UNIT 14: MAINTENANCE MANAGEMENT

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14.1 LEARNING OBJECTIVES

After going through this unit, you will be able to:

- explain the meaning and concept of Maintenance Management
- outline the objectives of Maintenance Management
- describe the different types of Maintenance Management
- explain the criteria for choice of a Maintenance policy
- understand the need and conditions for replacement of machinery
- understand the bath-tub curve and its importance

- understand the concept of reliability in Maintenance
- determine the optimal crew size in a Maintenance Program
- assess the importance of information systems in Maintenance

14.2 INTRODUCTION

Maintenance Management is the application of techniques of operations management to ensure breakdown free and smooth running of all plant and machinery within a facility and controlling the costs of maintenance. Maintenance management ensures improvement in efficiency of a facility by reducing possible loss that may occur by way of sudden faults in operation, frequent breakdowns inviting repairs leading to loss in man and machine hours thereby reducing profitability. Maintenance activities in different machinery are different; which is again different for different equipments within machinery. The heterogeneity of the work adds to the heterogeneity in the type of work man required for attending maintenance jobs. The function is not only complex but also costly. However the necessity of ensuring error free operation necessitates the presence of it mandatorily in any facility.

14.3 OBJECTIVES AND TYPES OF MAINTENANCE

14.3.1 Objectives of Maintenance Management

a) Early detection and diagnosis of problems in machinery within a facility
b) Minimal wear and tear of machinery to ensure enhanced performance of the plant and machinery.
c) Minimise repair time and the cost so involved
d) Ensure error free operation of machinery to prevent accidents costing life of workmen.
e) Attain optimal performance of the plant and machinery thereby reducing non-productive time and attaining economies of scale in performance.

f) Attain goodwill of customers by way of adherence to delivery schedules free from production stops, equipment breakdowns, etc.

g) Achieve profitability with minimal loss in productive time within a facility

h) To pursue policies of replacement of machinery and its parts to have reliability and availability of the facility at minimal costs.

14.3.2 Types of Maintenance

a) Planned Maintenance

b) Preventive Maintenance

c) Breakdown maintenance

d) Predictive Maintenance

These are discused as follows–

(a) Planned Maintenance

Planned maintenance carries out maintenance activities of plant and machinery in a prescribed format to prevent possible occurrences of faults, breakdowns, etc. the practice follows inspection, servicing and overhauling of machinery prior to the alarm of danger (breakdown) rings. The objective is to ensure smooth operation within a facility with minimal stops. Planned maintenance follows the larger premise of a planned shutdown of a facility with conscious attempts of improving on the performance of all stages in an operation. Planned maintenance is religiously practised in continuous industries where a minor error could cause shut down of the entire operation. Planned maintenance is conducted in complete two phases viz., running maintenance and shut down maintenance. Running maintenance is performed in the normal operating condition of the machinery without any halts in production. Shut down maintenance is performed with a complete

overhaul of the plant or its machinery. It is normally performed once in one or two years in continuous processes.

(b) Preventive Maintenance

Under preventive maintenance, maintenance is carried prior to occurrences of its need. It performs maintenance of possible locations of failures through periodic servicing and inspection of machinery. Usual lubricating, cleaning, set-up adjustments and other activities performed at regular intervals and during equipment slowdowns are part of preventive maintenance programs. Preventive maintenance aims at reducing repetitive repairs through identification by inspection of machinery susceptible to breakdowns. It provides a safe working environment to workers through reduced repairs and better control of machinery.

Preventive maintenance maintains the reliable and optimal efficiency at nominal cost of maintenance. It ensures maximum availability of machinery for production.

(c) Breakdown maintenance.

Breakdown maintenance is a rather a reactive program designed to activate on occurrence of breakdowns only. Whenever breakdown of machinery or its parts surfaces maintenance, which begins with repair works, is required to restore normalcy to the machinery and it's functioning. It is an emergency Breakdown maintenance is an expensive program since it is unpredictable in the costs of maintenance and the time involved. The facility may come to a sudden unpredictable halt for uncertain time in the process.

Breakdown maintenance performs necessary repairs at the point of breakdown to prevent replacement costs. Such maintenance is normally common in smaller factories where planned maintenance may be too expensive compared to the cost of a sudden halt or has

been running under capacity. Common breakdowns handled by breakdown maintenance those which have occurred due to lack of lubrication, wear and tear of parts, etc.

(d) Predictive Maintenance

Predictive maintenance is rather a new technique wherein equipment conditions are periodically observed to assess unusual operating behaviour like unusual sounds, vibrations, coolant failures, misalignment, abrasion, etc. Sensitive instruments like audio gauges, vibration analysers, amplitude meters, etc are employed for the purpose to asses and observe unusual behaviour in operating conditions of the machinery. Predictive maintenance is also known as condition monitoring and is conducted based on adequate study on the performance and behaviour of the machinery. Normally, mathematical analysis serves as a criterion in the decision of conducting predictive maintenance.



CHECK YOUR PROGRESS

Q1: Define Maintenance Management

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Q2: State two objectives of Maintenance Management

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Q3: What are the different types of Maintenance Programs?

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14.4 MAINTENANCE POLICY

Maintenance policy involves policy decisions in conducting maintenance of machinery, tools and equipment within a facility. It involves planning and scheduling of maintenance activities for error free smooth operation.

The following considerations are taken care of while designing the maintenance policy for a facility.

- **Type of process:**

A job shop operation caters to diverse types of jobs at any instant. The volume of jobs handled for each sequence of operation is low. Such a process need not go for a planned maintenance program, through stoppage of all the activities within the process. Furthermore the process of planned maintenance would be expensive compared to expenses incurred owing to sudden breakdowns. A continuous process however cannot afford to face sudden breakdowns in any stage of the process leading to complete halt in the entire process. The set-up time, setup costs, the loss of profitability, and goodwill due to gaps in production are too costly for a continuous process. Such a process cannot afford to wait and watch for error to creep in the operation in order to diagnose them.

- **Type of machinery:**

A stage in an operation will stop performing whenever machinery engaged in the stage stops performing. Some machinery works on simple techniques and are easily assembled and disassembled. Such machinery, if can be repaired without much of technical assistance and by the shop floor workmen, need not be maintained under planned or preventive maintenance programmes. There are however, equipments in operations which are installed and serviced by third party service providers. Repair and maintenance of such equipments require specialised know-how which cannot be easily sourced or cannot be performed by unauthorised staff and need to be maintained under supervision of competent maintenance personnel.

- **Costs involved**

All said and done the choice of maintenance program is ultimately a result of the costs associated. The costs here refer to the costs involved

in production stoppages due to maintenance in one hand and the cost of running a maintenance program on the other. Another cost is the one occurring due to the necessity of replacement of machinery for non-performance of maintenance. It is the economics of maintenance cost, loss of production units and goodwill that decides which maintenance type is to be followed. Following a planned maintenance necessitates in taking prior decisions to ensure a smooth flow of production units during the period of planned maintenance. Enabling an uninterrupted flow of output in the market takes care of the goodwill and profitability of the organisation. However the cost of a planned maintenance program is high, it can be justified only with cost incurred due to sudden breakdowns requiring breakdown maintenance. Preventive maintenance leads to consistency in the quality of the products produced. In case of breakdown maintenance, need based repairs are performed which often cost the quality of the output products so produced. Such inconsistency can be inconsistency in quality, deteriorated products leading to frequent returns from customers and a tarnished brand image.

- **Safety at the work place**

Workplace safety is a priority in any organisation. Maintenance programs are designed to prolong the productive life of any machinery and to reduce sudden breakdowns as far as possible. Maintenance ensures that operational parameters are set in safe limits to prevent accidental leakage of fluids, breakage of items, auto-ignition of vapour due to excessive heat generation, etc. Such operational limits ensure safety at the workplace. Cleaning being a part of maintenance prevents accidents that may be caused from spillage of fluids, scattered tools and equipments, etc.

14.5 NEED FOR REPLACEMENT

Replacement is a necessary requirement in any facility. Machinery and other equipments wear out in performance and gradually the cost of

supporting them follows a cost curve. Replacement is done for machinery and equipments whose productive life has elapsed. Additionally, it is done for machinery whose cost of maintenance is so high that it justifies replacing it with another. Sometimes the machinery stands no longer remains suitable to produce products demanded in the market. Under such circumstances it becomes imperative to substitute the functioning of the machinery with one of a higher specification or specifications that which may produce required products. In certain instances the technology of working of machinery can no more be serviceable necessitating the replacement of the same. Replacement has a cumulative effect in a facility. Replacing one equipment or machinery may necessitate modifications in the related machines or those immediately preceding or succeeding in the stages of operation. Efficiency or better performance obtained by way of replacement of certain machinery may not get revealed in the entire facility performance unless the performance of other machinery is also enhanced.

Replacement is imperative under the following conditions:

a) Wear and tear of machinery has lead to high costs of maintenance,

b) Loss in efficiency,

c) Deteriorated quality of the products produced, frequent and sudden break downs, etc

d) Obsolescence in the technology used in the machinery

e) Advanced technology being available which can produce better quality products, efficiency in power consumption, etc.

f) Servicing and maintenance cannot be arranged easily

g) Inability to produce products as per market demand.

h) Machinery creates unfit creating conditions hazardous or unsafe for the workmen.

14.6 CRITERIA FOR REPLACEMENT

Machinery can be replaced if it is technologically not suitable for use and if the costs of the replacement can be arranged by the organisation. Factors for deciding replacement of machinery can be discussed under two heads.

a) Technical aspects and

b) Financial aspects

- **Technical aspects**

  a) Functioning and deterioration of equipment
  b) Technological life of the machinery
  c) Adherence to safety and environmental regulations
  d) Frequency of breakdowns and shut downs
  e) Quality of products produced and demand in the market
  f) Adherence to production deadlines

- **Financial aspects**

  a) Cost of maintenance and repairs
  b) Cost of replacement of parts
  c) Cost of power consumed
  d) Salvage value towards end of service life
  e) Cost of deteriorated quality products produced by the machinery



CHECK YOUR PROGRESS

Q4: What are the conditions on which the choice of a Maintenance policy for machinery depends?

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Q5: State three conditions in which replacement becomes imperative.

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Q6: What are the technical aspects that should be considered for replacing machinery?

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14.7 REPLACEMENT PROBLEMS

Problem 1.

A Super bakery produces variety of cakes and biscuits everyday in Gurgaon. It has a number of machines for the same. The bakery recently purchased a blender of capacity 5000ml at a cost of Rs. 9,000. The cost of installation of the blender has been Rs. 500. The scrap value of it is Rs. 1200. The blender needs oiling and servicing every year. The cost of oiling per year is given in the table below. Oiling has to be done by experts, service charges for each service is Rs. 200. The Board of Management is suggesting substitution of the existing blender with one from Germany of make Bl-1. The Finance department is however sceptical to purchasing the same immediately. The Board of Management wants to decide the year in which the blender should be replaced. Advise the Board of Management.

Year	1	2	3	4	5	6	7	8	9
Cost of oiling, etc. in Rs.	800	1300	1980	2800	3000	3300	4000	4300	4600

Cost of the blender = Rs. 9000

Cost of installation = Rs. 500

Scrap value of blender = Rs. 1200.

Service cost per service = Rs. 200

Solution:

The cost C of the blender includes the price P at which the blender is purchased and the cost of installation I.

P+I = C

9000 + 500 = 9500 = total cost of the blender

Since the salvage value S of the blender is Rs. 1200, the cost C_1 of the machine stands at

$C_1 = C - S$

= Rs.(9500-1200)

= Rs. 8300

The annual cost incurred every year on the machine should hence include the cost of maintenance annually. The following table gives the annual cost incurred on the blender

Year	Cost of maintenance (oiling etc)	Cost of maintenance add service charge	cumulative maintenance charges	C-S (Fixed over all years)	Cost of blender and maintenance less scrap value	Amount spent on blender per year
1	800	1000	1000	8300	9300	9300.00
2	1300	1500	2500	8300	10800	5400.00
3	1980	2180	4680	8300	12980	4326.67
4	2800	3000	7680	8300	15980	3995.00
5	3000	3200	10880	8300	19180	3836.00
6	3300	3500	14380	8300	22680	3780.00
7	4000	4200	18580	8300	26880	3840.00
8	4300	4500	23080	8300	31380	3922.50
9	4600	4800	27880	8300	36180	4020.00

It has been observed from the table that year 6 onwards the annual cost incurred on the blender increases, hence the blender need to be replaced at the end of year 6.

Problem 2.

Delight bakery in Gurgaon purchased a blender for Rs. 55000. The cost of servicing is Rs. 15000 for the first four years and thereafter increases by Rs. 3000 every year. The blender has a salvage value of Rs. 0. The

servicing of the blender is to be done at the beginning of each financial year. For a time value of money at 10 %, determine when Delight bakery should replace the blender.

Solution

Cost of blender = Rs. 55000

Salvage value = Rs. 0

Time value of money = 10 %

Year	1	2	3	4	5	6	7	8	9	10	11	12
Maintenance cost in Rs.	15000	15000	15000	15000	18000	21000	24000	27000	30000	33000	36000	39000

The cost of servicing for each year is to be calculated considering the Time value of money @ 10 % per year.

Cost incurred on the blender every year is hence the cost of blender together with the servicing cost discounted at 10 %.

Year	Servicing cost in Rs.	PV factor @ 10 %	present value of servicing	cost add servicing cost	cumulative present value	Annual cost incurred
1	15000	1	15000	70000	1	70000
2	15000	0.909091	13636.36364	83636.36364	1.90909091	43809.52381
3	15000	0.826446	12396.69421	96033.05785	2.73553719	35105.74018
4	15000	0.751315	11269.72201	107302.7799	3.48685199	30773.54019
5	18000	0.683013	12294.2422	119597.0221	4.16986545	28681.26648
6	21000	0.620921	13039.34778	132636.3698	4.79078677	27685.71766
7	24000	0.564474	13547.37432	146183.7442	5.3552607	27297.22274
8	27000	0.513158	13855.26919	160039.0134	5.86841882	27271.23239
9	30000	0.466507	13995.22141	174034.2348	6.3349262	27472.18031
10	33000	0.424098	13995.22141	188029.4562	6.75902382	27819.02554
11	36000	0.385543	13879.55842	201909.0146	7.14456711	28260.49663
12	39000	0.350494	13669.26208	215578.2767	7.49506101	28762.71141
13	42000	0.318631	13382.49434	228960.771	7.81369182	29302.50849

14.8 RELIABILITY

The probability that a product provides uninterrupted service under normal operating conditions is a measure of its reliability. The duration during which a product is reliable is a measure of the time in which maintenance is not necessitated. The more reliable a product is, the less is its possibility of breakdown requiring maintenance. Knowledge of reliability of a product enables operations Managers to make approximate predictions of time of failure and the time for requirement of spares, and servicing. A measure of reliability enables managers to predict the life of a product and the possible time of replacement.

A washing machine with a reliability of 0.97 refers to 97 continuous working hours out of 100 available hours. The machine thus has a 0.03 chance of being faulty. Reliability is quality of a product over time since it is a measure of uninterrupted service from a product in a specified time. The higher the reliability the lesser is the need for maintainability.

A measure of reliability is obtained by the bath-tub curve popular in maintenance engineering.

The bathtub curve is a representation of failures that occur in the lifecycle of a product till its wear out. A product in its initial period of use is likely to fail more frequently. Normally such failures are a result of manufacturing flaws, design flaws, uneven stress developed in parts or components, improper handling or operation of the products, etc. Such failures are handled through improvement in product design and manufacturing processes. This period of failure is termed as infant mortality since the product is more likely to fail in its infancy. Normally as the infancy period elapses for a product, the product performance becomes relatively stable; the product operates with minimal or without failure. Failure is however possible during this period due to accidental causes of failure. This period is termed a youth and forms the useful stage in the life of the product. With usage over time, the product

gradually is subjected to wear and tear. Hence after a considerable period of use the products necessitates frequent maintenance as frequency of failures also rise. This is termed as the old age period. The failure rates during the entire life period of a product when plotted against time along the horizontal axis takes the shape of a bath tub and hence the name.

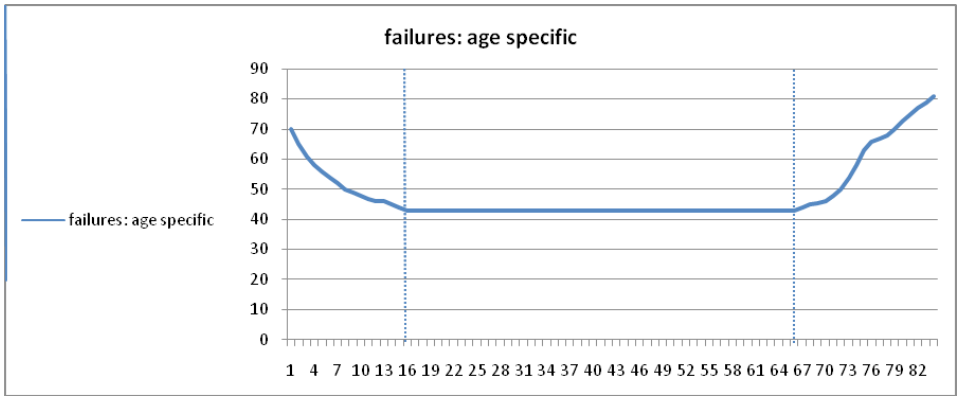


Fig: 14.8: Bath-tub curve

The bathtub curve is significant for the operations managers since it shows the length of each period in the life of the product. Ideally the infant mortality phase should be as short as possible and the youth period should be significantly long. Furthermore, the length and the frequency of failures during the infant mortality period enable managers to take significant decisions with regard to warranty of the products. Maintenance policies are to be adequately designed to minimise failures during the youth period. The later part of the life faces frequent failures. The frequency and type of failure may help the managers to take steps on replacement of products.

14.9 DETERMINATION OF MAINTENANCE CREW SIZE

Crew size required for maintenance depends on average job load which includes scheduled maintenance and anticipated number failure or breakdown maintenance that might be required. Each type of

maintenance has to be classified in terms of time required to attend the job. This in turn will help to assess the crew size. In case of breakdowns, the same needs immediate attention else it could prolong production stoppage. A larger crew size may render under utilisation of manpower whereas a smaller crew size may lead to backlog in the maintenance job. Non-occurrence of breakdown may lead to increased idle time of the crew. This in turn raises the cost of holding crew. Hence an estimated backlog of jobs is maintained. The optimal crew size is based on the backlogs and is given by:

Crew Size = Scheduled man hours per week/ (hours per week X backlog)

Where, Scheduled man hours per week= man hours required for attending scheduled maintenance and breakdowns based on prediction.

14.10 INFORMATION SYSTEM FOR MAINTENANCE MANAGEMENT

It is the detailed information of the operations that can help managers to decide and plan for performing maintenance function smoothly. For any machinery a record of the necessary maintenance required, with the tentative time for the same, may feed valuable input for decisions in future. It is imperative to have stored such information and to have ease of access to information pertinent to maintenance. Information necessary for the same may furnish useful input of the following types:

a) The available or the possible bathtub curve to locate the infancy, useful life and wear out phase to locate the time of probable breakdowns.

b) Possible locations of breakdowns and the maintenance crew that might be required.

c) The detailed activities involved in the operation of the machinery to assess the costs.

d) The necessary mathematical models and /or record of readings to trace the presence or absence and the behaviour (if at all present) of unusual sounds, vibrations, etc. for predictive maintenance.

e) Schedules for proactive maintenance programmes.

f) A record of reliability of the machinery to assess for replacements.

Organisations are nowadays equipped with Maintenance Information System which is a robust package that tracks, and generates necessary information aiding operations managers for maintenance related decisions. Such a system is equipped with latest data on records of maintenance schedules, costs of maintenance, and the crew size requirement. The system simplifies and serves as an essential tool in helping maintenance mangers in conducting error free and efficient maintenance functions.



14.11 LET US SUM UP

In this unit we have come through the following:

- Maintenance management ensures improvement in efficiency of a facility by reducing possible loss that may occur by way of sudden faults in operation, frequent breakdowns inviting repairs leading to loss in man and machine hours thereby reducing profitability.

- Some of the Objectives of Maintenance Management are
  - Early detection and diagnosis of problems in machinery within a facility.
  - Minimal wear and tear of machinery to ensure enhanced performance of the plant and machinery.

- Minimise repair time and the cost so involved
- Ensure error free operation of machinery to prevent accidents

- Four popular types of Maintenance are
  - Planned Maintenance
  - Preventive Maintenance
  - Breakdown maintenance
  - Predictive Maintenance
- Factors responsible for designing the maintenance policy for a facility are
  - Type of process
  - Type of machinery
  - Costs involved
  - Safety at the work place
- Sometimes when machinery no longer remains suitable to produce products it becomes imperative to replace the machinery with one of a higher specification or specifications that which may produce required products.
- Replacement becomes necessary under the following conditions:
  - Wear and tear of machinery causing high costs of maintenance,
  - Loss in efficiency,
  - Deteriorated quality of the products produced
  - Obsolescence in the technology used in the machinery
  - Availability of advanced technology being available.
- Replacement of machinery can be done in consideration technical aspects and

  financial aspects involved in the machinery.

- The probability that a product provides uninterrupted service under normal operating conditions is a measure of its reliability. The more reliable a product is, the less is its possibility of breakdown requiring maintenance.

- The bathtub curve is a representation of failures that occur in the lifecycle of a product till its wear out. The bathtub curve is significant for the operations managers since it shows the length of each period in the life of the product.

- Crew size required for maintenance depends on average job load which includes scheduled maintenance and anticipated number failure or breakdown maintenance that might be required.



14.12 ANSWERS TO CHECK YOUR PROGRESS

Ans. to Q. No.1: Maintenance Management is the application of techniques of operations management to ensure breakdown free and smooth running of all plant and machinery within a facility and controlling the costs of maintenance.

Ans. to Q. No.2: Two objectives of Maintenance Management are:-

- To attain minimal wear and tear of machinery for enhanced performance of the plant and machinery.
- To minimise repair time and the cost involved in repairs.

Ans. to Q. No.3: The four types of Maintenance are

- Planned Maintenance
- Preventive Maintenance
- Breakdown maintenance
- Predictive Maintenance

Ans. to Q. No.4: The conditions on which the choice of a Maintenance policy for machinery depends are

- Type of process
- Type of machinery used
- Costs involved in maintaining the machinery and the cost of replacing it.
- Safety at the work place

Ans. to Q. No.5: Three conditions in which replacement of machinery becomes imperative are

- Wear and tear of machinery leading to high costs of maintenance,
- Loss in efficiency
- Deteriorated quality of the products produced and frequent and sudden break downs, etc

Ans. to Q. No.5: The technical aspects that should be considered for replacing machinery are as below:-

- Functioning and deterioration of equipment
- Technological life of the machinery
- Adherence to safety and environmental regulations
- Frequency of breakdowns and shut downs
- Quality of products produced and demand in the market
- Adherence to production deadlines



14.13 FURTHER READINGS

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14.14 MODEL QUESTIONS

1. Why is Maintenance Management essential in any facility?
2. What are the objectives of Maintenance Management?
3. What is preventive maintenance? How is it different from breakdown maintenance?
4. How is preventive maintenance different from breakdown maintenance?
5. How does safety of workmen serve as a factor in deciding maintenance programs for a facility?
6. Under what conditions of machinery does its replacement become essential?
7. What is a bath-tub curve? How does it help in estimating maintenance programs?
8. Why is backlog an essential factor in determination of maintenance crew size?
9. How does information system provide useful input in maintenance decisions?

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