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Total Productive Maintenance: A Case Study in a Jute Industry

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ABSTRACT
One of the significant challenges that manufacturing companies face today's world is to sustain their production level for meeting their customer demand along with minimization of cost and ensuring quality to survive in the competitive market. This is particularly significant in Bangladesh, where many manufacturing companies are operating significantly below their potential capacity, or experiencing a high level of late-deliveries, due to problems with their current production scheduling and production management systems. This study attempts to apply the TPM strategy in a jute industry in Bangladesh to enhance their overall equipment effectiveness (OEE). Results show that OEE has improved from 64.97% to 69.50%, which is still very low compares the benchmark world class manufacturing OEE (85%). The company needs to work hard to improve their system machines and reduce the waste time.

Keywords: Total productive maintenance, Preventive maintenance, Overall equipment efficiency, Downtime, Equipment failure, Manufacturing

1. Introduction

Now days, machine maintenance has been largely considered as the support function in production. Industries are focusing on Total Productive Maintenance (TPM), an advanced Japanese concept of preventing machine failure via periodic inspection. It is a philosophy that proves how continuous taking care of machine can result in higher productivity and improvement. A large number of research works were explored the problems associated with jute process related industry in several part in the world. The problems such as breakdown of machine, production adjustments, poor working of defective equipment, poor maintenance and management were identified and this lead to low productivity and major losses in the company's growth. To overcome these problems Total Productive Maintenance (TPM) tools such as 5S, Jishu Hozen, Kaizen, and classification of abnormalities were implemented [1-5]. S. Nallusamy et al. implement the TPM in medium scale industries. They found that, the percentage OEE can be improved from 55.45% to 68.04% by implementing this technique in medium scale industries [6]. S. Krishna et al. applied the TPM in a jute industry and their results revealed that OEE increased 33% after implementation of this technique [7]. The overall equipment efficiency has increased by 3% almost after implementation of TPM. SPSS V23 software is used to analyze the data. CANON and ESEC these two processes are used and here OEE for ESEC is showing greater result than CANON. TPM brings a positive result for the semiconductor company by using three pillars TPM- planned maintenance (PM), autonomous maintenance (AM) and focused maintenance (FM) [8]. In a Malaysian electrical Industry five pillars of TPM were used and observed a great result in production, quality and efficiency. It also increased the involvement of the worker. It is also observed that if the TPM is applied for the long time the percentage of improvement is risen from 3 to 5 percent. [9]. Failure Mode Effect Analysis (FMEA) was introduced to run the quality and reliability in parallel line. In industries TPM and FMEA both are used for improving the productivity and the overall condition of the industry [10]. In Bangladesh, jute industries are considered as a great source of economic development. All industries are facing problems of downtime, process instability, and lower quality products, which result lower overall equipment effectiveness (OEE) and finally decrease the profit level. The authors believed that, the development of this type of industries can be a profitable sector in Bangladesh in the concern of foreign currency. Therefore, in this study a systematic way is presented to indentify root causes of big losses which are responsible for low OEE and then TPM strategy is implemented to reduce the losses and enhance the OEE in a jute bag manufacturing industry.

2. Pillar of TPM and Overall Equipment Effectiveness (OEE)

The term Pillar of TPM is some important factors that should be considered to practice TPM properly. Eight pillars of TPM strategy is shown in Fig.1.

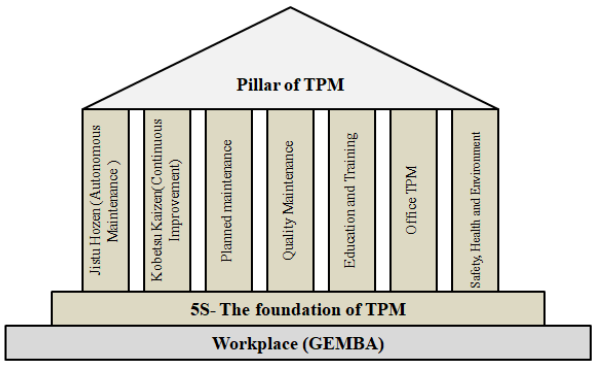

Figure 1 Pillar of TPM [1]

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Pillar 1- 5S

5S is the base and initial point of TPM implementation. It is used to reveal problems. Uncovering complications is the major phase towards improvement [1].

Table 1 Explanation of 5S

Japanese Term	Equivalent 'S' Term	Explanation
Seiri	Sort	Shorten the objects based on desired and not desired
Seiton	Straighten	Keep objects in right place
Seiso	Shine	Work zones, and equipment clean and free from dirt.
Seiketsu	Standardize	Standardize actions, processes and timetables.
Seitsuke	Sustain	To uphold new standards and techniques.

Pillar 2- Jitsu Hozen (Autonomous Maintenance)
This pillar is based on the concept that if operators take care of small activities like cleaning, lubricating, visual inspection, tightening of loosened bolts etc so that maintenance department can take care of most valuable task.

Pillar 3- Kobetsu Kaizen (Continuous Improvement)
The main principle of the Kaizen is that "a very large number of small improvements are more effective in an organizational environment than a few improvements of large value".

Pillar 4- Planned Maintenance
The main objectives of this maintenance are to achieve zero equipment failure and break down and maintenance cost keep optimum.

Pillar 5- Quality Maintenance
The main objectives of quality maintenance are to achieve customer satisfaction through delivery of highest quality product.

Pillar 6- Education and Training
The goal of this pillar is to develop multi skill employees whose morale is high and who has eager to come to work and perform all required function effectively. Basically, an educated and skill operator is able to identify and solve the problem.

Pillar 7- Office TPM
The main objectives of Office TPM are to reduce the losses related to office maintenance like processing loss, marketing, sales, inventories etc.

Pillar 8- Safety, Health and Environment
The main objectives of this pillar are to achieve zero accident, zero health damage and zero fires.

Overall Equipment Effectiveness (OEE)

OEE is calculated by multiplication of the three main bases for the main six big losses: [1]
OEE = Availability (A) × Performance Efficiency (PE) × Rate of Quality (QR) …… (i)
Where,
Availability (A) = [(Loading time - Downtime) ÷ Loading time] × 100 ……. (ii)
Performance Efficiency (PE) = [(Standard cycle time × Product unit processed) ÷ Operating time] × 100 …….(iii)
Quality Rate (QR) = [(Product unit processed –Defect Units) ÷Product unit processed] ×100… (iv)

1. The problem caused by the down time losses is called availability (losses due to equipment failure and setup and adjustment)
2. Performance indicates the losses caused by idling and minor stoppages and speed losses
3. Quality indicates the scrap and rework losses.

3. Case Study

The company under this study is based on Khulna, Bangladesh and is currently manufacture two types of jute products sacking (Thick) jute cloth and rope ring about 1800 loom machine. Monthly production approximately 73000 pieces of sack and 64000 pieces of rope ring. The key production equipment in the company are the softener machine, card machine, drawing, spinning, winding, beaming, measuring, cutting and sewing machine. Flow chart of processing steps of jute bag manufacturing is shown in figure 2.

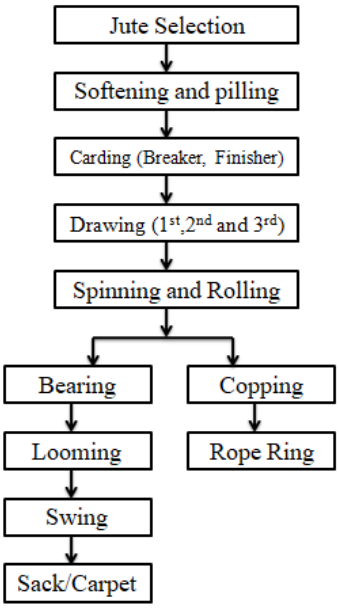

Fig. 2 Flow chart of processing steps

4. TPM Implementation

In this study equipments which cause major losses during production are identified and were decided to consider those for TPM implementation strategy. The machine stop time or any other situation that led to idle or stoppage time on equipment is noted down by using stopwatch. Data was accumulated on daily basis and summarized as monthly report. Two consecutive months of data is collected and summarized. In this selected industry, twelve major machines are involved with production and three machines having different causes for major losses due to downtime. The major reasons for their downtime are given in Table 2.

Table 2 Main reason for down time

No	Machine	Reason for Downtime
01	Softener	• Jute stuck in the roller
02	Drawing (1^{st}, 2^{nd}, 3^{rd})	• Breaking down of wooden pin between the bar and the pin holder. • Jute stuck in the roller
03	Sewing	• Breakdown the needle frequently

Three machines (softener, Drawing and sewing) are selected as model machines for TPM activities. TPM activities are described below.

5S

- Initially Unwanted items stored away from the operating machine.
- Frequently used items brought near the machines which reduce the time loss and material handling cost. A rack is placed near the machine and marked the rack number on the items

Jitsu Hozen (Autonomous Maintenance)

- Operator mentality is a key factor for autonomous maintenance.
- If the operator think as if he owes the machine, then he can take better care of machine.
- Initially all visible problem like oil leakage, loosen bolt and nut, unclean machine which leads to tighten the rotating parts, wire lose connection etc. were noted.
- Helpers are responsible for the cleaning and lubricating the machine. Also they are responsible for tighten the loosen nut and bolt. It were noted that regularly they are not cleaning and lubricating it therefore lots of work is accumulated during preventive maintenance.

Approaches:

- TPM activities like cleaning, lubricating rotor pin fixing and nut bolt tighten were handed over to operators to carryout individually.
- A check list was prepared for follow up of the daily activities and following the check list is mandatory for all the operators. Shop floor in-charge confirms that every operator fills up this checklist.

Kobetsu Kaizen (Continuous Improvement)

1. In softener machine jutes are stuck the roller frequently that causes stop the machine until the helper fixed the problem. As results big losses occur due to downtime.

Approaches: Operator and helper are asked to use sufficient boric powder every one hour for softening the roller. It was observed that frequency of jute stuck is reduced. As a result down time is reduced.

2. In drawing machine wooden pin is used in the roller which is broken frequently and operator can easily fix the problem within few minutes. However Operator waits until the maintenance department fixed the problem.
3. Also jutes are stuck the roller frequently that causes stop the machine until the helper fixed the problem.

Approaches: Operator and helpers are trained to fix the problem immediately. Operator and helper are asked to use sufficient boric powder every one hour for softening the roller. It was observed that frequency of jute stuck is reduced. As a result down time is reduced

4. In sewing machine universal needle is used and this needle is breakdowns frequently which causes stop the machine until operator fix the needle again.

Approaches: It is suggested to use leather needle which is used to sewing the leather materials.

Others TPM: It is suggested to implement other TPM

Suggestions:

- A training program should be scheduled every month so that all the operators, helpers and engineers of maintenance department can easily identify the areas are most likely to break down or fail. As a result they can inform maintenance engineer immediately and take corrective action before any major break down.
- Should be scheduled training for inspection to detect visual defects.
- Should be Conducted training to improve operation and maintenance skills- The maintenance department is taken on the role of teachers and guided to provide training, advice and equipment information to the teams.

- New computer system is proposed for maintenance.
- It is suggested to ensure Sufficient number of fire extinguisher is provided all over the plant floor
- It should be mandatory for all workers to wear mask in this work area to avoid health hazard.
- Washroom cleaners are advised to maintain regular cleaning of toilets.
- It is advised that every smoker is mandatory to smoke within the specific smoking area.
- Management should confirm the health checkup for all employees once a year.

5. Results and Discussion

Two consecutive months of data is collected and calculated the OEE as shown in table 3 and table 4.

Table 3 Overall Equipment Efficiency (OEE) Calculation before TPM implementation (February and March 2019)

No	Category	Average per day	February	March
1	Working time (total)	16 hr	384 hr	400 hr
2	Break time	2 hr	48 hr	50 hr
3	Planned production time	14 hr	336 hr	350 hr
4	Down time (equipment)	0.2 hr	7.2 hr	5 hr
5	Down time (setup & adjustment)	0.13 hr	3.12 hr	3.25 hr
6	Run time	13.67 hr	328.08 hr	341.75 hr
7	Cycle time	0.0056 hr	0.0056 hr	0.0056 hr
8	Jute processing	1640.4 kg	39369.6 kg	41010 kg
9	Total rejected jute	50.89 kg	1206.72 kg	1287 kg
10	Availability (A)		97.64%	97.64%
11	Performance Efficiency (PE)		67.20%	67.20%
12	Quality Rate (QR)= (Output – Defects)/Output		96.93%	96.86%
13	OEE (A × PE × QR)		63.59%	64.97%

From table 3 and table 4, it can be seen that, after implementation of above mentioned TPM strategy, the down time reduce by 27.32 %. Therefore the OEE increased by 4.53%. However the OEE (69.50%) still very low compare the benchmark world class manufacturing OEE (85%) [1]. The company needs to work hard to improve their system machines and reduce the waste time.

Table 4 Overall Equipment Efficiency (OEE) Calculation after TPM implementation (April and May 2019)

No	Category	Average per day	April	May
1	Working time (total)	16 hr	384 hr	400 hr
2	Break time	2 hr	50 hr	52 hr
3	Planned production time	14 hr	334 hr	348 hr
4	Down time (equipment)	0.19 hr	4.75 hr	4.93 hr
5	Down time (setup & adjustment)	0.11hr	2.75 hr	2.86 hr
6	Run time	13.7 hr	326.50 hr	340.21 hr
7	Cycle time	0.0056 hr	0.0056 hr	0.0056 hr
8	Total Jute processing	1642.4 kg	41060 kg	42751.67 kg
9	Total rejected jute	50 kg	1250 kg	1299 kg
10	Availability (A)		97.75%	97.76%
11	Performance Efficiency (PE)		70.42%	73.32%
12	Quality Rate (QR)= (Output – Defects)/Output		96.95%	96.96%
13	OEE (A × PE × QR)		66.74%	69.50%

6. Conclusions

In this study TPM strategy is implemented to improve the OEE in a jute industry in Bangladesh. Result shows that the OEE has improved from 64.97% to 69.50% by reduce the down time and wastage. However the OEE (69.50%) still very low compare the benchmark world class manufacturing OEE (85%). This study gives opportunity to the company to know where they are and what causes the low OEE and how it can be improved. Also this study gives them the chance to know what the best techniques that they can apply which will improve their performance.

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