Identification and Elimination of Bottlenecks: A Case Study

Dipanshu Jain, Munish Mehta & Janender Kumar

Abstract: Total Productive Maintenance (TPM) is an approach to equipment maintenance that focuses on elimination of problems and breakdowns and hence reduces the further maintenance cost. It also increases the availability and effectiveness of existing equipment throughout its entire life by the participation of the entire workforce. TPM consists of eight pillars and Autonomous Maintenance is the most important one. It aims at training and educating the workers about self maintenance of machines. The aim of the paper is to eliminate the problem from its root from old equipment which is being used in a piston manufacturing industry so that machine undergoes lesser breakdowns and also its working life increases.

Keywords: TPM, KOYO CLG, 5S, Autonomous Maintenance, Why-Why Analysis.

I. INTRODUCTION

Total Productive Maintenance (TPM) is a maintenance program, which involves a newly defined concept for maintaining plants and equipment. The goal of the TPM program is to markedly increase production while, at the same time, increasing employee morale and job satisfaction. The company organization is so built up that there is overlapping at several levels from small group of senior executives down to small group of shop floor workmen. Each autonomous small group is totally responsible for maintenance and all other jobs of their area. It is a team based preventive and productive maintenance approach that aims at equipment maintenance and involves every level, from top executive to the floor operator. It also promotes better team working in the workplace, as the operators will be helping the maintenance team with their tasks. It is a continuous improvement process and brings maintenance into focus as a necessary and vitally important part of the business. It is no longer regarded as a non-profit activity. Downtime for maintenance is scheduled as a part of the manufacturing day and, in some cases, as an integral part of the manufacturing process. Besides that, it is a methodology which focuses on the goal of building product quality by maximizing equipment effectiveness. A great amount of companies find, that in spite of the large improvements in the productivity in last year's, there is still a big potential to be better in utilizing the machine tools. It covers all departments such as the planning department, the user and the maintenance department. Under TPM, machine operators carry out routine maintenance such as checking, lubricating, tightening etc.

Dipanshu Jain pursuing M.tech from Department of Mechanical Engg., HCTM Technical Campus, Kaithal, Haryana. mail:dipanshujain_88@rediffmail.com

This may involve some training of machine operators. Through operator training they are able to do simple maintenance on machines which also promotes ownership and operators give more attention to their work. The actual maintenance team therefore should spend less time doing routine maintenance and concentrate more on urgent machine breakdowns. A formal definition and concept of TPM is given by Nakajima, 1988:

- TPM aims at maximizing equipment effectiveness through the optimization of equipment availability, performances, efficiency and product quality.
- TPM establishes a maintenance strategy for the life of the equipment.
- TPM covers all departments such as the planning department, the users and the maintenance department.
- TPM involves all staff members from top management down to shop floor workers.
- TPM promotes improved maintenance through small group autonomous activities.

The aim of TPM is to bring together management, supervisors and trade union members to take rapid remedial actions as and when required. Its main objectives are to achieve zero breakdowns, zero defects and improved throughputs by (Qureshi and Sagar 2013):

- Increasing operator involvement and ownership of the process.
- Improving problem solving by the team.
- Refining preventive and predictive maintenance activities.
- Focusing on reliability and maintainability engineering.
- Upgrading each operator's skills.

II. LITERATURE REVIEW

TPM was originated in Japan and was an equipment management strategy designed to support the Total Quality Management strategy. The Japanese realized that companies cannot produce a consistent quality product with poorly-maintained equipment. TPM thus began in the 1950s and focused primarily on the pre-ventive maintenance. As new equipment was installed, the focus was on implementing the preventive maintenance recommendations by the equipment manufacturer. However the concept of preventive maintenance was taken from USA. Nippondenso was the first company to introduce plant wide preventive maintenance in 1960. Preventive maintenance is the concept wherein, operators produced goods using machines and the maintenance group was dedicated with work of maintaining those machines, however with the automation of

Nippondenso, maintenance became a problem as more maintenance personnel were required. So the management decided that the routine maintenance of equipment would be carried out by the operators. (This is Autonomous maintenance, one of the features of TPM). Then in the 1970s, TPM evolved to a strategy focused on achieving PM efficiency through a comprehensive system based on respect for individuals and total employee participation. It was at this time that "Total" was added to productive maintenance. By the mid-1970s, the Japanese began to teach TPM strategies internationally and were recognized for their results. Over the past three decades, manufacturing organizations have used different approaches to improve maintenance effectiveness. 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 guideline to fundamentally transform their shop floor by integrating culture, process, and technology. TPM is considered to be Japan's answer to US style productive maintenance. TPM has been widely recognized as a strategic weapon for improving manufacturing performance by enhancing the effectiveness of production facilities.

According to (Al-Najjar and Alsyouf, 2003), the maintenance function has become more challenging in maintaining and improving product quality, safety requirements, and plant cost effectiveness.

Maintenance supports the production department to achieve the desired quantity and quality of products produced through ensuring the availability of equipment. Hence, equipment relies not only on availability, but also performance and quality (Nakajima, 1988).

According to (McKone et al., 1999) TPM is a methodology that "addresses equipment maintenance through a comprehensive productive-maintenance delivery system covering the entire life of the equipment and involving all employees from production and maintenance departments to top management".

G. Chand (2000) stated that "total productive maintenance is a Japanese concept of equipment management that allows a facility to improve decisively the equipment performance in the manufacturing area with the help and involvement of all employees".

Ahuja and Khamba (2007) from their study on an Indian manufacturing enterprise report that TPM implementation initiatives have shown marked improvements in the equipment efficiency and effectiveness, and have also brought about appreciable improvements in other manufacturing functions in the organization.

According to Tsang & Chan (2000), TPM holds the potential for enhancing effectiveness of production facilities.

TPM methodology is based on implementation of eight pillars in series. A perfect relationship between man and equipment is created by implementing these eight pillars in a systematic way. A brief description of all the pillars is described here:

III. TPM PILLARS

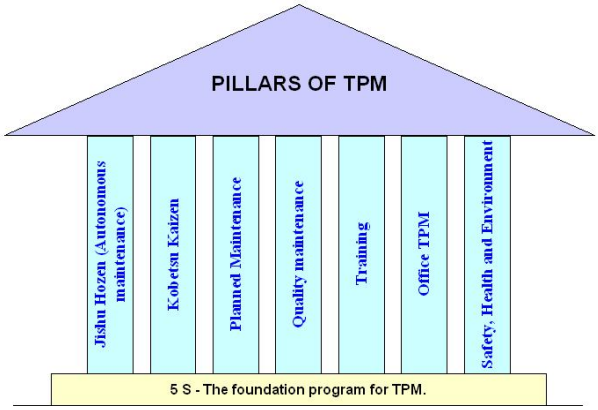


Fig. 1: Eight pillars of TPM

A. *Pillar 1- 5S*

5S is the base of TPM. TPM starts with the initiating of 5S at the workplace. 5S is basically a well organized and systematic process of 5 steps to achieve hassle free workplace. Problems cannot be clearly seen when the work place is unorganized. Cleaning and organizing the workplace helps the team to uncover problems. Making problems visible is the first step of improvement. Table below shows 5S terms and their equivalent meanings of each.

Table 1: 5S Terms

Japanese Term	English Translation	Equivalent 'S' term
Seiri	Organization	Sort
Seiton	Tidiness	Systematize
Seiso	Cleaning	Sweep
Seiketsu	Standardization	Standardize
Shitsuke	Discipline	Self – Discipline

A. *Pillar 2- Jishu Hozen*

This pillar is also named as Autonomous Maintenance and aims towards developing operators to be able to take care of small maintenance activities, thus freeing up the skilled maintenance team. The operators are also responsible for up gradation of their equipments to prevent them from frequent breakdowns.

The results of Autonomous maintenance can be measured by reduction in scheduled and unscheduled down time, increase in speed of the machine, decrease in product/process variability, increase in the number of flexible operators to operate & maintain the equipment, increase in the small group activities and the reduction in oil consumption etc.

B. *Pillar 3- Kobetsu Kaizen*

In Japanese Kaizen simply means change (kai) for the better (zen). Kaizen implementation requires very little or sometimes no investment. It is implemented by lower management and workers but depends strongly on support from senior management. Kaizen is basically for small improvements but when carried out on continual basis, it

effects in large manner. It also involves all people in the organization.

C. Pillar 4- Planned Maintenance

The aim of the pillar is to have trouble free equipments and producing defect free products for total customer satisfaction. Planned maintenance consists of four groups namely:

1. Preventive Maintenance
2. Breakdown Maintenance
3. Corrective Maintenance
4. Maintenance Prevention

With Planned Maintenance we evolve our efforts from a reactive to a proactive method and use trained maintenance staff to help train the operators to better maintain their equipment.

D. Pillar 5- Quality Maintenance

This pillar aims towards customer delight through highest quality and defect free manufacturing. The main focus is on eliminating non-conformances in a systematic manner, much like focused improvement. The target is to achieve and sustain zero losses with respect to minor stops, measurement and adjustments, defects and unavoidable down times. 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).

E. Pillar 6- Training

The pillar focuses on training and education of employees to upgrade their skill and knowledge. In modern times, it is not sufficient that workers only know "How to Operate" but they also know about "How to Maintain". The employees should be trained to achieve the four phases of skill. The goal is to create a factory full of experts. The different phase of skills are phase 1-do not know, phase 2-know the theory but cannot do, phase 3-can do but cannot teach, and phase 4-can do and also teach. Training policy's are focus on improvement of knowledge, skills and techniques, creating a training environment for self-learning based on felt needs, training curriculum including tools/assessment etc. conductive to employee revitalization, and training to remove employee fatigue and make, work enjoyable.

F. Pillar 7- Office TPM

Office TPM should be initiated after activating four other pillars of TPM (AM, KK, PM, and QM). 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.

Office TPM and its benefits are involvement of all people in support functions for focusing on better plant performance, better utilized work area, reduce repetitive work, reduced administrative costs, reduced inventory carrying cost, reduction in number of files, productivity of people in support functions, reduction in breakdown of office equipment, reduction of customer complaints due to logistics, reduction in expenses due to emergency dispatches/purchases, reduced manpower, and clean and pleasant work environment.

G. Pillar 8- Safety, Health and Environment

The pillar deals with the safety and health of the employees and also helps in providing a safer environment by avoiding accidents and other fatal incidents. It also affects the proper implementation of other pillars.

In most of the manufacturing industries a separate committee is formed for this pillar, constituting of officers as well as workers. The committee is generally guided by the senior manager or vice president of the industry. Besides these, it is also necessary to create general awareness about safety (related both to them and workplace) among the workers by different methods *viz.* slogans, markings, posters etc.

IV. TPM IMPLEMENTATION STAGES

TPM implementation is divided into four stages consisting of twelve steps which are briefed as following:

Stage 1: *Introduction Stage*
Step 1: Top management announces the introduction of TPM in the organization.
Step 2: Initial education and campaigning for TPM.
Step 3: Formation of TPM promotion organizations and pilot organization models.
Step 4: Set basic principles and targets.
Step 5: Build a master plan for developing TPM.

Stage 2: Kick Off
Step 6: TPM Kick Off.

Stage 3: Implementation Stage
Step 7: Establish the system for improving production efficiency.
Step 8: Establish the JISHU HOZEN.
Step 9: Establish the Quality Maintenance.
Step 10: Establish the system to improve the efficiency of administration department.
Step 11: Establish and accident free workplace.

Stage 4: Establishment Stage
Step 12: Completion of implementation of TPM.

V. PRESENT WORK

Our present work is to find out the root cause of problem from KOYO CLG which is being used in Pin shop floor in the industry by implementing the pillars of TPM. The equipment is being used for pre-finishing grinding operation on piston pins.

A. Reasons for selection of Machine

- Single machine available for pre-finishing grinding.
- Very old machine.
- Frequent breakdowns occurring.

- Replacement of old with new one requires huge capital investment.

B. 5S Implementation

5S are already defined in the introduction. These 5S pillars are implemented on KOYO CLG.

- Sort- This pillar helps in distinguishing the necessary items from waste items at the workplace which are no longer in use.
- Systematize- This helps in keeping or placing the necessary items at the correct place.
- Sweep- The main objective of this pillar is to keep the workplace clean and tidy.
- Standardize- It defines the standard activities, procedures, schedules and the persons responsible for keeping the workplace clean and organized.
- Self-Discipline- The main objective of last pillar is to sustain and maintain all these above standards and continuously improving the 5S status at the workplace.

C. JISHU HOZEN Implementation

Jishu Hozen also called autonomous maintenance is a team-based approach to maintenance activities. Its goal is to prepare operators to do some equipment care independently of the maintenance staff. Its implementation lays the foundation for other maintenance activities. Various tentative standards for cleaning, inspection and lubrication are set for KOYO CLG as shown in Table 2, 3 and 4.

Table 2: Tentative standards for Cleaning

Sr. No	Location	Cleaning Method	Standard	Time	Frequency
1	Grinding Wheel cover	Dry cloth/brush	No dust/ Sludge	10	Weekly
2	Dressing Slide	Dry cloth/brush	No dust/ Sludge/ Coolant	1	Shift
3	Dressor supporting channel	Dry cloth/brush	No dust/ Sludge/ Coolant	5	Weekly
4	Grinding wheel Dressor	Dry cloth/brush	No dust/ Sludge	10	Weekly
5	Regulating Wheel cover	Dry cloth/brush	No dust/ Sludge/ Coolant	10	Daily
6	Base body	Dry cloth/brush	No dust/ Sludge/ Coolant	10	Daily
7	Regulating wheel Dressor	Dry cloth/brush	No dust/ Sludge/ Coolant	15	Weekly
8	Main Motor	Brush	No dust / No Scale on the fins & fan cover	15	Once in a month
9	Hydraulic pack	Dry cloth/brush	No dust / No Oil	5	Shift
10	Front Chutte cleaning	Dry cloth/brush	No dust/ Sludge/ Coolant	10	Weekly

Table 3: Tentative standards for Lubricating

Sr. No.	Lubrication Point	Standard Required	Method	Quantity	Frequency
1	Lubrication level of Gear box unit	Lube oil servo spin 12	Lubricating Pump	As per requirement	Weekly
2	Lubrication of regulating wheel	Lube oil servo spin 12	Lubricating Pump	As per requirement	Weekly
3	Greasing of spindle bearing	Ball bearing grease	Manually	As per requirement	Quarterly

Table 4: Tentative standards for Inspection

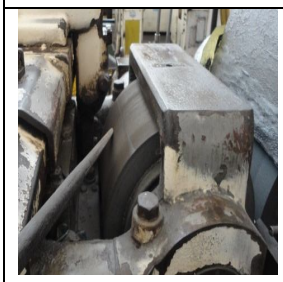
Sr. No	Location	Standard	Method	Time	Frequency
1	Hydraullic tank oil level	Min. and Max. level	Visually	10 seconds	Weekly
2	Hydraullic pressure gauge	Needle meeting green line	Visually	30 seconds	Shift
3	Coolant tank level	Min. and Max. level	Visually	60 seconds	Daily

D. Fugaies Identification

After setting up the standards for the equipment, fuguaies are identified in it. Fuguaies are the abnormalities found in the machine, during the initial cleanup. Table 5 shows some of the fuguaies found in KOYO CLG.

Table 5: Fuguaies found in KOYO CLG

Sr. No.	Location	Abnormality Description	Abnormality Type(A-G)	Impact Type(A-D)
1	Regulating wheel	Cleaning not adequate	A	D
2	Coolant tank	Poor filtration system	B	C
3	Machine base	Broken basement cover	B	C
4	Guide way fixture	Worn out bolt of setting guide	A	D
5	Fixture	Broken guide case	B	B
6	Grinding wheel	Coolant pipe not fitted on clamp	A	D
7	Hydraulic pack	Hydraulic Oil Leakage from Dressing Pipe	D	C
8	Main motor	Main Motor Cover Fan guard Chocked	A	B
9	Regulating wheel	Regulating wheel direction not marked	A	A
10	Electric wire	Loose wiring & loose socket	G	A
11	Motor fan	Bolt of fan cover missing	B	B
12	Electric panel	Main switch MCB not working	B	A

WHY-WHY ANALYSIS SHEET	
PROBLEM	**OCCURING DUE TO**
Grinding marks on Pin	Grinding Dust on Wheel
Why Grinding Dust on Wheel	Cleaning of Grinding wheel not according to standards
Why Cleaning not according to standards	Cleaning not done on regular intervals
Why Cleaning not done on regular intervals	Manual Cleaning
Why Manual cleaning	No arrangement for automatic cleaning
SOLUTION	**WIPER INSTALLED FOR REGULAR CLEANING**
	

E. Kobetsu kaizen Implementation

WHY-WHY ANALYSIS SHEET	
PROBLEM	**OCCURING DUE TO**
Pins not According to Specification	Ovality on Pins
Why Ovality on Pins	Dressing not on proper time
Why dressing not on proper time	Adequate no of pins dressed not known
Why adequate no of pins dressed not known	Manual counting of pins
Why Manual counting of pins	No arrangement for automatic counting
SOLUTION	**AUTOMATIC COUNTER METER INSTALLED**
	

Many Kaizens are performed on KOYO CLG by using why why analysis method. A proper why why sheet is made for each fugaie which contains all the information about the problems and its reasons thereof. So, if any further other modification is suggested then this sheet is very helpful for that.

Why why sheets are prepared for KOYO CLG and some of them are shown in Fig. 2, 3 and 4.

VI. CONCLUSION

From the above discussion, we thus conclude that after the successful implementation of TPM on KOYO CLG most of the problems are eliminated in a way that they don't occur in future. Also huge capital investment on purchasing new machinery is reduced and in future if the same problem occurs in other machines then also the above implemented method can be adopted.

Fig. 2: Why Why sheet analysis for Counter Meter

Figure 3: Why Why analysis sheet for Wiper

WHY-WHY ANALYSIS SHEET	
PROBLEM	**OCCURING DUE TO**
Grinding marks on outer dia. of Pin	Poor Coolant
Why Poor Coolant	Grinding dust mixed in coolant
Why Grinding dust mixed in coolant	Coolant filtration not adequate
Why Coolant filtration not adequate	No sectioning of Filtration system
Why No sectioning of Filtration system	No arrangement for movable portions
SOLUTION	**FILTRATION SYSTEM DIVIDED INTO MOVABLE PORTIONS USING FILTER SHEETS**
	

Fig. 4: Why Why analysis sheet for Coolant Tank

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Dipanshu Jain is pusrsuing M.tech from HCTM Technical Campus, Kaithal, Haryana and completed B.Tech from SKIET, Kurukshetra, Haryana.

Munish Mehta presently working as Asstt. Prof. in the Department of Mechanical Engineering at HCTM Technical Campus, Kaithal, Haryana. He is pursuing Ph. D. from PTU, Jalandhar. A lifetime member of ISTE, he has 10 research papers published in different international journals/conferences. He has 7 years of industrial and 10 years of teaching experience to his credit.

Janender Kumar presently working as Asstt. Prof. in Department of Mechanical Engineering at HCTM Technical Campus, Kaithal, Haryana. His research interests include TQM/TPM and mfg. processes. He has 3 years of industrial and 9 years of teaching experience. He has published 4 research papers in different international journals.