Int. J. Res. Ind. Eng. Vol. 8, No. 2 (2019) 176–186

International Journal of Research in Industrial Engineering

www.riejournal.com

Application of Total Productive Maintenance in Service Organization

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A B S T R A C T

This paper discusses the application of TPM in copy center in Woldia University located in Woldia town, north wollo, Amhara region, Ethiopia. The problem encountered in the center includes long waiting time due to frequent breakdown of equipment, unpleasant work environment, and defective product, etc. This leads to disrupt of the university programs such as exams, training, and so on. This paper uses TPM for solving above mentioned problem by employing Overall Equipment Effectiveness (OEE). The OEE value on the center is 35% which is less than the world class standard of 85%. Therefore, the center needs urgent improvement in typical equipment maintenance management program. Advantages of TPM for the center includes better utilized equipment, clean and pleasant workplace, highly motivated employee, and satisfied customer.

Keywords: Woldia university, Total Productive Maintenance (TPM), Overall Equipment Effectiveness (OEE), Copy centre.

Article history: *Received: 02 November 2018* *Revised: 16 February 2019* *Accepted: 27 March 2019*

1. Introduction

Woldia University (WU) is a public higher education institution located in Woldia town, Amhara region, Ethiopia. This study conducts WU copy centre in Woldia campus. The service given in the centre includes copying, printing, binding of exams, modules, etc. The centre has 16 modern photocopier machines. The university supplies its photocopier machines from Omedad plc, Addis Ababa, and the supplier maintenance personnel's maintains the machines when they fail.

However, maintenance personnel's sends to the university only once in the year unless all machines are broken. This results in high equipment downtime which may leads to disrupt the programs and long waiting time to get service in the center. To cope with this situation, instructors use printing machines in office for printing their exams into the required number and this would be very expensive. Furthermore, the impact of equipment downtime increases with

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DOI: 10.22105/riej.2019.170507.1076

increasing the demand of service in the centre. This makes the university to invest in new equipment or facility to satisfy the increased demand. Generally, investing in new equipment or facility is not a good option unless they are fully utilized. Therefore, it is essential to implement TPM in the center for achieving higher equipment utilization. Until now few studies have investigated the applicability of manufacturing maintenance system in other settings or service organizations.

Haddad and Jaaron [1] investigated implementation of TPM in healthcare industry. The study was carried out at a major hospital in Jordan using in-depth interview coupled with observations and documents collection. TPM implementation methodology developed for increasing medical device utilization and decreasing their failures though Autonomous Maintenance (AM), Preventive Maintenance (PM), and 5S modelling with a suggestion for additional working performance indicators.

Chompu-Inwai et al. [2] described a pilot implementation and evaluation of TPM for the dental units in the dental hospital, faculty of dentistry, Chiang Mai University, and Thailand. The paper aimed to develop a methodology for increasing the dental unit utilization and availability, as well as decreasing unplanned equipment downtime. The methodology was developed based on the first two phases of the phased equipment management approach, improvement of existing equipment, and maintaining improved equipment. Both Autonomous Maintenance (AM) by operator and Preventive Maintenance (PM) were implemented.

Bennett and Lee [3] proposed the objective of total productive maintenance to maximize plant and equipment effectiveness, and to create a sense of ownership for operators and promote continuous improvement through small group activities involving production engineering and maintenance personnel. This paper described and analysed a case study of TPM implementation at a newspaper printing house in Singapore. However, rather than adopting more conventional implementation methods such as employing consultants or through project using external training, a unique approach was adopted based on action research using a spiral of cycles of planning, acting observing, and reflecting. Finally, the paper identified the characteristics associated with the action research method when was used to implement TPM and discusse the applicability of the approach in related industries and processes [3].

The aim of this paper is to investigate applicability of TPM in copy center in Woldia University by employing overall equipment effectiveness.

Figure 1. Woldia University copy center in Woldia campus.

2. Total Productive Maintenance

TPM is an innovative Japanese concept. The origin of TPM can be traced back to 1951 when preventive maintenance was introduced in Japan. However, the concept of preventive maintenance was taken from USA. Nippondenso was the first company to introduce plant wide preventive maintenance in 1960. Preventive maintenance is the concept wherein operators produce goods using machines and the maintenance group is dedicated with work of maintaining those machines, however with the automation of Nippondenso, maintenance becomes a problem as more maintenance personnel are required. So, the management decided that the routine maintenance of equipment would be carried out by the operators (This is Autonomous maintenance, one of the features of TPM). The maintenance group took up only essential maintenance works.

Thus, Nippondenso which already follows preventive maintenance also adds autonomous maintenance done by production operators. The maintenance crew went in the equipment modification for improving reliability. The modifications were made or incorporated in new equipment; this leads to maintenance prevention. Thus, preventive maintenance along with maintenance prevention and maintainability improvement gave birth to productive maintenance. The aim of productive maintenance was to maximize plant and equipment effectiveness to achieve optimum life cycle cost of production equipment.

Then Nippon Denso made quality circles, involving the employee’s participation. Thus, all employees took part in implementing productive maintenance. Based on these developments, Nippondenso was awarded the distinguished plant prize for developing and implementing TPM by the Japanese Institute of Plant Engineers (JIPE). Thus, Nippondenso of the Toyota group became the first company to obtain the TPM certification.

3. Pillars of TPM

The core practices and activities of implementing TPM are usually called the pillars [4]. The naming and the number of pillars may differ slightly [5]. Japan Institute of Plant Maintenance (JIPM) suggested and promoted an eight-pillar plan for TPM implementation that leads to substantial increase in labour productivity through controlled maintenance, reduction in maintenance costs, and reduced production stoppages and downtimes. Eight pillars of TPM implementation include education and training, autonomous maintenance, planned maintenance, focused maintenance, quality maintenance, office TPM, health and environment, development management, and safety [5-7]. Figure 2 shows eight pillars for implementing TPM.

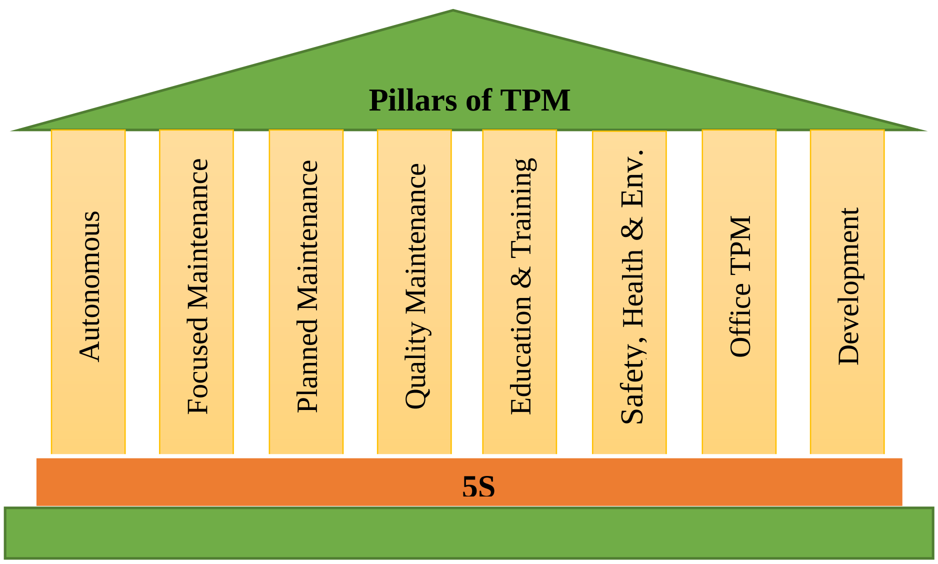

Figure 2. Eight pillars of TPM implementation plan.

The following is brief description of eight pillars of TPM implementation plan:

3.1. 5S

TPM starts with 5S; it is a systematic process of housekeeping to achieve a serene environment in workplace involving the employees with a commitment to sincerely implement and practice housekeeping. Problems cannot be clearly seen when the work place is unorganized. Cleaning and organizing the workplace helps the team to uncover problems. Making problems visible is the first step of improvement. 5S is a foundation program before the implementation of TPM.

If this 5S is not taken up seriously, them it leads to 5D delay, defects, dissatisfied customers, declining profits, and demoralized employees. This 5S implementation has to be carried out in phased manner. First the current situation of the workplace has to be studied by conducting a 5S audit. This audit uses check sheets to evaluate the current situation. This check sheet consists of various parameters to be rated say on a 5-point basis for each ‘S’; the rating gives the current situation. The each of the above-mentioned 5S is implemented and audit is conducted at regular intervals to monitor the progress and evaluate the success of implementation. After the completion of implementation of 5S, the random audits can be conducted using company check sheets to ensure that it is observed in true sprits by everyone in the work place.

3.2. Autonomous Maintenance (JISHU HOZEN)

This pillar is geared towards developing operators to be able to take care of small maintenance tasks, thus freeing up the skilled maintenance people to spend time on more value-added activities and technical repairs. The operators are responsible for upkeeping of their equipment to prevent it from deteriorating.

The policy of autonomous maintenance includes uninterrupted operation of equipment, flexible operators to operate and maintain other equipment, eliminating the defects of source through active employee participation, stepwise implementation of autonomous maintenance activities. Steps in autonomous maintenance are preparation of employees, initial clean-up of measures, take counter measures, fix tentative JH standards, general inspection, standardization, and autonomous management.

3.3. KAIZEN

‘Kai’ means change, and ‘Zen’ means good (for the batter). Basically, kaizen is for small improvements, but carries out a continual basis and involves all people in the organization. Kaizen is opposite to big spectacular innovations. Kaizen requires no or little investment. The principle behind is that a very large number of small improvements is moved effectively in an organizational environment than a few improvements of large value. This pillar is aimed at reducing losses in workplace that affects our efficiencies. By using a detailed and thorough procedure we eliminate losses in a systematic method using various kaizen tools. These activities are not limited to production areas and can be implemented in administrative areas as well.

KAIZEN policies are practice concepts of zero losses in every spare of activity, relentless pursuit to achieve cost reduction targets in all resources, relentless pursuit to improve overall plant equipment effectiveness, extensive use of PM analysis as a tool for eliminating losses, and focus of easy handling of operators. Kaizen target are to achieve and sustain zero losses with respect to minor stops, measurement and adjustments, defects and unavoidable downtimes, it also aims to achieve 30% manufacturing cost reduction. Tools used in kaizen include PM analysis, why-why analysis, summary of losses, kaizen register, and kaizen summary sheet.

3.4. Planned Maintenance

It is aimed at to have trouble free machines and equipment's producing defect free products for total customer satisfaction. This breaks maintenance down into four families or groups that are preventive maintenance, breakdown maintenance, corrective maintenance, and maintenance prevention. With planned maintenance we evolve our efforts from a reactive to a proactive method and use trained maintenance staff to help train the operators to better maintain their equipment.

Planned maintenance policies are achieved and sustain availability of machines, optimize maintenance cost, reduce spares inventory, improve reliability, and maintainability of machines. Targets of planned maintenance include zero equipment failure and breakdown, improve reliability and maintainability by 50%, reduce maintenance cost by 20%, and ensure availability of spares all the time.

Six steps in planned maintenance include equipment evaluation and recording present status, restore deterioration and improve weakness, build up information management system, prepare time-based information system, select equipment, parts and members, and map out plan, prepare predictive maintenance system by introducing equipment diagnostic techniques, and evaluation of planned maintenance.

3.5. Quality Maintenance (QM)

It is aimed at towards customer delight through highest quality through defect free manufacturing. Focus is on eliminating non-conformances in a systematic manner like focused improvement. We gain understanding of what parts of the equipment affect product quality and begin to eliminate current quality concerns, then move to potential quality concerns. Transition is from reactive to proactive (Quality control to Quality assurance).

QM activities is to set equipment conditions that preclude quality defects, based on the basic concept of maintaining perfect equipment to maintain perfect quality of product. The condition is checked and measured in time series to very that measure values are within standard values to prevent defects. The transition of measured values is watched to predict possibilities of occurred defects and to take counter measures beforehand.

QM policies are defect free conditions and control of equipment's, QM activities to support quality assurance, focus of prevention of defects at source, focus on poka-yoke (fool proof system), inline detection and segregation of defects, and effective implementation of operator quality assurance. TQM targets to achieve and sustain customer complaints at zero, reduce the process defects by 50%, and reduce cost of quality by 50%.

3.6. Training

It is aimed to have multi skilled revitalized employees whose morale is high and who has eager to come to work and perform all required functions effectively and independently. Education is given to operators to upgrade their skill. It is not sufficient know only 'know-how' by they should also learn know-why. By experience they gain, know-how to overcome the problem what to be done. This they do without knowing the root Couse of the problem and why they are doing so. Hence it become necessary to train them on knowing know-why. The employees should be trained to achieve the four phases of skill. The goal is to create a factory full of experts. The different phase of skills is Phase-1 do not know, Phase-2 know the theory but cannot do, Phase-3 can do but cannot teach, Phase-4 can do and also teach.

Training policies are focus on improvement of knowledge, skills and techniques; creating a training environment for self-learning based on felt needs; training curriculum /tools/ assessment etc. conductive to employee revitalization; training to remove employee fatigue and make work enjoyable.

Training targets are achieve and sustain downtime due to want men at zero on critical machines, achieve and sustain zero losses due to lack of knowledge /skill/ techniques, aim for 100% participation in suggestion scheme 477.

3.7. Office TPM

Office TPM should be started after activating four other pillars of TPM (JH, KK, QM, PM). Office TPM must be followed to improve productivity, efficiency in the admirative functions, and identify and eliminate losses. This include analysing processes and procedures towards increased office automation. Office TPM addresses twelve major losses. They are processing loss, cost loss including areas such as procurement, accounts, marketing, sales leading to high inventories, communication loss, idle loss, set-up loss, accuracy loss, office equipment breakdown, communication channel breakdown, telephone and fax lines, spent time on retrieval of information, non availability of correct online stock status, customer complaints due to logistics, and expenses on emergency dispatches/purchases.

3.8. Safety, Health and Environment

In this area, focus is on to create a safe workplace and a surrounding area that is not damaged by our process or procedures. This pillars will play an active role in each of the other pillars on a regular basis. A committee is constituted for this pillar which comprises representative of officers as well as workers. The committee is headed by Senior Vice President (Technical). Utmost importance to safety is given in the plant. Manager (safety) is looking after functions related to safety. To create awareness among employee's various competitions like safety slogans, quiz, drama, posters, etc. related to safety, can be organized at regular basis.

4. TPM Implementation

In this section, TPM implementation activities are briefly described and presented as follow:

Master plan: The TPM team, along with manufacturing and maintenance and union representatives determines the scope/focus of the TPM program. The selected equipment and their implementation sequence are determined at this point. Baseline performance data is collected and the programs goals are established.

Autonomous maintenance: The TPM team is trained in the methods and tools of TMP and visual controls. The equipment operators assume responsibility for cleaning and inspecting their equipment and performing basic maintenance tasks. The maintenance staff trains the operators how to perform the routine maintenance and all are involved in developing safety procedures. The equipment operators start collecting data to determine equipment performance.

Planned maintenance: The maintenance staff collects and analyses data to determine usage/need based maintenance requirements. A system for tracking equipment performance metrics and maintenance activities is created (if one is not currently available). Also, the maintenance schedules are integrated into the production schedule to avoid schedule conflicts.

Maintenance reduction: The collected data and the learned lessons from TPM implementation are shared with equipment suppliers. The ‘design for maintenance’ knowledge is incorporated into the next generation of equipment designs. The maintenance staff also develops plans and schedules for performing periodic equipment analysis (thermography, oil analysis, etc.). This analysis data is also fed into maintenance database to develop accurate estimates of equipment performance and repair requirements. These estimates are used to develop spare parts inventory policies and proactive replacement schedules.

Holding the gains: The new TPM practices are incorporated into the organizations standard operating procedures. These new methods and data collection activities should be integrated with the other elements of the production system to avoid redundant or conflicting requirements. The new equipment management methods should also be continuously improved to simplify the tasks and minimize the effort required to sustain the TPM program.

5. Overall Equipment Effectiveness

TPM initiative in production helps in streamlining the manufacturing and other business function and gathering sustained profits [8]. The strategic outcome of TPM implementations is the reduced occurrence of unexpected machine breakdowns that disrupt production and leads to losses, which can exceed millions of dollars annually [4]. OEE methodology incorporates metrics from all equipment manufacturing states guidelines into a measurement system that helps manufacturing and operations teams to improve equipment performance, therefore, to reduce equipment Cost of Ownership (COO).

TPM initiatives are focused upon addressing the major losses and wastes associated with the production systems by affecting continuous and systematic evaluations of production system, and affecting significant improvements in production facilities [9-11]. TPM employs OEE as a quantitative metric for measuring the performance of a production system. OEE is the core metric for measuring the success of TPM implementation program [12]. The overall goal of TPM is to raise the overall equipment effectiveness [11-14]. OEE is calculated by obtaining the product of availability of the equipment, performance efficiency of the process, and rate of quality products [15, 16]:

OEE= Availability (A) × Performance efficiency (P) × Rate of quality (Q), where, Availability (A) = [(Loading Time-Downtime) ÷ Loading time] × 100, Performance efficiency (P) = [Processed amount ÷ (Operating time ÷Theoretical cycle time)] × 100 and Rate of quality = [(Processed amount-Defect amount) ÷ Processed amount] ×100.

This metric has become widely accepted as a quantitative tool essential for measurement of productivity in manufacturing operations [17]. The OEE measure is central to the formulation and execution of a TPM improvement strategy [15]. TPM has the standards of 90 percent availability, 95 percent performance efficiency, and 95 percent rate of quality [18]. An overall 85 percent benchmark OEE is considered as world-class performance [19]. OEE measure provides a strong impetus for introducing a pilot and subsequently companywide TPM program.

A comparison between the expected and current OEE measures can provide the much-needed impetus for the manufacturing organizations to improve the maintenance policy and affect the continuous improvements in the manufacturing system. OEE offers a measurement tool to evaluate equipment corrective action methods and ensure permanent productivity improvement. OEE is a productivity improvement process that starts with management awareness of total productive manufacturing and their commitment to focus the factory workforce on training in teamwork and cross-functional equipment problem solving.

6. Case Study at Woldia University Copy Centre

In this section, OEE value is calculated for demonstrating the current status of the copy centre towards world class maintenance standard. The main identified losses are Breakdown of equipment, setup and adjustment, quality defect, reduced speed, wastage of raw material (ink), idling and stoppage, and equipment and capital investment. The copy centre works 5 shift per week and it is scheduled to run 8 hours per day. Miscellaneous planned downtime such as meetings is 2 hours per week.

OEE calculation in February, 2019

Breakdown downtime=3,800 min.

Setup and changeover time=840 min.

Downtime loss= 4,680 min.

Planned time available= 9,600 min.

Planned downtime=240 min.

Net available time= Planned time available - Planned downtime=9,360 min.

Actual operating time= Net available time-downtime loss=4,680 min.

Total output= 264,000 printed papers.

Design cycle time 80 papers/min.

Rejected paper = 1,040.

Therefore,

$$A = \frac{Actual\ operating\ time}{Net\ available\ time} \times 100 = \frac{4680}{9360} \times 100\% = 50\%$$

$$\mathrm{P} = \frac{Deign\ cycle\ time \times Total\ output}{Actual\ operating\ time} = \frac{0.0125 \times 264{,}000}{4680} \times 100\% = 71\%$$

$$\mathrm{Q} = \frac{Total\ output - Defected\ papers}{Total\ output} = \frac{264{,}000 - 1040}{264{,}000} \times 100\% = 99\%\,.$$

Thus,

$$OEE = 0.5 \times 0.71 \times 0.99 = 35\%.$$

Since OEE value for the centre is less than world class maintenance standard which is 85%, the centre needs urgent improvement in equipment maintenance program.

7. Conclusion

This study was conducted on WU copy center in Woldia campus. The successful implementation of TPM in the copy center leaded to zero defect, zero accident, and zero breakdown. Top management involvement, training, and employee’s ability to adapt to change were identified as the main factors for successful implementation of TPM in the copy center. The OEE value for WU copy center was 35% which indicated that the center needs urgent improvement in equipment maintenance management program.

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