

An Investigation into the Need and Implementation of Total Productive Maintenance in SMEs

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Abstract: This paper is an extensive survey of TPM implementation results by SMEs. The paper reveals the important issues in Total Productive Maintenance ranging from maintenance techniques, framework of TPM, TPM implementation practices etc. The contributions of comprehensive TPM program towards improving production competencies of SMEs also taken care of. TPM program is a practice that involves everyone including top level management to machines and equipment where the basic target being productivity increase with zero breakdowns. TPM practice optimizes the OEE and promotes autonomous maintenance. Being a proactive maintenance system, the TPM maximizes the effectiveness of facilities available in the plant. The aim of the study is to identify the success factors of TPM implemented in Indian SMEs.

Keywords: Total Productive Maintenance (TPM), TPM Model, SME, productivity, OEE

1. Introduction

Indian Small and Medium Enterprises (SMEs) are striving for excelling in their field. In order to reduce maintenance problems encountered in manufacturing environment, the Japanese developed the concept of Total Productive Maintenance (TPM). TPM is a maintenance system defined by Nakajima [1] in Japan. TPM covers the entire life of equipment in every division including manufacturing and maintenance. TPM implementation requires an integrated effort of the whole company. The positive correlation of most of the general and specific TPM construct with the financial, managerial, operational, and overall business performance allude to such relationship concluded by Shaukat Ali [3]. Shamsuddin et al [4] explains, a well-conceived TPM implementation not only improve the equipment efficiency and effectiveness but also brings appreciable improvements in other areas of a manufacturing plant. F T S Chan [5] opines that, there is only the model equipment being used to implement TPM, the next step is to disseminate the concept of TPM and implement TPM into the whole production area. Ranteshwar [11] made the following conclusion is derived from implementation of TPM in the machine shop of automotive company:

- 1) Success of TPM depends on various pillars like 5-S, Jishu Hozen, Planned Maintenance, Quality maintenance, Kaizen, Office TPM and Safety, Health & Environment.
- 2) Overall Equipment Effectiveness has improved from 63% to 79% indicating the improvement in productivity and improvement in quality of product.
- 3) It is observed that most of the defective components are because of the previous process namely casting hence to improve the productivity efforts must also be given to previous process as well.
- 4) The key factors for this implementation are workers involvement and top management support. Still world class TPM implementation is possible with continual

support at all the levels along with the supply of necessary resources.

1.1 Pillars of TPM

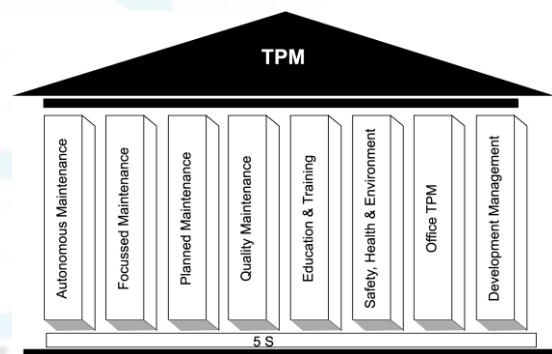


Figure: Pillars of TPM (Source: Nakajima)

2. Objectives

The objectives of the work are,

- To develop the model of TPM concepts for SMEs in India.
- To develop a strategy that could help with the implementation of TPM and ensure higher productivity for an organization.
- To develop the TPM towards Industry 4.0 principles that facilitates ability of machines, devices, sensors and people to connect and communicate with each other via the Internet of Things (IoT) or the Internet of People (IoP).

2.1 Hypothesis

The hypothesis framed for the research work is formulated as follows,

- Without implementing the developed model of Total Productive Maintenance program, organizations cannot achieve increased efficiency.

- Organizations that have not implemented the Total Productive Maintenance program have lower equipment efficiency and poor plant availability.
- Total Productive Maintenance improves the quality of products.
- Employees' exposure to safety risk is greatly reduced by application of TPM.

3. Research Methodology

The SMEs in the selected region of India those are working on implementation of Total Productive Maintenance form the sampling frame for this research. The organizations considered for our study are located in the northern region of Karnataka State in India. The survey data of this research consist of production managers, maintenance managers, production operators. This study is a cross-sectional research design. Data is obtained from the questionnaires. Frequency distributions will be used to confirm statistical inferences i.e. to confirm the hypothesis. Once data is analyzed, the necessary conclusions and recommendations will be made based on the results obtained.

3.1 Sampling design

The population selected in this research is the employees of different companies that have implemented the Total Productive Maintenance program along those which are planning to implement TPM. It is taken care that each one of these employees has some exposure to the Total Productive Maintenance initiative.

3.2 Sample Selection

The list of names from which the sample was drawn was obtained from the departmental heads i.e. section managers or the respective human resources managers. These departments comprise of Multidisciplinary Groups and the Small Industrial Units. Therefore a sufficiently representative sample was drawn. The Multidisciplinary Team consists of all the supervisors for different sections in the industry. These include staff from the maintenance department, quality department, and production department. The management people are also included in the Multidisciplinary Groups along with the Small industrial Units those include employees from specific departments. Thus a Small industrial unit is made up of a specific team that looks after each department. The employees present in such sections include all the production personnel. These teams consist of various individuals who are involved at various phases of the process. This sampling technique provides an increased statistical efficiency and provides required data from where statistical inferences can be obtained. To reduce the effect of measurement errors and uncertainties, the questionnaire is prepared with clear instructions. This is done to assist that, all respondents understand how the questions are to be answered.

3.3 Data collection tool – Questionnaire

There are different types of questions framed in questionnaire layout such as closed-ended, open-ended and combination. Closed-ended questionnaires are more suitable

for quantitative research because it is easier to generate statistics and perform analysis. Open-ended questionnaires have better consistency for qualitative research. This questionnaire framed provides respondents the freedom to express their opinion without any constraint. Along this, the mixed questionnaires have been more relevant in modern times. Further, these questionnaires might enclose a series of closed-ended questions, with boxes to mark or rate by scales along with open-ended questions for getting more detailed response.

3.4 Questionnaire design

The design process of questionnaire for this study involves three stages:

- 1) The objectives of questionnaire: The aim of the questionnaire is to collect data about how industries are benefited by application of TPM.
- 2) Population and Participants: Once the questionnaire objectives are identified clearly, then the next stage is to specify the sample frame and respondents those needed for conducting the survey. The aim is to find industries those have production lines in which downtime duration has a significant impact on their productivity and costs. The participants are to be appropriate for answering the questionnaire and have a good comprehension about the TPM related matters. Each questionnaire included the research topic and purpose of survey.
- 3) Procedure: The questionnaire used in this study consists Basic information, TPM implementation strategies and Contribution of TPM strategies. The questionnaire designed according to the standard of easy understanding and relevant, short questions.

3.5 Data Analysis

Quantitative data analysis is a potent form of a research. It is generally linked to extensive surveys along with case studies, experiments and correlation research. There are two techniques in analyzing the data namely descriptive and inferential statistical methods. The descriptive statistical analysis is made by mean, median, mode, range, variance, standard deviation, standard error, skew and kurtosis. Whereas inferential statistics includes Hypothesis testing, correlations, factor analysis, regression, etc. To draw rational conclusions the right analysis is being applied.

4. Survey Process

Based on the literature survey carried out in respect of the proposed research work and the gap analysis it is presumed that there is a positive relation between plant efficiency and Total productive maintenance implementation. As a part of preliminary survey for TPM implementation and its effect, a questionnaire is prepared. The questionnaire contains objective type queries those sent to the respondents at various cross sections of plant employees. The preliminary data is collected from various SMEs located in northern part of Karnataka for the survey conducted. Following is the data collected by primary survey. The responses so obtained have been analyzed by means of bar charts and Pie charts those clearly predict the orientation of the problem defined.

5. Results and Discussion

Table 5.1: Top Management Role Factor

Survey Factor: Top Management Role	More Importance	Reasonable importance	Some Importance	Very little Importance	No Importance	Mean
a) Top level management interacts with employees that TPM is an essential part of industrial policy.	6	8	2	0	0	4.25
b) Do Management spares time for TPM and provides resources for TPM implementation.	5	7	4	0	0	4.06
c) Whether targets, action plans are described by top management.	6	8	2	0	0	4.25
d) Is TPM organization team formed comprising team leader, members etc.	2	1	8	5	0	3.00
e) Is there an involvement of production and maintenance team in machine / equipment selection decision?	9	6	1	0	0	4.50
f) Do the achievements in productivity through TPM by employees are rewarded by management?	8	4	3	1	0	4.19
Total/ Average	36	34	20	6	0	4.04

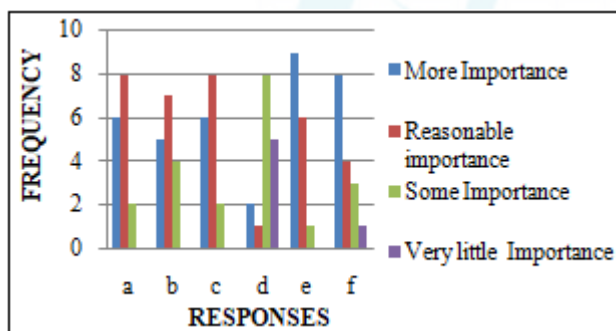


Figure 5.1 Survey Factor: Top Management Role

Table 5.2: Planned Maintenance Factor

Survey Factor: Planned Maintenance Management	More Importance	Reasonable importance	Some Importance	Very little Importance	No Importance	Mean
a) Is there an availability of efficient planned maintenance program exists that covers all plant machines?	4	4	8	0	0	3.75
b) Is there schedule made as a shift / Day reserved for maintenance activities?	8	6	2	0	0	4.38
c) Whether Planned Maintenance check sheets containing PM work is prepared for all equipment?	9	2	1	4	0	3.94
d) Is Monitoring and examination of machine failure is done regularly to take corrective actions?	9	5	2	0	0	4.44
e) Is Planned Maintenance schedule being followed consistently on time?	5	7	4	0	0	4.06

f) Is Maintenance inventory available when needed?	12	4	0	0	0	4.75
Total/Average	47	28	17	4	0	4.22

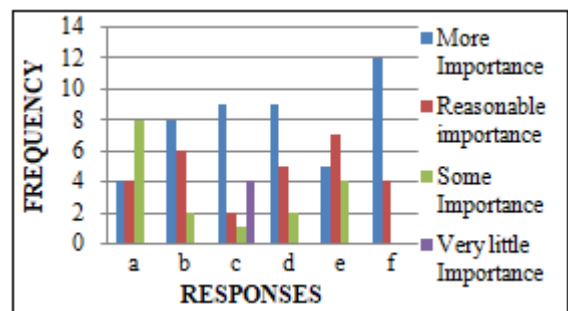


Figure 5.2: Planned Maintenance Factor

Table 5.3: Focused Improvement Factor

Survey Factor : Focused Improvement	More Importance	Reasonable importance	Some Importance	Very little Importance	No Importance	Mean
a) Whether any of Method of recording maintenance performance parameters being adopted?	10	4	2	0	0	4.50
b) Whether machines are in excellent working condition?	10	6	0	0	0	4.63
c) Do you feel even minor defects of equipment eliminated without delay?	10	3	3	0	0	4.44
d) Is Productivity information is available to all employees?	5	5	6	0	0	3.94
e) Use of Pareto chart, Fishbone diagram, FMEA etc. being done to analyze and eliminate losses.	8	6	2	0	0	4.38
f) Do you think TPM increases productivity and availability of the facility?	12	4	0	0	0	4.75
g) Is there a potential for improvement in the TPM program at your company?	12	2	2	0	0	4.63
h) Do you contribute to development of TPM?	6	4	6	0	0	4.00
i) Is there a logbook for every production facility?	5	5	5	1	0	3.88
j) Whether the failures are documented?	8	3	2	3	0	3.88
k) Are documented failures regularly checked & corrected?	8	6	2	0	0	4.38
l) Total/Average	94	48	30	4	0	4.31

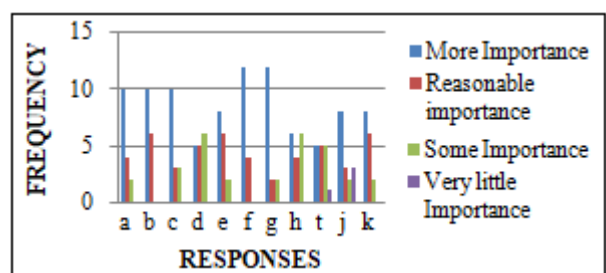


Figure 5.3 Focused Improvement Factor

Table 5.4 Autonomous Maintenance Factor

Survey Factor : Autonomous Maintenance	More Importance	Reasonable importance	Some Importance	Very little Importance	No Importance	Mean
a) Is there any initiative towards 5 s implementation?	6	6	3	1	0	4.06
b) Is there a provision placing all fixtures and tools in their places?	8	6	2	0	0	4.38
c) Do cleaning, lubricating performed properly?	8	8	0	0	0	4.50
d) Is there a small team formed for activity to help improve manufacturing processes in industry?	6	5	2	3	0	3.81
e) Solving the difficulties of hard to clean/inspect/access situations of machine tools in industry.	4	3	5	4	0	2.06
f) Are visual measuring gauge, Kanban system, TPM activity display boards, Labels etc. deployed?	6	6	2	2	0	4.00
g) Is demonstration of autonomous maintenance of machines is done for production operators?	8	6	2	0	0	4.00
Total/Average	46	40	16	10	0	3.83

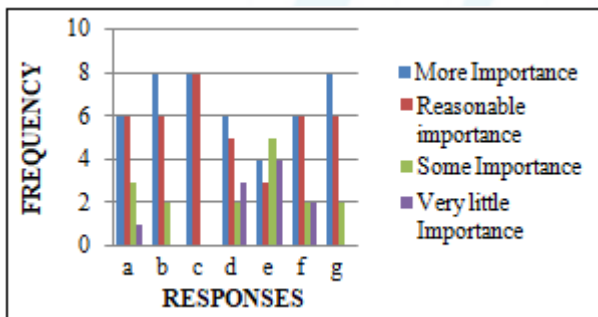


Figure 5.4 Autonomous Maintenance Factor

Table 5.5 Education and Training factor

Survey Factor : Education and Training	More Importance	Reasonable importance	Some Importance	Very little Importance	No Importance	Mean
a) Is TPM training conducted for all employees depicting concept of TPM, assigned roles of operators and maintenance people and expected benefits?	9	5	2	0	0	4.44
b) Are production operators trained to perform routine Planned Maintenance task, setting of machines?	9	4	3	0	0	4.38
c) Do all employees receive training to perform their respective tasks?	8	4	4	0	0	4.25
d) Is there a provision for conduction of staff development program that focuses on updating employees technical skills?	6	6	4	0	0	4.13
Total/Average	32	19	13	0	0	4.30

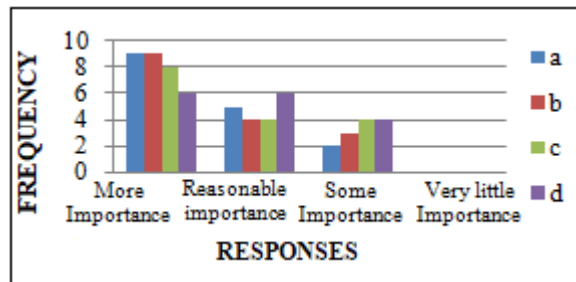


Figure 5.5: Education and Training factor

Table 5.6: Cost Reduction Factor

Survey Factor : Cost Reduction Factor	More Importance	Reasonable importance	Some Importance	Very little Importance	No Importance	Mean
a) Do you find there is reduction in operating cost due to TPM implementation?	10	6	0	0	0	5
b) Is there reduction in energy consumption and overhead expenditure after TPM implementation?	10	6	0	0	0	5
c) Whether maintenance cost is reduced after TPM implementation?	10	6	0	0	0	5
d) Reduction in downtime of equipment.	11	5	0	0	0	5
Total/Average	41	23	0	0	0	5

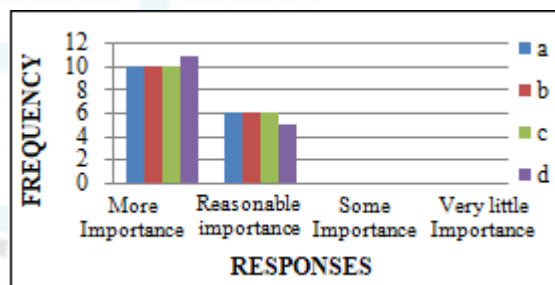


Figure 5.6: Cost Reduction Factor

Table 5.7 Quality Issues Factor

Survey Factor: Quality Issues	More Importance	Reasonable importance	Some Importance	Very little Importance	No Importance	Mean
a) Reduction in wastage, scrap and rework in operations because of TPM.	11	5	0	0	0	5
b) Improved customer satisfaction and conformance to the standard specification because of TPM implementation.	10	2	4	0	0	4
c) Improvement in overall product quality and processes within control limits because of TPM implementation.	11	4	1	0	0	5
Total/Average	32	11	5	0	0	5

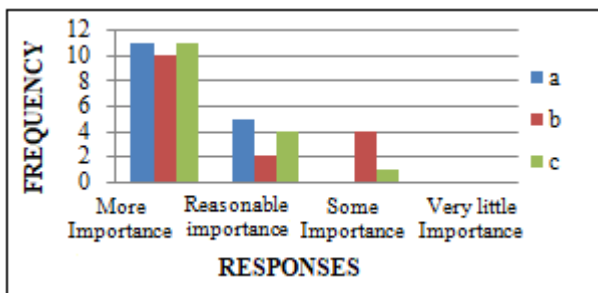


Figure 5.7 Quality Issues Factor

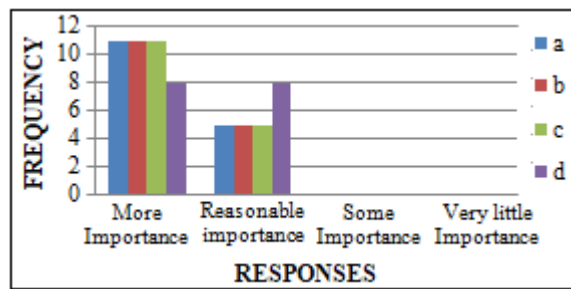


Figure 5.9: OEE and Productivity Concern

Table 5.8: Delivery Rate Factor

Survey Factor : Delivery Rate	More Importance	Reasonable importance	Some Importance	Very little Importance	No Importance	Mean
a) Achievement of dependable deliveries because of TPM implementation.	10	6	0	0	0	5
b) Reduction in process cycle time because of TPM implementation.	10	6	0	0	0	5
Total/Average	20	12	0	0	0	5

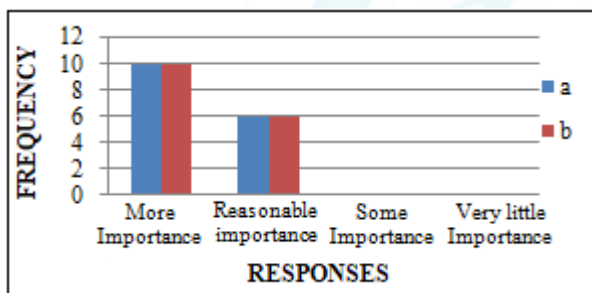


Figure 5.8 Delivery Rate Factor

Table 5.9: OEE and Productivity Concern

Survey Factor : OEE and Productivity Concern	More Importance	Reasonable importance	Some Importance	Very little Importance	No Importance	Mean
a) Improvement in equipment availability and reliability because of TPM implementation.	11	5	0	0	0	5
b) Reduction in setup times and downtimes because of TPM implementation.	11	5	0	0	0	5
c) Improvement in Overall Equipment Effectiveness (OEE) because of TPM implementation.	11	5	0	0	0	5
d) Improved control over production schedule because of TPM implementation.	8	8	0	0	0	5
Total/Average	41	23	0	0	0	5

The survey responses obtained for the top management role factor are positive enough to support TPM implementation since more importance and the reasonable importance cover the major portion of 74% for more importance level of the total responses. The mean value calculated is the weighted average of data collected. The maximum weight-age of 5 is taken for the more importance factor and 4, 3, 2 and 1 are for subsequent factors ranging from reasonable importance to no importance. The factor planned maintenance describes measure of availability of equipment and planned maintenance schedule along with monitoring of machine failures and maintenance activity performed on schedule. The responses are more concentrated, that is about 53% on more importance level. The factor focused improvement as a pillar of TPM depicts the methods of recording maintenance performance, use of statistical charts those contribute in deciding productivity. The factor autonomous maintenance explains 5s implementation, lubrication and cleaning of equipment done by operator by himself. The responses show about 78% for more importance level that indicates toward autonomous maintenance being carried out effectively. The factor education and training focused 50% on more importance level that means the employees are trained in maintenance activities and towards better production practices. Certainly, this indicates the education and training plays an important role in TPM implementation and Productivity improvement. The factor cost reduction in operation, energy consumption and downtime reduction after TPM implementation indicate clear concentrate at higher level of importance. The factor quality issues containing reduction in wastage and process being within control limits obtained have their distribution close to higher level of more importance. The achievement of dependable deliveries and reduction in process cycle time is made possible by TPM implementation. This statement conforms the implementation of TPM that is evident by the survey responses obtained. The factors OEE and Productivity are concentrated at higher levels of importance. This indicates higher availability, reliability and increase in OEE due to TPM implementation.

The following is a summary of the responses to the prepared pilot survey questionnaire by employees,

- Total Productive Maintenance has brought about improvement in both the operating and maintenance activities.
- TPM has improved the quality of work process and resulted in to improved overall equipment efficiency.
- TPM has created awareness and better understanding of organizational requirements and processes.

- A large number of bottlenecks have been eliminated as a result of the Total Productive Maintenance implementation.
- TPM has created safer working environment.
- TPM helps in diagnosing problem areas and to take corrective actions against malfunctions.
- There has been improved machine availability and reduced equipment failure as a result of TPM implementation.

The respondents felt that either maintenance or production departments are involved with TPM. The statistical results have shown a remarkable positive relationship between the Total Productive Maintenance program and plant efficiency. The results revealed that organizations that have implemented TPM had an increase in their production output. This is justified with reduced downtime, better quality products, increased machine speed and lower maintenance costs. The results show that it has also become easier to operate and work on equipment. The tabulated results from frequency distributions also show that TPM has increased productivity and reduced costs with safer working environment. This predicts that there is consistency in the responses obtained and the results calculated.

Conclusions on Survey Data

Based on the analysis of the survey, the following are the conclusions drawn:

- 1) The involvement of employees on TPM program irrespective of their departments indicates the trend of Autonomous maintenance.
- 2) Statistical results confirm that the TPM program impacts positively on productivity, downtime, quality and availability of the equipment and the plant. The table showing employee responses with regards to the TPM effectiveness has confirmed these results. So the hypothesis that without implementing TPM, industries cannot achieve increased productivity and meet their quality targets proved to be true.
- 3) There has been an increase in the availability of machines and improved quality as a result of the Total Productive Maintenance implementation. It concludes that the Overall Equipment Effectiveness of the organization has increased as result of the TPM program.

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