Changing Maintenance Strategies

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ABSTRACT

" Maintenance Strategy is to improve on stream factor of equipment, systems and plant at large by using all maintenance management techniques effectively and efficiently with maximum cost consciousness. The industries are using different types of equipment from different countries and companies and as such the maintenance problems are also of varied dimensions. Maintenance engineer problems are 'bought' with the plant. The decisions which are made when the plant is being designed, ordered, constructed and installed affect the way it will run and affect the way in which it has to be maintained and looked after.

In the process of specifying and designing new plant, when the user has given the plant maker all the information he can and the plant maker has incorporated this with his own expertise, and produced a design, there is at this stage a need and an opportunity to review and evaluate the design before it is finalized. The technique evolved is known as design review or design audit. This is carried out by a team of specialists of varied disciplines whose purpose is to examine the design, to identify and weakness of missed opportunities and to judge whether it will meet the laid down objectives".

INTRODUCTION

The development of technology, use of State of the art materials, improved instrumentation, control and automation, efficient and complex processes, higher recovery from waste streams and stringent environment regulations have all contributed to a change in approach towards maintenance.

In the 1970's the status of the industry was as follows:

- High product demand in an assured market environment.
- A focus on producing as much product as possible to cope with demand.
- Maintenance was carried out at 'whatever cost', ' Production and just production' was the motive, and maintenance cost was not an immediate concern.
- The interface between maintenance and operation was very limited since the maintenance philosophy was pre-dominantly tuned towards the performance of breakdown maintenance.
- Redundant plant and equipment were available to cater for breakdown situations.
- A large inventory of spare parts, and in certain cases even spare equipment itself was available to cater for this breakdown approach.
- Maintenance planning was simply an 'internal co-ordination'.
- Maintenance planning was carried out through an area planner using the manual work order system.
- There was no real 'cost centre' approach towards allocation of maintenance cost.
- The area of the plant to be maintained was small and therefore the physical assets to be maintained were less.

Maintenance management was regarded as minor function prior to 1970. Since 1970 the trend has been changing and maintenance is being required to integrate itself more into the overall structure of business and to make its contribution in the search for a fresh economic equilibrium. A Survey of changing maintenance strategies is presented in thirties.

The prime function of maintenance engineers is to improve on stream factor of equipment, systems and plant at large by using all maintenance management techniques effectively and efficiently with maximum cost consciousness. The industries are using different types of equipment from different countries and companies and as such the maintenance problems are also of varied dimensions.

Maintenance is expected to play a very important role in continuous process industry because of modern technologies, high capital cost, continuous and simple stream process, large capacities, severe service conditions, predominant safety hazards etc.

Maintenance engineer problems are 'bought' with the plant. The decisions which are made when the plant is being designed, ordered, constructed and installed affect the way it will run and affect the way in which it has to be maintained and looked after.

Due to this avalanche of change, maintenance management were forced to seek a renewed and articulated approach to maintenance. Maintenance was no longer accepted as an expense center, but was transformed into a profit center.

The new challenges facing maintenance have become evident due to the following:

- All new expansions were large in size with modern and efficient equipment.
- Equipments breakdown, and the resulting downtime, has always affected the effectiveness of the plant / equipment by reducing with customer service.
- Greater levels of mechanization and automation in the recent past meant that reliability, availability and maintainability (RAM) have

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now become key issues in the maintenance discipline.

- The ability to sustain high quality standards by aiming for the most efficient operation of equipment has gained high importance.
- The failure of equipment has serious safety or environmental consequences, at a time when the required standards in this area are rising rapidly.
- The point is approaching where organizations must either conform to society's safety and environmental expectations or cease to operate.
- The industry's greater dependency on the reliability and integrity of plant.
- Dependence on plant and machinery has been increasing so rapidly that the cost of operating these assets is also increasing.
- To justify the existence of the plant and the invested capital, modern plant must be kept working and maintained efficiently for as long as possible.

Effective Maintenance Management

We know the cost of everything but perhaps the value of nothing. It is fundamental to really understand why it is necessary or not to maintain functional assets. Analytical processes applied to develop maintenance tasks that when appropriately implemented will reduce the probability of failure or degradation of functional assets. This is particularly important in any industry where the operator must demonstrate risks are as low as are reasonably practicable.

Effective maintenance will not only ensure technical integrity but can reduce operating costs significantly and more importantly increase revenue streams through high equipment availability. Human aspects related to the maintenance process and how different are our perceptions of risk. It is critically important to understand for example the behavioural aspects as to why, after appropriate maintenance tasks have been developed, non-compliance with these tasks may be endemic and how different individual perceptions of risk may lead to flawed decision making.

New Tools

With the currently availability of vastly improved decision support tools, a new dimension in the development and application of modern maintenance techniques has occurred. These include:

- Risk Based Inspection
- Support tools: CMMMS (Computerized Materials and Maintenance Management Systems), hazard studies, failure mode and effect analysis (FMEA) etc.
- Predictive maintenance, proactive maintenance, total productive maintenance etc.
- Reliability in design.
- Maintenance optimization software packages.
- Advanced process control and optimization systems.
- Application of expert systems such as conditions monitoring, efficiency and performance monitoring.

Risk Based Inspection

Risk based inspection is the application of risk analysis principles to manage inspection programme for plant equipment. RBI is a systematic tool that helps users make informed business decisions regarding inspection and maintenance spending. The ultimate goal of RBI is to develop a cost effective inspection and maintenance programme that provides assurance of acceptable mechanical integrity and reliability.

Risk based inspection (RBI) schemes are planning tools used to develop the optimum plan for the execution of inspection activities. A risk based approach to inspection planning is used to :

- Ensure risk is reduced to as low as reasonably practicable.
- Optimize the inspection schedule
- Focus inspection effort onto the most critical areas.
- Identify and use most appropriate methods of inspection
- Improve the cost effectiveness of inspection and maintenance resources.
- Provide a basis for shifting resources from lower to higher risk equipment.
- Measure and understand the risks associated with current inspection programmes.
- Measure risk reduction as a result of inspection practices

Risk based inspection methodology leads to efficient resources allocation, improved safety, increased reliability and better compliance with applicable codes, standards and regulations.

A successful plant maintenance schedule using risk based inspection principles leads to optimised inspection and maintenance strategies, extended intervals between planned outages, increased plant availability and extended plant and equipment life-spans. The process plant industry focuses haphazardly on the monitoring and maintenance of stationary equipment such as boilers, vessels, heat exchangers, piping and furnaces. These types of equipment often account for a significant portion of the maintenance budget and frequently have severe financial consequences for a plant if in need of repair.

Implementation of RBI practices leads to a transition from maintenance and inspection cycles based on regulations or insurance requirements (timebased inspection) to structured and reliable maintenance and inspection methodology based on historical data and equipment needs (condition / risk based inspection)

Growing research in the maintenance field and the inbuilt reliability of equipment manufacturers (as a result of technology developments and feedback from users) has also drastically changed the way. We look at the failure pattern of machinery. These new failure patterns reveal that the relation between age of equipment and how likely they are to fail is diminishing. Hence, maintenance strategies have changed and can sometimes be different to the OEM

(Original Equipment Manufacturers) recommendations.

To meet these challenges, several audits / studies have been initiated to support the cost control and decision making process. These include:

- Hazop study on existing plant, plant modifications and expansion projects at the design stage.
- Technical integrity studies, reliability studies, reliability based inspection etc.
- Performance improvement programmes.
- Health / Safety / environment studies.
- Benchmarking studies.

These audits have helped to increase plant managements level of confidence by assuring the integrity of physical assets and the measures to realize this assurance by adopting a professional methodology. They also help to finalize long term plans and strategies in maintenance to suit with industry trends.

Maintenance Strategies & Extent of Maintenance

A maintenance strategy is the set of rules, which prescribes how to arrive at a decision about WHAT maintenance should be executed WHEN, on the basis of the failure behaviour of the system concerned. The result is the maintenance concept for such a system in particular organization.

Breakdown Maintenance (Repair when failed)

- Repair maintenance when dominant failure mode is sudden, or early symptoms of degradation are difficult to detect.
- Simple system where secondary failures are not extensive or costly.
- System in which failure is falling with time.
- Cost of unscheduled stoppage is not important.

Preventive Maintenance

- Preventive Maintenance is used where prior symptoms of degradation or failure are difficult to detect or interpret.
- Complex system where secondary failures can be extensive and costly.
- Components and parts to be periodically replaced are relatively cheap and costs of unscheduled stoppage high.
- Components are of stable, statical behaviour.
- Failure rate increasing with time.

Predictive Maintenance

- Predictive Maintenance is suitable for systems in which components deteriorate relatively slowly and consistently in time.
- Symptoms of deterioration can be detected and interpreted.
- Components relatively expensive and value of system availability is high.

Condition Monitoring

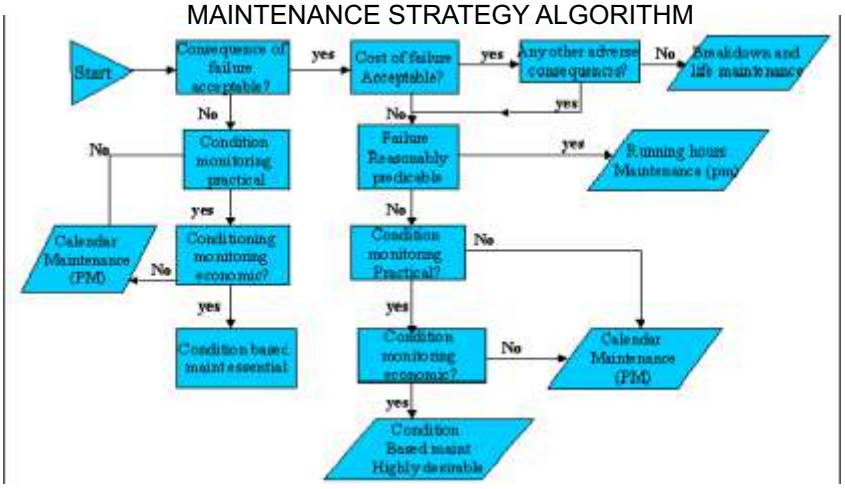
Condition monitoring is part of predictive maintenance and is only concerned with the detection of degradation. For it to be applicable, certain conditions must be satisfied.

- That the deterioration of components and parts occurs 'slowly' and consistently in real time.
- That some indication of the deterioration or degradation can be detected.
- That a sufficiently close correlation between the indicators and the state of operability of the component or system is available.
- That system aspects i.e. the economics, safety level etc, are favourable to the application of the method.

The proportion of maintenance carried out in various categories, such as breakdown, preventive, predictive etc has also changed, Predictive maintenance using state of the art conditions monitoring tools is taking precedence over PM, which has helped contain costs and encouraged the attendance of equipment only 'as and when required' and not according to a fixed time interval as previously. The activities to be carried out during a particular PM are thoroughly scrutinized to ensure that only the required activities are performed.

As highlighted earlier, the maintenance strategies practiced have changed in order to cope with maintenance challenges. For instance, the approach used to handle routine maintenance has changed to either of the following or a combination of both.

- Maintenance performed by a core of highly skilled company hired craft level and supervisory stall supported by body shop (long term hire of maintenance manpower at the craft level) contractor staff.
- Fully contracted out maintenance, in which the contractor's scope generally includes all the manpower (including supervisory) and the tolls needed to perform the maintenance work, the materials required, the workshops and necessary infrastructure being



provided by the owner. Skilled direct – hire supervisory staff will manage the maintenance performed by the contractor. This has been adopted successfully for certain activities such as HVAC system, plant lifts etc. In addition turnaround projects are often fully contracted out.

The above strategies have helped to slim down the core maintenance organization to only a skeleton of direct hire staff, resulting in less overheads.

Reliability in Maintenance

At present, maintenance efforts are concentrated on implementing a standardized, systematic & cost effective reliability programmes. Reliability consciousness in turn has driven maintenance organizations to turn towards reliability focused strategies in line with their peers in the West.

A number of companies have started the limited application of reliability centered maintenance (RCM) for critical systems. The data analysis during the RCM process complements the systematic / computerized approach.

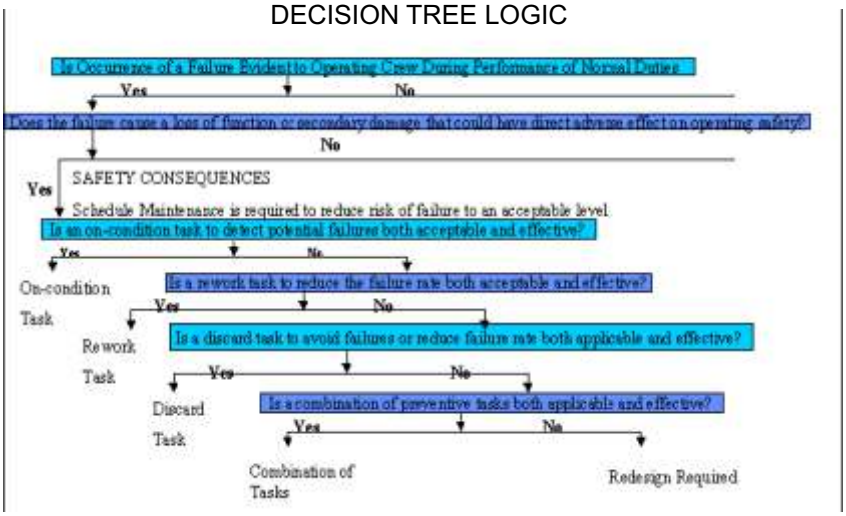
Reliability Centered Maintenance

Maintenance effectiveness importance increases directly with plant age. RCM is used to eliminate deficiencies in the administrative controls over maintenance and in the PM programme scope. RCM objectives is to fine tune and formalise a successful programme in anticipation of the future needs of a middle aged plant. It presents an opportunity to use the latest technology to economize plant efforts, to ensure that the effects of age on critical components are addressed, and to prepare for future renewal of the plant's operating license as it enters it's third decade of operation.

For developing or optimizing a maintenance programme, RCM makes use of decision tree logic (Fig.2) to identify:

- Equipment maintenance requirements based on the safety and operational consequences of possible failures.

DECISION TREE LOGIC



- Degradation mechanisms responsible for those failures.

Although it emphasizes use of both condition monitoring and predictive maintenance techniques, RCM also considers use of time-directed (periodic) tasks, where appropriate, as well as testing and modifications to ensure the reliability of critical components. At the same time, it identifies non-critical failures that are acceptable. The process embodies the following basic phase.

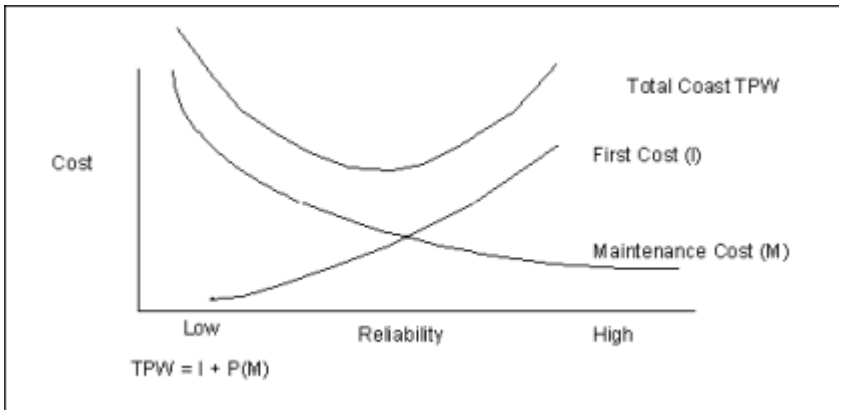
- Selection of plant systems.
- Delineation of system boundaries.
- Definition of system functions.
- Determination of critical components.
- Analysis of failure modes and effects.
- Evaluation of maintenance histories.
- Development of applicable and effective RCM tasks.

Cost of Reliability & Maintenance

For example, at the conceptual & design stage itself, trade-offs between High first cost (to ensure higher reliability) Vs High maintenance cost can be optimised.

Reliability can be increased by investing more on improved and redundant design, better material, quality of construction, more spares & corrosion protection – all adding up to higher initial and operating cost. Maintainability similarly can be improved by modular designs, standardization, accountability, fault detection & test equipment, preventive policies, spares skills & numbers of persons-partly reflected in cost design and partly in direct maintenance cost itself. Failure Rate (FR), Mean Time Between Failure (MTBF), Mean Time Between Maintenance (MTBM), Mean Time to Repair (MTTR) and Mean Down Time (MDT) can be measured & traded off at Design stage and subsequently to achieve desired operational availability MTBM / (MTBM + MDT) or inherent availability MTBF / (MTBF + MTTR) in the quest for optimality.

Uncritical application of lowest first



unless the equipment has very low life, one year or so, either because of anticipated functional obsolescence or for other operational / commercial causes.
All the above-mentioned reliability approaches have helped to fine tune maintenance strategy applied on equipment and hence the reliability of equipment.

Reliability in design

Reliability in design concept has also been seriously considered and meticulously applied for new projects as follows:

- Conducting reliability / availability / maintainability studies during the front and engineering phase.
- Requesting the vendors to demonstrate the reliability of the critical rotating equipment during the EPC stage of the project.
- Placing greater emphasis on considering the maintenance needs extensively during the detailed engineering, procurement and construction phases of the project.
- Diligently scrutinizing vendors / equipments during the tendering stage.
- Utilizing well proven technology equipment in instrumentation such as using equipment with self – diagnostic features; small instrumentation with diagnostic maintenance tools, dual redundant equipment etc.
- Identifying and enforcing the training needs in the early life of the project implementation.
- Encouraging the concept of entering into LTPA (long term purchase agreements) maintenance contracts, service agreements for proprietary systems such as DCs, condition monitoring etc.
- Evolving strategic partnership and networking among maintenance personnel and other discipline personnel.
- Insisting on optimization studies, return on investments (ROI) analysis, life cycle cost (LCC) analysis during the EPC stage.
- Specifying proven and state of the art condition monitoring and automated performance monitoring practices as mandatory requirements to provide accurate machinery diagnostics, so facilitating the efficiency calculations and resulting in conservation.

Design and Specification of New Plant

In the process of specifying and designing new plant, when the user has given the plant maker all the information he can and the plant maker has incorporated this with his own expertise, and produced a design, there is at this stage a need and an opportunity to review and evaluate the design before it is finalized. The technique evolved is known as design review or design audit. This is carried out by a team of specialists of varied disciplines whose purpose is to examine the design, to identify and weakness of missed opportunities and to judge whether it will meet the laid down objectives.

- To determine precisely what is required of the new plant and to lay down clear criteria for success.
- To maximize the information flow between customer and plant manufacturer to ensure that advantage is taken of all expertise and experience.
- To carry out a design audit ensure the right choices have been made, and no weaknesses have been overlooked.
- To think constantly in terms of whole life cost, particularly with regard to servicing, maintenance and breakdown costs during the life of the plant.

CONCLUSIONS

For improving on stream factor of plant and achieving higher reliability and maintainability, the following aspects require considering for incorporation in the organization philosophy.

- For new projects maintenance personnel to be included in the project team.
- Final design prior to order / manufacture is audited by team of specialists of varied disciplines for avoidance of functional failures in service.
- Complete maintenance backup programme including fault finding programmes, planned maintenance, frequency scheduled, spares requirement, are available as the plant is installed and commissioned.
- Life assessment of critical equipment to be carried out from the commissioning stage. Equipment replacement plan should be based on it
- Manufacturers, designer and service personnel assistance should be taken during overhaul for up gradation of equipment.
- Close interaction between similar industries and between developed and developing countries.
- Good contact and support from professional bodies.

Of late, the focus of maintenance is being directed towards reliability and 'maintenance cost optimization'. The sensible approach is to apply new technology coupled with past experience and strike a balance to proposer.