didactic materials



Key steps:

While delivering this activity, pass through the following steps:

Step 1: Engage trainees in group forming/ introduce the topic of the session and ask

Step 2: Monitor group discussion on given task that reflect on the following questions:

- i. Discuss on the following clamping techniques used in forging operations activities
 - a) Mechanical Actuation
 - b) Pneumatic and hydraulic
 - c) Vacuum
 - d) Magnetic
 - e) Toggle
 - f) Wedge
 - g) Spring

Step 3: Engage trainees in presentation of their findings.

Step 4: Provide expert view on presentations of the groups.

Step 5: Address any questions or concerns to trainees.



Points to Remember

- Clamping work pieces securely during machining or forging operations is critical for precision, stability, and safety. Different actuation methods such as mechanical, pneumatic, hydraulic, vacuum, and magnetic each has unique advantages and limitations based on the application.



Practical Activity 2.2.2 Clamping work piece using mechanical actuation, pneumatic and hydraulic, vacuum, and magnetic.



Notes to the trainer

- ✓ While delivering this session, trainer may use individualized work during practical works
- ✓ Trainer may use tutorial video for clamping using mechanical actuation, pneumatic and hydraulic, vacuum, and magnetic. as didactic materials



Key steps:

While delivering this activity, pass through the following steps:

- Step 1:** Introduce the activities and ask trainees to go in manufacturing workshop and perform mechanical actuation, pneumatic and hydraulic, vacuum, and magnetic
- Step 2:** Explain the task and provide clear work instructions (PPE, Time allocated)
- Step 3:** Demonstrate workpiece clamping by using mechanical actuation, pneumatic and hydraulic, vacuum, and magnetic. While demonstrating; explain the procedure
- Step 4:** Ask to trainees to perform work piece clamping using mechanical actuation, pneumatic and hydraulic, vacuum, and magnetic. Monitor the activity and provide additional clarification where necessary
- Step 5:** Evaluate whether the activity of clamping by using mechanical actuation, pneumatic and hydraulic, vacuum, and magnetic is effectively done
- Step 6:** Ask trainees to read the key reading 2.2.2 in trainee manual.
- Step 7:** Ask trainees to perform the task provided in application of learning 2.2



Points to Remember

- The choice of clamping method is crucial for securing work pieces during manufacturing, machining, or assembly operations. Each clamping technique (mechanical, pneumatic, hydraulic, vacuum, and magnetic) offers distinct advantages depending on the specific application requirement.



Practical Activity 2.2.3: Clamping the work piece using toggle, wedge, and spring



Notes to the trainer

- ✓ While delivering this session, trainer may use individualized work during practical works
- ✓ Trainer may use tutorial video for clamping using toggle, wedge and spring as didactic materials



Key steps:

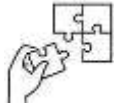
While delivering this activity, pass through the following steps:

- Step 1:** Introduce the activities and ask trainees to go in manufacturing workshop and perform Clamp the work piece using toggle, wedge, and spring.
- Step 2:** Explain the task and provide clear work instructions (PPE, Time allocated)
- Step 3:** Demonstrate work piece clamping by using toggle, wedge, and spring. While demonstrating; explain the procedure
- Step 4:** Ask to trainees to perform work piece clamping using toggle, wedge, and spring. Monitor the activity and provide additional clarification where necessary
- Step 5:** Evaluate whether the activity of clamping by using toggle, wedge, and spring is effectively done.
- Step 6:** Ask trainees to read the key reading 2.2.3 in trainee manual.
- Step 7:** Ask trainees to perform the task provided in application of learning 2.2



Points to Remember

- Using toggle clamps, wedges, and springs together can provide versatile and effective clamping for different manufacturing and machining processes. Each mechanism has unique strengths that, when combined, can offer precise control, strong clamping force, and consistent performance.



Application of learning 2.2.

In your manufacturing workshop there is an activity of machining large workpiece on lathe machine. Ask your trainees to go in manufacturing and clamp that workpiece on the lathe machine using appropriate clamping tool and appropriate technique

Checklist

S/N	Criteria	Indicators	Score		Comments
			Yes (1)	Yes (0)	
1	Metal work piece is effectively clamped onto a lathe machine	Appropriate clamping tool is used			
		Appropriate clamping technique is used			
		Work piece is secure and stable positioning.			
		PPEs are utilised			



Indicative content 2.3: Heating the Workpiece



Duration : 5 hrs



Theoretical Activity 2.3.1: Description of Heating Techniques



Notes to the trainer:

- While delivering this session, trainer may use video /tutorials to describe heating techniques as didactic materials



Key steps:

While delivering this activity, pass through the following steps:

- Step 1:** Introduce the activities and ask trainees to answer the following questions:
- i. Discuss on the following heating techniques used in forging operations activities
 - a. GAS Furnace
 - b. Induction
 - c. Electrical resistance
 - d. Salt bath
 - e. Dielectric
- Step 2:** Ask trainees to write the findings on the paper, flip chart blackboard or whiteboard
- Step 3:** Facilitate to trainees to present their findings and choose the correct answers
- Step 4:** provide the expert view and clarify ideas by using didactic materials
- Step 5:** Address any question or concerns
- Step 6:** Ask trainees to read key reading 2.3.1 in trainee manual.



Points to Remember

- While heating using gas furnace, induction, electrical resistance, salt bath, and dielectric make sure that the safety precautions are applied.
- Pay attention to the heating techniques process



Practical Activity 2.3.2: Performing heat treatment process by using annealing, normalizing, and tempering



Notes to the trainer

- ✓ While delivering this session, trainer may use tutorial video for annealing, normalizing, and tempering process as didactic materials



Key steps:

While delivering this activity, pass through the following steps:

- Step 1:** Introduce the activities and ask trainees to go in manufacturing workshop and perform heat treatment by using annealing, normalizing, and tempering.
- Step 2:** Explain the task and provide clear work instructions (PPE, Time allocated)
- Step 3:** Demonstrate heat treatment by using annealing, normalizing, and tempering. While demonstrating; explain the procedure
- Step 4:** Ask to trainees to perform heat treatment by using annealing, normalizing, and tempering. Monitor the activity and provide additional clarification where necessary
- Step 5:** Evaluate whether the activity of heat treatment by using annealing, normalizing, and tempering is effectively done.
- Step 6:** Ask trainees to read the key reading 2.3.3 in trainee manual.
- Step 7:** Ask trainees to perform the task provided in application of learning 2.3



Points to Remember

- While performing heat treatment process using annealing, normalizing and tempering make sure that the safety precautions are applied.
- Pay attention to the heat treatment process.



Practical Activity 2.3.3: Performing heat treatment process by using case hardening, surface hardening, and stress relieving



Notes to the trainer

- ✓ While delivering this session, trainer may use tutorial video for case hardening, surface hardening, and stress relieving process as didactic materials



Key steps:

While delivering this activity, pass through the following steps:

- Step 1:** Introduce the activities and ask trainees to go in manufacturing workshop and perform heat treatment by using case hardening, surface hardening, and stress relieving.
- Step 2:** Explain the task and provide clear work instructions (PPE, Time allocated)
- Step 3:** Demonstrate heat treatment by using case hardening, surface hardening, and stress relieving. While demonstrating; explain the procedure
- Step 4:** Ask to trainees to perform heat treatment by using case hardening, surface hardening, and stress relieving. Monitor the activity and provide additional clarification where necessary
- Step 5:** Evaluate whether the activity of heat treatment by case hardening, surface hardening, and stress relieving is effectively done.
- Step 6:** Ask trainees to read the key reading 2.3.3 in trainee manual.
- Step 7:** Ask trainees to perform the task provided in application of learning 2.3



Points to Remember

- While performing heat treatment process using case hardening, surface hardening, and stress relieving make sure that the safety precautions are applied.
- Pay attention to the heat treatment process because it can cause injuries.



Application of learning 2.3.

Ask your trainees to visit a factory near your surrounding that produces steel gear shafts and perform series of heat treatment processes including annealing, normalizing, tempering, case hardening, surface hardening, and stress relieving for the shafts.

Checklist:

S/N	Criteria	Indicators	Score		Comments
			Yes (1)	Yes (0)	
1	Heat treatment process are correctly performed on the steel gear shafts	Annealing is performed			
		Normalizing is performed			
		Tempering is performed			
		Case hardening is performed			
		Surface hardening is performed			
		Stress relieving is performed			
		Appropriate PPEs are worn			



Indicative content 2.4: Applying Cold Forging on the Workpiece



Duration : 5 hrs



Theoretical Activity 2.4.1: identification of defect in cold forging



Notes to the trainer:

- Trainer may use short questions on the heat treatment process used in forging operations activities and the defects in forged parts,
- Use some videos or pictures to discuss more about defect in cold forging as didactic materials



Key steps:

While delivering this activity, pass through the following steps:

- Step 1:** Introduce the topic of the session and ask trainees to answer the following questions:
- Explain the defects happen in forged parts during forging operation activities
- Step 2:** Engage trainees in presentation of their findings.
- Step 3:** Provide expert view on presentations of the groups.
- Step 4:** Address any questions or concerns to trainees.



Points to Remember

- Collecting and analysing defect data, manufacturers can significantly improve the reliability and efficiency of cold forging operations
- While performing cold forging using upsetting, extraction, heading, coining, cold roll, forming, and cold forging with machine, make sure that the safety precautions are applied.
- Remember to minimize the defects in Forged Parts.



Practical Activity 2.4.2: performing cold forging techniques



Notes to the trainer

- ✓ Trainer may use short questions on the heat treatment process used in forging operations activities and the defects in forged parts,
- ✓ Use some videos or pictures about cold forging techniques as didactic materials



Key steps:

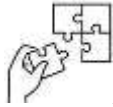
While delivering this activity, pass through the following steps:

- Step 1:** Introduce the activities and ask trainees to go in manufacturing workshop and perform cold forging techniques on a metal workpiece
- Step 2:** Explain the task and provide clear work instructions (PPE, Time allocated)
- Step 3:** Demonstrate how to perform the cold forging techniques on a metal workpiece. While demonstrating; explain the procedure
- Step 4:** Ask to trainees to perform the cold forging techniques on a metal workpiece. Monitor the activity and provide additional clarification where necessary
- Step 5:** Evaluate whether the activity is effectively done
- Step 6:** Ask trainees to read the key reading 2.4.2 in trainee manual.
- Step 7:** Ask trainees to perform the task provided in application of learning 2.4



Points to Remember

- Cold forging is a highly efficient and economical process for manufacturing metal parts, especially for large-scale production, with notable benefits in material conservation, mechanical performance, and product precision.



Application of learning 2.4.

Ask your trainees to go in manufacturing workshop of the school and produce a bolt and nut of (M24/3.0/36) Bolt Diameter (mm)/Thread Pitch (mm) and Wrench Size (mm) respectively by performing an appropriate cold forging technique

Checklist

S/N	Criteria	Indicators	Score		Comments
			Yes (1)	Yes (0)	
	Bolt and nut are effectively produced according to cold forging techniques.	Appropriate PPEs are worn			
		Appropriate cold forging technique is applied			
		Bolt is produced			
		Nut is produced			
		Given Dimensions are respected			



Learning outcome 2 end assessment

Written assessment

1. Read carefully the following questions related to forging operation and answers by **True** for the correct statement or **False** for the incorrect statement
 - a) Shearing is a cutting technique that uses a shearing machine or shear blades to cut through the workpiece. **T**
 - b) Heading is a cold forging technique used to form the end of a hexagonal workpiece into a specific shape, such as a bolt head or a rounded end **F**
 - c) Normalizing is a heat treatment process that involves heating the workpiece to a temperature below its critical transformation temperature, followed by air cooling. **F**
 - d) Punching is a cutting technique that used for creating holes or slots in metal sheets **T**
 - e) A vacuum pumping creates a positive pressure, which securely holds the workpiece against a surface or fixture. **F**
 - f) Spring clamps are versatile and can be used for a wide range of workpiece shapes and sizes. **T**
2. Read carefully the following statement related to forging operation and Encircle the correct answer.
 - i. The list below are the heating techniques used the cold forging process **Except**;
 - a) Induction Heating
 - b) Mechanical Actuation
 - c) Gas Furnace
 - d) Dielectric Heating
 - e) Extraction
 - f) Tempering
 - g) Stress Relieving

Answers/ b, e

- ii. the correct forging defects happen in forged parts during forging operations activities are:
 - a) Fibred flow lines discontinued will occur because of very rapid plastic flow of metal.
 - b) Scale pits are formed by squeezing of scale into the metal surface during forging.

- c) Oversize components is due to worn out dies, incorrect dies, misalignment of die halves.
- d) Incomplete Fill occurs when the material does not completely fill the die or Mold during the forging process.
- e) Flash is an excess material that is squeezed out between the dies during the forging process.
- f) Cracks can occur in forged parts due to various reasons, such as improper material flow, excessive deformation, or improper cooling.
- g) Cold Shut is a defect that occurs when two flow fronts do not properly fuse together during the forging process.
- h) Improper grain growth occurs when the grain structure of the material is not properly misaligned during the forging process

Answers/ a, b, c, e, f

3. The following table contains heat treatment process used in forging. Match the column A. heat treatment process to their correct meaning in column B and write the letter corresponding to the right question in Answer column

Answer	Column A	Column B
A.....	A. Extraction	1. Is a cold forging technique used to create intricate patterns or features on the surface of a workpiece.
B.....	B. Cold roll forming	2. Is a cold forging technique used to shape a long strip of material into a desired profile or cross-section.
C.....	C. Upsetting	3. Also known as piercing or punching, is a cold forging technique used to create holes or openings in the workpiece.
D.....	D. Coining	4. Is a cold forging technique that involves compressing and shortening the length of a cylindrical workpiece.

Answers/ A → 3
 B → 2
 C → 4
 D → 1

4. Read carefully the following sentences and Complete the empty spaces using the following words of cold forging techniques to make them meaningful. (**Coining Cold, Heading, Roll Forming, Hacksawing, Power Saw Upsetting and Extraction**)
- a) is a cold forging technique that involves compressing and shortening the length of a cylindrical workpiece
 - b) also known as piercing or punching, is a cold forging technique used to create holes or openings in the workpiece.
 - c) is a cutting technique that uses a shearing machine or shear blades to cut through the workpiece.
 - d) is a cold forging technique used to shape a long strip of material into a desired profile or cross-section. The material is passed through a series of rolls that gradually shape it into the desired form without heating.
 - e) is a cold forging technique used to create intricate patterns or features on the surface of a workpiece
 - f) such as bandsaws or circular saws, can be used to cut through larger workpieces or thicker materials.

Answers/

- ✓ **Coining:** Coining is a cold forging technique used to create intricate patterns or features on the surface of a workpiece
- ✓ **Cold Roll Forming:** is a cold forging technique used to shape a long strip of material into a desired profile or cross-section. The material is passed through a series of rolls that gradually shape it into the desired form without heating.
- ✓ **Upsetting:** Upsetting is a cold forging technique that involves compressing and shortening the length of a cylindrical workpiece
- ✓ **Extraction:** Extraction, also known as piercing or punching, is a cold forging technique used to create holes or openings in the workpiece.
- ✓ **Hacksawing:** Hacksawing is a cutting technique that uses a shearing machine or shear blades to cut through the workpiece.
- ✓ **Power Saw:** Power saws, such as bandsaws or circular saws, can be used to cut through larger workpieces or thicker materials.

Practical assessment

Suppose your trainees are a manufacturing technicians in a forging workshop, and their supervisor has assigned them a task to complete the initial stages of producing a forged component. A customer has ordered a mild steel part that requires specific dimensions and quality. their job is to:

1. Perform cutting of 20 cm long, 25 mm diameter mild steel bar from the raw material rack.
2. Perform Clamping of the workpiece in the designated bench vise or clamping fixture on your workstation, ensuring it is stable and ready for the next steps.
3. Perform Heating by Placing the clamped workpiece into the furnace and heat it to 1,200°C.
4. Perform Cold Forging: Once cooled to room temperature, shape the workpiece using the hydraulic press to produce a beveled edge.

Checklist

S/N	Criteria	Indicator of checklist	Yes (1)	No (0)	Comments
1.	Cutting techniques are effectively applied on large steel	Hacksaw cutting techniques is applied			
		Snip cutting techniques is applied			
		Shear cutting techniques is applied			
		Plasma cutting techniques is applied			
		Angle grinder cutting techniques is applied			
		Punch cutting techniques is applied			
		Power saw cutting techniques is applied			
2.	Clamping technique are	Mechanical Actuation technique is applied			

	effectively applied on large steel	Pneumatic and hydraulic technique is applied			
		Vacuum technique is applied			
		Magnetic technique is applied			
		Toggle technique is applied			
		Wedge technique is applied			
		Spring technique is applied			
3	Heating techniques are effectively applied on large steel.	GAS Furnace technique is applied			
		Electrical resistance technique is applied			
		Induction Furnace technique is applied			
		Salt bath technique is applied			
		Dielectric technique is applied			
4.	Heat treatment process	Annealing Heat treatment process is applied			
		Normalizing Heat treatment process is applied			
		Tempering Heat treatment process is applied			
		Surface hardening Heat treatment process is applied			
		Tress relieving Heat treatment process is applied			
		Case hardening Heat treatment process is applied			

5.	Cold Forging Technique	Upsetting technique is applied			
		Extraction technique is applied			
		Heading technique is applied			
		Coining technique is applied			
		Cold Roll technique is applied			
		Forming technique is applied			
		Cold forging with machine technique is applied			



Further information to the trainer

Altan, T., & Ngaile, G. (2005). Cold and Hot Forging: Fundamentals and Applications. ASM International.

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Learning Outcome 3: Carry out Hot Forging



Indicative contents

3.1 Applying hot forging on the work piece.

Key Competencies for Learning Outcome 3 : Carry out Hot Forging

Knowledge	Skills	Attitudes
• Description of extraction, upsetting heading used hot forging workk piece.	• Apply heating , forming compressing, cooling ,trimming and finish the work piece	• Paying attention to the heated metals during hot forging operation • Being organized while forming and compressing the work piece • Having precision while heating and work piece • Working as a team member while performing hot forging operation



Duration: 20 hrs

Learning outcome 3 objectives:



By the end of the learning outcome, the trainees will be able to:

1. Describe properly hot forging techniques as applied in hot forging the work piece.
2. Apply properly heat, form and compress the work piece as used in hot forging process.
3. Apply properly cooling, trimming and finishing the work piece as used in hot forging process.



Resources

Equipment	Tools	Materials
• Anvil • Angle Grinder • Shearing Machine • Chop Saw Machine • Torching Equipment • Plasma Cutter • Die • Punch • Blacksmith • Furnaces • Pressing Machine • Furnace • Swage Block • Powered Hacksaw Machine	• Tong • Chisel • Fuller • Hammer • Flatter • Swage • Hacksaw • File • Punches • File • Hardier • Break Iron • Driller • Clamps • Saw • Tape Measure • Steel Ruler • Vernier Caliper	• Ferrous • Non-Ferrous Metals

Advance Preparation:

Before delivering this learning outcome, you are recommended to:

- Have a tutorial videos related to hot forging operations.
- Avail safety equipment related to hot forging operations.
- Make sure there is metals for hot forging application.



Indicative content 3.1: Applying Hot Forging on the Workpiece



Duration: 20 hrs.



Theoretical Activity 3.1.1: Description of hot forging techniques



Notes to the trainer:

- While delivering this content, trainer may use Tutorial video to demonstrate hot forging techniques as didactic materials



Key steps:

While delivering this activity, pass through the following steps:

- Step 1:** Introduce the activities and ask trainees to answer the following questions:
- iii. What do you understand by upsetting, extraction and heading as applied on the work piece?
- Step 2:** Ask trainees to write the findings on the paper, flip chart blackboard or whiteboard
- Step 3:** Facilitate to trainees to present their findings and choose the correct answers
- Step 4:** Provide the expert view and clarify ideas by using didactic materials
- Step 5:** Address any question or concerns
- Step 6:** Ask trainees to read key reading 3.1.1 in trainee manual.



Points to Remember

- It is always advisable to perform hot forging as it provide easier to mold metal
- Always be careful when performing hot forging because Metals can warp easily



Practical Activity 3.1.2: Performing hot forging process



Notes to the trainer

- While delivering this content, trainer may use Tutorial video to demonstrate hot forging process as didactic materials
- Trainer may Prepare work piece to heat, form, compress, cool and finish



Key steps:

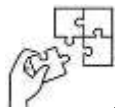
While delivering this activity, pass through the following steps:

- Step 1:** Introduce the activities and ask trainees to go in manufacturing workshop and perform heating, forming, compressing, cooling and finish the work piece.
- Step 2:** Explain the task and provide clear work instructions (PPE, Time allocated)
- Step 3:** Demonstrate heating, forming, compressing, cooling and finish the work piece by using furnace. While demonstrating; explain the procedure
- Step 4:** Ask trainees to perform heating, forming, compressing, cooling and finish the work piece by using furnace. Monitor the activity and provide additional clarification where necessary.
- Step 5:** Evaluate whether the activity of heating, forming, compressing, cooling and finish the work piece by using furnace are effectively done.
- Step 6:** Ask trainees to read the key reading 3.1.2 in trainee manual.
- Step 7:** Ask trainees to perform the task provided in application of learning 3.1



Points to Remember

- Consider the steps to be followed per each hot forging techniques into practice to avoid failure work piece.
- Ensure that Hot forging processes performed on the work piece should pass in all process to increase durability, strengthen properties and improve the quality.
- Remember that Hot forging enhances material strength and fatigue resistance through grain refinement.
- Always remember that by following the sequence, hot forging process ensures the creation of strong, durable, and high-quality metal parts.



Application of learning 3.1.

Ask your trainees to visit a metal forging company located in Kigali city or near your surrounding's company which produce various types of materials and tools. Ask them to fabricate the bolt and nut made in steel bar using hot forging process



Checklist

S/N	Criteria	Indicators	Score		Comments
			Yes (1)	No (0)	
1.	Safety measures are effectively applied	1.1 Overall are worn			
		1.2 Safety shoes are worn			
		1.3 Safety glasses are worn			
		1.4 Gloves are worn			
2	Hot forging technique is effectively performed	2.1. extraction is used			
		2.2 upsetting is used			
		2.3 Heading is used			
3.	Hot forging process is applied effectively according	3.1 Heating is applied			
		3.2. forming is applied			
		3.3.compressing is applied			
		3.4cooling is applied			
		3.5 trimming and finishing are applied			



Learning outcome 3 end assessment

Written assessment

1. Complete the table below, in column A by **Upsetting, Extraction, and Heading** as hot forging techniques to their correct meaning in column B as used in forging operation.

column A. Hot forging techniques	column B. Corresponding meaning
1.....	A. It is the techniques of forming the end of a cylindrical work piece into a specific shape, such as a bolt head or a rounded end, at elevated temperatures
2.....	B. It is known as piercing or punching, is a hot forging technique used to create holes or openings in the work piece.
3.....	C. It is used to increase the cross-sectional area (diameter) of a work piece by shortening its length through compression.

ANSWER:

Hot forging techniques	Corresponding meaning
1..Heading	A. It is the techniques of forming the end of a cylindrical work piece into a specific shape, such as a bolt head or a rounded end, at elevated temperatures
2. Extraction.	B. It is known as piercing or punching, is a hot forging technique used to create holes or openings in the work piece.
3. Upsetting.	C. It is used to increase the cross-sectional area (diameter) of a work piece by shortening its length through compression.

2. Read carefully the following sequence for hot forging process and Encircle the letter corresponding to the correct sequence order as used in hot forging operation;

- a) Trimming and finishing, Heating, forming, compression, cooling,
- b) Compression, cooling, Heating, forming, trimming and finishing.

- c) Heating, forming, compression, cooling, trimming and finishing.
- d) Sequence A and B are correct
- e) No correct sequence order

ANSWER: C

Practical assessment

Your trainees are newly hired technicians in a metal forging workshop. Their supervisor has assigned them to manufacture a high-strength crankshaft for a customer using the hot forging process. Ask them to perform the following tasks:

1. Select a cylindrical mild steel bar (50 mm diameter, 200 mm length) and heat it to 1,200°C furnace.
2. Using heat-resistant tongs, transfer the heated workpiece to the pre-heated forging die and Position it properly in the die cavity that matches the crankshaft's design.
3. Operate the hydraulic forging press to apply controlled compressive force to shape the metal.
4. Allow the forged part to cool naturally in air on the designated cooling rack.
5. Trim the flash (excess material) using the trimming press or grinder.

Checklist

S/N	Criteria	Indicators	Score		Comments
			Yes (1)	No (0)	
1.	Material Selection	Correct workpiece material (mild steel, 50 mm diameter, 200 mm length) chosen			
		Workpiece inspected for defects before starting (e.g., cracks, surface flaws)			
2.	Heating Process	Furnace temperature set to 1,200°C and maintained consistently			
		Workpiece evenly heated to achieve uniform orange glow			
		Thermocouple used to monitor and confirm heating temperature			
3	Forming Process	Pre-heated forging die used to minimize heat loss during forming			
		Workpiece positioned correctly in the die cavity			
		Material flows evenly into all die cavities during pressing			

4.	Compression	Hydraulic press operated at correct force for shaping the workpiece			
		Multiple pressing cycles applied if needed for complete forming			
		Grain alignment achieved to enhance strength			
5.	Cooling Process	Workpiece cooled uniformly in air without warping			
		Cooling area free of obstructions or uneven cooling sources			
6.	Finishing Process	Flash trimmed neatly with minimal material waste			
		Finished workpiece inspected for defects (e.g., cracks, distortions)			
		Dimensions and tolerances meet design specifications			
		Surface finish meets quality requirements			



Further information to the trainer

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Learning Outcome 4: Carry out Finishing Activities



Indicative contents

4.1 Applying finishing techniques

4.2 Applying protection techniques on product

4.3 Applying storage techniques

4.4 Reporting the work done

Key Competencies for Learning Outcome 4 : Carry out Finishing Activities

Knowledge	Skills	Attitudes
• Description of finishing techniques • Description of protection techniques on the product • Description of methods/ways of report.	• Applying finishing technics • Protecting the product (workpiece) with coating, inhibitors, and lubrication. • Protecting the product (workpiece) with sealant and adhesives, wrapping and packaging, electroplating and Anodizing • Storing the workpiece with shelving and hugging. • Making a report using the template.	• Paying attention during products finishing • Paying attention on hot surface • Using PPE while perform finishing on the product • Having precision while heating and workpiece



Duration: 10 hrs.



Learning outcome 4 objectives:

By the end of the learning outcome, the trainees will be able to:

1. Store correctly product by using different methods of storing.
2. Protect properly product according to the protection techniques
3. Report effectively in accordance with report Procedures.
4. Clean Correctly the workplace according to the cleaning method



Resources

Equipment	Tools	Materials
• Firefighting equipment • First Aid Kit • Grinders • Buffing • Paints Sprayers	• Paint • File • Dust bin • Wire brush • Flexible brush • Brooms • Hammers • Chisels • Tongs • Gloves	• Papers • sand paper • grinding disc • Soap • Water • Cloths lags • Dust masks

Advance Preparation:

Before delivering this learning outcome, you are recommended to:

- Have sample videos which demonstrate finishing techniques.
- Disorganized workshop with materials, tools, and equipment.
- Have sample images which showcase well stored tools and equipment
- Have samples of report.
- Avail materials apply protection techniques.



Indicative content 4.1: Applying Finishing Techniques.



Duration: 3 hrs.



Theoretical Activity 4.1.1: Description of finishing techniques



Notes to the trainer:

- This activity can be individual based; you are supposed to demonstrate how to apply surface finish technique; it is recommended to:
 - Avail a manufacturing workshop which is arranged
 - Avail final product I to be used for surface finish



Key steps:

While delivering this activity, pass through the following steps:

- Step 1:** Introduce the activities and ask trainees to answer the following questions:
- i. What do you understand by the following finishing techniques: trimming, grinding, polishing, sanding, brushing engraving and painting used in hot forging work piece?
- Step 2:** Ask trainees to write the findings on the paper, flip chart blackboard or whiteboard
- Step 3:** Facilitate to trainees to present their findings and choose the correct answers
- Step 4:** provide the expert view and clarify ideas by using didactic materials
- Step 5:** Address any question or concerns
- Step 6:** Ask trainees to read key reading 4.1.1 in trainee manual.



Points to Remember

- By covering these points, ensure to provide a comprehensive understanding that effectively wraps up (summarize) the evaluation of finishing techniques for hot forging work piece.



Practical Activity 4.1.2: Performing finishing techniques



Notes to the trainer

- Trainer may use the workshop to guide trainees on how to trim, grind, polish, sand, brush, engrave and paint. It is recommended to:
- Avail safe workshop
- Avail work piece to use.



Key steps:

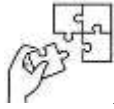
While delivering this activity, pass through the following steps:

- Step 1:** Introduce the activities and ask trainees to go in manufacturing workshop and perform Trim, grind, polish, sand, brush, engrave and paint the work piece
- Step 2:** Explain the task and provide clear work instructions (PPE, Time allocated)
- Step 3:** Demonstrate hot forging work piece by using Trim, grind, polish, sand, brush, engrave and paint. While demonstrating; explain the procedure
- Step 4:** Engage trainees to perform hot work piece using Trim, grind, polish, sand, and brush, engrave and paint. Provide additional clarification where necessary
- Step 5:** Evaluate whether trimming, grinding, polishing, sanding, and brushing, engrave and painting is effectively done on hot work piece.
- Step 6:** Ask trainees to read the key reading 2.1.1 in trainee manual.
- Step 7:** Ask trainees to perform the task provided in application of learning 4.1



Points to Remember

- While trimming, grinding, polishing, sanding, brushing and painting as techniques used to finish up the work piece be caution and precision. Unless, you will destroy your work piece.



Application of learning 4.1.

Request trainees to go in forging workshop at your school and perform grinding, sanding, trimming, and polishing finishing techniques on product

Checklist

S/N	Criteria	Indicators	Score		Comments
			Yes (1)	No (0)	
1.	Safety measures are effectively applied according to the finishing techniques.	1.1 Overall are worn			
		1.2 Safety shoes are worn			
		1.3 Safety glasses are worn			
		1.4 Gloves are worn			
2.	The finishing techniques are effectively applied according to the steel shaft	2.1. shaft trim is well-applied			
		2.2 Grinding is well applied			
		2.3 polishing is well applied			
		2.4 sanding is applied			
		2.5. Painting is applied			



Indicative content 4.2: Applying Protection Techniques on Product



Duration : 3 hrs



Theoretical Activity 4.2.1: Description of protection techniques on the product



Notes to the trainer:

- Trainer may use the workshop to guide trainees on how to protect finished products from hot forging.
- Avail safe workshop
- Avail non protected work piece in the workshop.
- Prepare group work



Key steps:

While delivering this activity, pass through the following steps:

Step 1: Introduce the topic of the session and reflect on the following questions.

- iv. What do you understand by these protection techniques as used on finished product?
 - a. Coatings
 - b. Sealants and adhesives
 - c. Rust inhibitors
 - d. Protective wrapping and packaging
 - e. Lubrication
 - f. Corrosion inhibitors
 - g. Electroplating
 - h. Anodizing

Step 2: Engage trainees in presentation of their findings.

Step 3: Provide expert view on presentations of the groups.

Step 4: Address any questions or concerns to trainees.



Points to Remember

- By keeping these techniques in mind, you can effectively protect work piece by enhancing their efficiency and quality while ensuring safety and cost-effectiveness.



Practical Activity 4.2.2: Performing protection of the product /work piece with coating, inhibitors



Notes to the trainer

- Trainer may use the workshop to guide trainees on how Protect the product /work piece with coating, inhibitors and lubrication.
- Avail safe workshop
- Avail unprotected products /work piece.



Key steps:

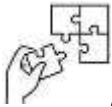
While delivering this activity, pass through the following steps:

- Step 1:** Introduce the activities and ask trainees to go in manufacturing workshop and protect the product /work piece with coating, inhibitors and lubrication
- Step 2:** Explain the task and provide clear work instructions (PPE, Time allocated)
- Step 3:** Demonstrate work piece protection with coating, inhibitors and lubrication. While demonstrating; explain the procedure
- Step 4:** Ask to trainees to protect the product /work piece with coating, inhibitors and lubrication. Provide additional clarification where necessary
- Step 5:** Evaluate whether the activity of work piece protection by using coating, inhibitors and lubrication is effectively done
- Step 6:** Ask trainees to read the key reading 4.2.2 in trainee manual.
- Step 7:** Ask trainees to perform the task provided in application of learning 4.2



Points to Remember

- Consider to protect work piece with Coatings, Rust/corrosion inhibitors, and Lubrication, protective wrapping and packaging, electroplating and anodizing as used for hot forging the products.



Application of learning 4.2.

Assign your trainees to go in forging workshop to protect the work piece by applying coating, inhibitors, electroplating and anodizing by following production management instructions.

Checklist

S/N	Criteria	Indicators	Score		Comments
			Yes (1)	No (0)	
1.	Safety measures are effectively applied according to the machine lubrication and cleaning	1.1 Overall are worn			
		1.2 Safety shoes are worn			
		1.3 Safety glasses are worn			
		1.4 Gloves are worn			
	Protection techniques are applied according to hot-forged steel gears.	2.1. Coating is applied			
		2.2 sealant and adhesives			
		2.3 rust inhibitor is applied			
		2.4 wrap and package is applied			
		2.5 Lubrication is applied			
		2.6 Electroplating is applied			
		2.7 Anodizing is applied			



Indicative content 4.3: Applying Storage Techniques



Duration : 2 hrs



Practical Activity 4.3.1: Applying storing techniques.



Notes to the trainer

As trainer, you may conduct this session in forging workshop and store where you are requested to guide trainees on how to Store the work piece using shelving and hugging.

- i. Prepare work pieces in the workshop to arrange.
- ii. Avail clean and dry workshop's place for storage.



Key steps:

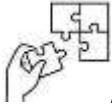
While delivering this activity, pass through the following steps:

- Step 1:** Introduce the topic and ask trainees to do the task described below:
By referring to the previous activity 4.3.1, you are requested to go to a manufacturing workshop to Store the work piece using shelving and hugging with respect to the trainer's instructions.
- Step 2:** Explain the task and provide clear work instruction (Task, PPE, Time allocated).
- Step 3:** Demonstrate how to Store the work piece using shelving and hugging. While demonstrating, explain storing techniques.
- Step 4:** Ask trainees to Store the work piece using shelving and hugging.
- Step 5:** Verify whether Storage of the work piece using shelving and hugging are properly stored and provide support where necessary.
- Step 6:** Ask trainees to read key reading 4.3.1.
- Step 7:** Ask trainees to perform the task provided in application of learning 4.3



Points to Remember

- While storing forged work piece take into consideration shelving and hanging as crucial techniques for hot forging to improve the inventory /workshop control.



Application of learning 4.3.

In forging workshop at your school, ask trainees to store forged products by passing through the following procedures:

- I. Shelving
- II. Arranging
- III. Hanging

Checklist

SN	Criteria	Indicators	Yes	No
1	Moulding box and pattern are properly stored according to work place guidelines	Forged product are hung		
		Forged product are arranged		
		Forged product are shelved		



Indicative content 4.4: Reporting the Work Done



Duration : 2 hrs



Theoretical Activity 4.4.1: Description of methods/ways of report.



Notes to the trainer:

- i. Avail sample of report template
- ii. Avail manuals, guide, video and photos as didactic materials of ways of reporting.



Key steps:

While delivering this activity, pass through the following steps:

- Step 1:** Introduce the activities and ask trainees to answer the following questions:
- ii. What do you understand by written and verbal report used for reporting the work done?
- Step 2:** Ask trainees to write the findings on the paper, flip chart blackboard or whiteboard
- Step 3:** Facilitate to trainees to present their findings and choose the correct answers
- Step 4:** provide the expert view and clarify ideas by using didactic materials
- Step 5:** Address any question or concerns
- Step 6:** Ask trainees to read key reading 4.4.1. In trainee manual.



Points to Remember

- A work report is a simple and cohesive document that outlines the fundamental activities and tasks conducted by an employee



Practical Activity 4.4.2: Making a technical report



Notes to the trainer

- As a trainer, you are requested to demonstrate trainees step-by-step on how to report finishing work activities
- Prepare individualized work to trainees
- Use some templates for more explanations



Key steps:

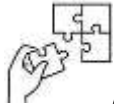
While delivering this activity, pass through the following steps:

- Step 1:** Introduce the activities and ask trainees to go in manufacturing workshop and make technical a report
- Step 2:** Explain the task and provide clear work instructions
- Step 3:** Demonstrate how to make technical report using appropriate template. While demonstrating; explain the procedure
- Step 4:** Ask to trainees to make technical report using appropriate template and provide additional clarification where necessary
- Step 5:** Evaluate whether making a technical report is effectively done, using appropriate template.
- Step 6:** Ask trainees to read the key reading 4.4.2 in trainee manual.
- Step 7:** Ask trainees to perform the task provided in the application of learning 4.4.



Points to Remember

- While reporting the work done ensure that the report is comprehensive, well-organized, and useful for future.
- While writing a report has several advantages, including documentation, communication, and quality control, it also has disadvantages such as time consumption, potential for errors, and documentation fatigue.



Application of learning 4.4.

Request trainees to visit forging workshop near to your school which is performing forging operation on mild steel and make a report on that activities

Check list

SN	Criteria	Indicators	Yes	No
1	1. Report is properly generated according to the work done	1. Purpose is defined		
		2. Information is gathered		
		3. Data organized		
		4. Draft is written		
		5. Report is finalized		
		6. Report is Proof readied		
		7. Report Submitted		



Learning outcome 4 end assessment

Written assessment

1. Read carefully the following statement related for forging operation and Encircle the letter corresponding to the correct answer.

- I. The list below are the finishing techniques applied on the work piece **Except**;
- a) Trimming
 - b) Grinding
 - c) Polishing
 - d) Anodizing

ANSWER: D

- II. protection techniques applied on the finished product. Are:

- A. Coatings
- B. Sealants and adhesives
- C. Rust inhibitors
- D. Protective wrapping and packaging
- E. Lubrication
- F. All the above are correct
- G. No answer

ANSWER: F

2. Observe carefully the following table of the storage techniques and Match the column A. storage techniques on the work piece to their correct meaning in column B and write the letter corresponding to the right answer in column of answers

Answer	Column A (storage techniques)	Column B (meaning)
1.....	1.Hanging	A.It is a popular storage method for forged products. It involves using shelves or racks to store the components in an organized and easily accessible
2.....	2. Shelving	B. This method is beneficial for products that must be kept upright or have delicate or intricate features that must be protected.

ANSWER: 1-B; 2-A

3. Read carefully the following statements related on the report of work done on the finished work piece and Answer the by **true** if the statement is correct or **false** if the statement is incorrect.
- a) A written report should include an introduction, body, and conclusion.
 - b) Written reports should be concise and to the point, avoiding unnecessary details
 - c) Verbal reports are typically used when immediate feedback is needed or when discussing complex issues that require clarification
 - d) Verbal reports are always more formal than written reports

ANSWER:

- a) **True**
- b) **True**
- c) **True**
- d) **False**

Practical assessment

SPNP company ltd located in Kirehe district is the company that forge different products to be used in engineering activities. They got a tender of forging 10 sledge hammers to break stones for building houses of DGH company ltd, which needs to increase the quantities of sledge hammers in stock to overcome the delaying of company activities.

As experienced blacksmith, you are requested to forge only one sledgehammer by performing all forging operations required for a sample within 4 hours.

The forged sledge hammer has the following specifications

- 1. Material for the sledge hammer is steel
- 2. Weight =10kg

All resources are available in the workshop of SPNP company workshop.



Checklist

S/N	Criteria	Indicators	Score		Comments
			Yes (1)	No (0)	
1.Prepare workplace for forging	Worksite is properly organized according to the work to be done	1.1 Hazardous materials are removed			
		1.2 Workplace is cleaned			
		1.3 Workplace items are arranged			
	Tools, materials, and equipment are properly selected according to the work specifications	1.4 Tools are selected			
		1.5 Materials are selected			
		1.6 Equipment is selected			
	Safety practices are properly applied work requirements	1.7 PPEs are worn			
		1.8.Safety sign are marked			
2.Carry out cold and hot forging	Work piece is correctly cut based on the work specification	2.1. Work piece is marked			
		2.2.Work piece is measured			
		2.3. Work piece is correctly clamped for cutting			
		2.4. Work piece is cut			
	Work piece is conveniently clamped	2.5.Workpiece is clamped for forging			

	basing on their methods				
	Work piece is correctly heated according to the required temperature	2.6. Work piece is correctly heated			
	Hot Forging techniques are correctly applied according to job specification	2.7. Workpiece is hold for forging			
		2.8. The work piece is appropriately forged			
		2.9. The product is treated			
3. Perform forging finishing activities	Surface finishing techniques are properly applied according to product material	3.1. Product is grinded			
		3.2. Product is polished			
		3.3. Product is coated			
	Product is conveniently Protected according to nature of material	Product is labelled			
	Work place is properly cleaned and materials stored according to workshop guidelines	3.3. Tools and equipment are cleaned			
		3.4. Tools and equipment are arranged			
		3.5. Wastes are disposed			
		3.6. Report is done			

	Report is properly elaborated according to the work done	3.7.All elements are indicated			
		3.8.Format is respected			

END



Further information to the trainer

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