Lecture Notes on: MAINTENANCE

Faculty: Prof. Nilesh Pancholi

MAINTENANCE

Over the past twenty years, maintenance has changed, perhaps more so than any other management discipline. The changes are due to a huge increase in the number and variety of physical assets (plant, equipment and buildings), which must be maintained throughout the world, much more complex designs, new maintenance techniques and changing views on maintenance organization and responsibilities.

Maintenance is also responding to changing expectations. These include a rapidly growing awareness of the extent to which equipment failure affects safety and the environment, a growing awareness of the connection between maintenance and product quality, and increasing pressure to achieve high plant availability and to contain costs.

The changes are testing attitudes and skills in all branches of industry to the limit. Maintenance people have to adopt completely new ways of thinking and acting, as engineers and as managers. At the same time the limitations of maintenance systems are becoming increasingly apparent, no matter how much they are computerized.

The main aim of maintenance is to ensure adequate operating, reliability and personal safety at minimum expenditure.

"Maintenance is an art of optimizing the available resources of man power, material, tools and test equipment etc. within asset of constraining to achieve goals and objective of an organization i.e. profit making or perform a mission in a cost effective manner."

OBJECTIVE OF MAINTENANCE.

The basic objectives of maintenance are as follows: -

- To minimize breakdown.
- To keep the plant in good working condition at the lowest possible cost.
- Machines and other facilities should be kept in such a condition, which permits them to be used at their optimum (profit making) capacity without any interruption.
- Maintenance division of the factory ensures the availability of machines, buildings and services required by other sections of factory for the performance of their functions at optimum return on investment.

MAINTENANCE PHILOSOPHY

The maintenance philosophy of a plant is basically to maintain a minimum level of maintenance staff that is consistent with the optimization of production and plant

availability without compromising safety. For achieving this philosophy, the following strategy can play an effective role if applied in the right mix and fashion.

1. Breakdown Maintenance.
2. Scheduled Maintenance.
3. Preventive Maintenance.
4. Condition-based (Predictive) Maintenance.

Breakdown Maintenance

- In this a machine is allowed to run till it fails. Although several machines are maintained in this way, it has many disadvantages. This type of may be quite justified in small factories which;

  (i) are indifferent to benefits of scheduling
  (ii) do not feel a financial justification

- Disadvantages of Breakdown maintenance includes;

  (i) excessive delay in production.
  (ii) reduction in output.
  (iii) faster plant deterioration.
  (iv) more spoilt material.
  (v) direct loss of profit.
  (vi) can't be employed for those plant items that are regulated by statutory provisions.

Scheduled Maintenance

- It is a stitch-in-time procedure aimed at avoiding breakdowns.
- This practice includes; inspection, lubrication, repair and overhaul of certain equipments.
- Generally employed for cleaning of water and other tanks, white-washing of building etc.

Preventive Maintenance

- Under this program each critical machine is shut down after a specified period of time and inspection or replacement of worn out parts is carried out. The main principal of this type is that prevention is better than cure.
- To maintain the control of the PM program following measures should be taken;
  (i) periodic review of pm programme with the operating department.
  (ii) review of monthly reports of pm inspections.
  (iii) analytical approach to the evaluation of pm

  Percentage of Performance,

  = (Hours worked as forecast jobs/Total hours worked) X 100

- Advantages of PM include;

  (i) reduced breakdowns.
  (ii) greater safety for workers.
  (iii) less repetitive repairs.
  (iv) less maintenance cost.
  (v) better product quality.
  (vi) improved equipment life.

- Disadvantages of PM includes;

  (i) it does not guard against deterioration between overhauls.
  (ii) production is still subject to unplanned stop.

Total Productive Maintenance (TPM)

Total Productive Maintenance is a management approach to maintenance that focuses on involving all employees in an organization in equipment improvement. It is Japanese concept in which total quality management and just in time approach is applied to the equipment maintenance area.
TPM is a maintenance approach and strategy that is focused on the following objectives:

- Maximize overall equipment effectiveness (OEE) and productivity and eliminate all machine losses
- Create a sense of ownership in operators through training and involvement
- Promote continuous improvement through group work involving production, engineering and maintenance
- Improve the overall efficiency of the maintenance process by focusing craftsmen on higher skilled tasks

The most important benefits of TPM includes:

1. Increase productivity and OPE (Overall Plant Efficiency) by 1.5 or 2 times.
2. Rectify customer complaints.
3. Reduce the manufacturing cost by 30%.
4. Satisfy the customers' needs by 100 % (Delivering the right quantity at the right time, in the required quality.)

Condition-based (Predictive) Maintenance

'Assessing the current state and estimating the future state of a system by means of measurements and calculations. The results of condition monitoring can be used to take corrective actions, to plan the availability and maintenance and to optimize the plant's performance'.

It is comparatively a newer maintenance technique. Regularly measuring the machine "Condition" and interfering with it can avoid the disadvantage of above methods. The fundamental difference between preventive maintenance and condition-based

maintenance is that preventive maintenance is carried out as soon as pre-determined time period is elapsed. While condition based maintenance requires checking at pre-determined intervals with maintenance carried out only if inspection shows that it is necessary.

Every dynamic system - electrical, hydraulic, mechanical or thermal - possesses a normal characteristic 'signature' when operating in the desired fashion. The small differences between normal and abnormal signatures have often been hidden by (or even assumed to be) 'noise' in the system. Modern transducers and associated signal-analysis techniques can now discriminate between truly random variations and significant trends, which, with knowledge of the system parameters and normal characteristics, can be used to predict time to failure. Such an approach is called Condition Based Maintenance.

Condition-based maintenance, also known as predictive maintenance, uses primarily no intrusive testing techniques, visual inspection, and performance data to assess machinery condition. It replaces arbitrarily timed maintenance tasks with maintenance scheduled only when warranted by equipment condition. Continuing analysis of equipment condition monitoring data allows planning and scheduling of maintenance or repairs in advance of functional failure.

Advantages of Condition-based Maintenance

Advantages of condition-based Maintenance are as follows: -

1. Prevention of damage.
2. Increasing the availability.
3. Increasing the reliability.
4. Increasing of life times.
5. Change to condition dependent maintenance.

Types of Condition Monitoring

The different types of condition monitoring programs followed by the process industries are as follows: -

1. Continuous Monitoring:

Continues monitoring is necessary on critical machines that are subject to problems, or where problems can develop rapidly and have severe financial consequences. Typical machineries in this category include; Large turbine generators, Boiler feed pump etc.

2. Periodic Monitoring:

Periodic Monitoring is typically applied to less critical machineries where advance warning of deterioting conditions will show a positive return on investment

HOW TO PLAN THE MAINTENANCE PROGRAMME

In order to have the result-oriented effective solution for the problems of process industries, it is required to plan the maintenance program systematically and for this purpose the following basic principles can be used.

Basic Principle Used to Design Better Maintenance Program

1. Capable to provide safe and effective function/operation of plant including other equipment to achieve desired target on time.
2. Should provide prolong life to the plant, equipment etc.
3. Capable to provide safety to the operators.
4. Should reduce idle hours due to components manufacturing.
5. Should improve the quality of the product.
6. Should be full proof and can be used for long time.
7. Capable to provide the information and recorded data regarding machines, equipments etc.

The Dynamic Model for Maintenance Plan

Consider a large process industry. The objective of production department is to manufacture a planned output over some given period, which depends upon sales demand.

The plant or some part of it may be in one of the following states;

- In production
- Not wanted for production
- Taken out of production for scheduled maintenance
- Failed inexpertly and corrective maintenance is being carried out
- Failed, but due to shortage of maintenance resources

The model of maintenance as shown presented as the operation of a pool of resources directed towards controlling the level of availability and condition of plant. Thus it can be considered that the function of maintenance is to use those resources to repair, replace, adjust or modify the parts of plant to enable it to operate at a specified availability and performance over specified time and for a specified life.

A Systematic Six-step Method for Planning Maintenance Program

Step 1 – Determine critical plant units and production windows.

- Determine the nature of plant process (continues, batch, etc.)
- Classify the plant into units.
- Carry out failure analysis and estimate the lost of production.
- Determine the production plan and availabilities.

Step 2 – Classify the plant into constituent items.

- This will be a complete classification in the case of critical units, and a partial classification in case of non-critical units.

Step 3 – Determine and rank the effective procedure.

- Determine the effective procedures for each item and the best of this from a cost and safety viewpoint.

Step 6 – Establish a plan for the identified work.

- This depends upon the type and complexity of plant unit, as either continues or batch or etc.

Step 5 – Establish a schedule for on-line maintenance, the off-line maintenance, condition based maintenance and the shutdown work.

- The main aim of all the case is to smooth the maintenance workload in order to make the best use of in-plant resources. However condition based maintenance plan is in operation then only inspection checks can be scheduled because timing of the work depends on the results of these checks.

Step 6 – Establish corrective maintenance guidelines.

- In spite of preventive maintenance there will still be some unexpected failures, which can be planned for in terms of spares and manpower.

Computerized Maintenance Management System (CMMS)

Computerized Maintenance Management Systems (CMMS) have evolved over the last three decades from elementary asset tracking and preventive maintenance functionality, to enterprise maintenance information systems. There are hundreds of vendors providing solutions on a variety of platforms. These "best of breed" systems provide users Comprehensive functionality to facilitate the flow of maintenance information and the ability to check the health of the maintenance organization at a glance.

CMMS is basically an information system used to serve maintenance. Its helps in the process of data collection, recording, storing, updating, processing, communicating, and forecasting for planning, scheduling and controlling maintenance activities. CMMS provides an effective reporting to the maintenance managers and engineers for sound decision making for control and improvement of maintenance process. Thus, CMMS can be used as the means for quick and timely response.

In design process of a CMMS one or more of the preceding functions are usefully grouped into one module. It consists of following five modules:

1. Equipment management
2. Work order control
3. Craft management

4. Material supply and control
5. Performance reporting

Reliability -Centered Maintenance

The significance of the word ‘reliability’ in RCM is to emphasize the role of reliability theory and practice in focusing the PM activities in a manner as to retain the inherent reliability of the equipment. The process of RCM employs the technique of failure mode and effect analysis (FMEA) to understand and programme the maintenance needs of equipment effectively. Reliability of any product is a design attribute. The product definition, which also encompasses the way it is operated and maintained, determines the inherent reliability that can be achieved. Any other action such as fabrication, assembly, testing, operation and even maintenance can only degrade the inherent reliability if they are not performed properly. It must be recognized that none of the above actions can enhance the reliability beyond the capability established by design and product definition.

Ideally, PM tasks must be initially specified during the product design and development phase. The RCM methodology is an effective method for developing such specifications at the initial stage. Often this step is relegated to lower priority leading to an inadequate PM programme. The goal of RCM methodology is to bring such products and systems under its fold and upgrade their PM programmes to realize their full potential of inherent reliability.

The RCM Process

RCM grew out of the aircraft industry in the late 1960s and 1970s. Since many aircraft equipment failures have disastrous consequences, the basic RCM process developed was very formal and rigorous. The basic steps in developing a formal RCM analysis are:

1. Define the major systems and components. The user defines the systems. Where systems are extremely complex and this complexity makes analysis difficult, the user may opt to define subsystems as a means of organizing the problem into manageable pieces.

2. For each system, define all "functions" of that system.

3. For each of those functions, define the possible "functional failures" that could occur (i.e., what could go wrong that would prevent the system function from occurring).

4. For each functional failure, define all possible "failure modes" (i.e., each equipment failure could be the cause of the functional failure).

5. For each failure mode, state whether it would be due to improper operation, improper maintenance, or both.