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IMPROVEMENT OF OVERALL EQUIPMENT EFFECTIVENESS IN A BUSH FORMING MACHINE

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ABSTRACT
The main objective of this study was to improve overall equipment effectiveness (OEE) at a bush forming machine through the implementation of innovatory maintenance strategies. A case study approach was used. The paper focuses on improving the maintenance in a bush forming machine using an innovative maintenance regime mix to improve overall equipment effectiveness. Frequent machine breakdowns, lesser plant availability and increased overtime are a great threat to a manufacturing plant as they increase operating costs of an industry. At the end of this study we published a last three month OEE result. Also we discussed about the kaizen (continuous improvement) activities for a bush forming machine.

KEYWORDS
Maintenance, Bush Forming Machine and Overall Equipment Effectiveness.

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INTRODUCTION

Maintenance has been extensively considered as a assisting function which is zero productive since it does not generate cash directly. However for industry to manufacture goods of the right quality and quantity for the customers and be able to deliver them at the right time its plant or equipment must work efficiently and accurately. For every manufacturing company the aim is to manufacture goods at profit and this is only gained by using an effective maintenance system (M. Ahmad *et al*, 2007) that helps increasing the availability by

reducing machine downtime due to unwarranted stoppages. Without an effective and economically feasible maintenance system, equipment reliability suffers, and the plant pays the price with poor availability and prolonged downtime. All these mentioned poor key performance indicators could be a result of poor machine condition and intermittent low employee morale. Low plant availability and overtime costs will negatively affect an industry's operational efficiency. Engineers of the company must therefore design an effective maintenance system for the plant and its equipment.

Research Objectives and scope,

1. To maximize overall equipment effectiveness
2. To reduce equipment downtime while developing quality and its capacity.
3. To maximize competing advantage.

The research targeted critical elements of production in trying to set up a framework for application of total productive maintenance as a management system.

MAINTENANCE AND ITS OBJECTIVE

Moubray explains maintenance as the execution of activities, which ensure physical assets continue to perform what their users need them to do. However Tsang *et al* look at maintenance as the routine and recurring process of keeping a selective resource or machine, in its normal operating condition so that it can deliver its expected pursuance (Kelly *et al*, 1997) or services. The Japanese craftsmen had defined maintenance as maintaining and improving the rectitude of the production and quality systems through the machines, processes, equipment and people who add valuable content to the products or services are the operators and maintainers of equipment. The goal of any well run maintenance organization as adverted to by Moubray and Kelly is by having the lowest cost of the sum of two quantities, i.e.

- Maintenance labour and material
- Loss in Production

The loss mentioned above includes lack of ability to produce, and value added material that is wasted as a result of a break down arising from an poor maintenance program. Maintenance itself can result in excessive downtime and affiliated costs. This turns out from the need to take the machinery off-line to carry out maintenance. According to Kutucuoglu by changing the manufacturing processes emphasizing lean manufacturing, the reliability and availability of plant are fundamentally essential.

Low machine performance, recess and ineffective plant maintenance directs to the reduction in the profit, loss of the market chances, and fall in production. The danger of infant mortality after it has been restored on line again and as well the cost of the maintenance action itself adds up to overall costs. Companies must be able to put a cost to their loss in production arising from equipment down time. When maintenance expenditure are at a minimum level then the cost of lost production is at its maximum. As maintenance effort and costs are intelligently increased the loss in production decreases in a step by step manner till the lowest combined cost is achieved. This is the maintenance goal. Maintenance attempt employed outside this point, hike costs. Maintenance (A.H.C.T sang *et al*, 1999) can increase costs on the account of the requirement to take the equipment off line to carry out maintenance, infant mortality after being put back in service. In addition there are costs of the maintenance along with worker and material costs.

Need of maintenance system

Existence of a well-formulated maintenance system aids an organization to increase machine availability, decrease production downtime, losses in production and overtime costs. It also lowers labor requirements for maintenance personnel making them to spend with more time on ordinary alterations and repairs rather than on breakdown repairs. Besides good maintenance practice directs to fewer large-scale repairs and insistent repairs, fewer product rejects and products with better quality control. Other commendable results are greater safety for workers and improved protection of the plant leading to reduced compensation and insurance costs. Maintenance activity can be divided into four general categories or strategies as shown in Figure No.2. The maintenance policy for the resources of a company will include all these strategies. Market

forces demands more importance on customization, quicker delivery and excellent quality, in response to these essentials manufacturers make a selection of using high-tech equipment as well as adopting non-traditional maintenance management tools such as TPM.

QUALITATIVE RESULTS

Qualitative analysis involves gathering, examining of, and interpreting data by observing what people do and say. In examining qualitative data, patterns like the changes over time or possible causal links between variables can be identified.

Interviews and Questionnaire findings

Interviews with various stakeholders were successfully held without any impedances and the general answers to the questions are detailed below. The interview questions were constructed to find out employees perspective about maintenance problems encountered during the manufacturing processes and how the problems can be surmounted so as to eradicate reworks and improve both maintenance management and productivity. Answers to unstructured interview questions for detailed understanding are also noted in the following sections. The questionnaire constitutes (A. Raouf *et al*, 2005) of six sections each comprising four questions that sought to solicit the respondents' views on different aspects of the company's maintenance systems and practices. The response rates for every section are analysed and discussed below.

Views of the employees towards maintenance Responsibility

All employees comply that the company had troubles with maintenance issue. When asked about who was responsible for maintenance various responses were given and the researcher has tabulated the responses into Figure No.3. A possible reason for different inferences was because employees are not associated in any maintenance activities and are not aware that maintenance is the responsibility for everyone.

Maintenance Management

The responses for maintenance management. From the responses, it shows that nearly all employees are well aware that the maintenance process is reactive rather than proactive as it is carried out, when there is a breakdown or failure in the departments. From the answers received, it shows that employees are well aware of the company's mission, as evidenced by the 45% of respondents who agreed.

Autonomous Maintenance

The responses on Autonomous Maintenance. The outcome shows that operators are liable for equipment and machinery as shown by the respondents who concurred. The respondents objected on the view. On the concern of carrying out basic maintenance, the results revealed that operators do regular checks and inspections on the machine, confirming that they carry out basic maintenance as proven by the response rate. Most of the respondents also agreed that operators practice autonomous maintenance.

Continuous Improvement

It seems there is a general lack of liability on continuous progress of maintenance by Management. This is evidenced by 13% of the respondents who believed that management lacked commitment.

QUANTITATIVE RESULT

Production

Production at the study company is based on the total number of formed bushes produced per day. The target number is 382800 at 100% availability. Face out and Bore Tight are the defects which affecting the manufacturing operations of bush forming. The company had to reset its targets from the usual figure of 90% production per day to a mere 50% per day due to Face out and Bore Tight defects. Figure No.1 shows the production statistics for the period of last four months are given below.

Down time

The term downtime is used to refer to periods when a system is not available. Downtime or outage duration which cites to a period of time that a system fails to provide or perform its essential function. Reliability, availability, recovery, and unavailability are related concepts. The unavailability is the distribution of a time span that a system is not available. Figure No.2 represents

the average downtime of the bush forming machine for a last four months.

Availability

Availability was used to measure the total lost time when each of the sections was not executing as a result of breakdown, set-up adjustment and other stoppages. It indicates the ratio of actual executing time to the planned time available. The planned time was calculated as 480 minutes per shift in figuring this value, a shift of 8 hours (460 minutes) was used as the basis Availability is the most important part of operations in the company.

The Availability (A) is calculated using the following formula.

$$A = \frac{Possible\ operating\ time - Downtime}{Possible\ operating\ time}$$

The availability patterns for the period of last four months are summarized in Figure No.3 below. Figure No.3 below graphically illustrates the relationship between target availability and the monthly availability figures for the period of the last four month.

Performance rate

The Performance rate is the quantity produced during the running time, Vs. the potential quantity, given the designed speed of the equipment.

A low performance rate emulates speed losses:

Minor and idling stoppages

Minimized speed operation.

The Performance rate (P) is calculated using the following formula.

The performance rate patterns for the period of last four months are summarized in Figure No.4 below. Figure No.4 below graphically illustrates the relationship between total output and potential output at rated speed.

$$\text{Performance Rate} = \frac{\text{Total Output}}{\text{Potential Output at Rated Speed}}$$

Quality rate

The quality rate is the amount of good products versus the total amount of products produced.

A less quality rate emulates defect losses:

- Scrap and rework
- Startup losses

The Quality rate (Q) is calculated the following formula.

$$\text{Quality Rate} = \frac{\text{Good Output}}{\text{Total Output}}$$

The quality rate patterns for the period of last four months are summarized in Figure No.5 below. Figure No.5 below graphically illustrates the relationship between good output and total output.

OEE CALCULATION

The three main categories of equipment related losses are downtime, speed loss, and defect or quality loss. These losses are also the main constitutents for figuring the overall equipment effectiveness.

Overall equipment effectiveness is computed by combining three factors that emulate these losses: the availability rate, the performance rate, and the quality rate.

To calculate OEE, we need to multiply the three factors together. i.e. OEE = Availability Rate x performance rate x quality rate.

The OEE calculation for the period of last four months are summarized in Figure No.6 below. Figure No.6 below graphically illustrates the relationship between good output and total output. Thus we calculated the OEE calculations and made a study for last four months.

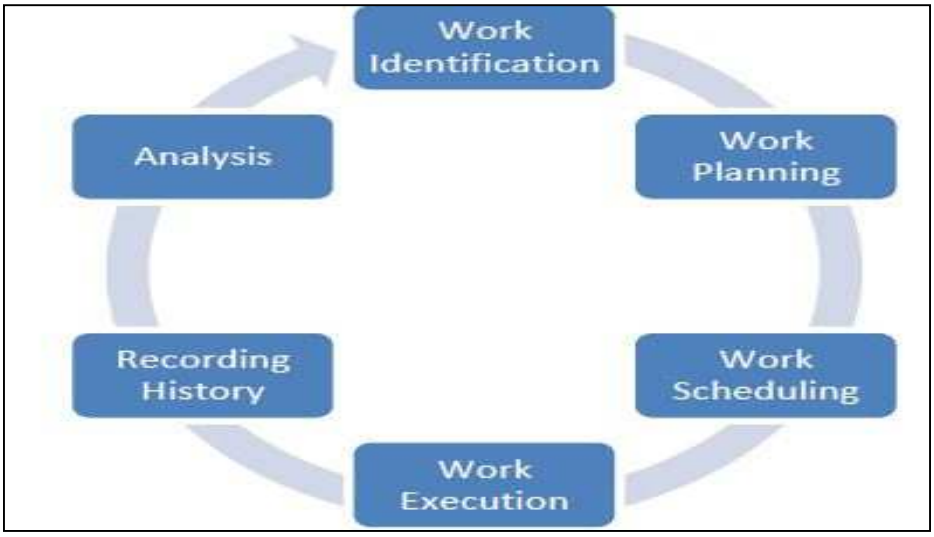


Figure No.1: Maintenance process

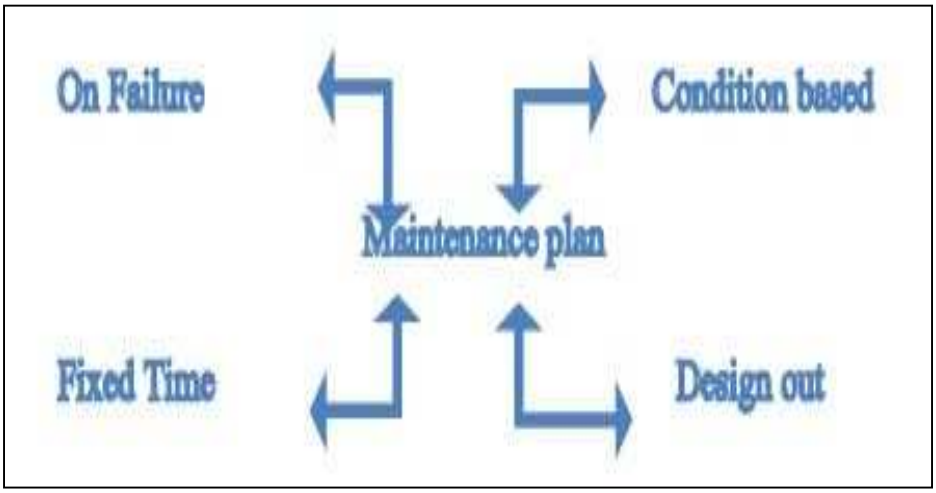


Figure No.2: Maintenance strategies

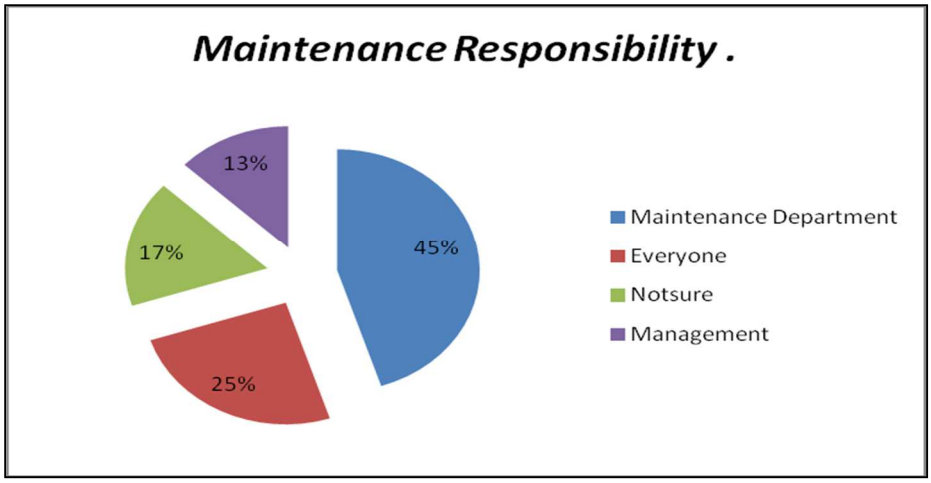


Figure No.3: Response of maintenance responsibilities

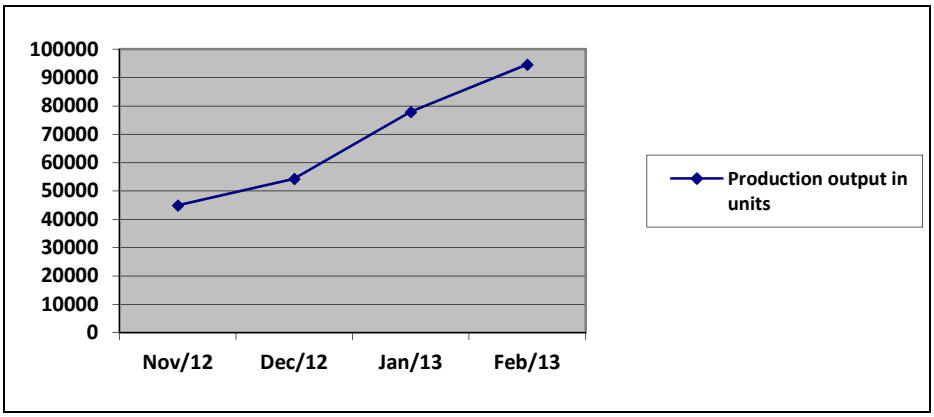


Figure No.1: The Production Statistics

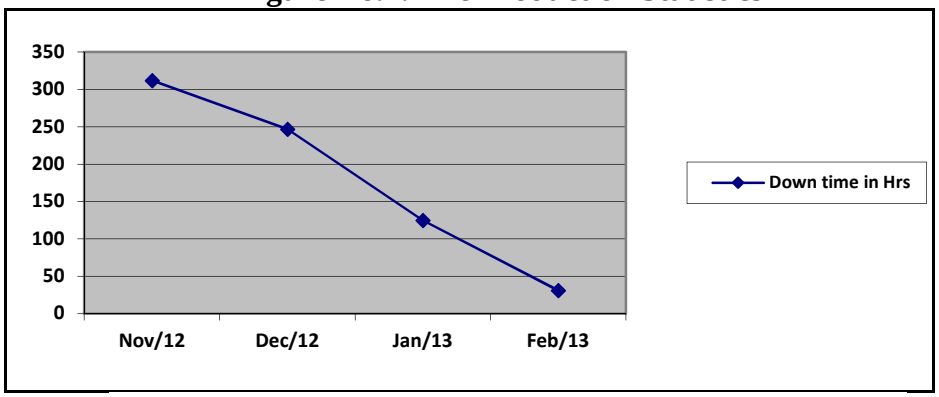
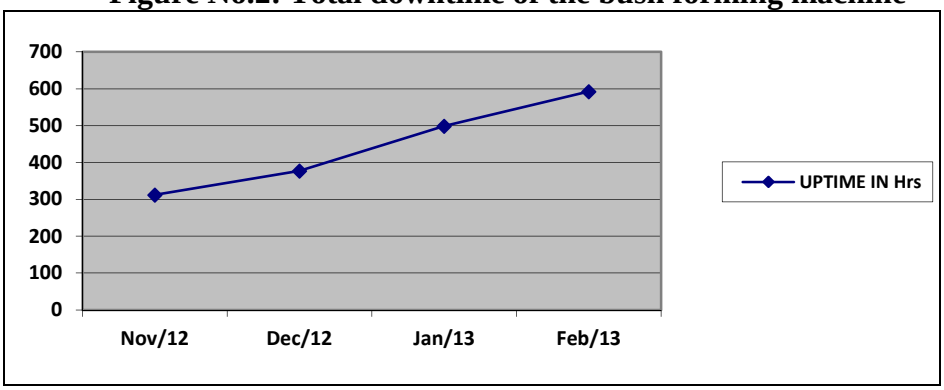


Figure No.2: Total downtime of the bush forming machine



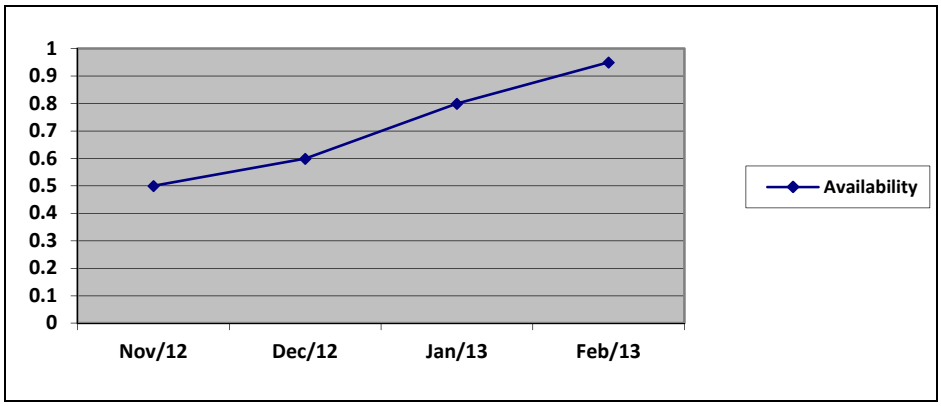


Figure No.3: Graphically illustrates the value of availability rate for the last four months

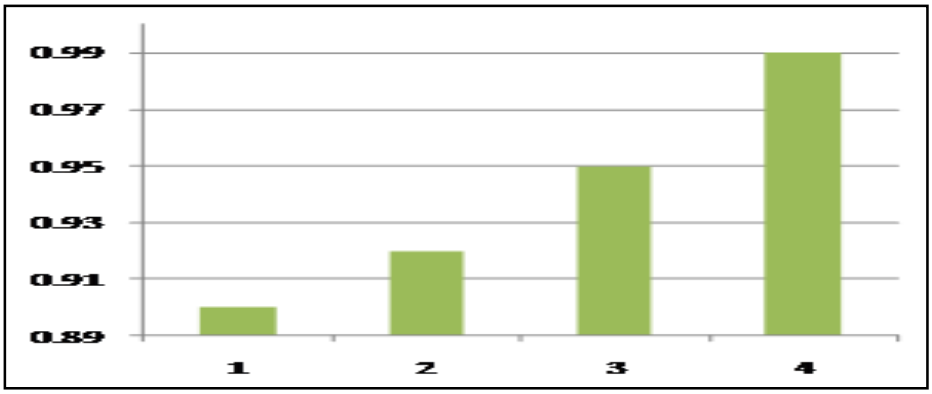


Figure No.4: Graphically illustrates the value of performance rate for the last four months

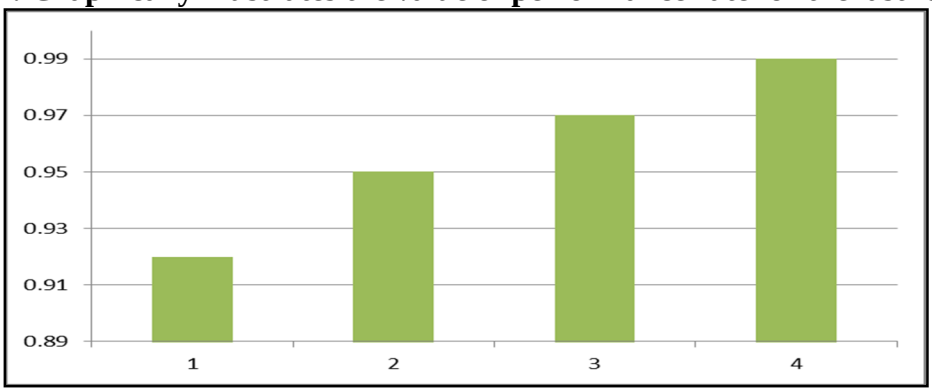


Figure No.5: Graphically illustrates the value of quality rate for the last four month

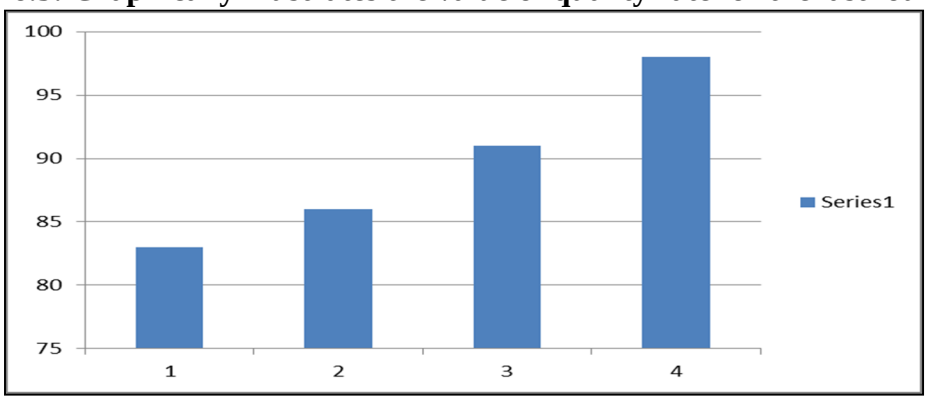


Figure No.6: graphically illustrates OEE performance value for the last four months

CONCLUSION

This paper focuses on the use of effective maintenance strategies to improve overall equipment effectiveness of production machines. Total Productive Maintenance (TPM) was selected as the appropriate tool for the company to implement to enhance its OEE. The consequent conclusions were made,

1. It can be concluded that TPM is a maintenance strategy that when confirmed with the application of the appropriate tools or following thoroughly all the pillars performance. From the data it is shown that no such tools are being used in the company and as a result the maintenance management system is weak.

2. The company can only gain from TPM if it ensures management commitment through activities such as permitting, supporting, managing, and leading by an example.

3. Adoption of TPM can minimize such losses and also reduce rework to or below the acceptable levels. TPM can also aid the company to

boost profitability and image, both of which will ensure its competitiveness in the current economic disorder.

4. The process of recording information must remain simple, but effective for future data analysis. If provision were made to highlight such problems and possible causes, then it may lead to the correction of common problems such as breakdowns and rework.

5. It is a maintenance program that works with TQM and lean management. Anyhow the employees must be suitably trained, capacitated and convinced that TPM is a sustainable and management should be entirely committed to the program. It is visualized that the adoption of the recommendations of the study will result in favorable levels of machine availability and sustained higher production rates. Empowerment will give every employee in the company the responsibility and authority to improve and totally eliminate the six big losses. It makes people effective decision makers nearer to the problem, emanating in faster action. Empowerment enables two way communications. Hindrances to empowerment are based on a conventional mistrust between management and the workforce. Empowerment requires process management to be successful as empowerment in the company will go through denial, resistance, exploration and liable phase and each will need action from management.

Computerized Maintenance Management System

To make the maintenance planning system effectual, it is necessary to keep track of all the corrective maintenance jobs and preventive maintenance inspections. For bigger processing plants these cannot be handled manually. The objective of CMMS is to ease the management of the maintenance resource, to monitor maintenance efficiency, and to provide appropriately analyzed management information for further consideration. It is therefore important for the company to implement CMMS.

Maintenance Bench marking

The company should actively bench mark its maintenance services against other organizations. Bench marking is essential to search for optimum methods for Maintenance Management practices in order to improve the overall effectiveness of operations and maintenance of the plant.

Manpower Training and Development

If the Maintenance Department is to comprehend its proper function in a progressive industrial society, then its personnel must be qualified to meet the current needs and future requirements. Training should be a continuous and progressive process designed to develop the individual capacity of maintenance staff members. This enables a person to understand the reason for and purpose of his efforts.

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CONFLICT OF INTEREST

We declare that we have no conflict of interest.

BIBLIOGRAPHY

1. Tsang A H C, Jardine A K S, Kolodny H. Measuring maintenance performance: a holistic approach, *International Journal of Operations and Production Management*, 19(7), 1999, 691-715.
2. Raouf A, Ben-Daya M. Total maintenance management: a systematic approach, *Journal of Quality in Maintenance Engineering*, l(1), 2005, 6-14.
3. Schuman C A and Brent A C. Asset life Management: towards improving physical asset performance in the process industry, *International journal of Operations and Production Management*, 25(6), 2005, 566-579.
4. Hansen R C. "*Overall Equipment Effectiveness: A Powerful Production Maintenance Tool*", *Industrial Press, USA*, 1st edition, 2001.
5. Koshal D. Manufacturing Engineer's Handbook, *Butterworth Heinemann, World Academy of Science, Engineering and Technology*, 61(6), 2010, 952-956.

6. Davis R. Making TPM a part of factory life', *Works Management*, 49(7), 1996, 16-7.
7. Smith D J. Reliability, Maintainability and risk: Practical Methods for Engineers including RCM and Safety-Related Systems, *Butterworth Heinemann*, 7th edition, 2005, 239.
8. Hartman E H. Successfully Installing TPM in a Non-Japanese Plant, TPM Press, Allison Park, P A, Koelsch J R, A dose of TPM: downtime needn't be a bitter pill, *Manufacturing Engineering*, 1(1), 1992, 63-6.
9. Kelly A. Maintenance Organisation and Systems, Business *Centred Maintenance*, *Butterworth-Heinemann*, Oxford, 2nd edition, 1997, 340.
10. Kutucuoglu K Y, Hamali J, Iran I and Sharp J M. A framework for managing maintenance using performance measurements systems, *International Journal of Operations and Production Management*, 21(1), 2001, 173-95.
11. Ahmad M and Benson R. Benchmarking in the process Industry, *Institution of Chemical Engineers, UK*, 2007, 54-58.
12. Moubray. *Reliability-Centered Maintenance II*, *Butterworth-Heinemann, Oxford*, 2nd edition, 1997, 384.
13. Ahmad M and Benson R. Benchmarking in the process, Industry, *Institution of Chemical Engineers, UK*, 2007, 54-58.
14. Maggard B and Rhyne D M. Total productive maintenance: a timely integration of production and maintenance, *Production and Inventory Management Journal*, 33(4), 1992, 6-10.
15. Mishra P R, Anand D and Kodali. Development of a framework for world-class maintenance systems, *Journal of Advanced Manufacturing Systems*, 5(2), 2006, 141-65
16. Nakajima S. TPM a challenge to the improvement of productivity by small group activities, *Maintenance Management International*, 6th edition, 1986, 73-83.
17. Robinson C J and Ginder A P. "*Implementing TPM: The North American Experience*", *Productivity Press, USA*, 1st edition, 1995, 3-11.
18. Nakajima S. Introduction to Total Productive Maintenance, *Productivity Press, Cambridge*, 1989, 165-217.
19. Sekine K and Arai K. TPM for the Lean Factory-Innovative Methods and Worksheets for Equipment, *Management, Productivity Press, Cambridge, MA*, 1998, 2-10.
20. Suzuki T. New Directions for TPM, *Productivity Press, Cambridge, MA*, 23(1-4), 1992, 7-10.
21. Tajiri M and Gotah F. TPM Implementation: A Japanese Approach, *McGraw-Hill, New York*, 1992, 4-26.
22. Wilmott P. Total Productive Maintenance, *The Western Way, Butterworth-Heinemann, Oxford*, 22(2), 1994, 187-196.
23. Borris Steven. *Total Productive Maintenance, New York, New York: McGraw Hill*, 2nd edition, 1994, 832.
24. Japan Institute of Plant Maintenance, *TPM for Every Operator (Shopfloor Series), Cambridge, Mass: Productivity Press.*

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