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Implementation of Total Productive Maintenance(TPM) to Enhance Overall Equipment Efficiency in Jute Industry – a Case Study

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Abstract:- The performance of equipment of industry depends on proper maintenance. Total Productive Maintenance (TPM) is a process which involves to maximize the performance of equipment thorough its full lifetime. It creates a dynamic environment where improvement efforts in safety, quality, cost, delivery and creativity are heartened with the participation of all employees. The purpose of the study is to improve the Overall Equipment Effectiveness (OEE) in jute mill by implementing Total Productive Maintenance (TPM) and also focuses on results oriented implementation methodology designed to minimize the big major equipment losses. For this research work, a case study has been taken in the Platinum Jubilee Jute Mill which is situated in Khulna, Bangladesh to evaluate the contribution of TPM initiatives to improve the manufacturing performance of equipment's. After proper implementation of TPM in selected factory the Overall Equipment Effectiveness (OEE) improved 23.42%.

Keywords:- *TPM; OEE; Big Losses, case study.*

I. INTRODUCTION

Total productive maintenance (TPM) is a pioneering Japanese concept, the term total productive maintenance which was accredited to Nippondenso, a company that created parts for Toyota. Seiichi Nakajima is considered as the father of TPM because of his plentiful contributions of TPM [1]. Nakajima (1989), a major provider of TPM and also defined TPM as a tool to maintenance the equipment efficiency, reduce breakdowns, and increase worker activities (Bhadury, 2000) [2]. The concepts of Total Productive Maintenance (TPM) have been accepted in many organizations across the world. Total Productive Maintenance (TPM) is a scientific company- wide approach in which every employee at levels in the organization is concerned about the maintenance, the quality and efficiency of their equipment [3]. Overall equipment efficiency (OEE) is used as the measure of success of TPM implementation. The main aim of TPM implementation is to reduce six big losses that are equipment failures or breakdown losses, setup and adjustment losses, idling and minor stoppage losses, reduce speed losses, defect in process losses and reduce yield losses [4] in all possible area of the industries including top level management to floor workers. This paper intends to discuss the activities of implementing eight important pillars of TPM concepts (5s, Autonomous Maintenance, Kobetsu Kaizen, Planned Maintenance, Quality Maintenance, Training, Office TPM, SHE) at Platinum Jubilee Jute Mill which situated at Khulna, Bangladesh. This paper focuses on improving the overall equipment efficiency (OEE) by implementing TPM to enhance in better utilization of equipment, high quality products and also increased employee confidence.

II. LETERATURE REVIEW

Some researchers showed that work approach, total productive maintenance (TPM) and overall equipment effectiveness (OEE) play a positive and momentous impact on production stability [5]. Others found that TPM plays an important role for keeping the assets in good condition to further enhance the production performance [6]. Many other have done an study on Libyan cement industry and found that the current production challenges are being faced due to lack of training (operational and maintenance), lack of encouragements for enlargements, and the lack of personal development system.[7]. S. Raut & N Raut (2017) implemented TPM in a medium scale industry and stated that it is the best strategy for industries to remain economical and effective when it comes to overall success of the company [8]. The statistical analysis OEE scores were found that intend to reduce breakdown losses and speed losses, which knowingly affected to OEE scores.[9]. Researcher studied autonomous maintenance in automotive manufacturer industry and found that equipment availability may increase 10% which also increased 8% OEE by reducing breakdown rate and MTTR (Mean time to Repair) in similar line.[10] . The losses associates with equipment are possible to identify by implementing TPM. With repeated support at all the levels along with the supply of obligatory assets in TPM are the key factors for being world Class Company.[11] The OEE scores helps to find out when equipment is able to work or not to produce a good quality product by reducing various type of losses during the production process [12].

III. METHODOLOGY

In This research eight pillars of total productive maintenance (TPM) are implemented on selected jute mill, in order to reduce equipment related losses and find out the Overall Equipment Efficiency (OEE). At first In this study

methodology adopted to undertake a bibliographical review of the analysis and optimization tools used in the maintenance sector, which is supported by theoretical concepts drawn from scientific articles and published books.

IV. EIGHT PILLARS OF TPM

The standard activities of TPM are structured as 'pillars'. Depending on the author, the mentioning and number of the pillars may fluctuate somewhat; however, the normally recognized model is based on Nakajima's eight pillars (Nakajima 1984; Nakajima 1988) [1].

A. Pillar - 1: 5s

TPM starts with 5S. 5S is a tool for shaping and improving a workplace particularly a shared workplace and keeping it in organized environments [11]. Following are the term of 5S:

Terms	Features
Sort (seiri)	Sorting has been focusing on disregarding and removing all redundant items from the jute mill that are not needed.
Set in order (seiton)	Organize necessary items in good order so that they can be easily chosen up for use.
Shine and clean (seiso)	Clean the workplace absolutely to make it free from dust and dirty.
Standardize (seiketsu)	Preserve high standard of work place.
Sustain (shitsuke)	Train and stimulate people to follow good housekeeping self-restraints autonomously.

B. Pillar-2: Autonomous Aintenance

Autonomous maintenance emphasizes in rising operators skill that helps to maintain and operate the equipment without any break down. The operators are liable for upkeep of their equipment to prevent it from failing on daily basis. The activities are involved with the simple nature like cleaning, lubricating, visual inspection, tightening of loosened bolts etc.

C. Pillar.3: Continuous Improvement (Kobetsu Kaizen)

The word Kaizen comes from japanes "Kai" means change and "Zen" means good (for the better).including all of people in the organization kaizen improves a small amount without or little investment. The principle behind is that "a few improvements of large value is not more effective in an organizational environment than a very large number of small improvements".

D. Pillar 4: Planned Maintenance

Planned maintenance is the fourth pillar of TPM and aims to produce defect free product for customers and safety environment for workers with breakdowns and trouble free machines & equipment. There are four categories planned maintenance which are defined earlier:

- .*Preventive Maintenance* – Preventive maintenance is a planned maintenance of plants and equipment in order to prevent or minimize the breakdown.
- *Breakdown Maintenance* - It is an alternative based policy in which is renovation the plant or equipment when it fails during operation..
- *Corrective Maintenance* - This is an organized maintenance that restore a failed unit.
- *Maintenance Prevention* - It provides facilities to keep running equipment without trouble.

E. Pillar-5: Quality Maintenance

The aim of Quality maintenance is towards customer pleasure through highest quality and a defect free manufacturing. Quality Maintenance is mainly focuses on preventive action 'before it happens' (cause oriented approach) rather than reactive measures 'after it happens' (results oriented approach).

F. Pillar-6: Training

The goal of training is to focus on improvement of knowledge, skills, and techniques of employees. Operators need to regular education for upgrade their skill, knowledge and techniques. It helps a worker to maintenance equipment by own way.

G. Pillar -7: Office Tpm

Office TPM is the seventh pillar and concentrates on other four pillars of TPM (Autonomous Maintenance, Kaizen, Quality Maintenance and Planned Maintenance) that provide administrative and support functions in the organization. Office TPM must be followed to improve productivity, efficiency in the administrative functions and identify & eliminate losses by analyzing process and procedures towards increased office automation.

H. Pillar-8: Safety, Health And Environment

This pillar focus to ensure safe working environment by eliminating incidents of injuries and accidents and provide standard operating procedures (Ahuja et. al., 2008) [13]

2.3 Overall Equipment Efficiency (Oee)

Overall Equipment Efficiency (OEE) is the part of TPM that detects the proportion of scheduled production time that is really dynamic. It was established to support TPM enterprises by accurately pursuing evolution towards succeeding "perfect production". An OEE score of 100% denotes perfect production, as fast as possible, with no down time.

V. COMPONENTS OF OEE

The main objectives of TPM implementations is to reduce occurrence of unforeseen machine breakdowns that interrupt production and lead to losses (Gosavi,2006)[14]. OEE is a essential and measureable metric for measuring the success of TPM implementation platform. The overall objective of TPM is to advance the overall equipment efficiency (Ljungberg, 1998; Dal et al., 2000):[15] [16]. The calculation of OEE is achieved by finding the product of availability of the equipment, performance efficiency of the process and rate of quality of products which may be expressed as:

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OEE = Availability (A) × Performance (P) × Rate of Quality (Q)

Where,

A. Availability

Availability is the proportion of time available for which a machine runs for production purposes. When a process is stopped, it's creating a cost with no associated value (8). Availability is the ratio of Operating time and Loading time.

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

B. Performance

Performance is the results of activities on an organization over given period of time. A Performance score of 100% means when the process is running as fast as possible.

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

C. Quality

Quality (Q) is percentage of good parts out of total produced parts. A quality score of 100% means there is no defect.

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

The OEE measure is crucial to the making and execution of a TPM improvement strategy [15]. The standards value of availability, performance efficiency and rate of quality for TPM implementation are 90%, 95%, and 99% respectively. And 85% overall OEE is considered as benchmark for world-class performance [17].

This study work was performed by flowing flow chart:

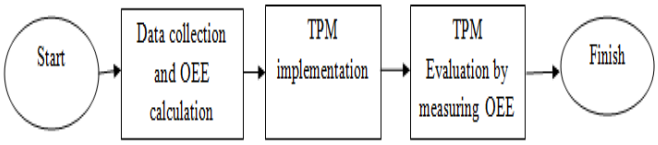

Fig 1:- Work flow chart

VI. RESULTS AND DISCUSSION

The **se**lected jute mill produces two types of jute products as hessian and sacking jute cloth and bag using about 1800 loom machine. Before implementation of TPM observed three months on production process and collected OEE data from April 2017 to September 2017. During this study, three big losses are found in selected factory as: Equipment failure, setup and adjustment losses and reject losses were recognized production losses. The monthly status among (winding section, weaving section, finishing section) is being showed by table-1:

3 Big loss	Before TPM Implementation			After TPM Implementation		
	April	May	June	July	August	Septem ber
Equipment Failure (hr)	81.99	83	80.66	75.82	70.99	61.16
Setup or Adjustment Failure (hr)	72	73.66	74.33	72.15	71.33	62.66
Rejection loss (Ton)	1.802	1.839	1.987	1.332	1.125	.89

Table-1: Big losses of selected jute mill

The reason behind this big losses are analyzing by using fish-bone diagram as shown in fig.2 and evaluation of implementation of focused maintenance pillar of TPM.[8]

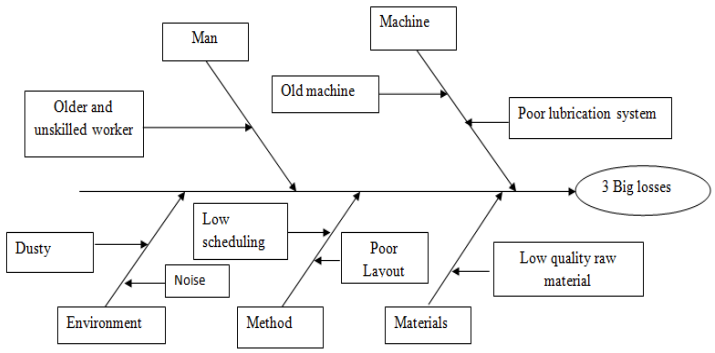

Fig 2:- Fish-bone diagram for 3- big losses

Before implementation of TPM the Availability rate, Performance rate, Quality rate and overall equipment efficiency (OEE) are calculated and presented in table-2:

Term	April	May	June
Availability (%)	72.75	69.71	69.15
Performance (%)	77.86	75.44	74.97
Quality rate (%)	92.68	89	88.31
OEE (%)	51.93	46.80	45.78

Table 2:- OEE before TPM implementation

After successfully implementation of all pillar of TPM the Availability rate, Performance rate, Quality rate and overall equipment efficiency (OEE) are calculated and shows that all of parameter of OEE is increasing from previous months which present as table-3

Term	July	August	September
Availability	77.44%	79.41%	82.86%
Performance rate	78.82%	88.57%	92.88%
Quality rate	94.19%	95.40%	97.91%
OEE	57.49%	67.10%	75.35%

Table-3: OEE after implementation of TPM

After successfully implementing all of TPM pillars following result are found:

Term	Before		After	
1.S Report	Unnecessary parts are placed in floor		Removed unused part from workplace	
2.S Report	Products pickup randomly		Products pickup in a systematic way	
3.S Report	Workplaces are not net & clean		Net & clean workplace	
4.S Report	No proper container used		Used standard container	
5.S Report		Discussion between worker and management did not hold About 5S.	Group work to sustain 5S	
6 pillar of TPM	No training program was held		Training program hold periodically	

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8.Pillar of TPM	Workers didn't use mask		Used mask	

Fig 3:- TPM pillar implementation report

The availability, performance and quality rate are increasing gradually as shown in figure - 4. Before implementation TPM in April 2017, the Availability, Performance and Quality rate of OEE were 72.75%, 77.86% and 92.68% respectively and

after implementation of TPM at September-2017, those rates were increased as 82.86%, 92.88% and 97.91% respectively.

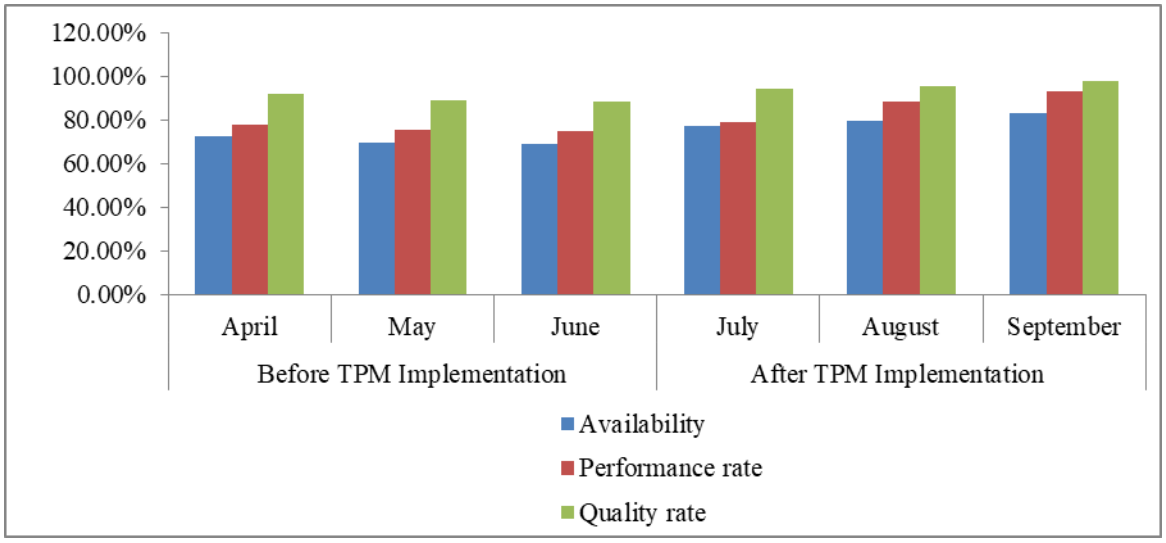

Fig 4:- Comparisons of Availability, Performance and Quality rate

OEE before TPM implementation at April-2017 was 51.93% shown in figure -4 which was very low than world class manufacturing (World class OEE is 85% to 90%) [18] and after implementation of TPM at September it was 75.35% which increased 23.42% . It indicates that the selected jute mill need to more emphasis to reduce losses in order to achieve as world Class Company. Monthly OEE are shown in figure -5.

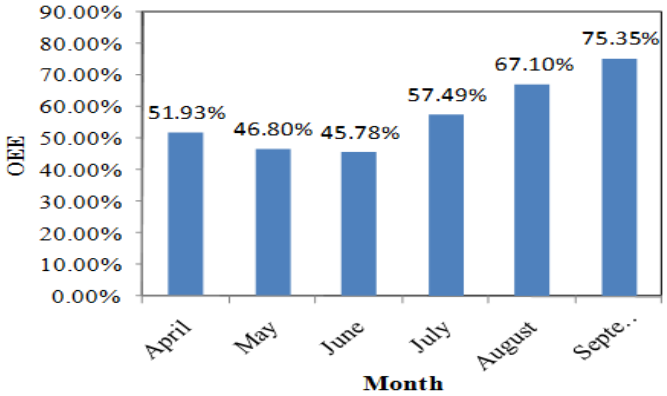

Fig 5:- Monthly status of OEE

VII. CONCLUSION

From this study it can be seen that successful implementation of TPM plays a very important role in fastener or any manufacturing industries to find out and eliminate various types of losses. It also helps the management to improve the overall performance of the firm including all levels of people. Overall Equipment Effectiveness (OEE) indicates the improvement of TPM implementation. For this study OEE has increased from 51.93% to 75.35% indicating the improvement of availability rate, Performance rate and quality rate and reduce the unnecessary usages of properties. From this study it can be conclude that by proper implementation of TPM concepts can help a manufacturing industry to achieve world Class Company with very less investment. TPM program is also helps to growth productivity while at the similar time aggregate employee self-esteem and job agreement.

REFERENCE

[1]. S.Nakajima, "Introduction to Total Productive Maintenance",Productivity Press, Portland, OR, 1988
[2]. B. Bhadury, Management of productivity through TPM. Productivity, 2000, 41(2), 240-51.
[3]. M. A. A. Hasin, "Quality Control and Management', 1st edition, Bangladesh Business Solutions, Dhaka, Bangladesh, 2007,
[4]. I.P.S. Ahuja, J.S. Khamba. "Total productive maintenance: Literature review and directions" International Journal of Quality and Reliability Management, (2008), **25**, 709-756 .
[5]. P.Haming, M. Nurnajamuddin, H. Hafied, & S. Serang " Effect of work attitude and total productive maintenance on the overall equipment effectiveness and production continuity". IRA-International Journal of Management & Social Sciences (ISSN 2455-2267), 2017, 7(3), 423-437.
[6]. M.Y, Badli Shah " Total productive maintenance: a study of malaysian automotive SMEs". World Congress on Engineering 2012 Vol III WCE 2012, July 4- 6, London, U.K.
[7]. M.. Graisa, & A. Al-Habaibeh, "An investigation into current production challenges facing the Libyan cement industry and the need for innovative total productive maintenance (TPM) strategy". Journal of Manufacturing Technology Management, 2011, 22(4), 541-558.
[8]. S. Raut & N Raut. "Implementation of tpm to enhance oee in a medium scale industry". International Research Journal of Engineering and Technology (IRJET), May - 2017 e-ISSN: 2395 -0056 Volume: 04 I.ssue: 05 |
[9]. N. E. Candra, A. Susilawati, Herisiswanto, W. Setiady "Implementation of total productive maintenance (tpm) to improve sheeter machine performance". MATEC Web of Conferences **135**, 00028 (2017) ICME'17 .
[10]. P. guariente,I. Antonilli, Pinto Ferreira, T.Pereira, F.J.G.Silva, "Implementing autonomous maintenance in an automotive components manufacturer", science direct Procedia manufacturing-13(2017) 1128-1134.
[11]. R. Singh, A.M.Gohil, D.B.Shah, S.Desai, "Total productive maintenance (tpm) implementation in a machine shop: a case study", science direct Procedia manufacturing-51(2013) 592-599.
[12]. I. Madanhire, C. Mbohwa. "Implementing successful total productive maintenance (tpm) in a manufacturing plant": proc. World Congress on Engineering 2015.
[13]. .P.S. Ahuja and J.S. Khamba, "Total productive maintenance: literature review and directions", International Journal of Quality & Reliability Management, Vol. 25 No. 7, 2008, pp. 709-756.
[14]. A.Gosavi, "A risk-sensitive approach to total productive maintenance". Automatic, (2006). 42(8), 1321-1330.
[15]. O.Ljungberg, "Measurement of overall equipment effectiveness as a basis for TPM activities:. International Journal of Operations & Production Management, (1998). 18(5), 495-507.
[16]. B. Dal, P.Tugwell & R. Greatbanks, "Overall equipment effectiveness as a measure for operational improvement: A practical analysis". International Journal of Operations & Production Management, (2000) 20(12), 1488-502. (London, UK, 1-3 July 2015) (2015) .
[17]. J. Levitt, Managing factory maintenance. Industrial Press Inc., New York, NY. (1996).
[18]. [18] M. W.Wakjira, A. P. singh. "Total productive maintenance: a case study in manufacturing industry". Global Journal of researches in engineering Industrial engineering Volume 12 Issue 1 Version 1.0 February 2012.