ME2037 MAINTENANCE ENGINEERING SYLLABUS

ME2037	MAINTENANCE ENGINEERING	L T P C
	(COMMON TO MECHANICAL AND PRODUCTION)	3 0 0 3

OBJECTIVES:

- To enable the student to understand the principles, functions and practices adapted in industryfor the successful management of maintenance activities.
- To explain the different maintenance categories like Preventive maintenance, condition monitoring and repair of machine elements.
- To illustrate some of the simple instruments used for condition monitoring in industry.

UNIT I PRINCIPLES AND PRACTICES OF MAINTENANCE PLANNING 9

Basic Principles of maintenance planning – Objectives and principles of planned maintenance activity – Importance and benefits of sound Maintenance systems – Reliability and machine availability – MTBF, MTTR and MWT – Factors of availability – Maintenance organization –Maintenance economics.

UNIT II MAINTENANCE POLICIES – PREVENTIVE MAINTENANCE 9

Maintenance categories – Comparative merits of each category – Preventive maintenance, maintenance schedules, repair cycle - Principles and methods of lubrication – TPM.

UNIT III CONDITION MONITORING 9

Condition Monitoring – Cost comparison with and without CM – On-load testing and off-load testing – Methods and instruments for CM – Temperature sensitive tapes – Pistol thermometers –wear-debris analysis

UNIT IV REPAIR METHODS FOR BASIC MACHINE ELEMENTS 10

Repair methods for beds, slideways, spindles, gears, lead screws and bearings – Failure analysis

– Failures and their development – Logical fault location methods – Sequential fault location.

UNIT V REPAIR METHODS FOR MATERIAL HANDLING EQUIPMENT 8

Repair methods for Material handling equipment - Equipment records –Job order systems -Useof computers in maintenance.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Srivastava S.K., "Industrial Maintenance Management", - S. Chand and Co., 1981

2. Bhattacharya S.N., "Installation, Servicing and Maintenance", S. Chand and Co., 1995

REFERENCES:

1. White E.N., "Maintenance Planning", I Documentation, Gower Press, 1979.

2. Garg M.R., "Industrial Maintenance", S. Chand & Co., 1986.

3. Higgins L.R., "Maintenance Engineering Hand book", McGraw Hill, 5th Edition, 1988.

4. Armstrong, "Condition Monitoring", BSIRSA, 1988.

5. Davies, "Handbook of Condition Monitoring", Chapman &Hall, 1996.

6. "Advances in Plant Engineering and Management", Seminar Proceedings - IIPE, 1996.

UNIT I

L_1 PRINCIPLES & PRCTICES OF MAINTENANCE PLANNING

Maintenance:

It is the routine and recurring process of keeping a particular machine or asset in its normal condition o that it can deliver the excepted performance or service without any loss or damage.

Principles of Maintenance Planning

Maintenance principles are followed in a system to guide the staff to work efficiently and effectively to achieve the overall objectives of the maintenance system.

i) Plant Management in Maintenance work:

The main role of the maintenance function is to provide safe and effective operation of the equipment to achieve the designed targets on time with economic usage of resources.

ii) Production and Maintenance Objectives:

The plant is driven by the production targets. The objective of these maintenance function is to support these targets.

Information based Decision Making:

The maintenance objectives are successfully achieved by the use ofreliable information system

Planning of Maintenance Function :

All the maintenance functions are to be carefully executed by a way of proper planning to ensure the effective utilization of manpower and materials.

Manpower for Maintenance:

The manpower requirements of the maintenance system must be carefullyevaluated based on the time and motion study.

Workforce control:

Determination of exact workforce required to meet the maintenance objectives of the system is difficult task due to the element of uncertainty. Hence the proper control and monitoring of workforce are needs to be ensured .

Role of spar parts:

A good maintenance management system requires appropriate tools. So the system should have good quality tools and that too available in required quantities to ensure the proper function of the maintenance works.

Important Factor to be considered in Maintenance Planning

The maintenance work include the following factors

- Job Distribution
- Programme
- Man Power Allocation
- Staffing
- Planning Techniques
- Planning Procedure.
- Maintenance Control

Jot Distribution :

The first and foremost task in maintenance planning is the distribution ofthe pots to the personnel for preventive and emergence maintenance works.

Programme:

A maintenance programme is a well formulated combination of the available skills and resources that ensures optimum and appropriate utilization to meet the

objective of the organization.

Man Power Allocation:

It is the most important task of the maintenance management group. The central idea of man power allocation can be drafted using the information available from maintenance records and planning the tasks to meet the objectives of the organization.

Staffing:

It is the task of provided the required manpower for the maintenance function. The advantage of preventine maintenance is that the work can be planned and scheduled properly for the effective use of resources.

Planning Techniques:

The planning methods are Gantt charts, Critical path method are recently used for maintenance planning and scheduling.

Maintenance Control:

It is the auditing technique to ensure the effective utilization of the maintenance budget. This involves the integration of with thesystem.

Important and benefits of sound maintenance management system

The profit of any industry depends only on the return of the investment. The capital cost and operating cost are the major factors involved in any industrial investment. The life of the equipment and maintenance schedule information provided by manufacturer may not be realized in practice to makethe need for having a sound management system.

The following are the benefits of sound maintenance management system.

- Minimization of colourtime.

- Improvement in availability of system.

- Extended life of equipment.
- Safety and smooth operation of the process
- Provide adequate back up supply
- Minimization of normal expected wear and tear of equipment.
- Safety of the personal involved in the organization.
- Increased reliability of the system.
- Provide proper working environment.

RELIABILITY IN MAINTENANCE

The concept of reliability has found increased use in industries engineering maintenance and management.

Need for reliability of Maintenance :

The reliability of a system, equipment and product is very important aspect of quality for its consistent performance over the expected life span.

Reality is defined as the probability that ac component / system, when operating under given condition will perform it intended functions adequate for a specified period of time. It refers to the like hood that equipment will not failduring its operation.

The four important factors required in the determination of reliability are

- Reliability expressed as probability
- Adequate performance acquirements
- Duration of adequate performance.
- Environmental or operating conditions.

i) Realiability expressed as probability

it is the ratio of the number of times we can expect an event to occur to the total number of trail undertaken. A Reliability factor can be expressed as probability. A reliability factor equal to one means that device performs satisfactorily for the prescribed duration under the give environmental condition.

ii) Adequate Performance Requiement:

a system may perform satisfactorily even though one or more components may not be functioning. In reliability analysis there is a need to define the magnitude of satisfactory or adequate performance of the system.

iii) Duration of Adequate Performance:

The duration of adequate performance is used to state the time up to which the desired performance of the system is achieved under the given operating conditions.

iv) Environmental or Operating condition:

environmental condition indicate the prevailing conditions at which the system is under operation.

Failure pattern of equipment

The failure pattern of equipment over its whole life cycle can be represented in the diagram given below. In phase I, the failure pattern inherent in a new product because of manufacturing or design defects. Phase II shows the useful life period of an equipment when the failure rates are normally modulateat the equipment gets set to the working environment. In Phase III, the failuresare excusing due to wear out failure that are caned due to again of the equipment.

Reliability (R)

Reliability is the probability of a device performing its purpose adequately for the period intended under the give operating conditions.

Reliability Model:

A basic measurement of the reliability of the product ie its probability ofis that of mean time between failures. Suppose that products are taken at random from a large group and let of them fail during the time period then the probability of failure during the period "t" is given by $P_t = \underline{n_t}$

It is necessary to evaluate the performance of the product over the intended length of time T for the determination of reliability. Then

When a large number of products are tested so that the relative frequency becomes a smooth function f(t) of time. Then reliability expressed by

$R_t = 1 - {}^{t} f(t)\, dt$

Failure rate is approximately constant in that of the practical cases. Then function assumes the form of the exponential probability function asgiven by

$F(t) = 1/Q\ e$

$^{-t/q}\ dt.\ R_t =$

e^{dt}

Probability of Failure

The probability of failure is the ratio of the number of unite that failed at specified period of time to the total population.

Mean Failure Rate (h)

The mean failure is the rate h is obtained by finding the mean of the failure rates for specified period of time.

Mean time is failure (MTTF)

Let t, is the time to failure for the first specimen, t is the time to failure for the second specimen and tn is the time to failure for the N specimen. Hence the mean time to failure for N specimens are

$HTTF = (t1+t2+\ldots\ldots tn)\ /n$

$= 1/N$

It is difficult to record the failure for each component when the numbers of specimens tested are large. Instead, we can record the number which fails during the specific intervals of time.

Mean time between failures (HTBF)

Mean time between failures (HTBF) is the mean or average time between successive failures of a product. Mean time between failures refers to the average time of breakdown until the device is beyond repair.

Mean time to Repair (MTTR)

Mean time to repair (MTTR) is the arithmetic mean of the time required to perform maintenance action. MTTR is defined as the ratio of total maintenance time and number of maintenance action.

MTTR = Total maintenance time

Number of maintenance action

Maintenance Action Rate:

Maintenance action rate is the number of maintenance action that can becassied out on equipment per hour.

= 1/MTTR

Types of Reliability:

Reliability can be generally of two typesInherent Reliability

It is associated with the quality of the material and design ofmachine parts

Achievable Reliability

It depends upon other factor such as maintenance and operation ofthe equipment.

MAINTAINABILITY

It is a concept closely related to the characteristics of equipments design and installation. It is defined as the probability that a unit or system will be restored to specified working conditions within a given period when maintenance action is taken in accordance with the prescribed procedures and resources.

Availability

It is the ratio of the time at which the equipment is available for the designated operation service to the total time of operation and maintenance of the equipment. It is also defined as the ration of equipments uptime to theequipment uptime and down time over a specified period of time.

The three types of availability are

- Inherent availability
- Achieved availability
- Operational availability

Inherent availability

It is the probability that a system or equipment shall operate satisfactorily when used under prescribed conditions in a ideal support environment without any scheduled or preventive maintenance at any given time.

Inherent availability = MTBM/ MTBM+MTTR

Achieved availability

It is the probability that a system or equipment shall operate satisfacily when used under prescribed conditions in an ideal support environment with periodic preventive and corrective maintenance at any given time.

Achieved availability = MTBM/ MTBM+M

Operational Availability

In industrial system a certain amount of delay will always caused by time

element such as supply downtime and administrative downtime.

Operational availability = MTBM/ MTBM+MDT

Where MOT is the mean downtime is the satisfied mena of the downtimesincluding the supply downtime and administrative downtime.

Resources

Resources include men, sparks and tools involved in the task ofmaintenance.

Administration

It include a nearby of authority and responsibility for decision making and plans for the execution of work.

Work planning and control system

This is the mechanism for planning and scheduling the wok. This also include the feedback of information to drive the maintenance effort to its defined objective.

The basic objective of the maintenance organization is the ensure that the maintenance function ae carried out effectively and hence to minimize the production loss due to maintenance. There has to be a close relationship between the production and maintenance departments to achieve the desired targets of the industry. Continuous monitoring of planned preventive maintenance schedules identififed for the identified for the equipment is required to complete the maintenance tasks in time.

A maintenance organization can be countered as made up of three basic and necessary components.

Resour

ces

Admini

stration

Work planning and control system.

Maintenance of modern equipment and industry requires a healthy, balanced

and rationalized organization, devoted to achieve the goals of maintenance task. The organization required for any system can be formed after study of the existing continuous and also the future demands of the industry.

The increasing complexity of present day equipment maintenancemanagement has brought into focus two other aspects known as maintainability and availability, both of them are closely related to reliability.

TASKS OF MAINTENANCE ORGANISATION

The tasks of the maintenance are as follows:

- Identification of organization roles pertaining maintenance function.
- Determination of maintenance workload.
- Uniform distribution of total maintenance work to all the personal inthe department.
- Identification and assignment of essential works to the various sections of the maintenance department
- Proper knowledge about the technical experlise/ experience of the workers deputed for the particular part
- Proper training of the staff of maintenance to meet the growing demands of the industry and to catch up with the modern trends inmaintenance.
- Designing the polices and procedures at an early stage to help the maintenance departe4mnet to achieve the goals of the industry.

Maintenance Functions and Activities

The functions and activities of the maintenance organization are asfollows:

- Identifying areas for implementation of preventive maintenance program.

- Making suitable arrangements for maintenance facilities for carryingout the maintenance works properly.
- Planning an scheduling the total maintenance work
- Ensuring proper and timely supply of spare parts.
- Managing proper inventory control of materials spares and tools required for maintenance.
- Standardization of maintenance work.
- Implementing modifications to the existing equipment wherever possible.
- Assisting the purchase department in processing materials.
- Identification of obsdate and surplus equipment for replacement and disposals.
- Training of maintenance personnel.
- Analysis of future demands and forecast the role of maintenance activities.
- Implementation of safety norms and procedures
- Ensuring safety of personnel and equipment.

Types of maintenance organization

The selections of a type of maintenance system will largely depend on the structure of an industry. Maintenance organization can be broadly classified into three types as follows.

i) Decentralized

this is suitable for large sized plants where enter unit communication is difficult to get. In this type of organization the maintenance is difficult to get. In this type of

organization, the maintenance is under the control of chief engineerof production to ensure understanding between the production and maintenance department.

ii) Controlized

this is suitable for small units where unit communication is feasible. In this typeof organization the maintenance is under the control of chief maintenance engineer. The responsibilities accountability is with the concerned department heads.

iii) Partially Controlized

this is the modified version of controlized maintenance organization and suitable for the industry where the units are located at far away locations.

In this type of organization, the maintenance personal attached with production unit will carryout the routine maintenance works. Scheduled maintenance works such as overhauls. Planned maintenance work, procurement of spare parts are under the control of chief maintenance engineer at the control office.

There are basically tow atleast two types of organization are followed inmost of the industries. They are

- Line organization
- Line staff organization.

LINE ORGANIZATION

Line organization consists of a general foreman and a number of specialist foremen with their under them is shown below.

General Foreman

Foreman Electrical Storekeeper

The specialist foreman execute maintenance work in their respective areas while the general foreman supervises the total work under his control and the various maintenance tasks carried out in the industry. This kind of structure is an old type

maintenance organization.

LINE STAFF ORGNISATION

A few more staff members such as storekeeper and clerk are added to the line organization to form the line organization structure as given below.

The advantage lies in separating the maintenance work from the storekeeping and the role of clerk is to record the maintenance activities. The recording of maintenance related activities helps the organization to restructure the strategies adopted to achieve the objectives of maintenance.

LINE STAFF ORGANISATION

Maintenance functional organization

Maintenance functional organization is the structure based on craft concept. In this organization structure persons joined the organization as appentices and devoted to higher positions such as forman after sufficient experience in their respective jobs. This organization the maintenance functional organization in which few workers are placed under each functional foreman.

Controlly Controlled Maintenance Organization

The limitation of this kind of maintenance is that it is possible onl for equipments which can be shifted to workshop.

Area Maintenance organization

Area maintenance organization provides better utility of manpower when the units are located at various locations.

For example mining industry, area maintenance manage takes care of maintenance for a particular area and is equipped with number of workers to carryout maintenance works including emergency work.

GENERAL ORGANIGATION OF MAINTANANCE DAPARTMENT

External maintanance service

It is available in two forms contract maintenance service andmanufacturers after sale service

Advantages of external maintenance service

- It is very economical
- Technically better and specialist are responsible for maintenance activities
- Skill preservation
- Better service
- Updating to modern and existing trends and needs

Outsourcing in maintenance

The term outsourcing assumed recent importance in the area of computer information technology and communication due to emergence of business process outsourcing (BPO) outsourcing is followed in small industries to hand once the maintenance activities to external agencies. This is due to the reason that economy of the industry does not permit to have maintenance people on their own. It is followed in large industries also ensure maximum control over themaintenance activities.

- Lost of maintenance is minimized
- No need for having maintenance as a department.
- Better quality of service achieved through employing specialists.
- Better maintenance practice

- Performance metrics are clearly defined and achieved by out sourcingthe maintenance jobs

Maintenance Economics

Lift cost Analysis:

The factors to be considered in the purchase of equipment for industriesinclude the cost, quality, performance and maintenance requirements. Some balance is to be made between the capital cost andn operating cost of the equipment in finding the suitability of the equipment.

Life cycle costing is the cost analysis for the equipment in an industry that accounts total cost of the equipment over a span of time which includes the capital cost, operating cost and maintenance cost. The aim of life cycle losting isto acertain the total cost of equipment over the span of its entire life period.

Advantages of life cycle costing

Integration of engineering, economics and financial aspects lead to the way of rotust metric for the selection and purchase equipment required for theindustry.

Reduced operating and maintenance cost of equipments due to costanalysis over span of time.

It leads to the selection of proper and economically viable equipment.

Estimation of Economic Life of Equipment

The economic life of equipment depends on the maintenance of repaircosts, availability an doperational efficenty. A plot of cumulative efficienty and maintenance and repair cost per cumulative hours vs operating hours of the equipment to find the economic lifie of the equipment.

Maintenance Cost

Budgets are allocated for all the activities in planning stage itself which includes the maintenance cost. The cost of maintenance is difficult to measuredue to random nature of failures. The words on maintenance history may be useful in determining the cost.

Component of Maintenance Cost

The maintenance cost is comprised of two factore

- Fixed cost
- Variable cost

Fixed Cost

This includes the cost of support facilities including the maintenance staff.

Variable Cost

This include the consumption of spare parts, replacement of componentsand cost other facilities required to meet the requirements of maintenance.

The evaluation of maintenance cost should consider the following factors

- The evaluation of maintenance cost should consider the following factors.
- Cost of maintenance from the recorded data.
- Level and requirements of maintenance.
- Cost of replacement of components and assemblies subjected to wear and tear.
- Accounting the number of break downs with their levels

- Downtime of the equipment for want of maintenance repair.
- Penalty cost due to loss of production .
- Cost of manpower involved.
- Cost of additional manpower requirement for emergency breakdownand maintenance.

Maintenance Budget

The maintenance budget is sued to set aside crtain amount of money tomeet the expenditures incurred in achieveing the objectives of maintenance.

The following are the types of maintenance budget.

i) Appropriation budget

budget used to allocate money for each activity independently

ii) Fixed Budget

Fixed used to allocate money for a specified period of time.

iii) variable budget

dynamic allocation of expenditure based on maintenance requirementsand activities.

Cost Minimization in Maintenance organization

- Controlized, planning, scheduling and control.
- Grouping of specialized workforce.
- Effective later utilization strategies.
- Proper and effective use of contract maintenance system to reduce the overhead costs on equipment and manpower.

- Purchase of reliable equipment and spares.
- Use of skilled and trained workforce.

- Proper selection of suitable type of spares, materials and bebricants.
- Proper safety education and formulating the safe practice.
- Constant appraisal and education to workforce about the objectives, stragies and modern techniques adopted in the area of maintenance.

Calculate the failure rate of a component from the following data

Number of components tested = 750

Period of time =

1000 hrs

No of failure reported for the given period of time = 5

Solution

Let R be the probability of reliable function for specified period of time andF be the probability of failure R + F = 1

Failure rate = No of failures in a unit time

= number of failures / time period.

= 5/750 x 1/1000

This is based on the assumption of uniform failure rate ofr the givenperiod of time.

Probability of failure = 1-R = 1-99.34 = 0.66%

Problems

Problem – 1

Equipment is subjected to maintenance. Time constant for completing thework is 60 minutes. If MTTR is 0.3 hrs calculate the probability that it will met the desired specification.

Solution

Probability of maintenance equipment, M = 1 – e

Problem -2

A process plant consists of fire equipments connected in services as shown in figure given below. In this continuous production environment, themajor failure is in the failure of the pumps delivering the fluid form one quipmentto other.

Health -> Reader -> Cooler -> vessel ->

TankP1 P2 p3 p4

Process plant with equipments connected in services.

The failure rate of pump delivered to the heater is 0.00001 per hr and the failure raters for the pump delivering the fluid to the reactor, cooler, sedimentation vessel and storage tank are 0.0002, 0.00018, 0.00003 and 0.00005 per hour. Calculate the reliability of the process plant.