RQF LEVEL 5

MATMO501

MANUFACTURING TECHNOLOGY

Milling Machine Operations

TRAINER'S MANUAL

October, 2024

MILLING MACHINE OPERATIONS

KOICA Korea International Cooperation Agency

TQUM TVET Quality Management Project

2024

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TABLE OF CONTENT

ACRONYMS

2D: Two Dimension

3D: Three Dimension

ADOC: Axial Depth Of Cut

CBT: Competency-Based Training

CMM: Coordinate Measuring Machine

CNC: Computer Numerical Control

DOC: Depth Of Cut

Ft: Feed Per Tooth

HQ: Head Quarter

IC: Indicative Content

KOICA: Korea International Coperative Agency

LED: Light Emitting Diode

LO: Learning Outcome

MAT: Manufacturing Technology

MO: Milling Operation

MRR: Material Remove Rate

PPEs: Personal Protective Equipment's

PVD: Physical Vapor Deposition

RDOC: Radial Depth Of Cut

RPM: Revolutions Per minutes

RQF: Rwanda qualification forum

RTB: Rwanda Tvet Board

TQUM: Tvet Quality Management Project

UV: Ultra Violet rays

VOCs: Volatile Organic Compounds

INTRODUCTION

This trainer's manual includes all the methodologies required to effectively deliver the module titled **"Milling Machine Operations."** Trainees 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 trainees 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: MATMO501 MILLING MACHINE OPERATIONS

Learning Outcome 1: Organize the workplace
Learning Outcome 2: Set the milling machine
Learning Outcome 3: Mill the workpiece


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PACIFIC


FIRE

Indicative contents
1.1 Introduction to Milling machine operation
1.2 Controlling Hazards
1.3 Interpreting product drawing
1.4 Preparing Materials, tools, attachments and accessories and equipment

Key Competencies for Learning Outcome 1: Organize the Workplace

Knowledge	Skills	Attitudes
• Definition of key terms used in milling machine operation • Description of milling machine • Identification of safety and security measures used in milling machine operation • Identification of milling machine accessories and equipment	• Controlling hazard while organizing workplace for milling machine operations • Interpreting product drawing before milling machine operations • Selecting materials, tools, equipment and attachments	• Having time management while preparing workplace for milling machine operations • Have self-confidence while organizing workplace for milling machine operations • Having a critical thinking while organizing workplace for milling machine operations • Working as team while organizing work place for milling operations

Duration: 15 hrs

Learning outcome 1 objectives:

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

1. Define correctly the key terms used in milling machine operation.
2. Describe properly milling machine found in manufacturing technology.
3. Identify properly safety and security measures applied for milling machine operation.
4. Apply effectively safety and security measures required in milling machine operation.
5. Interpret correctly product drawing to be produced on milling machine.
6. Describe properly materials, tools, accessories and attachments to be used in milling machine operations.
7. Select properly materials, tools, accessories and attachments to be used in milling machine operations.

Resources

Equipment	Tools	Materials
● Plain milling machine ● Universal milling machine ● Vertical milling machine Fixed bed type milling machine ● Ram type milling, Turret type milling - Planer Type milling ● Special type milling machine	● Computer ● Pain milling tools ● Face milling tools ● Side milling tools ● Straddle milling tools ● Angular milling tools ● Gang milling tools ● Form milling tools ● End milling tools ● Key way milling tools ● Drilling and reaming tools	● Steel bar ● Cutting fluid/coolant ● Cloth rugs

• Table type milling machine • Gloves • Safety Boots • Safety glasses • overall • Fire extinguisher • Air compressor • Dust pan	• Boring tools • Gear cutting tools • Flute milling tools • Thread milling tools • Cam milling tool • Thread Gauge • Oil Level Tester • Allen keys • Spanner • Drilling tools • inserts • Steel ruler • Vernier calliper • Micro-meter • Dial indicator	

Advance Preparation:

Before delivering this learning outcome, you are recommended to:

- Avail of video and/or photo showing an organized workshop for milling operations
- Avail an manufacturing workshop
- Avail Drawings of work piece to be milled
- Have photos, images or illustrations of different Milling machines
- Avail Safety equipment, sign and symbols

Indicative content 1.1: Introduction to Milling machine operation

Duration: 6 hrs

Theoretical Activity 1.1.1: Description of milling machine

Notes to the trainer:

- While delivering this content, small group can be used for describing milling machine operations.
- The use of images, videos, and illustrations of different milling machines as didactic materials

Key steps:

While delivering this activity, pass through the following steps:

Step 1: Introduce the activity, and ask trainees to answer the following questions relat ed to milling machine description:

i. What do you understand by the following terms:
   a) Milling machine
   b) Feed rate
   c) Table
   d) feed
   e) Spindle speed
   f) Depth of cut
   g) Tool path
   h) Milling cutter
   i) Indexing head
   j) Indexing plate

ii. What should be the typese of milling machne and their components

iii. What could be the working principle of milling machine?

Step 2: Ask trainee to write provided answers on flipcharts/papers

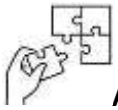
Step 3: Engage trainees in presentation of their findings

Step 4: Address any questions or concerns.

Step 5: Ask trainees to read the key reading 1.1.1. in trainee manual for more clarification

Points to Remember

- Always wear proper PPE, including safety glasses, hearing protection, and steel-toe shoes.
- Ensure all machine guards, emergency stops, and interlock systems are functional.
- Operate the machine only if trained and perform pre-operation checks before use.



Application of learning 1.1

Organize a visit to a local machining workshop for trainees and ask them to describe milling machine found in the place with refererring to it's working principles and their applications.

Checklist:

SN	Criteria	Indicators	Yes	No
1.	Milling machine is well described	1.1. Applications of milling machine are described		
		1.2: key terms of milling machine are defined		
		1.3 working princples of milling machine are described		

Indicative content 1.2: Controlling Hazards

Duration: 3 hrs

Practical Activity 1.2.1 : Applying safety and security measures

Notes to the trainer

- This activity should take place in workshop where you are supposed to demonstrate trainees how to apply safety and security measures, required for milling machine operation and ask trainees to perform the similar by facilitate them individually.
- You are recommended to avail of needed tools, materials and equipment required for applying safety and security measures

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:
you are requested to go to the workshop to apply safety and security measures required for milling machine operations according to the work to performed

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

Step 3: Demonstrate how to apply safety and security measures during milling machine operations

Step 4: Asks trainees to apply safety and security measures as required in milling machine operation.

Step 5: Verify whether safety and security measures required in milling machine operation are correctly applied and provide support where necessary.

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

- By keeping these key points of controlling hazards in mind and actively implementing safety, and security measures, you can ensure a safe and efficient milling machine operation environment.

Practical Activity 1.2.2: Applying 5S principles

Notes to the trainer

- This activity should take place in workshop where you are supposed to demonstrate trainees how to apply 5S principles, required for milling machine operation and ask trainees to perform the similar by facilitate them individually.
- You are recommended to avail of needed tools, materials and equipment required for applying 5S principles

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:

you are requested to go to the workshop to apply 5S principles required for milling machine operations according to the work to performed

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

Step 3: Demonstrate how to apply 5S principles during milling machine operations

Step 4: Ask trainees to apply 5S principles as required in milling machine operation.

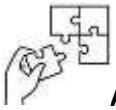
Step 5: Verify whether 5Sprinciples required in milling machine operation are correctly applied and provide support where necessary.

Step 6: Ask trainees to read key reading 1.2.2. in trainee manual

Step 7: Ask trainees to perform the task provided in application of learning 1.2

Points to Remember

- By following the steps of 5S principles, organizations can create a more organized, efficient, and safe work environment of milling machine operations.



Application of learning 1.2

Ask your trainees to go to manufacturing workshop and perform the following tasks:

a) Applying safety and security measures used milling operation

b) apply 5S principles on milling operation

Check list

SN	Criteria	Indicators	Yes	No
1	Safety and security measures are well applied	1.1. Safety sign are interpreted		
		1.2. Safety sign are applied		
		1.3. Safety symbols are applied		
		1.4. Security measures are taken		
2	5S principles are well applied	2.1. Sort is applied		
		2.2. Set in order is applied		
		2.3. Shine is applied		
		2.4. Standardize is applied		
		2.5. Sustain is applied		

Indicative content 1.3: Interpreting Product Drawing

Duration: 3 hrs

Practical Activity 1.3.1: Interpreting product drawing during milling machine

Notes to the trainer

- This activity should take place in drawing workplace where you are supposed to demonstrate trainees how to interpreting product drawing require for milling machine operations and ask trainees to perform the similar by facilitate them individually.
- You are recommended to avail all needed tools, materials and equipment required for interpreting product drawing during milling machine operations

Key steps:

While delivering this activity, pass through the following steps:

Step 1: Introduce the activities and ask trainees to do the task described below:

you are requested to go to the drawing workplace and interpreting product drawing required for milling machine operations according to the work to performed

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

Step 3: Demonstrate how to interpreting product drawing during milling machine operations by reading the product annotations

Step 4: Asks trainees to interpreting product drawing as required in milling machine operation.

Step 5: Verify whether product drawing required in milling machine operation are correctly applied and provide support where necessary.

Step 6: Ask trainees to read key reading 1.3.1.

Step 7: Ask trainees to perform the task provided in application of learning 1.3.

Points to Remember

- Understand machining symbols, lines, and views to accurately interpret product drawings.
- Focus on key views and precise dimensions to ensure clarity and avoid over-dimensioning.
- Follow assembly drawings and notes for proper component fitting and machining compliance

Application of learning 1.3.

Ask your trainees to go the drawing workplace and provide product drawing to be performed on milling machine then ask them to interpret the provided product drawing by Reading product drawing annotations include machining drawing symbols, work drawing views, work drawing dimensions tolerances and work drawing assembly.

Check list

SN	Criteria	Indicators	Yes	No
1	Provide product drawing is properly interpreted	1.1. Machining drawing symbols are interpreted		
		1.2. Work drawing views are interpreted		
		1.3. Work drawing dimensions tolerances are shown		
		1.4. Work drawing assembly are shown		

Indicative content 1.4: Preparing Materials, Tools, Attachments and Accessories and Equipment

Duration: 3 hrs

Theoretical Activity 1.4.1: Identify milling machine accessories and equipment

Notes to the trainer:

- While delivering this content, small group can be used for identifying milling machine accessories and equipment.
- The use of images, videos, and illustrations as didactic materials is required for more clarifications.

Key steps:

While delivering this activity, pass through the following steps:

Step 1: Introduce the activity, and ask trainees to answer the following questions related to identification of milling machine accessories and equipment:

:

i. What do you understand by the following accessories used for milling machine operations:
   a) Cutter holding device
   b) Work holding devices
   c) Chip guards and
   d) Coolant system

ii. What should be the types of milling machine equipment

iii. What should be the factors for selecting milling equipment

Step 2: Ask trainee to write provided answers on flipcharts/papers

Step 3: Engage trainees in presentation of their findings and discuss on provided answers.

Step 4: Address any questions or concerns.

Step 5: For more clarification read the key reading 1.4.1. in trainee manual and ask clarification if necessary

Points to Remember

- While identifying milling machine accessories and equipment remember that it is necessary to classify the types of milling machine.
- It is also necessary to know the factors for selecting milling equipment

Practical Activity 1.4.2: Selecting milling materials and tools

Notes to the trainer

- This activity should take place in drawing workshop where you are supposed to demonstrate trainees how to select materials and tools used for milling machine operations and ask trainees to perform the similar by facilitate them individually.
- You are recommended to avail all needed tools and materials required

Key steps:

While delivering this activity, pass through the following steps:

Step 1: Introduce the activities and ask trainees to do the task described below:

you are requested to go to the workshop then select materials and tools used for milling machine operations according to the work to performed

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

Step 3: Demonstrate how to select materials and tools for milling machine operations

Step 4: Asks trainees to select materials and tools as required in milling machine operations.

Step 5: Verify whether the select materials and tools required in milling machine operation are correctly selected and provide support where necessary.

Step 6: Ask trainees to read key reading 1.4.1.

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

Points to Remember

- In a workshop setting where milling machine operations are performed, the selection of materials and tools will depend on the specific work to be carried out

Practical Activity 1.4.2: Selecting milling equipment

Notes to the trainer

- This activity should take place in manufacturing workshop where you are supposed to demonstrate trainees how to select milling machine attachments used for milling machine operations and ask trainees to perform the similar by facilitate them individually.
- You are recommended to avail all milling machine attachments

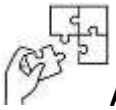
Key steps:

While delivering this activity, pass through the following steps:

Step 1: Introduce the activities and ask trainees to go to the manufacturing workshop and select equipmentcting to be used for milling machine operations according to the work to performed
Step 2: Explain the task and provide clear work instruction (Task, PPE, Time allocated).
Step 3: Demonstrate how to select attachment to be used for milling machine operations
Step 4: Asks trainees to select attachment required in milling machine operations.
Step 5: Verify whether the attachment are selected and provide support where necessary.
Step 6: Ask trainees to read key reading 1.4.2.
Step 7: Ask trainees to perform the task provided in application of learning 1.4

Points to Remember

- We select attachments for milling machine operations based on the work to be performed, it is essential to consider the specific requirements of the job to be performed



Application of learning 1.4.

With referring to the practical Activity 1.4.2 take the trainees in the manufacturing workshop where there are mixed tools , materials and attachment of different manufacturing machine (lather attachment, milling attachment, CNC) attachment and then ask them to perform the following:

1. Select the following milling machine attachment vertical head , horizontal head,indexing head attachment,offset boring head,vertical spindle attachment,universal attachment, circular attachment,slotting attachment,high speed attachment and rack attachment.
2. Select milling materials and milling.

Check list

SN	Criteria	Indicators	Yes	No
1.	Select properly attachment to be used for milling machine	1.1. Vertical head are selected		
		1.2. Horizontal head are selected		
		1.3. Indexing head attachment are selected		
		1.4. Offset boring head are selected		
		1.5. Vertical spindle attachment are selected		
		1.6.Universal attachment are selected		
		1.7.Circular attachment are selected		
		1.8.Slotting attachment are selected		
		1.9.High speed attachment are selected		
		1.10. Rack attachment are selected		
2.	Select properly materials and tools to be used for milling machine	2.1. Milling tools are selected		
		2.2. Milling materials are selected		

Learning outcome 1 end assessment

Theoretical assessment

Q1. Read carefully the following statement concerning the description of milling machine and answer by **True** if the statement is correct or **False** if the statement is wrong.

a) Milling machine is a machine which removes material from the machine by rotating a cutting tool (cutter) and moving it into the work piece. **Answer: False**

b) Milling machine is a machine which removes material from a work piece by rotating a cutting tool (cutter) and moving it into the work piece . **Answer: True**

c) Feed rate is simply the distance the tool travels during one revolution of the part. **Answer: True**

d) Spindle speed is the rotational speed of the cutting tool. It is usually measured in revolutions per minute (RPM) or surface feet per minute (SFM). **Answer: True**

e) In the machining process, depth of cut is simply how deep the cutting tool gets into a machine and cuts through it to create a chip. **Answer: False**

Q2. Ready the following statetment related to milling machine tools ,materials, attachment and equipment and choose the correct answer by encircling the corresponding letter

I. Which one of the following is a real meaning of milling cutters among the followings by writing the letter corresponding to the answer ?

a) Tools typically used in milling machines or machining centres to perform milling operations (and occasionally in other machine tools).

b) Equipment typically used in milling machines or machining centres to perform milling operations (and occasionally in other machine tools).

c) Material typically used in milling machines or machining centres to perform milling operations (and occasionally in other machine tools).

d) Attachment typically used in milling machines or machining centres to perform milling operations (and occasionally in other machine tools).

Answer: a)

II. The following are the components of milling machine **except**

a) Column and Base

b) Saddle and Swivel Table

c) Power source mechanic

d) Table

Answer: c) Power source mechanic

III. The following are common types of milling machine used in manufacturing workshops except

a) Vertical milling machine:
b) Horizontal milling machine
c) Universal milling machine
d) Drilling machine

Answer: d) Drilling machine

IV. The following are the applications of milling machine **except**

a) Gear Cutting
b) Gear painting
c) Thread milling
d) Milling T-slots

Answer: b) Gear painting

Q3. Read carefully the meaning of 5S principles in column **A** and match them to their corresponding 5S in column B then put the answer in provide column of answers.

Answers	**Column A**	**Column B**
....G...	1. Develop and implement standards for maintaining workspace organization.	A. Sort
....C...	2. Clean the workspace thoroughly to identify defects and maintain a pleasant environment.	B. **Select**
....D...	3. Arrange necessary items for easy access and use, creating visual management systems.	C. Shine
...E...	4. Create a habit of following procedures and promoting continuous improvement.	D. Set in Order
...A...	5. Separate necessary items from unnecessary ones and remove the latter from the work area.	E. Sustain
		F. Section
		G. Standardize

Practical assessment

KANYANA Machining company has won a tender from Car Furniture Company Ltd to manufacture the gears. Due to long holdays, workshop is not well organized. request trainees to prepare the workshop by applying the 5S principles and preparing the tools, materials and equipment to be used in manufacturing of that gears.

All needed tools, materials, attachment, accessories and equipment are available in workshop of KANYANA Machining Company.

Check list

SN	Criteria	Indicators	Yes	No
1	5S principles are properly applied	1.1. Sort is applied		
		1.2. Set in Order is applied		
		1.3. Shine is applied		
		1.4. Standardize is applied		
		1.5. Sustain is applied		
2	Tools, materials and equipment are properly selected according to the work to be done	2.1. Tools are selected		
		2.2. Materials are selected		
		3.3. Equipment are selected		

Further information to the trainer

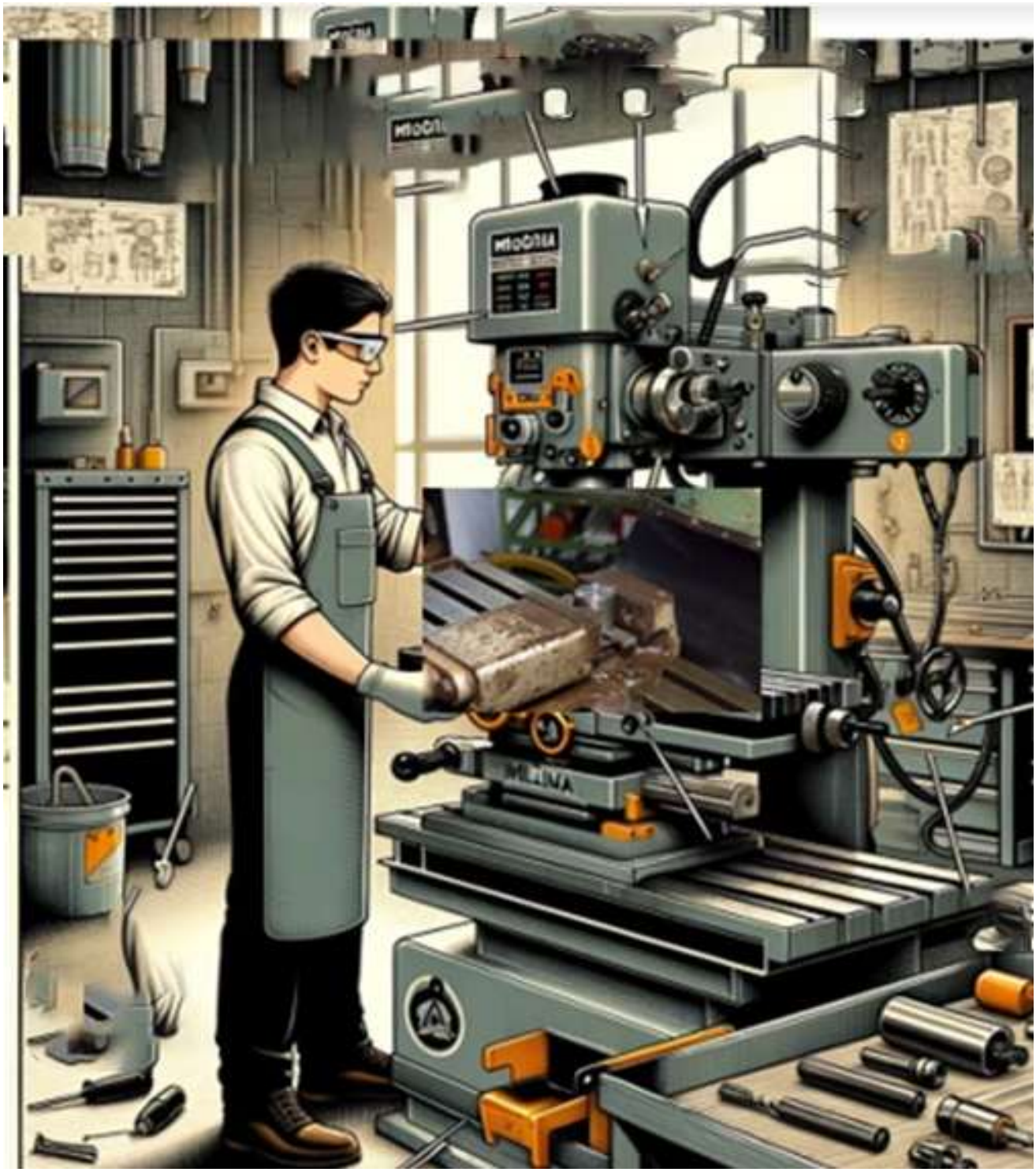
Audel Machine Shop Tools and Operations, All New 5th Edition" by Rex Miller and Mark Richard Miller, **ISBN**: 978-0764555275, Wiley Publishing, 2004

Choudhury and A.K. Hajra Choudhury, **ISBN**: 978-8185099149, Media Promoters & Publishers Pvt. Ltd.

Elements of Workshop Technology, Volume 1: Manufacturing Processes" by S.K. Hajra

Elements of Workshop Technology, Volume 2: Machine Tools" by S.K. Hajra Choudhury and A.K. Hajra Choudhury, **ISBN**: 978-8185099156, Media Promoters & Publishers Pvt. Ltd

Machining Fundamentals" by John R. Walker, **ISBN**: 978-1635638776, Goodheart-Willcox



Indicative contents

2.1 Setting mechanical components

2.2 Adjusting parameters for milling operation

2.3 Mounting the work piece in milling machine

Key Competencies for Learning Outcome 2: Set the Milling Machine

Knowledge	Skills	Attitudes
• Identification of factors that determine the spindle speed adjustment • Identification of factors that determine milling feed adjustment • Identification of factors that determine depth of cut adjustment	• Mounting cutter holding devices and mill cutters on milling machine • Set up work holding device while operating milling machine. • Apply Indexing methods while operating milling machine • Adjusting parameters for milling operations • Selecting work holding methods while operating milling machine operations • Applying Procedures of mounting work piece on milling machine operations	• Working on time while mounting cutters on milling machine • Working in team while operating milling machine operations • Having self-confidence while setting the milling machine • Being attentive while setting milling machine operations • Respect workshop rules and regulations while setting milling machine

Duration: 35 hrs

Learning outcome 2 objectives:

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

1. Mounting correctly milling cutters holding devices and mill cutters on milling machine
2. Set properly work holding device on milling machine .
3. Apply properly Indexing methods while operating milling machine
4. Adjust efficiently parameters for milling operations
5. Select correctly work holding on milling machine operations
6. Apply correctly procedures of mounting work piece on milling machine.

Resources

Equipment	Tools	Materials
• Plain milling • machine • Universal milling machine • Vertical milling machine Fixed bed type milling machine • Ram type milling, Turret type milling - Planer Type milling • Special type milling machine • Table type milling machine	• Arbor • Collet • tapers • adapter • bolt and nut • wrenches • Plain vice • Swivel Vise Universal Vise • V- Block • T bolts • Angle Plate • Plain milling cutter • Side milling cutter • Metal slitting saw	• Steel bar

● PPEs	● Angle milling cutter ● End milling cutter ● 'T' – Slot milling cutter ● Fly cutter ● Formed cutter ● Indexing head ● Indexing pate ● Angle plate	

Advance Preparation:

Before delivering this learning outcome, you are recommended to:

- Prepare sample illustration, Picture or Videos to be used as didactic materials
- Avail all needed materials, tools, instruments and equipment used for description
- Have the organized workshop to be used while setting milling machine.

Indicative content 2.1: Setting Mechanical Components

Duration: 10 hrs

Practical Activity 2.1.1 Mounting milling cutters holding devices and mill cutters on milling machine

Notes to the trainer

- This activity should take place in workshop where you are supposed to demonstrate trainees how mount milling cutters holding devices and mill cutters on milling machine and ask trainees to perform the similar by facilitate them individually.
- You are recommended to avail all tools materials and equipment needed for Mounting milling cutters holding devices and mill cutters on milling machine

Key steps:

While delivering this activity, pass through the following steps:

Step 1: Introduce the activities and ask trainees to do the task described below:

you are requested to go to the workshop and mount milling cutters holding devices and mill cutters on milling machine according to the work to performed

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

Step 3: Demonstrate how to mount milling cutters holding devices and mill cutters on milling machine

Step 4: Asks trainees to mount milling cutters holding devices and mill cutters on milling machine

Step 5: Verify whether the milling cutters holding devices and mill cutters are mounted on milling machine.

Step 6: Ask trainees to read key reading 2.1.1.

Step 7: Ask trainees to perform the task provided in application of learning 2.1

Points to Remember

- When mounting milling cutter holding devices and milling cutters on a milling machine, it is crucial to follow proper procedures to ensure safe and efficient operations based on the work to be performed.
- Choose a holding device based on the type of milling operation, ensuring it accommodates the cutter's size, shape, and the required precision and rigidity for stable cutting. Always verify compatibility with the machine's spindle and prioritize safety features to prevent accidental dislodging during operation

Practical Activity 2.1.2 Setting work holding device on milling machine

Notes to the trainer

- This activity should take place in workshop where you are supposed to demonstrate trainees how Set work holding device on milling machine and ask trainees to perform the similar by facilitate them individually.
- You are recommended to avail all tools materials and equipment needed for setting work holding device on milling machine

Key steps:

While delivering this activity, pass through the following steps:

Step 1: Introduce the activities and ask trainees to do the task described below:

you are requested to go to the workshop and Set work holding device on milling machine according to the work to performed

Step 2: Explain the task and provide clear work instruction (Task, PPE, Time allocated).
Step 3: Demonstrate how to Set work holding device on milling machine
Step 4: Asks trainees to Set work holding device on milling machine
Step 5: Verify whether the work holding device is well on milling machine.
Step 6: Ask trainees to read key reading 2.1.2
Step 7: Ask trainees to perform the task provided in application of learning 2.1

Points to Remember

- When setting up a work holding device on a milling machine, precision and safety are crucial to ensure accurate machining and to prevent accidents remember to follow all the guide needed setting up a work holding device on milling machine.

Practical Activity 2.1.3 Applying Indexing methods on milling machine

Notes to the trainer

- This activity should take place in workshop where you are supposed to demonstrate trainees how apply Indexing methods on milling machine and ask trainees to perform the similar by facilitate them individually.

Key steps:

While delivering this activity, pass through the following steps:

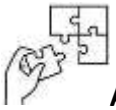
Step 1: Introduce the activities and ask trainees to do the task described below:

you are requested to go to the workshop and apply Indexing methods on milling machine according to the work to performed

Step 2: Explain the task and provide clear work instruction (Task, PPE, Time allocated).
Step 3: Demonstrate how to apply Indexing methods on milling machine
Step 4: Asks trainees to apply Indexing methods on milling machine
Step 5: Verify whether the Indexing methods is well applied
Step 6: Ask trainees to read key reading 2.1.3
Step 7: Ask trainees to perform the task provided in application of learning 2.1

Points to Remember

- While applying indexing methods on a milling machine, precision and accuracy are essential for achieving the desired results in machining complex shapes and features



Application of learning 2.1

Request trainees to go to the manufacturing workshop and ask them to perform the following:

1. Select cutter-holding devices
2. Apply procedures for mounting cutter-holding devices and use standard mill cutter
3. Apply the method of mounting cutters.
4. Set work holding device on milling machine by using either the plain vice, swivel vice, universal vice, v- block
5. Apply different indexing methods

Check list

SN	Criteria	Indicators	Yes	No
1.	Mount properly milling cutters holding devices and mill cutters on milling machine	1.1. criteria of cutter holding devices are followed		
		1.2. Cutter-holding devices are selected		
		1.3 procedures for mounting cutter-holding devices are applied		
		1.4. Standard mill cutter are used		
		1.5. Method of mounting cutters are applied		
2.	Set properly work holding device on milling machine according to the work to be done	2.1. Plain vice is used		
		2.2. Swivel vice is used		
		2.3. Universal vice is used		
		2.4. V- block is used		

		2.5. Clamps is used		
3.	Indexing methods are properly applied according to the work to be performed	3.1. Direct or rapid indexing is applied		
		3.2. Plain or simple indexing is applied		
		3.3. Compound indexing is applied		
		3.4. Differential indexing		
		3.5. Angular indexing		

Indicative content 2.2: Adjusting Parameters for Milling Operation

Duration: 10 hrs

Practical Activity 2.2.1: Adjusting parameters for milling operations

Notes to the trainer

- This activity should take place in workshop where you are supposed to demonstrate trainees how adjust parameters for milling operations and ask trainees to perform the similar by facilitate them individually.
- You are also recommended to avail all needed tools, materials and equipment

Key steps:

While delivering this activity, pass through the following steps:

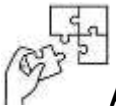
Step 1: Introduce the activities and ask trainees to do the task described below:

you are requested to go to the workshop and adjust parameters for milling operations according to the work to performed

Step 2: Explain the task and provide clear work instruction (Task, PPE, Time allocated).
Step 3: Demonstrate how to adjust parameters for milling operations
Step 4: Asks trainees to adjust parameters for milling operations
Step 5: Verify whether the parameters for milling operations are well adjusted
Step 6: Ask trainees to read key reading 2.2.1
Step 7: Ask trainees to perform the task provided in application of learning 2.2

Points to Remember

- While adjusting parameters for milling operations it is necessary for achieving the desired machining results, including proper surface finish, dimensional accuracy, and tool life because all the parameters include spindle speed, feed rate, depth of cut and coolant flow rate are properly adjusted.



Application of learning 2.2

With referring to the Practical Activity 2.2.1, take trainees to the workshop and request them to adjust parameters for milling operations on milling machine by referring to spindle speed , feed rate , depth of cut and coolant flow rate.

Check list

SN	Criteria	Indicators	Yes	No
1	Parameters for milling operations are properly adjusted according to the work to be done	1.1. Spindle speed is adjusted		
		1.2. Feed rate is adjusted		
		1.3. Depth of cut is adjusted		
		1. 4. Coolant flow rate is adjusted		
		1.5. Angular indexing is adjusted		

Indicative content 2.3: Mounting the Work Piece in Milling Machine

Duration: 15 hrs

Practical Activity 2.3.1: Mounting the Work Piece in Milling Machine

Notes to the trainer

- This activity should take place in workshop where you are supposed to demonstrate trainees how to mount the work Piece in Milling Machine by apply procedures of mounting work piece.and ask trainees to perform the similar by facilitate them individually.
- You are also recommended to avail all needed tools, materials and equipment

Key steps:

While delivering this activity, pass through the following steps:

Step 1: Introduce the activities and ask trainees to do the task described below:
you are requested to go to the workshop and mount the Work Piece in Milling Machine by apply procedures of mounting work piece

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

Step 3: Demonstrate how to mount the work piece in milling machine by apply procedures of mounting work piece.

Step 4: Asks trainees to mount the Work Piece in Milling Machine by apply procedures of mounting work piece

Step 5: Verify whether the workpiece is well mounted in the milling machine

Step 6: Ask trainees to read key reading 2.3.1

Step 7: Ask trainees to perform the task provided in application of learning 2.3

Points to Remember

- Before performing milling machine operations, selecting the right work holding method is crucial for ensuring precision, efficiency, and safety of both worker and machine.
- It is necessary to know that, the specific details of each step may vary depending on the work piece, machining operation, and the milling machine being used. Always prioritize safety, precision, and adherence to the machining requirements

Application of learning 2.3

Ask trainees to go to the workshop and then Mount work piece by applying the procedures of mounting work piece on milling machine by using work holding device methodes

Checklist

SN	Criteria	Indicators	Yes	No
1.	Select properly work holding methods to be used on milling machine operations.	1.1. workpiece is clamped on table		
		1.2. workpiece is clamped to the angle plate which is selected		
		1.3. workpiece is positioned in milling machine		
2.	Apply properly procedures of mounting work piece on milling machine.	2.1. Prepare the milling machine table is done		
		2.2. Position the work piece is done		
		2.3. Secure the work piece is done		
		2.4. Check the work piece alignment are done		

Learning outcome 2 end assessment

Theoretical assessment

Q1. The following are statements used in milling machine operations, answer by True if the statement is correct otherwise False if the statement is wrong.

i. A Shrink Fit Tool Holder uses thermal expansion to clamp the tool.
Answer: True

ii. The Weldon Shank Holder is commonly used for light-duty applications. **Answer: False**

iii. Collet Chucks are not suitable for high-speed machining. **Answer: False**

iv. Morse Taper Holders self-lock under cutting forces. **Answer: True**

v. End Mill Holders use hydraulic pressure to secure the tool. **Answer: False**

Q2. Ready the following statetment and choose the correct answer by writing the letter corresponding to the answer

I. Which cutter-holding device is ideal for holding small and precision tools?

a) End Mill Holder
b) Collet Chuck
c) Milling Cutter Arbor
d) Quick Change Tool Holder

Answer: b) Collet Chuck

II. What is the primary advantage of a Hydraulic Tool Holder?

a) Low cost
b) Excellent vibration damping
c) High speed
d) Easy maintenance

Answer: b) Excellent vibration damping

III. Which of the following is specifically designed to hold end mills?

a) Morse Taper Holder
b) End Mill Holder
c) Shrink Fit Tool Holder
d) Weldon Shank Holder

Answer: b) End Mill Holder

IV. What does a Milling Cutter Arbor primarily hold?

a) Small drills
b) Large cutting tools
c) Precision tools
d) Quick change tools

Answer: b) Large cutting tools

V. What is a key feature of the Quick-Change Tool Holder?

a) It can only hold one type of tool.
b) It is designed for heavy cutting.
c) It uses hydraulic pressure.
d) It allows fast tool changes

Answer: d) It allows fast tool changes.

Q3. Ready carefully the following work holding method of milling machine found in column

B and match With their appropriate application in column A by writing the answer in provided column.

Answers	**Columun A**	**Column B**
…C…	1. Used for cylindrical workpieces needing accurate concentric machining.	A. Clamping to the table
…B…	2. Ideal for machining operations requiring the workpiece to be oriented at specific angles	B. Clamping to the angle plat
...A…	3. Common in operations where the entire surface of large, flat workpieces needs to be machined.	C. Clamping in fixture
…D…	4. Suitable for small to medium-sized workpieces with regular shapes	D. Holding in the vice
…E…	5. Ideal for round or irregularly shaped workpieces needing multi-axis machining.	E. Holding in a chuck
		F. Milling machine
		G. Drilling machine

Q4. Ready the following statements related to the factors that determine depth of cut adjustment and filling the gaps by using words which are in blacket(**dimension, cooling ,finishing**

rigid ,shallower).

I. The hardness of the workpiece material affects the depth of cut; harder materials like steel require __ depths of cut compared to softer materials.

Answer: shallower

II. Larger diameter cutting tools can handle greater depths of cut because they are more __ and distribute cutting forces over a larger area.

Answer: rigid

III. In roughing operations, deeper cuts are used to remove material quickly, while __ operations require shallower cuts for a smooth surface.

Answer: finishing

IV. Adequate __ prevents overheating during deep cuts, allowing for more effective machining without damaging the tool.

Answer: cooling

V. When precision is critical, such as in finishing cuts, the depth of cut must be minimal to avoid overshooting the desired __. **Answer: dimension**

Practical assessment

UHN Ltd needs to maintain their machines, which includes fabricating shafts to replace damaged ones. You are requested to set milling machine by mounting the work piece in 5 milling machines within 2 hours

The work piece that you are requested to mount has the following specification: L*Ø=200mm*60mm

Where L: Length and Ø: Diameter

All needed tools, materials, attachment, accessories and equipment are available in workshop of UHN Ltd.

Check list

SN	Criteria	Indicators	Yes	No
1.	Set properly work holding device on milling machine according to the work to be done	1.1. Plain vice is used		
		1.2. Swivel vice is used		
		1.3. Universal vice is used		
		1.4. V- block is used		
		1.5. Clamps is used		
2.	Indexing methods are properly applied according to the work to be performed	2.1. Direct or rapid indexing is applied		
		2.2. Plain or simple indexing is applied		
		2.3. Compound indexing is applied		
		2.4. Differential indexing		
		2.5. Angular indexing		
3	Parameters for milling operations are properly	3.1. Spindle speed is adjusted		
		3.2. Feed rate is adjusted		
		3.3. Depth of cut is adjusted		

	adjusted according to the work to be done	3. 4. Coolant flow rate is adjusted		
		3.5. Angular indexing is adjusted		
4.	Mount properly milling cutters holding devices and mill cutters on milling machine	4.1. criteria of cutter holding devices are followed		
		4.2. Cutter-holding devices are selected		
		4.3 procedures for mounting cutter-holding devices are applied		
		4.4. Standard mill cutter are used		
		4.5. Method of mounting cutters are applied		
5.	Select properly work holding methods to be used on milling machine operations.	5.1. workpiece is clamped on table		
		5.2. workpiece is clamped to the angle plate which is selected		
		5.3. workpiece is positioned in milling machine		
6.	Apply properly procedures of mounting work piece on milling machine.	6.1. Prepare the milling machine table is done		
		6.2. Position the work piece is done		
		6.3. Secure the work piece is done		
		6.4. Check the work piece alignment are done		

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Indicative contents
3.1 Carrying out Milling operations
3.2 Inspecting milled parts.
3.3 Finishing the milled part.

Key Competencies for Learning Outcome 3: Mill the Workpiece

Knowledge	Skills	Attitudes
● Identifying selection factors of surface finishing techniques.	● Executing milling operations. ● Checking the accuracy of the milled part after milling operations ● Applying milled parts inspection methods after milling machine operations ● Applying surface Finishing techniques after milling machine operations	● Working on time while mill the workpiece ● Working in team while mill the workpiece ● Having self-confidence while mill the workpiece ● Respect workshop rules and regulations while operating moiling machine

Duration: 60 hrs

Learning outcome 3 objectives:

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

1. Execute properly the operations performed on milling machine.
2. Check correctly the accuracy of the milled part after milling operations.
3. Apply efficiently milled parts inspection methods after milling machine operations
4. Identify properly selection factors of surface finishing techniques after mill the work piece.
5. Apply efficiently surface Finishing techniques after milled workpiece.

Resources

Equipment	Tools	Materials
● Plain milling machine ● Universal milling machine ● Vertical milling machine Fixed bed type milling machine ● Ram type milling, Turret type milling - Planer Type milling ● special type milling machine ● table type milling machine	● Arbor and support ● Plain milling cutter ● Side milling cutter ● Metal slitting saw ● Angle milling cutter ● End milling cutter ● 'T' – Slot milling cutter ● Fly cutter ● Formed cutter ● Vertical head - Horizontal head - Dividing head - Offset boring head	● Carbon and alloy steel ● High-speed steel (HSS) ● Steel bar.

• computer • polishing machine • compressor • spray gun • Angle grinder	• Vertical Spindle Attachment • Universal milling attachment • Circular milling attachment • wrenches, • pliers.	

Advance Preparation:

Before delivering this learning outcome, you are recommended to:

- Avail all drawing materials, instrument and equipment used for mill the work piece
- Have an organized machining workshop
- Avail milled parts
- Avail video, photos and illustration to be used as didactic materials

Indicative content 3.1: Carrying Out Milling Operations

Duration:30 hrs

Practical Activity 3.1.1: Executing milling operations

Notes to the trainer

- This activity should take place in workshop where you are supposed to demonstrate trainees how to execute milling operations on milling machine
- This activity should be done individual based
- You are also recommended to avail all needed tools, materials and equipment

Key steps:

While delivering this activity, pass through the following steps:

Step 1: Introduce the activities and ask trainees to do the task described below:
you are requested to go to the workshop and to execute milling operations on milling machine according to the work to performed

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

Step 3: Demonstrate how to execute milling operations on milling machine

Step 4: Asks trainees to execute milling operations on milling machine

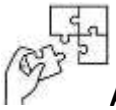
Step 5: Verify whether the operations are well executed on milling machine .

Step 6: Ask trainees to read key reading 3.1.1

Step 7: Ask trainees to perform the task provided in application of learning 3.1

Points to Remember

- It is necessary to know that, the specific details of each step may vary depending on the workpiece, machining operation, and the milling machine being used
- Always prioritize safety, precision, and adherence to the machining requirements.



Application of learning 3.1

Ask trainees to go to the workshop and task them perform at least 4 different operations (plain milling , keyway milling, side milling and end milling)on milling.

Check list

SN	Criteria	Indicators	Yes	No
1	Milling machine operations are properly performed according to the work to be done	1.1. Plain milling is done		
		1.2. Keyway milling is done		
		1.3. Face milling is done		
		1.4. Side milling is done		

Indicative content 3.2: Inspecting Milled Parts.

Duration: 20 hrs

Practical Activity 3.2.1: Checking the accuracy of the milled part

Notes to the trainer

- This activity should take place in workshop where you are supposed to demonstrate trainees how to check the accuracy of the milled part by applying milled parts inspection methods and ask trainees to perform the similar by facilitate them individually.
- Avail all needed tools, materials and equipment.

Key steps:

While delivering this activity, pass through the following steps:

Step 1: Introduce the activities and ask trainees to do the task described below:
you are requested to go to the manufacturing workshop and check the accuracy of the milled part by applying milled parts inspection methods

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

Step 3: Demonstrate how to check the accuracy of the milled part by applying milled parts inspection methods

Step 4: Asks trainees to check the accuracy of the milled part by applying milled parts inspection methods

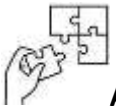
Step 5: Verify whether the milled parts is well checked according to the desired work.

Step 6: Ask trainees to read key reading 3.2.1

Step 7: Ask trainees to perform the task provided in application of learning 3.2

Points to Remember

- It is necessary to check the accuracy of a milled part because is crucial to ensure that it meets the required specifications and tolerances.
- After milling machine operation It is necessary to make the inspections methods of milled because is crucial to ensure that it meets the required specifications and functionality test.



Application of learning 3.2

Organize a study visit in the local machining area where there are milled parts and task trainees to perform the following

1. Check the accuracy of milled parts by referring to the surface finish, dimensions, tolerance, geometry, feature alignment and edge quality.
2. Applyling milled parts inspection methods

Check list

SN	Criteria	Indicators	Yes	No
1	Check properly the accuracy of milled part.	1.1. Surface finish is checked		
		1.2. Dimensions are checked		
		1.3. Tolerance is checked		
		4. Geometry are checked		
		5. Feature alignment are checked		
		6. Edge quality are checked		

2.	Apply properly milled parts inspection methods according to the work requirement.	1. Visual inspection are Conducted		
		2. Dimensional are inspected		
		3. Geometric Dimensioning and Tolerance (GD&T) are inspected		
		4. Surface Finish are inspected		
		5. Functionality Testing are inspected		

Indicative content 3.3: Finishing the Milled Part.

Duration: 10 hrs

Theoretical Activity 3.3.1: Identification of selection factors of surface finishing

Notes to the trainer:

- While delivering this content, small group can be used for : Identifying selection factors of surface finishing after milling operations.
- The use of images, videos, and illustrations as didactic materials is required for more clarifications.

Key steps:

While delivering this activity, pass through the following steps:

Step 1: Introduce the activity, and ask trainees to answer the following question related t o finishing milled parts:

i. What are the factors to consider when choosing surface finishing methods

Step 2: Ask trainee to write provided answers on flipcharts/papers

Step 3: Engage trainees in presentation of their findings.

Step 4: Ask trainees to discuss the provided answers and choose the correct ones.

Step 5: Address any questions or concerns.

Step 6: Ask trainee to read the key reading 3.3.1 in trainee manual and ask clarification if necessary

Step 7: Ask trainees to perform the task provided in application of learning 3.3

Points to Remember

- It is necessary to know the selection of surface finishing methods because it is crucial in manufacturing, and help us to achieve the desired surface properties.

Practical Activity 3.3.1: Applying surface Finishing techniques

Notes to the trainer

- This activity should take place in workshop where you are supposed to demonstrate trainees how to apply surface finishing techniques and ask trainees to perform the similar by facilitate them individually.
- Avail all needed tools, materials and equipment.

Key steps:

While delivering this activity, pass through the following steps:

Step 1: Introduce the activities and ask trainees to do the task described below:
you are requested to go to apply surface finishing techniques after milling operations.

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

Step 3: Demonstrate how to apply milled parts inspection methods.

Step 4: Asks trainees to apply surface finishing techniques

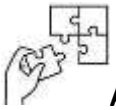
Step 5: Verify whether the finishing techniques is well applied

Step 6: Ask trainees to read key reading 3.3.1

Step 7: Ask trainees to perform the task provided in application of learning 3.3

Points to Remember

- It is necessary to know the selection of surface finishing methods because it is crucial in manufacturing, and help us to achieve the desired surface properties.
- While applying surface finishing techniques to milled parts, it's essential to consider the specific requirements of the parts and the according to the desired outcomes



Application of learning 3.3

With referring to the theoretical Activity 3.3.1 and 3.3.2, take trainees to the school manufacturing workshop and ask them perform surface finishing techniques on different milled parts

N.B : Do not apply all surface finishing techniques on one milled part.

Checklist:

SN	Criteria	Indicators	Yes	No
1.	Surface finishing techniques are properly applied	1.1. Deburring is applied		
		1.2. Polishing is applied		
		1.3. Brushing is applied		
		1.4 . Smoothing is applied		
		1.5. Painting is applied		
		1.6. Powder coating is applied		

Learning outcome 3 end assessment

Theoretical assessment

Q1. The following are statements used in milling machine operations, answer by "**True"** if the statement is correct or **"False"** if the statement is wrong.

a) Drilling is a finishing operation that enlarges and refines the diameter of an already drilled hole. It improves the hole's accuracy, surface finish, and ensures a tighter tolerance. **Answer: False**

b) Reaming is a finishing operation that enlarges and refines the diameter of an already drilled hole. It improves the hole's accuracy, surface finish, and ensures a tighter tolerance. **Answer: True**

c) Flute milling is a machining process used to create internal or external threads on a workpiece using a rotating cutter. **Answer: False**

d) Thread milling is a specialized milling operation used to machine helical grooves or flutes into cylindrical or tapered workpieces, such as drill bits, taps, reamers, or end mills . **Answer: False**

e) Angular milling is a milling operation where the axis of the milling cutter is set at an angle other than 90° to the surface of the workpiece**. Answer: True**

Q2: Ready the following statetment and choose the correct answer by writing the letter corresponding to the answer.

I. The following are steps for performing plain milling operations on milling machine Except:

a) Preparation and Setup:
b) Align the Workpiece:
c) Position the Cutter:
d) Positioning tools

Answer: d) Positioning tools

II. The following are types of milling machine, choose one which is generally used for plain milling by writing the letter which corresponding to the answer?

i. Vertical milling machine
ii. Horizontal milling machine
iii. Universal milling machine
iv. CNC milling machine

Answer: b)

III. The following are goals of milling machine, choose goals which is reflecting on the main goal of plain milling machine writing the letter which is corresponding to those goal?

a) To create a cylindrical surface
b) To remove material in a parallel direction to the axis of rotation
c) To cut a keyway
d) To drill holes

Answer: Letter b)

IV. One of the following is not importance of importance of painting during milling machine operations choose the letter corresponding to the statement which is not importance of painting.

a) Aesthetic Appeal
b) Corrosion Resistance
c) Weather Protection
d) Decreasing length of product

Answer: Letter d)

Q3. Match the following milling operations in column **B** with their corresponding meaning in the column **A** and give the answers in provided column of answers

Answers	**Meaning (A)**	**Milling operation (B)**
…G…	1. is a fundamental milling operation where the surface is machined parallel to the axis of rotation of the cutter.	A. Taper turning
…C…	2. milling operation where the axis of the milling cutter is set at an angle other than 90° to the surface of the workpiece.	B. Side milling
...B…	3. milling operation in which the sides of a workpiece are machined using the peripheral cutting edges of the milling cutter.	C. Angular milling
… E…	4. a special form of side milling where two cutters are mounted on an arbor to machine two parallel surfaces on opposite sides of the workpiece simultaneously.	D. Gang milling
...D…	5. milling technique where multiple cutters are mounted on the same arbor or spindle	E. Straddle milling
		F. Rolling
		G. Plain milling

Q4. Ready the following statement related to the types of paints and coatings and filling the gaps by using words which are in bracket **(chemical, solvents, water, Soap, Gas, glossy, electrostatically).**

I. Water-based paints are made with __ as the solvent, making them environmentally friendly and easy to clean up.

Answer: water

II. Solvent-based paints use organic __, such as turpentine or acetone, to carry the paint pigments.

Answer: solvents

III. Powder coating is a dry, powder-like substance that is __ applied and cured in an oven to form a hard finish.

Answer: electrostatically

IV. Epoxy paint consists of a resin and a hardener, forming a hard, __-resistant coating suitable for industrial environments.

Answer: chemical

V. Enamel paint is a solvent-based paint that creates a hard, __ finish, commonly used for metal surfaces and outdoor furniture.

Answer: glossy

Practical assessment

RMCT Machining Company has received a tender from Car Furniture Company Ltd to manufacture Worm gear for replacing the damaged one. Ask trainees to produce the new worm gear to replace the damaged one by using milling machine.

All needed tools, materials, attachment, accessories and equipment are available in workshop of RMCT Machining Company.

Note: respect the following worm gear specifications and dimension

		Worm
1	Material	Mild steel
2	Normal module	2.178206
3	N^{o} of teeth	3
4	Normal pressure angle	14^{o}
5	Helix angle	18^{o}
6	Hand	Right
7	Tip diameter	19.1mm
8	Pitch circle diameter	14.1mm
9	Base circle diameter	10.97mm
10	Flank surface roughness	0.15µmRa

Check list

SN	Criteria	Indicators	Observation	
			Yes	No
1	Milling operations are properly performed	1.1. Keyway milling is performed		
		1.2. Keyway milling is performed		
		1.3. Gear cutting is performed		
2	Milled part is properly inspected	2.1. Measurements are respected		
		2.2. Tolerance is respected		
		2.3. Edge quality is respected		
		2.4. Feature alignment is respected		

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