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# A Study on Productivity Improvement through Application of Total Productive Maintenance in Indian Industries - A Literature Review

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***Abstract:*** *This paper is a survey of TPM implementation results by industries. The paper reveals the important issues in Total Productive Maintenance ranging from maintenance techniques, framework of TPM, overall equipment effectiveness(OEE), TPM implementation practices, productivity improvement etc. The contributions of comprehensive TPM program towards improving production competencies of industries also taken care of. The review is carried out by surveying number of papers presented about various TPM implementation results demonstrated by industries. 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 focus of the study is to identify the success factors of TPM implemented in Indian industries. The purpose of this study is to survey the various tools of TPM applied to increase the productivity.*

***Key Words:*** *Total Productive Maintenance (TPM), 5 s, productivity.*

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## I. Introduction

Due to global competition, Indian industries are preparing themselves towards improvement in productivity. The quality of maintenance considerably affects productivity. The importance of maintenance functions has increased due to its role in keeping and improving the availability, product quality, productivity, safety requirements. 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. It enables a complementing relationship among all organizational functions, specifically between production and maintenance in improving product quality, operational efficiency, productivity and safety. TPM is a program that focuses on equipment maintenance through a comprehensive productive-maintenance system covering the entire life of the equipment and involving all employees from production team, maintenance personnel to top management. TPM is a philosophy of working together to improve equipment effectiveness. According to Nakajima [1], the word total in TPM has three meanings:

1. Total effectiveness indicates TPM's pursuit of economic efficiency and profitability.
2. Total maintenance system includes Maintenance Prevention and Maintainability Improvement. Basically, this refers to maintenance-free design through the incorporating the reliability and maintainability characteristics in to the equipment design.
3. Total participation of all employees includes Autonomous Maintenance by operators through small group activities. Essentially, maintenance is achieved through a team effort.

### 1.1 Development of TPM

Equipment management started with the concept of preventive maintenance that was adopted by Japanese Industries in 1951. Preventive maintenance was treated as a physical inspection and preventing possible breakdowns. The dedicated maintenance crew was formed. The Japanese company Nippon Denso Co. introduced program called Total Productive maintenance in 1971.

**1.2 Pillars of TPM**

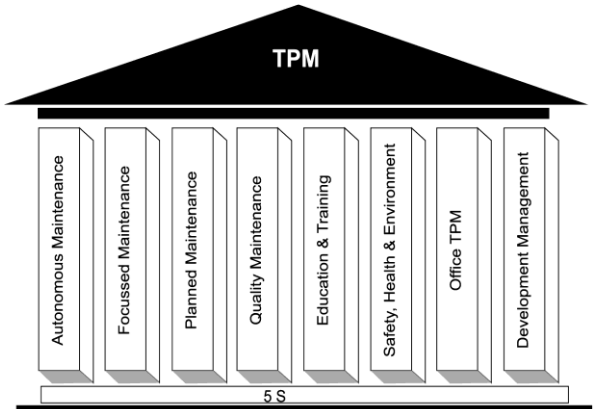


**Figure 1.2**Pillars of TPM (Source: Nakajima)

**Base – 5S**

This is base for TPM. 5s is a lean concept and it is a system of improving the process through reduction in wastage at plant. It is a process of maintaining plant to achieve a good environment or clean and tidy workplace. If 5s is not adopted, then it leads to process delays, defects, dissatisfaction, and reduction in production along with unrest among employees.

Following are the details of 5s,

Seiri – Sort - out: This means sorting out unwanted objects from the shop floor.

Seiton - Set in Order: This means arranging objects in a right order so that, they are readily available for use when needed.

Seiso - Shine: This means keeping the workplace free from burrs, grease, oil, water, waste, scrap etc.

Seiketso - Standardizations: This means to set and practicing standard procedures for different activities.

Shitsoke – Self - discipline: This means to train and orient people towards organized plant maintenance.

**Pillar 1 – Autonomous Maintenance (Jishu Hozen)**

Autonomous Maintenance is the process of keeping equipment upright by the operator by himself. The concept is that, the operators are responsible to keep their equipment ready by daily check-ups and prevent it from unprecedented breakdown. The activities required are regular inspection, lubrication and fixing up of deviations. The defects are monitored by careful inspection.

**Pillar 2- Focused Maintenance**

The critical issues with equipment or processes sometimes are difficult to identify. So, the cross-functional teams are made to investigate the troubles and to find right solutions. The problems identified are fixed so that, the resulting situation would provide a positive, cost-effective benefit. Identification and removal of losses may be made by FMEA analysis. The various losses may be listed as,Availability Loss includes all possibilities those halt planned production for a considerable length of time. These include unplanned halts, such as breakdowns and planned pauses, such as changeovers.Performance Loss includes the parameters those cause production to take place at lesser rate than the maximum possible speed. For example, Cycles at slower speeds and small pauses.Quality Loss includes rejection of produced pieces that do not match quality standards, including pieces those need rework.OEE counts all losses like availability loss, performance loss, and quality Loss that gives a measure of real production time.

Such losses may be minimized by following measures:

1. Tracking OEE for the considered equipment for one month. Perform compiling the results by various shifts.
2. Review all shift results, keeping follow up of the best individual result for availability, performance, and quality for all shifts.

**Pillar 3- Planned Maintenance (Kiekazu Hozen)**

This pillar suggests having a trouble free machine and equipment that increases the reliability, maintainability and also customer satisfaction.

Planned Maintenance is mainly divided into four categories:

(1) Preventive maintenance
(2) Corrective maintenance
(3) Predictive maintenance

(3) Breakdown maintenance
(4) Condition Based Maintenance

**Pillar 4 – Quality Maintenance (Hinshitsu Hozen)**

This pillar takes care of attaining the customer needs to obtain required quality by defect free production through focused improvement. It is the process of detecting reasons of defect. The process is completed by identifying the parameters of machine those affect the product quality. This is the process of transition from quality control towards quality assurance.

**Pillar 5- Education and Training**

This pillar aims in development of a trained employee to increase his morale that makes him to work eagerly and perform up to the mark. An operator is to be educated and trained to imbibe an ability to solve existing problems. The purpose of this pillar is to create a plant full of skilled employees. Training policy targets on improvement of knowledge and skill.

**Pillar 6- Safety, Health and Environment**

This pillar focuses on creating a safe workplace and surrounding. This pillar plays a key role since other pillars are dependent on this pillar. It is needed to create awareness among employees with safety measures, displays, enactments those publicize the safety practices and these are to be organized often.

**Pillar 7- Office TPM**

Office TPM is the seventh pillar and concentrates on all areas that provide administrative and supporting functions in the organization. The pillar applies the TPM principles in reducing wastages and losses from these departments. The pillar ensures that all processes support the optimization of manufacturing processes.

**Pillar 8- Development Management**

This pillar describes the methodology on how to produce new products and new arrangements at a very short time and at lowest cost. The tools and techniques that are to be followed at each step in the development of a new machine or the new product is to be defined clearly. Vertical start up, that is achievement of full production within a very short time can be met by adopting TPM and the methodologies are laid down by the Development Management Pillar.

### 1.3 Objectives of TPM:

TPM gives a new way of thinking which works not only on the shop floor but across all cross sections of the organization. TPM concept has a broad scope, focusing on customer, the organization and employees.

### 1.4 TPM implementation stages

TPM is the policy that is being implemented in different phases. The various stages may be described as,

A. Preparatory Stage
- Proposal of TPM implementation by management.
- Conducting awareness program.
- Forming TPM committees.
- Constituting TPM working system.
- Comprehensive plan for implementation.

**B. Introduction Stage**

In this stage, a small gathering is arranged that includes suppliers as they should know the quality policy of an organization to complement their effort towards betterment of product. Even people from related companies who can be the customers are also invited. In this stage customer will receive the message that, the organization care for quality output, keeping cost low and maintaining delivery schedule.

**C. TPM Implementation**

Pilot implementation: A TPM pilot implementation should cover between 10 and 25 percent of plant equipment with few selected machines. There will be a separate TPM team to insure sustainability of the implementation process. Areas appropriate for pilot installations are those major spots where improvement is needed (too many breakdowns, delays, or idle time, or low capacity or productivity) and where quick success is

likely. A good feasibility study is needed for all pilot areas. All employees in the pilot areas must receive TPM training. Clear goals and deadlines must be established and team meetings must be held on schedule.

Plant-wide implementation: TPM crew of most organizations observes before expanding the TPM implementation over the whole plant. A good and well thought out expansion plan is prepared.

**D. Executing Stage**

By this stage, the TPM Implementation activities would have reached to the final stage and is achieved by preventive maintenance policy. By execution of TPM the improvement in efficiency is to be measured. Following are the terms related to measurement of efficiency and performance.

1) Availability: It can be defined as the ratio of difference in time of production to operate the equipment and the other planned downtime to the required availability.

2) Performance: It can be defined as the design cycle time to produce the item multiply by the output of the equipment and then divided by the operating time.

3) Quality: It is the ratio of production output to the production input.

4) Overall Equipment Efficiency: It is the product of Availability, Performance, and Quality.OEE is the product of availability, performance and Quality.

**1.3 Benefits of TPM**

Tangible Benefits:

The review of various journals shows that the implementation of TPM results in Tangible benefits in the different aspects, such as productivity, minor pauses, breakdowns, accidents, water and steam consumption, lubricant consumption, defect rate, labor productivity, overall equipment effectiveness.

Intangible Benefits:

Autonomous maintenance activity as a pillar of TPM motivates operators to take care of machines by themselves without being ordered to. With achievement of zero breakdowns and zero defects, operators get new confidence in their own abilities. Workplaces those used to be covered with oils & chips become clean and pleasant.

**1.6 Productivity Measurement**

In the course of TPM implementation there is need of measuring productivity that is focus of our study. Productivity is a measure of ratio of production output to the raw material input. Productivity when quantified by specific parameters is termed as partial productivity based on output per labor hours, units per shift machine hours or output per unit machine. When more than one resource is used in production, the productivity is termed as multifactor productivity. The total productivity includes all inputs in an organization in terms of revenue generated and inputs supplied.

Total productivity is the broadest measure of production and is concerned with the performance of entire plant or organization.

## II. Literature Survey

In 2001, Irel and and Dale[2] in their paper, "A study of TPM implementation" with case studies of three companies followed Nakajima's seven steps of Autonomous maintenance. These three companies were suffering from major losses like inadequate skill levels, low employee participation in its affairs and lack of application of appropriate continuous improvement. The process of TPM involved steering committee to achieve zero losses, create system to maximize efficiency and developing small group activities, optimum operating conditions by modifying the machine tools.

In 2004, Shaukat Ali Brah [3] published paper on Relationship of TPM and Performance made the following constructs namely, Corporate strategic learning, Top management leadership, Contextual focus, Human resource focus, Process focus, TQM Focus, Information system focus

The study was conducted on the hypothesis base that, there is a significant relationship between TPM and Business performance. It was carried out by preparation of questionnaire. The measurement verification scales were used for reliability of data were, Cronbach's alpha, Factor Analysis, Pearson's correlation to measure correlation.

The study proved business performance of TPM firms being far superior to non-TPM firms. The study also revealed that for implementation of TPM requires integrated effort of the whole company.

In 2005, an international journal paper on TPM can go beyond maintenance: excerpt from a case implementation [4], by Shamsuddin Ahmed, Masjuki Hj. Hassan and Zahari Taha University of Malaya, Kuala Lumpur, Malaysia, explains a well-planned TPM implementation not only improve the overall equipment effectiveness but also brings considerable developments in all areas of a manufacturing organization. The small

groups of autonomous teams were formed in an organization. It resulted in minimization of customer complaints, reduction of inventory levels and increase in the quality production rates as well as sales profit status.

In 2005, According to F.T.S Chan et al. [5], recent trends indicate many systems in use are not performing as intended and about 28% of total production cost is attributed to the maintenance activities. To overcome this situation TPM is an aggressive strategy that aims to increase availability and effectiveness.

In 2006, the paper on evaluating the efficiency of implementing Total Productive Maintenance [6], by Fu-Kwun Wang, National Taiwan University of Science and Technology, Taiwan, describes Total Productive Maintenance (TPM) has been widely recognized as a strategic tool for improving manufacturing performance. The evaluation of TPM efficiency can assist factories in improving their operations across a variety of dimensions. In particular, it helps factories in monitoring their performance in comparison with other factories. The Data Envelopment Analysis (DEA) was used to evaluate the efficiency score. A prediction model by the multiple regression method was obtained. This regression equation was used to obtain the expected efficiency score for checking the performance of implementing TPM. The actual improvement process involved, identifying the operating practices and procedures of the benchmark factories and engaging in re-engineering programs. The conclusions were made on methodology and analysis on the proposed model. This article has proposed a simple methodology for efficiency evaluation in TPM. The analysis is based on a CCR (Charnes, Cooper and Rhodes) model with input minimization that allows for incorporation of multiple inputs and outputs in evaluating a single, composite score, referred to as efficiency. Classifying factories of four categories benchmarks are provided for improving the operations of poorly performing factories. The efficiency scores resulting from the DEA for all identified units were obtained during the study period. Further a multiple linear regression model was constructed to estimate the efficiency score of implementing TPM. The company can use this multiple linear regression model to obtain the estimated efficiency score for monitoring the efficiency of implementing TPM.

In 2008, the paper, Implementation of Total Productive Manufacturing Concept with Reference to Lean Manufacturing in a Processing Industry in Mysore [2008]: A Practical Approach [7], by V Ramesh, K V Sreenivasa Prasad and T R Srinivas, Sri Jayachamarajendra College of Engineering (SJCE), Mysore, India, explains Total Productive Maintenance plays an important role in effectively managing the machines and in improving the machine capability. TPM is not the same activity like a maintenance department that repairs breakdowns. TPM is a critical adjunct to lean manufacturing. If machine up time cannot be predicted and process capability not sustained, then it may not be possible to produce the products at the required rate. TPM is not for fixing machines, but to prevent deterioration and reduction in maintenance. For this reason, often TPM is referred as 'Total Productive Manufacturing' or 'Total Process Management'. TPM is a proactive approach that essentially aims to prevent any kind of delay before occurrence. Its purpose is 'zero error, zero work-related accident, and zero loss.' TPM is considered to be the medical science of machines and is a maintenance program, which involves a newly defined concept for maintaining plants and equipment. The goal of the TPM is to considerably increase production along with increasing employee morale and job satisfaction. This study was done in a medium scale industry that manufactures tires in Mysore. It was observed that, the breakdown of some of the mills has been critical. So, it was decided to apply Total Productive Maintenance (TPM) concept to this industry. In this paper, data was collected of the breakdowns of a four roll calendar mill, a four roll calendar warm-up mill and a warm-up mill overhead conveyor and discussion is on the remedial measures for reducing the breakdowns of the four roll calendar mill. Lean manufacturing tools like Cause and Effect diagram, why-why analysis and Kaizen techniques are applied for the analysis. By implementing Kaizen, equipment availability for production was improved. In turn, Overall Equipment Efficiency (OEE) increased considerably. Further, Kaizen implementation resulted in the reduction of idle man and machine hours. The case study of Jishu Hozen (Autonomous Maintenance) on four roll calendar warm-up mill revealed that the down time was due to the telescopic rod assembly. Improvement of the rod reduced the breakdown from 560 minutes/month to 80 minutes/month. Secondly, a Kaizen technique was implemented on four roll calendar and the study yielded new avenues of improvements in the process of manufacture. In summary, the TPM has a double sided advantage for management of lean production process in any manufacturing setup. It improved the cycle-time, reduced machine breakdowns and built a psychological well-being and confidence from shop floor operator to works manager. It also improved the productivity, efficiency and drastically reduced the breakdowns leading to the reduction of idle time of the line.

In 2010, the paper, Methodology for TPM Activities: A Practical Analysis [8] by Mahesh Pophaley, Medi-Caps Institute of Technology& Management, Indore, India, describes equipment maintenance has traditionally been viewed as a separate entity outside of the manufacturing process. When organizations started to identify the role of maintenance in the manufacturing process, a gradual change in thinking started. With increasing importance, plant maintenance is no more regarded as nonproductive activity but now it is widely accepted that plant maintenance has a great impact on the overall profitability of an organization. However,

traditional approach to maintenance cannot provide any considerable improvement. Total Productive Maintenance, as an effective industrial maintenance program, seems to be providing the solution. TPM is a new and fast catching up concept among industries. Further equipment effectiveness calculation has been the helping tool for plant managers in identifying the inefficiencies and determining where to focus for improvement. Traditionally, equipment performance has been measured using various matrices, but the Overall Equipment Effectiveness (OEE) is being used as an evaluation metric to judge the effectiveness of TPM implementation since its execution. This work was done on previous outcomes, that examined the role of OEE measurement systems in TPM, with due reference given to developing a new framework for assessing the implementation effectiveness of TPM. This research work was targeted to develop a new model and its analysis for measuring the TPM implementation effectiveness as per the definition of TPM. The conclusion was made as, the original OEE is oriented towards equipment inefficiencies, but it has evolved its different OEEs in order to measure total plant effectiveness or to translate inefficiencies into economic terms (e.g., overall process effectiveness, overall system effectiveness, etc.). This evolution had been necessary to adopt the original OEE to the increasing management requirements. This emphasizes the necessity of translating achievements into measurable terms so the research work proposed a new OEE metric, oriented towards the quantification of TPM implementation effectiveness objectives. The proposed TPM-effectiveness model has to be tested in a company, where the original OEE has been done previously. It was found that the results of the new model helped the operators and executives to quantify the results of investments made in TPM efforts. The total concept is based on: "Measurement is an important requisite of the continuous improvement process".

In 2011, the paper, Measuring efficiency of total productive maintenance (TPM): a three-stage data envelopment analysis (DEA) approach [9], by Jeonghwan Jeona, Chulhyun Kimb and Hakyeon Leec, Seoul National University, South Korea, opines that, Total productive maintenance is a manufacturing strategy that has been successfully employed globally for the last three decades. A prerequisite for benefiting from TPM is to measure the performance of TPM activities. The overall equipment effectiveness has widely been used as a performance measure of TPM activities. It is required to measure the performance of TPM implementation in terms of efficiency. This study was made to measure the efficiency of TPM implementation using data envelopment analysis (DEA) with consideration of the overall process of TPM implementation. Since more and more organizations have started relying on self-directed work team (SDWT) to accomplish organizational tasks in TPM implementation, the study employed SDWT as a unit of analysis. The process of TPM implementation is taken up in a three-stage model: stage 1 (from TPM input to TPM intermediate output), stage 2 (from TPM intermediate output to TPM final output), and stage 3 (from TPM input to TPM final output). Every SDWT in every team is evaluated together by DEA for each stage. The relationships between the efficiency scores of the three stages are analyzed by correlation analysis. Along this, cluster analysis was conducted to identify different types of SDWTs in terms of TPM implementation. The study concluded with the measurement of the efficiency of TPM by SDWT using DEA. It was found that SDWTs efficiently transforming intermediate outputs into final outputs are also efficient at transforming inputs into final outputs. SDWTs were grouped by efficiency scores of the three stages: activity-oriented group, result-oriented group, and all-efficient. The findings of this study provided fruitful implications for the firm to manage and implement TPM more efficiently. The research work concluded in to the following inferences: Firstly, original scores of TPM were taken from the short period. Data with longer periods would trace the way to investigate the influence of TPM more deeply. Time series analysis will also be relevant for measuring TPM performance. Secondly, although the unit of analysis is SDWT, the TPM final outputs were measured by a group. Measuring final outputs for each SDWT is expected to produce more realistic results. Thirdly, it will be useful to analyze the relationship between the efficiency of TPM implementation and manufacturing performance in future research since TPM practices are ultimately intended to contribute to improving manufacturing performance.

In 2013, an international journal paper on Study of Total Productive Maintenance and its Implementing Approach in Spinning Industries [10], by Sarang G. Katkamwar1, Sadashiv K. Wadatkar, Ravikant V. Paropate, India, presents the study and overview for the implementing approach of Total Productive Maintenance in Indian spinning industries. The study is carried out in medium scale cotton spinning industry using the observations supplemented with documents collection. The TPM implementation methodology is suggested for improvement in the availability, performance efficiency and the quality rate, results in improvement of the overall equipment effectiveness of the equipment. The aim of this paper was to suggest and study the implementation of the TPM program in the spinning industry. After implementation of TPM on model machine, both direct and indirect benefits were shown to be obtained for equipment and employees respectively. It is team-based preventive and productive maintenance and involves every level, from top executive to the floor operator. TPM has been proven to be successful for helping to increase the productivity and overall equipment effectiveness. TPM can be defined as a program for fundamental improvement of the maintenance functions in an organization, which involves its entire human resources.TPM philosophy requires the development of a preventative maintenance program for the life-cycle of the equipment and the involvement of operators in

maintaining the equipment in order to maximize its overall efficiency and effectiveness.TPM is all about Total Plant Maintenance. The underlying concept is, if the plant machinery properly maintained there will see a sharp decline in machine breakdowns, safety and quality problems. There is emerging need for TPM implementation in the Indian Industry and need to develop TPM implementation practice and procedures. The conclusions of the paper is that, Total productive maintenance successfully gives the improvement in the availability, performance efficiency and the quality rate, results in improvement of the overall equipment effectiveness of the equipment. TPM is the effective tool to increase the productivity of Indian industries. One can compete with the other countries in this increased globalization. Spinning industries can also have the benefit of TPM for the improvement in all aspects. While implementing TPM, it is found that, there are some barriers for effective implementation of TPM, such as lack of management exposure, difficulty in understanding TPM methodology and philosophy by middle management, long time taken for implementation because of people showing strong resistance to it. But it is the only thing between the success and failure for many companies as far as the maintenance is concern. The aim of this paper was to spread awareness about TPM methodology in modern technocrats and industries in India. It was tried to understand the TPM concepts for the Indian scenario.

In 2013, the paper by Ranteshwar Singh et al. [11] describes the quality and maintenance of manufacturing system is closely related functions of any organizations. It was observed in industry that, there is huge wastage occurring due to operators, process, tooling problems and non-availability of components in time. The paper is an exclusive study on quality improvement of product by implementing TPM is established.

In 2015, the paper on Productivity improvement in small scale industries [12] by Venugopal, Amrita Vishwa Vidyapeetham University, Coimbatore, describes that the Small scale industries play an important role in Indian economy and TPM has emerged as powerful tool in providing relatively larger employment next to agriculture. It contributes more than 50% of the industrial production in value addition terms and generate one third of the export revenue. Global markets are continuously changing and demanding product of high quality at low cost. In this paper, the needs of TPM implementation in Indian SMEs and its effects on productivity, quality of product, culture of the organization, maintenance activity etc. are discussed. The outcomes of literature of case studies dictate that the implementation of TPM in SMEs is still very low or negligible in India. Therefore, more effort should be given in developing a better model or there is a need to develop a proposed model for TPM implementation in SMEs. The objective of this paper was to study the roll of OEE in Indian manufacturing industries either from small scale to large scale industries. Through a case study of implementing TPM in a small scale Industry for enhancing OEE of the company, assessment of performance losses in the production facilities, contributions of TPM initiatives in improving the organizational performance are discussed and analyzed. The conclusions done by author are summarized as follows. The higher productivity can increase people's real income and improve their ability to purchase goods and services, enjoy leisure activities, access better housing and education, and contribute to social and environmental programs. Thus the productivity improvement is essential for any Industry. In today's world the competition in industry at an all-time high, TPM may be the only thing that stands between success and total failure for some companies. It has been proven to be a program that works. It can be adapted to work not only in industrial plants, but in construction, building maintenance, transportation, and in a variety of other situations. Employees must be educated and convinced that TPM is not just another "Program of the month" and that management is totally committed to the program and the extended time frame necessary for full implementation. TPM is not merely a concept but a practical and simple to adopt technique for achieving significant savings and increase in profits. Involvement of everyone in a TPM program by performing ones part, a high rate of return compared to resources invested may be expected. Finally, it is concluded that the process can be improved based on method study, work procedure and proper utilization of machine and material. It will improve the current process by reducing the number of workstations, transportations, combining the operations and reducing the workers' fatigue. After implementing the suggested improvement ideas small scale industries can be able to increase its productivity. Hence, it is concluded that all new concepts, tools, techniques, models and incentive schemes must be tried to enhance small industrial productivity. There is a lot of potential for improvements in industrial performance of the industries by using advanced approaches to improve industrial performance in highly competitive world.

In 2015,a journal paper on A Systematic Approach towards Implementation of TPM in an Automobile Industry [13] by Rachin Goyal, Dr. Sandeep Jindal, evidences that a well-drawn TPM implementation plan not only improves equipment efficiency and effectiveness but also brings appreciable improvements in other areas such as reduction of manufacturing cycle time, size of inventory, customer complaints, and creates cohesive small group autonomous teams and increases the skill and confidence of individuals. The resulting system is found to be more productive in terms of both partial and total productivity measures. The Purpose of this paper is to evaluate the success of TPM on the basis of improvement in overall equipment effectiveness (OEE) as it has been found to be a very important parameter for success of TPM implementation. Maintenance is undertaken to preserve the proper functioning of a physical system, so that it will continue to do what it was designed to do. Recent trends indicated that many systems in use were not performing as intended, so far as

effectiveness in terms of their operation is concerned. Manufacturing systems often operate at less than full capacity, with low productivity and the cost of producing products are high. So the author concludes the implementation of TPM in the following way. In today's times TPM can be adapted to work not only in industrial plants, but in construction, building maintenance, transportation, and in a variety of other situations. While implementing TPM there existed some barriers for effective implementation of TPM, such as lack of management exposure, difficulty in understanding TPM methodology and philosophy by middle management, long time taken for implementation and even people showing strong resistance to it. Employees must be educated and convinced that TPM will bring increase in productivity and so the profitability of the plant. The management is to be totally committed to the program and implementation of TPM. One of the important and widely used methods of measuring performance in manufacturing is OEE especially for firms applying TPM. TPM activities in administrative and support departments do not involve production equipment, but these departments increase their productivity by documenting administrative systems and reducing waste and loss. Total productive maintenance is one of the best tools for making our industries competitive and effective in the field of maintenance. TPM may be the only thing that stands between success and total failure for many companies.

In 2017, Swapnil and Niyati [14], describe in their paper about the main goal of effective TPM program effort is to bring critical maintenance, skilled trades and production personnel together. Total employee involvement, autonomous maintenance by operators, small group activities to improve equipment reliability, maintainability, productivity and continuous improvement are the principles embraced by TPM. The losses were observed in housekeeping of machines, time loss during loading and setting of job, time loss during change over from one job to another, breakdowns. The paper contains the work done to improve OEE by TPM implementation on various selected machines like bolt forming, drilling, rolling and surface grinding. The following table referred from the paper indicates the effect of TPM implementation.

**Table 2.1** Benefits of TPM implementation
(Source: Swapnil and Niyati 2017)

| | Before TPM Implementation | After TPM Implementation |
|---|---|---|
| Availability (%) | 48.46 | 93.69 |
| Performance (%) | 94.52 | 95.4 |
| Quality (%) | 99.81 | 99.9 |
| OEE (%) | 36.19 | 82.6 |

In 2017, Saureng et al [15], explains in their paper about the work done on equipment-wise breakdown analysis and study in steel industry. Since the study cleared the frequency of Mechanical breakdowns is higher, the case study has been focused on prevention of Mechanical breakdowns. The comparative study of breakdowns has been illustrated in the following Pie diagram in Figure 2.2.In the conclusion of this case study, six months breakdown analysis has been performed and observed during six months total of 146 numbers of breakdown occur with maximum 66% breakdown occur in Mechanical section i.e. 96 breakdowns out of 146. Hence, finally it is observed that equipment identified with often breakdowns, there is need of corrective action & preventive action (CAPA) is required to accomplish TPM goal.

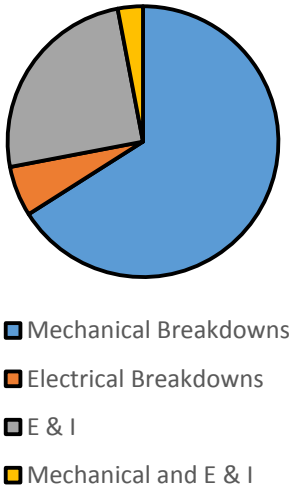


**Figure 2.2** Section-wise Breakdown
(Source: Saureng Kumar et al. TPM on Steel Industry, 2017)

In 2017, Nofri Eka Candra et al. [16], presented paper on TPM implementation to improve machine performance are quantified by OEE measure. The analysis on big losses was done by fishbone or cause and effect diagram as follows,

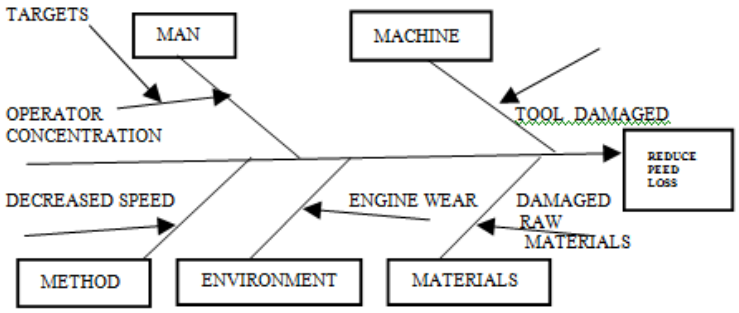


**Figure2.3** Cause and Effect Diagram
*(Source: Nofri Eka Candra et al., 2017)*

**Figure2.3** Cause and Effect Diagram
(Source: Nofri Eka Candra et al., 2017)

From the fishbone diagram it was recommended for the company to focus more on machine maintenance such as, implementation of autonomous maintenance and conduct multi-skill training for operators to improve the ability and expertise of them to tackle the existing problems to reduce OEE losses value on the machine for the future.

## III. Research Gap Analysis

The literature survey reveals that, lot of research work is going on TPM implementation, barriers in implementing, effect of it on OEE, reduction in accidents and development of different models of TPM. The literature study shows there was an increase in availability and maintainability of equipment in the plant.

In 2005, F.T.S. Chan, H.C.W. Lau b, R.W.L. Ipc, H.K. Chan, S. Konga [5] Implementation of total productive maintenance: A case Study, have concluded with following inferences. The general aim of the project is to study the effectiveness and difficulties encountered in an electronics manufacturing company during the TPM implementation and also the major success factors that contribute to the success of TPM. The objective of this project is to study the implementation of TPM and the evaluation of its result on model machine in front-end section, Automated Assembly Department.

In 2012, Ranteshwar Singh, Ashish M Gohil, Dhaval B Shah, Sanjay Desai [11] in the paper Total Productive Maintenance (TPM) Implementation in a Machine Shop: A Case Study, following conclusion is derived from implementation of TPM in the machine shop of automotive company. Those are listed as, 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.

In 2017, Jonathan David Morales Méndel & Ramon Silva Rodriguez [19] concluded in the paper Total productive maintenance (TPM) as a tool for improving productivity: a case study of application in the bottleneck of an auto-parts machining line, International Journal of Advanced Manufacturing technology, that the organized and dynamic involvement of all areas with the production processes via TPM generates solid and sustainable productivity increases.

The above survey shows that, there is much less work has been carried out on the gross effect of TPM on productivity of the plant.

There various kinds of productivity measures for quantification which may be listed as, Partial Productivity, Multifactor Productivity, Energy Productivity, Total Productivity

The present research work is to be carried out on the effects of TPM implementation on productivity. There are many parameters affecting the productivity like, Management policies, Worker performance, Machine /equipment performance, Raw material compatibility

Among the parameters listed above, this study is intended to be focused on machine and equipment availability, maintainability and performance towards productivity improvement. The study is planned to measure the productivity losses because of machine breakdowns. The related losses by workers idle time, losses

due to delays in deliveries are monitored and remedial actions taken by TPM implementation. The tools like Autonomous Maintenance, Focused Improvement, Planned Maintenance, Root-cause analysis are being used to analyze and reduce the wastages.

This study is proposed to be conducted among selected industries those are planning to implement TPM, those already started implementing TPM and also those companies which have executed TPM. The relationship between the implementation factors and performance are to be analyzed. According to the book 'TPM Reloaded' by Joel Levitt [29], the objectives of TPM result in to the reduction of scheduled and unscheduled downtime, increase in speed of the machine, decrease in product and process variability and reduction in lubrication oil consumption.

Research objectives are to assess the impact of top management commitment, to assess the impact of equipment and process management practices on performance of equipment, to assess the impact of Training and development practices on performance of equipment, to assess the impact of Measurement, Analysis and Improvement practices on performance of equipment from various manufacturing companies.

The research study data is to be collected by the questionnaire prepared. The questions regarding these implementation factors are derived from the previous research queries in this area and also with references from books of TPM. The data collection is by direct interview with officials, by observing the plants, verifying the secondary data etc.

The companies are identified on a judgment sampling method those include both TPM awarded companies and those already started implementing the TPM practices. The equipment is selected by simple random sampling from the selected companies.

## IV. Conclusions

The literature review highlights the contributions of various TPM implementation initiatives for obtaining positive effects for facing the challenges posed by global competition. TPM has emerged as a key competitive policy for industrial organizations in the global front. An effective TPM implementation program addresses the organization's maintenance related difficulties in a view to optimize equipment efficiency. TPM has become a new management tool in all types of industrial organizations. In recent time, many industrial organizations have proved that significant improvements in organizations can be obtained through TPM. TPM philosophy can be effectively employed to apprehend considerable improvements of manufacturing efficiency in the industrial organization, which leads the industry efficiently in the highly competitive environment. TPM is expected to prove as an efficient policy for contributing the industrial units a consistent improvement of performance in achieving core competencies. So, in the highly competitive environment, TPM may prove to be the best among the proactive initiatives that can help the industrial organizations to score new heights of attainments.

The questionnaire for the survey of selected industries is to be prepared. The primary and secondary collected by the survey is to be analyzed to discuss about the benefits of TPM implementation.

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