PREVENTIVE MAINTENANCE ; METHOD OF PREVENTING TROUBLE

by

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Abstract

Technological advances are increasing almost exponentially and are constantly being applied in modifying plant and machinery to improve performance and reliability. This paper deals with the maintenance aspect of Plant and Machinery which is complex due to the combined applications derived from technological advances made in engineering disciplines. Along with the new generation of plant and machinery there arises a need for more refined maintenance methods and techniques in the achievement of high plant reliability within a reasonable cost structure. The Paper discusses how the development of a comprehensive preventive maintenance program can benefit organization in multiple ways instead of ad-hoc maintenance methods often practiced in industry.

Introduction

Up-to-date, nothing has been designed which requires no maintenance. All plant, machinery and equipment are subject to the universal phenomenon of natural degradation and/or degeneration from a functional state to a non-functional state. By maintaining what is achieved is a postponement of natural degeneration by the reduction of failure intensity thus increasing reliability to carry out the function for which it is designed.

Among many maintenance methods, past experience has proved that Preventive Maintenance is the most efficient and effective way of preventing trouble. Its main objective is to plan, organize, control and regulate timing of maintenance activities in order to assure the usefulness and increase the serviceable life of plant and machinery. Although this is often preached, it is seldom practiced due to budgetary and manpower constraints and dictates to keep preventive maintenance on a low priority. Therefore, system maintenance is often performed under emergency circumstances such as after a breakdown.

Benefits of a well-managed preventive maintenance program are many; Minimum down-time thus reducing loss of production and/or inability to meet service requirements, reduction on replacement/ repair costs, avoidance of tender and procurement procedures, prevention of customer dissatisfaction, and, most important of all is the prevention of undue stress on maintenance staff.

History of Maintenance

Since the early days of mankind, men were using tools to serve as a means of extension of human capabilities in utilizing natural resources in the productive processes for growing and harvesting, building of dwellings, bridges, canoes, hunting equipment, and so on:

Along with the use of tools, they learned by experience that tools are subject to wear and tear and the occurrence of sudden breakdowns. In many cases unsound tools were restored to their serviceable state. Though not familiar with today's economic criteria, early men from experience learnt that the effort and time for restorative proceses were considerably shorter than the replacement of tool. Thus repair was born.

Today, large and complex systems are designed, although vast amount of scientific knowledge and experience are included in the design of such systems, deterioration, degeneration and breakdown have not disappeared. This means that it is unthinkable that maintenance as such will ever become superfluous by elimination of causes.

Failure Causation

Failures of plant and machinery are caused because of the attempt to return to original status from what it had become. This is in conformity with the Second Law of Thermodynamics which states that the direction of all natural changes is one of degradation.

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Looking from another angle, the plant and machinery take on a life of their own, once they leave the hands of the manufacturer. Designers', concepts are transformed into tangible material. Parts are made and assembled into systems which are called upon to perform. Sometimes their behavior and response do not conform to what designers had in mind. This is because they are subjected to multitude of real-world forces and influences. They are misused and abused, used in a way unforeseen by designers, used beyond their useful lifetime without carrying out life extension methodologies, or pushed beyond their limits. Environmental effects can be more aggressive, defective connections, assembly errors, missing parts all have a part to play in the life of plant and machinery.

In summary failure causation is a complex process resulting from one or a combination of causative elements such as design errors, human errors in operation, environmental effects and material related deficiencies. Charles E Witherell wrote in his book "Mechanical Failure Avoidance": - *"No two failures are ever exactly alike; The causative network that produced it is unique to that situation and so are the players, the conditions, flaws and deficiencies, actions and inactions, and all circumstances surrounding and leading up to the culmination of event".*

Maintenance

The literature shows a variety of definitions of maintenance:

"MAINTENANCE IS THE TOTAL OF ACTIVITIES SERVING THE PURPOSE OF RETAINING THE PRODUCTION MEANS IN OR RESTORING THEM TO THE STATE THAT IS CONSIDERED NECESSARY FOR THE FULFILMENT OF THEIR PRODUCTION FUNCTION".

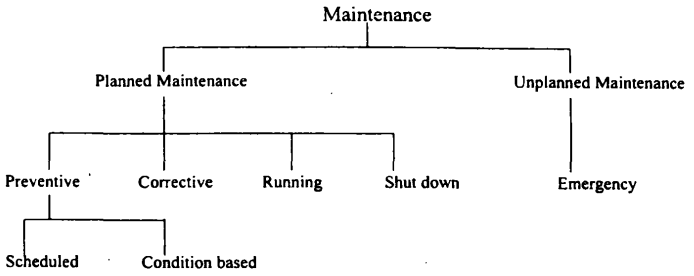
Maintenance Policy

Maintenance policy is defined in B.S. 3811 as *" a strategy within which decisions on maintenance are taken."*

The resource requirements such as personnel, tools, instruments, spares, oils and greases, and so on. required to carry out a successful maintenance program is dependent on the policy established and the decision whether to provide for operation and maintenance of the system by a contract arrangement with a specialist external organization, or by use of suitably trained, in-house personnel, or by a combination of both.

Budgetary allocation for maintenance is based on the policy decision and is part of a company's strategic plan.

Types of Maintenance



PLANNED MAINTENANCE is the function of organizing and carrying-out maintenance with forethought even using past records to a predetermined plan.

Note: Preventive maintenance is normally planned whereas corrective maintenance may or may not be planned.

PREVENTIVE MAINTENANCE is carried out at predetermined intervals or to other prescribed criteria and intended to reduce likelihood of failure or breakdown of plant and machinery.

CORRECTIVE MAINTENANCE is the restorative process including adjustments and minor repair of plant/machinery which ceased to meet an acceptable condition while in service. This may require short duration plant outage.

RUNNING MAINTENACE is carried out while the plant and machinery are in service.

SHUT DOWN MAINTENANCE This is an important maintenance activity. The plant/machinery is put out of service for a predetermined period to attend to all maintenance activities such as replacement of bearings, impellers, chains and so on, and intends to bring back the plant to the status that it can perform trouble-free for a predetermined length of time. Advantage is taken to modify the plant system to accommodate solutions for recurring problems. A typical example is the annual maintenance of Sugar Plants.

EMERGENCY MAINTENANCE is sometimes necessary to avoid serious consequences by stopping plant/machinery without giving prior notice.

Behaviour of Objects to be Maintained

Three quantifiable properties are identified to describe maintenance aspect of plant and machinery. They are as follows;

Failure Intensity -(FI) = n/T
where n = No of failures

T - Unit measures of life; Examples of unit measures of life are Time, Kilometer, Cycles

From the Failure Intensity it is possible to derive another property called "Reliability" which is the probability that a system will accomplish a mission successfully in a given time under stated operational and environmental conditions.

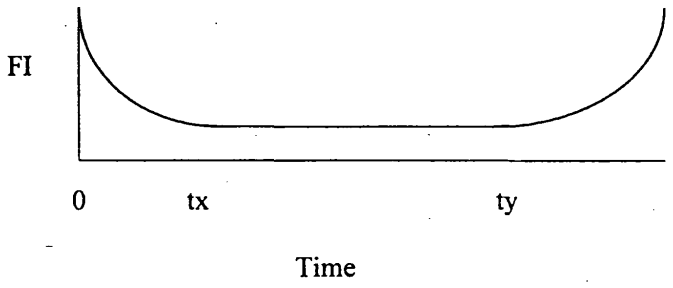
Mean Time To Repair- (MTTR) = tcr/Tx
where tcr= time taken to repair the failed system
Tx= total corrective maintenance actions during a specified period

Availability = t/T
where t = Time plant and machinery available for production/service function over a unit measure of time. Therefore Down time = T-t

Computer-aided maintenance methods need above data in the decision-making process.

Life Characteristic Curve

Experience shows most plant and machinery go through a life cycle similar to a bath-tub curve as shown below.



Graph of Failure Intensity (FI) verses Time

0 tx Infant mortality region
(tx - ty) Useful life region
* ty Wear out region

Note that "useful life" or design life of a machine is not definitive, as periodical overhauls, selective replacement of components with improved versions, performance monitoring and operational evaluations can significantly extend useful lifetime. Some plants such as electric power generating plants, probably because of size, complexity, critical need and cost are installed with life extension methodologies.

Performance Criteria of Maintenance Functions

The performance of plant and machinery maintenance can be judged by the following indicators:

Plant and Machinery Performance
Down time
Service life- i.e. Period within which Return On Investment is expected
Efficiency
Safety
Environmental impact- It must operate in a manner not detrimental to the environment.
Cost

In the event, any of above indicators become unacceptable against the criteria specified by the management, particularly against the cost of maintenance, the plant and machinery will have to be considered uneconomical to maintain and even can be designated redundant.

Preventive Maintenance Methods

Widely accepted in industry are the RCM and CBM methods.

RCM- RELIABILITY CENTRED MAINTENANCE METHODS

STEPS IN RCM METHODS

* *Selection of plant and equipment-* In the selection of plant and machinery for production and/or service functions it must be based on reliability amongst other criteria in order to reduce annual maintenance costs.
* *Define functions-* Once selected, functions of each assembly of the plant must be understood how it is designed to perform specific functions. Once the functions are understood, all the potential failures that must be considered are much easier to identify.
* *Identify failures-* Any part, subsystem or even the function itself can suffer failures. In this step, determine what constitutes the failure.
* *Determine root cause-* Apply Root Cause Failure Analysis (RCFA), which is a powerful tool for determining "what really went wrong" when plant and machinery outages are experienced.
* *Assess effects*
* *Decide on prevention*
* *Implement the plan.*

RCM method is expensive and laborious to apply on highly complex plant and machinery.

CBM- CONDITION-BASED MAINTENANCE METHOD

Most failure modes experienced in complex plant and machinery systems are random in nature - that they cannot be foreseen with confidence, but they can often be detected early. This is the essence of the CBM method in which two interrelated general approaches are used; *Operational appraisals* based on historical information particular to plant and *Material condition* assessment which deals with the monitoring of materials conditions mostly susceptible and vulnerable to failure.

Operating appraisal - The available data pertaining to the plant- design calculations, maintenance service records, loading history, environmental factors, production records are used to estimate extent of cumulative wear and tear already sustained and the remaining operating life. This information is used to take remedial action before plant encounters a sudden breakdown.

Material condition assessment - Non Destructive Evaluation (NDE), and Non Destructive Testing (NDT) methods are used to monitor the condition of plant and machinery. To a greater extent the information gathered from above evaluations/testing are used to identify components likely to fail in the near future, thus avoiding sudden breakdown.

NDE and NDT METHODS

Inspection methods	Monitoring methods
* Visual	Visual
* Liquid penetrant	Steriophotography
* Magnetic particle	Leak monitoring
* Eddy current	Photography
* Radiographic	Vibration monitoring
* Ultrasonic	Strain monitoring
* Acoustic emission	Corrosion monitoring

A typical case of monitoring the bearing performance using Vibration monitoring technique is given in the Appendix.

Record Keeping

Accurate record keeping is essential in a maintenance program. There are various computer packages available as aids to maintenance, for which in-puts are obtained from the records.

* Asset register
* Plant history cards - It is a record of the history of plant and machinery at a glance.
* Service schedule - This guides when the plant and machinery are scheduled for inspection and lubrication.
* Overhaul Schedule - Based on various information a decision is made when and what equipment are to be overhauled, modified, upgraded, etc.
* Work schedule: Shut down, monthly, daily
* Spares list
* Costing of work
* Insurance file.
* Test details, energy details and performance evaluations of plant subsystems.

Worker Participation

Even with best preventive maintenance programs things go wrong in a plant as the real world effects are unforeseen. This is where worker participation at all levels of operational, supervision to maintenance are essential. They can immensely contribute towards achieving trouble-free operation of plant and machinery. "LLF" - Look, Listen, Feel - usually is the first step in the detection of unusual situations.

Benefits of Preventive Maintenance

* Increase reliability of plant and machinery
* Minimize interruptions of various processes and reduction of down time
* Control maintenance costs, unplanned purchases and tender work
* Increase productivity of employees and better utilize the available work force
* Improve plant safety
* Keep accurate records to establish plant and machinery breakdown frequency
* Establish cost records so that excessive costs can be highlighted and decisions on repair or replacement can be based on solid facts
* Provide better conservation of assets by elimination of premature replacement
* Minimize large scale repairs
* Increase plant performance
* Control excessive use of spare parts
* Reduce worker stress
* Increase production, therefore profits against investment

Conclusion

Capital intensive plant and machinery are often imported, draining a bigger share of hard-earned foreign exchange of the country. It is the Engineers responsibility to protect such costly investments and this is only possible by ensuring that proper maintenance management supplies are in place.

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