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Total Productive Maintenance Theoretical Aspect:A Journey Towards Manufacturing Excellence

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ABSTRACT

I*n today's industrial scenario huge losses/wastage occur in the manufacturing shop floor. This waste is due to operators, maintenance personal, process, tooling problems and non-availability of components in time etc. Other forms of waste includes idle machines, idle manpower, break down machine, rejected parts etc are all examples of waste. The quality related waste are of significant importance as they matter the company in terms of time, material and the hard earned reputation of the company. There are also other invisible wastes like operating the machines below the rated speed, startup loss, break down of the machines and bottle necks in process. Zero oriented concepts such as zero tolerance for waste, defects, break down and zero accidents are becoming a pre-requisite in the manufacturing and assembly industry.*

A fundamental component of world-class manufacturing is that of the ***Total Productive Maintenance*** *(TPM), which has been recognized as one of the significant operation strategy to regain the production losses due to equipment inefficiency. TPM is the methodology that aims to increase both availability of the existing equipment hence reducing the need for the further capital investment. The aim of the paper is to study the implementation of the TPM program in an Indian manufacturing industry. Using JH-Check sheet, PM-Check sheet, One Point Lessons, empirical and comprehensive approach toward the methodology results proper implementation of TPM. After implementation of TPM on model machine, both direct and indirect benefits are shown to be obtained for equipment and employees respectively.*

KEY WORDS: -*TPM, JH, OPL, JSA, CLITA, KK.*

I. INTRODUCTION

What Is TPM?- Kaizen introduced the idea that employee expertise generates improvements. TPM stands for Total Productive Maintenance, is first developed in Japan, 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 [1].TPM is all about Total Plant Maintenance. The underlying concept is, if you properly maintain plant machinery 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 [2]. The successful implementation of TPM in the industry is a function of ability of an industry to approach and Practice TPM; support and improvement, providing empowerment and incentives, promoting cross functionality and team work.TPM is an excellent work philosophy that really produces gain in the productive process[3]

Under TPM, machine operators carry out routine maintenance such as checking water, oil, coolant, and air levels. This may involve some training of machine operators. Through operator training to do simple maintenance on machines will promote ownership and more attention to detail. The actual maintenance teams should as a result of spending less time doing routine maintenance is in a position to concentrate on more urgent machine breakdowns. TPM should promote better team working in the workplace, as the operators will be helping the maintenance team with their tasks. It is the continuous improvement process. The goal is to reduce emergency and unscheduled maintenance. TPM was introduced to achieve the following objectives. The important ones are listed below**. Avoid wastage in a quickly changing economic environment. Producing goods without reducing product quality. Reduce cost. Produce a low batch quantity at the earliest possible time. Goods send to the customers must be non-defective. Establishing a total system of Preventive Maintenance for the life of equipment**..

1.1 GOALS OF TPM

1. Obtain Minimum 90%OEE (Overall Equipment Effectiveness)

2. Run the machines even during lunch. (Lunch is for operators and not for machines!)
3. Operate in a manner, so that there are no customer complaints.
4. Reduce the manufacturing cost by 30%.
5. Achieve 100% success in delivering the goods as required by the customer.
6. Maintain an accident free environment.
7. Increase the suggestions from the workers/employees by 3 times

1.2. OVERALL EQUIPMENT EFFICIENCY (OEE):-

Equipment that does not operate well or is always breaking down causes more work for everyoneand customer dissatisfaction.Production equipment not being able to produce products with normal equipment performance isdue to six major losses [5]:

1. Equipment Failure Loss
2. Setup and change over loss
3. Startup Loss
4. Speed Loss
5. Minor Stops/Idling Loss
6. Defects/Rework Loss

If the equipment operates without breakdowns and is consistently working well, everyone'swork is easier, the company is more profitable, and working conditions are improved.The inverted stair step diagram ref fig.1 shows graphically how the losses inavailability, performance, and quality work together to reduce the overall effectiveness of amachine.

The basic measure associated with Total Productive Maintenance (TPM) is the OEE. This OEE highlights the actual "Hidden capacity" in an organization. OEE is *not* an exclusive measure of how well the maintenance department works. Thus OEE is a function of the three factors mentioned below Ref fig.1

1. Availability or uptime (downtime: planned and unplanned, tool change, tool service, job change etc.)

2. Performance efficiency (actual vs. design capacity)

3. Rate of quality output (Defects and rework)

Thus

$$\mathbf{OEE = AvailabilityRatexPerformanceRatexQualityRate}$$

The top bar, total operating time, shows the total time a machine is available to make a product. This is usually considered to be 480 minutes per 8-hour shift.

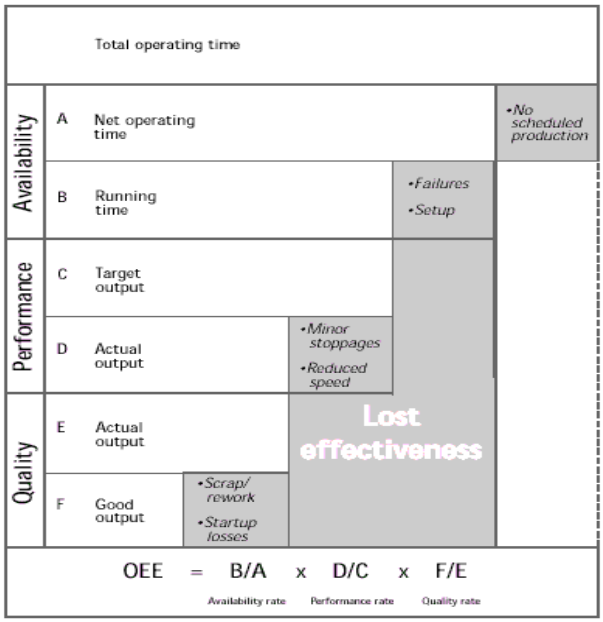


Fig.1 Overall Equipment Efficiency

1.2.1Availability of the machine (A) - Availability is proportion of time machine is actually available out of time it should be available. Bar A represents the net operating time, which is the time available for production after subtracting planned downtime (no scheduled production) such as a holiday, no orders, or no personnel.

$$\textbf{Availability} = \frac{(\textbf{Plannedproductiontime} - \textbf{unscheduleddowntime})}{\textbf{Plannedproductiontime}}$$

Production time = Planned production time – Downtime

1.2.2 Performance Efficiency (PE) -The second category of OEE is performance. Bar B shows the actual running time after subtracting downtime losses such as equipment failures and setup and adjustments. Bars C and D show performance.

$$\textbf{Performance (Speed)} = \frac{(\textbf{CycletimexNumberofproductsprocessed})}{\textbf{productiontime}}$$

Net production time is the time during which the products are actually produced.

1.2.3 Refers to quality rate (Q) -Which is percentage of good parts out of total produced. Sometimes called "yield". Quality losses refer to the situation when the line is producing, but there are quality losses due to in-progress production and warm up rejects.

We can express a formula for quality like this:

$$\textbf{Quality (Yield)} = \frac{((\textbf{Numberofproductsprocessed} - \textbf{Numberofproductsrejected}))}{\textbf{Number of products processed}}$$

Bar C represents the Target Output of the machine during the running time, calculated at the designed speed of the machine.Below it, bar D represents the actual output, reflecting speed losses such as minor stoppages and reduced operating speed.Bars E and F show quality. As you can see, the actual output (E) is reduced by defect lossessuch as scrap and startup losses, shown as the shaded portion of bar F.As this diagram shows, the bottom-line good output is only a fraction of what it could be if losses in availability, performance, and quality were reduced. The diagram also suggests that to maximize effectiveness—to grow the good output on the bottom line—you must reduce not only quality losses, but also availability and performance losses. The three factors work together, and the lowest percentage is usually the constraint that most needs addressing.

1.3 MAINTENANCE

Maintenance is defined as "activities that retain machine performance". The number, frequency, and severity of equipment breakdowns can be decreased with propermaintenance. Maintenance includes servicing current conditions and taking action to preventfuture problems. The major categories of Maintenance include:

- Breakdown Maintenance
- Preventive Maintenance
- Predictive Maintenance
- Corrective Maintenance
- Maintenance Prevention

Equipment breakdown is classified according to the duration of the stop. Ref fig.2.

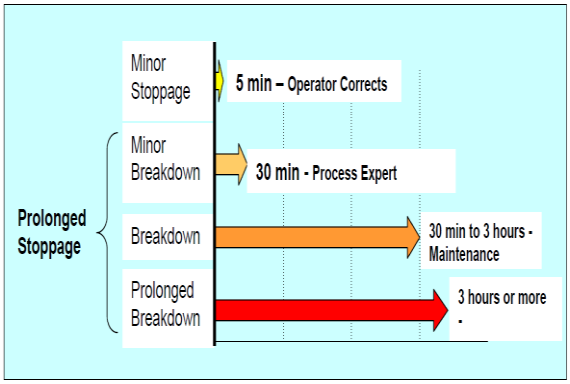


Fig.2 Breakdown Classification

II.PILLARS OF TPM

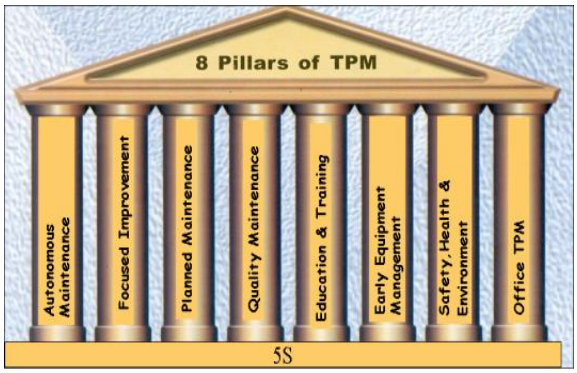


Fig.3 TPM Pillars

2.1. 5S-THE FOUNDATION OF TPM

TPM starts with 5S. It is a systematic process of housekeeping to achieve a serene environment in the work place involving the employees with a commitment to sincerely implement and practice housekeeping[4]. **If this 5S is not taken up seriously, then it leads to 5D. They are Delays, Defects, Dissatisfied customers, declining profits and Demoralized employees.** Following are the pillars of 5S.

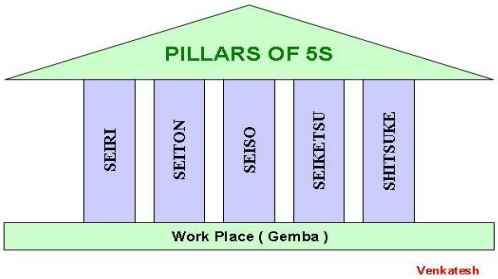


Fig.4 5S Pillars

2.1.1 SEIRI - Sort out:

This means sorting and organizing the items as critical, important, frequently used items, useless, or items that are not need as of now. Unwanted items can be salvaged. Critical items should be kept for use nearby and items that are not be used in near future, should be stored in some place. For this step, the worth of the item should be decided based on utility and not cost. As a result of this step, the search time is reduced.

2.1.2 SEITON -Organize:

The concept here is that "Each items has a place, and only one place". The items should be placed back after usage at the same place. To identify items easily, name plates and colored tags has to be used. Vertical racks can be used for this purpose, and heavy items occupy the bottom position in the racks.

2.1.3 SEISO - Shine the workplace:

This involves cleaning the work place free of burrs, grease, oil, waste, scrap etc. No loosely hanging wires or oil leakage from machines.

2.1.4 SEIKETSU - Standardization:

Employees have to discuss together and decide on standards for keeping the work place / Machines / pathways neat and clean. These standards are implemented for whole organization and are tested / inspected randomly.

2.1.5 SHITSUKE -Self discipline:

Considering 5S as a way of life and bring about self-discipline among the employees of the organization. This includes wearing badges, following work procedures, punctuality, dedication to the organization etc.

2.2 TPM Pillar 1 - JISHU HOZEN (Autonomous maintenance)

This pillar is geared towards developing operators to be able to take care of small maintenance tasks, thus freeing up the skilled maintenance people to spend time on more value added activity and technical repairs. The operators are responsible for upkeep of their equipment to prevent it from deteriorating.

2.3 TPM Pillar 2 – KOBESTU KAIZEN

"Kai" means change, and "Zen" means good (for the better). Basically kaizen is for small improvements, but carried out on a continual basis and involve all people in the organization. Kaizen is opposite to big spectacular innovations. Kaizen requires no or little investment.

2.4 TPM Pillar 3 - Planned Maintenance

It is aimed to have trouble free machines and equipments producing defect free products for total customer satisfaction. Maintenance types are discussed in topic3.1.1 earlier.

2.5 TPM Pillar 4- Quality Maintenance

It is aimed towards customer delight through highest quality through defect free manufacturing. Focus is on eliminating non-conformances in a systematic manner, much like Focused Improvement. We gain understanding of what parts of the equipment affect product quality and begin to eliminate current quality concerns, and then move to potential quality concerns. Transition is from reactive to proactive (Quality Control to Quality Assurance).

2.6 TPM Pillar 5 – Training

It is aimed to have multi-skilled revitalized employees whose morale is high and who has eager to come to work and perform all required functions effectively and independently. Education is given to operators to upgrade their skill. It is not sufficient know only "Know-How" by they should also learn "Know-why".

2.7 TPM Pillar 6- Office TPM

Office TPM must be followed to improve productivity, efficiency in the administrative functions and identify and eliminate losses. This includes analyzing processes and procedures towards increased office automation.

2.8 TPM Pillar 7 - Safety, Health, Environment

Target

1. Zero accident,
2. Zero health damage
3. Zero fires.

In this area focus is on to create a safe workplace and a surrounding area that is not damaged by our process or procedures. This pillar will play an active role in each of the other pillars on a regular basis.

III.JISHU HOZEN (Autonomous maintenance)

What is JH? JH is the Japanese word for autonomous maintenance. It means that we have to do our machine maintenance; no PM man will come on the machine to do the maintenance. For this operator should know the basic things about his machine and its ideal condition, also he should know the corrective measures for the small breakdown of the machine. There are 5 s in the 5S technique. Its basic is that "I operate I maintain". *JishuHozen*, which means autonomous or self-maintenance, promotes development ofproduction operators to be able to take care of small maintenance tasks, such as cleaning,inspecting, and lubricating their equipment, thus freeing the maintenance associates to spend
time on more value-added activities and technical repairs. The operators are responsible forupkeep of their equipment to prevent it from deteriorating. JishuHozen (JH) has been shown toreduce oil consumption by 50% and processtime by 50%. You should sense the abnormalities. For example,
1) Loosen bolts can be seen or it can be sensed by your hands, 2) Air leakage can be heard with your ears, 3) some abnormal smell can be detected with your nose. These abnormalities are eliminated by using the technique such as Abnormality Sheet, CLITA, One Point Lesson (OPL's).

3.1 INSPECTION

Inspect the conditions of each part of equipment using the human senses of sight, hearing, smell, and touch to detect signs of equipment failure [5].Symptoms of potential problems can include unusual vibrations, noises, abnormal smells, abnormal component heating, or unusual sights, such as smoke, metal chips, or fluid

leakage.By identifying potential problems withinspections, we can plan and implement repairor replacement before a breakdown or defectoccurs.Inspection can be aided through the use ofstickers affixed to the equipment to show whichsense is to be used at which location. Ref fig.5

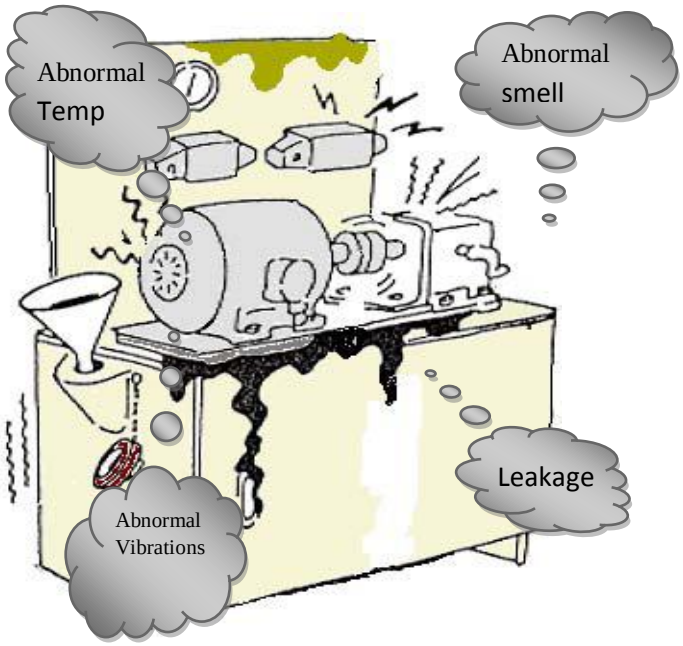


Fig.5 Inspection

Inspection Findings Address any problems found during inspections with countermeasures. Example Countermeasures:

• If many screws must be unscrewed to open a cover plate door, use a hinged door instead.
• Instead of opening a machine inspection door, use a see-through acrylic sheet.
• Modify machine parts to prevent buildup of chips, dirt, and dust.

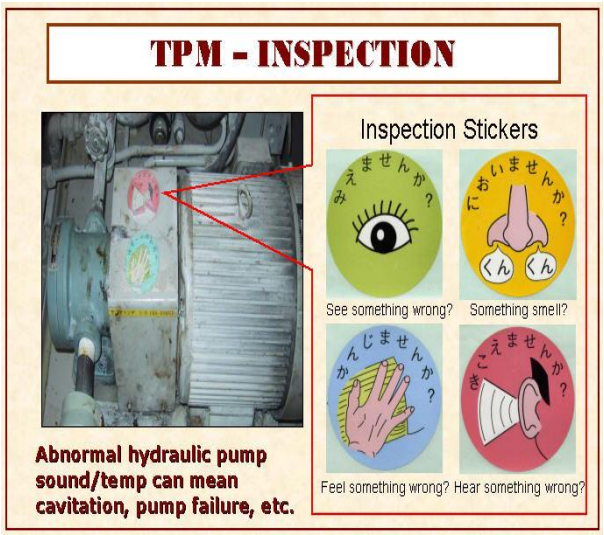


Fig.6 TPM Inspection

3.2LUBRICATION

Prime movers transfer power so the equipment can do work. This involves a number of movingcomponents, e.g., bearings, gears, shafts, spindles, sprockets, chains, levers, and slides. Withoutproper lubrication, ALL of these components WILL FAIL.

Machinery must be properly lubricated to reduce surface wear, prevent corrosion, cool movingparts, dampen shock, and seal out contaminants. Proper lubrication involves using the propertype of lubricant in the proper amount at the proper time. Too much lubricant can causeproblems including overheating the components; collecting dust, dirt, and debris; and causingslip hazards, etc.

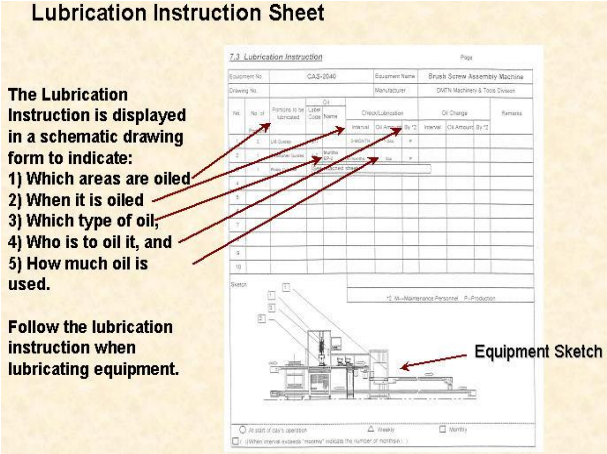


Fig.7 Lubrication Instruction Sheet

3.3. CLITA

CLITA means the symbolic representation for the operation cleaning, Lubrication, inspection, retightening, if it is done regularly with proper time interval then breakdown will minimized.

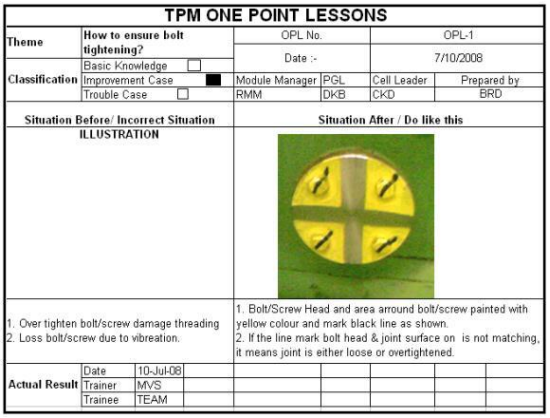
CLITA SYMBOLS	
SYMBOLS	**DESCRIPTION**
◯	OK CONDITION
⊗	CORRECTED AFTER NOT OK
	LUBRICATION / REFILL NEW LUB RICATING OIL
	WEEKLY CLEANING
	WEEKLY VISUAL INSPECTION
	MONTHLY RETIGHTINING
╳	NOT OK

Fig.8 CLITA Symbols

3.4. ONE POINT LESSON (OPL)

Sometimes we are so busy that we think we don't make time to develop the people around us. Instead we fight fires or give direct instructions. This might be effective in the short-term but inevitably small problems are missed. The greatest cost is being unable to teach others how to solve and prevent the problems that we are encountering. A simple countermeasure to this is the focused education and development method known as the one-point lesson (OPL).

Following (fig.10) is the one OPL sheet is given in which the bolt tightening instruction is convey to the operator, that how to make a mark after tightening so that in any loose condition improper position of the bolt or nut is easily identified by the operator.



TPM ONE POINT LESSONS							
Theme	How to ensure bolt tightening?		OPL No.		OPL-1		
			Date :-		7/10/2008		
Classification	Basic Knowledge ☐						
	Improvement Case ■		Module Manager	PGL	Cell Leader	Prepared by	
	Trouble Case ☐		RMM	DKB	CKD	BRD	
Situation Before/ Incorrect Situation			Situation After / Do like this				
ILLUSTRATION							
1. Over tighten bolt/screw damage threading 2. Loss bolt/screw due to vibreation.			1. Bolt/Screw Head and area arround bolt/screw painted with yellow colour and mark black line as shown. 2. If the line mark bolt head & joint surface on is not matching, it means joint is either loose or overtightened.				
Actual Result	Date	10-Jul-08					
	Trainer	MVS					
	Trainee	TEAM					

Fig.10 TPM One Point Lesson

IV KOBESTU KAIZEN (KK)

Kobetsu Kaizen uses a special event approach that focuses on improvements associated with machines and is linked to the application of TPM [6]. It defines a project that works through a problem-solving process [7]. It analyses machine operations information, uncovers waste, uses a form of root cause analysis to discover the causes of waste, applies tools to remove waste, and measures results. Kaizen and just-in-time are related, but Kaizen is used even where production is not "just-in-time." Kaizen is the Japanese word for continuous improvement or striving for perfection. Kaizen strives toward perfection by eliminating waste.

Methods of Kaizen- Kaizen eliminates waste by allowing workers to uncover improvement opportunities and either suggest or make changes. In common usage, the term Kaizen may refer to different kinds of improvement activities. In some cases term used to refer to a process that gathers suggestions for improvements from employees. Others use the term to refer to periodic meetings of employees who brainstorm improvement ideas and immediately select and make an improvement. Still others add to the activities of Kaizen observation and measurement of the work process and of the results the Kaizen activity produces.

Following (fig.11) is the one example of Kaizen sheet with the help of See Through is given. Here electric panel covering is replace by transparent cover which will help the worker to identify breakdown reasons form the electric board. Kaizen is done on the critical components to minimize the time for searching the reasons of breakdown or to eliminate the breakdown by skilled worker by sensing the abnormality.

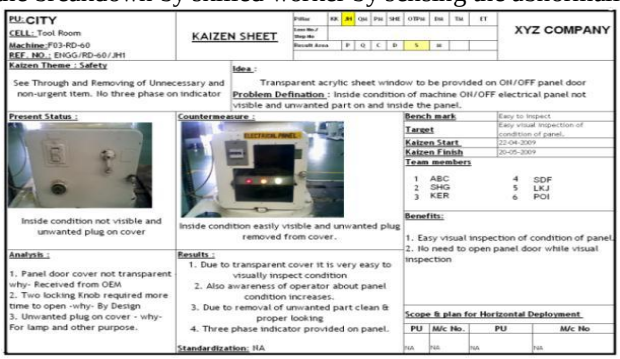


Fig.11 Kaizen Sheet

V.DIRECT BENEFITS OF TPM

1. Increase in productivity and OEE (Overall Equipment Efficiency)
2. Reduction in customer complaints.
3. Reduction in the manufacturing cost by 30%.
4. Satisfying the customer's needs by 100 % (Delivering the right quantity at the right time, in the required quality) & reduced accidents.

VI.CONCLUSION

Today as we are moving towards globalization, to compete with other worldwide industries like Japan, Korea, China etc. therefore it is necessary to move our industries towards modern trend development in all sectors of

industries including maintenance department. So we found total productive maintenance (TPM) is one of the best tools for making our industries competitive and effective, in the field of maintenence.TPM may be the only thing that stands between success and total failure for some companies as far as maintenance is concerned. While implementing TPM we found 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 so people shows strong resistant to it. TPM works on major 8 pillars which are (JH, KK, PM, QM, E&T, OT, 5s and SHE) It works on methodologies like CLITA, JSA, P-M Analysis for achieving its goal of success. Through this paper we are trying to advocate the concept of TPM for Indian Scenario. The main objective is to understand TPM concept and to generate awareness among the budding technocrats and budding enterprises about TPM philosophy adoption in Indian Context.

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