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A Review of Maintenance Policies for Manufacturing Units

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ABSTRACT

This paper is deals, various maintenance issues of manufacturing/production units. An unexpected breakdown occurs at unexpected time, which is major cause of delay production and consequently the target of production cannot be achieved. Then company suffers from revenue loss. So, maintenance plans have been made well, in advance to prevent the losses due to breakdowns. In order to achieve flats free output particularly when the production system grows and the production quantity increases. These plans of activities must carried out to ensure that the machines and plants of production are working continuously. All concerning activities including the maintenance priorities as well as preventive and corrective maintenance, plans are carried out with optimal maintenance policies. The objective of this paper is to maximize effectiveness of plant, equipment, engineering and maintenance personnel to grow production rate.

KEYWORDS: Maintenance, Performance Management, Optimal Maintenance

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INTRODUCTION

The growth and diversity of production as well as the enhancement of productivity and the competitive power under the market scenario which are getting harder among the basic aim of production plant. Today management has more concerned with productivity, quality and cost. Machinery and equipment are used in the production of goods and delivery of services constitute the large majority of most industry's capital. It is extremely important to avoid failure rate during actual operation because it can be dangerous or disastrous. Maintenance of the systems are efficiently used to prevent the losses resulting from the failures during the production. The halting of machines and plants due to breakdown/ failure or the fact that they work below the production capacity causes significant losses for an production units**.** To evaluate the perform maintenance; the following components are required, spare parts, trained personnel, facilities, tool and test equipment. These resources are mandatory to get appropriate maintenance. Maintenance actions can be generally divided into two types: corrective maintenance (CM) and preventive maintenance (PM). For a deteriorating repairable system, the corrective maintenance is conducted upon failure to recover the system from a failure, whereas the preventive maintenance is performed at the plan time to improve the reliability of the system. Corrective maintenance, periodic maintenance and conditional based maintenance are mostly encountered in practice and in academia both. If corrective maintenance is applied with maintenance being performed upon failure than the demand for spare parts depend on the failure behavior of the assets only. It is different if maintenance is performed preventively. As far as periodic maintenance is concern, it is combination of deterministic demand of spare parts for periodic maintenance interventions and some random demands when a component breaks down prior to the preventive maintenance. Maintenance interventions may mean various things but here it considers/takes as a replacement of a failed component by a spare part. The random nature of degradation behavior of production units can be cure by maintenance only. Generally it is considered that a component can be categorized in three states, good, defect and failed. The time that the component remains good, the time to defect has a certain distribution, however the time that the component remains in the defect state the delay time has an other distribution. Such degradation behavior is monitored by inspection. The time to failure of the component is the convolution of the time to defect and the delay time.

LITERATURE REVIEW

In the literature, numerous studies of maintenance and repair optimization have been performed assuming minimal repairs between PMs. Alsyouf[1] illustrated how an effective maintenance policy could influence the productivity and profitability of a manufacturing process.

Bupe[3] considered the safety issues in maintenance with the freedom from danger, protection from the risk and injury during the process of carrying out maintenance procedures**.** Cheng and Chen[4] the periodic preventive maintenance Policy for deteriorating systems by using improvement factor model has been focused. Dekker[5] gave detail maintenance analysis and it's optimal application. Gupta et al.[6] The relationship between preventive maintenance and manufacturing system performance relationship between maintenance and production surveyed. Jaturonnatee et al[7] an optimal preventive maintenance through corrective minimal repair of leased equipments have been discussed. Lee and Cha[9] considered periodic preventive maintenance policies for a deteriorating repairable system. Levitin and Lisnianski[10] optimization of imperfect preventive maintenance for multi-state systems policies have been discussed. Nakagawa and Mizutani[12] gave a detail summary of maintenance policies for a finite interval. Poppe[13] studied the impact of the maintenance policies on the inventory requirements and the corresponding costs of items. Pongpech and Murthy[14] studied preventive maintenance policy for optimal periodic intervals. Sharma et al[15] discussed maintenance perspectives along with optimization. Singh et al[16] improve productivity by reducing ideal time using Queueing model is discussed. Swanson[17] studied of the relationship between production technology and maintenance management reports based on the responses from a survey of plant managers and maintenance managers, the analysis shows a strong relationship between technical complexity and maintenance practices that increase the technical expertise of the maintenance workforce. Wang[18] discussed maintenance policies which covers all aspects of maintenance as well as repair, each kind of policy has different characteristics, advantages and disadvantages. Wang and Zhang[19] introduced optimal repair–replacement policies for a system with two types of failures.

THE MAINTENANCE STRATEGY

The rapid changes are coming in production systems which needs to keep up with the modified systems and environment the maintenance strategy therefore needs to be reviewed periodically. Furthermore, the strategy should be customized, which implies that it should consider all relevant factors of the situation. Every company have their own maintenance strategy and up course it is unique for each company but the underlying structure needed to develop such strategy may be very comparable. The maintenance strategy development process starts with stating the maintenance philosophy which is an expression of the maintenance function's role within the company and the chosen approach for how to fulfill it. The main objective of the maintenance function is driving force for production.

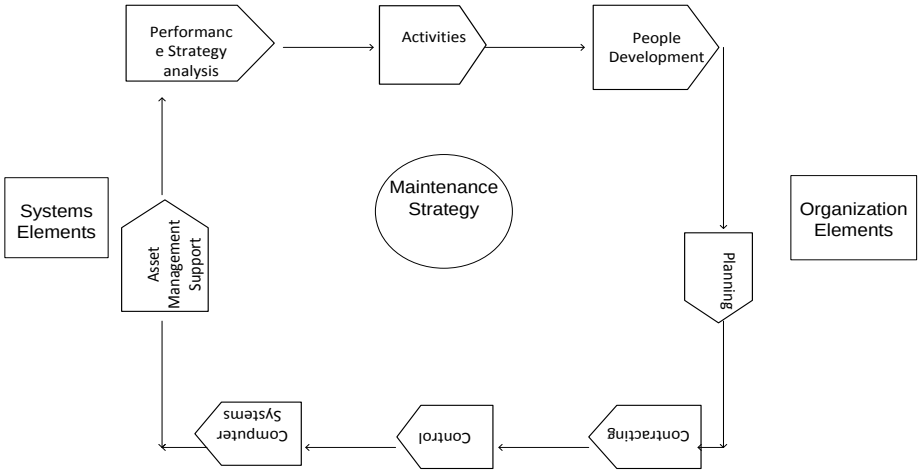

Figure1. Maintenance Strategy and Corresponding Practices

The following figure is described the general organizational factor, technically describe each system to maintain, as well as factors that describe interrelations between the different systems should be addressed. The maintenance concept will not reach its full potential if some of the required aspects are not included in the development of the strategy. A careless analysis, lost data or lack of knowledge might be reasons for an inadequate strategy. Due to the operational impact that maintenance may have on the equipment's performance and the involvement of high direct as well as indirect cost, for both in-house and outsourcing maintenance, the development of the maintenance strategy should be done in a structured way.

MAINTENANCE EVOLUTION/POLICY

Due to the increasing consciousness of maintenance management, this process has undergone successive changes over recent years, describe in fig. 1. A maintenance policy is one of the most important part of effective maintenance management. It is essential for continuity of operation and a clear understanding of the maintenance management program, regardless of the size of a maintenance organization. Maintenance can be classified into two categories: Preventive maintenance and corrective maintenance. Preventive maintenance is performed in order to keep the system in a condition that is consistent with the required levels of performance and reliability. This is achieved by regular checking all the operating systems, cleaning, adjusting, Lubricating and etc,. The objective of the maintenance procedure is to keep the system up-to-date so that desire production can be achieved. It's purpose is to restore system operation as soon as possible after failure by

replacing, repairing or adjusting the components which have caused interruption or breakdown of the system.

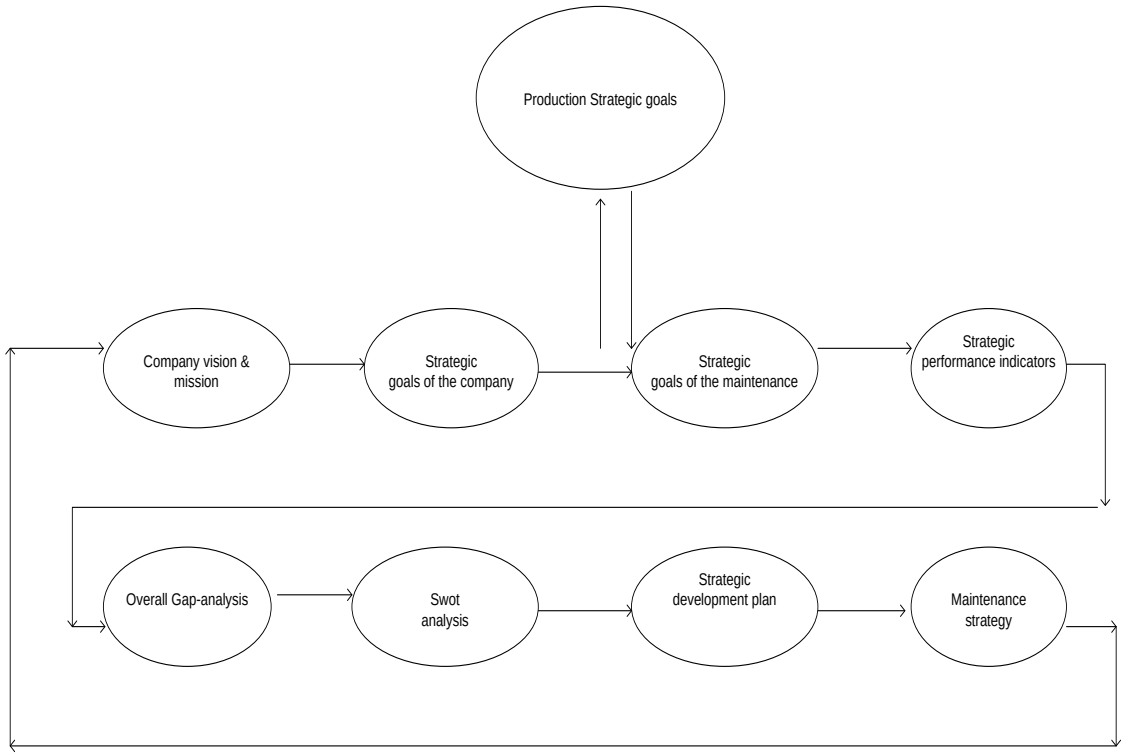

Figure2. A schematic view of the work-process when formulating a maintenance strategy

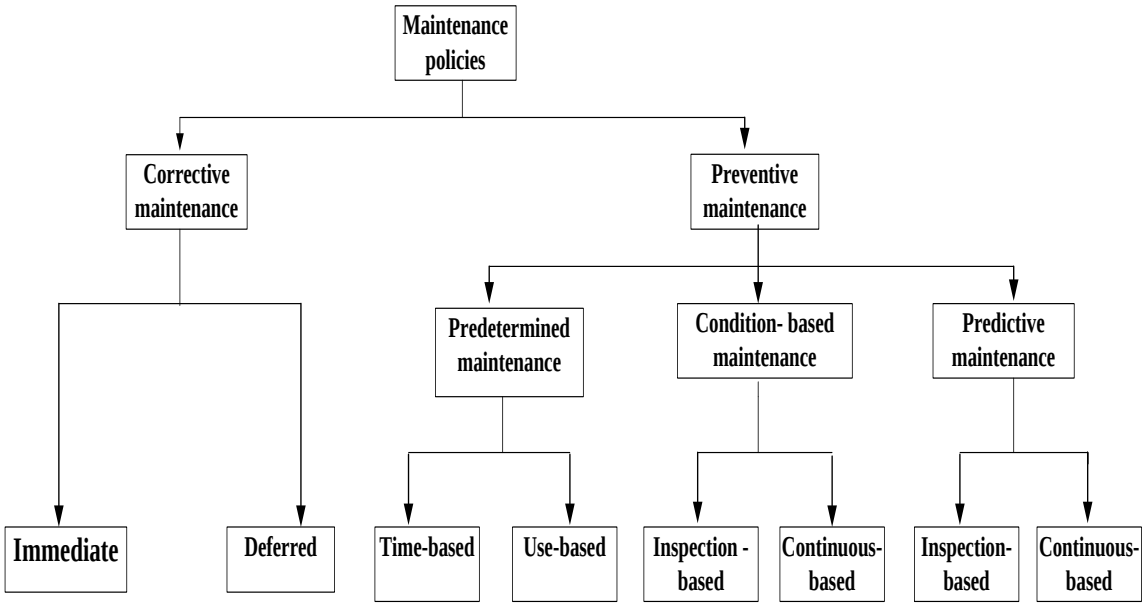

Figure3. Evolution of Maintenance Policy

Three different maintenance policies are discussed. The simplest policy is the corrective maintenance policy, also known as failure-based maintenance. Maintenance is that executed upon failure of a component, i.e when a component does not fulfill its intended purpose mentioned in

figure.1 here it is assumed that the degradation level goes from 0% to 100% and 100% equals to failure of component. The main advantage of this policy is the minimal number of part is used and the minimal number of maintenance action is required. The drawback of the corrective maintenance policy is that when maintenance is required, the resources have not been scheduled to be sent to the machine yet, which means that costly emergency measures may be required and the machine will be waiting down for the resources, incurring high downtime costs.

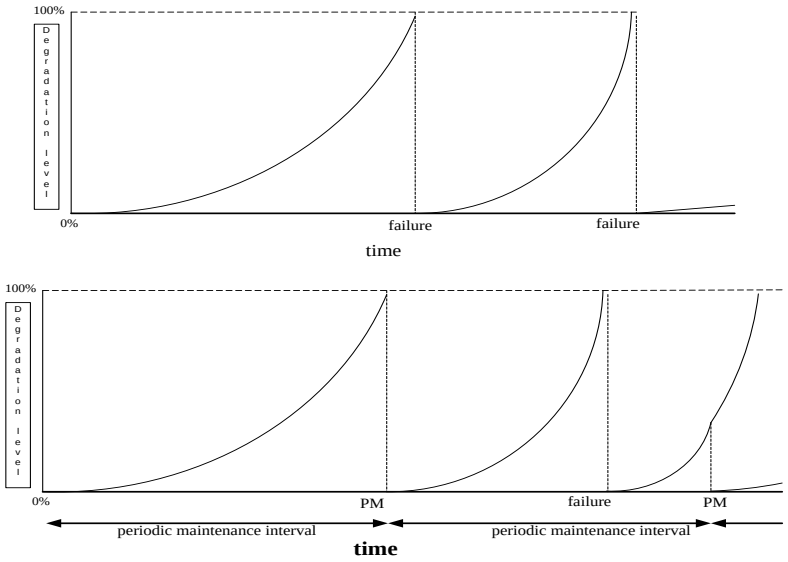

Figure4. Evolution of Maintenance Policy

To prevent this, a periodic maintenance policy can be adopted. Preventive maintenance intervention is planned (time based maintenance). This interval of periodic maintenance is denoted by t. Fig.2 illustrate this policy particularly a block replacement policy. In this policy, the maintenance interventions are not rescheduled if a failure occurs within a certain periodic maintenance interval. When the interventions are planned in advance, its planning of resource can be anticipated therefore the intervention cost is usually lower than in a CM policy. The disadvantage of PM is that the lifetime of components is not fully utilized (the component is over serviced). It is observed that t increases to ∞, the PM policy reduces to a CM policy. This is the trade off when determining the optimal maintenance interval t^* in this policy. Under the PM policy the length of the maintenance interval t^* can be optimized. On contraries to the corrective maintenance policy, the PM interference are well planed and known (well in advance). Consequently the information of demand of spare parts is known in advance.

TYPE OF MAINTENANCE

Corrective Maintenance

Corrective Maintenance, is usually causes an emergency interruption of service and it must be repaired or replaced immediately. Corrective Maintenance is very expensive operation and more costly than scheduled repairs.

Although every effort is made for engineering systems as reliable as possible through design, preventive maintenance and so on and time to time they do fail. Consequently, they are repaired to their operational state. Thus, repair or corrective maintenance is an important component of maintenance activity. Corrective Maintenance may be defined as the remedial action carried out due to failure or deficiencies discovered during preventive maintenance to repair an equipment/item to its operational state. There are five components responsible for corrective Maintenance shown in figure 5.

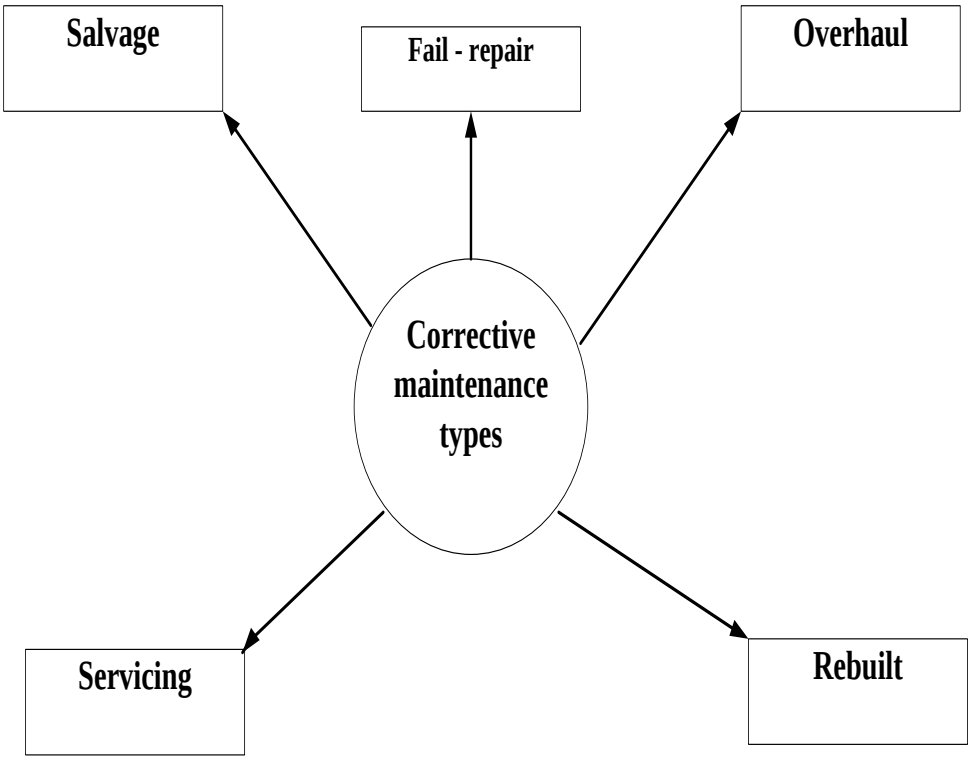

Figure5. Element of Corrective Maintenance

Reduction in corrective maintenance time is useful to improve maintenance effectiveness. Corrective Maintenance is composed of five sequential steps, which discussed below

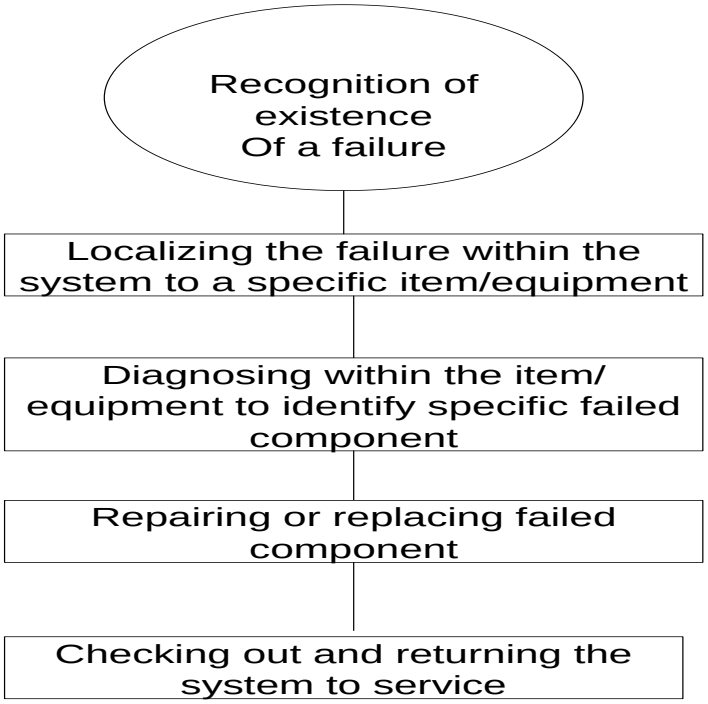

Figure 6. Flow Chart of Corrective Maintenance Programme

Preventive Maintenance

Preventive Maintenance is an important component of a maintenance activity. Preventive Maintenance may be described as the care and servicing by individuals involvement with maintenance to keep machine in working state by providing for systematic inspection, detection and correction of incipient failures either prior to their occurrence or prior to their development into major failure. The objective of Preventive Maintenance are to enhance capital equipment productive life, reduce critical equipment breakdown, allow better planning and scheduling of needed maintenance work, minimize production losses due to equipment failures and promote health and safety of the person who involve in maintenance. There are six components responsible to Preventive Maintenance shown in figure. 2. Preventive maintenance is divided into three parts.

Scheduled Maintenance

Preventive maintenance carried out in accordance with an established time schedule or established number of units of use.

Predetermined Maintenance

Preventive maintenance carried out without previously condition investigations and in accordance with established intervals of time or number of units of use.

Condition Based Maintenance

Preventive maintenance consisting of performance and parameter monitoring and the subsequent actions. The performance and parameter monitoring may be scheduled on request or continuously.

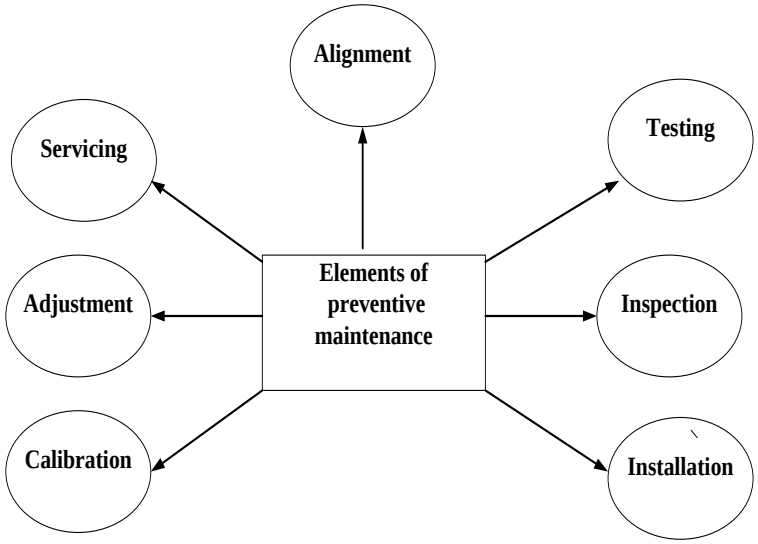

Figure7. Element of Preventive Maintenance

To develop an effective preventive maintenance program, the availability of a number of items are necessary. There are certain numbers of steps involved in developing a Preventive Maintenance. it is described below

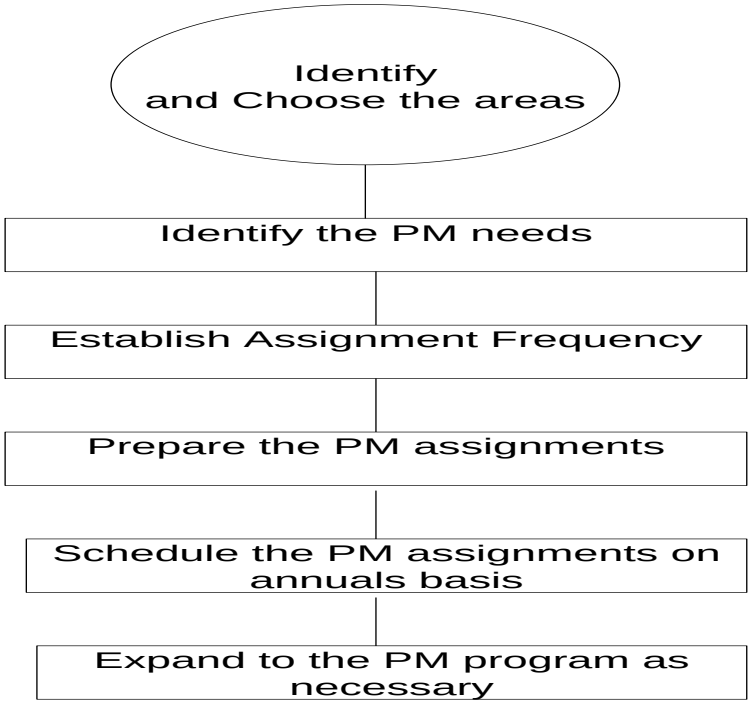

Figure8. Flow Chart of Preventive Maintenance Programme

Predictive Maintenance and Operator Maintenance

There are two additional types of maintenance, which are important to emphasize

Operator Maintenance

Maintenance carried out by qualified user or operator

Predictive Maintenance

Condition based maintenance carried out following a forecast derived from the analysis and evaluation of significant parameters of the degradation of the item. According to predictive maintenance basically to check if something is going to fail. Predictive maintenance is therefore proactive, i.e. the tasks are performed before a failure occurred and thereby the failure is prevented. Conditions that can cause deterioration and lead to failure are searched for in predictive maintenance. Predictive maintenance means improving product quality, productivity, and overall effectiveness in production and manufacturing plants. Predictive maintenance is an attitude or philosophy which uses the actual operating condition of equipment and systems within a plant to optimize total operation of the plant. Equipment is used to monitor the condition of other equipment.

Proactive Maintenance

Proactive maintenance is different from traditionally known as predictive and preventive maintenance. It is contrary to corrective tasks which deal with the already failed state. Proactive maintenance is based on theoretical risk analyses. The tasks undertaken before a failure occurs, in order to prevent the item from getting into a failed state proper counter measures are taken to avoid failures. The characteristics of proactive maintenance are a control over the maintenance resources. With the advent of correct maintenance scheduling and planning procedures the understanding of what is required of the maintenance resources weekly often change vast and rapid.

PERFORMANCE MANAGEMENT OF MAINTENANCE

Performance indicators will be monitored to ensure that the delivery of maintenance services fulfill the required standard.

Table1. Priorities of maintenance

Categorization of Maintenance Priorities	Response Time	Performance indicators
First priority Serious safety issues Irreplaceable loss of organization Major asset damage	Within one hour	Quick response Achieve 90% output in specified time
Second priority Low risk safety hazards Replaceable loss to organization Malfunction of equipment	Within two working days	Outstanding work Achieve 60% output in specified time Minimize the asset replacement value
Third priority Asset requires maintenance not urgently Minimal risk to organization Damage is under control(negligible)	Within one working week	Maintenance index Facilities Condition Risk Management
Fourth priority Routine Maintenance Programmed work No loss to organization Work scheduled as per agreement with customer	Not specified	Condition Auditing Maintenance Customer service rating Asset life cycle

These standards control by control center on priority basis, which depends on information received from the requestor. Completion of a work request may be affected by the number of factors, such as parts may need to be ordered or equipment may need to be taken to another location for repair. Response and completion time may also be affected by the volume received by a control center. Priorities may distinguish in the following manner.

OPTIMAL MAINTENANCE POLICIES

The objective of maintenance is to improve the system availability and mean time between failure to minimize failure frequency and downtime. Stochastic approach of system is considered to study the maintenance policies. Generally, it is represented by system maintenance cost rate, discounted cost rate and system reliability, availability, MTBF and failure frequency. Various factors which may affect an optimal maintenance policy is depicted in Fig. 9. If system is working in series then there exist some shut-off-rules. When a series system fails its require immediate repair and all other components remain in suspended mode, thereby longer down time and worse reliability measures. However, a parallel system fails, the system will still function even if a component is not repaired immediately. Proper maintenance schedule should adopt by the production units. Which incorporate various maintenance policy mention below.

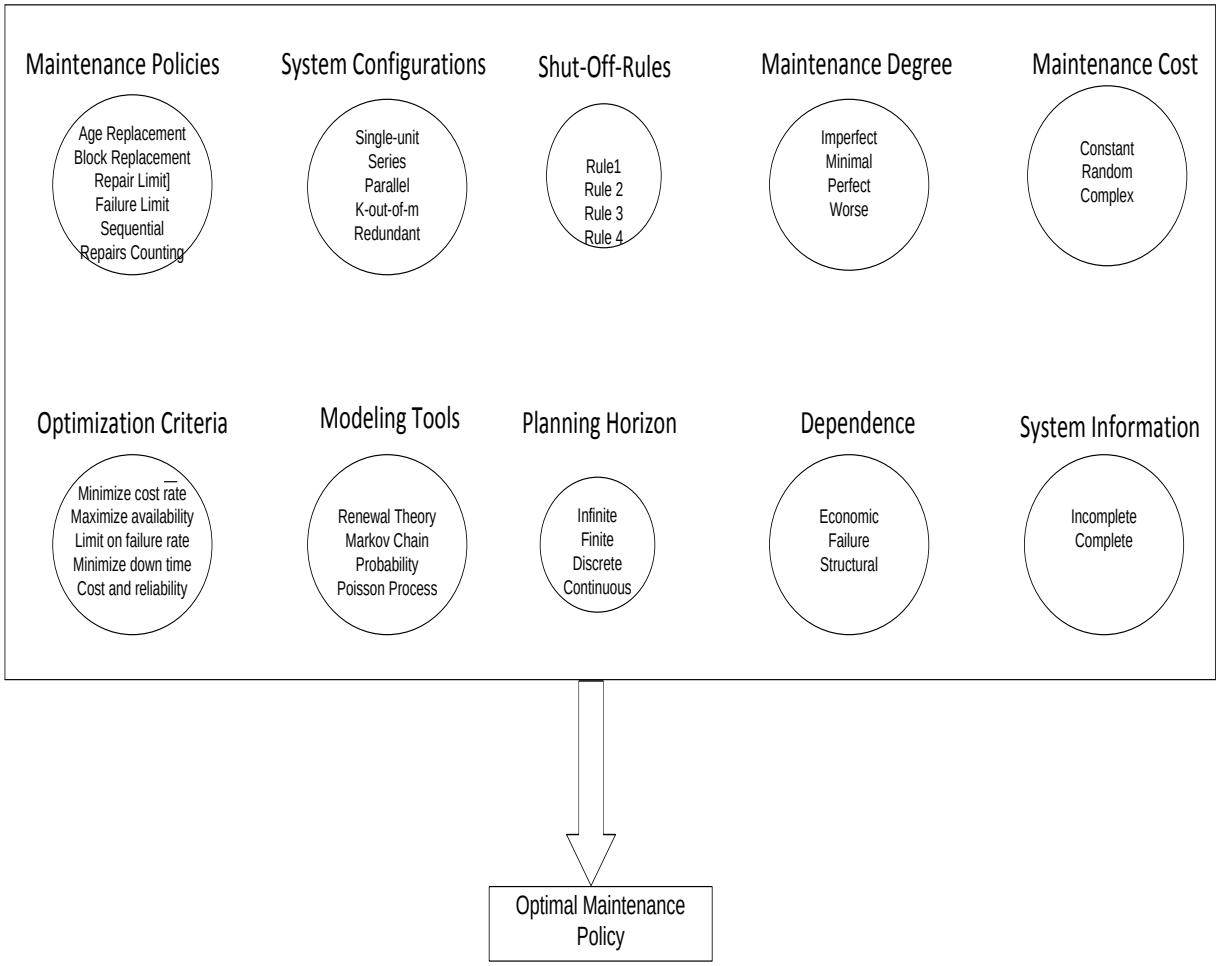

Figure9. A schematic view of the work-process of optimal maintenance policy

To minimize the system maintenance cost rate with considering the reliability of system. Maintenance goal is to improve system reliability as well as maintenance cost rate. An optimal maintenance policy needs to consider both maintenance cost and reliability measures simultaneously without it best performance of the system cannot be achieved. In theory, the maintenance time is considered to be negligible.

OVERALL EQUIPMENT EFFECTIVENESS

The total productive maintenance (TPM) concept given by Nakajima (1988) for overall equipment effectiveness (OEE) for measuring productivity of manufacturing equipments. OEE is a method to analyze the most popular equipment performance indicator capable of measuring different production losses, and identify possible limitations (Hansen, 2002). It also evaluate the percentage effectiveness of the manufacturing process. The OEE concept has become increasingly popular and has been widely used as a quantitative tool essential for measurement equipments‟ performance in industries. The important maintenance factors in the OEE are availability, performance efficiency and quality.

OEE = Availability (A) X Performance (P) X Quality (Q) (1)

Performance efficiency is the amount of products produced within a given time compared to the expected amount of products it would have produced. Furthermore, quality describes amount of products not require rework (Gazdziak, 2010). Thus, following equations describe availability, performance efficiency and quality.

$$Availabili\quad ty\quad (A) = \frac{Scheduled\quad \Pr oduction\quad Time\quad - Unplanned\quad Failure\quad Time}{Scheduled\quad \Pr oduction\quad Time} \qquad (2)$$

$$Performanc\quad e\ Efficiency\quad (PE) = \frac{Complete\quad time\quad \times \Pr oducts\quad \Pr ocessed}{\Pr oduction\quad Time} \qquad (3)$$

$$Quality\quad (Q) = \frac{\Pr oducts\quad \Pr ocessed\quad - \mathbf{P}roducts\quad need\quad to\ rework}{\Pr oducts\quad \Pr ocessed} \qquad (4)$$

In the first instance OEE should be applied to bottlenecks or other critical equipment. When driven correctly, as a fact of monitoring and improving the OEE, these areas will make significant improvements to the overall performance of the manufacturing line (Hansen, 2002). One of the most critical success factors influencing survival, profitability, and competitive advantage of manufacturing organization is to select proper maintenance policy. OEE is mostly used in one of the policies.

CONCLUSION

Maintenance is very crucial for manufacturing units without it qualitative and quantitative production cannot be desire. There are certain points which has to put emphasize on maintenance related tasks

- Effective communication of information relating to maintenance tasks.
- Proper communication amongst workers working in noisy environment.
- Workers should avoid horse play and unsafe working habits.
- Appropriate tools should be used in performing maintenance tasks and it has no any substitution.
- Unsafe maintenance procedures should be performed by knowledgeable and experienced maintenance personnel.

- Proper machinery/equipment inspections should be conducted before maintenance procedures are performed.
- Maintenance safety trainings should be conducted for every employee in the maintenance departments.
- Adoption of the developed maintenance safety framework.

The objective of this paper is to review the maintenance performance analysis of production plants. The preventive maintenance avoid the corrective maintenance. Predictive downtime may able to diagnose the required maintenance of defective machine. Thus maintenance plays key role to get desire production from plant, which also help in proper operation of plant to evaluate the performance and further improvement. Since the availability of maintenance metrics may not necessarily guarantee low maintenance cost, hence a maintenance cost metrics may be derived for the low cost repair, replacement and maintenance in practice.

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