

UNIT – II MAINTENANCE ENGINEERING

Introduction

Maintenance Engineering is the discipline and profession of applying engineering concepts to the optimization of equipment, procedures, and departmental budgets to achieve better maintainability, reliability, and availability of equipment. Maintenance engineering is the occupation that uses engineering theories and practices to plan and implement routine maintenance of equipment and machinery. This must be done in conjunction with optimizing operating procedures and budgets to attain and sustain the highest levels of reliability and profit. Maintenance engineers are often required to have knowledge of many types of equipment and machinery. A person working in the field of maintenance engineering must have in-depth knowledge of or experience in basic equipment operation, logistics, probability, and statistics. Experience in the operation and maintenance of machinery specific to a company's particular business is also frequently required. Since the position normally requires oral and written communication with various levels of personnel, excellent interpersonal communication and participatory management skills are also desirable. Maintenance engineering positions require planning and implementing routine and preventive maintenance programs. In addition, regular monitoring of equipment is required to visually detect faults and impend equipment or production failures before they occur. These positions may also require observing and overseeing repairs and maintenance performed by outside vendors and contractors. In a production or manufacturing environment, good maintenance engineering is necessary for smooth and safe daily plant operations.

Maintenance engineers not only monitor the existing systems and equipment, but they also recommend improved systems and help decide when systems are outdated and in need of replacement. Such a position often involves exchanging ideas and information with other maintenance engineers, production managers, and manufacturing systems engineers. Maintenance engineering not only requires engineers to monitor large production machine operations and heavy-duty equipment, but also often requires involvement with computer operations. Maintenance engineers may have to deal with everything from PCs, routers, servers, and software to more complex issues like local and off-site networks, configuration systems, end user support, and scheduled upgrades. Supervision of technical personnel may also be required. Good

maintenance engineering is vital to the success of any manufacturing or processing operation, regardless of size. The maintenance engineer is responsible for the efficiency of daily operations and for discovering and solving any operational problems in the plant.

Maintenance

Definition: “Maintenance is a routine and recurring activity of keeping a particular machine or facility at its normal operating condition so that it can deliver its expected performance or service without causing any loss of time on account of accidental damage or breakdown”.

- Once equipment is designed, fabricated and installed, the operational availability of the same is looked after by the maintenance requirement. The idea of maintenance is very old and was introduced along with the inception of the machine. In the early days, a machine was used if it worked. When it stopped working, it was either repaired/serviced or discarded.
- The high-cost sophisticated machines need to be properly maintained/serviced during their entire life cycle for maximizing their availability. The development of mechanization and automation of production systems and associated equipment, with the accompanying development of ancillary services and safety requirements, has made it mandatory for engineers to think about proper maintenance of equipment.
- Maintenance function also involves looking after the safety aspects of certain equipment where the failure of component may cause a major accident. For example, a poorly maintained pressure vessel such as steam boilers may cause a serious accident.

Objectives of maintenance

The objectives of maintenance should be formulated within the framework of the overall organizational set-up so that finally the goals of the organization are accomplished. For this, the maintenance division needs to ensure that:

- (a) The machinery and/or facilities are always in an optimum working condition at the lowest possible cost
- (b) The time schedule of delivering to the customers is not affected because of non-availability of machinery /service in working conditions

- (c) The performance of the machinery /facility is dependable and reliable.
- (d) The performance of the machinery /facility is kept to minimum to the event of the breakdown.
- (e) The maintenance cost is properly monitored to control overhead costs.
- (f) The life of equipment is prolonged while maintaining the acceptable level of performance to avoid unnecessary replacements.

Maintenance is also related to profitability through equipment output and its running cost. Maintenance work enhances the equipment performance level and its availability in optimum working condition but adds to its running cost. The objective of maintenance work should be to strike a balance between the availability and the overall running costs. The responsibility of the maintenance function should, therefore, be to ensure that production equipment /facilities are available for use for maximum time at minimum cost over a stipulated period such that the minimum standard of performance and safety of personnel and machines are not sacrificed. These days, therefore, separate departments are formed in industrial organizations to look after the maintenance requirements of equipment and machines.

Primary Functions of Maintenance

1. **Preventing Equipment Downtime:** The primary function of maintenance is to prevent equipment downtime. Downtime can result in significant losses for an organization, including reduced productivity, missed deadlines, and increased costs. Regular maintenance ensures that equipment is operating efficiently and effectively, reducing the likelihood of downtime due to equipment failure.
2. **Maximizing Asset Life:** Another primary function of maintenance is to maximize the life of an organization's assets. Proper maintenance can help to extend the life of equipment, reducing the need for costly replacements and repairs. This can lead to significant cost savings for the organization over the long term.
3. **Improving Safety:** Maintenance also plays a critical role in improving safety in the workplace. Regular maintenance can identify potential safety hazards, such as faulty equipment or systems, and take corrective action before accidents occur. This can help to minimize the risk of injuries and accidents in the workplace.

4. **Enhancing Equipment Performance:** Maintenance can also enhance equipment performance. Regular maintenance can help to optimize equipment performance, ensuring that it operates at peak efficiency. This can lead to increased productivity, improved quality, and reduced costs.

Secondary Functions of Maintenance

1. **Cost Reduction:** Maintenance can also help to reduce costs for an organization. Regular maintenance can identify potential issues with equipment early, allowing for timely repairs and replacements, which can be less expensive than waiting until the equipment fails. This can also help to minimize downtime, which can be costly for the organization.
2. **Regulatory Compliance:** Maintenance can also help to ensure regulatory compliance. Many industries have regulations and standards that organizations must comply with, including maintenance requirements. Regular maintenance can help to ensure that the organization is meeting these requirements, reducing the risk of penalties and fines.
3. **Environmental Sustainability:** Maintenance can also play a role in promoting environmental sustainability. Regular maintenance can identify opportunities for energy efficiency improvements and waste reduction, helping to reduce the organization's environmental footprint.
4. **Asset Management:** Maintenance can also play a critical role in asset management. Proper maintenance can help to ensure that assets are being used efficiently and effectively, reducing the need for additional investments in new equipment or facilities.

Responsibility of maintenance department

The responsibilities of a maintenance department involve the coordination and supervision of the plant or facility's maintenance. The maintenance department ensures that everything runs smoothly and at optimal performance.

The responsibilities of a maintenance department involve, but is not limited to:

- Make sure machines are operating properly to prevent the machines from potentially breaking

- Maximize the availability and reliability of all operating systems
- Maintaining operating systems and machines or equipment prevents safety issues and performance capability
- Work with a team to make sure production goals are met while also supporting the efforts of other departments
- Provide efficient maintenance and repair services
- Provide the previously listed tasks while staying within a designated budget

The maintenance department requires the efficiency and cooperation of many departments within the plant or facility to provide the expected efficiency.

DIFFERENT TYPES OF MAINTENANCE

There are 7 main ways companies take care of their equipment, and they can be either proactive or reactive. The choice you make can affect your business in terms of cost and effectiveness. Picking the right maintenance strategy is crucial because it impacts your customers, and the overall cost compared to the benefits.

1. Preventive Maintenance

Preventive maintenance, or PM refers to the regular upkeep of equipment while it's still functional. It aims to minimize the risk of future failures by proactively addressing potential issues.

There are 2 main approaches to PM:

- **Time-based PM:** This involves scheduling maintenance tasks at predetermined intervals, regardless of how often the equipment is used. These intervals can be based on factors like calendar time, operating hours, or production cycles.
- **Meter-based PM:** This approach triggers maintenance based on the actual usage of the equipment. Tasks are scheduled after reaching specific usage milestones, such as a certain number of operational hours or production cycles completed.

2. Reactive Maintenance

Unlike preventive maintenance, reactive maintenance is essentially waiting until something breaks down before fixing it. Because of the unpredictable nature of breakdowns, it's hard to forecast how much reactive maintenance will cost. While reactive maintenance might be the ideal plan for a small, inconsequential piece of equipment, like a lightbulb, it's not recommended for more important machinery.

3. Corrective Maintenance

Corrective maintenance involves fixing things when a problem presents itself. The main aim is to get things back to normal quickly. Unlike preventive maintenance, there's no schedule for fixing things in advance – it only happens when there's something wrong. For example:

- Fixing an HVAC unit that's broken down.
- Fixing a new hole in the wall of a building.
- Replacing a fleet vehicle's damaged tire.

4. Condition-Based Maintenance

Condition-based maintenance is all about focusing on outcomes by measuring or observing the performance of machines. Machines operate within a normal range of conditions, where their performance is acceptable. However, when they start operating near the limits of this range, maintenance might be necessary.

5. Predictive Maintenance

Predictive maintenance is like condition-based maintenance but smarter. Instead of just waiting for something to go wrong, it analyses historical asset data to accurately predict future problems. For example, in condition-based maintenance, you wait until the engine temperature goes above a certain level before doing maintenance. You only pay attention to the sensor when it's outside of normal ranges. However, with predictive maintenance, the software is always observing and analysing collected data using complex algorithms to find clues about potential issues. So, even if the engine temperature seems fine, the software can detect early signs of trouble and trigger maintenance before problems occur.

6. Routine Maintenance

Routine maintenance involves regular, planned tasks aimed at identifying and preventing potential issues. It is generally performed as part of ongoing maintenance procedures and does not typically require specialized training or equipment. For instance, the daily safety checklists completed by machine operators are a form of routine maintenance.

7. Prescriptive Maintenance

Prescriptive maintenance builds upon predictive maintenance by incorporating advanced tools such as condition monitoring and machine learning algorithms. It not only predicts when maintenance should occur but also provides specific instructions on the type of maintenance required to optimize equipment performance and longevity.

TYPES OF MAINTENANCE TOOLS

Depending on your specific tasks, you may require a variety of different tools. These are some of the most common tools that maintenance professionals use:

1. Safety gear

Safety gear is an important part of maintenance equipment. It ensures the protection of maintenance workers when using chemicals and power tools. These are some pieces of safety gear that are useful for maintenance employees:

- **Gloves:** Gloves are useful for protecting employees who commonly use cleaning chemicals, sealants, lubricants and adhesives.
- **Safety goggles:** Eye protection can help maintenance professionals avoid injury when working with chemicals or sanding.
- **Ear protection:** Many maintenance employees use loud power tools and ear protection can help them avoid hearing loss.
- **Dust masks and respirators:** Dust masks and respirators can help maintenance professionals avoid inhaling chemical fumes, dust and other particles while working.

2. Storage equipment

Maintenance professionals usually need a place to safely store the tools that they use in their daily work. They may also require travel equipment if they work in multiple locations. These are some pieces of equipment that maintenance professionals can use to store their tools and supplies:

- Toolboxes: Toolboxes are small portable cases that allow maintenance professionals to store and transport their gear.
- Shelving units: Shelving units are a useful way to organize tools and supplies in a permanent shop setting.
- Lockers: Many maintenance professionals use lockers to safely store and organize large equipment and chemicals.
- Tool belts: Tool belts are a good way for maintenance professionals to transport their tools and to carry them while they work.

3. Power tools

Power tools are often an essential part of maintenance work. They allow professionals to complete tasks effectively with minimal effort in less time. These are some important power tools for maintenance professionals:

- Power drills: Power drills allow maintenance professionals to drill holes and drive screws using a variety of interchangeable bits.
- Orbital sanders: Power sanders use rapid rotary motion and replaceable sanding pads to smooth surfaces, including wood, paint and varnish.
- Circular saws: Circular saws allow maintenance professionals to easily cut a wide variety of materials, including wood, plastic, plywood and sometimes metal.
- Impact wrenches: Impact wrenches are power tools that allow maintenance employees to tighten and remove nuts and bolts.

4. Hand tools

While power tools are important, many maintenance professionals use a variety of hand tools in their daily work. These tools have the advantage of not requiring power sources and are often more portable. These are some of the most common hand tools for maintenance professionals:

- **Screwdrivers:** Screwdrivers are common tools that allow maintenance employees to tighten and remove screws during repair, construction and assembly.
- **Hammers:** Many maintenance professionals use hammers to drive and remove nails.
- **Crescent wrenches:** Crescent wrenches are common hand tools that allow professionals to tighten and remove nuts and bolts with hexagonal heads.
- **Hand saws:** Many maintenance professionals use hand saws and hacksaws to cut materials such as wood, metal and plastic.

5. Electrical tools

While electricians normally complete most electrical maintenance and repair, some maintenance professionals complete minor electrical repairs. This can include installing lighting fixtures, outlets and switches and replacing light bulbs. These are some electrical tools that maintenance employees might use:

- **Wire and cable strippers:** These tools allow electricians and maintenance professionals to remove the rubber coating from the outside of electrical wires.
- **Multimeters:** Multimeters are tools that can test the functionality of electrical circuits by measuring voltage, resistance and current.
- **Crimpers:** Crimpers are tools that allow maintenance professionals to join wires, connectors and other electrical components.

6. Cleaning supplies

Cleaning is often an important part of maintenance work. Maintenance professionals use a wide variety of supplies to clean interior and exterior surfaces and their tools. These are some common cleaning supplies for maintenance professionals:

- Vacuum cleaners: Maintenance employees often use vacuum cleaners to clean carpets and other surfaces.
- Cleaning chemicals: Maintenance professionals often use a wide range of cleaning chemicals, including bleach, ammonia, degreaser and other surface cleaners.
- Brooms and mops: Brooms and mops are some of the most important tools that maintenance professionals use to clean floors.
- Window washing tools: Window washing is often an important part of maintenance and custodians often keep window scrubbers, squeegees and extension handles for this task.

7. Landscaping equipment

Maintenance work often involves working indoors and outdoors. Professionals who provide maintenance services often require a variety of specialized tools for mowing lawns, trimming trees and other landscaping tasks. These are some common landscaping tools for maintenance professionals:

- Lawnmowers: Maintenance professionals use a variety of push and riding lawnmowers to cut grass on their properties.
- Trimmers: Trimmers are tools that allow professionals to cut grass and trim plants in hard-to-reach areas.
- Aerators: Aerators are tools that remove small plugs of soil from the ground to increase irrigation and fertilization.
- Clippers: Maintenance employees often use different types of clippers to trim hedges, trees and other plants.

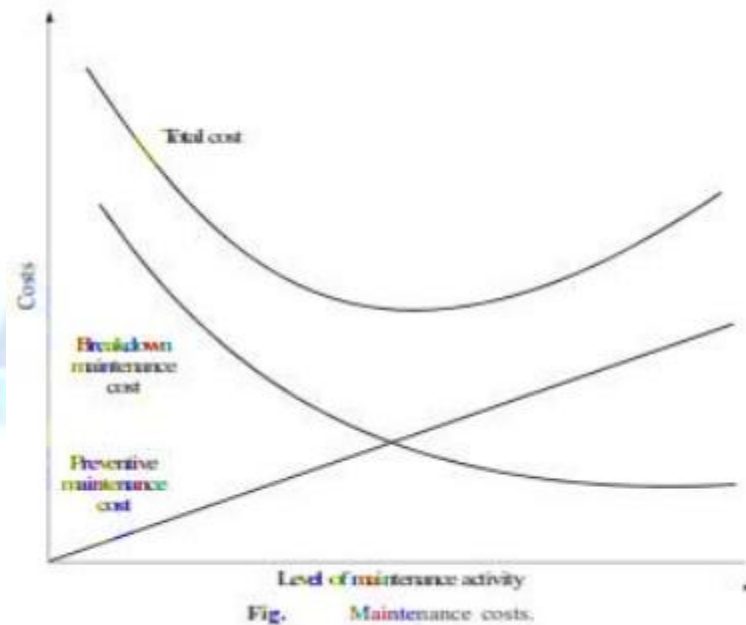
Maintenance activity

Maintenance activity can be classified into two types:

- ü Preventive maintenance and
- ü Breakdown maintenance.

- Preventive maintenance (PM) is the periodical inspection and service activities which are aimed to detect potential failures and perform minor adjustments or repairs which will prevent major operating problems in future.
- Breakdown maintenance is the repair which is generally done after the equipment has attained down state. It is often of an emergency nature which will have associated penalty in terms of expediting cost of maintenance and down time cost of equipment.

Preventive maintenance will reduce such cost up to a point. Beyond that point, the cost of preventive maintenance will be more when compared to the breakdown maintenance cost. The total cost, which is the sum of the preventive maintenance cost and the breakdown maintenance cost, will go on decreasing with an increase in the level of maintenance up to a point. Beyond that point, the total cost will start increasing. The level of maintenance corresponding to the minimum total cost is the optimal level of maintenance. The concepts are demonstrated in Fig



Types of Replacement Problem

Replacement study can be classified into two categories:

(a) Replacement of assets that deteriorate with time (Replacement due to gradual failure, or wear and tear of the components of the machines). This can be further classified into the following types:

- (i) Determination of economic life of an asset.
- (ii) Replacement of an existing asset with a new asset.

(b) Simple probabilistic model for assets which fail completely (replacement due to sudden failure).

Determination of Economic Life of an Asset

Any asset will have the following cost components:

- ü Capital recovery cost (average first cost), computed from the first cost (purchase price) of the machine.
- ü Average operating and maintenance cost (O & M cost). Total cost which is the sum of capital recovery cost (average first cost) and average maintenance cost.

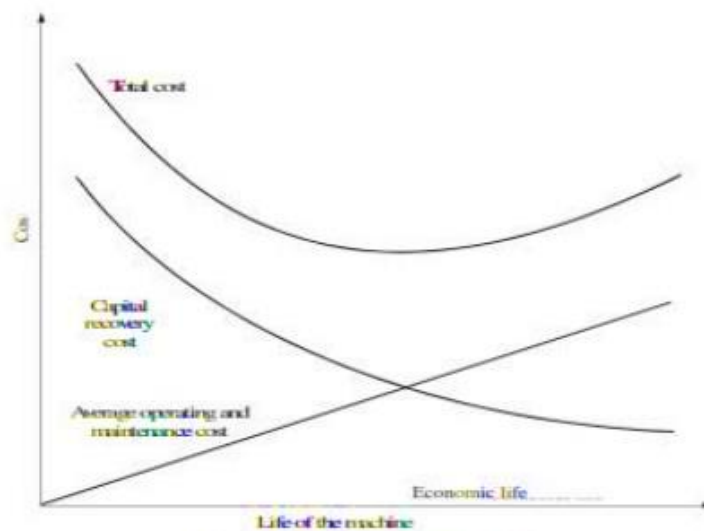


Fig. Chart showing economic life.

SERVICE LIFETIME

Service life is the duration throughout which a product or equipment remains economically useful and functional. It represents the period from acquisition to the point where the asset can no longer be productively used in business operations.

Key Characteristics

Service life encompasses several important aspects:

- Measures the **durability of assets**
- Determines the economic usefulness of equipment
- Helps in planning maintenance and replacement strategies

Definition and Scope

Service life is defined by:

- The length of time an asset can be productively used
- The period during which equipment maintains its basic safety and performance specifications
- The economic duration before replacement becomes more cost-effective than maintenance

Factors Influencing Service Life

Several elements impact the service life of equipment:

- Maintenance quality
- Usage intensity
- Environmental conditions
- Technological advancements
- Availability of spare parts

Practical Considerations

In real-world scenarios, service life can be extended through:

- Regular maintenance
- Periodic refurbishing
- Careful usage
- Strategic repairs

The end of service life occurs when:

- Maintenance costs become prohibitively expensive
- Equipment fails to meet performance specifications
- Replacement becomes more economical than continued use

Businesses use service life calculations to plan budgets, manage inventory, and make strategic equipment replacement decisions.

