International Conference on Mechanical, Industrial and Materials Engineering 2017 (ICMIME2017)
28-30 December, 2017, RUET, Rajshahi, Bangladesh.

Paper ID: IE-268

Improving OEE of a Garment Factory by Implementing TPM Approach

Sajib Saha*, Sadi Mohammad Akash and Tarun Kumer Biswas

Department of Industrial & Production Engineering, Jessore University of Science & Technology, Jessore-7408, Bangladesh
**E-mail: sajibsaha@yahoo.com*

Abstract

To sustain in the competitive global market, maximization of resources utilization have become the staple goal to the manufacturers. This paper proposes TPM approach to increase the overall equipment effectiveness for garment industry. This work extracts the OEE level 76.51% for one of the leading garment factory of Bangladesh which also delineates the overall scenario of RMG sector in Bangladesh. The obtained result is far behind from the global standard but it is still possible to increase the OEE level by applying TPM approach. Therefore, how Total Productive Maintenance system can be actualized in the production floor to enhance overall equipment effectiveness level have been suggested. This paper finishes up that TPM technique may be skilled to decrease equipment breakdown that result in more overall equipment effectiveness (OEE) level. Anyway its great usage will be very much difficult without impassioned backs about top managements alongside every last one of offices.

Keywords: Total productive maintenance, Implementation, Overall equipment efficiency, Garments industry.

1. Introduction

In Bangladesh, the Ready Made Garment (RMG) industry is taken into consideration as “The Engine of Growth” for the economic development of the country [1]. Today, the RMG industry of Bangladesh accounts for more than 70% of its total exports income and affords employment to approximately 40% of the overall manufacturing workforce [2]. One of the predominant successes of RMG sector in Bangladesh is that they produce garments at lower labor cost. It is anticipated that Bangladesh is going to stand at stiff position along with the large number of apparel producing countries remarkably China, India and Pakistan [1]. To survive in global competitive market most manufacturing companies focus their manufacturing strategies on minimizing their production costs, increasing productivity, improving product quality, resources utilization, and increasing customer satisfaction. In manufacturing industry high productivity through appropriate distribution of these resources and adequate operational procedures becomes a priority. Proper maintenance of equipment plays an important role in this regard. If equipment breaks down during production, many other processes can be affected. Production equipment not being able to produce products with normal equipment performance is due to six major losses. Overall equipment efficiency (OEE) is used as an indicator of how well equipment is used in batch/lot production. Maintenance becomes more challenging in the current dynamic business environment and facing lower OEE level [3]. In order to solve this problems, the Japanese developed and introduced the idea of Total Productive Maintenance (TPM), initially in 1971. Nakajima (1988) defined TPM as a maintenance system, which covers the entire life of equipment in every department including planning, manufacturing, and maintenance [4, 5, 6].

Total productive maintenance (TPM) methodology is a proven approach to increase overall equipment efficiency (OEE) of equipment. The successful application of TPM affirms that the higher productivity and good quality along with increased employee morale and job satisfaction [7]. The basic objective of TPM approach is to ensure efficient functioning and optimum utilization of resources. This approach emphasizes the role of teamwork, small group activities by which the entire organization works together to maintain and improve the system [9]. As an initial initiative it is critical to measure even a small change. Overall Equipment Efficiency (OEE) is a metric originally developed to measure the success of TPM by associating the six big losses with three measurable: Availability, Performance, and Quality [10]. OEE allows organization to benchmark and monitor their progress with simple, easy to understand metrics. OEE offers both a gauge for the success of TPM and a frame work to identify areas that can be improved [11].In short, the goal of TPM is to create a sense of joint responsibility among supervisors, operators and maintenance workers, not only to keep machines running smoothly, but also to optimize their average performance [12,13]. This study shows the impact of TPM in garments industry for improving considering our culture and business environment.

2. Theoretical frameworks

2.1 Overall Equipment Effectiveness (OEE)

Overall equipment effectiveness (OEE) is a term to determine the percentage of truly productive manufacturing time. According to Nakajima (1988), OEE measurement is an effective way of analyzing the efficiency of a single machine or an integrated manufacturing system. Thus it shows that there is a significant room to increase the productivity [4]. OEE is considered as a key measure of TPM and it is a function of availability, performance rate, and quality rate [14]. Factors affecting OEE are not equally important in all instances. A wider classification of losses is required for better understanding of machine utilization.

2.1.1 The factors that is related to OEE

The OEE measure can be applied at different levels within a manufacturing environment. OEE does not diagnose a specific reason why a machine is not running as efficiently as possible but it helps to categorize the regions for initiating the equipment's improvement. Nakajima (1988) [15] defined six basic categories of losses those are responsible for reducing the effectiveness of the equipment; In Table 1, The first two losses are defined as time losses, affect the Availability of equipment. The third and fourth losses are speed losses those affect the Performance efficiency of an equipment. The last two losses are known as quality losses; these losses are responsible for causing downtime and production losses in a plant. Based on these six losses, the Availability, Performance, Quality rate and OEE [16] can be calculated.

Table 1. Classification of six major losses

Factors	Related Losses
1. Availability	Breakdown
	Set up and adjustment
2. Performance efficiency	Idling and minor stoppage
	Speed loss
3. Quality rate	Quality defects and rework
	Start up

2.1.2 Necessary formulas for OEE calculation

Calculation of OEE given bellow;

$$\text{OEE} = \text{Availability (A)* Performance (P)* Quality (Q)} \tag{1}$$

$$\textbf{Availability (A)} = \frac{\text{Actual run time}}{\text{Planned production time}} = \frac{\text{Planned production time} - \text{Down time}}{\text{Planned production time}} \tag{2}$$

Where Planned production time = Shift time – Breaks time (3)

$$\textbf{Performance (P)} = \frac{\text{Design cycle time} * \text{Total count}}{\text{Actual run time}} \tag{4}$$

$$\textbf{Quality (Q)} = \frac{\text{Total count - Reject count}}{\text{Total count}} \tag{5}$$

2.2 Total Productive Maintenance (TPM)

TPM is a company-wide approach in which people of the organization become concerned about quality, efficiency and maintenance. Seiichi Nakajima [14] has defined TPM as an "innovative approach to maintenance that optimizes equipment effectiveness, eliminates breakdowns, and promotes autonomous maintenance by operators through day-to-day activities involving the total workforce". TPM is a competitive approach focuses on improving the characteristics and design of the production equipment [17]. It addresses the causes responsible for accelerated deterioration when it creates the correct environment between operators and equipment to create ownership.

The origin of TPM can be traced back to 1951 when preventive maintenance concept was first used in Japan. However, the concept of preventive maintenance was come from USA. Plant wide preventive maintenance was first introduced by a company named Nippondenso in 1960.

2.2.1 Pillars of TPM

Some methodologies are implemented one by one to implement TPM perfectly which are called pillars of TPM. There are 8 pillars on those TPM stands, which are shown in the figure 1, (Singh et al., 2013; Bartz et al., 2014).

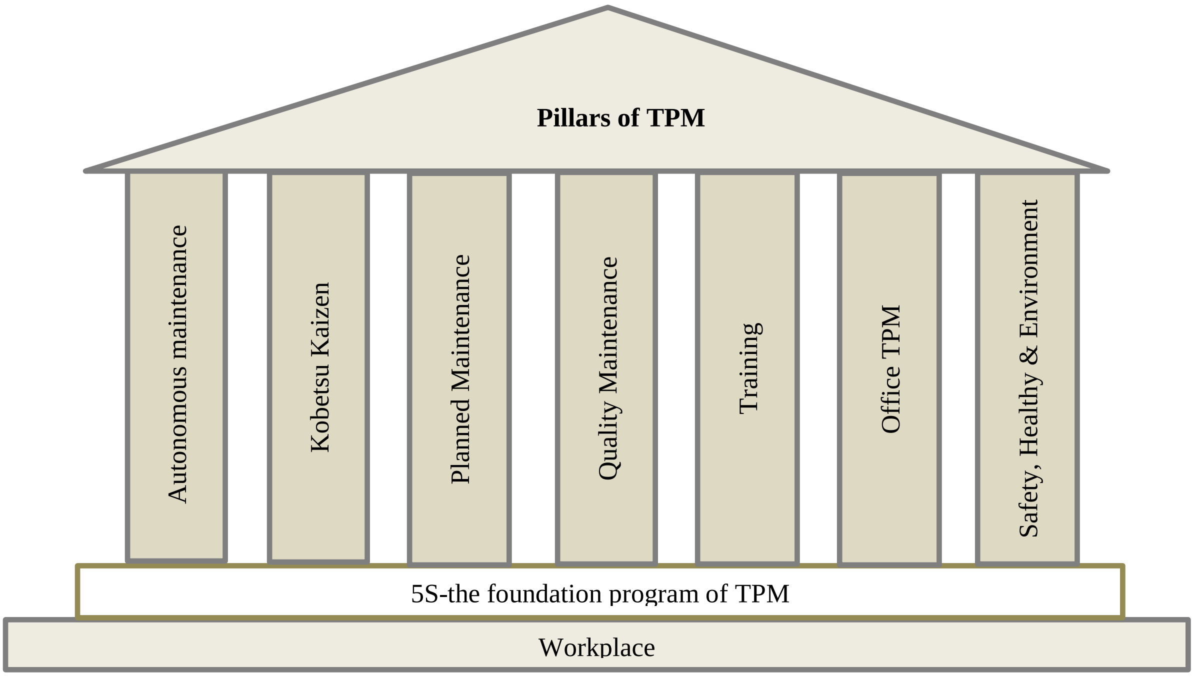

Fig. 1. Pillars of TPM

2.2.2 Goals of TPM

TPM mainly focuses on improving corporate culture through continuous improvement of human resources and plant equipment [18]. Ravikant et al. (2011) [19,20] specified the goals of TPM as:

(1) Obtain a minimum 90 per cent OEE (Overall Equipment Effectiveness) and 90% OPE (Overall Plant/Performance Effectiveness)

(2) Run the machines even during lunch (Lunch is for operators not for machines)

(3) Operate in a manner, so that there are no customer complaints

(4) Reduce the manufacturing cost by 30 percent

(5) Achieve 100 percent success in delivering the goods as required by the customer

(6) Maintain an accident-free environment and

(7) increase the suggestions from the workers/employees by three times.

3. Case study

A case study on OEE of garment production line is conducted in a leading garments factory named "The Rose Dresses Ltd." in Dhaka. The factory produces both knit and woven products and having almost 228 male and 3983 female workers. To analysis the OEE condition, we have taken a single knit production line and sought the reason of having lower effectiveness of machines used in production of a specific product through this study. Various types of losses that are often occurred in a production floor and associated with OEE are critically studied and founded out. The OEE of that production line has been used to investigate the existing condition of the selected factory and then recommendation has been given to improve present condition. The details of the study are given in the following sections.

3.1 Data collection and analysis

The factors on which OEE depends are availability, performance and quality. To determine these factors, down time, operation cycle time and total number of production including rejected products are needed to be known. The design of a basic t-shirt production on which our study has been carried out was continued for three days in the selected floor. Average down time, average total count and average rejects have been taken from the production of three days. And operation cycle time has been taken by taking each operation's taken time thrice and then making their average. Table 2 presents the collected data from a selected production line.

Table 2: Average data of three consecutive days

Machine name	Down time (min)	Run time (min)	Cycle time (min)	Rejects per day
1. Band Knife	20	440	0.05	35
2. Over Lock (Shoulder Join)	47	413	0.24	12
3. Lock Stitch (Neck rib tuck)	38	422	0.26	5
4. Over Lock (Neck join)	48	412	0.29	9
5. Flat Lock (Front neck top)	46	414	0.28	5
6. Lock Stitch (Back neck top)	35	425	0.45	10
7. Flat Lock (Sleeve hem)	43	417	0.50	13
8. Over Lock (Sleeve join)	32	428	0.48	6
9. Flat Lock (Side seam)	52	408	0.68	10
10. Lock Stitch (Sleeve tuck)	43	417	0.23	12
11. Flat Lock (Body hem)	46	414	0.28	10
12.Thread Suction	25	435	0.13	0
13. Iron Machine	25	435	0.55	3
14. Metal Detector	23	437	0.08	0

3.2. OEE calculations

Using equation through (1) to (5) the OEE of the selected production line is calculated. Here, shift time = 9 hour =540 min, Scheduled break time =60 min, Planned production time =480 min, Nonscheduled break time =20. Here the down time includes equipment failure, idling and minor stoppage, speed loss, defects (scarp and rework), start-up etc. The following table 3 represents OEE condition of the selected production line of the selected floor.

Table 3. OEE calculation of a line of the selected production floor

Machine Name	Total production	Rejected Production	Availability %	Perform. %	Quality %	OEE %
1.Band Knife	8350	35	91.66	94.88	99.58	86.60
2.Over Lock (Shoulder join)	1430	12	86.04	83.09	99.16	71.05
3.Lock Stitch (Neck rib tuck)	1390	5	87.91	85.63	99.64	75.00
4. Over lock (Neck join)	1212	9	85.33	85.31	99.25	72.24
5. Flat lock (front neck top)	1237	5	86.25	83.64	99.59	71.84
6.Lock Stitch (Back neck top)	810	10	88.54	85.76	98.76	74.99
7. Flat Lock (Sleeve hem)	736	13	86.87	87.76	98.27	74.91
8. Over Lock (Sleeve Join)	760	6	89.16	85.23	99.21	75.39
9. Flat Lock (Side seam)	495	10	85	82.5	97.97	68.70
10 Lock Stitch (Sleeve tuck)	1567	12	86.87	86.42	99.23	74.49
11. Flat Lock (Body hem)	1230	10	86.25	83.18	99.18	71.15
12.Thread Suction	3130	0	90.62	95.91	100	86.91
13.Iron Machine	740	3	90.62	92.28	99.61	83.29
14. Metal Detector	4780	0	91.04	92.97	100	84.63
Production line OEE %	-	-	88.01	87.46	99.24	**76.51**

4. Results & discussions

In table 3, it is seen that cutting and finishing section have higher OEE value than of sewing section. The overall OEE level of the studied production line is 76.51 percent. There exists a huge opportunity to enhance OEE level by applying a systematic method like TPM. This approach suggests that how the implementation of TPM can be helpful to increase the OEE level and how to introduce TPM methodology in the factory. What types of systematic actions should be taken are discussed below.

4.1 Introduction of TPM process to the factory

Step 1 – Realization by top Management about how the TPM approaches are going to help them.
Step 2- Providing education and campaigning among workers about TPM through training.
Step 3- Forming TPM and departmental committees, specialized subcommittees, Form an organizational structure that will take care of autonomous maintenance, quality maintenance.
Step 4- Fixing up TPM principles, targets and working procedure.

Step 5- Making an action plan for TPM implementation.
Step 6- Eight pillars of TPM are implemented in the production floor to achieve different benefits from it.
Step 7- Continuous monitoring and controlling is needed to sustain the development for long run.

4.2 Pillar wise actions needed to implement TPM

The actions that should be taken in implementing eight pillars of TPM are as follows:

Pillar-1: 5S

Table 4. Actions to implement 5S.

Terms	Activities
1. Seiri (Sort)	Identification of the items those are not frequently needed. According to their frequency of use, priority must be provided and items with less frequency should be eliminated. And unnecessary item have to be kept in a red tagged area so that they can be found when they are required.
2.Seiton (Set in order)	At first making sure that all the unnecessary items have been eliminated and keeping the necessaries in a way so that they can be easily picked up for use. Certain places for needed items should be allocated and locations must be selected on frequency of use.
3. Seiso (Clean)	Keeping workplace clean and free from dust, dirt and clutter. Engaging all the persons for cleaning their table, chair, machines etc.
4. Seiketsu (Standardize)	Making the activities have been performed in first three stages standardize. Standard operating procedure and color coding can be used in the factory for this purpose.
5. Shitsuke (Sustain)	Providing various Trainings and incentives to the people so that they follow good housekeeping disciplines. Raising awareness among people through using 5S poster and 5S slogan and well as arranging monthly meeting on 5S.

Pillar 2: Autonomous maintenance

To implement Autonomous maintenance successfully various approaches must be taken like giving training to operators on their daily maintenance by floor in-charge. Operator’s mentality is an important factor for successful implementation. An operator will take good care of machines only if they feel ownership of the machines. Prepare Autonomous maintenance check list by floor in-charge and make it mandatory for all the operators.

Pillar-3: Kobetsu Kaizen

Various Kaizen tools and procedures like why-why analysis, WWBLA, FTA, FMEA and kaizen summary sheet etc. may be used in a systematic way to analyze the problem and to eliminate losses.

Pillars-4: Planned maintenance (PM)

Steps in Planned Maintenance include:
(1) Evaluate and record present equipment status, (2) Restore deterioration and improve weaknesses, (3) Build information management system, (4) Prepare time-based data system, select equipment, parts, and team, and make plan, (5) Prepare predictive maintenance system by introducing equipment diagnostic techniques and (6) Evaluate planned maintenance.

Pillars-5: Quality maintenance (QM)

This step focuses on effective implementation of operator quality assurance and detection and segregation of defects at the source. Opportunities for designing Poka-Yoke (foolproof system) are implemented as practicable.

Pillar-6: Training

Training should be provided to the operators and floor in-charge on the regular basis at aims to have multi-skilled revitalized employees whose morale is high and who are eager to come to work and perform all required functions effectively and independently. It necessary to train them to enable the operators to maintain their own machines, understand why failures occur, and suggest ways of avoiding the failures occurring again.

Pillar-7: Office TPM

Office TPM should be started after activating four other pillars of TPM (Autonomous maintenance, Kobetsu Kaizen, Quality Maintenance, and Planned Maintenance). Office TPM must be followed to improve productivity, efficiency in the administrative functions, and identify and eliminate 8 big losses.

Pillar-8: Safety, Health and Environment

The focus is on creating a safe workplace and surrounding areas that are not damaged by our process or procedures. The target to achieve: a) zero accidents, b) zero health damage, and c) zero fires.

5. Conclusions

The aims of this study are to scrutinize the maintenance system of a garment industry, find out the losses occur in the production floor and demonstrate how much they impacting on productivity. TPM approach is possible solution to eradicate or reduce problems in the maintenance system and improve OEE condition of the machines. Successful implementation of TPM pillars are not an easy task as it requires all workers involvement and top management's support. This study has extracted an overall scenario in a production floor of the selected garments. Basically, the TPM strategy focus on improving productivity by improving quality of product, increasing machine availability, decreasing machine breakdown and that all result in increasing overall equipment effectiveness. Cost of reworks and repairs are also possible to reduce by limiting the amount of rejected products. If TPM is implemented effectively, the overall work place will be neat and clean, productivity will be high, productivity as well as workers satisfaction will be high. Therefore, it can be concluded that necessity of TPM implementation to garments industry is now "crying need" for the sustainability of our current position in global market. In future, the authors would like to end up the research by implementing TPM into that factory and arrange a well-organized training program to make the operators educated about these losses and possible ways of improving the OEE condition.

Acknowledgements

The authors acknowledge the people of "The Rose Dresses Ltd." for their support in carrying out the research work successfully

References

[1] A. K. M. Masud, A. Al-Khaled, S. Jannat, A. S. A. Khan, and K. J. Islam, "Total productive maintenance in RMG sector a case: burlingtons limited, Bangladesh", Journal of Mechanical Engineering, vol. 37, pp. 62–65, 2007.
[2] R. Karim and C. M. Rahman, "a performance analysis of oee & improvement potential at a selected apparel industry", in Proceedings of the 6th International Mechanical Engineering Conference and 14th Annual Paper Meet (6IMEC&14APM), 2012, pp. 28–29.
[3] B. Al-Najjar and I. Alsyouf, "Selecting the most efficient maintenance approach using fuzzy multiple criteria decision making", International journal of production economics, vol. 84, no. 1, pp. 85–100, 2003.
[4] A. K. Gupta and R. K. Garg, "OEE improvement by TPM implementation: a case study", International Journal of IT, Engineering and Applied Sciences Research, vol. 1, no. 1, pp. 115–124, 2012.
[5] T. Suzuki, TPM in process industries. CRC Press, 1994.
[6] M. C. Eti, S. O. T. Ogaji, and S. D. Probert, "Implementing total productive maintenance in Nigerian manufacturing industries," Applied energy, vol. 79, no. 4, pp. 385–401, 2004.
[7] A. Jain, R. Bhatti, and H. Singh, "Total productive maintenance (TPM) implementation practice: A literature review and directions," International Journal of Lean Six Sigma, vol. 5, no. 3, pp. 293–323, 2014.
[8] F. T. S. Chan, H. C. W. Lau, R. W. L. Ip, H. K. Chan, and S. Kong, "Implementation of total productive maintenance: A case study," International Journal of Production Economics, vol. 95, no. 1, pp. 71–94, 2005.
[9] D. M. Nayak, M. N. Vijaya Kumar, G. S. Naidu, and V. Shankar, "Evaluation of OEE in a continuous process industry on an insulation line in a cable manufacturing unit", International Journal of Innovative Research in Science, Engineering and Technology, vol. 2, no. 5, pp. 1629–1634, 2013.
[10] P. Press, TPM: Collected Practices and Cases. CRC Press, 2005.
[11] F. Lee Cooke, "Implementing TPM in plant maintenance: some organizational barriers", International Journal of Quality & Reliability Management, vol. 17, no. 9, pp. 1003–1016, 2000.
[12] K. G. Eswaramurthi and P. V. Mohanram, "Improvement of manufacturing performance measurement system and evaluation of overall resource effectiveness", American Journal of Applied Sciences, vol. 10, no. 2, 2013.
[13] H. S. Rajput and P. Jayaswal, "A Total Productive maintenance (tpm) approach to improve overall equipment efficiency," International Journal of modern engineering research, vol. 2, no. 6, pp. 4383–4386, 2012.
[14] S. Nakajima, "Introduction to TPM: Total Productive Maintenance.", Productivity Press, Inc., 1988, p. 129, 1988.
[15] C. M. Rahman and M. A. Hoque, "Evaluation of total productive maintenance implementation in a selected semiautomated manufacturing industry," Int J Modern Eng Res, vol. 4, no. 8, pp. 19–31, 2014.
[16] Swanson, Laura, "Linking maintenance strategies to performance.", International Journal of Production Economics, 70(3), pp. 237–244, 2001.
[17] Dashrath, k., Dinesh, K., Er., Rohit, Rawat, "Methodology used for improving overall equipment effectiveness by Implementing Total Productive Maintenance in plastic pipe manufacturing industries", International Journal of Modern Engineering Research, vol. 4, issue 9, 2014.
[18] R. V. Paropate, S. R. Jachak, and P. A. Hatwalne, "Implementing approach of total productive maintenance in Indian industries & theoretical aspect: An overview," International Journal of Advanced Engineering Sciences and Technologies, vol. 6, no. 2, pp. 270–276, 2011.
[19] Singh, R., Gohil, A. M., Shah, D. B., & Desai, S. Total productive maintenance (TPM) implementation in a machine shop: A case study. Procedia Engineering, 51, 592-599, 2013.
[20] T. Bartz, J. Cezar Mairesse Siluk, and A. Paula Barth Bartz, "Improvement of industrial performance with TPM implementation," Journal of Quality in Maintenance Engineering, vol. 20, no. 1, pp. 2–19, 2014.
[21] M. W. Wakjira and A. P. Singh, "Total productive maintenance: A case study in manufacturing industry," Global Journal of Research in Engineering, vol. 12, no. 1–G, 2012.