International Journal of Engineering and Technical Research (IJETR)
ISSN: 2321-0869 (O) 2454-4698 (P), Volume-3, Issue-7, July 2015

Optimization of Preventive Maintenance-A Review and Analysis

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Abstract— **This Paper highlights the development process of preventive maintenance optimization techniques and activity to observe situation of reliability, availability and ingenious maintenance. This is designed in a way to identify probable failure modes of far above the ground outcome, strategy, steps, and standards to safely reduce the probability and impact of the failure by using data, experience, and the passion of employees. The standardization and feature of PMO effecting by developing steps and standards for PM tasks can be increased by these strategies. The execution of PMO is a technique that will allow the analysis to increase the efficiency of the Maintenance approach. The conclusion of this new technique will not be evident immediately and shall prove to be fruitful in long run.**

Index Terms— **Maintenance strategies, maintainability, reliability, availability.**

I. INTRODUCTION

Preventive maintenance (PM) is an important constituent of a maintenance alliance. In a maintenance institute it repeatedly accounts for a major proportion of the total maintenance exertion. PM may be described as the care and servicing by individuals involved with maintenance to keep equipment facilities in satisfactory operational state by providing for regular examination, recognition, and improvement of incipient failures either prior to their occurrence or prior to their development into major failure. Some of the main objectives of PM are to improve capital equipment creative life, decrease of critical equipment breakdowns, allocate better planning and scheduling of needed maintenance work, minimize losses in production due to apparatus failures, and enhance strength and safety of maintenance workforce.

Preventive maintenance is predetermined work performed to a schedule with the aim of preventing the wear and tear or sudden failure of equipment components. Preventive maintenance helps in -

- Carry on assets and improve the useful life of production equipment
- Improve system reliability
- Decrease cost of replacement
- Decreases system downtime
- Reduce injury

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Mechanical process or categorize equipment failure are capable of having adverse results in both human and economic terms besides down time and the costs involved to repair or replace equipment.

1.1-Preventive maintenance and its optimization:-

Optimization of Preventive maintenance is a process to progress the effectiveness and efficiency of the PM process. Effective PM's address and lessen the corollary of specific and viable failure modes. Proficient PMs are value-added tasks which are performed using the least labor, downtime, and material required to complete the task. The main center of attention is on the development process of our Maintenance strategies and will also briefly present the tools that there are developing in order to reach desired goals .PMO, which is a tool in spacious use at the moment, is primarily concerned with finding a proper way to optimize the Maintenance Plans through the maintenance task, by adding up or either removing some of tasks. The results of this optimization can't be instantaneous, but will become clear in the long term.

Optimization of Preventive maintenance is a new technique that has grown recently in popularity and it is structured as follows:

- To prepare the PMO
- To define system or equipment according to Reliability requirement
- To review existing PM
- To screen the task for removal
- To optimize remaining tasks
- To fill gaps on PM
- To review the manufacture recommendations
- To optimize PM work order
- To implement change
- To evaluate improvement.

1.2-Scope of preventive maintenance optimization-

One of the critical issues in determining the key to success of a factory is to maintain high equipment reliability. Higher equipment efficiency arise the scope in field of preventive maintenance optimization that improved productivity and profitability, which relies heavily on a maintenance planning. Preventive maintenance is an extensive term that surrounds a set of activities meant at improving the overall reliability and availability of a system. All types of that system create different future work in PM. That regarding scope of preventive maintenance optimization some points are given here-

1-Deciding the amount of preventive maintenance i.e. choose the maintenance intervals
2-Deciding whether to do first line maintenance on the site or depot maintenance
3-Choosing the right number of spare parts in stock

4-Preparedness with respect to corrective maintenance
5-Time of renewal
6-Grouping of maintenance activities
1.3-Preventive maintenance optimization steps-
Gonzalez, C et.al [14] used in PMO an important part of the Maintenance internal process and during the development of its various use tools in order to progress through the different established steps. The step shown below marks the flow process for sequential development PMO.

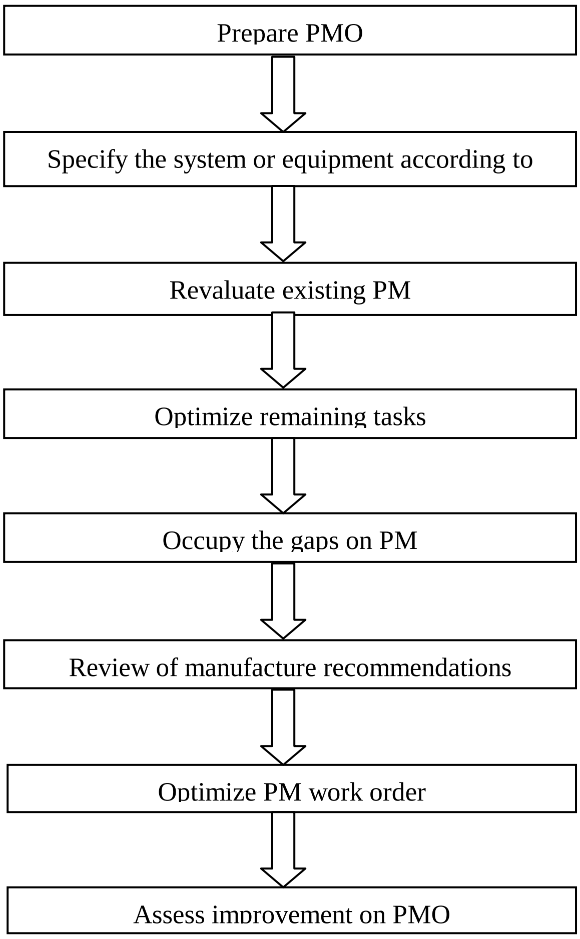

Fig.1 Preventive Maintenance Optimization Steps

Preventive maintenance optimization steps are given step by step here-

1-Prepare PMO:
Specify systems reliability requirement.
Set up system criticality ranking.
Modify and establish system availability ranking.
Select the equipment and system, according reliability, criticality and availability.

2-Specify the system or equipment according to reliability requirements:
Collecting information about the related equipment selected.
Categorize the information collection.

Accomplish failure Mode.
Analyze the information for reliability.
Analyze the failures modes of the system reliability.

3-Revaluate existing PM:
Check each one of the existing tasks of the actual plan.
Check the above failure modes are covered by the existing task.

4-Optimize remaining tasks:
Optimizing the existing task in the way of add more information and changing existing information.

5-Occupy the gaps on PM:
Recheck each task and verify that nothing is missing.

6-Review of manufacture recommendations:
Double checks manufacture recommendations.

7-Optimize PM work order:
Modify actual PM work order and apply all the changes made on site

8-Assess improvement on PMO
Evaluate all changes with inspections. Regardless of any plant process and product, preventive maintenance matters. That services hospital, oil fields, manufacturing site and data centers, asset reliability affects output. It comes out that well-organized, effectual, maintenance affects production and maintenance cost.
Studies show that. To establish effective maintenance workflow, we have to pay attention on the main key steps "key maintenance activities" in which activities include:
In which each of these steps are drastically affected our Preventive Maintenance Optimization process.

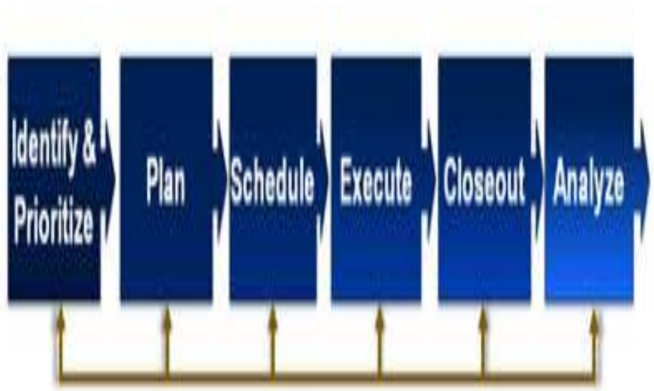

Fig.2:-Activities include in PMO [14]

In which without value-added preventive maintenance, It will not identify and estimate all work, prioritize properly, and can not affect the scheduling, execution, analysis for work. With value-added PM, It will not just make the maintenance work more effectual and value performance, in which lessen the downtime of the equipment for PM and for repair.
1.4-Strategies applied in preventive maintenance optimization-
All these approaches use some widespread elements for coming at the most value-added preventive maintenance strategy for the equipment and system. When optimizing is done on PMs, we will look after and check at failure records, PMs, experience, and functional diagrams to generate a list of probable failure modes. Then use the theory of failure patterns, Potential to Failure curves, consequences, and operating condition to develop an improved strategy.

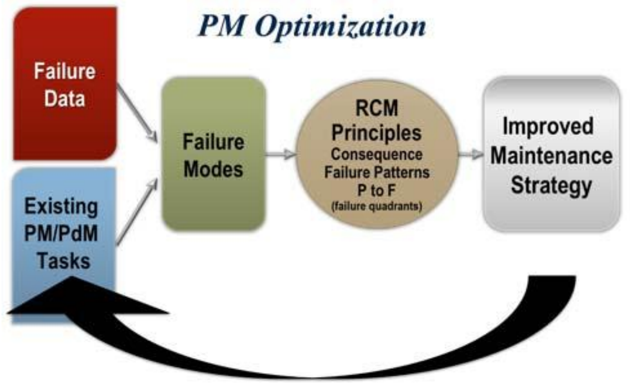

Fig.3:-Preventive Maintenance optimization failure pattern [13]

Using the operating environmental conditions, failure patterns, and P to F, three basic points can be maintained: Replacement of part in a known interval or practice reduces the probability of failure.

1. It in the process of failure with enough time to respond.

2. The impact of the failure high enough to necessitate the cost of a PM strategy

These above three elements will help us in determining the type of PM strategy and approaches that is value-added.

In this there will be developing the most value-added strategy, to increase the standardization and quality of PMO execution by making steps and standards for PM tasks. Perform five simple questions when we create the PM task to improve the PM standard. Then a high consequence, value-added PM should address the steps, criteria, references, and, obviously, include safety information. To support this development we make use of the following five steps:

1. Insure about task type.
2. Method of working.
3. Check acceptability level of working, it may well-
   Condition-based—criteria or specification determines which will pass or fail.
   Interval-based— criteria and equipment function making sure about completion of task.
4. Course of action should the craftsman should take if the results are improper.
5. Ensure safety Level.

So there will be listing of the safety instructions first on the job plan, but should understand what is to be done and how before we can determine the safety implications.

To précis this information into a simple thought, it may be helpful to consider the following questions. While this may not be the most effectual way to process many tasks, it does help us in accepting the process.

1. Specific failures stop process.
2. History related to this failure.
3. Task addressing this failure process.
4. Check the failure coming (P to F).
5. Predict when the failure is likely to occur.
6. Check the impact whether there be on Safety, manufacture,
   (Consequence) if this has to occur.
7. Add some more detail or pictures to the job to ensure the higher quality of execution.
8. Check period duration in which you feel comfortable letting this run without checking or changing Frequency.
9. Best resource to execute the task.

Preventive Maintenance Optimization is a process that will identify feasible failure modes of high consequence. It then develops the strategy, steps, procedures and standards just too safely reduce the probability and brunt of the failure. By using data, experience, and the zeal of your employees, we can manage the high impact modes of failure.

1.5-PMO Planning Model-

Based on the collected data, several ideas have been derived in achieving effective PM in this company as illustrated. Fig.4 shows strategies and tactics evaluated from the proposed ideas in implementing effective PM. Main ideas generated for this PM are to have simple maintenance schedule, do preparation for technicians and operators in maintaining machines to be in good conditions, do routine inspections and also integrations with production. In terms of integrating with productions, maintenance department must integrate with productions in doing PM periodically. Communicate with productions strategy to stop operation for a short time to do PM and joint shutdown schedule.

II. Research Approaches on Preventive Maintenance Optimization-

Bris et.al [1] appreciated the new method to minimize the preventive maintenance cost of series–parallel systems and proposed mainly the maintenance policy influence. The other causes can be taken into account with the developed method. Among the different types of maintenance policy, we put forward to study the preventive maintenance, widely applied in large systems such as transport systems and production systems,

Jose et.al [5] developed an algorithm for the maintenance management of a series system based on preventive maintenance over the different system components, in order to guarantee a pre-determinate reliability level.

Sofia Panagiotidou et.al [11] presented an economic model for the optimization of preventive maintenance in a production process with two quality states. In this paper allows for maintenance decisions dependent on the quality state of the process since the two quality states are characterized by different failure rates and revenues.

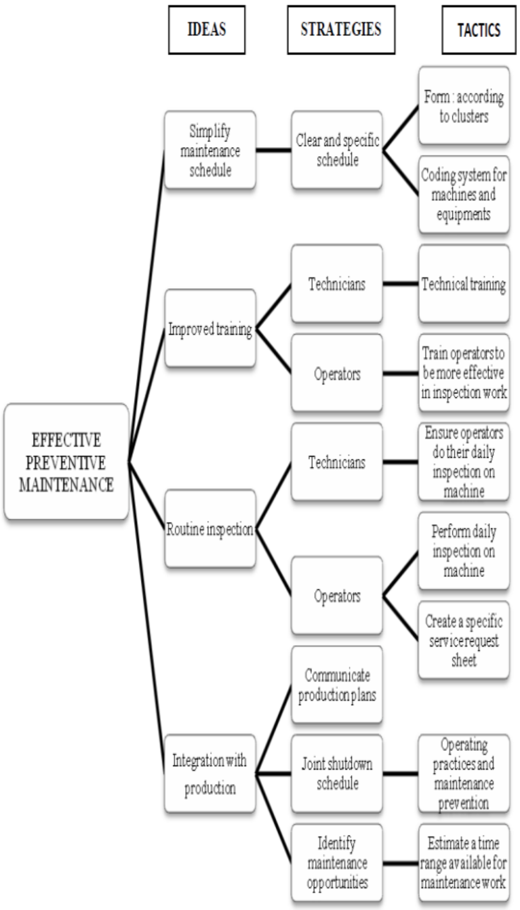

Fig.4:-Analysis of effective PM using Tree diagram [10]

Geoffrey Lamptey et.al[4] studied PM schedules for pavement management decision support because they can provide an indication of what preventive treatment is desired and when it is required, and can therefore help in estimating highway pavement monetary needs in the period between resurfacing events.

M. Samrout et.al [7] used genetic algorithm to minimize preventive maintenance cost problem for the series–parallel systems. Improvement on their results developing a new method based on another technique, the Ant Colony Optimization (ACO).

Michael Bartholomew-Biggs et.al [6] approached with the problem of scheduling imperfect preventive maintenance (PM) of some equipment. It uses model of Kijima in which each application of PM reduces the equipment's effective age but without making it as good as new. The approach existing here involves minimizing a performance function which allows for the costs of minimal repair and eventual system replacement as well as for the costs of PM during the equipment's operating lifetime.

Xiaojun Zhou et.al [12] develops a dynamic opportunistic preventive maintenance model for a multi- component system with considering changes in job shop schedule. When a job is completed, preventive maintenance opportunities arise for all the components in the system. The most advantageous maintenance practice is dynamically determined by maximizing the short-term cumulative opportunistic maintenance cost savings for the system.

Ruey Huei et.al [10] study proposes a maintenance scheme for leased equipment using failure rate reduction method and derives an optimal preventive maintenance (PM) policy that minimizes expected total cost. In this study, an efficient algorithm is developed to derive the optimal PM policy and a closed-form solution is obtained for the case where the lifetime distribution of the equipment is Weibull. The expected total cost by using the optimal PM policy under the proposed maintenance scheme is then compared with the performance of other policies under various maintenance schemes.

Mustapha Nourelfath et.al [8] formulated a joint redundancy and perfect preventive maintenance optimization model for series–parallel multi-state deteriorated systems. The status of each component was considered to deteriorate with use. The objective was to determine jointly the structure of series–parallel system and the preventive maintenance policies that maximize the system availability, subjected to budget constraints.

Upcoming research would discover more numerical experiments to confirm the efficiency, when solving the problem developed in this paper, and to compare it with other heuristic techniques in terms of execution time and solution quality.

E. Moradi et.al [3] investigates integrated flexible job shop problem (FJSP) with preventive maintenance (PM) activities under the multi-objective optimization approaches. Finding compromise solutions among the production objectives and maintenance ones is under concern. In order to perform the maintenance

Activities, reliability models are in use.

In which attempts to simultaneously optimize two objectives:

-The minimized make span for the production part and

-The minimized system unavailability for the maintenance part.

Romulo I. et.al [9] worked on the determination of the optimal maintenance policy for a manufacturing facility and the optimal buffer inventory to suit the demand during the interlude period due to a maintenance action. In which consider the possibility of damaged production and that opportunities for the fabrication of the buffer stock and opportunities to carry out a maintenance accomplishment to the production facility are random.

Cláudio M.N.A. Pereira et.al [2] presented a Particle Swarm Optimization (PSO) approach for non-periodic preventive maintenance scheduling optimization. The probabilistic model, which is paying attention on reliability and cost evaluation, is developed in such a move that flexible intervals between maintenance interventions are allowed.

As a future work, such approach might be extended to a more practical but complex approach, involving Pareto based multi-objective optimization in order to provide a more effective and practical tool for multi-criteria optimization problems.

III. PMO Advantages & Disadvantages

A. Advantages-

1- Opportunity to replace parts subject to wear and tear sooner they fail.
2-To preserves and restores equipment reliability preventing failures.
3-Protects and prolongs the functional life of the equipment.
4-Decreases downtime compared to unplanned repairs.
5- Decreases costs associated with earlier replacement.
6- Allows planning to occur and eliminates complete shutdown of a process.
7- Reduces injury and exposure to workers.

B. Disadvantages-

The disadvantage of preventive maintenance is obstruction in operation, expenses of spare parts, consumable, manpower and contractor cost is high. It will not maximize the life span of equipment part and if not properly executed the PM or if the in charge of PM activity is incompetent, it will result to worst scenario of unacceptable losses, it also caused early wear and tear of equipment.
According to Bris, Cha telet et.al [1] in the new method to minimize the preventive maintenance cost of series–parallel systems. The Preventive maintenance consists of a set of technical, organizational and management actions to decrease the component ages in order to improve the availability of a system. These actions can be characterized by their effects on component age: the component becomes as fine as new. The component and system age is reduced, or the status of the component is lightly affected only to assure. It is necessary operating conditions, the component remaining appears to be as bad as old.

In paper of Jose A. Caldeira Duarte et.al [5].The components are maintained preventively at periodic times, which according linearly increasing hazard-rate function and a constant repair rate.

Sofia Panagiotidou et.al [11] presented an economic model for the optimization of preventive maintenance in a production process with two quality states. In the production process is characterized by two quality states.

-An in-control and an out-of-control state
-A failure state.

But we use a general distribution for the time of transition to the out-of-control state and we allow for different failure time distributions in each quality state.
On the other hand, Paper considers lot sizing and inspection decisions.

Geoffrey et.al [4] analyzes that eliminate catastrophic failures does not consider.
More labor intensive and includes some invasive activities that have the potential to cause incidental damage to components.

IV. Conclusions

In this paper a new effective link between various developed methodology and strategies involved in preventive maintenance optimization has been elaborated which can be further summarized as follows-

1-Implementing the steps of preventive maintenance optimization, the efficiency and effectiveness of preventive maintenance plans can be increased achieving required maintain ability, reliability and availability.

2-The implementation of this new tool in conjunction with other pre-existing techniques will contribute to maintain the reliability, availability and efficiency of any system.

3-The reliability group will suggest other PM's that could benefit from similar Optimization techniques.

4-The continuous improvement of the existing maintenance plan will contribute to increase the reliability of all others systems.

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