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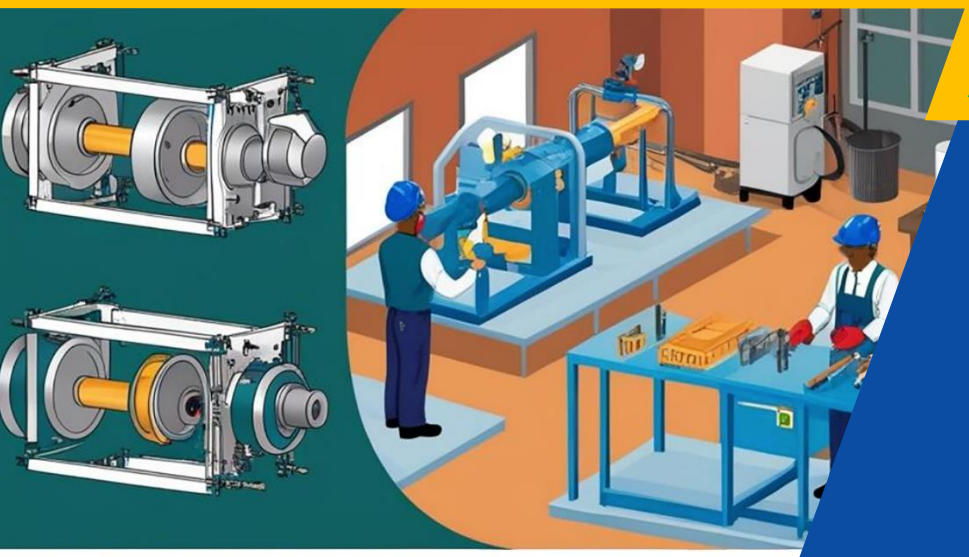
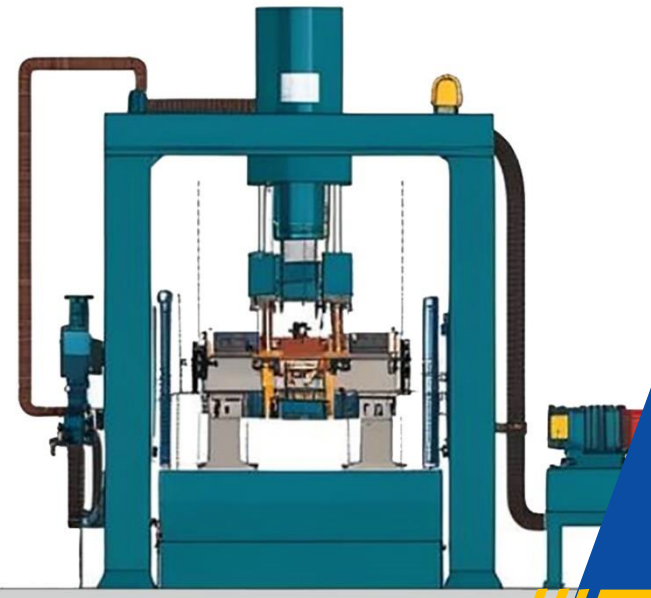


MATIM501

MANUFACTURING TECHNOLOGY

Industrial Machines Installation and Maintenance



TRAINEE'S MANUAL

October, 2024

INDUSTRIAL MACHINES INSTALLATION AND MAINTENANCE

KOICA Korea International Cooperation Agency

TQUM TVET Quality Management Project

2024

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TABLE OF CONTENT

ACRONYMS

ANSI: American National Standards Institute

CBM: Condition-Based Monitoring

CBT: Competency-Based Training

DCS: Distributed Control System

FCAW: Flux Cored Arc Welding

FMEA: Failure Mode and Effects Analysis

FOD: Foreign Object Damage

ISO: International Organization for Standardization

MAG: Metal Active Gas Welding

MIG: Metal Inert Gas Welding

PLC: Programmable Logic Controller

PLC: Programmable Logic Controllers

PPE: Personal Protective Equipment

RTB: Rwanda TVET Board

SOP: Standard Operating Procedure

TQUM Project: TVET Quality Management Project

TVET: Technical and Vocational Education Training

VFD: Variable Frequency Drives

INTRODUCTION

This trainee's manual includes all the knowledge and skills required in manufacturing technology specifically for the module of **“Industrial Machines Installation and Maintenance".** 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 trainee'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 trainee, you will start by addressing questions related to the activities, which are designed to foster critical thinking and guide you towards practical applications in the labor market. The manual also provides essential information, including learning hours, required materials, and key tasks to complete throughout the learning process.

All activities included in this training manual are designed to facilitate both individual and group work. After completing the activities, you will conduct a formative assessment, referred to as the end learning outcome assessment. Ensure that you thoroughly review the key readings and the 'Points to Remember' section.

MODULE CODE AND TITLE: MATIM501 INDUSTRIAL MACHINES INSTALLATION AND MAINTENANCE

Learning Outcome 1: Perform Fitting Works
Learning Outcome 2: Operate Industrial Machines
Learning Outcome 3: Preform Industrial Machines Maintenance

Indicative contents

1.1 Preparing Workplace
1.2 Assembling Machines Parts and Components
1.3 Fixing Attachment and Accessories of Machines

Key Competencies for Learning Outcome 1: Perform Industrial Machines Installation and Maintenance

Knowledge	Skills	Attitudes
• Description of the industrial machines workplace preparation • Description of the classifications criteria of industrial machines • Description of machine and equipment layout	• Applying workplace safety measures of industrial machines • Positioning and fixing industrial machines • Assembling procedures of industrial machine parts and components • Fixing industrial machine attachment and accessories	• Being attentive while applying workplace safety measures • Being attentive while positioning industrial machine • Having attention while assembling industrial machine parts and components • Having time management while fixing industrial machines attachment and accessories

Duration: 30 hrs.

Learning outcome 1 objectives:

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

1. Describe properly the workplace preparation of industrial machines in accordance with workplace regulations
2. Apply correctly workplace safety measures of industrial machines in accordance with environmental regulations
3. Describe clearly the classifications criteria of industrial machines accordance with their functions
4. Describe properly industrial machines and equipment layout while preparing workplace
5. Position and fix effectively industrial machines according to workplace layout
6. Assembly effectively industrial machines parts and components according to the procedures
7. Fix effectively the industrial machines attachment and accessories according with the fixing techniques

Resources

Equipment	Tools	Materials
• Air compressor • Angle grinder • Grinding machines • Clamping machine • Cylinder trolley • Drawing board • Drawing table • Hammer drill • Drilling machine • Extension cable • Fit Holders • Hydraulic press • Drill Press, • Hydraulic Shrink • Fit Holders • Hydraulic press	• Adjustable wrench • Ratchet spanners • Torque wrenches • Bevelling tools • Blooms • Boring tools • Bowl gouge • Brushes • Centre punch • Centre supporting drill • Chamfering tool • Chisels • Chop saw for metal • Control software • Crescent wrenches • Crevice Tools	• Grease • Cleaning material • Cutting discs • Gas diffusers • Gouging rods • Grinding disks • Lifting lugs • Lubricants • Marker pen • Drawing pens • Metal Plate • Mud Paper • Pipes and fittings • Rubber materials • Sanding discs • Welding electrodes

• Drill Press, • Hydraulic Shrink • SMAW welding machines • TIG welding machine • Equipment • FCAW MIG/MAG Welding kits • Oil Can • Oil pump • Lifting equipment • Overall • Gloves safety shoes • helmet • Safety glasses • Earmuff • face mask	• Cutters, Cutting Taps • Cylinder key • Die Grinder • Draw spike • Drawing software • Drill Blithered • Drill Bits • Dust masks • End Mill • Erasers • Face Mill • Facing tool • Fasteners • Files • Fit Holders • Floor Tools • Lifting tackles	• Welding steak • Fasteners • Gaskets and seals • Silicone sealants • Concretes • Steels

Indicative content 1.1: Preparing Workplace

Duration: 5 hrs.

Theoretical Activity 1.1.1: Description of industrial machines workplace preparation

Tasks:

1: Answer the following questions related to the workplace preparation of industrial machines:

i. What do you understand by safety measures to be applied while preparing workplace of industrial machine?
ii. What could be the classification criteria of industrial machines?
iii. What do you understand by the layout of machines and equipment while preparing workplace?

2: Provide answers to the asked questions and write them on papers or flipcharts

3: Present the findings/answers in the whole class.

4: Read the key readings 1.1.1 for more clarification,

Key readings 1.1.1: Description of industrial machines workplace preparation

Introduction to workplace is crucial for the industrial and manufacturing industries. Not covering the safety basics can lead to decreases in employee productivity and potentially costly fines. However, when safety is a priority, businesses see a boost in employee performance and company growth.

- **Description of industrial machines workplace safety measures**
  - ✓ **Identification of hazards**: Identification of hazards is the process of recognizing and defining potential sources of harm or danger in a given environment, activity, or process. Look around your workplace and think about what may cause harm (these are called hazards). **During identification of hazards Think about:**
    - how people work and how plant and equipment are used
    - what chemicals and substances are used
    - what safe or unsafe work practices exist
    - the general state of your premises
  - ✓ **Risk assessment:** is required to perform periodic risk assessments to protect the assets, systems, and other resources. Risk assessment helps in reducing the

chances of injuries, mismanagement of activities at the workplace, and the chance of the occurrence of different hazards and incidents. Once you have identified the hazards, decide how likely it is that someone could be harmed and how serious it could be.

- **Steps needed to manage a risk:**
  - Identify the hazards of the activities carrying out
  - Understand who might be harmed and how
  - Evaluate the risks and decide on precautions
  - Record your findings in a Risk Assessment and implement them
  - Review your assessment and update if necessary.

✓ **Control measures:** Refers to the aspect or system of safety management concerned with managing who gets access and control to specific tasks in industries. There are 5 types of controls that can be applied, each intended for a specific purpose:

- Eliminate the hazard
- Substitute the hazard with a lesser risk
- Isolate the hazard
- Use engineering controls
- Use administrative controls
- Use personal protective equipment (PPEs)

- **Description of classification criteria of industrial machines**

Understanding the criteria can help in selecting the right machine for a specific industrial application, optimizing production processes, and ensuring efficient operation. Here are some key classification criteria:

✓ **Based on function:** Machine tools can be classified based on their function, such as shaping, drilling, and milling, grinding, and cutting. Each type of machine tool is designed to perform a specific function or operation.

- **Processing Machines:** Classified based on their role in transforming or processing materials (e.g., lathes, milling machines, grinders).
- **Assembly Machines:** Machines used for assembling components or products (e.g., conveyor systems, robotic arms).
- **Manufacturing Machines:** Involved in the creation of parts or products (e.g., injection molding machines, CNC machines).
- **Inspection Machines:** Used for quality control and measurement (e.g., coordinate measuring machines, vision systems).
- **Packaging Machines:** For packaging finished goods (e.g., bottling lines, labelling machines).

✓ **Based on Industry application:**

- **Automotive Machines:** Specific to the automotive industry, including engine assembly and testing machines.

- **Textile Machines:** Used in textile production, like spinning machines and looms.
- **Food Processing Machines:** Used in food and beverage industries, such as mixers, ovens, and packing machines.
- **Construction Machinery:** Used in construction, like bulldozers, cranes, and excavators.

✓ **Based on Power source:**

- **Electric Machines:** Powered by electricity, including most modern industrial machines.
- **Hydraulic Machines:** Use hydraulic fluid pressure to perform work, like hydraulic presses and excavators.
- **Pneumatic Machines:** Operated by compressed air, such as pneumatic tools and actuators.
- **Combustion Engines:** Powered by internal combustion engines, typically used in portable machinery and equipment.

✓ **Based on Size and Capacity:**

- **Small Machines:** Suitable for small-scale production or precision tasks.
- **Medium Machines:** For moderate production needs and versatility.
- **Large Machines:** Used for heavy-duty tasks and high-capacity production, such as large presses and industrial mixers.

✓ **Based on Complexity:** The complexity of industrial machines can be explained through various dimensions, each reflecting different aspects of their design, functionality, and integration. The term is also generally used to characterize something with many parts where those parts interact with each other in multiple ways, culminating in a higher order of emergence greater than the sum of its parts.

- **Basic Machines:** Require straightforward operation and maintenance (e.g., simple hand tools, basic pumps).
- **Intermediate Machines:** Have moderate complexity with standard maintenance requirements (e.g., standard CNC machines, conveyor systems).
- **Complex Machines:** Involve advanced technology and sophisticated maintenance (high-precision CNC machines, large-scale automation systems).

✓ **Based on Control mechanism**: Is a general term that covers various types of control systems such as electrical, mechanical, hydraulic and pneumatic that act together to achieve the processes.

- **Manual Machines:** Operated directly by human control without automated systems. Examples include manual lathes and hand-operated drills.

- **Semi-Automatic Machines:** Require some human intervention but have automated functions. Examples include semi-automatic screwdrivers and packaging machines.
- **Automatic Machines:** Operated fully by automated systems with minimal human intervention. Examples include fully automated assembly lines and robotic systems.
- **Programmable Logic Controller (PLC):** is a digital computer used for automation of industrial processes. It can be programmed to control various machine functions through inputs and outputs.
- **Distributed Control System (DCS):** Used for large, complex processes, DCS allows for control and monitoring from multiple locations and integrates with various subsystems.

- **Description of layout of industrial machine and equipment:** is refers as the way something is designed, arranged, or laid out.
  - ✓ **Objectives of layout:** While using a process layout have the ability to complete various processes simultaneously with the following objectives:
    - Increase the output of the workplace by optimizing the use of resources and time.
    - Create a safe working environment by minimizing hazards and ensuring compliance with safety regulations.
    - Ensure that all processes and operations are performed with minimal wasted effort or time.
    - Ensure that products or services meet quality standards consistently.
    - Enhance employee comfort and reduce the risk of injury or strain.
    - Improve the overall experience for customers, whether they are visiting a retail space or a production facility.
    - For customer-facing layouts, create a welcoming and efficient environment that guides customers through their journey.
    - Improved productivity leads to higher wages.
    - Increased morale and motivation of machine operators.
    - Improved health and welfare.
  - ✓ **Types of industrial machines layouts:** In manufacturing, the layout of the workplace is critical for optimizing efficiency, productivity, and safety. The choice of layout depends on various factors including the type of production, product characteristics, and operational goals. The following are the types of layout:
    - **Process Layout:** Machines and equipment are grouped based on their function or type. For example, all milling machines might be in one area, and all lathes in another.

- **Product Layout:** Equipment and workstations are arranged in a linear sequence that mirrors the production process. Each station performs a specific task in the manufacturing of a single product or product type**.**
- **Cellular Layout:** Machines and workstations are grouped into cells, each dedicated to producing a specific family of products or performing a set of related tasks.
- **Fixed/Position Layout:** The product remains stationary, and workers, equipment, and materials are brought to the product. This layout is suited for large, heavy, or complex items.
- **Combination/grouped layout**: is also known as a **hybrid layout**, integrates elements from various traditional layout types to leverage the strengths of each while addressing specific operational needs. Combines aspects of product, process, cellular, and fixed-position layouts to create a more versatile and efficient workspace.

✓ **Plant layout procedures:** is a mechanism which involves knowledge of the physical arrangement of every component of the production Process for the facilities to additional space efficiency for manufacturing cost reduction to continuous and steady movement of the production cycle.

Fig: Plant layout

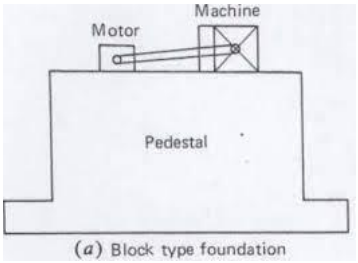
- **The Plant layout procedures have the following objectives:**
  - To determine what will be produced.
  - To determine how many products will be produced.
  - To determine what components will be made or purchased.
  - To determine required operations.
  - To determine the sequence of operations.
  - To set time standards for each operation.

✓ **Foundation of industrial machine:** The foundation of an industrial machine is typically made of concrete or reinforced concrete to provide stability and

support for the machinery. A stable foundation is essential for maintaining proper alignment and functionality of the machinery, as it provides a solid base to support its weight, absorb vibrations, and counteract external forces. An industrial machine foundation usually consists of:

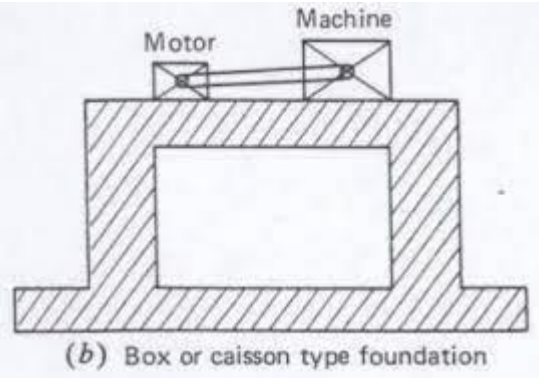
- **Concrete or reinforced concrete:** The foundation of an industrial machine is typically made of concrete or reinforced concrete to provide stability and support for the machinery. Concrete is a strong and durable material that can withstand heavy loads and vibrations.
- **Base plates:** Base plates are used to distribute the weight of the machine evenly across the foundation, reducing the stress on the concrete and ensuring proper alignment of the equipment.
- **Anchor bolts:** Anchor bolts are embedded in the concrete foundation to secure the machine in place. These bolts help prevent the machine from shifting or moving during operation, ensuring safety and stability.
- **Grouting:** Grouting is the process of filling gaps and voids between the machine base and the foundation with a special cementations material. This helps improve the contact between the machine and the foundation, enhancing stability and reducing vibrations.
- **Vibration isolation devices:** In some cases, vibration isolation devices such as rubber pads or springs may be used to further reduce the transmission of vibrations from the machine to the foundation and surrounding structures, minimizing noise and potential damage. By incorporating these components, an industrial machine foundation is designed to provide a solid and secure base for the machinery, ensuring optimal performance, safety, and longevity.

- **Types of machine foundations**:
  - **Block foundation:** block foundation consists of a massive block of concrete resting directly on soil or supported on piles or a pedestal resting on a footing.



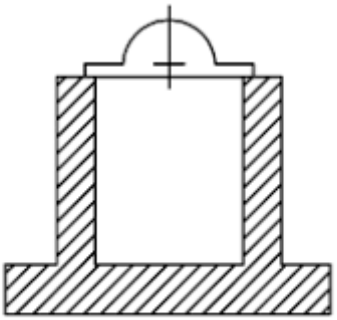
(a) Block type foundation

  - **Box or Caisson foundation:** consists of a hollow concrete block (can be used as operational space) that supports the machine on its top. Hammers may also be mounted on block foundations, but their details would be quite different than those for reciprocating machines.

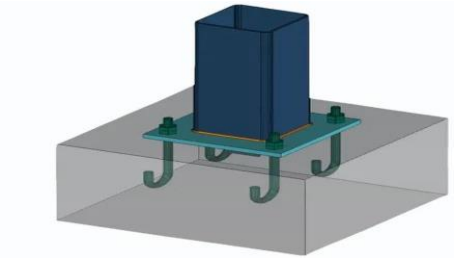


(b) Box or caisson type foundation

- **Wall-type foundation:** is a walls typically consist of concrete, block or brick with steel reinforcing bars added for extra strength.


Wall Type Machine Foundation

- **Plate Foundation:** A plate foundation, often referred to as a "mat foundation" or "raft foundation," is a type of foundation used to support structures by distributing the load over a large area. It is particularly useful when the soil has low bearing capacity or when loads need to be spread to reduce the risk of excessive settlement.



Practical Activity 1.1.2: Preparing industrial machines workplace

Task:

You are requested to go in manufacturing workshop to position and fix any available machine while preparing workplace. Apply Safety measures according to the work to be performed.

1: Apply safety measures at workplace.

2: Perform positioning and fixing of any available industrial machines by following work instructions

3: Present your work to the trainer, workshop assistant or classmate

4: Read the key reading 1.1.2.

5: Perform the task provided in application of learning 1.2

Key readings 1.1.2: Preparing industrial machines workplace

- **Applying workplace safety measures:** are actions or precautions taken to prevent accidents, injuries, or damage in various working environments, such as workplaces, or other public spaces.
  - ✓ **Identification of hazards:** is part of the process used to evaluate if any particular situation, item, thing, etc. may have the potential to cause harm by inspecting the Workplace. Walking around the workplace and observing how work is carried out can help you predict what could go wrong. After identified cause of hazard you should:
    - Allow only trained and competent employees to operate machines.
    - Put up warning signs to warn employees of machine hazards.
    - Ensure all machines are properly guarded.
    - Educate employees on all machine hazards, relevant control measures
    - Provide employees with the correct PPE.
    - Schedule regular preventive maintenance for machines.
  - ✓ **Risk assessment:** is the process of identifying hazards that could negatively affect an organization's ability to conduct business. Risk assessments help to ensure the health and safety of employees and customers by identifying potential hazards. The goal of this process is to determine what measures should be implemented to mitigate those risks. For example, certain hazards or risks might determine the type of protective gear and equipment a worker needs.

- **The 5 main steps of risk assessment**

  Step 1: Identify the hazards.

Step 2: Decide who might be harmed and how.

Step 3: Evaluate the risks and decide on precautions.

Step 4: Record your findings and implement them.

Step 5: Review your risk assessment and update if necessary.

- ✓ **Control measures:** are actions that are taken in response to a risk factor that has the potential to cause accidents or harm in the workplace. The control measures can either be designed to reduce the risks or eliminate them completely. Control measures follow a hierarchical step being worked through and implemented to control and minimise the risk identified:

- **Step 1: Risk Elimination:** is at the top of the hierarchy, being the most preferred option to control an identified risk. It will obviously not be possible to completely remove all risks, but this should be the first option considered and assessed as it offers the greatest protection by removing the risk completely.
- **Step 2: Risk Substitution:** Substituting a risk won't be as effective as removing the risk completely as it is possible that the new system will introduce new risks and hazards. These hazards are likely to be unknown initially and will, therefore, require a new risk assessment to evaluate any new or changed risks.
- **Step 3: Risk Isolation:** is a control measure designed to either isolate the risk itself from the employee or person that may experience it or isolate access to the risk factor to only authorized personnel, properly trained in its handling and usage. This could involve placing dangerous or noisy equipment in a locked or soundproof room where operators can monitor it remotely, or it could be storing dangerous chemicals in a secure area that only chemical safety trained personnel can access.
- **Step 4: Engineering Controls:** This control measure involves redesigning something at the engineering level to remove or reduce the risk. Examples of engineering risk control measures could be installing a physical safety guard between the moving parts of a machine and the operator, or it could be installing safety cut-offs to allow fast shutdown in the case of imminent accident or injury.
- **Step 5: Administrative Controls:** are control measures based on the training, planning, and personnel assignment of hazardous environments. This control measure may involve things such as developing best practice guidelines, arranging additional training, and ensuring that employees assigned to areas highlighted as a risk factor have the requisite training.

- ✓ **Step 6: Personal Protective Equipment:** is the least preferred option, that doesn't mean it should be ignored. Personal Protective Equipment (PPE) should normally be utilized even when the risks are being controlled by measures further up the hierarchy. PPE serves as the last line of defense to protect

- ✓ **Procedures for applying safety and security measures in workplace:**
  - **Step 1: Review the activities:** Observe and document the physical

environment and how tasks are performed.

- **Step 2: Job Safety analysis:** Break down tasks into steps to identify where hazards may occur.
- **Step 3: Consult regulations and standards:** Refer to occupational health and safety regulations and industry standards to understand common hazards and requirements.
- **Step 4: Engage Employees:** Involve workers in hazard identification since they often have first-hand knowledge of potential risks in their tasks and work environment.
- **Step 5: Analyze Incident Reports:** Review records of past accidents, near-misses, and injuries to identify patterns and recurring hazards.
- **Step 6: Examine Equipment and Materials:** Safety Data Sheets (SDS): Review SDS for chemicals and materials used to understand their hazards. Inspect machinery and tools for wear and tear or design flaws that could pose risks.
- **Step 7: Assess Work Environment:** Look for environmental factors like poor lighting, ventilation issues, or extreme temperatures. Consider Human Factors: Evaluate how human behavior or lack of training could contribute to hazards. You should learn more about machine hazards and control measures to minimize or eliminate hazards
- **Step 8: Eliminate Chemical and Fire Hazards:** Always store combustible chemicals and flammable materials in a safe storage area away from any potential sources of ignition. How you dispose of chemicals and other fire hazards is also crucial for workplace safety. Always use metal trash receptacles and follow local and state laws regarding disposal,
- **Step 9: Conduct Frequent Safety Inspections and Audits:** Casually strolling through the workplace doesn't mean you are going to catch all of the potential safety violations. It's something you actively need to look for.
- **Step 10: Always Report Unsafe Conditions:** Encouraging employees to report unsafe working conditions to their managers is one of the best ways to ensure workplace safety. Your staff should feel like they can freely report hazardous conditions without fear of reprisal.
- **Step 11: Encourage Employees to Take Breaks from Time to Time:** Industrial safety tips include encouraging employees to take regular breaks. It helps them stay alert and focused on the job.
- **Step 12: Create an Emergency Action Plan:** Having an emergency action plan in place is a vital industrial safety tip when had an emergency exit plan.

- **Fixing and positioning industrial machines:** is the process of assembling, positioning and configuring industrial machinery and equipment within a

designated area. This process involves various technical tasks, including aligning components, connecting power sources, and ensuring that all parts work harmoniously to achieve optimal performance. Positioning industrial machines efficiency, safety, and maintenance.

- ✓ **Step 1: Transport equipment:** is refers to move tools, or equipment from one location to another. This equipment can be found in various industries, including manufacturing, logistics, and warehousing. Common way of transport equipment include: Manual, Lift, Dock Leveler, Ball Transfer Table, Air Film Device and Hoist
- ✓ **Step 2: Positioning equipment:** is used to handle material at a single location so that the material is in the correct position for subsequent handling, machining, transport, or storage. Unlike transport equipment, positioning equipment is usually used for handling at a single workplace.
- ✓ **Step 3: Moving safe heavy machinery and equipment:** Use appropriate lifting equipment, such as cranes, forklifts, or hoists, to lift and position the machinery securely. Ensure the lifting capacity of the equipment matches the weight of the machinery. How to move heavy equipment in a safe and efficient manner. Here is a complete guide for you to follow when moving heavy equipment and machinery:
  - **Conduct a risk assessment:** The first step in moving heavy equipment is to conduct a full risk assessment. This will allow you to identify any potential dangers and mitigate them to a certain extent
  - **Have a detailed plan of moving process:** This means planning where the equipment will be moved and which moving equipment to use. For example, you can prioritise moving the heaviest equipment first so you have more room to make adjustments later on. This reduces the amount of time moving the equipment from one location to another since there are less obstacles in the way.
  - **Use tools designed for moving heavy equipment:** Making use of these tools will help facilitate the moving and minimise the hazards associated with it. These tools are include: Roller skids, Toe jacks,
  - **Transport services:** Some construction sites require moving massive machines where conventional moving tools aren't enough to get the job done. If this is the case, then you should consider hiring a professional machinery transport service.
- ✓ **Step 4: Alignment of industrial machine:** is the process of aligning rotating shafts on horizontal and vertical planes; if these shafts are not aligned correctly, it causes a machine misalignment.
  - **Types of Alignment**
    - **Horizontal Alignment:** Ensures machines are level along the

horizontal plane.

- **Vertical Alignment:** Checks alignment along the vertical axis.
- **Angular Alignment:** Ensures the machines are aligned at the correct angles relative to each other.

- **Process of Alignment:**
  - **Step 1:** Preparation of necessary tools and equipment for alignment
  - **Step 2:** Measure the initial alignment using the selected method.
  - **Step 3:** Make necessary adjustments to align the machines involve adjusting bolts, or repositioning components.
  - **Step 4:** After adjustments, recheck the alignment to ensure everything is within acceptable tolerances.
  - **Step 5:** Record measurements and adjustments for future reference and maintenance planning.
  - **Step 6:** Monitor machine performance for signs of misalignment (e.g., vibrations, unusual noise).

✓ **Here are some factors to consider while positioning industrial machines:**

- **Space Assessment:** Evaluate the available space, considering both the machine's dimensions and the workflow around it.
- **Workflow Optimization**: Arrange machines to minimize movement and maximize efficiency.
- **Safety Clearances:** Ensure there are adequate clearances around each machine for safe operation, maintenance, and emergency access
- **Vibration and Noise Considerations:** Position machines to minimize vibration and noise disturbances. Use mats or pads if needed to reduce vibration transmission.
- **Electrical and Utility Access:** Ensure that machines are easily accessible to power sources, water, air, or any other necessary utilities without creating hazards.
- **Ventilation:** Ensure proper ventilation, especially for machines that generate heat or fumes, to maintain air quality and worker safety.
- **Emergency Exits:** Keep pathways clear for emergency exits, ensuring that machines are not obstructing escape routes.

✓ **The general procedures for fixing and positioning industrial machines in industry are:**

- **Step 1: Planning and Preparation:** Before any physical work begins, a comprehensive project plan should be established. This includes assessing the installation site, reviewing equipment specifications, and identifying potential challenges. Safety measures should be outlined at this stage to minimize risks

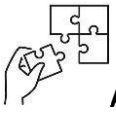
during installation.

- **Step 2: Site Preparation:** Clear the installation site of any obstructions and ensure that the area is clean and well-organized. Adequate space should be allocated for machinery components, taking into consideration factors such as access for maintenance and ventilation.
- **Step 3: Unloading and Transport:** Carefully unload the machinery from transportation vehicles and move it to the installation site using appropriate lifting equipment. Follow proper lifting techniques and use certified lifting gear to prevent accidents.
- **Step 4: Assembly and Alignment:** Assemble the machinery components according to the manufacturer's instructions. Precise alignment is crucial for smooth operation. Laser alignment tools can be used to ensure accurate positioning.
- **Step 5: Connection and Integration:** Connect power sources, hydraulic systems, and other necessary components as specified in the equipment's documentation. Check for proper wiring and ensure all connections are secure.

Step 6: Testing and Calibration: Thoroughly test the machinery's functions, ensuring that all moving parts operate smoothly. Calibrate sensors, controllers, and other instruments to guarantee accurate readings and optimal performance.

Points to Remember

- For ensuring that the industrial machine operate efficiently and safely, the installation steps must be followed
- Manufacturers and maintenance teams could manage and operate industrial machines smoothly for ensuring optimal performance and efficiency.
- A proper positioning of industrial machines and equipment enhance production
- To ensure that industrial workers are safe, put into practice safety measures to prevent accidents



Application of learning 1.1.

You are asked to go to manufacturing workshop of the school and perform the following task:

- Apply safety measures
- Position and fix any available industrial machines

Indicative content 1.2: Assembling Machines Parts and Components

Duration: 10 hrs.

Practical Activity 1.2.1: Assembling industrial machine parts and components

Task:

You are requested to go in manufacturing workshop and assemble any available industrial machine parts and components by using machines catalogue. This task should be done individually.

1: Apply safety precautions related to the task
2: Perform techniques of assembling machines parts and components
3: Take notes of the findings on papers
4: Present your work to the trainer/whole class
5: Read the key reading 1.2.1, and ask clarification where necessary.
6: Perform the task provided in application of learning 1.2.

Key readings 1.2.1: Assembling industrial machines parts and components

Machine assembling: is the process of putting parts together according to engineering specifications for securing parts or components such as gears, bearings, motors, electrical wiring, and other mechanical components. To make a machine operate.

- **Procedures of assembling industrial machine parts and components**

✓ **Step1: Interpreting installation manual of machines:** These manuals provide step-by-step instructions and guidance on how to correctly and safely install the product. By following the instructions provided in the manual, users can avoid errors, ensure proper installation, and prevent potential safety hazards. These guidelines serve as a framework for developing clear, user-friendly, and comprehensive manuals that facilitate successful installations.

Fig: interpretation of manual

- **Dimensioning:** Dimension inspection is a type of appearance inspection. It plays an important role in making pass/fail judgments of whether parts or products have been worked or assembled according to specifications such as:
  - Model
  - Length
  - Weight
  - Diameter
  - Motor Size
  - Launch Pad Type
  - Manufactured
- **Process and procedures:** is a detailed document that outlines step-by-step instructions and guidelines for carrying out specific tasks or procedures within an organization.
  - Familiarize Yourself with the Manual Structure
  - Read the Safety Instructions to ensure safe installation
  - Follow the Step-by-Step Instructions to take your time with each step, and don't skip ahead
  - Use Additional Resources if necessary such as online videos related to the installation.
  - Double-check before final assembly to ensure every parts or components are correctly assembled.
  - If you're stuck, don’t hesitate to reach out support or assistance from someone with experience.
- **Representation of Fits:** In engineering and manufacturing, "fits" refer to the relationship between mating parts, especially in terms of their tolerances and how they fit together. Machine Representation fits are:
  - Tolerances: Fits are often represented using tolerance specifications (e.g., ±0.01 mm) for the dimensions of the parts. Geometric Dimensioning and Tolerance symbols may be used to indicate the types of fits.

- Nominal Size and Limits: Each part will have a nominal size, with upper and lower limits defined. Example: A hole might be specified as 10 mm with a tolerance of +0.05/-0.00 mm.
- Fit Classes: Different standards (like ISO, ANSI) categorize fits into classes (e.g., H7/g6) to indicate the type of fit. The letter denotes the type of fit (e.g., H for hole, g for shaft), and the number indicates the tolerance grade.
- Assembly Drawings: Technical drawings often include detailed representations of fits, showing the relationships between parts and how they are assembled.

The purpose of installation manual are including:

- **Standardization:** Guidelines establish consistent formatting, writing styles, and design elements across all installation manuals. This enables users to easily navigate and comprehend the content, regardless of the specific product or installation process.
- **Clarity and Comprehension:** Guidelines focus on using clear and concise language to convey instructions effectively. By providing guidelines for writing in a user-friendly manner, manuals become more accessible to a diverse audience.
- **Usability and User Experience:** Guidelines emphasize organizing information in a logical manner, incorporating visual aids, and utilizing appropriate formatting techniques. These practices enhance the usability and overall user experience by making the manual visually appealing and easy to follow.
- **Accuracy and Consistency:** Guidelines ensure that the information provided in the installation manual is accurate, up-to-date, and consistent with the product and its installation process. This helps users trust the instructions and reduces the chances of errors or confusion during installation.

✓ **Step 2: Applying assembling methods:** There are different assembly techniques: some are based on **non-permanent methods** such as screws, bolts or clips, which allow disassembly and maintenance; others involve **permanent methods** such as welding, gluing or riveting. Assembling methods where two or more components are joined together to create an entirely new unit called an assembly or subassembly. Components can be joined together using methods such as **adhesive bonding**, **brazing, soldering, and welding.**

Non-permanent methods generally involve the following steps:

- **Cleaning and preparation of the components:** the individual parts must be cleaned and, if necessary, protected with grease lubricants before assembly.
- **Alignment and preliminary fastening:** the components are precisely aligned with each other and fastened with pins or temporary screws.

- **Tightening and checking torques:** screws and bolts are then tightened to the specified torque values, checking their actual value.
- **Functional test:** once the various assembly stages have been completed, the fitter carries out functional tests to verify correct assembly.

- **Permanent methods:** Permanent methods of joining components together are used in applications where the components are required to remain together and not easily disconnected.

Fig: Assembling machines parts and components

- ✓ **Step3: Correct machines assembling faults:** is a method of finding the cause of a problem and correcting it. The ultimate goal of troubleshooting is to get the equipment back into service as quickly and as fully as possible.
  - **Misalignment of machines parts:** is the process of aligning rotating shafts on horizontal and vertical planes; if these shafts are not aligned correctly, it causes a machine misalignment. Machine alignment keeps the power of the machine's motor or engine moving through the machine effectively. Without alignment, the power is unevenly dispersed and can cause damage to the whole machine, parts, and/or products on the production line. Staying on top of machine alignment ensures the machine is working the best way it can. Realign components if misalignment is causing the looseness. Ensure that parts fit together properly and are aligned according to specifications.

- **Imbalance of components:** Imbalance occurs when the centre of mass differs from the centre of rotation. This creates a centrifugal force, leading to high vibration amplitudes at frequencies equal to 1xRPM (1x rotational speed) in spectral data, with a sinusoidal waveform in the time domain.
- **Looseness of joint:** is crucial for ensuring proper function and longevity. Looseness can lead to excessive wear, vibration, and eventual failure.

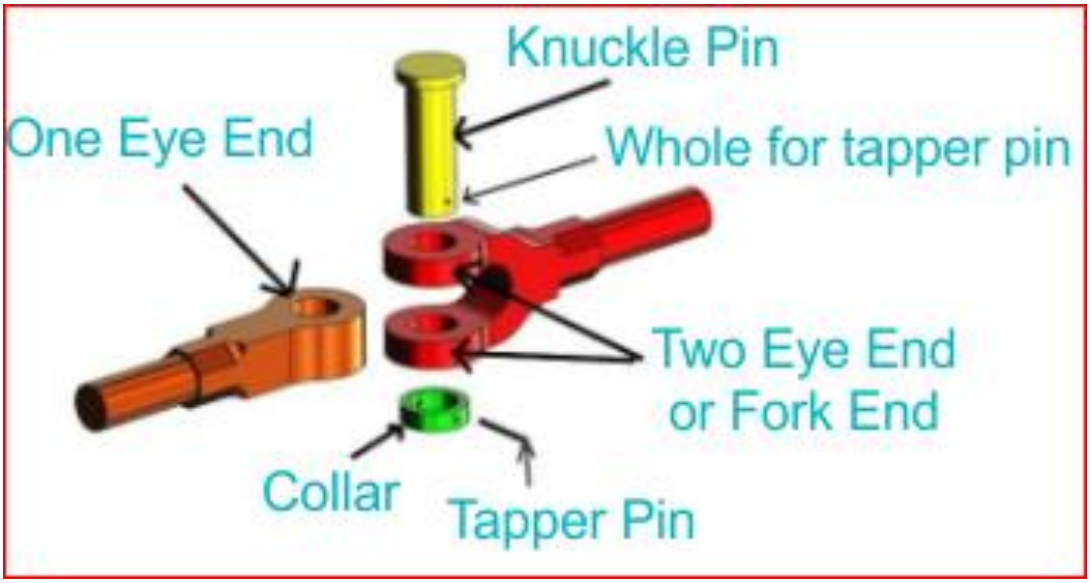


Fig: Looseness of machine joint

- **How to correct the Looseness**

Step 1: Tighten well bolts, nuts, and screws to the manufacturer's specified torque values.

Step 2: Follow any specific tightening sequences or patterns required for the assembly.

Step 3: Utilize locking nuts, washers, or lock washers where appropriate.

Step 4: Inspect components for wear or damage that could contribute to looseness.

Step 5: Replace any worn or damaged parts or components as needed.

Step 6: After making corrections, test the machines to ensure that the looseness has been resolved and that the joint functions correctly.

Step 7: Observe the machine during operation to ensure that no new issues arise and that the joint remains secure.

Step 8: Implement a routine maintenance schedule to regularly check and tighten joints as part of preventive maintenance.

Points to Remember

- For improving both the quality and reliability of machines, it is recommended to address and correct faults during machine assembly
- Always keep in mind that the misalignment of industrial machines may cause damage of the shafts and bearings

Application of learning 1.2.

You are requested to assemble any available industrial machines parts and components which were supplied in your manufacturing workshop and perform the following tasks:

- Apply assembling methods of machines by following installation manual
- Correct assembling faults of machines.

Indicative content 1.3: Fixing Attachment and Accessories of Machines

Duration: 15 hrs.

Practical Activity 1.3.1: Fixing attachment and accessories of industrial machines

Task:

You are requested to go in manufacturing workshop and fix any available industrial machine attachment and accessories

1: Apply safety measures at workplace.

2: Fix any available industrial machine attachment and accessories following the work instruction

3: Present your work to the trainer, workshop assistant or classmate

4: Read the key reading 1.3.1.

5: Perform the task provided in application of learning 1.3

Key readings 1.3.1: Fixing attachment and accessories of industrial machines

- **Fixing industrial machines:** is a process that involves setting up industrial equipment and machinery to ensure their proper functioning within a facility. It requires careful planning, expertise, and adherence to safety guidelines to guarantee both the safety of personnel and the longevity of the equipment. In this article, we will break down the essential steps involved in the machinery installation process, highlighting safety measures and best practices to follow.
- **Methods of Fixing industrial machines attachments and accessories** is the act of holding and securing a machine in place (sometimes called the fixing method); and **Fastener** is the holding down and securing connectors used for fixing (sometimes called the fixing device).

✓ **Industrial machines attachments** are essential for maximizing productivity and ensuring safety in industrial operations. The following are the types of attachments: **Mechanical attachment** and **Electrical Attachments.**

- **Mechanical attachments for industrial machines:**
  - **Bolts and Nuts:** Essential for securing machine parts together, facilitating easy assembly and disassembly during maintenance
  - **Washers:** Used in conjunction with bolts and nuts to distribute loads and prevent damage to surfaces, thereby enhancing stability

- **Rivets:** Used for permanent connections in machinery where disassembly is not anticipated, such as in structural components.
- **Brackets:** Support and secure various machine components, improving alignment and stability.
- **Hinges:** Facilitate movement in parts such as covers and access panels, allowing for easy access to machinery during maintenance.
- **Pulleys:** Used in belt-driven systems to change the direction of movement and provide mechanical advantage.
- **Bearings:** Reduce friction and support rotating parts, such as shafts and axles, critical for machine performance.
- **Couplings:** Connect shafts to transmit torque and power, accommodating some degree of misalignment.

Electrical attachments for industrial machines:

- **Sensors:** Devices like proximity sensors, photoelectric sensors, and pressure sensors are used for monitoring and controlling processes.
- **Drives and Controllers:** Variable frequency drives (VFDs) and programmable logic controllers (PLCs) help control the speed and operation of motors and other machinery.
- **Actuators:** Electric actuators convert electrical energy into mechanical motion, often used in robotic arms or automated systems.
- **Transformers:** Used to step up or step-down voltage for different parts of a machine or for power distribution.
- **Switches and Relays:** Control the flow of electricity in the system, allowing for safe operation and automation.
- **Power Supplies:** Provide the necessary voltage and current to operate various components of industrial machines.
- **Control Panels:** Houses the necessary controls and displays for monitoring machine operation.
- **Cables and Connectors:** Essential for establishing electrical connections between different components of the machinery.

Example of Lathe Machine Accessories and Attachments

- Chuck.
- Center
- Mandrel
- Carriers
- Drive Plate
- Face Plate
- Angle plate
- Rest

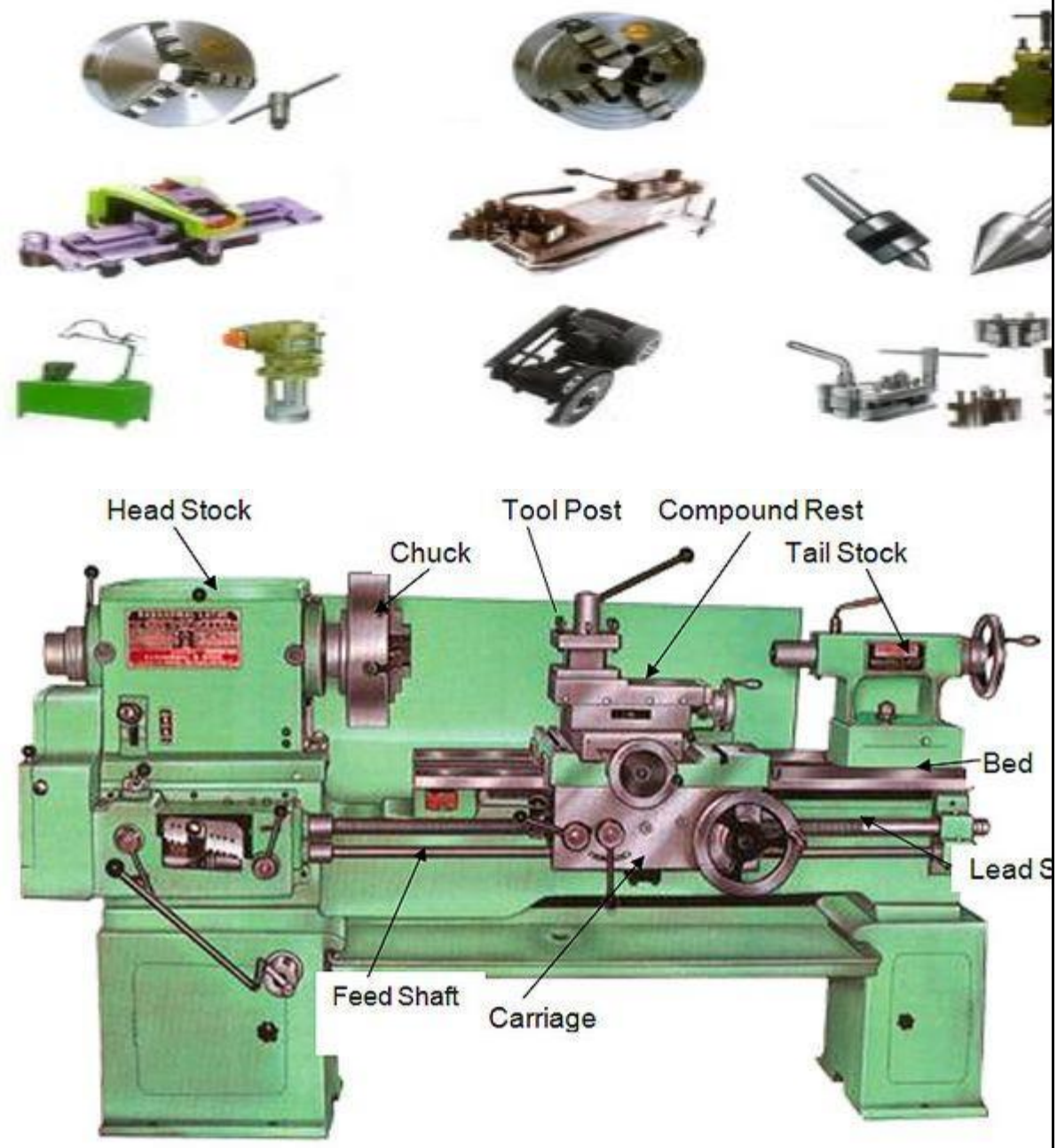


Fig: Lathe machine attachments and accessories

✓ **Identify types of accessories:** Accessories are additional components designed to extend the functionality of a machine. Types of industrial machines accessories:

- **Lubrication Accessories**
  - **Lubricants and Oils:** Essential for the smooth operation of moving parts, reducing friction and wear.
  - **Grease Guns:** Tools used to apply grease to machinery components, ensuring proper lubrication during maintenance.

- **Cleaning Accessories:** used to clean machinery surfaces and remove contaminants that can hinder performance.
  - **Industrial Vacuums:** For cleaning up debris and contaminants.
  - **Pressure Washers:** For cleaning machines and work areas.
- **Safety Accessories**
  - **Emergency Stop Buttons**: Ensure quick shutdown of machines in emergencies.
  - **Guards and Shields**: Protect operators from moving parts or flying debris.
  - **Diagnostic equipment:** Instruments such as vibration analysers and thermal imaging cameras for condition monitoring and troubleshooting machine issues.
- **Tooling Accessories**
  - **Cutting Tools:** End mills, drills, and blades tailored for specific machining tasks.
  - **Fixtures:** Devices that hold work pieces securely in place during machining.
  - **Clamping devices:** Used to secure tools or work pieces for stability.

✓ **Connect utilities** is a critical step to ensure that the machine operates correctly and efficiently. This typically involves ensuring that all necessary utilities—such as **electricity, water, air, or gas**—**pipes** are properly connected and functioning.

- **The following are the steps for connecting utilities for industrial machines:**

Step 1: Check if the machine or attachments require electrical power.

Step 2: Determine the voltage, current, and type of electrical connection needed.

Step 3: Check if there is water for cooling systems on certain manufacturing equipment when processing.

Step 4: Ensure that the machine is powered off and disconnected from any power sources before you start connecting utilities.

Step 5: Connect the airlines to the machine, ensuring that they are securely attached and free of leaks.

Step 6: Operate the machine to verify that all utilities are connected and functioning correctly.

Step 7: Regularly inspect utility connections to ensure are in good working conditions.

Step 8: Always disconnect power sources before working on electrical connections.

Fig: Connecting utilities for industrial machines

Points to Remember

- Remember that each type of machine has its own set of attachments designed to enhance its performance during operation.
- You must ensure that utilities are correctly connected and functioning to allow the machine to operate effectively and safely.

Application of learning 1.3.

You are requested to go to the manufacturing workshop of the school and perform the activity of fixing attachment and accessories of any available industrial machine

Learning outcome 1 end assessment

Theoretical assessment

1. Read carefully the following questions related to the techniques of Assembling machines parts and components and circle the letter corresponding to the right answer.

i. One of the following is the classification criteria of industrial machines

A. Assembly Machines
B. Manufacturing Machines
C. Power source
D. Inspection Machines

ii. The layout of machines and equipment are classified according to the following:

A. Analysis the production processes
B. Foundation of industrial machines
C. Fixed Position
D. Plant layout procedures
E. None above

iii. The following are safety measures to be applied when preparing workplace during industrial machine installation, Except:

A. Examine Equipment and Materials
B. Identification of hazards
C. Risk assessment.
D. Control measures.

iv. The following are the methods of Fixing and positioning industrial machines, Except:

A. Transport equipment
B. Move the machine so that all axes are at the center
C. Process of safe heavy machinery and equipment moving
D. Alignment of industrial machine

2. Complete the following questions related to the techniques of Assembling machines parts and components by using the following words (**Dimensioning, Standardization, Process and procedures, Representation of Fits, Installation manual, resource allocation**) and provide the answers in the empty spaces

A. By following the instructions provided in the ……**……** …. users can avoid errors, ensure proper installation, and prevent potential safety hazards.

B. …… plays an important role in making pass/fail judgments of whether parts or products have been worked or assembled

C. A document which is detailed step-by-step instructions and guidelines for carrying out specific task is called ……..……

3. Read carefully the following statements related to the techniques of Assembling machines parts and components and answer by **True** if statements is correct or **False** if statement is not correct

i. Assembling methods are based only non-permanent methods such as screws, bolts and clips which is allow disassembly and maintenance of machines?

ii. Misalignment of machines parts is not the process of aligning rotating shafts on horizontal and vertical plane?

iii. Looseness of joint is crucial for ensuring proper function and longevity that can caused wear, vibration, and eventual failure.

iv. Fixed machine and Equipment mean that none securely placed or fastened and stationary within a building workshop.

v. Industrial machine attachments types are additional components designed to extend the failure of a machine.

Practical assessment

Rotech Ltd is a company which specialised in installation of industrial machines. You are requested to perform the following tasks:

1. Apply safety measures in workplace
2. Assembly industrial machines parts and components
3. Correct assembled machine faults
4. Fix and position industrial machines
5. Fix attachment and accessories of industrial machines
6. Connect utilities

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Indicative Contents

2.1 Setting Up Machine Parameters
2.2 Testing Industrial Machines
2.3 Controlling Machines Production Processes

Key Competencies for Learning Outcome 2: Operate industrial machines

Knowledge	Skills	Attitudes
• Description of industrial machine parameters • Description of testing techniques for industrial machines • Explanation of Quality Control Measures on industrial machines operation	• Adjusting mechanical parameters while operating industrial machine • Testing industrial machines while operating industrial machine • Adjusting electrical and electronics parameters while operating industrial machine • Inspecting industrial machines operation while operating industrial machine • Applying Final product inspection while operating industrial machine • Evaluating the performance of industrial machine while operating industrial machine	• Being carefully and focusing on duties while operating industrial machine • Being harder worker and punctual during industrial operation • Being responsible in operating of industrial machine • Being vigilant while working operation on industrial machine. • Being continuously updated to new techniques in operation of industrial machine

Duration:30hrs

Learning outcome 2 objectives:

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

1. Describe clearly the industrial machine parameters according to operation manual.
2. Describe clearly the testing techniques of industrial machines according to operation manual.
3. Explain clearly the Quality Control Measures on industrial machines operation according to operation manual.
4. Adjust correctly the mechanical parameters in accordance to the industrial machine operation
5. Test properly industrial machines in accordance to the testing techniques
6. Adjust properly electrical and electronics parameters according to operation manual.
7. Inspect properly industrial machines operation according to machine operation manual
8. Apply properly Final product inspection in accordance to implementation of quality control measures
9. Evaluate correctly the performance of industrial machine according to operation manual.

Resources

Equipment	Tools	Materials
• Computer • Machines • Overall • Gloves • safety shoes • helmet • safety glasses • earmuff • face mask.	• Tape measure • Vernier calliper • Micrometer • dial indicator • surface plate • protractor and angle finder • thread gauge • feller • gauge • temperature gun • pressure gun • vibration checker • bearing checker • wrenches	• Steel • Aluminum • Brass • Copper • titanium • Hardwood • Softwood • plywood • Acrylic • Nylon • PVC • Coolants • lubricants

	• screw drivers • pliers • hammers • Allen keys • diagnostic tool • Multi-meter • tachometer .	

Indicative content 2.1: Setting Up Machine Parameters

Duration:10 hrs

Practical Activity 2.1.1: Setting up machine parameters during operation of industrial machine

Task:

Visit the manufacturing workshop of your school and set up any available machine, for adjusting electrical, electronic and mechanical parameters with respect to the trainer demonstration. This task should be done individually.

1: Apply safety precautions
2: set up the available machine parameters.
3: Present the work done to the trainer
4: Read the key reading 2.1.1
5: Perform the task provided in application of learning 2.1.

Key readings 2.1.1 Setting up machine parameters during operation of industrial machine

- **Electrical Parameters**

Electrical parameters: refer to the various measurable aspects of an electrical circuit or system, such as **voltage, current, resistance, power, and frequency**. Adjusting these parameters can be necessary for various reasons, including optimizing performance, ensuring safety, and achieving desired operational characteristics.

- **Electronics Parameters**

Electronics parameters involve the characteristics of electronic components and circuits, such as **gain, bandwidth, and impedanc**e. Adjusting these parameters is often about fine-tuning the performance of electronic devices and systems

Fig: adjusting electrical and electronic

- **Here are the steps for adjusting electrical and electronic parameters in industrial machines:**

Step 1: **Safety Precautions**: Use appropriate protective equipment (insulated gloves, safety glasses).

Step 2: **Consult Documentation**: Refer to the machine's electrical and electronic schematics or manuals parameters to be adjusted (e.g: voltage, current, frequency).

Step 3: **Measure Existing Values**: Use multimeters, oscilloscopes, or other testing tools to measure the current values. Record baseline readings for future comparison.

Step 4: **Adjust Voltage/Current**: For analogy systems, adjust the potentiometer or variable resistor, for digital systems modify settings in the control software.

Step 5: **Adjust Frequency or Timing**

Step 6: Modify settings for motor drive systems, PLC timers, or oscillators.

Step 7: Make gradual changes and test the effect on machine operation.

Step 8: **Calibrate Sensors and Instruments**

Step 9: Adjust sensors (e.g., pressure, temperature, proximity) to ensure accurate readings.

Step 10: **Use calibration tools** and follow the manufacturer's calibration procedures.

Step 11: **Monitor Results**: Power the machine on and monitor the adjustments using measurement devices.

Step 12: **Finalize Settings**: Once desired settings are achieved, secure the adjustments.

Step 13: **Documentation**: Record the new electrical/electronic parameters for maintenance and future reference.

- **Mechanical parameters:** involves modifying various aspects of a mechanical system to achieve desired performance, efficiency, or safety. some common mechanical parameters are force and torque

✓ **Force:** is the push or pull used to move an object in a straight line, **Adjusting**

- **Load Adjustment**: Change the load applied to a spring or a mechanical component. For example, adjusting a spring's tension can change the force exerted by it.
- **Actuators**: Use adjustable actuators to vary the force applied in systems like robotic arms or presses. **Hydraulic/Pneumatic Systems**: Control the input pressure to adjust the force exerted by hydraulic or pneumatic cylinders.

✓ **Torque:** torque is the amount of effort used to rotate an object.

- **Gear Ratios**: Change gear ratios in gearboxes to adjust the torque transmitted. Higher gear ratios increase torque but decrease speed.
- **Wrench Settings**: Adjust the length of the handle or the applied force in a wrench to modify the torque applied.
- **Motor Settings**: Use variable settings on electric motors to adjust the torque output, often controlled through a motor controller or drive system

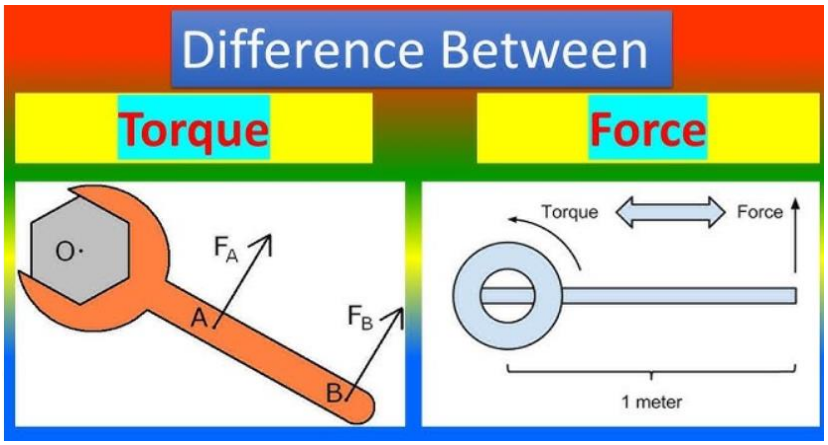


Fig: difference between torque and force

- **Steps for Adjusting Mechanical Parameters**

Step 1: Wear appropriate PPE (e.g., gloves, hard hats).

Step 2: Review machine drawings, manuals, to identify the specific mechanical parts and parameters to adjust (e.g: tension, alignment).

Step 3: Inspect belts, chains, gears, shafts, and other moving parts.

Step 4: Identify wear, misalignment, or incorrect tension that may need adjustment.

Step 5: **Alignment of** shaft or pulley misalignment.

Step 6: Adjust tension on belts, chains, or other tensioned components using tension meters or feel methods.

Step 7: Apply appropriate lubrication to moving parts where needed.

Step 8: Check and adjust torque settings on bolts, screws, and fasteners using torque wrenches to meet the correct specifications.

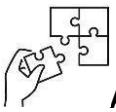
Step 9: **Test Machine Movements** to ensure smooth, vibration-free operation after mechanical adjustments.

Step 10: Update machine manuals if significant adjustments were made if necessary

Fig: Adjusting Mechanical Parameters

Points to Remember

- Adjusting electrical and electronics parameters is necessary for proper performance, maintaining safety, and producing the desired product.
- Each parameter plays a role in the overall behaviour of the system, and precise control of these parameters is often necessary for high-performance applications
- Make sure that machine is working properly before setting parameters with respect to the industrial machine manual guide.



Application of learning 2.1

Visit your manufacturing workshop of the school and set up machine parameters of the available machines. You are requested to perform the following tasks:

- Adjust electrical and electronic parameters for producing a desired product according to the industrial machine setting parameters manual.
- Perform the Mechanical parameters adjustment on machine for producing a desired product. According to the industrial machine setting parameters manual

Indicative content 2.2: Testing Industrial Machines

Duration:10 hrs

Practical Activity 2.2.1: Testing industrial machines during operation of industrial machines

Task:

Visit the manufacturing workshop of your school and test any available machine with respect to the trainer demonstration. This task should be done individually.

1: Apply safety precautions

2: test the machine performance.

3: present the work done to the trainer

4: Read the key reading 2.2.1

5: Perform the task provided in application of learning 2.2

Key readings 2.2.1: Testing industrial machines during operation of industrial machines

- **Testing techniques of industrial machine:**
  - ✓ **Functional testing:** Is a type of testing that validates the functionality of industrial machine to ensure it behaves according to specified requirements such as **Visual Inspection of damage, wear, or corrosion of industrial machine parts and connections**
  - **Steps for performing functional test**

Step 1: Identify The Functional Requirements,

Step 2: Design Test Cases That Cover Various Scenarios,

Step 3: Execute The Tests by Providing Inputs And Evaluating Outputs,

Step 4: Compare The Actual and Expected Results

Fig: Performing functional test

- ✓ **Safety testing**: Safety testing for industrial machines involves a series of evaluations and assessments to ensure that the equipment operates safely and complies with relevant safety standards and regulations.

Steps for safety testing:

Step 1: Review operation manuals, maintenance records, and previous inspection reports of industrial machine.

Step 2: Conduct a Visual Inspection

Step 3: Test Functionality of machine

Step 4: Clean and lubricate industrial machine parts and components

Step 5: Eliminate Hazards on industrial machine

Step 6: Make a report of finds fault during operation testing

- ✓ **Performance testing:** Testing is a type of testing that evaluates how a system performs under a particular workload. The goal is to ensure that the machine runs smoothly, efficiently, and reliably under expected (and sometimes

stressfully high) conditions.

- **Steps for performance testing:**

Step 1: Prepare test environment, tools and equipment to be used.

Step 2: Identify the production environment or workplace environment

Step 3: Define acceptable performance criteria of machine

Step 4: Plan and design tests of industrial machine

Step 5: Run the performance tests

Step 6: Resolve and retest of industrial machines

✓ **Environmental testing**: Environmental testing for industrial machines involves evaluating how machines perform under various environmental conditions and ensuring they can operate safely and effectively in their intended settings.

- **Steps for environmental testing**

Step 1: Determine the relevant environmental conditions (e.g., temperature, humidity, vibration) the machine will encounter.

Step 2: Create scenarios to simulate these environmental conditions and test procedures.

Step 3: Set up a controlled environment to replicate the desired conditions.

Step 4: Conduct tests under various environmental conditions, monitor the machine's performance, and record observations.

Step 5: Assess the machine's ability to operate effectively under different environmental conditions.

Step 6: Identify environmental impacts: Evaluate any adverse effects of the machine on the environment.

Step 7: Record test results, observations, and any environmental concerns.

✓ **Electrical systems testing:** Involves evaluating electrical systems, components, or equipment to ensure they operate correctly, safely, and in compliance with required standards. The testing aims to detect any malfunctions, inefficiencies, or safety hazards such as electrical shorts, overloads, or failures before the systems are used in real-world environments.

- **The types of electrical system testing**

- Visual Inspection
- Earth Continuity Test
- Insulation Resistance Test
- Leakage Test

Fig: Electrical system testing

- **Evaluate performance of machine**

✓ **Introduction machine performance evaluation**

Involves assessing how well a machine functions in terms of its efficiency, accuracy, reliability, and productivity under defined operating conditions. This process is crucial to ensure that machines meet the expected operational standards and can perform optimally in various industrial or application environments.

Speed and Cycle Time:

- **Speed** refers to how fast a machine can perform a task or operation. It is often measured in terms of units produced per hour, operations per second, or time taken to complete a specific task. In evaluating machine performance, faster speeds generally mean higher productivity, but this should be balanced with quality.
- **Cycle Time** is the time required for a machine to complete one full cycle of its operation, from the start to the finish of a task. It directly impacts throughput and productivity. Lower cycle times typically indicate higher efficiency since more units can be produced in a given period.

Example in manufacturing:

If a machine has a short cycle time and operates at high speed, it can produce more units in less time, leading to higher productivity. However, reducing cycle time too much may strain the machine and affect product quality.

- **Energy consumption**: measures how much power or energy the machine uses to perform its operations. It is crucial in evaluating machine performance because energy-efficient machines can reduce operating costs and have a lower environmental impact. Energy consumption is usually measured in kilowatt-hours (kWh) or joules.

Example in manufacturing:

A machine that consumes less energy for the same amount of work is more cost-effective and sustainable. Over time, the energy savings can make a significant difference in operational costs, especially in large-scale production.

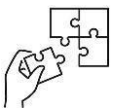
- **Reliability:** refers to how consistently a machine performs its tasks without breakdowns or failures over time. A reliable machine has less downtime, requires fewer repairs, and ensures steady production. Reliability is often measured through metrics like Mean Time Between Failures and Mean Time To Repair

Example in manufacturing:

A reliable machine minimizes disruptions in the production process, ensuring that operations run smoothly without unexpected downtime. This can improve overall efficiency, reduce maintenance costs, and prevent delays in product delivery.

Points to Remember

- Make sure that you follow all rules and regulation before testing and respect to the industrial machine manual guide.
- Testing machine plays a crucial role in various fields by assessing the properties, performance, and quality of materials, products, or systems.



Application of learning 2.2.

Visit your manufacturing workshop of the school and apply testing techniques for available industrial machines. You are tasked to perform the following tasks:

- Perform testing techniques on the available machine to identify its functioning condition according to the machine manual.
- Conduct evaluation performance of available machine by using different techniques of industrial machine.
- Based on your findings, provide a working condition of the available machine. And suggest some advice in the way of improving the proper working condition of machine

Indicative content 2.3: Controlling Machines Production Processes

Duration: 10 hrs

Practical Activity 2.3.1: Controlling machines production processes during operation of industrial machine

Task:

Visit the manufacturing workshop of your school and perform a control for production process on the available industrial machine which is in working condition and make a production process according to the trainer demonstration. This task should be done individually.

1: Apply safety precautions
2: control the production process of the available machine
3: Present the work done to the trainer
4: Read the key reading 2.3.1
5: Perform the task provided in application of learning 2.3.

Key readings 2.3.1: Controlling machines production processes

- **Monitoring of industrial machines operation**

✓ **Real-Time Data Collection**

Real-Time Data Collection refers to the immediate and continuous acquisition of data from machines, equipment, and manufacturing processes as production is ongoing. This data can include information such as machine performance, production rates, cycle times, temperature, pressure, and other key performance indicators

✓ **Process Control Systems**

Process Control Systems are automated systems that regulate and control the operational parameters of manufacturing processes to ensure consistent product quality and efficient operation. These systems include software, hardware, and sensors that manage the various stages of a manufacturing process.

✓ **Condition monitoring**

Condition Monitoring involves continuously assessing the health and performance of machinery and equipment during operation to detect potential failures before they occur. The goal is to prevent unexpected breakdowns, reduce downtime, and extend the lifespan of machines**.**

- ✓ **Energy monitoring**

Energy Monitoring involves tracking and analysing energy consumption within a manufacturing facility to optimize usage, reduce waste, and improve overall energy efficiency. It enables manufacturers to understand how energy is used across different processes, equipment, and shifts

- **Implement Quality Control Measures**

- ✓ **Inspect the raw material:**

Raw material inspection is the process of verifying the quality and conformity of materials before they enter production. This step ensures that the raw materials meet the necessary standards and specifications required for manufacturing. Poor quality materials can lead to defects in the final product, increased waste, and production delays**.**

- **Method of Inspecting the raw material:**

- Chemical analysis.
- Testing physical properties and measurements.
- Testing mechanical properties.
- Regulatory testing.

- ✓ **In-process control**

In-process control refers to the monitoring and inspection of products during various stages of production. This ensures that manufacturing processes are functioning correctly and that products are being made according to specifications throughout the production cycle, rather than only at the end.

- **Inspecting industrial machine during operation:**

During industrial machine operation check following items:

- Strange noises.
- Leaks in pipelines
- Parts heating up significantly.
- Burning smells.
- Clogged or corroded pipes.
- Vibrating more than usual

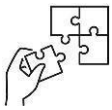
✓ **Final product inspection**

Final product inspection is the last quality control step, where the finished product is thoroughly inspected to ensure it meets all required specifications and standards before being shipped to customers. This inspection ensures that any defective products are caught before they leave the factory.

- **This section will walk you through the process of inspecting products in five steps:**
- Select a Product Sample from the Factory
- Review the Design and Quality Specifications
- Run a Visual Inspection of the Product and Its Packaging
- Perform Physical Testing(checking dimension, aesthetic, defects, etc)

Points to Remember

- Remember that a well-controlled manufacturing machine will work properly and produce production as written by manufacturer on machine manual.
- Once the machine production process conducted properly will maintain and improve proper working condition of a machine production process.



Application of learning 2.3

Visit your manufacturing workshop of the school and control production process of the available industrial machines. You are tasked to perform the following tasks:

• Collect the real-time data of the machine for monitoring industrial machines operation.

• Conduct appropriately the process of control system of the machine as for industrial machine manual

• Perform the inspection of the raw material and final product according to the manufacturer manual.

Learning outcome 2 end assessment

Theoretical assessment

1. Read the following statements related to the operation of industrial machines and answer by True if it is a correct statement or False if it is a wrong statement:

i. Adjusting electrical and electronic parameters can help improve the efficiency of industrial machines.
ii. Adjusting mechanical parameters has no impact on the performance of an industrial machine.
iii. Functional testing is used to verify whether an industrial machine operates as intended.
iv. Safety testing of industrial machines ensures that they meet safety standards and reduce the risk of accidents.
v. Performance testing measures how well an industrial machine performs under normal operating conditions.
vi. Environmental testing involves assessing how industrial machines function in different environmental conditions, such as temperature and humidity.
vii. Electrical systems testing only checks for mechanical issues in industrial machines
viii. Energy consumption is not a significant factor when assessing the performance of an industrial machine.

2. Observe carefully the following table and match the following terms in column C with their correct descriptions in column B and provide answers in column A

Column A: Answers	**Column B: Description**	**Column C: Terms**
1…….	1.Verifies that all electrical components are working correctly.	A. Adjusting Electrical and Electronics Parameters
2…….	2.Checks how a machine operates in different environmental conditions, such as temperature or humidity.	B. Adjusting Mechanical Parameters
3……	3.Modifying mechanical components like gears and pulleys to improve machine performance.	C. Functional Testing
4…….	4.Ensures the machine operates as intended and fulfils its functional requirements.	D. Safety Testing
5…….	5.Adjusting electronic circuits or power settings to optimize machine performance.	E. Performance Testing

6……..	6.Evaluates the machine's ability to run consistently without failure over a period of time.	F. Environmental Testing
7…….	7.Measures the time it takes for the machine to complete a task or cycle.	G. Electrical Systems Testing
8……..	8.Ensures the machine meets safety standards to prevent accidents.	H. Software Testing
9……..	9.Tests software to ensure it runs smoothly and does not cause system errors.	I. Speed and Cycle Time
10…..	10.Measures the machine's performance in terms of output and efficiency.	J. Energy Consumption
11…….	11.Assesses how much energy the machine consumes during operation	K. Reliability L. credibility M. CAD

2. Read carefully the following statements related to industrial machines maintenance and circle the letter corresponding to right answer

I. What is the primary goal of controlling machines in production processes?

A) To reduce energy consumption
B) To ensure that machines are operating at their optimal performance levels
C) To increase the number of operators required
D) To manually adjust machine parameters for every product batch

II. Which of the following is a key benefit of monitoring industrial machines' operation?

A) Prevents human intervention in machine processes
B) Helps identify issues before they lead to machine breakdowns
C) Increases the complexity of machine control systems
D) Reduces the need for machine maintenance

III. Real-Time Data Collection is important because it:

A) Allows for immediate response to machine faults
B) Slows down the production process
C) Only works for energy monitoring
D) Reduces the need for quality control measures

Practical assessment

XYZ Manufacturing Ltd Located in KIGALI City is a company which produce manufacturing machine parts. They use company's milling machine to produce a metal block to the specific dimensions and features. Ask trainees to set and test milling machine parameters.

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Indicative contents
3.1 Introduction to machine maintenance **3.2 Diagnosing machines faults** **3.3 Performing predictive maintenance** **3.4. Performing corrective maintenance** **3.5. Performing post maintenance activities.**

Key Competencies for Learning Outcome 3: Preform Industrial Machines Maintenance

Knowledge	Skills	Attitudes
• Description of the industrial machine maintenance types • Description of the maintenance report	• Diagnosing industrial machine faults • Performing predictive maintenance • Performing corrective maintenance • Cleaning the repaired equipment and work place • Storing tools and equipment used during maintenance activities • Writing report for maintenance	• Having ability to pay attention to details during diagnosis of industrial machine faults • Being punctual while maintaining industrial machines • Being hard worker while maintaining industrial machines • Being responsible during maintenance of industrial machines • Being proactive to problem solving during maintenance of industrial machines • Having self-confidence during maintenance of industrial machines • Being continuously updated to new machine technology

Duration: 20 hrs

Learning outcome 3 objectives:

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

1. Describe clearly the types of maintenance for industrial machines in accordance with maintenance manual
2. Diagnosing properly the industrial machine faults in accordance with maintenance manual
3. Perform properly the predictive maintenance of industrial machines in accordance with maintenance manual of a machine
4. Perform properly the corrective maintenance according to the diagnosed fault and maintenance manual of machine
5. Clean properly the repaired equipment and workplace in accordance with environmental regulations
6. Store properly the tools and equipment as per store regulations
7. Describe clearly the maintenance report according to the report procedures
8. Write correctly the maintenance report according to the report procedures

Resources

Equipment	Tools	Materials
• PPEs (overall, gloves, safety shoes, helmet, safety glasses, earmuff, face mask) • Air compressor, • Grease gun • grease pump • Lubrication pumps • Dustpan • Toolbox • Forklift • Crane • Jack • Welding machine	• Rivet gun • Staple gun • Zip ties • Pry bars • Chisels • Punches • Scraper set • Wire strippers • Wire crimpers • Multimeter • Wire brush set • Grease gun • Oil can • Lubrication brush • Gear puller	• Lubricants • Oils • cleaning agents • Coolants and freeze • Grease • Water • Solvents • Gasoline • Gasoil • Petrol • Electrodes • Gas

	• bearing puller • Stud extractor set • Toolbox or tool chest • Tool organizer • Trays • Magnetic parts • tray Tool • pouch or belt • Flashlight or headlamp • Inspection mirror • Magnet • pickup tool • Telescoping magnet tool • Hacksaw • Utility knife • Bolt cutters • Tin snips • Tape measure • Combination square • Digital calipers • Measuring tape • Dial indicator set • Wrenches • Screwdrivers • Pliers • Hammers	

Indicative content 3.1: Introduction to Machine Maintenance

Duration: 1 hr

Theoretical Activity 3.1.1: Description of industrial machine maintenance

Tasks:

1: Answer the following questions related to industrial machine maintenance

i. What do you understand by the term machine maintenance?
ii. What should be the types of industrial machine maintenance?

2: Provide answers to the asked questions and write them on papers or flipcharts

3: Present the answers to the whole class.

4: Read the key readings 3.1.1 for more clarification,

Key readings 3.1.1: Description of industrial machine maintenance

- **Industrial machine maintenance**

Industrial machine maintenance is a critical aspect of ensuring optimal production efficiency and minimizing downtime. It involves a range of strategies to maintain the health and functionality of machinery.

✓ **Types of Industrial machine maintenance**

Corrective maintenance

Corrective maintenance is carried out immediately after the detection of a defect on a piece of equipment or on a production line. The objective is to get the equipment back in working order so that it can perform its function again as quickly as possible.

Corrective maintenance is rarely planned, except when a maintenance plan has been established beforehand.

This type of maintenance is less commonly used predictive maintenance because it inevitably leads to breakdowns and failures.

Predictive maintenance

Predictive maintenance is done to identify when an equipment failure is likely to occur and then prevent that failure by performing maintenance just before the breakdown occurs.

An effective predictive maintenance strategy requires the ability to monitor the condition of equipment. Technicians use technologies such as vibration analysis, oil and fluid analysis, noise analysis and thermography.

When done properly, this type of maintenance provides significant benefits:

- Reduction of equipment maintenance time
- Minimize lost production hours due to maintenance
- Reduced cost of purchasing replacement parts

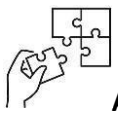
Predictive maintenance ensures that equipment requiring maintenance is only shut down just before an impending failure. This reduces the time and total cost of equipment maintenance. But even the slightest error in judgment can result in equipment failure. At your own risk!

✓ **Difference between Corrective Maintenance and Predictive Maintenance**

SN	Feature	Corrective Maintenance	Predictive Maintenance
1.	Timing	After a failure	Before a failure
2.	Approach	Reactive	Proactive
3.	Cost	Higher due to unexpected downtime and repairs	Lower due to planned maintenance and prevention of failures
4.	Efficiency	Lower due to unplanned downtime	Higher due to optimized maintenance schedules

Points to Remember

- Both predictive maintenance and corrective maintenance must be planned to ensure optimal production efficiency and minimize downtime of a machine
- Ensure that data collected for predictive maintenance is accurate and reliable to make informed decisions.
- Maintenance intervals should be appropriately determined based on equipment usage, operating conditions, and manufacturer recommendations.
- Invest in training for maintenance personnel to ensure they have the necessary skills and knowledge to effectively perform both corrective and predictive maintenance tasks.



Application of learning 3.1.

Go to manufacturing workshop of your school, observe how industrial machine maintenance is done and ask clarifications on machine maintenance to the workshop assistant.
Make a summary report of acquired knowledge

Indicative content 3.2: Diagnosing Machines Faults

Duration: 6 hrs

Practical Activity 3.2.1: Diagnosing industrial machines faults

Task:

Go to the manufacturing workshop of your school and diagnose the available industrial machine which is not starting. Identify and analyse root cause of fault with respect to the trainer demonstration. This task should be done individually.

1: Apply safety precautions
2: perform diagnosing of the machine fault.
3: Present the found machine fault to the trainer
4: Read the key reading 3.2.1
5: Perform the task provided in application of learning 3.2.

Key readings 3.2.1: Diagnosing industrial machines faults

- **Introduction to machine diagnosis**
  - ✓ **Diagnosis**: refers to the process of identifying the specific cause of a machine's malfunction or failure. It involves analyzing symptoms, gathering data, and using diagnostic tools to pinpoint the underlying problem. This information is essential for determining the necessary corrective action and preventing future breakdowns.
  - ✓ **Machine maintenance manual:** is a comprehensive document that provides detailed instructions and guidelines for the proper care and maintenance of a specific industrial machine. It typically includes:
    - **Operating procedures:** Step-by-step instructions for starting, stopping, and operating the machine safely.
    - **Maintenance schedules:** Recommended intervals for routine maintenance tasks, such as oil changes, inspections, and replacements.
    - **Troubleshooting guides:** Procedures for diagnosing and resolving common problems.

- **Parts diagrams and lists:** Illustrations and specifications of machine components for easy identification and replacement.
- **Safety information:** Warnings and precautions to ensure the safety of operators and technicians.

- **Procedures of diagnosing industrial machines faults**

Step 1: **Interpreting maintenance manual** involves understanding the instructions and guidelines provided for the care and upkeep of a specific machine or equipment.

- ✓ **Standard operating procedure** are detailed instructions that outline the steps involved in performing specific tasks. For industrial machine inspection, SOPs provide a standardized framework to ensure consistency, safety, and efficiency
- ✓ **Inspection of industrial machines:** Check for obvious signs of damage, leaks, corrosion, or excessive wear.
- ✓ **Machine warning signs:** check for unusual noises (e.g., grinding, squealing, knocking), excessive vibrations, overheating, leaks, decreased performance, or error messages**.**

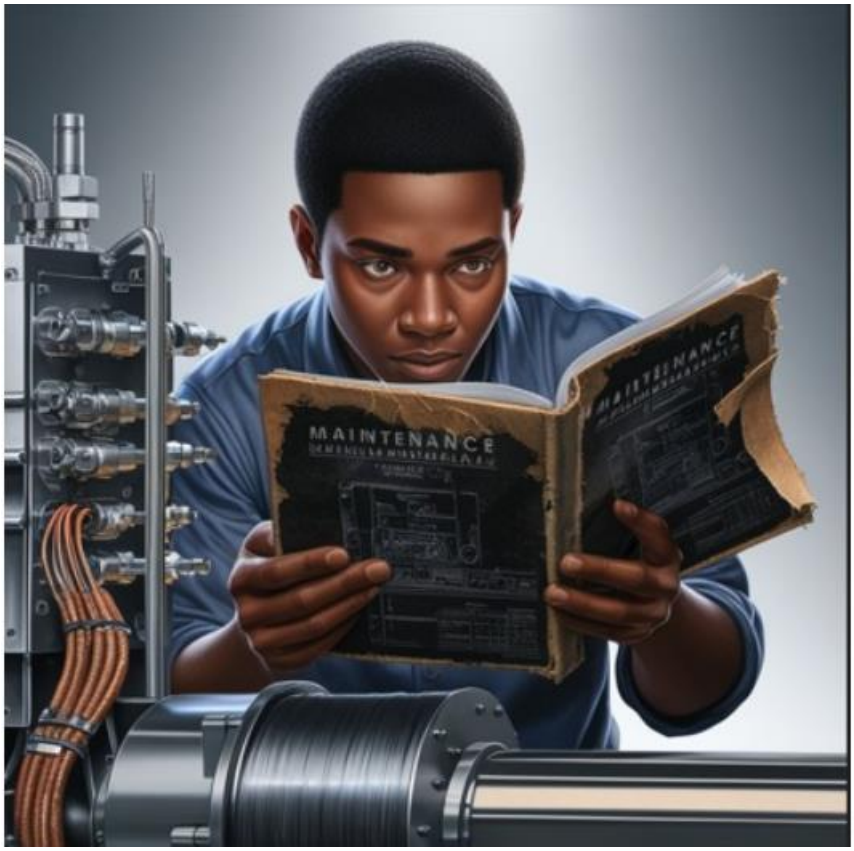


Fig: Interpreting maintenance manual

Step 2: **Apply methods of faults diagnosis**

- ✓ **Identify the Problem by** looking for unusual noises, vibrations, leaks, or

changes in performance.

- ✓ **Gather Information by** consulting historical data, interview operators and check environmental conditions like temperature, humidity, and power supply stability.
- ✓ **Perform a Visual Inspection by l**ooking for signs of wear, damage, or abnormalities like loose connections, corrosion, or misalignment and checking for leaks.

Fig: Apply methods of faults diagnosis

- ✓ **Use Diagnostic Tools:**
  - **Vibration analysis:** Measure vibrations to detect imbalances, misalignment, or bearing problems.
  - **Temperature monitoring:** Use infrared thermography to identify overheating components.
  - **Oil analysis:** Test oil samples for contaminants, wear particles, and changes in viscosity.
  - **Acoustic emission:** Monitor sound waves to detect faults like crack propagation or bearing damage.
  - **Electrical testing:** Use multimeters or oscilloscopes to check for voltage, current, or resistance issues.

Fig: Use Diagnostic Tools

- ✓ **Isolate the Fault by** testing components, checking connections and verifying settings

Step 3: Analysing root cause of faults

- ✓ **Mechanical causes:**
  - **Bearing failure:** Caused by excessive load, contamination, misalignment, or lubrication issues.
  - **Misalignment:** Can result in increased vibration, premature wear, and reduced machine efficiency.
  - **Imbalance:** Can cause excessive vibration, noise, and premature wear of components.
  - **Looseness:** Loose bolts, screws, or connections can lead to vibration, noise, and reduced performance.
  - **Foreign object damage:** Objects that enter the machine can cause damage to components and lead to malfunctions.
- ✓ **Electrical causes:**
  - **Overloading:** Exceeding the machine's rated capacity can cause overheating, component failure, and reduced performance.
  - **Short circuit:** A faulty connection or insulation can cause a short circuit, leading to electrical damage and potential fire hazards.
  - **Open circuit:** A broken, or disconnected circuit can prevent the machine

from functioning properly.

- **Voltage fluctuations:** Fluctuations in the power supply can damage sensitive components and cause intermittent operation.

✓ **Hydraulic and Pneumatic causes:**

- **Contamination:** Contaminants in hydraulic or pneumatic fluids can clog valves, reduce efficiency, and cause component damage.
- **Leakage:** Leaks in hydraulic or pneumatic systems can lead to reduced pressure, loss of fluid, and component damage.
- **Air binding:** Air trapped in hydraulic or pneumatic systems can interfere with the flow of fluid and cause malfunctions.

✓ **Environmental Factors:**

- **Temperature extremes:** Extreme temperatures can cause thermal expansion or contraction of components, leading to misalignment or damage.
- **Humidity:** High humidity can cause corrosion and damage to electrical components.
- **Vibration:** External vibrations can cause damage to components and reduce machine accuracy.

✓ **Human Error:**

- **Improper installation:** Incorrect installation procedures can lead to misalignment, damage, or reduced performance.
- **Lack of maintenance:** Neglecting routine maintenance can result in premature wear, component failure, and increased downtime.
- **Operator error:** Incorrect operation or misuse of the machine can cause damage or malfunction

Fig : Picture showing machine diagnosis

Points to Remember

- During diagnosis of industrial machine faults always pay attention to all details in order to discover the main fault
- Make sure that machine parts are not disturbed during diagnosis of industrial machine faults to avoid new faults
- Once the root cause of machine fault is detected, provide the recommendation to the machine operator to prevent future machine breakdown

Application of learning 3.2.

You are requested to go to the manufacturing workshop of the school and perform the diagnosis of the available industrial machine which is in abnormal working condition to discover its fault and its root cause.

Indicative content 3.3: Performing Predictive Maintenance

Duration: 5 hrs

Practical Activity 3.3.1: Performing predictive maintenance of industrial machine

Task:

Go to the manufacturing workshop of your school and conduct a predictive maintenance on the available industrial machine which has been experiencing intermittent tool breakage and decreased accuracy to solve the machine issues and to recommend a maintenance plan for optimal machine performance with respect to the trainer demonstration. This task should be done individually.

1: Apply safety precautions
2: conduct a predictive maintenance on the machine.
3: Present the work done to the trainer
4: Read the key reading 3.3.1
5: Perform the task provided in application of learning 3.3.

Key readings 3.3.1: Performing predictive maintenance of industrial machine

- **Procedures of performing predictive maintenance of industrial machine**
  Step 1. Apply Lubricate on machine parts is the process of applying oil/greases to reduce friction between two surfaces in relative motion. This reduces wear and tear, heat generation, and noise, ultimately extending the lifespan of the machine.

Fig : Apply Lubricate on machine parts

Step 2. Replace worn parts on the machine involves identifying and removing components that have deteriorated due to wear, tear, or other factors, and substituting them with new or reconditioned parts.

Fig : Replace worn parts on the machine

Step 3: Applying Predictive Techniques

- ✓ **Condition-based monitoring:** This involves continuously monitoring the condition of equipment using sensors and other technologies. By collecting

data on vibration, temperature, pressure, and other parameters, it's possible to detect signs of wear or impending failure.

- ✓ **Predictive modeling:** This involves using statistical and machine learning techniques to analyze historical data and predict future equipment behavior. By identifying patterns and trends, it's possible to forecast potential failures and schedule maintenance accordingly.
- ✓ **Failure mode and effects analysis:** This is a systematic approach to identifying potential failure modes and their effects on equipment performance. By understanding the potential consequences of failures, it's possible to prioritize maintenance activities and allocate resources effectively.

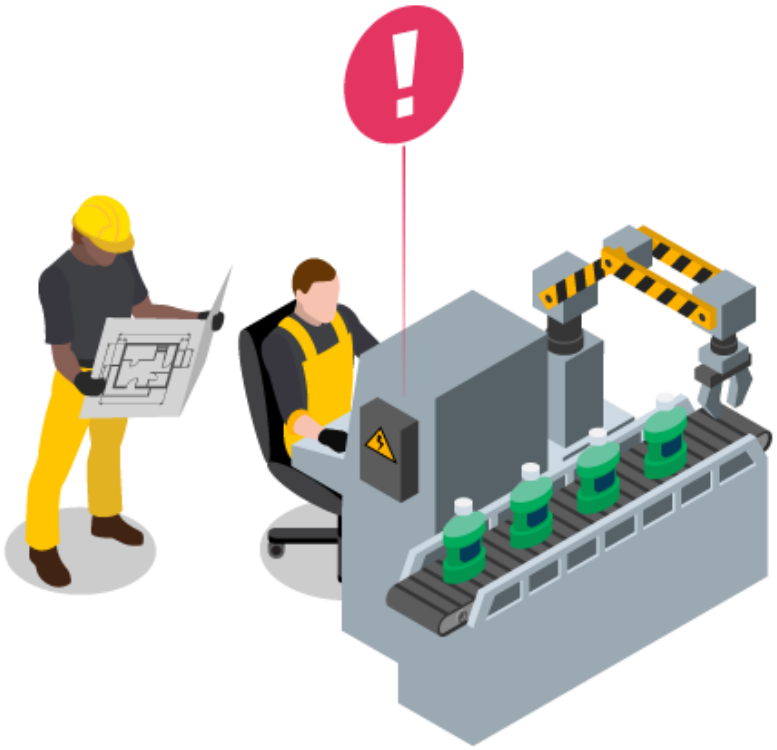
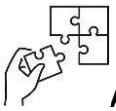


Fig: picture showing a predictive maintenance

Points to Remember

- It is recommended to always consult the machine maintenance manual during predictive maintenance
- During predictive maintenance, ensure that sensors used for data collection are accurate and reliable.

- During predictive maintenance, choose predictive models that are suitable for the specific type of equipment and data being analysed.
- Ensure that maintenance personnel have the necessary skills and knowledge to effectively implement and utilize predictive maintenance techniques.



Application of learning 3.3.

You are requested to go to manufacturing workshop of your school where a machine has experienced high friction of machine parts that caused wear and tear in machine parts and exhibited signs of increased vibration, noise, and decreased accuracy and perform the following:

- Apply lubricate machine parts
- Replace worn parts due to wear and tear of machine parts
- Use appropriate predictive maintenance techniques to solve the machine's issues.
- Recommend a maintenance plan to prevent future failures.

Indicative content 3.4: Performing corrective maintenance

Duration: 6 hrs

Practical Activity 3.4.1: Performing corrective maintenance on industrial machines

Task:

Go to the manufacturing workshop of your school and conduct a corrective maintenance on the available industrial machine which has been experiencing a misalignment of parts and gears which caused excessive vibration and noise to solve those machine issues with respect to the trainer demonstration. This task should be done individually.

1: Apply safety precautions
2: conduct a corrective maintenance on the machine.
3: Present the work done to the trainer
4: Read the key reading 3.4.1
5: Perform the task provided in application of learning 3.4.

Key readings 3.4.1 Performing corrective maintenance on industrial machines

- **Steps involved in corrective maintenance on industrial machines**

Step 1. Detecting the Faults: Identifying the signs of a malfunction through visual inspections, diagnostic tools, and symptom recognition.

- ✓ Recognizing the signs of a malfunction, such as unusual noises, vibrations, leaks, or performance issues.
- ✓ Using tools like multimeters, oscilloscopes, or specialized diagnostic software to pinpoint the exact problem.
- ✓ Conducting a thorough examination of the equipment for physical damage, wear, or corrosion.

Fig: Detecting the Faults

Step 2. Repairing Faulty Parts: replacing or repairing damaged components.

- ✓ If the faulty part can be easily replaced, it's often the most straightforward solution.
- ✓ In some cases, the faulty part can be repaired, such as fixing a broken wire or resurfacing a worn component.
- ✓ For expensive or critical components, components refurbishment may be a cost-effective option. It involves repair, clean, and recondition the component

Fig: Repairing Faulty Parts

Step 3. Aligning and Calibrating New Parts: Ensuring proper alignment and calibration of new or repaired parts.

- ✓ Ensuring that new or repaired parts are properly aligned with other components to prevent misalignment and excessive wear.
- ✓ Adjusting equipment settings to ensure accurate and consistent performance. This is particularly important for precision machinery.

Fig: Aligning and Calibrating New Parts

Step 4. Testing the Repaired Equipment: Verifying that the repaired equipment is functioning correctly and safely.

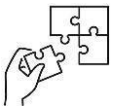
- ✓ **Functional testing:** Verifying that the repaired equipment is operating as

intended and meeting performance specifications.

- ✓ **Load testing:** Simulating real-world operating conditions to ensure the equipment can handle the expected workload.
- ✓ **Safety testing:** Checking for any potential hazards or safety issues that may have been introduced during the repair process.

Points to Remember

- While performing corrective maintenance, always wear appropriate PPEs inorder to maintain your safety
  - Ensure that the machinery is isolated from power sources before beginning work.
  - Consult the machine's maintenance manual for specific instructions and procedures regarding corrective maintenance.
  - Keep a record of the maintenance performed, including the date, time, and any issues encountered.
  - Always test the repaired machine to ensure it is functioning properly before returning it to service.



Application of learning 3.4.

You are requested to go to manufacturing workshop of your school where a machine has experienced Gearbox problems of wear, misalignment, and lubrication issues that caused gearbox failures and perform the following:

- Detect the faults' location
- Repair and replace the faulty parts
- Align and calibrate new part repaired
- Test the repaired machine

Indicative content 3.5: Performing Post Maintenance Activities

Duration: 2 hrs

Practical Activity 3.5.1: Performing post maintenance activities after industrial machine maintenance.

Task:

Go to the manufacturing workshop of your school where maintenance activity of industrial machines took place and perform the following tasks:

- Clean the repaired equipment
- Clean the workplace
- Store the tools used during maintenance
- Write a maintenance report

1: Apply safety precautions
2: perform the following tasks (Clean the repaired equipment, Clean the workplace, Store the tools used during maintenance, Write a maintenance report)
3: Present the work done to the trainer
4: Read the key reading 3.5.1
5: Perform the task provided in application of learning 3.5.

Key readings 3.5.1: Performing post maintenance activities after industrial machine maintenance.

- **Post maintenance activities**

Once corrective maintenance is complete, it's essential to perform post-maintenance activities to ensure the equipment is ready for operation and that the maintenance process is documented properly.

Here's a breakdown of these activities:

Activity 1. Clean the Repaired Equipment and Workplace:

- ✓ **Remove debris and contaminants:** Clean away any dirt, grease, or other substances that may have accumulated during the maintenance process.
- ✓ **Restore the workplace:** Return the workplace to its original condition, ensuring

that it is safe and organized.

Fig: cleaning the workplace

Activity 2. Store Tools and Equipment:

- ✓ **Proper storage:** Store tools and equipment in their designated locations to prevent damage and loss.
- ✓ **Maintenance of tools:** Ensure that tools are properly maintained and cleaned for future use.

Fig: storing of tools

Activity 3. Document the Work Done:

- ✓ **Maintenance reports:** Create detailed maintenance reports that document the work performed, any issues encountered, and the parts replaced.
- ✓ **Record keeping:** Maintain accurate records of maintenance activities for future reference and compliance purposes.

Types of Maintenance Reports

- **Daily maintenance reports:** Record routine inspections, maintenance tasks, and any issues encountered on a daily basis.
- **Weekly/monthly maintenance reports:** Summarize maintenance activities over a specified period.
- **Incident reports:** Document any unexpected equipment failures or safety incidents.
- **Corrective action reports:** Outline steps taken to address identified problems.

Components of a Maintenance Report

- **Equipment identification:** Clearly identify the equipment being serviced.
- **Maintenance date and time:** Record the start and end times of the maintenance activity.

- **Maintenance personnel:** List the names of the technicians involved.
- **Work performed:** Describe the specific tasks completed, including part replacements and adjustments.
- **Issues encountered:** Note any problems or challenges faced during the maintenance process.
- **Recommendations:** Suggest any preventive measures or future maintenance needs.

Activity 4. Writing Maintenance Report Procedures

- ✓ **Clarity and conciseness:** Use clear and concise language to effectively convey information.
- ✓ **Consistency:** Adhere to a consistent format for all maintenance reports.
- ✓ **Accuracy:** Ensure that all information is accurate and up to date.
- ✓ **Completeness:** Include all relevant details, such as part numbers, serial numbers, and maintenance history.
- ✓ **Timeliness:** Submit maintenance reports promptly to ensure timely record-keeping.

Fig: writing a maintenance report

Points to Remember

- While performing cleaning activities, always wear appropriate PPEs in order to maintain your safety
  - Ensure that the machines are isolated from power sources before beginning cleaning works for ensuring your safety.
  - Consult the machine's maintenance manual for specific instructions and procedures regarding to cleaning-maintained equipment, cleaning workplace and storing tools used.
  - After their lubrication, store tools and equipment in their designated locations to prevent damage and loss.

Application of learning 3.5.

You are requested to go to your manufacturing workshop of your school where a corrective maintenance of the machines have been done and perform the post maintenance activities. You are tasked to:

- Clean the repaired equipment and workplace
- Store tools and equipment used
- Writing maintenance report

Learning outcome 3 end assessment

Theoretical assessment

1. Read the following statements related to maintenance of industrial machines and answer by **True** if it is a correct statement or **False** if it is a wrong statement**:**
   I. Predictive maintenance is a reactive approach to equipment maintenance.
   II. A machine maintenance manual only includes safety information.
   III. Predictive maintenance mainly aims at replacing worn parts.
   IV. Corrective maintenance is always the only most effective way to prevent equipment failures.
   V. Post-maintenance activities should be performed for all maintenance tasks
2. Read carefully the following statements related to industrial machines maintenance and circle the letter corresponding to right answer
   I. The primary benefit of predictive maintenance is:
      a) Increased equipment downtime
      b) Higher maintenance costs
      c) Reduced equipment failures
      d) Lower production efficiency
   II. The following is not a method of fault diagnosis
      a) Vibration analysis
      b) Temperature monitoring
      c) Oil analysis
      d) Machine maintenance manual
   III. The following is not a predictive maintenance technique
      A. Condition-based monitoring
      B. 3-4-5 method
      C. Predictive modeling
      D. Failure mode and effects analysis
   IV. The following is not a step involved in corrective maintenance
      A. Detecting the faults
      B. Replacing faulty parts
      C. Aligning and calibrating new parts
      D. Preventive maintenance
   V. the following is not a type of maintenance report?
      A. Daily maintenance report
      B. Weekly/monthly maintenance report
      C. Incident report
      D. Original maintenance report

3. Read carefully the following sentences related to industrial machines maintenance and complete the empty spaces using the appropriate word from the following words**(before, faulty, after, correct, during, cables, fluid, friction, parts, aligned, failure, straight clarity)**

i. Corrective maintenance is typically carried out …… a breakdown occurs.
ii. A short circuit can be caused by a ……. connection or insulation.
iii. Lubricating machine parts helps to reduce …….
iv. To ensure proper alignment and calibration, new or repaired parts should be……with other components.
v. Maintenance reports should be written with ……, consistency, accuracy, completeness, and timeliness.

4. Observe carefully the table below containing three columns. Match Column B (**mixed Corrective and predictive Maintenance tips**) with Column C (**type of maintenance**) and write the letter corresponding to the right answer in the Column A (**Answer**)

Column A (Answer)	**Column B (mixed Corrective and predictive Maintenance tips)**	**Column C (type of maintenance)**
1……	1.After a failure	A. predictive maintenance
2…….	2. Proactive	B. corrective maintenance
3…….	3.Higher due to unexpected downtime and repairs	
4…….	4. Higher due to optimized maintenance schedules	
5……	5.Before a failure	
6……..	6. Reactive	
7……	7.Lower due to planned maintenance and prevention of failures	
8……..	8. Lower due to unplanned downtime	

Practical assessment

ABC Manufacturing Ltd Located in Kigali city is a company which produce Automotive parts. The company's CNC milling machine has been experiencing intermittent breakdowns, resulting in production delays and increased costs. Upon investigation, it was determined that the machine's control system is faulty. As a manufacturing technician, you are tasked with diagnosing and repairing the control system to restore the machine's functionality in 8hours. Your tasks are to:

1. Gather information by collecting data on the machine's recent performance, error messages, and maintenance history.
2. Inspect the control system by Visually inspect the control cabinet for any signs of damage, loose connections, or corrosion.
3. Test the control system by using a multimeter to measure voltages, currents, and resistances in the control circuit.
4. Diagnose the fault by analyzing the collected data and testing results to identify the specific cause of the control system failure.
5. Repair or replace components based on the diagnosis, repair or replace faulty components within the control system.
6. Test the machine after completing the repairs and to conduct a thorough test run of the machine to ensure it is operating correctly.

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