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Evaluation of OEE for Implementing Total Productive Maintenance (TPM) in Sewing Machine of a Knit Factory

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The aim of this study is to reduce unplanned stoppage, breakdowns, accidents and losses obstructing equipment effectiveness in Comfit Composite Knit Ltd. (CCKL) where maintenance is considered as an evil activity. By implementing TPM the industry can increase their Overall Equipment Effectiveness (OEE) and productivity. This implementation of Total Productive Maintenance in sewing machine of CCKL industry first evaluate the Overall Equipment Effectiveness (OEE) of the sewing machine which was 51%, where the availability rate was 71% of the production time, performance rate 81% and quality rate 89%, to a significant level of upgrading. Set of techniques like Autonomous Maintenance activities, Training and Office TPM is being suggested to implement in the industry after calculating the OEE with improvement of their maintenance procedures and productivity. Total Productive Maintenance (TPM) program is to change the culture of the company maintenance policy with involvement of all employees toward the maintenance system of the company. Several issues that affected the failure of initial TPM, here incorporate some suggestions in TPM implementation plan of the company. With proper planning of maintenance schedules, less energy and effort are wasted, improved productivity will be occurred and greater financial surpluses will be achieved.

Keywords: TPM, OEE, Autonomous Maintenance, Office TPM.

1. Introduction

Through short daily inspections, cleaning, lubricating, and making minor adjustments, minor problems can be detected and corrected before they become a major problem that can shut down a production line. The goal of the TPM program is to increase production and at the same time increase employee morale and job satisfaction (Tsang and Chan 2000). Maintenance is one of the areas in modern management to increase machine productivity and to produce quality products. This obviously improves equipment efficiency rates and reduces costs (Lemma (2008). Generally the study will focus on assessing the existing maintenance system of the Comfit Composite Knit Ltd. (CCKL) Industry to investigate potential area of improvement and to develop suitable system for the success of their business. New technologies and innovative practices have positioned the maintenance function to be an integral part of the overall profitability of many businesses.

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2. Literature Review

Modern maintenance techniques and practical approaches have the potential for significantly increasing competitive advantages in the global market. Production, Safety, Design Engineering and other team members must do maintenance work together to achieve true excellence (Ho 1999).The dual goals of TPM are zero breakdowns and zero defects. Chana et al. (2003) have described Total Productive Maintenance (TPM) is a methodology that aims to increase the availability of existing equipment and reducing the need for further capital investment. After the implementation of TPM model, both tangible and intangible benefits are shown to be obtained for equipment and employees respectively. These intangible benefits resulted from the change of organizational culture, change of paradigm for production people in realizing the importance of maintenance activities and the relationship between maintenance, productivity and quality. Ahmed and Mohiuddin (2005) have mentioned that good maintenance is fundamental to a productive manufacturing system. The main objective of maintenance is to reduce the adverse effect of breakdown and to maximize the availability of facilities at a minimum cost. The concept of TPM was introduced in conjunction with EOM and 5S system namely preventive maintenance, autonomous maintenance and maintenance prevention to bear on the successful implementation of TPM in their work. Lemma (2008) has shown that in most of Ethiopian industries maintenance is considered as evil activity. By implementing TPM the industries can increase their equipment effectiveness and productivity. That paper was aimed at implementation of Total productive maintenance in Ethiopian textile industries and calculated Overall Equipment Effectiveness (OEE) of the machines was 0.272 that was poor. As a result, the machinery that was failed for long period of time to shortage of spares parts and poor controlling system. The above problems lead the company spend more money for maintenance and also high down time. Shahanaghi and Yazdian (2009) have shown that maintaining a reliable manufacturing process is a key success factor of a company. It can be achieved through implementing a proper maintenance strategy. It reduced breakdown down maintenance and increased machine reliability, process quality and product's net throughput. Taisir and Almeanazel (2010) focused on the goals and benefits of implementing Total Productive Maintenance by calculating the overall equipment effectiveness in one of Steel Company in Jordan and it discussed what called the big six losses in any industry. They adopted the autonomous maintenance operations (daily maintenance) that achieved 99% in quality factor of overall equipment effectiveness and 76% in availability where in performance 72%. Set of techniques like Single minute exchange die, computer maintenance management system, and production planning were suggested to the industry after calculating the OEE to improve their maintenance procedures and improve the productivity. Sivakumar and Saravanan (2011) have mentioned an overview of the various processes in textile fabric industry. From analysis of data taken during the past three years, the company has not achieved the targeted productivity. Total Productive Maintenance (TPM) has been a major component of improvement strategy to organizational productivity and profitability. Fabric industry could not get the determined productivity since TPM was not followed. A systematic methodology was presented and analyzed for improvement of productivity at factory level. The total fabric rejection is greatly reduced by implementing maintenance steps for all machineries. The result is observed that the OEE before implementing TPM is less than present result of OEE. Based on

observed problems this paper is trying to identify the problem in sewing machine and the key potential area for the improvement of the system and as well as to provide systemized maintenance policy by developing the implementation model of the TPM in the CCKL.

3. Methodology

Both Human-oriented and Process-oriented Strategy are critical success factors of TPM (Tsang and Chan 2000). It was implemented Human oriented strategy of TPM. Three important aspects of Human-oriented strategy are: (1) Top management commitment and leadership, (2) Total Employee Involvement, and (3) Training and Education. Relevant primary and secondary information was assembled to induce superior maintenance system for the industry. The secondary data was collected from the technical manual, monthly and annual report of the industry. Information was also gathered using questionnaire and interview in direct observation on site visit in the industry. The literatures are also reviewed. Primary data acquired from interviews and observations to develop better maintenance system to the industry. The collected data mainly aims at assessing the existing maintenance system with core TPM activities, OEE (Overall Equipment Effectiveness) and Industrial Engineering Technique that to be applied to solve the problem. Finally, Total Productive Maintenance system is developed along with its implementation and master plan stated in the figure 1.

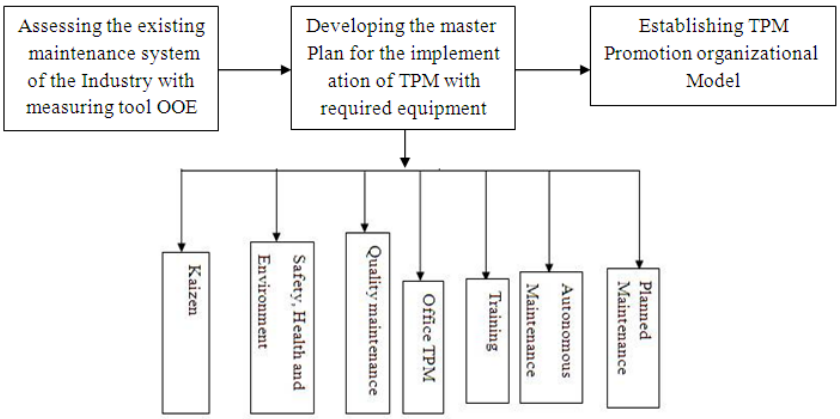
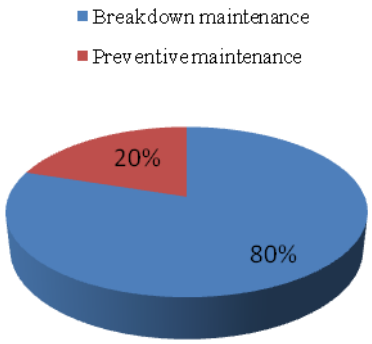


Figure 1: Overall Development Strategy

4. Case Study and Data Collection

4.1 Maintenance System of the Sewing Machine

The maintenance department of the company has no manual due to insufficient supply of materials by the equipment vendors. The maintenance personnel just changes the items which failed by the operation after the failure occurs. There is no analysis done to find the cause and the effect of the failure. Some of the maintenance plan of the company contains cleaning and making minor inspection on the machineries. The plans are not based on the maintenance manuals. The maintenance system the company uses is almost 85% breakdown type and very small percentage about 15% lubrication and change of oils. The maintenance system of the company doesn't allow the operators to change any items before it break. The maintenance policy and causes of idle time distribution of the company are shown in Figure 2 and Figure 3 respectively.



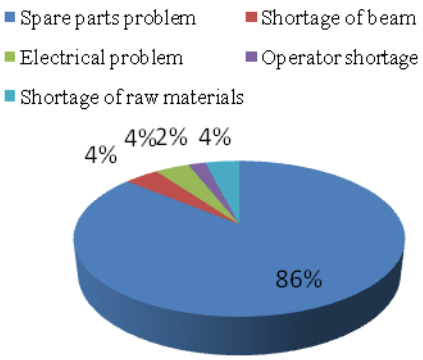


Figure 2: Maintenance policy

Figure 3: Causes of idle time distribution

4.2 Six Big Losses of the Company

To find the overall equipment efficiency of the CCKL Industry, identifying the major losses of the machines was first target. The major losses that are identified and the OEE of the selected machineries presented as follows:

- Equipment failure loss
- Set-up and adjustment loss
- Start-up loss
- Minor stoppage and idling loss
- Speed Loss
- Defect and rework loss

4.3 Overall Equipment Effectiveness (OEE)

OEE is the ratio of actual equipment output to its theoretical maximum output. The aims of TPM is to achieve the ideal performance and the Zero loss which means no production scrap or defect, no breakdown, no accident, no waste in the process running or changeover. The quantification of these accumulations of waste in time and its comparison to the total available time can give the production and the maintenance management a general view of the actual performance of the plant. It can help them to focus the improvement on the bigger loss. It is calculated using the following formula:

OEE = Availability * Performance Rate * Quality Rate

4.3.1 Availability Ratio

Table 1: Run Times of the sewing machine from July to December 2011

Months	Scheduled Run Time(hrs)	Unplanned Stoppage(hrs)	Actual Run Time(hrs)
July	312	78	234
August	312	81	231
September	312	90	222
October	312	95	217
November	312	97	215
December	312	98	214

The availability is the ratio of actual run time and the scheduled time. Actual run time is the difference between scheduled run time and unplanned stoppage.

Availability (%) = $\frac{\text{Actual Running Time}}{\text{Schedeled Running Time}}$ *100

= $\frac{\text{Schedeled Running Time} - \text{Unplanned Stoppages}}{\text{Schedeled Running Time}}$ *100

Using data from the table 1 the availability rate of the machine is 71%.

4.3.2 Performance Ratio

This factor indicates the ratio of the actual output and the targeted output. In other words, loss of production occurs due to under-utilization of the machinery. Losses are incurred when the equipment is not run with full speed due to rough running of the equipment, jams and equipment wear. Performance Rate (%) = $\frac{\text{Actual Output}}{\text{Targeted Output}}$ *100

Table 2: Output of the sewing machine from July to December 2011

Months	Targeted output in pcs	Total output in pcs
July	1283568	990315
August	1283568	825850
September	1036728	842760
October	1365655	1283568
November	1036728	975150
December	1359072	1243800

Using data set of the table 2 the performance rate of the machine is 81%.

4.3.3 Quality Ratio

The amount of the production has to be discharged or scrapped which is calculated using the following formula:

Quality Rate (%) = $\frac{(\text{Good output})}{\text{Total Output}}$ *100 = $\frac{(\text{Total Output} - \text{Defects})}{\text{Total Output}}$ *100

Table 3: Quality rate of the sewing machine from July to December 2011

Months	Total output in pcs	Reject/Defect in pcs	Allow in pcs
July	990315	112619	877696
August	825850	110459	715391
September	842760	109352	733408
October	1283568	134585	1148983
November	975150	102856	872294
December	1243800	103654	1140146

Using data set of the table 3 the quality rate of the machine is 89%.

4.3.4 Comparison

Table 4: Comparison between world class OEE & CCKL OEE

OEE Factor	World Class	OEE CCKL Industry
Availability	90.0%	71%
Performance	95.0%	81%
Quality	99.9%	89%
Overall OEE	85.0%	51%

Therefore, Overall Equipment Efficiency of the sewing machine is obtained by multiplying those three factors and the result is
OEE = Availability Rate * Performance Rate * Quality Rate =0.71*0.81*0.89 = 51%.
This is far behind from the world class OEE as 85%.

4.4 Problem Areas of Sewing Machine in CCKL Industry

In CCKL Industry, there are many problems and causes that contributed to defective products. After careful observations and interviews with maintenance operators and management the main defects are identified which is provided in table 5.

Table 6: Sewing defects and their causes

Defects	Causes
Level mistake	Due to non-sewing of level.
Size mistake	Due to size change from required size.
Spot	Due to color contamination
Open seam	Due to not perform sewing
Skip stitch	Due to avoid sewing
Down stitch	Due to stitch below accurate line
Broken stitch	Due to break down stitch
Measurement defect	Due to wrong measurement
Bad tension	Due to tight stitch
Twisting	Due to fold of any part
Wrong SPI	Due to less or more stitch per inch
Button hole	Due to hole created in any part.
Stitch missing	Due to mistake of stitch

5. TPM Implementation Plan

5.1 Levels of TPM Implementation Plan

This section endowed with developed steps that are required to implement Total Productive Maintenance System in CCKL Industry. This plan can be used as a step-by-step guide to introduce TPM in the workplace of the Industry.

5.1.1 Level-1 TPM Implementation

The following activities of the selected pillars of TPM are carried out in this level.

Autonomous Maintenance Activity

- Provide basic training to operators of the industry about safety equipment structure and functions of machines.
- Make cleaning plan for each parts of the machines.
- Removing unnecessary articles around the machineries of the industry.
- The initial clean up include fiber dust, oil, etc. and has to be removed and minor defects of the machineries should be detected.

Training

- Setting policy and priority measures to train the operators in the industry. Need to set the basic training policy and measuring matrices suiting it and training for developing and fostering the maintenance people in office work.
- Establish training system for the maintenance men in all textile machineries.
- Establish training system for the operators of the machines.

- Establish training calendar for the operators of the machines in industry.

TPM Office

- Providing awareness about office TPM to all support departments such as quality control, and marketing departments of the industry.

5.1.2 Level-2 TPM Implementation

Autonomous Maintenance Activity

In this step hard to access area should be improved and causes of forced deterioration should be eliminated from the machineries of the industry.

- Taking action at the source of problems observed in level one.
- This action includes avoiding of recurrence of the accumulation of fiber dusts.
- Develop proper procedures for cleaning, lubrication, retightening and etc.

Training

After the first level of training implementation, implement the following activities:

- Implement the training system for the employees of the industry.
- Evaluate the activities of the training system.
- Training of instructors for maintenance skill.
- Operation skills upgrade training for operator.
- Provide training for skill upgrade to correct operation, as required.
- Provide training for skill upgradation for inspection and routine restoration.
- Provide maintenance skill training to leaders of the operating sectors.
- Provide maintenance skill training to all maintenance men by instructors.

TPM Office

- Initial cleanup of every offices of the industry.
- Removal of unnecessary articles.
- Clean dirt, dust and strains in the work place.
- Identify all documents in lockers and desks.
- Classify documents in accordance with nature of work.

5.1.3 Level-3 TPM Implementation

Autonomous Maintenance Activity

- Tentative standards of cleaning will be set for the machines.
- Mastering the inspection skill of the operators of all machines.

Training

- Understand the right method of cleaning, lubrication and inspection.

TPM Office

- Fault finding work in the offices
  - Survey condition of work to expose the faults and remove the faults.
- Improve the problems observed in previous step to reduce work flow stagnation.

5.1.4 Level-4 TPM Implementation

Autonomous Maintenance Activity

- To understand the structures functions and principles of equipment in textile industry and learn their optimal conditions.
- Train the operators of the machines in the industry to carry out the inspection.
- Find and restore slight defects through general inspection.
- Evaluate inspection skills provided in the previous levels and provide training.
- Advance the inspection system.

Training

- Train the operators for the causes of abnormal conditions.
- Train the operators to replace parts.
- Train the operators about the quality products.

Office TPM

- Check stores of files and documents.
- Clean the storage areas and set standard time table for cleaning.

5.1.5 Level-5 TPM Implementation

- Review clean-up, lubrication and general inspection criteria for the machines.
- Preparation and implementation of autonomous inspection checks sheets.
- Review equipment and human factors abnormal conditions.
- Maintain optimal equipment conditions once restored by general inspection.
- Organize the surrounding of machinery.
- Reducing material searching time by organizing material in the workplace.
- Identification of very important parts to be accessible everywhere.
- Standardize the work place of the organization.

Training

- Make the operators practice to estimate failure causes.
- Make the operators to assist in overhauling.

Office TPM

- Clear the emergency passages and set standard to check them.
- Allocate articles in correct place.
- Safety and environmental factors.
- Give one point lesson to employees of the industry.
- Encourage the participation in the activities.

5.1.6 Level-6 TPM Implementation

Automate maintenance system

- Standardization: Ensuring maintenance and management of these activities (level1-5) and at expanding the operator roles to work related to the equipment and areas around it.
    - Standard work criteria.
    - Data record standards.
    - Spare parts management.
- All out autonomous maintenance management.

Training

- Upgrade maintenance and operation skill.
- Increase the technological power of diagnosing equipment.

Office TPM

- Clear the emergency passages and set standard to check them.
- Allocate articles in correct place.

5.2 Overall TPM Development Program for the Industry

Implementation of TPM is required for the industry to avoid unplanned downtime and to continue daily inspection and routine maintenance. By implementing TPM, the maintenance personnel can begin to make use of the skills operators to perform the expected maintenance activities. Maintenance personnel expand more on proactive maintenance and elimination of recurrence failure. Since TPM has a companywide

concept, the implementation is also required to integrate every activities of the industry from top management to frontal workers.
The implementation of TPM in the industry is to be carried out by using of the appropriate pillars of TPM. It is supposed that full implementation of TPM program of the industry will take approximate 18 months. Six implementation levels have been discussed above. In each level, the required implementation steps for each activity of the selected pillars of TPM executed according to their precedence. The target is set for each level and the results are measured against it. If the implementation of that level is successfully succeeded, the other activities of TPM pillar will be started to be implemented. But if it fails, a thorough investigation carried out to discover the causes of the failure until it becomes satisfactory. The successful implementation of the TPM, as it has been mentioned, require a long term commitment and a continuous provision of training to all level of employee. The proposed Standardization model of the implementation process is shown in figure 3.3. Before the launching of the implementation model there is preparatory step. In this step the commitments of top management and necessary budget will be allocated. An overview of TPM and committee will be formed for each TPM pillars. It takes six months to perform such activity. After six months of preparatory step the evaluation will be done to know whether the progress can make the organization to continue to the next level or not.

5. Conclusion

Total Productive Maintenance system is to integrate every activities of a company with maintenance department as well as involving the operators in maintenance activities. This paper has been conducted and written in relation to the implementation of Total Productive Maintenance System in CCKL industry. The aim of study was to find maintenance system of the industry and categorically the high rate of unplanned failure reigns. The condition of equipment was poor due to negligence of the operator and shortage of spare parts. The operator in minor inspection and restoration of equipment step-by-step increased unexpected number of failures of equipment's. In CCKL Industry, the Overall Equipment Effectiveness (OEE) of the sewing machine was 51% where the availability was 71% of the production time and the performance was 81% while the quality factor 89%. Set of techniques like Autonomous Maintenance activities, Training and TPM Office were suggested to the industry after calculating the OEE to improve their maintenance procedures and improve the productivity. It can be concluded that the industry may phase out unless some sustainable actions are implemented. In order to alleviate the current situations of the maintenance system, a typical model has been proposed based on the above findings. The model emphasizes on three main techniques of core TPM activities like autonomous maintenance activities, training and office TPM. The four major duties of maintenance are inspection management, failure management, work management and spare part management. The concepts rely on the continuous improvement, empowering the employee and standardizing every activity to minimize the time of execution.

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