A Survey Report on Total Productive Maintenance in a Small Medium Indian Manufacturing Industry – A Case Study

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Abstract

Total productive maintenance is a maintenance technique which improves the effectiveness and the life of the equipment by reducing wastages and losses and improves productivity with the help of involvement of all the employees of the organization. TPM has become a technique that is used world-wide for improved productivity. The aim of this paper is to understand the current status of the selected organization's 4 core departments regarding the pillars of TPM as TPM has not been implemented there yet. The methodology used to prepare this paper was with the help of structured questionnaires along with studying of literature and plant visit. For data analysis the software used is the Minitab-17: multivariate-item analysis and Minitab-17: One-way ANOVA. The results obtained with a response rate of 58.5% in which every response was valid and usable and reliable as obtained by the calculation of Cronbach's alpha. Further, one-way ANOVA technique helped to determine the type of hypothesis selected which is the null hypothesis H_0. It is concluded from this result that without even the implementation of TPM the 4 core departments work in harmony with respect to the pillars of TPM.

Keywords: *Total Productive Maintenance (TPM), Questionnaires, Cronbach's alpha, One-way ANOVA.*

1. Introduction

Total productive maintenance (TPM) is a maintenance technique carried out by all the employees of the organization through small group activities giving productivity the first preference [1]. In the era of highly competitive environment the maintenance techniques are looked upon by the organizations to be able to reduce the wastages and improve productivity and getting an edge over the competition, and therefore Total Productive Maintenance's (TPM) strategies by the leading organization worldwide are being adopted exclusively. TPM employs overall equipment effectiveness (OEE) as a measuring parameter which refers to the performance of a production system. OEE is termed as quantitative tool for measuring the performance of a production system and therefore the performance of the organization [2].

Total Productive Maintenance (TPM) is a productivity improving practice. TPM is also described as a Japanese concept of managing the equipment such that it allows the organization to improve the equipment performance with the help and involvement of all the employees in the organization [3]. The main focus in this concept is to focus on eliminating or at least reducing the six big losses which are as follows [1]:

- Equipment Failure,
- Set-Up and Adjustment Time,

- Idling and Minor Stoppages,
- Reduced Speed,
- Defects in Process and
- Reduced Yield.

The objective of TPM is to continuously improve the availability and prevent the degradation of equipment to achieve maximum effectiveness and these objectives require strong management support as well as continuous use of work teams and small group activities to achieve incremental improvements. TPM is analyzed into three words;

Total: It means involvement of all the employees in the organization

Productive: It refers to the zero wastages regarding time or scraps etc.

Maintenance: It refers to keeping the equipment in optimum working condition either as good as new or better than the new condition at all times.

Total Productive Maintenance is so designed that maximizes the equipment's effectiveness in turn improving the overall efficiency by a productive maintenance system which covers the entire equipment's life with the total participation of all the employees in the organization [4]. And therefore, for all these reasons, TPM is also considered as 'Medical Science of Equipment' [5]

The company understudy is a small medium Indian direct reduced iron or sponge iron manufacturing company which uses two 350 TPD or tons per day rotary kilns for producing sponge iron which is further used in making steels.

Studies has shown, by earlier works, that companies should not only focus on the equipment but also should focus on the work force [6]. TPM basically has dual nature one is the maintenance of the equipment for better productivity and another is the synchronization of all the employees in the organization.

The company understudy has not implemented TPM yet and therefore the aim of this paper is to find the current status of the company's 4 core departments regarding TPM pillars which would have been executed in the process of TPM implementation.

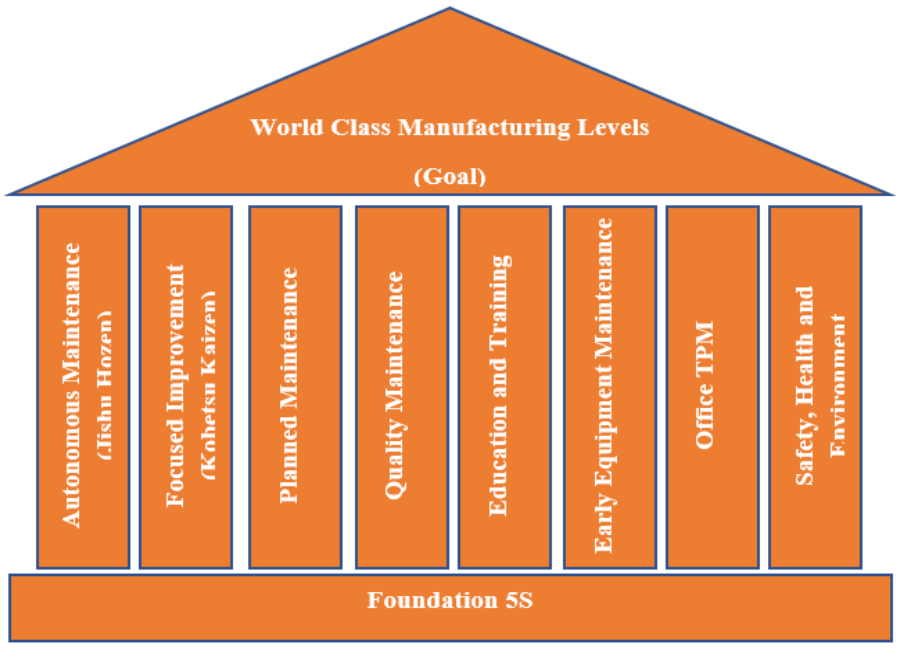

Figure 1. Pillars of TPM

With the foundation 5S the pillars of TPM is show in Figure 1 and a descriptive overview of the TPM pillars is show in Table 1.

Table 1. Overview of TPM Pillars

TPM Pillars	Description	Advantages
Autonomous Maintenance (Jishu Hozen)	The operators of the equipment are given the responsibility for carrying out basic maintenance activities.	Operators feel responsible for their machines, equipment becomes more reliable
Kobetsu Kaizen (Focused improvement)	Use of cross-functional teams for improvement activities	Improves problem solving capabilities of the workers
Planned Maintenance	Scheduling the maintenance activities by using the past equipment failure rate.	Maintenance can be scheduled when production activities are few
Quality maintenance	Maintaining the in-built quality of the equipment so as to reduce defects.	Decrease in the defects and as a result increase in the profits of the industry.
Education & Training	Association of the skills and knowledge gap by training of all the workers in the organization.	It helps the employees of the organization to gain necessary skills to solve the basic problem on their own.
Early Equipment Maintenance	Designing of the new equipment keeping in mind the previous TPM activities.	This helps the new equipment to achieve its full potential in shorter period of time
Office TPM	Spreading the principles to all the administrative functions within the organization.	The support functions in the organization understands the benefits of the improvements in the organization.
Safety, Health & Environment	The ideal working environment is created in this by eliminating the presence of any hazardous condition and trying to achieve for zero accidents.	Eliminating harmful conditions & achievement of healthy workforce

Source: [7].

2. Methodology

The methodology used in this paper is the study of an extensive literature and plant visit and thereafter with the help of survey, in which questionnaires were prepared, which were then distributed among the 4 units which are active participants in the organization in charge of all the big and small variations that were observed in rotary kilns which is the main functioning equipment of the organization, these departments are:

1. Production Department
2. Mechanical Department
3. Electrical Department
4. Quality Control Department

Although every department is important for an organization to function, the above stated departments are the heart of this organization.

A structured survey was conducted in the month of May 2017 in which questionnaires were prepared keeping the pillars of TPM in mind and were distributed to the respective departments. Around about 200 employees were among the 4 departments which were noticed and informed by the respective managers of the 4 departments and therefore a total of 200 questionnaires were distributed among the 4 departments out of which 117 responses came back which were all useful and valid. A valid response of 58.5% was obtained. In general, a lower response rate is also acceptable world-wide even in developed nations [8] [9] [10] [11].

The questionnaire prepared was a 5 points Likert-scale questionnaire with 1 = Strongly Disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, 5 = Strongly Agree, for 46 questions or 46 items for 8 parameters which are as follows:

1. Leadership and Ownership: This parameter was intended towards knowing the autonomous maintenance and leadership in the departments.
2. Liaison: It was intended towards knowing communication in between personnel of the organization which propels focused improvement.
3. Planned Activities: It was intended towards knowing the quality of the planned activities and frequency of its successful implementation.
4. Education and Training: Status of training levels and education in the departments.
5. Safety: Safety standards in the departments.
6. Productivity: Productivity of the departments.
7. Employee Satisfaction: Satisfaction levels in the departments.
8. Working Environment and Standards: Standards maintained in departments.

3. Analysis and Results

This section is divided into 2 sections. Firstly, it was checked if the obtained responses from the respondents did have internal consistency or reliability to them or not and secondly using ANOVA (Minitab-17) it was checked if it satisfies the null hypothesis or satisfies alternative hypothesis.

3.1 Data Reliability:

Data reliability needs to be checked if all data obtained from the questionnaires were useful or not for which Cronbach's alpha is calculated [12]. Cronbach's alpha is very useful in checking the reliability of the obtained data from the questionnaire which were measured with the help of (Minitab-17) multivariate-item analysis, if the value of Cronbach's alpha is greater than 0.7 then it is considered that the data collected is reliable enough to be used [2] [13] [14]. The calculated Cronbach's alpha value for 8 different parameters in 4 departments are mentioned in table 2:

Table 2. Cronbach's Alpha

S. No.	Parameters	Cronbach's Alpha				No. of items/ questions
		Production Department	Mechanical Department	Electrical Department	Quality Control Department	

1	Leadership and Ownership	0.8724	0.9383	0.8408	0.7782	4
2	Liaison	0.9162	0.8678	0.8417	0.8809	4
3	Planned Activities	0.9040	0.95	0.8966	0.8508	5
4	Education and Training	0.7877	0.8159	0.9068	0.9406	5
5	Safety	0.9109	0.8792	0.8105	0.9165	5
6	Productivity	0.7950	0.7337	0.9112	0.9252	5
7	Employee Satisfaction	0.9349	0.8580	0.8112	0.8125	10
8	Working Environments and Standards	0.8034	0.8065	0.8341	0.8288	8

The above table's data were obtained from the software Minitab-17 which shows that all the values of Cronbach's alpha are sufficiently greater than 0.7 which implies that data obtained is reliable enough to be used for selection of our hypothesis.

3.2 Hypothesis Selection:

ANOVA (One way) method is used to determine if the departments have some significant difference of means in between them or not, 2 hypotheses are stated:

- Null hypothesis H_0: $\mu_{production} = \mu_{Mechanical} = \mu_{Electrical} = \mu_{Quality\ Control}$, i.e., the means of the 8 different parameters are all equal for the respective departments.
- Alternative Hypothesis H_a: At least one of the means is significantly different from others.

The mean values of all the different parameters obtained from the structured questionnaires are shown in table 3:

Table 3. Mean Values

Parameters	Production Department	Mechanical Department	Electrical Department	Quality Control Department
Leadership	2.91	3.06	3.20	3.20
Liaison	2.96	2.83	3.23	3.16
Planned Activities	2.89	3.60	3.12	2.85
Education	2.89	3.06	3.16	3.35

and Training				
Safety	2.93	2.94	2.59	3.30
Productivity	2.99	3.02	2.98	3.05
Employee Satisfaction	3.02	3.16	2.99	3.08
Working Environment and Standards	3.01	2.78	2.66	3.06

With a confidence level of 95% and a level of significance of 0.05 and 4 departments being 4 number of population the data obtained from one-way ANOVA (using Minitab-17) are as show in table 4:

Table 4. Analysis of Variance

Analysis of Variance					
Source	DF (Degree of Freedom)	Adj. SS (Ad-joint Sum of Squares)	Adj. MS (Ad-joint Mean Square)	F-Value	P-value
Factor	3	0.1506	0.05019	1.33	0.286
Error	28	1.0600	0.03786		
Total	31	1.2105			

From the above data it is clear that the p-value is 0.286 which is greater than 0.05 which means that we fail to reject the null hypothesis.

Also, from the F distribution curve, for the values (3, 28) it can be noticed that the critical value of F comes out as $F_{Critical}$ = 2.95 and the F value 1.33, from the ANOVA results, is less than the critical value which supports our previous statement of being able to fail to reject null hypothesis and therefore accepting the null hypothesis which means that there is no significant difference in the means of the parameters among these 4 departments in the organization.

From all this data it can be observed that there is no significant difference among the means of the parameters, based on pillars of TPM in the selected departments and therefore, we fail to reject the null hypothesis and therefore accepting the null hypothesis.

Graphs obtained from ANOVA (Minitab-17):

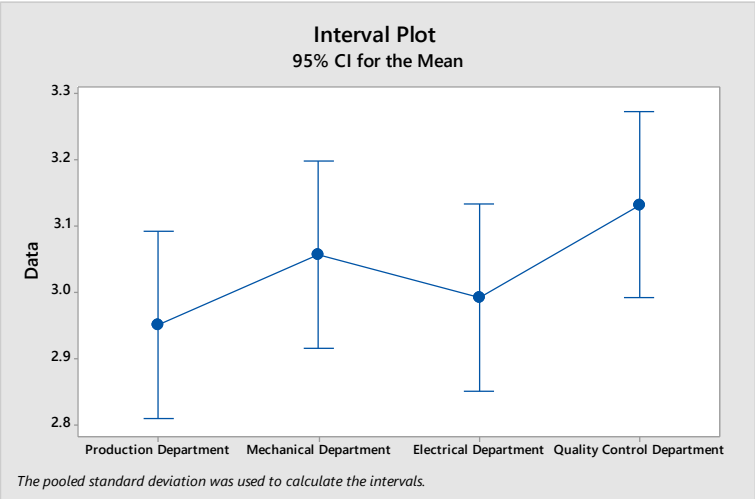

Figure 2. Interval Plot

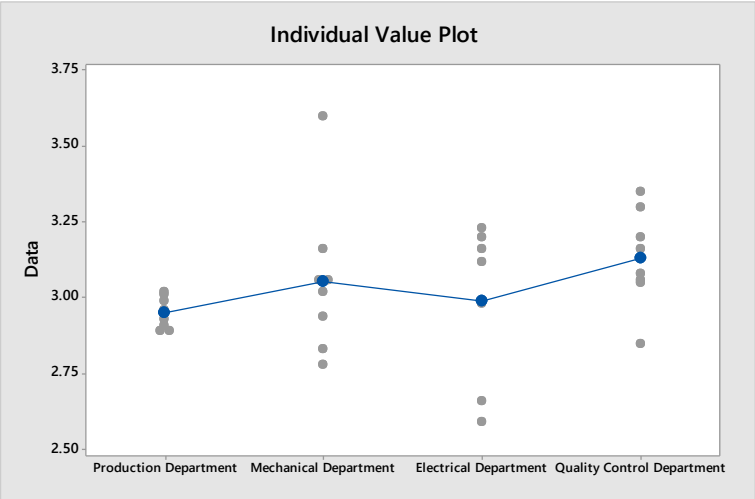

Figure 3. Individual Value Plot

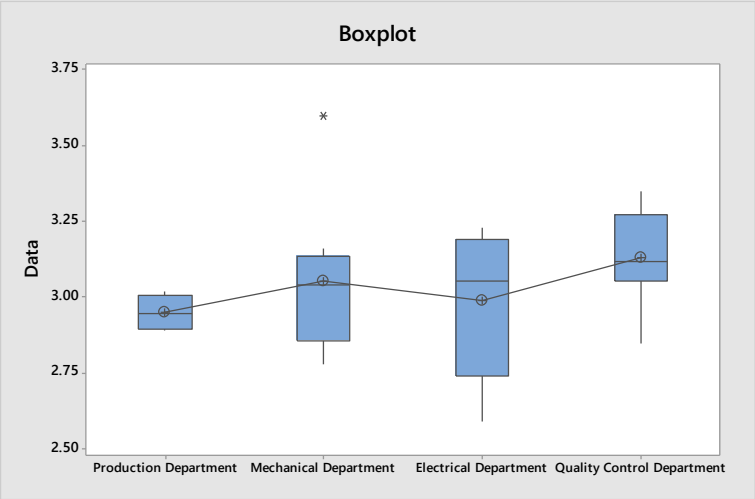

Figure 4. Boxplot

The interval plot, individual value plot and the boxplot of the 4 departments shown, indicates the mean values of all the 8 parameters and their variation from each other and in-between departments.

4. Conclusion

A survey was conducted in a small medium Indian manufacturing industry in the month of May 2017, the method of surveying was the use of questionnaire, along with brief studying of literature and plant visit, this paper was prepared. The response obtained were checked if they are valid or not by using Cronbach's coefficient alpha which proved that all the data were valid having a high internal consistency to them and therefore are all usable for further analysis. One-way ANOVA is used for further analysis to reach the main aim of this paper that is to understand the current status of the industry with respect to the parameters leadership and ownership, liaison, planned activities, education and training, safety, productivity, employee satisfaction and working environments and standards which are based on the pillars of TPM among the production, mechanical, electrical and quality control departments, giving the result of accepting the null hypothesis H_0.

Therefore, it can be concluded from the results obtained that these departments i.e., production, mechanical, electrical and quality control works quite well with each other harmoniously in terms of the parameters chosen on the basis of Total Productive Maintenance pillars, without even the implementation of TPM, and therefore no significant difference in the means of these departments were observed.

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