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IMPLEMENTATION OF TOTAL PRODUCTIVE MAINTENANCE IN A JUTE BAG INDUSTRY: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, unhealthy working area and this lead to low productivity, increasing wastage, fire damage 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 evaluate the contributions TPM initiatives towards improving manufacturing performance in a Jute bag manufacturing industry in Bangladesh. Specific objectives of this study are identification and reduction of major losses by using TPM tools and evaluation of the effectiveness by analyzing Overall Equipment Efficiency (OEE). The correlations between various TPM implementation dimensions and manufacturing performance improvements have been evaluated and validated by employing overall equipment effectiveness (OEE) in the jute bag plant. In this study TPM tools such as 5S, Autonomous Maintenance, Kobetsu Kaizen, Planned Maintenance and Education and Training have been implemented in the selected company. The equipment failure losses are reduced 3.85% through continuous improvement concept. The defect rate is reduced by 1.84% by taking preventive action. Most importantly it is observed that the OEE is improved from 7.42% i.e improved the productivity as well as improved the quality of product.

1. INTRODUCTUION

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 depends more on the equipment effectiveness employed. Productivity, cost, inventory, quality and delivery all are depend on the efficient functioning of the company's facilities. 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 (williamson *et al*, 2000 ; venkatesh *et al.,* 2005 ; hartmann *et al.*, 2000; chan *et al.,* 2005 ; mayank *et al.,* 2015). 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 (chan *et al*., 2005). Huge amount of losses/wastage occur in the manufacturing shop floor, due to maintenance personal, operators, process, non-availability and tooling problems of components in time etc and also includes idle manpower, idle machines, rejected parts, break down machine, etc. (mayank *et al.,* 2015 ; a.gosavi *et al.,* 2006 ; o.ljungberg *et al.,* 1998) . Among them, the top most areas for hampering productivity improvement in jute industry are machine breakdown, idle machines. Poor machine maintenance etc. Shortage of skill manpower and lack of control of process wastage accounts loss in productivity. Some suggestion of strategies has been highlighted for implementing tpm in jute industry (b. Dal *et al.,* 2000; j. Levitt *et al.,* 1996). Up to now tpm has been accepted as the most promising technique for improving the level of product quality and reduce the all losses and thereby increasing the overall equipment effectiveness of the industry (s. Nakajima *et al.,* 1988). Ranteshwar singh et al implemented the tpm approach in a machine shop and found that oee has improved significantly and hence productivity and product quality is improved (singh *et al.,* 2013). Jagdeep singh et al proposed a mobile maintenance concept in their study to improve the oee (singh *et al.,* 2018). They observed that oee is significantly increased by implementing this concept. Osama taisir et al reviewed and implemented the tpm strategy in a steel company in jordan (taisir *et al.,* 2010). They concluded that by implementing the tpm strategy industry eliminated most of the waste happened like the time waste and downtime losses. As results oee is improved as well as productivity is increased. Nazrul

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idzham kasim et al. Implemented the tpm method in a manufacturing company (kasim *et al.,* 2015). Based on their case study it was observed that tpm is an effective tool to improve the oee. A fore et al implemented an innovative maintenance strategy to improve oee at a manufacturing company (fore *et al.,* 2010). They concluded that tpm is a sustainable and effective tool for improving oee. Eight pillars for the success of tpm implementation has summarized in a depth literature review (ahuja *et al,.* 2008). M. C. Eti et al. Implemented the concept in a manufacturing industry in nigeria (eti *et al.,* 2004) . Based on their study, necessary training of operator and worker can be a key factor to success of tpm. C.j. Bamber et al. Developed a generic model of factor affecting the successful implementation of tpm (bamber *et al.,* 1999). The most influencing factors such as the involvement of people, knowledge and beliefs, involvement of people, motivation of management and workforce etc. Are obstacles of successful implementation of tpm. Rajiv kumar sharma et al. Investigated of tpm implementation issues on semi automated cell (kumar *et al .,* 2006). Their findings indicate that tpm leads to increase the effectiveness of manufacturing systems. Also by adopting and implementing tpm organization can meet the challenges of competitive manufacturing in twenty-first century. Another researchers, study the effectiveness and implementation of the tpm strategy for an electronics manufacturing company. Their findings indicate that productivity increased by adopting and implementing tpm. (wang *et al.,* 2006).t. Bartz et.al developed a maintenance management model based on tpm for improvement of a production line of a metallurgical company (bartz *et al.,* 2014). They concluded that the tpm leads to improve industrial performance and competitiveness of the production line and allows the company to apply the model in their others production lines successfully. Analysis was carried out to identify oee losses such as downtime, speed loss and quality loss of cnc shop and calculated the oee percentage and necessary recommendations were given to enhance the efficiency of the cnc shop (nallusamy *et al.,* 2016 ; samad *et al.,* 2012). A survey report suggested that tpm practices significantly positively affect affective commitment and employee retention (wickramasinghe *et al.,* 2022). A positive relationship has been suggested between tpm and operation performance in footware industry in bangladesh (chowdhury *et al.,* 2020).

Based on the above discussion, it can be conclude that tpm implementation is improved the level of quality and reduce the all losses and thereby increasing the overall equipment effectiveness of the industry.
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 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. 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.

The company under this study is based on Khulna, Bangladesh and is currently manufacture the jute products such as jute cloth and bag using about 1800 machines. The standard production of this industry is 45.57 tons jute cloth bag for each day. The production is running two shifts and each shift is 8 hours. 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. These machines are supposed to function without interruptions. However the real situation is different as there are numerous breakdowns which affect process continuity and hence reduce the product quality due to drops and fluctuations in operating times. These breakdowns are also affecting the production targets. With the advent of lack of electricity in bangladesh, availability of the machines has been drastically affected. The shortage of raw material is also affecting the production target. To overcome these problems and improve the oee, in this study tpm practices such as 5s, autonomous maintenance, kobetsu kaizen, planned maintenance and education and training were suggested in the selected company. Some tpm tools were used to measure performance before and after tpm implementationresults and discussions.

2. MATERIALS AND METHODS

The methodology flowchart of this study is shown in Figure 1 In the competing market the selected company found difficulty and the exact reasons are unknown. This study started with data collection of as existing and analysis is carried out. The big losses are identified through Pareto chart. The results were collected after implantation of TPM techniques and compared with the existing data.

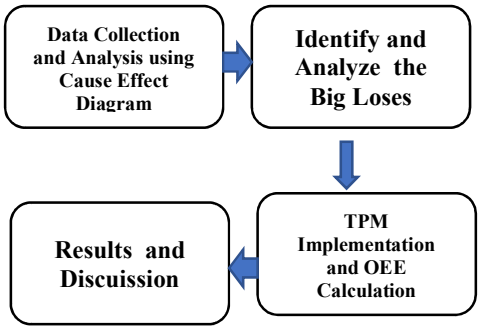


Figure 1: Flowchart of the Methodology.

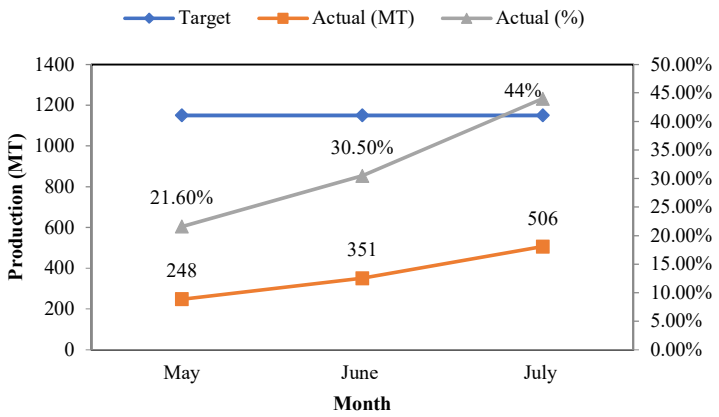


Figure 2: Actual productions of three consecutive months of year 2019

2.1 Data Collection

All the production activity in the company was closely monitored and three consecutive months of data such as actual production and individual machine losses is collected of the year of 2019. Data was collected on daily basis and summarized as monthly report. The monthly actual production achievement is shown in Figure 2. The present scenario of the company is average 32% target is fulfilled in the consecutive three months.

2.2 Identify the Major Losses

TPM methodology aimed is to reduce or eliminate big losses which causes of low productivity and quality in manufacturing. The big losses can be involved equipment breakdown losses, setup and adjustment time, losses due to speed: losses due to defect or quality, rework and quality defects, yield losses etc. In this study equipments which cause major losses during production are identified and were decided to consider those for TPM implementation strategy. A fish bone diagram is shown in Figure 3 which is representing the different causes of low OEE. From this figure it can be seen that equipment failure occurred due to overage machine and poor maintenance strategy. Additionally, absence of TPM techniques, unskilled workers, lack of technical person and poor management system are responsible for low OEE. The Pareto chart for various time losses during different operations are shown in Figure 4. From the Pareto chart, it can be seen that the equipment failure, setup delay and rework are the major losses. In this selected industry, nine major machines are involved with production and among them four machines having different causes for major losses due to downtime. The major reasons for their downtime are given in Table 3.These three machines of are selected as model machine for TPM activities.

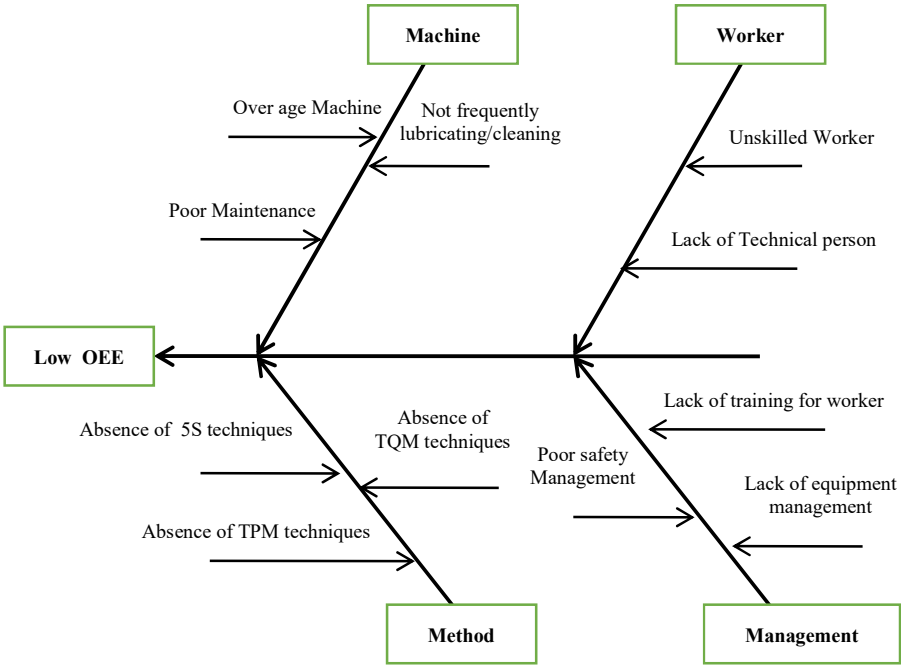


Figure 3: Cause and effect diagram for low OEE.

Table 1: Main reason for down time.

No	Machine	Reason for Downtime
01	Drawing	Due to irregular sliver Lack of proper pilling with jute batch oil (JBO), and Oiling Machine sliber being jammed and as a results share pin is broken and machine stopped occurred.
02	Spinner	Corrosion of drawing roller is produced irregular shape of string. Due to corrosion (stress cracking) inside the warve and flyer leg Eye of spinning machine, the string is cut down and machine stoped frequently. Due to loosen of cotton listing tape the speed (rpm) of warve/flyer is reduced. As a results string is cut down and also quality of string is not perfect. Due to loosen Linux belt the speed (rpm) of warve/flyer is reduced. As a result production becomes poor. The raw jute supply is not enough, that's why spinning machine cannot supply the yarn for the next processing step.
03	Sewing	Alignment of needle is not perfect due to old/over aged machine as results needle is broken frequently Due to the improper machine pulley size, sewing quality becomes poor. All sewing machines are connected by one motor as a result if the motor is fault then all sewing department is idle.

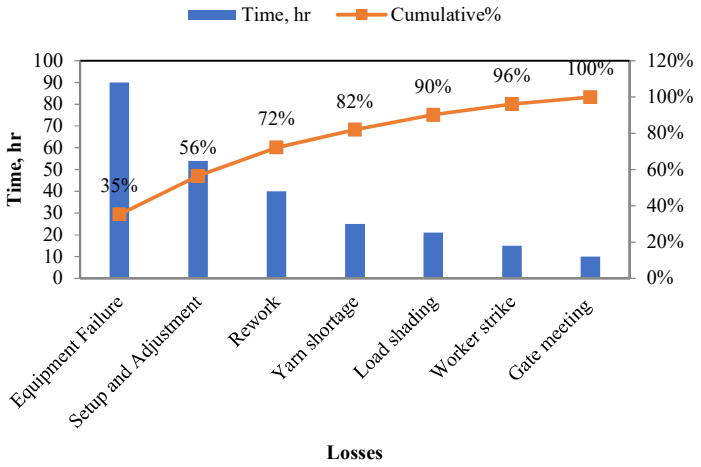


Figure 4: Pareto chart for various time losses.

2.3 Data Collection and Data Analysis before Implementation of TPM

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. The analysis is based on monthly report. 3 consecutive month data is given below. Table 2 and Table 3 shows the Data Chart of Batching to Finishing Production before Implementation of TPM

Table 2: Three Month Data before TPM.

SL No	Description	Average	Month-1	Month-2	Month-3	Total
1.	Working Day Target (hr)	1	25	20	27	72
2.	Working Hours Target (hr)	16	400	320	432	1152
3.	Planned Production Time (hr)	15.75	393.75	315	425.25	1134
4.	Actual Production Time (hr)	11.6	290.09	232.22	312.95	835.26
5.	Down Time (Equipment Failure) (hr)	1.92	47.55	37.59	53.43	138.57
	Setup and Adjustment Failure	1.21	30.10	25.10	32.43	87.63
	Other losses (load Shading, strike, gate meeting)	1	26.01	20.09	26.44	72.54
6.	Total Down Time (hr)	4.15	103.66	82.78	112.3	298.74
7.	Run Time (hr)	11.60	290.09	232.22	312.95	835.26
8.	Cycle Time (hr)	2.848	2.848	2.848	2.848	2.848
9.	Wastage (M.T)	1.58	38.6	31.84	43.52	113.96
10.	Budget Production (M.T)	45.57	1139.25	911.4	1230.39	3281.04
11.	Total Net Finish Goods (M.T)	24.54	609.1	485.33	672.84	1767.27
12.	Total production(M.T)	26.12	647.7	517.17	716.36	1881.23

Table 3: Losses Due to Defect: Process defect.

Month	Equipment	Reason	Loss (MT)	% Loss (MT)
1	Spinning and Winding Machine	Defect of finished product due to cut the string during spinning and Winding process. Also this side producing fire damage and caddice.	25.59	3.95
	Loom	Defect of finished product due to cut the string during weaving process. Also this side producing fire damage and caddice.	13.01	2
		Sub Total	**38.6**	5.95
2	Spinning and Winding Machine	Defect of finished product due to cut the string during spinning and Winding process. Also this side producing fire damage and caddice.	20.10	3.88

Month	Equipment	Reason	Loss (MT)	% Loss (MT)
	Loom	Defect of finished product due to cut the string during weaving process. Also this side producing fire damage and caddice.	11.74	2.27
		Sub Total	**31.84**	6.15
3	Spinning and Winding Machine	Defect of finished product due to cut the string during spinning and Winding process. Also this side producing fire damage and caddice.	26.34	3.67
	Loom	Defect of finished product due to cut the string during weaving process. Also this side producing fire damage and caddice.	17.18	2.39
		Sub Total	**43.52**	6.07
		Total	**113.96**	6.05

2.4 OEE Calculation before TPM

Table 4: Overall Equipment Efficiency (OEE) before TPM.

	Month 1	Month 2	Month 3	Total 3 Month	Average
Availability factor (%)	73.67	73.72	73.59	73.65	73.65
Performance factor (%)	73.72	73.38	75.49	74.29	74.28
Quality factor (%)	94.04	93.84	93.92	93.94	93.95
OEE (%)	51.07	50.76	52.17	51.39	51.39

Table 4 shows the OEE before TPM. From this table it can be seen that the average OEE from 3 month data is 51.39% which is very low compare the benchmark world class manufacturing OEE standard (85%). The company needs to work hard to improve their system through adopting some of the best practices.

2.5 TPM Practices

OEE is the key indicator of success therefore to improve the OEE; the company was motivated to implement TPM strategy to increase their productivity and product quality. Root cause identification and the approach of implementation of each pillar of TPM are discussed in following subsections.

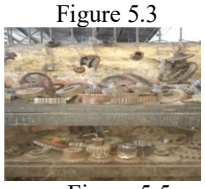
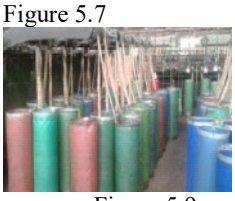
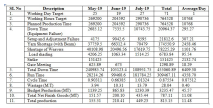
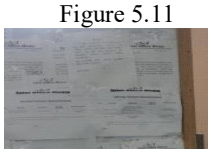
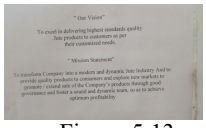
5S (SEIRI, SEITON, SEISO, SEIKETSU, SHITSUKE): 5S is called the base of TPM implementation. It is Japanese techniques to keeping the workplace clean and organized. In an unorganized work place, no one can identify the problem. Present condition of workplace was investigated by 5S audit team and data collected with check sheet.

TPM Strategy: Physically visited the workplace and found that work place was not so clean and unnecessary items are take place near the machine. Some critical items those are frequently used are not placed back after usage at the same place. Some workers are not punctual and dedicated. Also workers are not properly following the dress code.

Approaches: Clean the work place and unwanted items stored away from the operating machine. Critical 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. Management is taken necessary steps and motivates their workers. A noticed is hanging on notice board that everybody is mandatory to follow the dress code properly. The 5-S reports are summarized in Table 5.

Table 5: 5-S Report.

Term	Before		After	
1-S	Unnecessary parts and objects are place d in the floor	 Figure 5.1	Unnecessary parts are removed from the floor	 Figure 5.2

Term	Before		After	
2-S	Product pick up is not systematic	 Figure 5.3	Product is systematically arranged.	 Figure 5.4
3-S	Parts are not clean and not arranged properly	 Figure 5.5	Parts are cleaned and arranged properly.	 Figure 5.6
	Dirty machine part	 Figure 5.7	Cleaned and lubricating machine part	 Figure 5.8
4-S	Not proper container	 Figure 5.9	Proper container	 Figure 5.10
	No production cycle time displayed in the factory		Production standard cycle time is prepared.	 Figure 5.11
	Instruction sheet and information is not displayed on the notice board.		Working instructions, daily maintenance sheet, and control process plan are displayed on each section.	 Figure 5.12
5-S	Company's Mission and Vision statements are not displayed on the board.		Company's Mission and Vision statements are displayed in the board.	 Figure 5.13

Practices of Jitsu Hozen (Autonomous Maintenance):

The concept of this pillar is based on that operators take care of small maintenance so that skilled maintenance people to concentrate on more value added activity and technical repairs.

TPM Strategy: The success of autonomous maintenance is depending on the operator mentality. If the operator think as if he owes the machine, then he can take better care of machine.

Approaches:

i) The operators were initially trained in autonomous maintenance for implementation of TPM. Management were motivated the operators to change their mentality by training and counseling.

ii) At first all visible problem like unclean machine and work place, oil leakage, wire lose connection, loosen bolt and nut, etc. were find out and noted. Additionally noted that rotor pin of spinning machine was breakdown frequently which causes the machine stop and operator can easily fix the problem within

few minutes. However Operator waits until the maintenance department fixed the problem. TPM activities like lubricating, cleaning, nut bolt tighten and most importantly the rotor pin fixing works were handed over to operators to carryout individually.

iii) It were noted that they machines, different machine parts even the workplace are not cleaning and lubricating regularly, which causes lots of work is accumulated during preventive maintenance. 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 check list regularly.

Practices of Kobetsu Kaizen (Continuous Improvement)

The goal of this pillar is to reduce losses in the workplace that affect the efficiency. The big losses includes downtime losses, breakdown losses, setup and adjustment losses, speed losses, defect or quality losses. These losses are the common causes of efficiency loss in manufacturing.

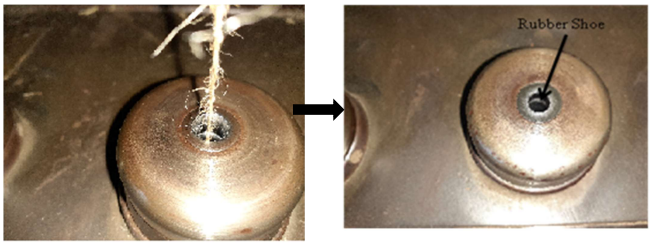
TPM Strategy:

i) It is noted that, frequently jutes are stuck in the roller of softener machine that causes machine stopped as a result big losses occur due to downtime.

Approaches: A slippery roller can solve the problem and it is suggested to use boric powder every one hour for the roller.

ii) Due to corrosion (stress cracking) inside the warve of spinning machine, the string is cut down and stops the machine frequently (figure 5). Spinning machine usually supply the yarn for next processing step. Due to stop the spinning machine the bottleneck is occurred and fails to supply the sufficient yarn for the next machine. In consequence all machines are idle and big losses occurred. Another reason for yarn shortage is lack of raw jute supply.

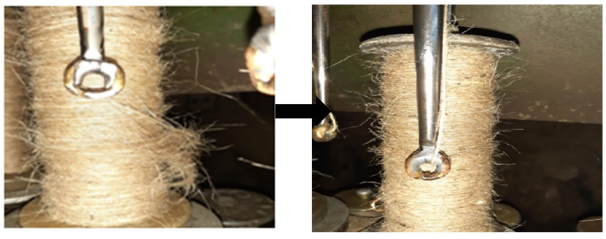
Approaches: Timely changed eye inside the warve and flyer eye. Additionally a rubber shoe is used inside the warve eye to reduce the friction. Hence the string cut down frequency is reduced as a result downtime significantly reduced. It is suggested to buy raw jute in jute produce season (August and October).



Before: Warv of spinning machine without rubber

After: Warv of spinning machine with rubber shoe

Figure 5: Wrave eye of spinning machine.



Before: Loosen bobbin carrier

After: Clean and tight bobbin carrier

Figure 6: Flyer eye of spinning machine.

iii) Actual rpm of the Spinning Frame is 3200. But the machine can operate only 2000-2300 rpm because of old/overage machine.

Approaches: It is suggested to install new machine. Due to the high cost of new machine, company is not interested to install new machine. Therefore, down time for speed was unchanged.

iv) The cotton listing tape become loses frequently as a result reduces the warve rpm that causes the downtime.

Approaches: An extra tension pulley support was provided to avoid loosen the tape. As results wrave rpm remain same and downtime reduced.

Due to loosen Linux belt the speed (rpm) of warve/flyer is reduced. As a result production becomes poor.

Approaches: properly routine wise chake all Linux belt and change properly. An extra tension pulley support was provided to avoid loosen the Linux belt. As results wrave rpm remain same and downtime reduced.

v) A needle breakdown is a common problem in sewing section. It causes due to the old/over aged sewing machines and the needles of the machines were not aligning properly.

Approaches: It was suggested to use leather needle which is used to sewing the leather materials. Additionally it was suggested to reinstall some new sewing machines.

vi) In Bangladesh, load shedding is a provocative question and electricity cannot meet the demand of the present electricity consumption. Therefore all industries are affected.

Approaches:Tried to convince the management to install big size generator to overcome load shading problem. Management was not interested to install.

Practices of Planned Maintenance

Zero equipment failure and ensure the availability of spares all the time is the main focus of this maintenance.

TPM Strategy:

It is important that the engineers of the maintenance department and all the operators how easily identify the areas are most likely to fail or breakdown. It can be ensure by the training program and it was suggested to schedule the training program every month. It can help to take corrective action before any major breakdown.

Practices of Quality Maintenance

Quality maintenance is to ensure the customer satisfaction through delivery of highest quality product.
TPM Strategy:
It was ensure the quality check by visual inspection. Training program was scheduled for 100% visual inspection to detect visual defects.

Practices of Education and Training

The goal of this pillar is to develop an educated and skill operator is able to identify and solve the problem properly.
Approaches: Due to lack of operation and maintenance skill of workers, now every month management is 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. Figure 7 is shown the sample of scheduled training program.

Figure 7: Training program is scheduled.

Practices office TPM

The purpose of Office TPM is to improve productivity and efficiency of the administrative functions.
TPM Strategy:

(i) Daily report of maintenance department was written in manually and hard copy is stored. Their chances to loss valuable data. New system is proposed for maintenance department to store all data in computer.

(ii) Database of all employee were not updated. New data base of all employee are prepared and convey to all so that everyone can reach any body whenever anybody without wasting time.

Practices of Safety, Health and Environment

Zero accident, zero health damage and zero fires are the main purpose of this pillar.

TPM Strategy:

(i) Sufficient number of fire extinguisher is provided all over the floor. Training is scheduled for every individual to know the use of fire extinguisher in case of accident.
(ii) In the finishing section, abnormal jute husk in the air causes the workers health hazards. A noticed is hanged that all workers are mandatory to wear mask in this work area.
(iii) Washroom cleaners are advised to maintain regular cleaning of toilets.
(iv) Some workers are smoking here and there. Specific smoking area is selected and noticed that smokers are mandatory to smoke within the specific smoking area that is company premises.
(v) Management confirms the health checkup for all employees once a year.
(vi) All workers must follow the dress code of the company.

3. RESULTS AND DISCUSSION

In this study, three consecutive months of data is collected of the year of 2019. Except holidays the 24 working days each month and total 72 days is running the factory. The standard production of this industry is 45.50 metric tons (MT) jute cloth bag for each day. The production is running two shifts and each shift is 8 hours. There was a stoppage of 30 min for each shift, which gives in total 72x 30= 2160 min = 36 hours.
Total operating time = 72x8x2= 1152 hours
Available operating time = 1152-36 = 1116 hours
Actual Operating time = 1116-498.932 = 617.068 hours.
Ideal cycle time = (72x45.5)/1116 = 2.93 MT/hr = 0.341hr/MT.
Three consecutive months of data is collected and calculated the OEE. Different types of individual losses are shown in Table 6, Table 7, Table 8, and Table 9.

Table 6 : Losses due to equipment failure.

Month	Equipment	Reason to failure	Before TPM Downtime (hrs)	After TPM Downtime (hrs)
Before TPM: Month 1,2, and 3-2019	Carding Machine (Breaker and Finisher)	Jute stuck on the roller and machine stop. Repining Cylinder Staves and sometimes staves change and Change pinion.	25	20
	Drawing Machine	Breaking down of wooden pin between the bar and the pin holder and over flow of sliver.	30	26
After TPM: Month 7,8, and 9-2019	Spinning Machine	i) Due to Inside the Warve, Flyer eye Corrosion (stress cracking) and the string is cut down and machine is stop. ii) Due to the machine stop, yearn and weaver is not produce. For the next processing step yarn is shortage and machine became idle.	75.57	61.36
	Swing Machine	Breakdown the needle and motor fault.	8	6
		Sub Total	**138.57**	**113.36**

Table 7: Setup and adjustment losses.

Month	Equipment	Reason	Before TPM Downtime (hrs)	After TPM Downtime (hrs)
Before TPM: Month 1,2, and 3-2019	Starting Set-up	Cleaning / Warm up	12.54	9.96
	Oiling and Cleaning	Major Adjustment	9.96	8.10
After TPM: Month 7,8, and 9-2019	Bobbin shifter	Tooling Adjustment	10.17	9.19
	Wooden pin change, sliver overflow, Drawing roller adjustment.	Tooling Adjustment	25.12	23.12

Month	Equipment	Reason	Before TPM Downtime (hrs)	After TPM Downtime (hrs)
	Flyer eye, Warve eye change of Spinning Machine	Planned Maintenance	29.84	27.1
		Sub Total	87.63	**77.47**

Table 8: Losses Due to Defect: Process defect/ rework loss.

Month	Equipment	Reason	Before TPM Loss (MT)	After TPM Loss (MT)
Before TPM: Month 1,2, and 3-2019	Spinning and Winding Machine	Defect of finished product due to cut the string during spinning and Winding process. Also this side producing fire damage and caddice.	80.03	60.10
	Loom		**33.93**	**26.93**
After TPM: Month 7,8, and 9-2019		**Sub Total**	**113.96**	**87.03**

Table 9: Other Losses.

Month	Factor	Reason	Before TPM Downtime (hrs)	After TPM Downtime (hrs)
Before TPM: Month 1,2, and 3 2019	Load Shading	In Bangladesh, load shedding is a provocative question and electricity cannot meet the demand of the present electricity consumption. .As results all machines are idle for some time due to load shading.	4	3.10
After TPM: Month 7,8, and 9 2019	Worker strike	Some time worker call the shut down because of their financial benefits, wages and other demands.	65.54	59.35
	Worker Gate meeting	Some workers are gathering to a meeting without any prior notice that affects the production.	3	1.12
	Sub Total		**72.54**	**63.57**

The OEE calculation before and after TPM implementation is show in Table 10. From the data analysis it is observed that the OEE for the three consecutive months (Month 1, 2, and 3 2019) was about 51.39 % which is very low compare the benchmark world class manufacturing OEE standard (85%). The company needs to work hard to improve their system through adopting some of the best practices. This assessment of maintenance performance indicates that the company under this study was facing so many problems. Therefore, TPM techniques are suggested and implemented in the selected machine and management to improve their productivity as well as the OEE. However it was not easier to convince management to apply the TPM technique as it requires all employee involvement and need strong support of top management. Finally the top management was agreed to support as much as possible to implement some of the TPM techniques. After implementation of TPM practices OEE is increased (58.81%) about 3.8 % during the three consecutive moths (Month 7,8, and 9 2019). However the OEE (58.81%) is still very low compare the benchmark world class manufacturing OEE standard. The down time also reduce by 14.84 % and defect losses reduced by 19.45 % by introduction of autonomous and preventive maintenance actions. No significant changed is not found in quality rate (QR). 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. Therefore, the company should practice the following suggestions.

i) Top management should gain more knowledge about TPM tools.
ii) Every worker should strictly adapt 5S concept.
iii) Implement regular training programs to all the labor and staff.
iv) TPM approaches should practices on regular basis.
v) TPM practices should not stop with OEE improvement.
vi) Try to minimize idling time like load shedding, shut down and gate meeting.

Table 10: Overall Equipment Efficiency (OEE) Calculation before and after TPM implementation (Average 3 month Data).

Sl. No.	Category	Before TPM Implementation	After TPM Implementation
01.	Total Working day (consecutive three months)	72	72
	Total operating time (hr)	1152	1152
02.	Available operating time (hr)	1134	1134
03	Actual operating time (hr)	835.26	879.6
04.	Target production (MT)	3281.04	3281.04
05.	Target production per day (MT)	45.57	45.57
06.	Actual Production /Output (MT)	2492.07	2597.04
07.	Actual Production per day (MT)	33.02	34..8
08.	Standard cycle time (hr/MT))	2.848	2.848
09.	**Unplanned Downtime (hr)**		
	) Equipment Failure (%)	12.02	9.84
	i) Set up and adjustment losses (%)	7.60	6.72
	ii) Other losses (load Shading, strike, gate meeting) (%)	6.29	5.51
	Sub Total (hr)	**298.74**	**254.4**
	Sub Total (%)	25.93	22.08
10	Defect/Rework (MT)	113.96	91.79
11.	Availability (A) %	73.65	77.58
12.	Performance Efficiency (PE) %	74.28	79.15
13.	Quality Rate (QR)= **(Output – Defects)/Output**	93.95	95.79
14.	OEE (A × PE × QR) %	**51.39**	**58.81**

4. CONCLUSIONS

In this study TPM strategy is implemented to improve the OEE of a jute industry in Bangladesh and followings are the key findings.

i. The equipment failure losses are reduced 14.84 % through continuous improvement concept.
ii. The defect rate is reduced by 19.45 % by taking preventive action.
iii. Most importantly it is observed that the OEE is improved from 3.8 % i.e improved the productivity as well as improved the quality of product.

Unfortunately the company under this study is facing lots of problems The OEE (58.81%) is still very low comparing 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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