

# Implementation of Total Productive Maintenance (TPM) to Improve the Operational Efficiency of a Plant

\* Asmita Joshi

## Abstract

*The purpose of this paper is to evaluate the contribution of Total Productive Maintenance (TPM) in improving the operational efficiency of an automobile component manufacturing company. It explains the steps in implementation of TPM. The paper also explains the way in the organizational objectives as stated in the vision and mission of the organization can be realized using TPM. TPM is a Japanese approach of maintenance that maximizes machine utilization through better utilization of maintenance and production resources. TPM activities lead to good results and contribute to improve the operational efficiency parameters PQCDMS (Productivity, Quality, Cost, Delivery, Safety and Morale). Employee involvement is the key to improve the operational efficiency. The aim of TPM is zero BAD i.e. zero breakdown, zero accidents and zero defects. The entire process from declaration, target setting to master plan for achieving the results is explained with the help of a case study.*

**Keywords :** Total Productive Maintenance (TPM), Operational Efficiency, PQCDMS

## Introduction

Total Productive Maintenance (TPM) can be considered as the medical science of machines. TPM is a maintenance program which involves maintaining plants and equipment. The goal is to hold emergency and unscheduled maintenance to a minimum.

TPM is an innovative approach of maintenance developed by Japanese manufacturers for their plants and machines. TPM maximizes machine utilization through better utilization of maintenance and production resources. The ultimate goal of TPM is to develop an operational system which is maintenance free. TPM activities lead to good results and contribute to improve the operational efficiency parameters PQCDMS (Productivity, Quality, Cost, Delivery, Safety and Morale). Employee involvement is the key to improve the operational efficiency. The aim of TPM is zero BAD i.e. zero breakdown, zero accidents and zero defects. This done by creating a workplace where machines are simple to operate, work can be done safely and easily, and productivity is high.

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\* Assistant Professor, Mahatma Gandhi Mission Institute of Management, Aurangabad

## Objectives of the Study

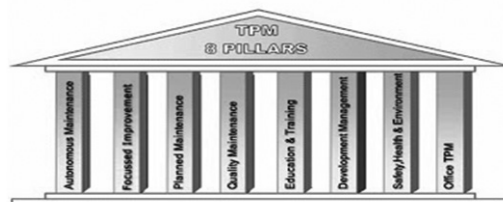
1. To understand the methodology of implementation of TPM in the selected organization
2. To understand tools and techniques used to implement TPM
3. To study the impact of TPM on operational efficiency of the organization

## Conceptual Background

TPM has 8 pillars of activity, each being set to achieve a “zero” target. These 8 pillars are:

1. Focused Improvement (Kobetsu Kaizen-KK): Increasing productivity, production and cost reduction
2. Autonomous Maintenance (Jishu Hozen-JH): Involvement of operators in maintenance activities
3. Planned Maintenance (PM): Concept of zero breakdown
4. Quality Maintenance(QM): Concept of zero defects
5. Training and Education (T&E): enhancing knowledge of employees at all levels
6. Office TPM (OTPM): Improvement of office working
7. Development Management (DM): Development of machines and lines in lesser time and cost
8. Safety, Health, and Environment (SHE): Concept of zero accidents, creating a safe and better workplace

Few organizations also add Pillars according to their work place requirement like Vendor Improvement, Tools improvement etc.



**Fig 1: TPM Pillars**

Implementation of any quality improvement system is a management initiative. This top down approach ensures allotment of required resources to achieve the objectives of the organization. Following are the steps in implementation of TPM:

## **Stage – I: Preparatory Stage**

- 1) Declaration by Management: Official announcement is made by the top management about their decision to implement TPM in the organization. Interlinking of Mission, Vision and TPM policy is done. It is informed to all employees through different modes of internal communication.
- 2) Initial training and awareness: Top management identifies key people who would be assigned to carry out the TPM related tasks in their respective cells / units / departments. A visit of these people is arranged to organizations who have successfully implemented TPM. Training is given to all the people involved which is either in-house or by a consultant.
- 3) Setting-up Committees: Pillar chairman is identified for each pillar. A TPM circle comprising 8 to 10 people is also established. Depending upon the size and scope of working, a cell may have multiple TPM circles. A plan for working of the pillar is drawn. This step integrates the ISO / TS / OSHAS and TPM system activities.
- 4) Setting the target: Based in the internal benchmarking, a target is set for each activity. Business targets are translated into plant level targets, pillar targets and cell level targets. The target is expressed numerically in most of the cases.
- 5) Master plan: To achieve the targets, activities which are to be done are identified. Then the required resources are committed to the cause and a schedule is drawn for each activity.

## **Stage - II: Introduction Stage**

- 1) Kick-off: Once the master plan is approved, a kick-off ceremony is organized. The suppliers, customers, OEMs are all invited to this function. This function lets the stakeholders know about the commitment of the organization to achieving excellence and it also raises the morale of the employees.

## **Stage – III: Implementation stage**

- 1) Phase – I: The TPM implementation is done on two phases. Phase-I focuses on the shop floor activity and includes five pillars namely: KK, JH, QM, PM and SHE. A model machine or model cell is chosen to implement these five pillars. After achieving the desired results, the company goes forward to implement these five pillars in other cells. After the satisfactory achievement of the set targets, the company challenges the TPM award. The OEM or the organizations where the parts are supplied are invited for the TPM audit. After successfully facing the audit, the organization gets the TPM award.
- 2) Phase-II: Next the organization decides to go wider and deeper by increasing the scope of TPM activities. This is done by implementing all the 8 pillars organization

wide. This organization wide implementation results in achievement of the organization targets as per the TPM policy.

#### **Stage – IV: Institutionalizing stage**

- 1) Sustain: After reaching a maturity level, the company now aims at sustenance and achieving higher targets. The company can now challenge the TPM excellence award. The highest award is the Japanese Institute of Plant Maintenance JIPM TPM award.

#### **Literature Review**

The purpose of literature review is to study the literature on WCM and to present an overview of WCM implementation practices adopted by the manufacturing organizations. An extensive literature review was done related to the topic.

TPM is a unique Japanese philosophy, which has been developed based on the Productive Maintenance concepts and methodologies. This concept was first introduced by M/s Nippon Denso Co. Ltd. of Japan, a supplier of M/s Toyota Motor Company, Japan in the year 1971. Total Productive Maintenance is an innovative approach to maintenance that optimizes equipment effectiveness, eliminates breakdowns and promotes autonomous maintenance by operators through day-to-day activities involving total workforce (Bhadury, 2000). A strategic approach to improve the performance of maintenance activities is to effectively adapt and implement strategic TPM initiatives in the manufacturing organizations. TPM brings maintenance into focus as a necessary and vitally important part of the business. The TPM initiative is targeted to enhance competitiveness of organizations and it encompasses a powerful structured approach to change the mind-set of employees thereby making a visible change in the work culture of an organization. TPM seeks to engage all levels and functions in an organization to maximize the overall effectiveness of production equipment. This method further tunes up existing processes and equipment by reducing mistakes and accidents.

Focused (Continuous) improvement is an essential requirement for sustaining and gaining a competitive advantage for the organizations. A successful continuous improvement program is one where in the operational defects are eliminated at the root cause level and are prevented from reoccurring. According to Anil S. Badiger, R. Gandhinathan, V.N.Gaitonde, Rajesh S. Jangaler (2003), TPM methodology is a proven approach to increase overall equipment effectiveness (OEE) of equipment.

H. Yamashina, (2000) deals with the basic requirements for world-class manufacturing and discusses the role of total productive maintenance (TPM) in helping to achieve world-class manufacturing. It examines the roles of TPM in TQM and JIT. Finally, impacts of TPM on the culture and structure of the organization are discussed and pitfalls of TPM implementation are dealt with. Provides an in-depth look at the development

of Japanese manufacturing strategy and concludes with the view that the first step to world-class manufacturing is to implement TPM successfully and to create an active organization.

Melesse Workneh Wakjira, Ajit Pal singh (2012). This paper evaluates the contributions of TPM initiatives towards improving manufacturing performance in Ethiopian malt manufacturing industry. The correlations between various TPM implementation dimensions and manufacturing performance improvements have been evaluated and validated.

TPM is a world class manufacturing (WCM) initiative that seeks to optimize the effectiveness of manufacturing equipment (Shirose, 1995). Whereas maintenance departments are the traditional center of preventive maintenance programs, TPM seeks to involve workers from all departments and levels, including the plant-floor to senior executives, to ensure effective equipment operation. Over the past two decades, manufacturing organizations have used different approaches to improve maintenance effectiveness (Roup, 1999). One approach to improving the performance of maintenance activities is to implement and develop a TPM strategy. The TPM implementation methodology provides organizations with a guide to fundamentally transform their shopfloor by integrating culture, process, and technology (Moore, 1997). TPM is considered to be Japan's answer to US style productive maintenance (Wal and Lynn, 2002). TPM has been widely recognized as a strategic weapon for improving manufacturing performance by enhancing the effectiveness of production facilities (Dwyer, 1999; Dossenbach, 2006).

Gupta & Garg (2012) have studied a case of a manufacturing firm and have shown that, after successful implementation of TPM, it is found that Overall Equipment Effectiveness is increased

TPM has been accepted as the most promising strategy for improving maintenance performance in order to succeed in a highly demanding market arena (Nakajima, 1988). TPM is the proven manufacturing strategy that has been successfully employed globally for the last three decades, for achieving the organizational objectives of achieving core competence in the competitive environment (Ahuja et al., 2004). TPM is a highly influential technique that is in the core of "operations management" and deserves immediate attention by organizations across the globe (Voss, 1995, 2005).

## **Research Methodology**

Research methodology is a method to collect an evidence to test the theories by collecting the data from the concerned resources. Moreover there are different methods that can be used in any research, these methods commonly uses questionnaires studies, interviews, and experiments. These methods can be a collection of qualitative data or quantitative data.

Research design constitutes the blueprint for the collection, measurement, and analysis of data. It is the plan and structure of investigation so conceived as to obtain answers to research questions. The plan is the overall scheme or program of the research.

### **Data Collection**

This study uses case study as a strategy to collect the data. Researcher Robert K. Yin (1984) defines the case study research method as an empirical inquiry that investigates a contemporary phenomenon within its real-life context; when the boundaries between phenomenon and context are not clearly evident; and in which multiple sources of evidence are used (Yin, 1984). Basically, a case study is an in depth study of a particular situation rather than a sweeping statistical survey. It is a method used to narrow down a very broad field of research into one easily researchable topic. A key strength of the case study method involves using multiple sources and techniques in the data gathering process. The researcher determines in advance what evidence to gather and what analysis techniques to use with the data to answer the research questions. Data gathered is normally largely qualitative, but it may also be quantitative. Tools to collect data are interviews, documentation review, and observation.

### **Case Study**

The company a manufacturer of automotive components for two and three wheelers is established in the year 1998. It has four plants in Maharashtra and one plant in Sanand, Gujarat. It is a single source supplier for 3 wheelers silencer assembly, fuel tank, large and medium chassis assembly and Jack assembly.

In October 2004, the Managing Director, made a declaration that the company will be adopting TPM for achieving business excellence in manufacturing operation. The company won a series of awards in quality from various professional bodies and OEMs. The company received the TPM award in March 2012. Having realized the satisfaction of learning “The TPM WAY”, it was thought a necessity to move towards excellence. The activities demonstrate the approach in implementing TPM excellence and importance of implementing it widely and deeply.

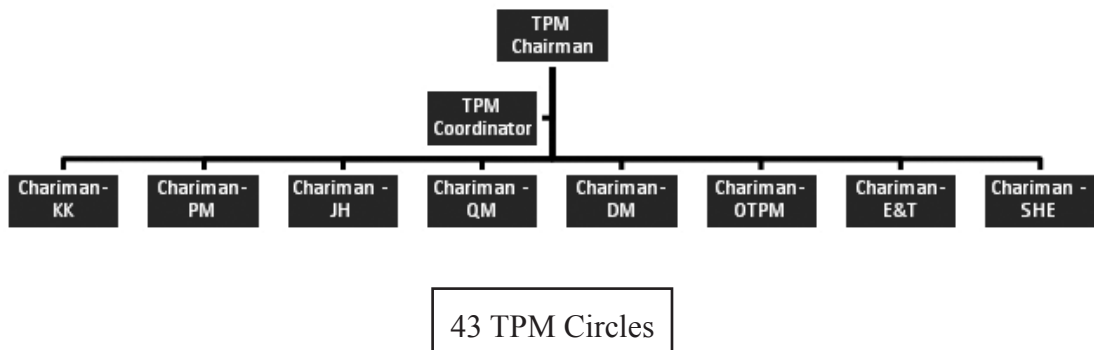
The Chassis Line was chosen as a Manager Model cell and the pillar activities started. In a span of 6 months, very good results were achieved in that cell. In 1st phase of TPM implementation, the focus was on 5 Pillars (KK, JH, QM, PM and SHE) in production function. Having realized the benefit of TPM in model cells, the plant wide implementation started with Kick off in November 2004. In March 2012, the company successfully challenged the prestigious Bajaj Auto Ltd. (BAL) TPM Award. In 2012-13, implementation and practice of TPM was started companywide. Thus the TPM activity moved from manufacturing side to companywide TPM activity. The company is now challenging for prestigious BAL TPM excellence Award.

The company's vision and mission statements focus on customer satisfaction and employee development and growth. Interlinking of the vision and mission was done with the TPM policy, Quality policy and EHS Policy.

**Table 1: Interlinking of Company Vision and TPM policy**

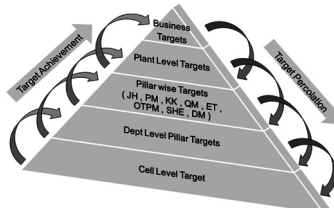
Focus Area	Company Vision	TPM Policy
Customer	Customer focus, most trusted and preferred vendor / source.	Aim is customer satisfaction.
Employee	Technically competent and cohesive team that works on mutual trust.	Healthy and safe work environment. High morale. and team work.
Company	Centre for manufacturing excellence. Process oriented.	Elimination of losses. Capability enhancement, Flexibility and organizational profitability.

The organization structure to achieve the TPM objectives is as follows.



**Fig 2: TPM Organization structure**

The targets were taken with respect to the business plan. The business targets are percolated to plant level targets, then to pillar targets and at last to cell level targets. So with achievement of cell level targets the pillar targets were achieved and this in turn results in achievement of the business targets.



**Fig 3: Target Setting**



The business plan was made in which the production volumes of the customers were

Work Area		Measuring Parameter	UOM	Cell	TPM Excellence Criteria
<b>P</b>		Overall Equipment Efficiency (OEE)	%	Cell	90% for cells with set-up and 95% for cells without set-up
		Overall Line Efficiency	%	Assembly	
		Output /Hr.	Nos.	Assembly	Min 15% up (YOY)
		Output/Man/Shift	Nos.	Assembly	Min 5% up (YOY)
<b>Q</b>		Early Failure	PPM	Plant Level	-
		Matured Warranty	PPM	Plant Level	-
		Customer Complaints	PPM	Plant Level	Silver Award
		In-house rejection	PPM	Plant Level	50% down
		Supplier Rejection	PPM	Plant Level	-
<b>C</b>		Labor cost / Pc	Rs.	Plant Level	10% down than earlier level
		Consumable Cost / Pc	Rs.	Plant Level	
		Maintenance Spare Cost	Rs.	Plant Level	30% down than earlier level
		Power Cost	% of sales	Plant Level	10% down than earlier level
		Fuel Cost	% of sales	Plant Level	
<b>D</b>	<b>D1</b>	Semi Finished Goods	Days	Plant Level	Sustain
		Finished Goods		Plant Level	Sustain
		Delivery Adherence (OE and Spare parts)	%	Plant Level	100%
	<b>D2</b>	Mfg. Lead Time	Hrs.	Cell	20% down than earlier level
<b>S</b>		Accidents	Nos.	Plant Level	0
<b>M</b>	<b>M1</b>	Kaizen / Man / Month	Nos.	Plant Level	3/Man/Month
	<b>M2</b>	Mgmt of Manpower Training	-	Plant Level	Effective Training System
		Mgmt of Equipment	-	Plant Level	All M/c ownership
		Mgmt of Material	-	Plant Level	Vendor upgradation
		Mgmt of Method	-	Plant Level	100% adoption of MP sheets
		Calibration of Tools / Fixtures	-	Plant Level	100% adherence to schedule
		Vendor Rating	Level	Vendor Rating Level	

**Table 2: Plant Level POCDSM Targets**

• UOM – Unit of Measurement • PPM – Parts per Million • YOY – Year on Year • MP – Maintenance Prevention



taken into the account. Analysis of the requirement and existing capacity of each process was done. This helped to identify the gaps. So the targets for improvement were set on the basis of business targets. In case of any gaps, the activity for capacity enhancement was initiated in TPM Way.

### 1) Kobetsu Kaizen KK:

Pillar	Methodology	Parameter
Kobetsu Kaizen KK	Productivity improvement	To improve OEE by reducing management loss.
		To improve OLE of fabrication from 86% to 90%.
		Improve production / hr.
		Yield improvement (identification of scope and improvement on yield loss)
	Cost reduction	Manufacturing cost reduction by reducing tool cost and consumable cost
		Labor cost reduction by reducing manpower or increasing output / man
		FG inventory reduction
		WIP inventory reduction

### 2) Jishu Hozen JH:

Pillar	Methodology	Parameter
Jishu Hozen JH	Step 1 to 5*	Sustenance of step 3 on all machines
		Updation of JH standard for Class A machines
		Preparation of Training material
		Preparation of Machine Manual (Know Why Manual) for all machines
		Preparation of Training calendar
		Practicing step 4 – finding abnormalities of class A machines
		JH step 4 audit of all Class A machines
		JH step 5 awareness and execution for all class A machines

**\*JH Steps**

Step 1: Initial Cleaning and Inspection

Step 2: Countermeasures for contamination sources and hard-to-access areas

Step 3: Setting tentative standards

Step 4: Overall inspection

Step 5: Autonomous inspection / Attainment of line balance

Step 6: putting standards in place; execution of work standards

**3) Planned Maintenance PM**

<b>Pillar</b>	<b>Methodology</b>	<b>Parameter</b>
Planned Maintenance PM	Support to JH	Preparation of machine manuals
		Training of maintenance and production operators
	Periodic maintenance	Preparation of PM calendar (TBM / CBM) for all equipments
	Cost reduction	Maintenance cost budget and control ( MTTR and MTBF) by implementing Kaizens
		Energy cost reduction by removing over capacity motors, auto On-Off of street lights and shop lights.
		Energy cost reduction by replacing conventional devices with energy efficient devices
	E & T	On the job training

**4) Quality Maintenance QM**

<b>Pillar</b>	<b>Methodology</b>	<b>Parameter</b>
Quality Maintenance QM	Defect prevention	Training on basic QM pillar activity
		Defect data collection, preparation of defect matrix
		Defect analysis and preparation of QA matrix
		4M 1T condition analysis
		Study countermeasure and restore malfunction for each defect

		Use of various QC tools for removal of defects, their causes and factors
		Use of Kaizens and their horizontal deployment
		Addition of Q points in JH and PM check sheet
		Improvement of inspection check points
		Preparation of QM matrix
		Standardization, result monitoring and sustenance
		Review of QM points in JH / PM standard

#### 5) Education and Training E&T

Pillar	Methodology	Parameter
<b>Education and Training E&amp;T</b>	<b>Reactive approach</b>	Collection of data of past breakdowns, defects and accidents due to poor skill and knowledge
		Preparation of training needs
		Prepare training calendar
		Impart trainings
	<b>Proactive approach</b>	Class room training to new joiners
		Enhancement of skill level of maintenance operators
		Enhancement of skill level of production operators
		Evaluation of effectiveness of training
		Preparation of Tech Centre

#### 6) Office TPM OTPM

Pillar	Methodology	Parameter
<b>Office TPM OTPM</b>	<b>OTPM</b>	Formation of OTPM committee
		Starting of 1S, 2S and 3S activity across the plant
		Sustenance of 1S, 2S and 3S activity
		Department wise activities listed down and losses identified
		Fixed and variable cost data captured for cost control
		Reduction of supplier lead time by developing local vendors
		Loss elimination Kaizen and deployment and vendor end
		Up gradation of vendor by ISO and vendor audits

## 7) Development Management DM

Pillar	Methodology	Parameter
<b>Development Management DM</b>	<b>Equipment and Product development</b>	Formation of DM committee
		Kaizen data collection
		MP sheet preparation
		Preparation of standard check sheet
		Collection of data and analysis of current work flow
		Collection and assessment of MP data from users
		Prepare standard and engineering document
		Verify for effectiveness
		Review results and horizontal deployment

## 8) Safety, Health and Environment SHE

Pillar	Methodology	Parameter
<b>Safety, Health and Environment SHE</b>	<b>SHE</b>	Safety awareness training
		Safety Audit
		Safety Meeting
		Safety improvement (reactive and proactive)
		Near Miss capturing
		Medical check up
		Water pollution monitoring
		Air pollution monitoring
		Green belt development
		CSR activities

## Conclusion

The organization under study has implemented TPM in two phases. In the first phase, five pillars namely: KK, JH, QM, PM and SHE were implemented. The first phase is the implementation of TPM in the production function. The second phase is the implementation of all the eight pillars organization wide. This was done by the formation of 43 TPM circles in the organization.

The tools used in the various pillars were: Lean management, 5S, Kaizen, QA matrix, 4M1T, ISO and the basic seven Quality Control tools. Lean management aims to remove all the wastes including inventory, excess transportation, storage and movement. 5S is

the name of a workplace organization method that uses a list of five Japanese words: Seiri, Seiton, Seiso, Seiketsu, and Shitsuke. Kaizen means continual improvement in all the activities that are being carried out. The Quality Assurance (QA) matrix shows the relationship between product quality and individual sub processes. 4MIT analysis (Manpower, Materials, Machines, Methods and Tools) is used in finding the root cause of the problem. ISO International Standards ensure that products reliable and of good quality. For business, they are strategic tools that reduce costs by minimizing waste and errors, and increasing productivity.

It was seen from the PQCDMS chart that the implementation of TPM has improved the operational efficiency and overall productivity of the organization. The company has won a series of awards in quality from various professional bodies and OEMs. The involvement of the top management has lead to achieving the objectives of the organization. The company has achieved improved levels of productivity, quality, delivery, safety and morale at the same time keeping the costs low.

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