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Improvement of Overall Equipment Effectiveness through Total Productive Maintenance: A Case Study

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ABSTRACT
In this competitive world, manufacturing industries are suffering from several problems such as breakdown of machine, production adjustments, poor working of defective equipment, poor maintenance and management and this lead to low productivity and major losses in the company's growth. Total Productive Maintenance (TPM) approaches can be promising solution to overcome these problems. Therefore, this study attempts to apply the TPM strategy in a jute bag manufacturing company in Bangladesh to enhance their overall equipment effectiveness (OEE). A consecutive three month data is taken and identified the cause root of major losses. TPM strategy is applied based on these losses. As a results company achieved 50.33 % OEE which is still very low compare the benchmark world class manufacturing OEE (85%). By calculating the OEE Company can know where they are and where the weakness point is and how to it can be improved.

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

1. INTRODUCTION

In this competitive world, industries are trying to maximize the usage of their assets and equipment to minimize their operational cost as well as production cost. Production efficiency and effectiveness of these industries are depend on the efficient functioning of the company's facilities like equipment and man power. 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]. Chan et al. investigated the effectiveness and implemented of TPM in electronics manufacturing company. They conclude that TPM implementation can be increased the productivity significantly [4]. TPM is a technique that aims to increase the productivity, product quality and reduced labor costs [5]. A significant amount of losses/wastage occur in the production industry due to operators, maintenance personal, process, tooling problems and non-availability of components in time, idle machines, idle manpower, break down machine, rejected parts etc.[6-7]. Machine breakdown, unskilled manpower, poor machine maintenance and idle machines, are the top most areas for hampering productivity and low product quality. Company top management is required to take effective action of these areas. Some suggestion of strategies has been highlighted for implementing TPM in jute industry [8-9]. Jute industries have enormous prospects in Bangladesh in where to utilize the natural resources for the development of its economic strength. There are a great number of public and private jute processing and manufacturing industries inside the country. Unfortunately they all are facing problems of downtime, process instability, and lower quality products, which result lower overall equipment effectiveness (OEE) and finally decrease their 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. For this it is needed to eliminate the unplanned downtime and process instability and also have to improve product quality. Therefore, the aim of this study was to eliminate root causes of the losses by using TPM tools to improve OEE in a jute bag manufacturing company in Bangladesh.

2. METHODOLOGY

In this study TPM strategy is implemented to enhance the OEE in a selected jute bag manufacturing company. The following proceeding is performed for fulfill the objectives of this study.

Step 1: Find out the main factor of major losses
The selected company (Jubilee Jute Mills Ltd, Khulna, Bangladesh) is suffering from following factor of major losses.

i) Equipment failure.
ii) Adjustment failure.
iii) Reject of finish goods.

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iv) Manpower utilization
v) Process loss.
vi) Wastage
vii)

Step 2: Identify and collect data for big losses

One of the major goals of TPM is to reduce or eliminate big losses which are the most common causes of low efficiency in manufacturing. The big losses can be described as follows [10].

The losses due to downtime:

Equipment Breakdown Losses: These losses are measured by time require for replace or fixing the problem.

Setup and adjustment time: These losses are measured by the time require for changeover or exchange the tools.

Losses due to Speed:

The time difference between the theoretical and actual working load is speed losses time.

Losses due to Defect or quality:

These losses occurred when the product does not meet the quality specifications. Two type of defect losses rework and quality defects and yield losses occurred during production.

Step 4: Implementation of 5S

Short (SEIRI): Shorten the objects based on desired and not desired
Set in Order (SEITON): Keep objects in right place
Shine and clean (SEISO): Work zones, and equipment clean and free from dirt.
Standardize (SEIKETSU): Standardize actions, processes and timetables.
Sustain (SHITSUKE): To uphold new standards and techniques

Step 5: Implementation of Jitsu Hozen (Autonomous Maintenance)

The concept of this pillar is that operators can 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.

Step 6: Implementation of 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".

Step 7- 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.

Step 8- Office TPM

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

Step 9- 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: [11]

OEE = Availability (A) × Performance Efficiency (PE) × Rate of Quality (QR) Where,

Availability (A) = [(Loading time - Downtime) ÷ Loading time] × 100

Performance Efficiency (PE) = [(Standard cycle time × Product unit processed) ÷ Operating time] × 100

Quality Rate (QR) = [(Product unit processed –Defect Units) ÷Product unit processed] ×100

1. The problem caused by the down time losses is called availability.
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 as hessian (Thin) and sacking (Thick) jute cloth and bag using about 1800 loom machine. The key production equipment in the company are the emulsion plant rapisonic, softener machine, spreader machine, card machine, drawing, spinning, winding, beaming, measuring, cutting swing, hamming and press machine. Flow chart of processing steps of jute bag manufacturing is shown in figure 1.

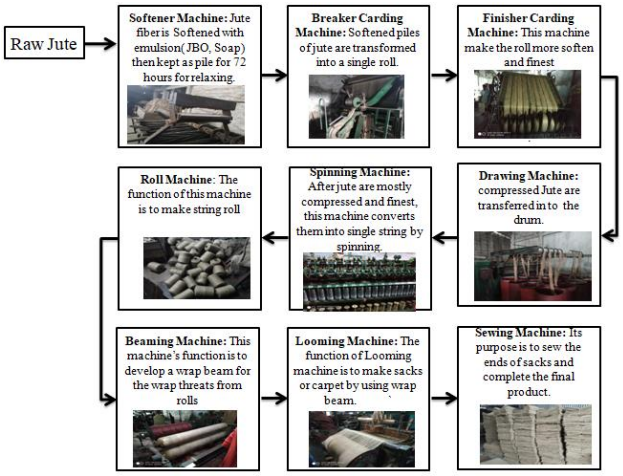


Fig 1 Flow chart of processing steps

4. Data Collection & Data Analysis

Data was accumulated on daily basis and summarized as monthly report. The analysis was based on monthly report. Accumulated data for different losses is shown in table 1, table2, table3 and table 4. A cause and effect diagram was developed to highlight the problem occurred during the OEE measurement. The cause and effect diagram for low OEE is shown in figure 2.

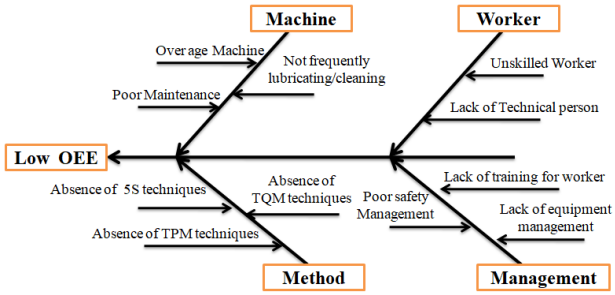


Fig. 2 Cause and effect diagram for low OEE

Table 1 Equipment failure data

Month	Target working hours	Target finished goods (MT)	Equipment	Reason to failure	Frequency	Loss (MT)	Down time (hrs)
1	269200	151.57	Spinning Machine	Due to Inside the Warve Corrosion (stress cracking) and the string is cut down	01	1.52	2685
			Generator	Cooling water supply failed and tripped	01	0.002	4
				Sub Total		**1.522**	**2689**
2	204592	135.21	Spinning Machine	Due to Inside the Warve Corrosion (stress cracking) and the string is cut down	02	4.97	7535
				Sub Total		**4.97**	**7535**
3	290736	435.44	Spinning Machine	Due to Inside the Warve Corrosion (stress cracking) and the string is cut down	03	25.74	17189
			Generator	Cooling water supply failed and tripped	01	0.005	4
				Sub Total		**25.745**	**17193**
				Total		**32.237**	**27417**

Table 2 Setup and adjustment losses data

Month	Equipment	Reason	Frequency	Loss (MT)	Downtime (hrs)
1		Starting Set-up	01	0.01	15
	Flyer change of Spinning Machine	Corrosion (Stress cracking)	01	0.18	24
		Sub Total		**0.19**	**39**
2		Starting Set-up	01	0.01	15
	Flyer change of Spinning Machine	Corrosion (Stress cracking)	01	0.18	24
		Sub Total		**0.19**	**39**
3		Starting Set-up	01	0.01	15
	Flyer change of Spinning Machine	Corrosion (Stress cracking)	01	0.18	24
		Sub Total		**0.19**	**39**
		Total		**0.57**	**117**

Table 3 Losses due to speed data

Month	Equipment	Reason	Loss (MT)	Downtime (hrs)
1	Spinning Machine	Actual spindle rpm is 3200. But due to old machine operating speed remain 2300-2700 rpm.	3.67	65164
	Warve of Spinning Machine	After certain period of time cotton listing tape become loses and slip. It reduces the then warve rpm.	0.05	8000
		Sub Total	**3.72**	**73164**
2	Spinning Machine	Actual spindle rpm is 3200. But due to old machine operating speed remain 2300-2700 rpm.	3.67	65164
	Warve of Spinning Machine	After certain period of time cotton listing tape become loses and slip. It reduces the then warve rpm.	0.05	8000
		Sub Total	**3.72**	**73164**
3	Spinning Machine	Actual spindle rpm is 3200. But due to old machine operating speed remain 2300-2700 rpm.	3.67	65164

Table 4 Losses due to defect data

Month	Reason	Loss (MT)
1	Defect of finished product due to cut the string during spinning process	2.65
	Raw material wastage	0.91
	Sub Total	**3.72**
2	Defect of finished product due to cut the string during spinning process	2.87
	Raw material wastage	1.01
	Sub Total	**3.88**
3	Defect of finished product due to cut the string during spinning process	2.70
	Raw material wastage	0.94
	Sub Total	**3.68**
	Total	**11.31**

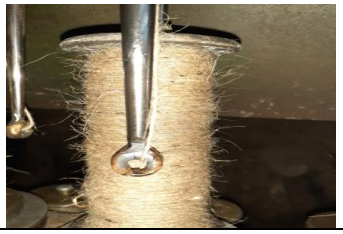
5. Implementation of TPM strategy

As the present OEE is very low compare with benchmark OEE, the company was motivated to implement TPM to cope with the new market need and to increase their production performance to the international level. The strategy of TPM implementation is summarized in Table 5.

6. Results and Discussion

Three consecutive months of data is collected and calculated the OEE as shown in table 6. From table 6, it can be seen that after implemented of above mention TPM strategy, the down time reduce by 21% and defect losses reduced by 11%. Therefore the OEE increased by 32%. However the OEE (50.33%) still very low compare the benchmark world class manufacturing OEE (85%). After implementation of above mention TPM strategy, there is no significant change in quality rate (QA). But there is significant difference in the percentage improvement of availability (A) and performance efficiency (PE) indicates that apply of the TPM tool made an improvement of downtime losses as well as losses due to idle time, minor stoppages and speed. The OEE is still very low and the company need strive to achieve the world class manufacturing OEE benchmark.

Table 5 Summary of TPM implementation Strategy

TPM	Root Cause Identified	Action	Impact
5S (SEIRI, SEITON, SEISO, SEIKETSU, SHITSUKE)	It was observed that some unwanted items are take place near the machine.	Unwanted items stored away from the operating machine. 	The search time is reduced.
	It was observed those critical items that are frequently used are not placed back after usage at the same place.	Critical items brought in to 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. 	The search time is reduced.
	It was observed that work place is not so clean.	Developed awareness among the workers to clean their work place and machine.	Better work environment for workers
	It was observed that some workers are not punctual and dedicated	Management took necessary action by warning.	Increase productivity
Autonomous maintenance	Some time rotor pin is fall down which stop the Sack machine. Operator wait until the maintenance department fixed the problem	Operator have been trained and fix the problem immediately	The downtime is reduced
Kaizen to eliminate six big losses (Continuous Improvement)	Due to corrosion (stress cracking) inside the warve of spinning machine, the string is cut down frequently	Used a rubber shoe inside the warve eye. 	The frequency of cut down the string is reduced as results down time is reduced.
	Cooling water supply failed and generator tripped	Ensured the sufficient cooling water supplied.	The Downtime is reduced
	After a certain period of time, flyer of spinning machine is changed due to the inside cracking.	Used a rubber shoe inside the flyer eye. 	The Downtime is reduced

	Actual spindle rpm is 3200. But due to old machine operating speed remain 2300-2700 rpm.	Tried to convince the management to install new machine	Due to the high cost of new machine, management is not interested to change. Therefore, down time for speed is unchanged.
	After certain period of time cotton listing tape become loses and it's slipped. As a result reduces the warve rpm.	An extra support is provided to avoid loosen the tape. As results slipping frequency is reduced.	Losses due to speed is reduced.
	Defect of finished product due to cut the string during spinning process.	After uses of rubber shoe inside the warve eye and flyer eye, the frequency of string cut down is reduced.	The defect of finished product is reduced. As a results productivity increased.
Education and Training	Lack of operation and maintenance skill of workers	Conduct 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	The down time is reduced and productivity is increased.

Table 6 OEE calculated before and after TPM (average three month data)

Sl. No.	Category	Before TPM Implementation	After TPM Implementation
01	Total Production /Output (MT)	787.11	1103.24
02	Average Production per day (MT)	11.086	15.322
03	Standard cycle time (Hour)	2.848	2.848
04	Running time/Shift (Loom Hour)	6.33	7.93
05	**Unplanned Downtime**		
	• Equipment Failure (Loom Hour)	35372	26975
	• Shortage of Weavers (Loom Hour)	63805	94096
	• Yarn Shortage (with Beam)	158205	213923
	• Set up & adjustment losses (Hour)	196385	194946
	• Load Shading (Hour)	6788	4825
	• Startup losses (Hour)	1797.97	1138.15
	• Cleaning, inspecting & tightening of insert (Hour)	1797.97	1138.15
06	Ideal cycle time (Hour)	2.848	2.848
08	Output/Shift (MT)	5.54	7.66
09	Defect/shift (MT)	0.20	0.22
10	Availability (A) %	40.47	55.53
11	Performance Efficiency (PE) %	76.65	93.33
12	Quality Rate (QR)= **(Output – Defects)/Output**	96.46	97.13
13	OEE (A × PE × QR) %	29.92	50.33

7. Conclusions

In this study TPM strategy is implemented to improve the OEE of a jute industry in Bangladesh. Root cause of major losses are identified those are causes the low OEE (fig. 3) and TPM strategy is implemented to reduce those losses. Results show that OEE has improved from 30% to 50% i.e improved the productivity as well as improved the quality of product. However the OEE (50.33%) 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.

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