

Technical Note on Total Productive Maintenance (TPM) Program - An Overview

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Abstract: *Total Productive Maintenance (TPM) is a maintenance program which involves newly defined evidence driven concepts for successful maintenance of plants and equipment. The goal of the TPM program is to markedly increase production while, at the same time, increasing employee confidence and job satiation. The TPM program closely resembles the popular Total Quality Management (TQM) program. Many of the same tools such as employee empowerment, benchmarking, documentation, etc. are used to implement and optimize TPM. This paper will define TPM in some detail, evaluate its strengths and weaknesses of TPM and even explicated the implementation procedures.*

Keywords: Total Productive Maintenance, Employee and industry

1. Introduction

Total Productive Maintenance (TPM) is a maintenance program driven concept. Philosophically, TPM resembles Total Quality Management (TQM) in several aspects, such as (1)total commitment to the program by upper level management is required, (2) employees must be empowered to initiate corrective action, and (3) a long range outlook must be accepted as TPM may take a year or more to implement and is an on-going process. Changes in employee mind-set toward their job responsibilities must take place as well. TPM brings maintenance into focus as a necessary and vitally important part of the business. It is no longer regarded as a non-profit activity. Down time for maintenance is scheduled as a part of the manufacturing day and, in some cases, as an integral part of the manufacturing process. It is no longer simply squeezed in whenever there is a break in material flow. The goal is to hold emergency and unscheduled maintenance to a minimum.

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.

2. Types of maintenance adapted in an organized industries / plants

1. Breakdown maintenance

In such maintenance people waits until equipment fails and repair on its own. Those things could be used when the equipment failure does not significantly affect the operation or production or generate any significant loss other than repair cost.

2. Preventive maintenance

It is a daily maintenance (cleaning, inspection, oiling and re-tightening), design to retain the working condition of equipment and prevent failure through the prevention of deterioration, periodic inspection or equipment condition diagnosis, to measure deterioration. It is further divided into periodic maintenance and predictive maintenance. Just like human life is extended by preventive medicine, the equipment service life can be prolonged by doing preventive maintenance.

2a. Periodic maintenance (Time based maintenance - TBM):

Time based maintenance consists of periodically inspecting, servicing and cleaning equipment and replacing parts to prevent sudden failure and process problems.

2b. Predictive maintenance:

This is a method in which the service life of important part is predicted based on inspection or diagnosis, in order to use the parts to the limit of their service life. Compared to periodic maintenance, predictive maintenance is condition based maintenance. It manages trend values, by measuring and analyzing data about deterioration and employs a surveillance system, designed to monitor conditions through an on-line system.

3. Corrective maintenance:

It improves equipment and its components so that preventive maintenance can be carried out reliably. Equipment with design weakness must be redesigned to improve reliability or improving maintainability.

4. Maintenance prevention:

It indicates the design of a new equipment. Weakness of current machines are sufficiently studied (on site information leading to failure prevention, easier

maintenance and prevents of defects, safety and ease of manufacturing) and are incorporated before commissioning a new equipment.

The Japan Institute of Plant Maintenance (JIPM) approach to TPM

The JIPM definition of TPM is:

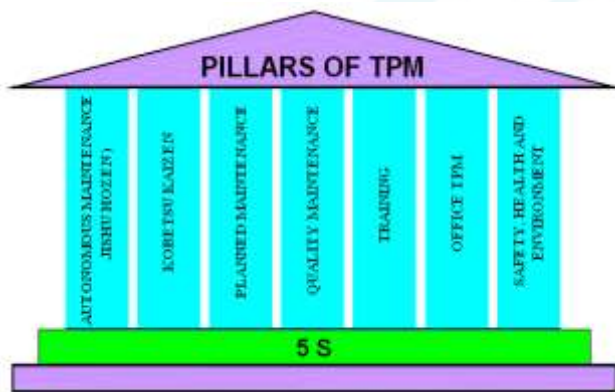
T = Total. Must involve all employees at all levels of the organisation.

P = Productive. Effective utilisation of all resources.

M = Maintenance. Keeping the Man-Machine-Material system in optimum condition.

JIPM developed an eight pillar approach to TPM focused on achieving:

- Zero Accidents
- Zero Break-downs
- Zero Defects



3. TPM 5S Foundation

5S is considered the foundation of the lean TPM program because without it the initiative will founder under the weight of disorganization, indiscipline and inefficiency.

It is important because it results in a clean, visually organized workplace that is self-maintaining. 5S consists of five basic steps:

- Sorting all the items in the workplace and removing everything that is not necessary and does not contribute to the creation of value for the customer
- Setting in Order everything that remains in an organized manner such that find items and raw materials is easy. This reduces waiting and searching time in the process enhancing the flow of value throughout the value chain
- Shining (Cleaning) is a way of making any abnormalities visible as well ensuring that quality of the final product is of a high standard. It has been observed that a clean and organized workplace has a positive effect on worker morale, not to mention that it also ingrains a sense discipline – all of which has an impact on overall productivity

- Standardizing ensures that the improvements made are documented for posterity as well as serving as a basis for further improvements and training
- Sustaining the improvements through scheduled audits is a way of stabilizing the system by ensuring the agreed standards are been followed. Audits also serve as a measure of the effectiveness of the established standards – feedback that can be used to determine whether the standards need further revision or improvement.

The 5S program sets the pace for the introduction of Total Productive Maintenance and must be fully mature before any attempts are made to implement other aspects of the system.

As a stand-alone component, 5S is very effective in improving the organizational metrics and has been shown to increase aspects such as productivity and quality.

For example, if the workplace is clean and organized, tools used in maintenance are easily located – this has a positive effect on machine uptime.

4. The Eight TPM Pillars

Once a high degree of stability is established using the 5S program, an organization can start implementing the total productive maintenance in earnest.

Total productive maintenance has eight pillars that are aimed at proactively establishing reliability of machines.

One point that has to be made here is that people are centre of this system and must be continuously trained to identify and eliminate waste.

It is a system that is based on a clear set of principles and structures and should not be interpreted to be a set of tools or techniques to be applied haphazardly.

TPM Pillar 1: Autonomous Maintenance (Jishu Hozen)

Jishu Hozen or Autonomous Maintenance places the responsibility of basic maintenance activities on the hands of the operators and leaves the maintenance staff with more time to attend to more complex maintenance tasks.

Maintenance activities that are carried out by shop floor workers include basic cleaning of machines, lubricating, oiling, and tightening of nuts and bolts, inspection, diagnosis of potential problems and other actions that increase the productive life of machines or equipment.

By carrying out these maintenance activities, the workers become more responsible towards their work and downtime is reduced because there is no need of waiting for maintenance staff as they can correct simple problems that may occur from time to time.

Maintenance staff on the other hand will be more concerned with issues that require a higher technical ability such as replacement and servicing of internal parts. They will also carry out scheduled or planned maintenance

which means production will not be interrupted unnecessarily.

Autonomous maintenance has benefits to both the workers and the organization as a whole:

- Operators become more responsible and concerned about the condition of equipment they use on a daily basis
- Skill levels of workers increase as they gain an understanding of the general working of equipment thus achieving the multi-skilling objective of a lean organization
- Machines operate at their optimal level because basic maintenance such as cleaning and lubrication is carried out more regularly
- Problems are identified and corrected before they go out of control leading to major breakdown of equipment.
- Engineering staff are freed-up to carry out higher-level maintenance activities on sensitive and critical equipment thus reducing the overall system downtime

By carrying out the simple activities in this TPM pillar, capital investments are drastically reduced because the organization has reliable equipment and does not have to replace machines as often. This is because the lifespan of machines is drastically increased as forced deterioration is checked through constant monitoring and maintenance.

TPM Pillar 2: Planned Maintenance

Planned maintenance is the scheduling of maintenance activities based on observed behaviour of machines such as failure rates and breakdowns. By scheduling these activities around such metrics, the cycle of breakdowns and failure is broken thus contributing to a longer service life of machines.

Because there is a specific time for maintaining equipment, production is rarely interrupted as these activities are scheduled around the time when they are idle or are producing very little. In fact, production functions can build up some inventory to allow for the planned maintenance to be carried out as they have prior information of when these activities are scheduled.

This is in contrast to reactive maintenance that waits for problems to occur which has a negative impact on productivity due to machine downtime. Production will never be sure when they will be able to get back to work because the problems are not clear and technicians will just be doing exploratory work to find causes.

There are many obvious benefits of taking the planned maintenance approach as compared to being reactive when technical issues arise:

- By constantly scheduling maintenance activities, the number of breakdowns gradually decrease and this then increases the capacity for productive activities
- Production functions can continue with their activities uninterrupted because they know exactly when maintenance will take place.

- Maintenance is done when the production floor is not very busy
- Capital investments in machinery are reduced as the equipment is utilized to its fullest potential
- Expensive machine parts do not have to be kept in inventory as there is better control of the various categories of parts.

Pillar 3: Quality Maintenance

This TPM pillar addresses the issue of quality by ensuring equipment is able to detect and prevent errors during production. By detecting errors, processes become reliable enough to produce the right specification the first time.

The quality aspect of maintenance is very important because it helps in preventing defects from moving down the value chain which only leads to a lot of rework.

Using lean tools such as autonomation (jidoka) and andon, machines detect and report any abnormal conditions, thereby releasing the operators from the tedious monitoring that is common in non-lean operations.

The quality maintenance pillar of TPM also ingrains in the workforce the habit of finding the root cause of problems instead of rushing to solutions that are not permanent. This is done through tools such as 5 Whys root-cause-analysis and Ishikawa diagrams which are structured ways of getting to the real reasons why problems occur.

Quality maintenance offers a number of advantages including:

- Targeted improvement activities address quality issues that arise from time to time in the workplace by coming up with permanent countermeasures
- Defects are minimized or completely eliminated
- Cost of poor quality is reduced by getting quality right the first time. This happens because errors are caught before they move down the value stream which reduces the amount of rework that has to be done to correct them.

Pillar 4: Focused Improvement (Kobetsu Kaizen)

In this pillar, cross-functional teams are assembled with the main working on problematic equipment and coming up with improvement suggestions.

The use of cross-functional teams is important so as to have a large and varied number of employees involved so as to bring in different experience as well as viewpoints to the table.

These teams are better placed to come up with solutions to the issues that arise concerning crucial machines. The kaizen projects for maintenance also serve as training sessions on the total productive maintenance tool which results in the organization having a large pool of skilled personnel.

Once a focussed improvement team for maintenance has been identified and trained, they choose at least one piece of equipment as a pilot for their activities. Problems relating to the equipment are identified and improvement goals set in a three to five day in-house kaizen event.

During the events, the participants map the current state of affairs as a baseline performance measure on which they will compare any future performance after improvement.

The teams work together to make sure that any solutions that they come up with are implemented and any follow-up activities are completed within the agreed timelines.

The focussed improvement pillar of TPM is therefore advantageous as quick gains are made which helps in promoting the lean methodology to workers who may not have bought in to the program.

The organization is able to build-up a large base of employees that are conversant with the right tools for solving problems and getting to the root cause.

Pillar 5: Early Equipment Maintenance

The fifth TPM pillar of Early Management uses the experience gathered from previous maintenance improvement activities to ensure that new machinery reaches its optimal performance much early than usual.

Working with a myriad of stake-holders including suppliers, the company is able to hit the ground running with highly reliable and productive equipment.

Such an approach has a positive impact on profitability of the company as maintenance costs are dramatically reduced.

The productivity as well as output quality of the machines is also guaranteed from the very first day when the equipment is commissioned.

Using the input from the people who use these machines on a daily basis, suppliers of the equipment can improve the maintainability and operability in the next iteration of their products.

Among the factors that should be considered when designing new equipment include:

- Ease of cleaning and inspection
- Ease of lubrication
- Accessibility of equipment parts
- Improving operability of machines through ergonomically placing controls in such a way that they are comfortable to use by operators
- Making it easier for changeover to take place through simplification of procedures or eliminating the unnecessary ones
- Feedback mechanisms that prevent out-of-spec situations as well as clear indications of the correct specifications for quality products
- Increased safety features

Though the machines may be designed and manufactured with all the above considerations in mind, it is still possible that there will be bugs that will need to be removed before full commissioning.

Early management is a system that addresses these concerns and uses input from the staff who will be using the equipment before installation.

Pillar 6: Education and Training

This pillar is concerned with filling the knowledge gap that exists in an organization when it comes to total productive maintenance.

Lack of knowledge in the tools can stand in the way of proper implementation leading to mediocre results at best and failure at worst.

Without proper training, tools such as TPM can be misunderstood by the staff which can result in disastrous results for the company.

Ensuring that employees are trained gives the organization a reliable pool of knowledgeable staff that can drive the initiative competently.

TPM education and training pillar is a company-wide initiative that does not leave out any employee cadre. In fact, all levels in the organization – from the operators to senior managers – get involved in the TPM training as well projects.

Through training, operators' skills levels are raised to the point where they are able to carry-out basic maintenance activities that were previously the preserve of maintenance staff.

The technical staff is then taught higher level skills such as preventive maintenance and analytical skills to help become more proactive to problem solving.

At the managerial level, managers also learn the TPM skills so as to become competent mentors to their juniors as well as be involved in coaching programs.

Pillar 7: Health, Safety & Environment

That workers must be able to perform their functions in a safe environment devoid of health risks cannot be gainsaid.

The health, safety and environment pillar of total productive maintenance ensures that all workers are provided with an environment that is safe and that all conditions that are harmful to their well-being are eliminated.

While the goal of any organization is to produce value for the customer in an efficient and productive manner, this should be done in a way that does not put to risk the safety of workers. It is therefore important that any

solutions which are put in place should consider the well-being of the worker above all else.

When workers are in a safe environment, their attitude towards work changes dramatically with a resultant increase in important metrics such as productivity. This is because injuries or fatalities reduce when there is a concerted effort to make the workplace an accident-free environment.

The cross-functional teams will work towards making machines safe to use by the operators by putting in place such features as guards, works standards, use of personal protective equipment and first-aid kits in the work-area. Each of these measures are aimed at improving the safety of the machines so as to have a more productive workforce.

Pillar 8: TPM in Office Functions

Taking TPM to the administrative functions is the next logical step in the total productive maintenance program so as to have the whole organization speaking from the same page.

As these are supportive functions, making them understand and apply the principles of lean in their own operations makes it easy for them to provide efficient service to the main value-creating processes.

In addition, spreading the initiative into other functions removes the silo mentality and encourages horizontal cooperation within the workforce. The organization will also benefit by having a larger pool of workers who understand the principles of TPM and can easily be called upon to play a positive role in its implementation.

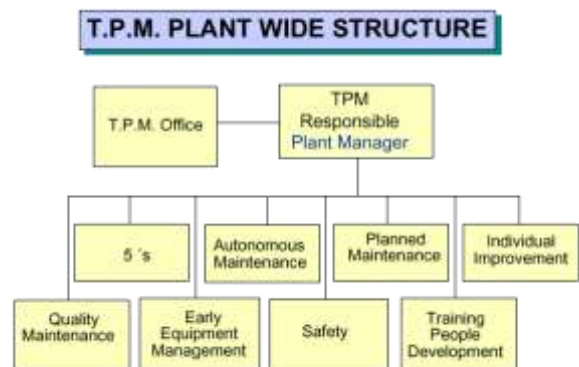
The TPM principles can also be applied as stand-alone techniques to improve the efficiency of these supportive functions. For example, if the administrative functions are able to improve their order processing procedures, then material will get to the shop-floor in a flawless manner which will have a positive effect on the workflow.

If suppliers are paid on time, they will have the ability to provide the services that they have been contracted to give without any problem.

As we conclude with this pillar, it is important to note that each has its role in the greater scheme of things and should be employed at the appropriate time.

While each TPM pillar has can be applied as a stand-alone component, the aim should be to sequentially implement each of the pillars so as to have got the full benefits of a complete system.

5. Organization Structure for TPM Implementation



6. Implementation of TPM

To start with applying TPM concepts to plant maintenance activities, the entire work force must first be convinced that upper level management is committed to the program. The first step in this effort is to either hire or appoint a TPM coordinator. It is the responsibility of the coordinator to exuberate the TPM concepts to the work force through an educational program. To do a thorough job of educating and convincing the work force that TPM is just not another "program of the month," will take time, perhaps a year or more or so.

Once the coordinator is convinced that the work force is sold on the TPM program and that they understand it and its implications, the first study and action teams are formed. These teams are usually made up of people who directly have an impact on the problem being addressed. Operators, maintenance personnel, shift supervisors, schedulers, and upper management might all be included on a team. Each person becomes a "stakeholder" in the process and is encouraged to do his or her best to contribute to the success of the team effort. Usually, the TPM coordinator heads the teams until others become familiar with the process and natural team leaders emerge.

The action teams are charged with the responsibility of pinpointing problem areas, detailing a course of corrective action, and initiating the corrective process. Recognizing problems and initiating solutions may not come easily for some team members. They will not have had experiences in other plants where they had opportunities to see how things could be done differently. In well run TPM programs, team members often visit cooperating plants to observe and compare TPM methods, techniques, and to observe work in progress. This comparative process is part of an overall measurement technique called "benchmarking" and is one of the greatest assets of the TPM program.

The teams are encouraged to start on small problems and keep meticulous records of their progress. Successful completion of the team's initial work is always recognized by management. Publicity of the program and its results are one of the secrets of making the program a success. Once the teams are familiar with the TPM process and

have experienced success with a small problem, problems of ever increasing importance and complexity are addressed.

As an example, in one manufacturing plant, one punch press was selected as a problem area. The machine was studied and evaluated in extreme detail by the team. Production over an extended period of time was used to establish a record of productive time versus non-productive time. Some team members visited a plant several states away which had a similar press but which was operating much more efficiently. This visit gave them ideas on how their situation could be improved. A course of action to bring the machine into a "world class" manufacturing condition was soon designed and work was initiated. The work involved taking the machine out of service for cleaning, painting, adjustment, and replacement of worn parts, belts, hoses, etc. As a part of this process, training in operation and maintenance of the machine was reviewed. A daily check list of maintenance duties to be performed by the operator was developed. A factory representative was called in to assist in some phases of the process.

After success has been demonstrated on one machine and records began to show how much the process had improved production, another machine was selected, then another, until the entire production area had been brought into a "world class" condition and is producing at a significantly higher rate.

Note that in the example above, the operator was required to take an active part in the maintenance of the machine. This is one of the basic innovations of TPM. The attitude of "I just operate it!" is no longer acceptable. Routine daily maintenance checks, minor adjustments, lubrication, and minor part change out become the responsibility of the operator. Extensive overhauls and major breakdowns are handled by plant maintenance personnel with the operator assisting. Even if outside maintenance or factory experts have to be called in, the equipment operator must play a significant part in the repair process.

Training for TPM coordinators is available from several sources. Most of the major professional organizations associated with manufacturing as well as private consulting and educational groups have information available on TPM implementation. The Society of Manufacturing Engineers (SME) and Productivity Press are two examples. Both offer tapes, books, and other educational material that tell the story of TPM. Productivity Press conducts frequent seminars in most major cities around the United States. They also sponsor plant tours for benchmarking and training purposes.

7. Conclusion

Today, with competition in industry at an all time high, TPM may be the only thing that stands between success and total failure for some companies. It has been proven to be a program that works. It can be adapted to work not only in industrial plants, but in construction, building maintenance, transportation, and in a variety of other

situations. Employees must be educated and convinced that TPM is not just another "program of the month" and that management is totally committed to the program and the extended time frame necessary for full implementation. If everyone involved in a TPM program does his or her part, an unusually high rate of return compared to resources invested may be expected.

References

- [1] Robinson, Charles J., Ginder, Andrew P., "Implementing TPM", Productivity Press, Portland Oregon, 1995.
- [2] Society of Manufacturing Engineers, P.O. Box 6028, Dearborn, MI 48121
- [3] Steinbacher, Herbert R., Steinbacher, Norma L., "TPM for America", Productivity Press, Portland, Oregon, 1995.
- [4] Takahashi, Yoshikazu, and Osada, Takashi, "TPM", Asian Productivity Organization, Tokyo, 1990

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