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Total Productive Maintenance to Improve Overall Equipment Effectiveness

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Introduction- In today' s industrial scenario huge losses/wastage occur on the manufacturing shop floor. This waste is due to operators, maintenance personnel, process, tooling problems and non-availability of components in time etc. Other forms of waste include idle machines, idle manpower, break down the machine, rejected parts etc. are all examples of waste. The quality related waste is 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, setup-up loss, the breakdown of the machines and bottlenecks in the 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. In this situation, a revolutionary concept of Total Productive Maintenance (TPM) has been adopted in many industries across the world to address the above-said problem.

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Total Productive Maintenance to Improve Overall Equipment Effectiveness

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Chapter – 1

I. Introduction

In today‟s industrial scenario huge losses/wastage occur on the manufacturing shop floor. This waste is due to operators, maintenance personnel, process, tooling problems and non-availability of components in time etc. Other forms of waste include idle machines, idle manpower, break down the machine, rejected parts etc. are all examples of waste. The quality related waste is 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, setup-up loss, the breakdown of the machines and bottlenecks in the 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. In this situation, a revolutionary concept of Total Productive Maintenance (TPM) has been adopted in many industries across the world to address the above-said problem. The goal of any TPM program is to improve productivity and quality along with increased employee morale and job satisfaction. Earlier preventive maintenance was considered as a nonvalue-adding process, but now it is an essential requirement for the longer life cycle of machines in an industry. TPM is an innovative approach to maintenance that optimizes equipment effectiveness, eliminates breakdowns, and promotes autonomous operator maintenance through day-to-day activities involving the total workforce. The study reveals that the TPM elements- top management leadership, planned maintenance management, focused improvement, autonomous maintenance and education and training have a significant contribution towards manufacturing performance such as lower cost, higher quality, strong delivery and increased productivity.

TPM is an innovative Japanese concept. The origin of TPM can be traced back to 1951 when preventive maintenance was introduced in Japan. However, the concept of preventive maintenance was taken from the 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). Maintenance group took up only essential maintenance works. Thus Nippondenso which already followed preventive maintenance also added Autonomous maintenance done by production operators. The maintenance crew went in the equipment modification for improving reliability. The modifications were made or incorporated in new equipment. This lead to maintenance prevention. Thus preventive maintenance along with Maintenance prevention and Maintainability Improvement gave birth to Productive maintenance. The aim of productive maintenance was to maximize plant and equipment effectiveness to achieve optimum life cycle cost of production equipment.

By then Nippon Denso had made quality circles, involving the employee‟s participation. Thus all employees took part in implementing Productive maintenance. Based on these developments Nippondenso was awarded the distinguished plant prize for developing and implementing TPM, by the Japanese Institute of Plant Engineers (JIPE). Thus Nippondenso of the Toyota group became the first company to obtain the TPM certification.

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a) Project Industry Introduction

Anupriya Ultratech was established in October 2010. The stepping stone was put up at Ambad, Nashik, and Rich Industrial Green Belt in Nashik. The company is headed by Mr. R Patil. In a Hi-tech world, they at Anupriya Ultratech cater to OEM in many sectors. They Innovate Technology to the customer satisfaction at an optimum cost. A state of art plant to manufacture products by well-qualified personnel"s to meet optimum quality levels. A strong research and Development Centre to take up challenging jobs in designing Innovative and world class quality products. The working environment is fully air-conditioned and dust free to meet Lowest Cost at on Optimum quality levels.

To delight our Customers, Stakeholders & Employees by consistently manufacturing high-quality products through Innovation, Research, and Development and by maintaining Global best practices in Quality standards and Safety. Anupriya Ultratech will provide the highest-quality end products to our customers while striving to make them the leaders in their respective industries. To guarantee our continued success we will achieve a reasonable profit, continue to be the leader in our industry through individual and combined dedication, innovation, and integrity. We will give our employees the opportunity for both personal and professional growth.

The mission of the company is to be the market leader in the product engineering with a Global perspective by exceeding Customer expectations in Quality and Service, attain operational excellence in Manufacturing, Total Quality Management, Safety & Supply Chain facilitated through our fully compliant state-of-the-art manufacturing plant.

Anupriya Ultratech is committed to manufacturing and supply of High Conductivity Aluminium/ Copper/Brass components, shafts, riveting, CNC, VMC and welding jobs and Engineering Applications to meet customer satisfaction in term of quality requirement & on-time delivery. The company management has adopted new management tools, techniques for continuous improvement and to achieve a quality target. This policy will be reviewed periodically and changes made if needed.

With the ISO 9001 Quality System Certification, Anupriya Ultratech established the quality of its products. Effective implementation of Quality Assurance System assures that the products of Anupriya Ultratech are produced in compliance with customer requirements, national and international standards and regulations.

Anupriya Ultratech is small-scale industry, they are a manufacturer of a various mechanical component in which Electrical parts which is specially made up of copper, Racks, angles, pulleys and many more according to order.

Fig. 1.1: Components manufacture in company

b) Problem Statement

After carrying out several visits and direct observations of machines on the production shop floor and analyzing previous machine utilization records at Anupriya Ultratech. Pvt. Ltd it was found that machines were not operating up to its full production capacity due to following problems associated with the machines.

- Housekeeping of the machines is carried out during machining hours which accounts for production delay.
- Time loss occurs during loading and setting of the job on machines which accounts for setup loss.
- Time loss during the changeover from one job to other on machine accounts for setup loss.
- Breakdowns of machines due to improper cleaning and lubrication of machine parts which accounts for availability loss.
- Lack of planned maintenance schedule for machines which accounts for performance loss.

- Frequent tool breakage due to operator inefficiency which accounts for performance loss.

All the above-mentioned problems are affecting the overall equipment effectiveness of machines on the production shop floor and thereby affecting overall plant efficiency. Hence there is need to implement total productive maintenance strategy in order to overcome the above mention problems and achieve improvement in overall equipment effectiveness.

c) Objective of the Project

- To increase the productivity of the product and its equipment with a modest investment in maintenance.
- To increase the overall equipment Effectiveness.
- Improving the effectiveness of machines
- Improving the efficiency, reliability and effectiveness of maintenance of machine
- Scheduling maintenance for avoiding early maintenance
- Involving operation team also in smaller scale maintenance, such as machine checklist inspection before starting and after closing the machines.
- Arrangement of training for amending the skills of employees

d) TPM Basic Concepts

TPM seeks to maximize equipment effectiveness throughout the lifetime of the equipment. It strives to maintain the equipment in optimum condition in order to prevent unexpected breakdown, speed losses and quality defects occurring from process activities. Thus the three ultimate goals of TPM are zero defects, zero accident, and zero breakdowns. Among the principles embraced by TPM to achieve these goals are total employee involvement, autonomous maintenance by operators, small group activities to improve equipment reliability, maintainability and productivity and continuous improvement (kaizen).[2] A structured implementation process is an identified success factor and a key element of TPM programs. These basic practices or programs of TPM are often called "pillars" of TPM.

i. *Pillars of TPM*

The entire edifice of TPM is built and stands on eight pillars[3] which are focused improvement; autonomous maintenance, planned maintenance, training and education, early-phase management, quality maintenance, office TPM, and safety, health, and environment. TPM paves way for excellent planning, organizing, monitoring and controlling practices through its unique eight pillar methodology. These eight pillar implementation plan which is proposed by JIPM results in an increased in labor productivity through controlled maintenance, reduction in maintenance costs and reduced production stoppages and downtimes. [2]

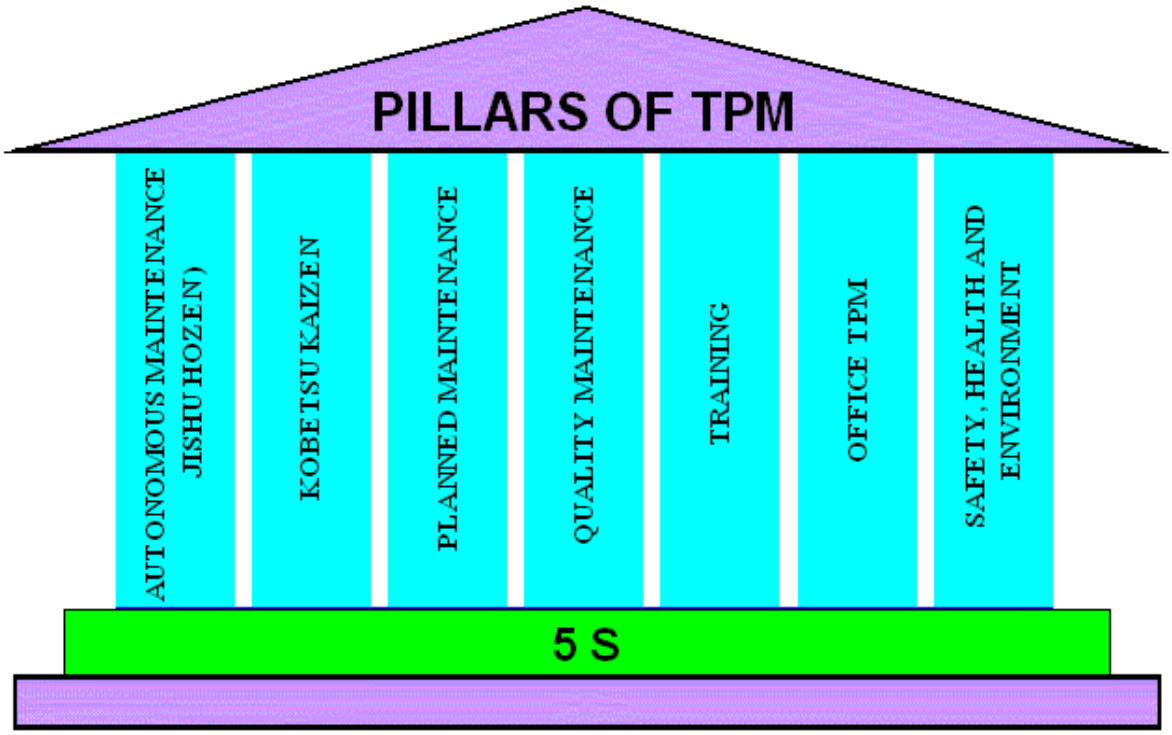


Figure 1.2: Pillars of TPM

- 5S:-

TPM starts with 5S. 5S can be called as foundation stone of TPM implementation. It is a Japanese way of housekeeping. Problems cannot be recognized if the work place is unorganized. Cleaning and organizing the workplace helps us to pop up the problems. Making problems visible and seen to the people gives an opportunity of improvement. If this 5S is not taken up seriously, then it leads to 5D i.e. Delays, Defects, Dissatisfied customers, Declining profits and Demoralized employees. [3]

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. 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. 5S is a foundation program before the implementation of TPM. [7]

Meaning of each „S" is explained in Table 2.1.

Table 2.1: Meaning of „S"

Japanese Term	**5S Step**	**Description**
Seiri	Sort	Remove all items from the workplace that are not needed for current production (or clerical) operations. Excess material (waste) at the work place can lead to errors and defects.
Seiton	Set in Order	Arrange needed items so that they are easy to locate and use. Label them so that they are easy to find and put away.
Seiso	Shine	Clean floors, equipment, and work stations. The Shine step of 5S also includes identifying and preventing the sources of contamination or dirt. Shine is integrated with daily maintenance tasks to maintain condition as pristine as possible.
Seiketsu	Standardize	Create methods and practices to maintain Sort, Set in Order, and Shine on an ongoing and continuously improving manner.
Shitsuke	Sustain	Make 5S an integral part of standard operating procedure.

- Pillar 1-Autonomous maintenance (JISHUHOZEN)

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. By use of this pillar, the aim is to maintain the machine in new condition. The activities involved are very simple nature. This includes cleaning, lubricating, visual inspection, tightening of loosened bolts etc. Autonomous Maintenance policy are-uninterrupted operation of equipment"s, flexible operators to operate and maintain other equipment"s, and eliminating the defects at source through active employee participation. Steps in AM are preparation of employees, initial clean-up of machines, take counter measures, fix tentative AM (JISHU HOZEN) standards, general inspection, autonomous inspection, and standardization.

- Pillar 2-Kaizen

"Kai" means change, and "Zen" means good (for the better). Basically kaizen is for small

- Pillar 2-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. The principle behind is that "a very large number of small improvements are move effective in an organizational environment than a few improvements of large value". This pillar is aimed at reducing losses in the workplace that affect our efficiencies. By using a detailed and thorough procedure we eliminate losses in a systematic method using various kaizen tools. These activities are not limited to production areas and can be implemented in administrative areas as well.

- Pillar 3-Planned maintenance (PM)

It is aimed to have trouble free machines and equipment"s producing defect free products for total customer satisfaction. This breaks maintenance down into four "families" or groups, viz., preventive maintenance, breakdown maintenance, corrective maintenance, and maintenance prevention. With PM 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. In PM policy are achieve and sustain availability of machines, optimum maintenance cost, reduces spares inventory, and improve reliability and maintainability of machines.

- Pillar 4-Quality maintenance (QM)

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).QM activities are to set equipment conditions that preclude quality defects, based on the basic concept of maintaining perfect equipment to maintain perfect quality of products. The condition is checked and measure in time series to very that measure values are within standard values to prevent defects. The transition of measured values is watched to predict possibilities of defects occurring and to take countermeasures before hand. In QM policy are defect free conditions and control of equipment‟s, quality maintenance activities to support quality assurance, focus of prevention of defects at source, focus on Poka-Yoke (fool proof system), in-line detection and segregation of defects, and effective implementation of operator quality assurance. QM targets are achieve and sustain customer complaints at zero, reduce in-process defects by 50percent, and reduce cost of quality by 50percent.

Policy:

1. Defect free conditions and control of equipment‟s.
2. QM activities to support quality assurance.
3. Focus of prevention of defects at source
4. Focus on poka-yoke. (fool proof system)
5. In-line detection and segregation of defects.
6. Effective implementation of operator quality assurance.

Target:

1. Achieve and sustain customer complaints at zero
2. Reduce in-process defects by 50 %

Data requirements:

Quality defects are classified as customer end defects and in house defects. For customer-end data, we have to get data on

1. Customer end line rejection
2. Field complaints.

In-house, data include data related to products and data related to process

Data related to product:

1. Product wise defects
2. Severity of the defect and its contribution - major/minor
3. Location of the defect with reference to the layout
4. Magnitude and frequency of its occurrence at each stage of measurement
5. Occurrence trend in beginning and the end of each production/process/changes. (Like pattern change, ladle/furnace lining etc.)
6. Occurrence trend with respect to restoration of breakdown/modifications/periodical replacement of quality components.

Data related to processes:

1. The operating condition for individual sub-process related to men, method, material and machine.
2. The standard settings/conditions of the sub-process.
3. The actual record of the settings/conditions during the defect occurrence.

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”. By experience they gain, “Know-How” to overcome a problem what to be done. This they do train them on knowing “Know-why”. 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 is 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.

Policy:

1. Focus on improvement of knowledge, skills and techniques.
2. Creating a training environment for self learning based on felt needs.
3. Training curriculum / tools /assessment etc conductive to employee revitalization
4. Training to remove employee fatigue and make work enjoyable.

Target:

1. Achieve and sustain downtime due to want men at zero on critical machines.
2. Achieve and sustain zero losses due to lack of knowledge / skills / techniques
3. Aim for 100 % participation in suggestion scheme.

Steps in Educating and training activities:

1. Setting policies and priorities and checking present status of education and training.

2. Establish of training system for operation and maintenance skill up gradation.
3. Training the employees for upgrading the operation and maintenance skills.
4. Preparation of training calendar.
5. Kick-off of the system for training.

- Pillar 6-Office TPM:

Office TPM should be started after activating four other pillars of TPM (AM, Kaizen, 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 addresses twelve major losses, they are processing loss; cost loss including in areas such as procurement, accounts, marketing, sales leading to high inventories; communication loss; idle loss; set-up loss; accuracy loss; office equipment breakdown; communication channel breakdown, telephone and fax lines; time spent on retrieval of information; non availability of correct on line stock status; customer complaints due to logistics; and expenses on emergency dispatches/purchases. 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.

- *Pillar 7-Safety, health and environment*

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. safety, health and environment target are zero accident, zero health damage, and zero fires.

A committee is constituted for this pillar, which comprises representative of officers as well as workers. The committee is headed by senior vice president (technical). Utmost importance to safety is given in the plant. Manager (safety) looks after functions related to safety. To create awareness among employees various competitions like safety slogans, quiz, drama, posters.

ii. *Overall equipment efficiency (OEE) Calculation for the product*

OEE calculation is based on a composite of the six big losses of your equipment broken down into three main areas; Availability, performance and quality. It is a very simple calculation in reality;

OEE = Availability% x Performance% x Quality%

OEE (Overall Equipment effectiveness) is the main performance measure that drives action within Total Productive Maintenance (TPM) and is used by the teams to focus their continuous improvement activities as well as identifying those areas that require resource.

TPM Six Losses

There are six equipment losses identified within TPM that are used to calculate your OEE;

- *Availability*

1. Breakdowns:-Breakdown losses categorized as time losses and quantity losses caused by equipment failure or breakdown.
2. Changeovers:-Set up and adjustment losses occur when production is changing over from requirement of one item to another.

- *Performance*

1. Minor Stoppages:-Idling and minor stoppage losses occur when production is interrupted by temporary malfunction or when machine is idling.
2. Reduced Speed:-Reduced speed losses refer to the difference between equipment design speed and actual operating speed.

- *Quality*

1. Defects:-Quality defects and rework are losses in quality caused by malfunctioning production equipment.
2. Start-up:-Reduced yield during start-up are yield losses that occurred from machine start up to stabilization.

Chapter -2

II. Literature Review

Early TPM implementation in Japan was primarily within the automotive industry, particularly within Toyota and their associated component suppliers (Robinson and Ginder, 1995). However, not many Japanese companies initiated TPM in the beginning and earlier TPM implementation was met with limited success (Tajiri and Gotoh, 1992). This all changed in the 1970"s when Japan faced a worsening economic climate and adoption of TPM began to accelerate as a means to improve manufacturing productivity. Structured and phased implementation processes such as those developed by Nakajima (1989) provided standardized and repeatable methodology for TPM. (Nakajima, 1989).[1]

TPM represents a radical change in the way maintenance is being look at. It is a methodology and philosophy of strategic equipment management focused on the goal of building product quality by maximizing equipment effectiveness. Originally introduced as a set of practices and methodologies focused on manufacturing equipment performance improvement, TPM has matured into a comprehensive

equipment-centric effort to optimize manufacturing productivity (Ahuja and Pankaj, 2009). The goal of TPM or also known as Total Productive Manufacturing is to continuously improve all operational conditions of a production system by stimulating daily awareness of all employees.[2]

In 2012 Ranteshwar Singh and their team did the study of Total Productive Maintenance (TPM) Implementation in a Machine Shop, they stated that Quality and Maintenance of manufacturing systems are closely related functions of any organization. Over a period of time two concepts have emerged which are Total Productive Maintenance (TPM) and Total Quality Management (TQM) along with other concepts to achieve World Class Manufacturing system. In this paper experience of implementing Total Productive Maintenance is shared and investigated for a company manufacturing automotive component. Concept is implemented in the machine shop having CNC turning centers of different capacity. Overall Equipment Effectiveness is used as the measure of success of TPM implementation. The losses associated with equipment effectiveness are identified. All the pillars of TPM are implemented in a phased manner eliminating the losses and thus improving the utilization of CNC machines and they got results Overall Equipment Effectiveness has improved from 63% to 79% indicating the improvement in productivity and improvement in quality of product.[3]

Also according to Prof Pradeep Kumar, Total productive maintenance is practical technique aimed at maximizing the effectiveness of facility that we use within our organization .Total productive maintenance establishes a system of productive maintenance, covering the entire life cycle of equipment, covers all department, involves participation of all employees from top to bottom and promotes small group autonomous activities. During high growth era companies are making technical progress in automation and centralization of the plants, which needs large amount of manual work to maintain the automation systems. Framework of total productive maintenance TPM seeks to maximize equipment effectiveness throughout the lifetime of the equipment. It strives to maintain the equipment in optimum condition in order to prevent unexpected breakdown, speed losses, and quality defects occurring from process activities. There are three ultimate goals of TPM: zero defects, zero accident, and zero breakdowns. [4]

In 2013 Prasanth S. Poduval explains Barriers in TPM Implementation in Industries, As mentioned in his research, TPM implementation though easy on paper, is difficult to achieve and this is mainly due to reluctance by the organization to understand and implement the concepts of TPM and failure to realize the benefits obtained by implementation of TPM. Let us look at the various factors: Lack of top management commitment, Organization resistance to change, Unwillingness to commit resources, Work culture, Resistance by employees due to this they faced alot of barrier to implement TPM. [5]

Bupe. G. Mwanza , Charles Mbohwa in 2015 Design of a total productive maintenance model for effective implementation in a chemical manufacturing company, and they found that TPM is designed to maximize equipment effectiveness (improving overall efficiency) by establishing a comprehensive productive-maintenance system covering the entire life of the equipment, spanning all equipment-related fields (planning, use, maintenance, etc.) and, with the participation of all employees from top management down to shop-floor workers, to promote productive maintenance through motivation management or voluntary small group activities. The company should involve achieving the company goal through the implementation of operator initiated daily maintenance consisting of cleaning, adjustment, and regular inspections, as well as improvement activities and minor restoration of equipment. And the maintenance men should only participate in inspection and restoration of equipment which requires high skill and specialization. Empowering the operators and maintenance personnel through training. This should be conducted in sustainable manner to maximize the efficiency of the equipment in order to eliminate the operators‟‟ mistakes and improper repair. [6]

Chapter -3

III. Methodology Used And Product Information

Anupriya Ultratech runs either in two shifts or in three shifts depending upon the work load. Usually the shifts are of 8 hours which includes a 35 minutes break for lunch or dinner. Our primary study involved tabulation of all factors leading to the calculation of the Overall Equipment Efficiency and Productivity of the system and its direct influence in determining the efficiency of the existing system. Following chart shows Methodology used for this study.

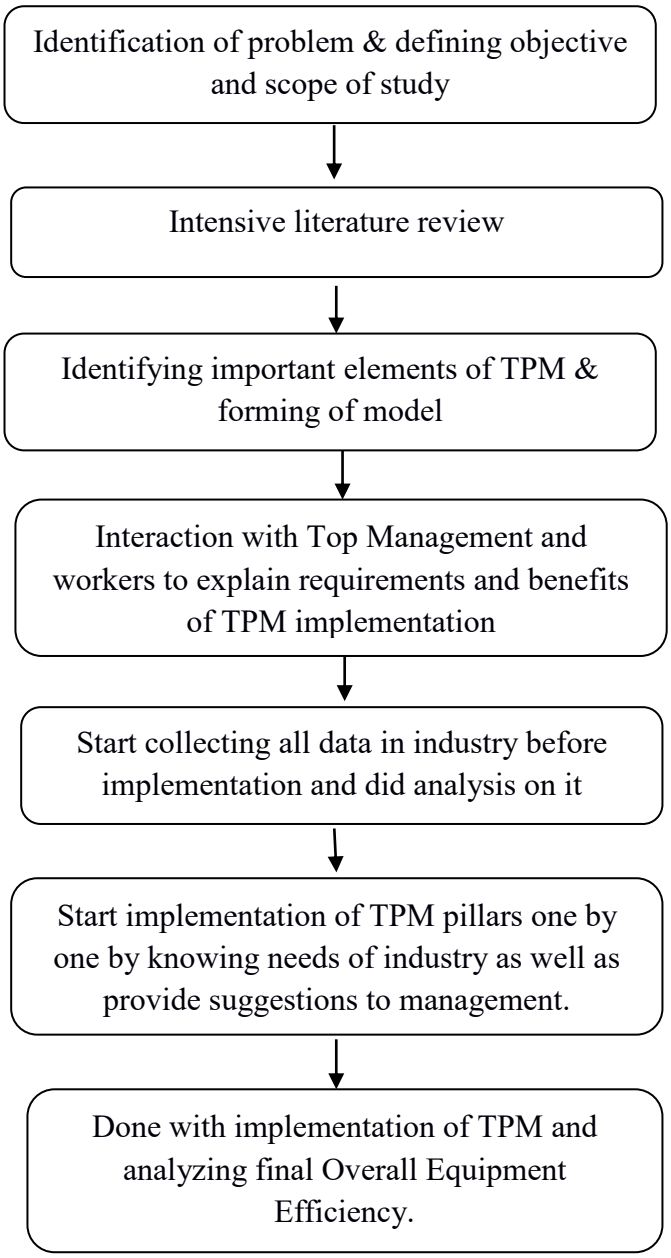


Fig. 1.3: Methodology used for this study

a) TPM Model

TPM Model is used to identify the components of the elements or strategies of TPM and manufacturing performance dimension. Each component will be studied in detail together with the theory that supports it. The relationship between these TPM elements and manufacturing performance will be analyzed to develop an understanding of contribution of TPM implementation element emphasis on manufacturing performance dimension. Figure 3.2 shows the proposed model for evaluating the relationship between TPM elements/strategies and manufacturing performance.

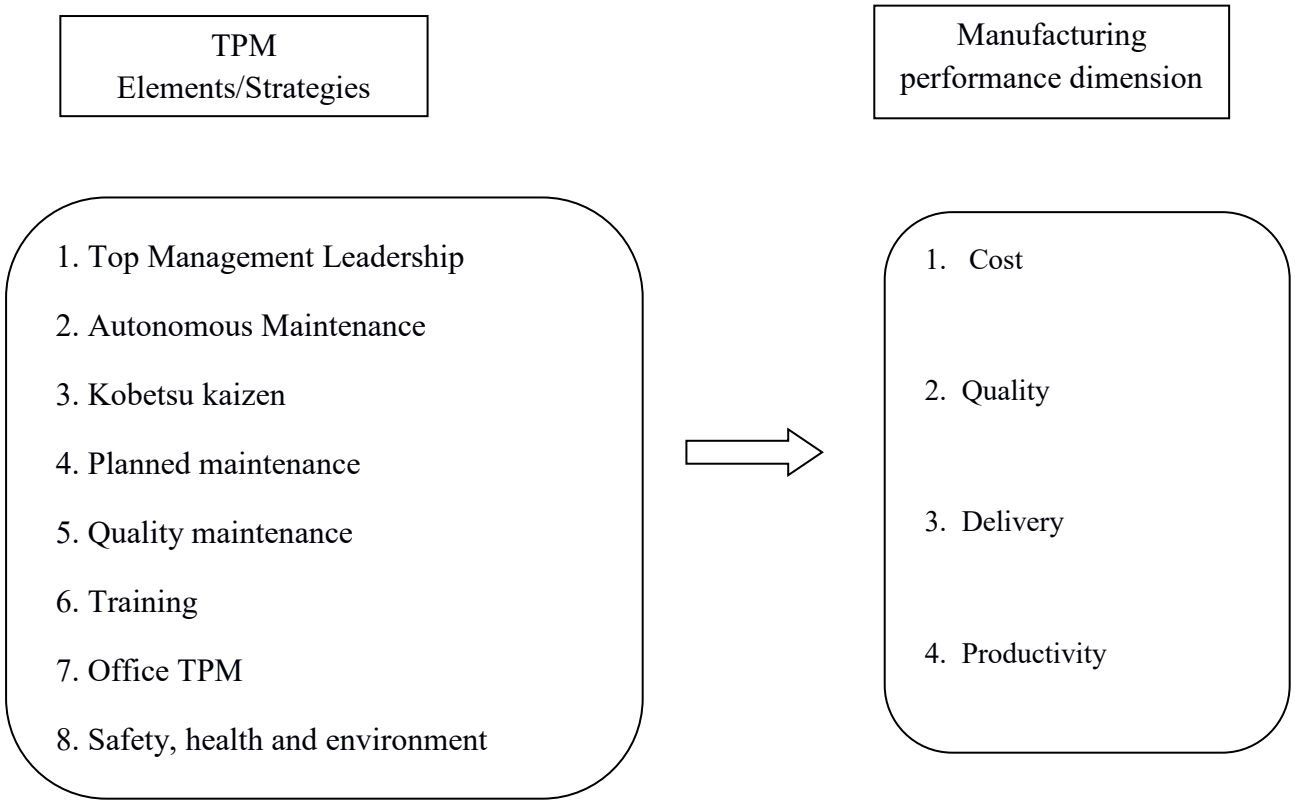


Figure 1.4: Proposed models for evaluating the relationship between TPM elements/strategies and manufacturing performance

b) Product Drawing and Process flow chart

Table 3.1: Process flow chart

Name	Symbol	Time (min)	Action
Transport	⇨	1	Storage to cutting machine
Operation (Cutting)	○	0.5	cutting operation
Transport	⇨	1	To CNC 1 for further operation
Operation (CNC 1)	○	3.5	Operations like facing, tapper, groove
Operation (CNC 2)	○	3.5	Same operation on another side
transport	⇨	0.5	To hydraulic press to fixed bearing in it
Operation (Hydraulic Press)	○	1	Bearing fixed by use of hydraulic press

Based on this method and collection of data from the industry OEE of the selected product is calculated very carefully.

Table 3.2: Calculation of OEE%

Sr. No.	Category	Before Implementation		
		Week 1	Week 2	Week 3
1	Shift time	960min/day	960 min/day	960min/day
2	Total production in a shift	155parts	154 parts	152 parts
3	scheduled break	70min	70 min	70 min
4	Non-scheduled break	12min	15 min	15 min
5	Breakdown	25min	20 min	30 min
6	Cleaning, inspecting & tightening of insert	20min	20 min	20 min
7	Operator absent	45min	65 min	50 min
8	Non-conforming product	8parts	9 parts	10 parts
9	Changeover or Setup	60 min	60 min	60 min

Calculating Availability:-

Availability is the percentage of time available to run the machine within a shift after losses due to setups and breakdowns. It is calculated by recording the time lost due to breakdowns (unplanned stoppages of more than 10 minutes) in minutes and the time lost during setup (Last good part of one product to the first good part of the next) also in minutes, we then compare this to the total available time within the shift.

$$\frac{\text{Total time available} - \text{Breakdowns} - \text{Changeover}}{\text{Total Time Available}} \times 100$$

Performance Calculation:-

The performance percentage is based around the total number of parts that are produced within your available time compared to how many you should have made if you produced at the planned (design) rate. So in our example above with 410 available minutes, if our production rate is designed to be 1 part per minute we should have produced 410 parts. However this is often reduced by reduced speed losses (running machines slower than design speed) and minor stoppages (such as small jams that have to be cleared). In our example our actual production is only 350 parts, so our performance percentage is;

$$\frac{\text{Total Number of parts produced}}{\text{Available time X production rate}}$$

Quality Calculation:-

Your percentage calculation for quality within your OEE measure compares the total number of parts produced and the total number of good parts. Product losses can be due to either bad quality parts produced during normal production or parts produced during a setup for a new product. In our example we have produced 350 parts, but of these 15 were lost through setup and 15 were defective products. Our quality percentage therefore becomes;

$$\frac{\text{Good Parts}}{\text{Total Number of Parts Produced}} \times 100$$

Table: OEE%

Sr no.	Category	Before Implementation		
		Week 1	Week 2	Week 3
1	Availability (A)	84%	82%	82.58%
2	Performance Efficiency(PE)	96%	95%	93.82%
3	Quality Rate(QR)	95%	94%	93.42%
4	OEE (A × PE × QR)	76.60%	73%	72.37%

After calculation of OEE we decided to implement TPM (Total Productive Maintenance), according to TPM we should first identify the problematic areas in industry, In next chapter we explain all identified problems which is causes low OEE %. And TPM will implement according to problem identified.

Chapter – 4

IV. Identification Of Problematic Areas

While observing the industry, we came along a lot of areas where improvement can be done or say Total Productive Maintenance can be implied. There were some issues where implementation of the particular was necessary. Such areas have been identified in this chapter.

Crane used to load chuck for bell housing is still kept in between CNC machines even after its use is over.

Waste bins, plastic bag and rejected parts are placed in corner near the staircase.

Waste boxes, bins and plastic bag are kept behind CNC- 01

Unwanted angles and pipes are kept near machine shop.

Rejected parts are kept besides machine and there are no red tags on them.

Earlier patches on the floor were disturbing material movement using trolley.

No labeling is done and tools are placed randomly in racks.

Allen keys, nut bolts and other tools are keep randomly.

CNCs are not cleaned from top side.

Coolant overflow from the tank is spilled on the ground without any provision to clean it.

Jaws and blocks are kept randomly.

To be dispatched parts are kept randomly.

Other areas which are identified include –

- No operator is writing hourly report.
- Employee details are not displayed on the notice board.
- No working information is displayed on the notice board.
- Maintenance sheets of the machines and equipment‟s is not maintained.
- Workers/operators don‟t have awareness for maintenance of the machines they are operating.
- Fire extinguishers are in limited number also training is not provided to workers for how to operate it.

Chapter -5

V. Implementation of Tpm

A detailed analysis of all the problems is done and techniques are identified to overcome this problems and to deal with them. Thus subset of TPM are implemented for overcoming different issues in the industry as follows.

5.1 5S:-

a) Sort /Arrangement (SEIRI)

(Eliminate unnecessary items) Through the suitable sorting it can be identified the materials, tools, equipment and necessary information for realization the tasks. Sorting eliminates the waste material (raw materials and materials), nonconforming products,and damaged tools. It helps to maintain the clean workplace and improves the efficiency of searching and receiving things, shortens the time of running the operation. The 1S rules proceedings.

A. On the first stage one should answer to so called Control Questions:

– Are unnecessary things causing the mess in the workplace?
– Are unnecessary remainders of materials thrown anywhere in the workplace?
– Do tools or remainders of materials to production lie on the floor (in the workplace)?
– Are all necessary things sorted, classified, described and possess the own place?
– Are all measuring tools properly classified and kept?

On the basis of the answer to the above questions it is possible the estimation of the workplace in terms of the 1S rule so littering the workplace. If on any question answer is yes, it should execute sorting of things, which are in the workplace.

B. On the second stage one should execute there view of all things which are in the workplace and group them according to the definite system. According to carried out sorting it should execute elimination from the workplace the things, which were found unnecessary.

C. To permanent usage the 1S rule is so-called the Programmed of the Red Label. It means giving the red label to things, which operator will recognize as useless within his workplace. This label will make possible not only the elimination of the given thing, but through its own formula will make possible the liquidation of the reasons of appearing on the workplace this given thing.

Before - Crane used to load chuck for bell housing is still kept in between CNC machines even after its use is over.

After - Crane is taken to the corner of the shop floor after its use is over thus eliminating the interference during normal operation.

Before - Waste bins, plastic bag and rejected parts are placed in corner near the staircase.

After - The place is utilized by finished good material storing rack.

Before - Unwanted angles and pipes are kept near machine shop.

After - That much area is used to keep accepted and rejected parts.

Before - Coolant tank which was delivered by CNC manufacturer by mistake was lying in machine shop.

After - Tank is stored in central store room. The space is free for storing accepted parts.

Before - Chip conveyor tank which was delivered by CNC manufacturer by mistake and lying in machine shop.

After - Tank is stored in central store room. The space is free for storing defective parts.

Before - To be dispatched parts are kept randomly.

After - The parts are covered packed and kept at proper place and stands.

b) Set in Order/Neatness (SEITON)

Efficient and effective storage method Especially important is visualization of the workplace (eg. painting the floor helps to identify the places of storage of each material or transport ways, drawing out the shapes of tools makes possible the quick putting aside them on the constant places, colored labels permitted identify the material, spare parts or documents etc.). Implementing the 2S rule It should execute the segregation of things and mark the places of their storing.

Before - No labeling is done and tools are placed randomly in racks.

After - Labeling is done and materials are stored in their respective places identified.

Before- Earlier patches on the floor were disturbing material movement using trolley.

After - Patches are filled with Cement thus helping smooth material flow.

Before - Plastic bags and waste cotton is randomly kept.

After - They are kept systematically, unnecessary thing thrown away and space freed.

Before -Trolleys are randomly placed anywhere.

After - Space is dedicated for keeping trolleys whenever not needed.

c) Shine/Cleanliness (SEISO)

(Thoroughly clean the workplace) Regular cleaning permits to identify and to eliminate sources of disorder and to maintain the clean workplaces. During cleaning It is checked the cleanness of machine, workplace and floor, tightness of equipment, cleanness of lines, pipes, sources of light, current data, legibility and comprehensibility of delivered information etc. Indispensable is also taking care of and maintenance the personal tidiness of the operator.

Before - CNCs are not cleaned from top side.

After - CNCs are cleaned from the top as well as covered to avoid unwanted contamination.

Before - Coolant overflows from the tank.

After - It is cleaned and overflow problem is solved.

d) Standardize / Order (SEIKETSU)

(Order and control to be established for) Worked out and implemented standards in the form of procedures and instructions permit to keep the order on the workplaces. Standards should be very communicative, clear and easy to understand. Regarding this during preparation and improving, it should be involved all participants of the process on the given workplace, it means direct workers. The group knows the best specificity of its own activities, and process of elaboration and after that, usage gives them possibility of understanding the essence and each aspect of the operation. In the aim of assuring all the easy access, obligatory standards should be found in constant and visible places. It is assumed that standards should not be implemented only in the typical operational processes e.g. production, movement maintenance, storing, but also in the administrative processes, for example: book-keeping, customer service, human resources management, or secretariat service.

Before:-

1. No operator is writing hourly report.
2. Employee details are not displayed on the notice board
3. No working information is displayed on the notice board

After:-

1. Writing hourly report is compulsory
2. Employee details are displayed on the notice board
3. Working instructions, control process plan daily maintenance sheet and part drawing are displayed on each CNC.

e) Sustain / Discipline (SHITSUKE)

(Sustain new status quo everything in its place) Implementing the idea of the 5S will demand from workers the compact self-discipline connected with implementing and obeying the rules of regularity incleaning and sorting. It leads to increasing the consciousness of staff, and decreasing the number of non-conforming products and processes, improvements in the internal communication, and through this to improvement in the human relations. It is also important to understand the need of executing the routine inspections of usage the 5Srule. This inspection is executed by helping of so-called check List and created on its basis the radar graph of the 5S, which serves to estimation of the workplace. The inspection of realization of the 5Srule is executed once a month by chosen team implementing the 5S rule – the control team.

Before:-

1. Company s Mission and Vision statements are not displayed.
2. No suggestion scheme

After:-

1. Company‟s Mission and Vision statements are displayed in Hindi as well as Gujarati.

2. Suggestion scheme stating that whoever gives the best suggestion will be given reward of Rs 500/-.

f) Autonomous maintenance (JISHU HOZEN)

The workers are to be self aware of the machines they are operating. They should learn to take care of the machines themselves on the daily and periodic basis. Autonomous Maintenance is very crucial important in improving Equipment efficiency.

For implementation of Autonomous Maintenance we took following steps and did work which is expressed in following table

Table 5.1: AM seven Step Implementation Methodologies

Autonomous maintenance seven step Implementation report	
Step	Work done
1.Cleaning and Inspection	Remove all dirt and grime from the machine
	Uncovered and highlighted all problems within the machine.
	All fluids drained and covers removed so that every part of the machine can be inspected and cleaned.
	Used Red/green Tags to highlight any problems,
	Cleaned machine by Operator as well as Maintenance persons.
2.Remove Causes of Contaminationandimprove Access	After cleaning, Identified root cause of contamination
	Identified inaccessible areas
3.Cleaning and Lubrication standards	Prepared Cleaning, Lubricating, Re-tightening, Inspection (CLRI) check sheet.
	Mapped cleaning frequency for Big machines
4.Train for general Inspections	Conduct in depth training with the operators to explain the function and purpose of each component of the machine as wells training in problem solving skills such as the Cause & effect and 5 whys.

	We then have the operators re-inspected the machines with their new-found knowledge and highlighted new problems discovered in much the same way that we did in step one.
5.Conduct Autonomous Inspections	With what they have learned in stage 4 the operators modified the standards and instructions that they put in place for the first three stages of autonomous maintenance to streamline and improve their maintenance tasks.
	The tasks at this stage are also compared and rationalized with the maintenance departments own maintenance schedules allowing tasks to be allocated correctly and prevent duplication of effort.
6.Implement Visual MaintenanceManagement	Provides Green/Red marks on Pressure gauges, oil level indicators.
	stickled JH stickers that what to clean by which Tool
	Fix Machine area Dashboard which Displays all the details regarding that machine
	Highlight the direction of flow of fluids through pipe work.
	highlighted “safe” and “normal” operating values on gauges and sight glasses in green and undesirable readings in red
7.Continuous Improvement (KAIZEN)	Repeated and improved on all that we have found and done in the previous stages to continually improve and reinforce what done with autonomous maintenance
	Team leaders, managers and maintenance technicians audited the work done by the operators on a regular basis and both congratulated the operators on a job well done and to give them the benefits of their knowledge.

g) 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. The principle behind is that “a very large number of small improvements are move effective

in an organizational environment than a few improvements of large value". This pillar is aimed at reducing losses in the workplace that affect our efficiencies. By using a detailed and thorough procedure we eliminate losses in a systematic method using various kaizen tools. These activities are not limited to production areas and can be implemented in administrative areas as well.

- *Poka Yoke Device:-*

Arrangement of the tools in proper order so that no time is wasted in searching them and also that tools are prevented from unnecessary wear and tear. A tool board is to be prepared as shown below in the figure.

Fig. 1.5: Arranged all tools by poke yoke concept

- Coolant leakage problem:-

Coolant leakage was a major issue and all the leakage is clearly visible on the ground and causing trouble in the movement of workers as well as flow of material and parts. A keen observation is done to find out the reason of this leakage, the risk associated with the leakage and what preventive measures should be taken to avoid it. And a fish bone diagram is prepared showing the reasons for the leakage.

Fig. 1.6: Coolant leaked problem

To identify the reasons of coolant leakage fish bone diagram is prepared

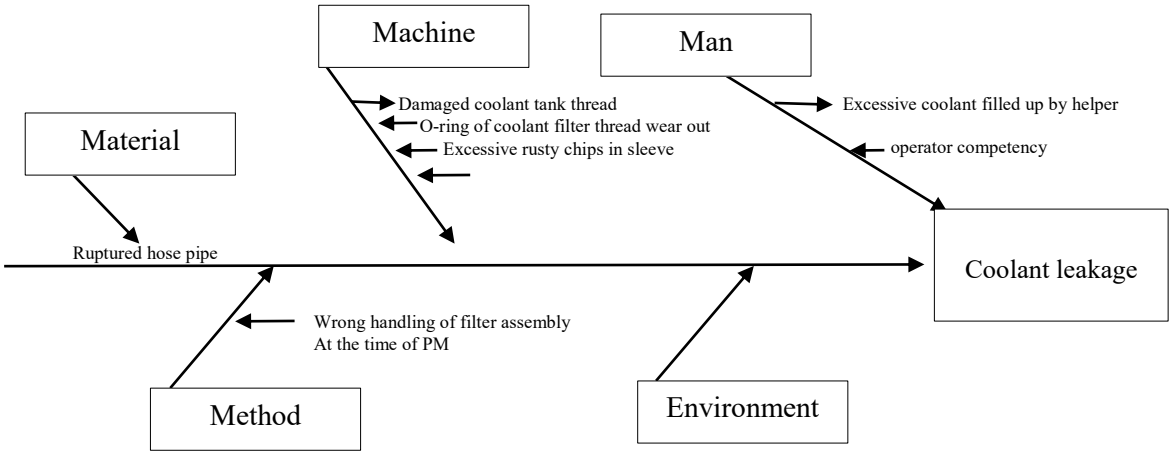


Fig. 1.7: fish bone diagram

The following table shows complete analysis of the coolant leakage problem and how it can be eradicated. The corrective measures that should be taken are also highlighted.

Table 5.2: Analysis of fish bone diagram

Problem	Occurrence	Risk	Severity	Corrective Action
Coolant leakage from filter	1. Due to O-ring (gasket) in the filter head got damaged	Moderate	High	New O-ring has been ordered.
	2. While tightening filter back into filter head is filter is not held at 90° and because of aluminum casted body and cross taper its threads are damaged.			Proper training is given to helpers who are doing Weekly preventive maintenance.
Coolant leakage from tank	1. One of the punching nut of coolant tank got damaged may be due to application of over pressure on the nut while tightening it.	Moderate	High	Gasket in the tank is changed and new punching nut is installed.

	2. Overflow from tank due to Overfilling of coolant by helper.			Training and number of bucket to be filled is clearly specified to the helper
Coolant leakage from hose pipe	Due to it‟s to and fro motion along with turret and it has certain life span after which it gets ruptured.	Low	Low	Installing new hose pipe

h) Planned maintenance (PM)

As we know it is aimed to have trouble free machines and equipment‟s producing defect free products for total customer satisfaction. This breaks maintenance down into four "families" or groups, viz., preventive maintenance, breakdown maintenance, corrective maintenance, and maintenance prevention.

Six steps in planned maintenance:

1. Equipment evaluation and recoding present status.
2. Restore deterioration and improve weakness.
3. Building up information management system.
4. Prepare time based information system, select equipment, parts and members and map out plan.
5. Prepare predictive maintenance system by introducing equipment diagnostic techniques and Evaluation of planned maintenance.

To prevent all breakdowns and for maintenance of plant and machineries we provide them maintenance sheets which is on Daily, Weekly and Monthly basis. Due to maintenance sheets they found tremendous change in their system because they are not used this maintenance sheets before. Due to sheets many of breakdowns are cleared and time are saved which is shown in calculations in final implementation analysis The product that we have considered requires three major machines for its production namely CNC, Cutting Machine and Hydraulic press. The charts for the maintenance of these machines. The parameters that affect the machines are written down in the charts and classified on the basis of maintenance requirement where they are to be changed or serviced on daily, monthly and quarterly basis.

i. *For CNC machines*

Daily basis – Three types of maintenance are to be done on daily basis mainly Checking, Cleaning, areas like tool holders and spindle. The operators in that particular shift is supposed to fill the form and submit it to the production manager. The maintenance is to be done at the end of the shift. Tick mark is to be done in the column when its done.

Monthly basis - There are some parameters that does not need to be checked on daily basis because they can sustain for a month at least. They are to be checked every month to avoid the further failure. This is a part of the preventive Maintenance.

Table 5.3: For Daily maintenance of CNC

ANUPRIYA ULTRATECH - Daily maintenance report for CNC

Month :	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CHECKING															
Hyraulic pressure															
Chuck presure															
Lube levels															
Coolant levels															
leaks															
CLEANING															
Chips															
Grease parts															
Windows															
Doors															
CUTTING TOOLS & TOOL HOLDERS															
Tighten the drawbar															
Tighten work holder devices															
Replace worn tool pump and motor															
SPINDLE															
Clean the spindle taper															
Test run the spindle															

Name of the operator :	
Submited on :	
REMARKS :	

Table 5.4: For monthly Maintenance of CNC

ANUPRIYA ULTRATECH - Monthly maintenance report for CNC

Month :	oct	nov	dec	jan	feb	march	april	may	june	july	Aug	Sept
Mechanical												
Tool holders												
Check for breakage and Thread damage												
Inspect way covers and wipers												
Check dawbar height												
Electrical												
Motor Check for condition and testing												
Check for condition and testing												
Check voltages												
Check limit switches/safety locks												

General Note

Check entire machine for loose or missing fasteners

All of the oily matter, chips, etc, on the machine should be removed completely and put a thin lubricating oil on the sliding surface of machine to prevent the corrosion.

Name of the operator :	
Submited on :	
REMARKS :	

Quarterly basis –

Table 5.5 : Quarterly maintenance report for CNC ANUPRIYA ULTRATECH - Quarterly maintenance report for CNC

ANUPRIYA ULTRATECH - Quarterly maintenance report for CNC

Month :	**Yes**	**No**	**Remarks**
1. Clean coolant tank of sludge, chips, and oil			
2. Clean chuck and jaws			
3. Drain hydraulic tank and replace hydraulic oil			
4. Change line filter and suction filter			
5. Clean radiator and straighten any bent fins			
6. Drain and clean lubrication unit, add fresh way lube			
7. Drain and refill cooling unit			
8. Ensure the machine is level, adjust if necessary			
9. Clean and inspect way wipers, replace damaged ones			
Name of the operator :			
Submitted on :			
REMARKS :			

ii. *For Cutting machine*

On daily basis – Blades, Oil, Belt and below mentioned parameters needs to be changed in a cutting machine more often. Thus a sheet is to be maintained to keep the track of changed things. Moreover to prevent unwanted breakdown they are to be changed and checked from time to time.

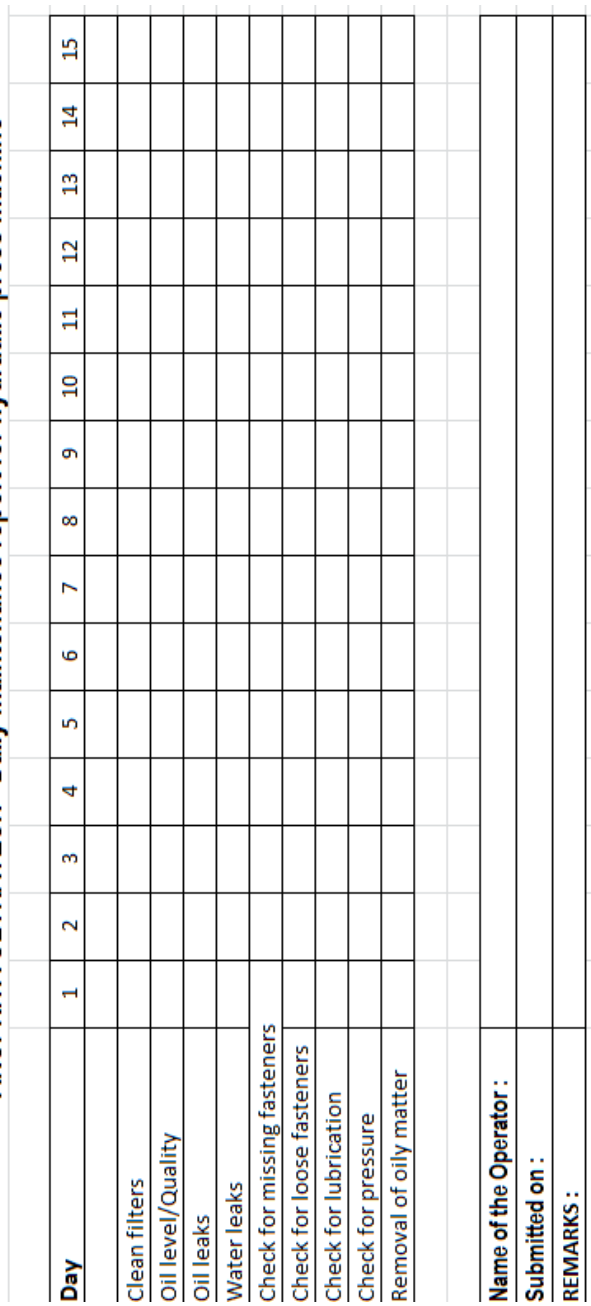
Table 5.6: For maintenance of Cutting machine

ANUPRIYA ULTRATECH - Quarterly maintenance report for Bensaw Cutting Machine

Month :	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Changing															
Blade															
Belt															
Hydraulic oil															
Gear Oil															
Coolant															
Name of the operator :															
Submited on :															
REMARKS :															

iii. *For Hydraulic press machine*

On daily basis – Cleaning of filters, checking oil level, water and oil leaks, checking for loose fasters, pressure adjustments etc are being checked.



ANUPRIYA ULTRATECH - Daily maintenance report for hydraulic press machine

Day	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Clean filters															
Oil level/Quality															
Oil leaks															
Water leaks															
Check for missing fasteners															
Check for loose fasteners															
Check for lubrication															
Check for pressure															
Removal of oily matter															

Name of the Operator :	
Submitted on :	
REMARKS :	

iv. *For Hydraulic press machine*

On monthly basis – Following criterias are to be checked on monthly basis.

i) Training

Continuous improvement is possible only through continuous improvement in knowledge and skill of the people as different levels. To reduce the defects training is provided to the concerned as show below:

- Training given for 100% visual inspection to detect visual defects
- Training given for using "Go and No go" gauges for 100% inspection and also for educating them how to use measuring instrument for e.g. verniercaliper, screw gauge and dial gauge etc.
- Training given by shop floor in charge regarding necessary force required to clamp the job into the chuck.
- Training given optimum set up for machine including how to mount chuck on the machine, in which order reduction sleeves, blocks and jaws should be installed etc.
- They are also advised to do setting at mean value given in the control copy of the drawing, earlier they setting machine at minimum value or we can say lower control limit, and thus causes rejection

j) Office TPM

- Now operators are writing daily rejected quantities in their daily report, so that time required in getting data for daily rejection from Quality department is reduced.
- New computer system is proposed for Maintenance department because Maintenance department is writing its daily report in a notebook and then that notebook is given to administration and then they document it and also for making schedules for maintenance they have to wait for person in administration to document it and take its hardcopy. And also their chance of loss of old records having valuable data.
- Earlier daily insert usage report was maintained in a notebook, and at the end of the month the person has to sit along with calculator to sum up the monthly consumption. Now the report is prepared in MS Excel saving lots of time and effort.
- Now employee details are displayed on the notice board having information like their name, designation, phone number so that whenever anybody need to consult them can reach them on their mobiles, without wasting time.

k) Safety, Health and Environment

- Sufficient number of fire extinguisher is provided all over CNC shop floor.
- Training is given to each and every individual about how to use fire extinguisher in case of emergency in every 6 months.
- Management is given suggestion for giving training to employee what to do in case of emergency? What should be the exit plan?
- Management is also given suggestion to conduct mock drill once in a year.
- Earlier water camper in the shop floor was washed weekly now helpers are advised to wash it within 2 days.

Workers are advised to maintain cleanliness of toilets, regular cleaning of toilets is also done. Workers are also advised not to chew tobacco and spit it in CNC shop floor and not to smoke within company premises.

Chapter -6

VI. Conclusion

After implementation of all the tools and techniques of Total Productive maintenance, again the data of the same product is collected and this tie again the OEE (overall equipment efficiency) is calculated as below.

Table 6.1: Calculation of OEE%

Sr. No.	Category	After implementation
1	Shift time	960min/day
2	Total production in a shift	155 parts
3	scheduled break	70 min
4	Non-scheduled break	20 min
5	Breakdown	15 min
6	Cleaning, inspecting & tightening of insert	20 min
7	Operator absent	10 min
8	Non-conforming product	4 parts
9	Changeover or Setup	62 min

Table 6.2: OEE% After implementation

Sr. no.	Category	After implementation
1	Availability (A)	79.03%
2	Performance Efficiency(PE)	95.25%
3	Quality Rate(QR)	96.12%
4	OEE (A × PE × QR)	72.07%

Thus we can say that after implementation of TPM all the objective of the project are fulfilled mainly the productivity is increased, The overall equipment efficiency is increased, The task of timely Maintenance of the machines is achieved. Unnecessary breakdown of machines is drastically reduced. Workers are given training and knowledge of the importance of timely maintenance of the machine.