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Analysis and Implementation of TPM in Plastic Industry

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Abstract

The key point in this paper is to analysis and to develop an effective TPM model to advance the maintenance system in a Plastic manufacturing industry. The researchers set target to evaluate the existing maintenance system of the plant, to calculate overall equipment effectiveness (OEE). Continuous compression molding (CCM) plants faces the problems of machine breakdown and solid waste of materials during production process of closure. A method to resolve all these issues is to introduce of Eight pillar strategy (EPS), one of these is Total Productive Maintenance (TPM) strategy to minimize the machine breakdown, reduce the solid waste of material and enhance equipment efficiency. (A) for Availability, (PE) for performance efficiency, (QR) for quality rate were determined by evaluating equipment effectiveness through (OEE) Overall Equipment Effectiveness[1]. In this study, Continuous Compression Molding machine was considered as a case study for the analysis of Total productive Maintenance. Availability increase as breakdown reduces, PE performance efficiency and QR quality rate were found before implementing EPS to CCM machine as clearly determine in paper.

Key Words: Total Productive Maintenance (TPM), TPM model, Production management, Eight pillar strategy (EPS), Plastic Industry

1. Introduction

Total Productive Maintenance (TPM) is productivity enhancement training. Total means each employ in industry, from managerial level to the floor workmen. Productive means zero waste or no loss of production or not to exceed customer's demand. Maintenance means to keeping equipment and plant in good working condition[2].

A comprehensive change is being faced by the nature of manufacturing and machinery facilities in information technologies because of a massive integration. Process management Should adapt the change[3] Currently it is important for an organization to certify efficiency, availability, reliability and process of maintaining machines because it directly affect the quality, price and delivery of the products. In customer point of view products have three properties, which are Quality, Costs and delivery time. For the most business operation with the rising dependence of technologies, TPM ensures that these organizations can bring high quality and reliable services to their customer. It is crucial to design a suitable maintainability and reliability plans. For introducing maintenance into any organizational, total productive maintenance (TPM) method is a recognized and successful technique. TPM involves all staff from top level to bottom working as a team to decrease wastage, improve the quality of product and reduce downtime. My study interrelated to the application of TPM in a plastic industry producing plastic product such as closure, preform, shell, bottles, and jars. The focus on enhancing the quality and minimizing the cost of the products by using TPM technique, to meet the customer requirement and to eliminate issues related to losses, downtime and quality improvement. In 1971 Eight pillars strategy (EPS), was established by the Japan Institute of Plant Maintenance (JIPM)[4] which is known as the total productive maintenance (TPM) technique. Eight pillar strategy gives the concept of non-defected products, no failures, minimum loss and improved operations. EPS purpose is to enhance efficiency and availability of existing machine in the given condition. By applying these concepts, we can reduce material wastage from closure production plant, failure rate can be decreased, enhance efficiency and improve skills to operators and fundamentally handle with damaged[1]. In this paper researcher discuss current maintenance system, losses, involvement of operators in maintenance, Maintenance technique, causes of breakdown, frequency of breakdown in a plastic industry. Evaluate data using OEE technique.

Pascal, V et al (2019) [3] Researcher discuss about the maintenance manager indicator which can assess the significance action execute along with alteration of planned maintenance program. To achieve this goal, he proposed a lot of indicators for analysis, prediction and reliability to judge and expand the maintenance plan based on TPM. To attain these indicators a method used based on operating maintenance actions. He focuses on a maintained procedure based on TPM in which existing sensor statistics are not telling about degradation level attained by the system.

Marcus Bengtsson and Gunnar Lundstrom (2018) [5] Discuss about advancement in technology worldwide. Demonstrate the importance of merging management and basic maintenance ideas e.g. early product management, preventative maintenance, the main reason of failure analysis and eradication, with the help of technological progression e.g., predictive maintenance, cyber systems, in order to enhance the total maintenance efficiency.

Saetta, S. and V. Caldarelli (2018) [3] introduce new structures in maintenance system, along with all of the possible implications. In the paper, an operational case of two different manufacturing plants of a company is discussed. Maintenance management system for both plants identified by taking different data and discuss about possibilities, how to evaluate plant performance.

Kigsirisin, S., S. Pussawiro, and O. Noohawm (2016) [1] Discuss about a water treatment plant, issue relating to equipment failure and loss of water during production. Eight pillar strategy applied to overcome these losses to decrease equipment failure, reduce water losses increase equipment effectiveness and evaluate OEE.

C. C. Shen (2015) [6] compare literature and actual case to find out the factors by which TPM can be implemented successfully. In how much duration an organization can implement TPM. To check the organization, current performance, and compare it with those organization which successfully implemented [6].

E. Chlebus et al 2015 [7] presents about the introducing of lean manufacturing approaches in the mining plant focused on the main problems associated to the total productive maintenance. From author point of view TPM in mine based on three pillars. Perfection of working environment planned maintenance and autonomous maintenance and standards in development. Several steps were taken to implement TPM in mining conditions. For this purpose, a pilot group of machines was selected.

Singh, R., et al (2013) [8] In CNC machine shop the concept of TPM implemented. To measure the success of the implementation OEE researcher find out the loss associated with equipment and operation. EPS (eight pillar strategy) applied simultaneously to overcome losses and increasing the availability thus improves the operation of CNC machines.

Bakri, A.H., et.al (2012) [9] This paper is about the study of the application related to (TPM) total productive maintenance in manufacturing industry. Main focused on the importance of (TPM) total productive maintenance in established quality enhancement technique, like lean production and the beneficial outcome of TPM methodology.

Marcelo Rodrigues and Kazuo Hatakeyama (2006) [10] Study about interaction between maintenance and production in the manufacturing plants. How productivity increase by the help of maintenance strategy. For this purpose, the most used technique is total productive maintenance. Author classified the companies into three categories regarding to total productive maintenance. Companies classified in three ways regarding to TPM: One that who are truly organized and have working procedures;[11] the ones who claim they have it, but they do not have even the basic principles; and the ones who had previously implement the pillars but let this structure to fall. This paper is about this third case, in which previously implemented pillars going down. For the investigation of the failure top to bottom level employee involved in the productive process were heard.

Chan, F.T.S., et al (2005) [12] A case Study for effective implementation of TPM in electronic manufacturing industry. Discuss and analyzed about practical features within and beyond fundamental TPM theory, complications in the implementation of TPM[13] Moreover, for achieving TPM the critical success factors are also comprised based on the practical results obtain from the study.

G. Chand, B. Shirvani (2000) [14] Discuss a case study of a cellular manufacturing .TPM is the world class manufacturing fundamental component, linked the concept of continuous manufacturing and total quality management. A study was started in coordination with an automotive component supplier to determine the (OEE) of a semi-automated assembly cell. The losses identified associated with equipment effectiveness[15]. Over the observed time period the production output is 2651 cell which shows 97% good cell, 0.33% useless and 2.67% rework. During this period 156 breakdown notes, then 10 most common breakdown were identified. Losses are 38% and overall equipment effectiveness is 62%. Based on the results, it is recommended to conduct a pilot project to implement TPM in the whole plant.

2. Methodology

2.1 Research Approach

In this research work, data will be collected of Continuous Compression Molding machine (CCM32) by SACMI. The researchers work on both qualitative and quantitative method to evaluate the maintenance systems. Collected data of CCM 32 used to determine overall equipment effectiveness. Collected data was analyzed by using MS Excel and Origin Pro.

2.2 Data Collection

Data was collected by interviewing of company employ, company one-year record check and direct observations of Plant.

2.3 Interview

Maintenance team, Machine operators and other employees of production departments was interviewed. The researchers absorbed on the following.

- losses experienced by CCM 32 Machine
- Maintenance problems and cause
- Whether TPM concept exist or not in the plant.
- Factors that can helps to implementation of TPM

2.4 Direct Observation

Researcher observed the maintenance process and production process. Researcher observes inspection and lubrication activities, maintenance process, Maintenance techniques used, involvement of employ in maintenance process. Direct observation helps the researcher to collect date without relying on the respondent.

2.5 Questionnaire

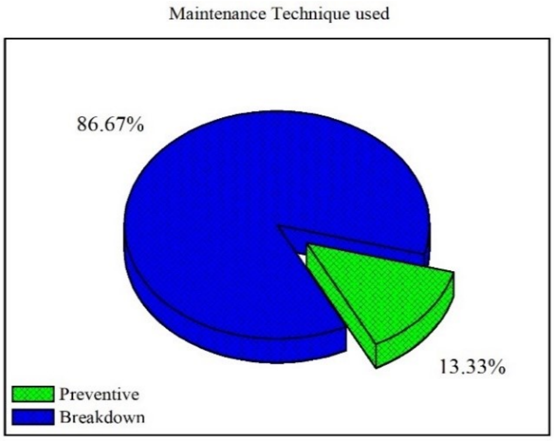
A total of 21 employ including Production Manager, Production Engineer were questioned about CCM 32 Plant. Losses of CCM 32, maintenance technique and inquire about the spare parts availability.

3. Data Collection and Analysis

Information was collected by questionnaires, interviews of employ, previous company reports and direct observations of plant. The data was then analyzed using Microsoft excel and origin Pro.

3.1 Maintenance Technique

The figure 1 tells about the maintenance technique used in plant 86.67% maintenance is Breakdown and rest 13.33% is preventive maintenance.



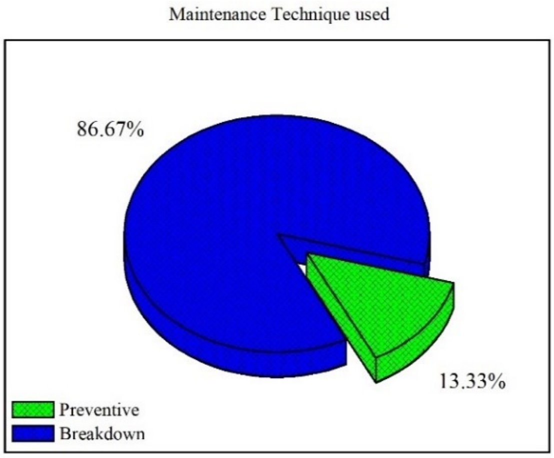


Fig. 1: Operator involvement in Maintenance

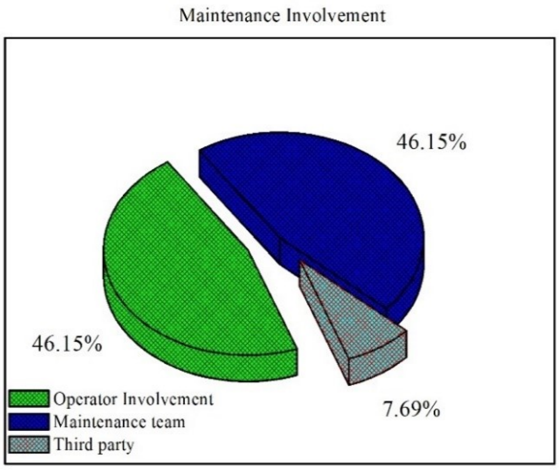


Fig. 2: Operation involvement, maintenance team, third party

It is observed in figure 2 that operator involvement in maintenance is about 46.15%

technical team contributed to maintenance activity 46.15% and 7.69% contributed by third party. Operator involvement is necessary because he knows machine batter than any other person. Operator involvement helps to identify and resolve problem quickly.

3.2 Parts Availability

Researcher observer that when a machine fails need to replace a part the part availability is very less. Part needed is sent to market which takes too many times causing production loss.

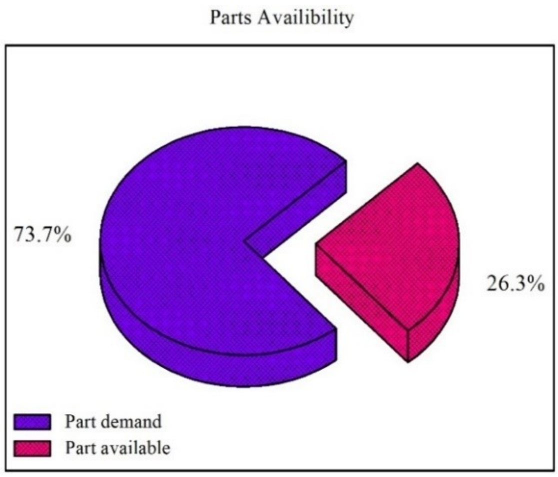


Fig. 3: Parts demand and parts availability

Above figure 3 show that only 26.3 % part available on time rest of 73.7% parts not available on time.

3.3 Overall Equipment Effectiveness

There are six major losses in TPM data relating to these losses was collected by direct observations, interviews and company records. The six big losses related to TPM were identified and clustered with their OEE factor and OEE Loss type in table 1.

Table 1: Overall equipment effectiveness (OEE)

Sr. no.	Overall Equipment effectiveness (OEE)	Six Big Loss	
1.	Availability Loss	Unplanned stop	Equipment Failure
		Planned Stop	Setup & Adjustment
2.	Performance Loss	Small Stop	Idling and minor stop
		Slow Cycle	Reduce Speed
3.	Quality Loss	Product Rejected	Process defects
		Startup Rejection	Product out of Specification

3.4 Availability Ratio

It is the actual time which is supposed to available for production. It considers Downtime Loss, which includes Unplanned stop (equipment failure, for an appropriate time period) Planned stop includes machine stop for lubrication, calibration, inspection also called preventive Maintenance.

$$\text{Availability}=\frac{(\text{Total Time}\ -\ \text{Total Downtime})\ 100}{\text{Total Time}}$$

Table 2: Calculation of availability ratio

Month	Planned Production Time (Hrs.)	Down -time (Hrs.)	Availability %
20-Feb	504	329.3	34.66
20-Jan	360	163	54.72
19-Dec	182	53.44	70.64
19-Oct	192	43	77.60
19-Sep	120	34.85	70.96
19-Aug	528	108	79.55
19-Jul	504	92.23	81.70
19-May	480	149	68.96
19-Apr	240	120	50.00
19-Mar	360	68	81.11

Using the above table 2, the availability ratio calculated is 0.67 (67%).

3.5 Quality Rate

It defines good parts that effectively pass all the manufacturing process first time and did not need to rework. Quality considers all the parts manufactured that did not achieve the quality standards, including the parts that need to rework.

Quality rate is evaluating as:

$$\text{QR}=(Good\ Pieces \times 100)/\ (Total\ Pieces)$$

Table 3: Quality rate is evaluating as

Month	Total Piece	Good Piece
20-Feb	5240911	5155231
20-Jan	5888202	5827002
19-Dec	4131196	4100256
19-Oct	4496677	4464037
19-Sep	2554497	2534097
19-Aug	12841075	12751315
19-Jul	12400162	12314482
19-May	9408032	9326432
19-Apr	4082584	4041784
19-March	7880114	7818914

Using the above table 3, we calculate the quality rate is 0.99 (99%).

3.6 Performance Efficiency

Performance deals with the Speed Loss, which includes any issue that did not allow operating the process at maximum possible speed. It may cause due to machine condition such as machine part wear out, proper cooling system not install, and material specification (Figure 4).

$$P.E = \frac{Total\ Actual\ quantity\ of\ product \times 100}{Total\ target\ quantity\ of\ Product}$$

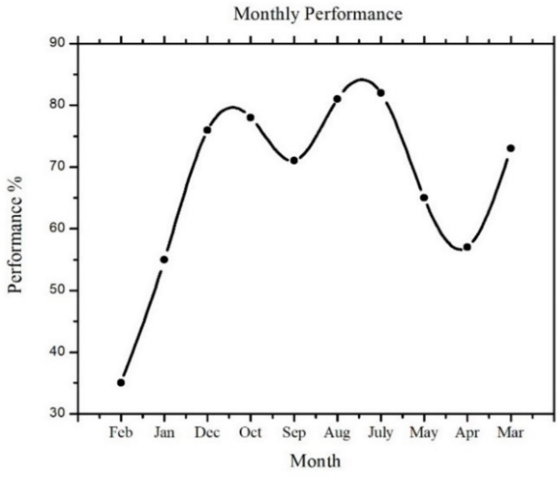


Fig. 4: Performance efficiency

3.7 Overall Equipment Effectiveness (OEE)

Overall Equipment Effectiveness (OEE) is a standard for measuring[16] the effectiveness and efficiency of a process, by breaking it down into three subcomponents (Availability, Quality rate, Performance efficiency). It tells the percentage of manufacturing time that is productive[17]. 100% OEE ideal condition means you are only producing good Products, as fast as possible, without time lose.

OEE graph in figure 5 with blue bar showing world class OEE which is 85% and the Red bar in graph represent the actual plant OEE before TPM implementation.

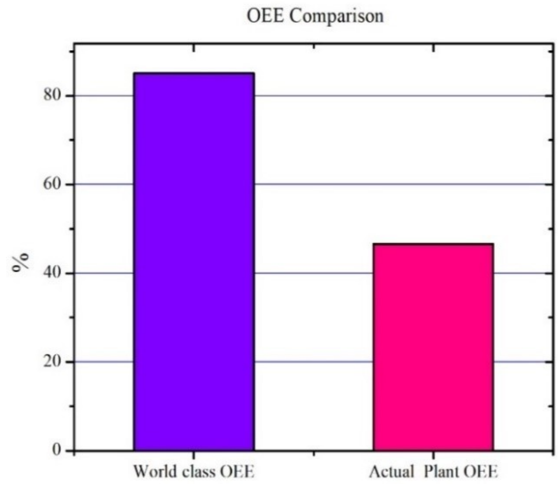


Fig. 5: Overall equipment effectiveness (OEE)

3.8 Causes of Downtime

Time in which equipment is out of service/Machine stop due to Technical Fault, Power failure or shortage of materials. Data collected for ten months in which four major factors of Downtime found is (Poor Planning, Power Failure, Maintenance, Operator mistake). Most of downtime cause due to maintenance which is 51.87%, Poor planning cause 33.16% and power failure is 11.28% (Figure 6).

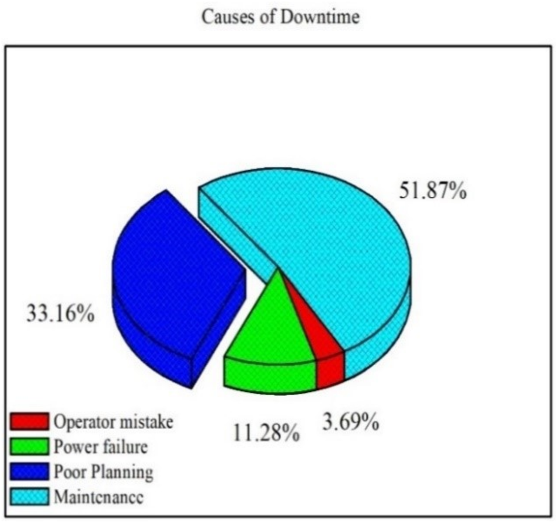


Fig. 6: Causes of downtime

3.9 Breakdown Frequency

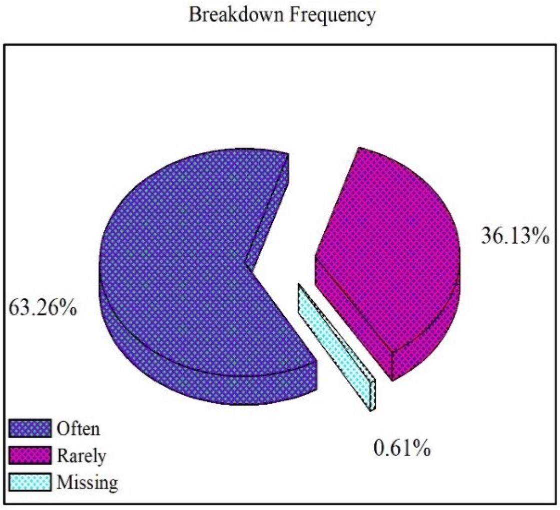


Fig. 7: Breakdown frequency

Figure 7 indicates that 63.26% of graph indicates that breakdown is often, 36.13% of graph represents that breakdown is rarely happen and 0.61% of graph is not applicable. Researcher concluded that plant often breakdown.

Results and Discussions

Result after TPM implementation

After implementation we again collect data for a period of three month from July -20 to sep-20 we noted that great improvement in downtime. This improvement happened by improving two factor communication from MD level to shift engineer through a software named ORACLE Netsuite and operator authorized to maintenance. OEE improve from 46.65 to 65.89 (Table 4).

3.10 OEE After TPM Implementation

Before implementation of TPM OEE is 45.65 which are indicated by orange bar in the graph after implementation of TPM OEE improved to 65.89 indicated by red bar in the graph whereas blue bar in graph represent the world class OEE standard (Figure 8).

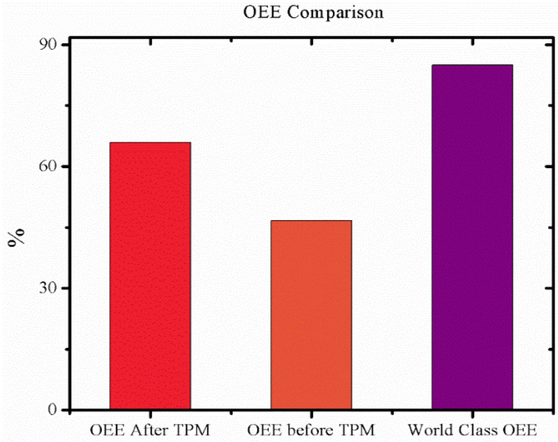


Fig. 8: OEE after TPM implementation

4. Conclusion

Evaluation of the present maintenance system indicates that the company is facing downtime, equipment breakdown production loss prolong downtime. The maintenance technique used by the company is very poor (86.67%) maintenance is breakdown only 13.33% in preventive. Involvement of machine operator is 46.15% which is not good on the other hand operator are not properly trained and skilled. Company faces the high percentage of downtime 51.87% is maintenance which is purely downtime maintenance.

Poor planning is also main factor for downtime 33.16% consumed by poor planning and 11.28% is due to power failure. 63.26% of the breakdown is often and 36.13% downtime rarely happens. Poor planning is also main factor for downtime 33.16% consumed by poor planning and 11.28% is due to power failure. 63.26% of the breakdown is often and 36.13% downtime rarely happens.Evaluating the date conclude that availability is 67% and quality rate is good which is 99%. OEE of plant is 46.65% whereas world class OEE is 85%.

Table 4: Results achieved after the implementation of TPM

Month	Planned time	Down time	Availability	Performance %	Quality rate	OEE
Jul-20	680	135	0.80	0.80	0.99	63.69
Aug-20	658	113	0.83	0.83	0.99	68.12
Sep-20	690	127.8	0.81	0.81	0.99	65.87

After TPM implementation Overall Equipment Effectiveness improve from 46.65 to 65.89 which indicated a great improvement in Overall Equipment Effectiveness

This paper evaluates the maintenance method at Plastic industry. Results indicate the lacks in the maintenance system of plant. KPI (key Performance indicator) is determined for effective implementation of TPM. Calculated OEE of the plant compares with the world class OEE. Research therefore concluded that OEE of the plant can be increase by implementing TPM in effective manner. Therefore, researchers recommended the following.

Implementation of TPM can minimize losses and rework. TPM can also enhance company image and profit. Both will ensure competitiveness and financial turnout.

To accomplishing the company goal company should involve through the execution of operator initiated daily maintenance including inspections, cleaning, and adjustment, along with progressive actions and minor repair of machine parts. Maintenance team should only contribute to inspection and repair of machine part where high specialization and skills required.

Authorizing the operators and maintenance team through training[18]. This should be led in sustainable manner to eliminate the operators' mistakes improper repair and improve the efficiency of the equipment.

Scheduled maintenance (weekly, monthly, three month and yearly) must be implemented to reduce breakdown losses and equipment failure.

Planning should be made after collecting complete information and availability of raw materials and machine status. Spare parts availability should enhance to overcome production loss.

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