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TOTAL PRODUCTIVE MAINTENANCE (TPM); AS A VITAL FUNCTION IN MANUFACTURING SYSTEMS

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Abstract:

Maintenance is a vital function in manufacturing systems for maintaining quality. During the coming period two ideas are evolved Total Productive Maintenance and Total Quality Management simultaneously with other facts to attain excellence in production systems. Various feature of putting into practice Total Productive Maintenance (TPM) is expressed and examined in this study. Total productive maintenance is explained thoroughly; the philosophy, planning, improvements, goal setting and developments of implementation plans. The eight pillars of TPM are explained. Various aspect of implementation of TPM is elaborated. Also the benefits of TPM are explained.

Keywords: maintenance; predictive maintenance; total productive maintenance; philosophy; advantages of TPM, TPM planning.

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1. TPM - History

Preventive maintenance had been put in practice in 1951 in Japan, USA first initiated it. Nippondenso was the first company to introduce preventive maintenance plant wide. In preventive maintenance operators and maintenance group was dedicated to maintenance of the equipments. Maintenance came out as difficulty, because of the more requirement of maintenance staff. Management decided that the regular maintenance of equipments and machines would be performed by particular operator of the machine. (Termed as Autonomous maintenance, part of Total Productive Maintenance). Department of Maintenance had to accomplish only essential maintenance task.

The maintenance team worked in the equipment modification for upgrading reliability. The new machines are incorporated with new modification. Maintenance prevention was led by this. Productive maintenance was introduced with preventive maintenance and Maintainability. The productive maintenance objective had been to make the most of works and machine efficacy to achieve best life cycle cost.

Quality circles were also structure at Nippon Denso, utilizing the workforce. All people contributed in doing Productive maintenance. Nippondenso was given award of distinguished plant was given to for executing and developing and Total Productive Maintenance by the JIPE (*Japanese Institute of Plant Engineers)*. The Toyota group firm Nippondenso obtained the certification of TPM first.

TPM is necessary for operation of a plant at the optimum level by keeping the plant and equipment well maintained. Conventional barriers between maintenance and production people are to be resolved. People ought to work together applying their skills must have a common goal for optimum performance or better productivity. Predictive and preventative maintenance are important in building a base for a right TPM environment. Data and statistical tools are used for Predictive maintenance to decide when an equipment may stop working, and preventative maintenance is performing activities at regular intervals like lubrication to avoid its failure. A novel concept for equipment and plants maintenance is encompassed by program like TPM encompasses. TPM program objective is to enhance production and also improving people morale and job satisfaction.

As a crucial part of the business TPM focuses on maintenance. Panning for down time for maintenance is done for a day's part. Objective of it is keep minimum unscheduled maintenance.

The TPM function ought to be focussed towards the removal of unplanned equipment and plant maintenance. The aim is to generate a system in which every maintenance activities can be planned and not hinder the production activities. Prior to the arrival of computer-aided manufacturing, workers in few organizations were in charge for their machines and used to take a definite pride of ownership. Operators used to spend fraction of their work time in keeping their equipment in running condition with the help of maintenance people. New technical advancement has provided us additional tools to do the maintenance function.

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Analyzing TPM can be explained simply as:

Total = Involving all

Productive = Material Production and services that satisfy or go beyond client's hope.

Meaning of Maintenance is Putting machinery and plant in proper working state.

2. Objectives of TPM

1) Sustaining and improving equipment capacity.
2) Maintenance of machine for whole life cycle.
3) To get help from each operational section.
4) Motivation of employees encouraging contribution.
5) Putting teams for continuous improvement.

Firms which apply principles of total quality management, employee involvement, FMEA, continuous improvement, JIT manufacturing, SPC, and experimental design, to name a few, can be successful by applying simultaneously the principles of total quality management. For instance, when equipment downtime and equipment failures are not sure, a firm cannot implement JIT. Employee involvement cannot be practiced if machine operators or the maintenance department people are not part of the team and encouraged to report trouble.

3. Maintenance Types

3.1. Breakdown Maintenance

Breakdown maintenance is done when equipment fails and then it is repaired. It could be considered when the failure of equipment does not considerably affect the work or production or produce any noteworthy loss except repairing expense.

3.2. Preventive maintenance

Preventive maintenance is a routine maintenance (cleaning, inspection, greasing and oiling etc.), for retaining equipment's healthy condition and failure prevention. Preventive maintenance is divided in Periodic maintenance and predictive maintenance.

(i) TBM - **Time based maintenance.** Periodic inspection, cleaning and servicing of equipment and to prevent sudden failure replacing parts, are the part of TBM.

(ii) **Predictive maintenance.** Based on inspection or diagnosis, the important parts' service life is predicted for using parts to its service life. Predictive maintenance is condition based maintenance. Surveillance system is employed, planed to an on-line system monitoring.

3.3. Corrective maintenance

Improvements of equipment and its components are carried out so that preventive maintenance can be done correctly. Poor designed Equipment ought to be redesigned for improved reliability and maintainability

3.4. Maintenance prevention

Here design of a new equipment is incorporated prior to new equipment commissioning.

3.5. On-Condition Maintenance

It is an another type of maintenance to be taken care. To detect brake wear, car designers have sensors which will sense wear and tear of brake pads and give indication when they are to be replaced. It is an inspection-free system. On-condition maintenance can be used to reduce the amount of work and, hence, the machine downtime needed. Condition monitoring is an element that constantly examines itself and requires no intervention. Incorporating microcomputer and electronics data is incessantly recorded and can be accessed for backward-looking analysis.

Better technology of sensors with contemporary electronics can make simpler modifying systems to employ monitoring. With regard as the other improvements in vehicles; many have electronic ignition systems and sensors built-in all through the engine. For tyre pressure monitoring sensors are fitted in wheels, further sensors are provided for fluid level measurement, also for skids detecting and locking of wheel. If one has to incessantly monitor the parts' state in machine, a lot of effort is required. Then, at some time, the wear rate will change clearly; it woll increase and can be detected. Continuous running of tool rate of deterioration amplifies rapidly and there will be a drop in performance and reaches to failure completely. On finding the upcoming failure, action ought to be taken to stop.

An approximation of the remaining lifetime can be estimated and planning of another test can be done it can be mended. In this minimal checks are there and as per set warning and fixing the problem. Right sensors are required for the particular part.

Various types of sensors are: particle counters, vibration sensors, acoustic sensors, strain gauges, ultrasonic, leak rate measurements, vacuum monitors, x-rays, motor currents or flow meters. Many others are there, few need oil sample for consistency or to gauge gas release rate or chemicals in cracks finding in casings. Vibration monitoring is also used; however, it is complex in nature. If used correctly, the data can find deterioration of to shafts, specific gears, or bearings. The strategy is finding if the noise pattern, or alteration in it, shows a real failure threatening. It is necessary to educate people methodically in its use to attain a greater extent of resolution. Now and then, an increase in a simple noise level or alteration in frequency are sufficient for making frequent checks or planning replacement of the component.

4. The TPM planning

Assessment of performance is done by determining the existing operating parameters.

To initiate Total Productive Maintenance basic steps are.

1. The top executives has to understand the new viewpoint.
2. Management supports the new philosophy.
3. Training programs are developed and funded for everybody.
4. Spots of improvement needed are identified.
5. Formulations of Performance goals.
6. Implementation plan is to be developed.
7. Independent work groups are to be established.

These steps can give a good framework.

5. Understanding new philosophy

To deal with is change is one of the difficult things for top management. They require to learn about TPM and its affect on their working. There are many successful and failures. Benchmarking with a successful firm will make available precious information.

For any cultural change an extraordinary commitment is required by management. It is needed to let workforce to take decisions. This viewpoint is not broad-minded management, since management is still responsible for the performance of the firm. This idea may have reliability problems with workforce. There is a change in management and new manager build up a "different system" that will in all probability answer all of the firm's problems. Be deficient in of possession may source down morale and annoyance with management. Possessiveness ought to be dependent on what is good for the point of view of customer and for the people that take care of the customer. Southwest Airlines or Hewlett Packard emphasize staff well-being and empowerment. To begin with this change will need additional efforts by management.

6. Encouraging the new Philosophy

Significant time must be spent by top management in encouraging the system. Top management have to put the idea and let the people be acquainted with that they are completely devoted to its achievement. Full commitment from the management will be there. If the faith in the recent philosophy and dedication are not there, then there will be no positive. Over and over again lip service provided a "new idea." It gives a faith that the newest system will answer some on the spot problems and show the way to an instant return on investment. For the new philosophy a long term commitment is required. It has been established by other firms to be a improved way of accomplishing business. Management ought to lead the way by taking on the newest ideology. Firms that are going through problems consider it, in part, to deceitful leadership. The precise ways to put into practice the new philosophy is just to start implementing it. That is start giving the maintenance and production people more autonomy. Introducing TPM with a huge ordeal leads employees to wave it off as the newest technique for getting them to work harder. Firstly, management must build trustworthiness, and the finest way to do that task is to transform first and lead the system. In paper by Ireland & Dale (2001) TPM study in three firms is focused. The firms put into practice TPM due to the business problems they came across. TPM is supported in these firms by top management and also set up appropriate organizational systems to make achievable its accomplishment is also supported. Nakajima's Seven steps regarding autonomous maintenance had been trailed, yet diverse TPM pillars were accepted, with the similar ones are improvements, training and education, quality maintenance and safety. The major alterations in execution of TPM connected to the applications of ABC arrangement system and the facilitators role. By McKone et al. (2001) , they examined the link amongst TPM and producing performance by SEM (Structural Equation Modelling). It is noticed that TPM has a considerable connection with small cost, elevated quality points and powerful delivery working. I was also found that the connection amid Total Productive Maintenance and MP can be depicted by both indirect and direct relationships. Paper introduced by Pomorski (2004) inspects the fundamental TPM concepts and reviews the noteworthy literature linked to implementation, design, Total Productive Maintenance programs implementation in operations of manufacturing. Findings comprises the organization structures, human interaction, statistical tools and criteria of success related to the operations of Total Productive Management programs. Hadaad & Jaaron (2007) proposed work related to healthcare industry where introduction of the investigation related to implementation of the TPM program.

The methodology of TPM execution was applied for enhancing utilization of medical related devices and lessening the failures where the it was investigated the application of production maintenance systems in different settings and that major functioning benefits can be generated. Ahuja & Khamba (2008) The point of this study is to re-examine the text on TPM and to illustrate a common idea of TPM accomplishment practices well thought-out by the producing companies. It also looks for to emphasize suitable enablers and accomplishment factors for removing obstacles in winning TPM performance. Mad Lazim et al. (2008) defines the purpose of TPM is to produce a dynamic part taking of all workers in functions of production and maintenance, with the workers who run the machines. It was discussed in this paper part of a initial study finding concentrating on main two Total Productive M maintenance practices planned maintenance and autonomous maintenance in a SME of Malaysia. The outcome proposes vital views of planned maintenance and autonomous maintenance that put in to the upgrading in cost and quality (Robbins, 2008).

7. Training Programs

Philosophy to be taught to managers, at all positions. Starting with senior management, and then to first-line supervisors. Top management have to use time in learning and understanding the effects of concerning the philosophy to their firm. Senior management must be dedicated to the long-term commitment necessary to attain constructive results. A few managers may require to be changed or take premature retirement since they will not transform their manner of dealing with people. The managers who willingly accept to the new philosophy ought to be recognized. Supervisors ought to understand

dealing with the team working and be acquainted with small autonomous work groups working. This organizational level appears to have the most difficulty with such type of change. In current years, cutting back has come at the cost of middle managers. Certainly, in history this has been an extravagant area of management. The viewpoints that are promoted within TPM and TQM lead to compliment management structures. When employees are permitted to take their self-decisions, there may be no need of many layers of managers ensuring people are performing their job perfectly.

Supervisors in first-line are required to understand their role according to the new environment. Supervisors who have been applied guiding their groups will find it a simple transition. The day of the despotic manager has changed. Those managers who have been telling the subordinates the whole thing to do will find it complicated.

Supervisors will give up some of their power, yet that power may be more perceived than real. An intellectual employee does not bear that style of management. Employees require learning about a variety of tools employed in doing their tasks as part of an independent work group. Some instruction is needed in the bifurcation of jobs of maintenance people and the jobs of production people. A huge advantage of TPM is the cross-generation of information between maintenance and production department.

8. Finding out Improvement Areas

Some machines may to be going to break down or necessitate a large maintenance. Workers who work with the equipment regularly are better able to identify these conditions rather than anyone else in the organization. A primary step is to let the operators and maintenance technicians inform management about the equipment and machines which need the main consideration. A functioning team of technicians and workers & to harmonize this process is necessary. This action will build trustworthiness and start the firm towards TPM. Primary step for the team is to make out the current status.

Major 6 loss areas which are needed to be followed and gauged:

Downtime Losses

1. Planned
a. Starting-up
b. Change time in shifts
c. Food breaks
d. Shutdowns for planned maintenance
2. Unintentional Downtime
a. Machine or Equipment breakdown
b. Changing over
c. Be short of material

Reduced Speed Losses

3. Idling and small stoppages
4. Slowing down

Losses due to Poor Quality

5. Method nonconformities
6. Scrap

9. Goal Setting

When the improvement needs are found goals have to be set. First goal is to set up the timeframe for fixing the first problem in priority. Technicians and operators will work faster than management since it can cause more problems on a day after day basis. Recognizing requires and set goals begins the process of putting the whole people to work collectively as a team.

10. Developing Implementation Plans

Firstly, an overall plan of action for training all employees to be developed and implemented. Procedure for developing the independent work groups have to take place all through the training phase. Using teams of maintenance people and operators to work on mainly difficult problems is to be planned. Preferences can be put and administration can make a commitment with resources to remove few of the fundamental troubles. Putting the team method will put the stage for the development of independent work groups, which are teams recognized for daily task. Now, employees have to get input into how such non-dependent teams are prepared.

Elements of the planning course have to take into thought that independent work groups will change over time. As processes and procedures are enhanced, the structure of the entire organization will transform.

11. Independent Work Groups

Independent work groups are established depending on the usual flow of activity. Initially, the operator is to be made accountable for the machine and the point of maintenance that he is skilled of performing. Further, find the maintenance staff who work in specific areas or have meticulous skill efficiencies. Production workers and maintenance staff are brought together, ensuing in an autonomous work group. Such groups possess the power of decision making for keeping the machine in ideal running order. The preparation of independent work groups will be different with dissimilar applications and types of companies. Maintenance technicians can give to the operators. They educate machine operators in accomplishing certain tasks, like greasing, oiling, slight troubleshooting, and setting up. The in general goal of the independent work group is to decrease the times for maintenance activity. Other benefit is sparing highly skilled maintenance technicians from the more ordinary routine jobs. Skilled technicians can be used resourcefully in doing main repairs and baked up with trouble solving that the autonomous work group cannot take care.

12. Total Productive Maintenance (TPM) eight pillars

Seiichi Nakajima developed conventional TPM in Japan. Nippon Denso used to produce components for

Toyota, started TPM. The outcome of it was accepted internationally as benchmark for TPM accomplishment. Addition of lean manufacturing methods, supported on eight pillars TPM on the 5-S. The system in Japanese described as:

- Seiri (organize): Removing litter from the workplace
- Seiton (orderliness): Make sure order by putting everything in its place
- Seiso (cleanliness): workspace cleaning and maintaining it
- Seiketsu (standardize): All work processes, standardizaton making them sustainable.
- Shitsuke (sustain): Repetitively strengthening the prior four steps

Figure 1: Pillars of TPM.

Proactive and preventive techniques are focussed in the eight pillars of total productive maintenance to help get better equipment reliability.

The 8 pillars explained (Figure 1) as:

1. Autonomous maintenance;
2. Focused improvement (kaizen);
3. Planned maintenance;
4. Quality management;
5. Early equipment management;
6. Training and education;
7. Safety, health and environment; and
8. TPM in administration. Let's break down each pillar below.

1. Autonomous maintenance

It implies making sure workers are entirely trained on regular maintenance as inspecting, cleaning, and lubricating and also giving that duty exclusively in the hands of the workers. It provides operators a sense of possession of their machine and enhances their knowledge about their machine. It also ensures the machinery is always lubricated and clean, which helps recognize problems prior to failures, and spares maintenance people for important assignments.

Following autonomous maintenance includes cleaning the machine to a determined standard that the machine operator has to uphold. It contains education of the operator on technical know-how for carrying a routine inspection as per the manual of the machine. Once educated, the operator sets his or her own autonomous inspection plan. Standardization ensures everybody uses same processes and techniques.

2. Focused improvement

It is dependent based on "kaizen," means "improvement." In production, kaizen needs improving processes and functions constantly. Deputing small teams for positively acting together to apply, step by step upgrading to processes be relevant to operation of equipment is important for Total Productive Maintenance. Different team members of groups permit the recognition of persistent problems by brainstorming. Focused development adds to effectiveness by lessening defects of processes though getting better safety by calculating each independent action risks. Further, improvement focus makes sure they are standardized, repeatable and keep going.

3. Planned maintenance

It comprises observing metrics as failure rates and past downtime then preparation of repairs task depending on such predicted breakdown rates. As a particular time is there to perform maintenance of machine, one can plan maintenance at the time equipment is not in use not disturbing disrupting production. Further, it lets for inventory building up for when scheduled maintenance takes place. When maintenance is scheduled for each piece of equipment, inventory must be built so that there is no reduction in production.

This proactive approach is adopted and it lessens the random downtime by doing the maintenance when machine is free. Inventory planning can also be done in better way by enabling better control of parts that may be expected to fail. Further benefits are lessening in breakdowns so that equipment can be used to their optimum capacity.

4. Quality maintenance

I f the maintenance is not enough, all the maintenance planning and strategizing is not fruitful. This pillar centres on working design error judgment and keeping away from the process of production. From root cause analysis it is performed to find and throw out returning defect sources. By predicatively finding the error source, processes turn out to be more dependable, and parts are produced with the precise conditions at the first time.

Major advantage of quality maintenance is that it stops defected products from moving forward, that could result in more rework. By scheduled quality maintenance, quality matters are taken care of, and continuing steps are applied, reducing or fully eradicating imperfections and downtime concerned to imperfect parts.

5. Early equipment management

It gets the realistic information and on the whole knowing of production equipment obtained by TPM and employs it in improvement of design of recent equipment. Input

of worker is to be taken to get better maintainability. It is essential to take care about work like the lubrication and cleaning ease, parts accessibility, controls placed ergonomically in a comfortable way for the operator of machine. This approach is followed and it augments more efficiency.

6. Training and education

Be short of knowledge regarding equipment can disrupt a Total Productive Management program. Education and Training should be for the maintenance people, operators and managers. There should not be any gap in awareness of every so that Total Productive Maintenance goals are attainable. From this operator must learn talents to practically maintain machine and equipment and make out up-and-coming bottlenecks. The maintenance people ought to learn to put into practice a preventive and proactive maintenance program, and managers must be made well-acquainted in Total Productive Maintenance principles and development of employees.

7. Safety, health and environment

Sustaining a protected environment of working environment implies people can do their work in a secure area devoid of risk of health. It's significant to create an environment which makes production well-organized, it must not be at the cost of the safety of a worker. To achieve it, any efforts put in the TPM process ought to forever focus on the safety, health and the environment. Further, when people work in a protected environment, their feelings becomes superior, because they have not to think about this important aspect. It can enhance productivity in an obvious manner.

8. TPM in administration

TPM ought to look further by taking care and eradicating waste areas in work of administration. It means holding up manufacturing by getting better things like procurement, scheduling and processing. Administration functions are a lot the primary step in the whole process of manufacturing, so it's imperative they are organized and free of waste. If procedures of order-processing for instance become more organized, then raw material reaches the floor more quickly and with small errors, eradicating major downtime while lost parts are tracked.

13. TPM Implementation guidelines

There are five steps to carry out this. Major area identification, equipment restoration to original working condition, OEE measurement, finding and lessening main losses, also accomplishing planned conservation.

13.1. Step 1: Pilot Area identification

Searching a key area to start carrying out helps to obtain more acceptances from employees when they observe the advantages that emerge from process. When selecting machine for a major area, think about three questions:

- *Discover what is most easy to get better?* Choosing machine or instrument that is most easy to improve provides the possibility to a person for immediate and assenting results; Yet, TPM process is not tested as strongly as the further two options.
- *Bottleneck Finding.* Pinpointing machine depending on at what place production is affected gives a quick elevation in total output and presents faster payback. Drawback is that using this equipment as a pilot means you're using a significant asset as an example and risk the chance of it being offline longer than you would like.
- *Finding most challenging?* Correcting the trouble of the equipment will be well-attained, energizing TMP program support. Though, it will not provide much instant payback as per the previous approach, and it will be a challenge to get a fast outcome from checking out the problem unsolved, may lead to lack of interest.

  If someone is putting into practice a TPM program at first time, best alternative is normally the number one approach (improve the easiest equipment). People who have good knowledge with TPM, one may make a decision to set right the bottleneck. It is there since one can make provisional inventory; ensuring downtime can be tackled, which lessens risk.

  In the pilot selection process employees are to be included across all aspects of your business. A project board visual can be put so that progress for all can be posted to for awareness of all.

13.2. Step 2: Restoration of Equipment to optimum working Condition

Autonomous maintenance and 5-S system is key to it. First, participants of TPM have to understand to continuously put equipment to its usual condition applying the 5-S system: organize, cleanliness, orderliness, standardize and sustain. It may comprise:

- Taking Photograph of the region and equipment's existing condition and then putting it to project board.
- Unused tool may be removed, cleaning up the area, remains and waste.
- Putting in order the tools and components regularly used
- Equipment cleaning and cleaning thoroughly the surrounding area.
- Taking Photographs of augmentations of machine and equipment and nearby area and then putting it on the project board.
- A 5-S work process creation to uphold the process stability.
- Process auditing with attenuation frequency to make sure the following of 5-S process.
- Once a starting point equipment state is established, autonomous maintenance program can be put into practice by educating workers on maintenance while probing it for abnormalities and wear. By creation an autonomous maintenance program also develops a standardized method to do the tasks like clean, inspect and lubricate equipment rightly. During period of planning items to address for the autonomous maintenance program have:

- Recognizing and recording inspection points, comprises of components which can tolerate wear.
- Improving distinguishability wherever attainable to assist with checking while the equipment is in working condition.
- Checking and visibly labelling set points with the equivalent.
- During changeovers or planned downtime. finding all points of lubrication and maintenance scheduling.
- Educating workers making them reactive for any coming up issues so that they can convey to their superior.
- For all operator controlled tasks generating a checklist for autonomous maintenance.
- Process auditing with decreasing occurrence to make sure follow the checklist.

13.3. Step 3: Measuring OEE

Next Step to OEE tracking for the selected equipment. Regularly determining OEE provides a data-driven verification on TPM program working and lets one track progress with time. As the most of the losses in connection to machine or equipment are the result of random downtime, it's significant to categorize each random slowdown occurrence. It provides an extra precise look at the place where a stoppage is taking place. For random causes comprise an "unknown" or "unallocated" category of stoppage time.

A minimum of two weeks gathering data is suggested to get a precise showcase of the unexpected stoppage time and an obvious view of how slow cycles and small stops affect production. There is a easy example of a top 5 loss chart. Each loss is categorized and is in downward order from the loss that causes the majority downtime to the loss that causes the minimum.

Overall Equipment Efficiency

OEE = A × PE × Q

A = Machine availability

It is proportion of time machine is actually available out of time it ought to be available.

A = (MTBF-MTTR) / MTBF

MTBF = Mean Time Between Failures = (Total Running Time) / Number of Failures.

MTTR - Mean Time to Repair.

PE = Performance Efficiency.

It is given by RE × SE. Rate efficiency (RE): Because of jams, etc. Real average cycle time is lesser than design cycle time. Because of jams output is reduced.

Speed efficiency (SE): Real cycle time is lesser than design cycle time machine output is lessened since it is running at decreased speed.

Q = It means quality rate. It is the % of good parts out of total items produced also called "yield".

13.4. Step 4: Lessening main Losses

After data-driven picture of major losses is obtained, it is the time to take care of them. This step applies the previously explained pillar of kaizen. For performing this, a cross-functional operators' team is put together, managers and maintenance staff who can inspect the OEE data applying RCA and make out the key causes for losses. The process may look like:

- Selection of a loss dependent on OEE and data of work stoppage time. It ought to be the chief basis of unexpected time of stoppage.
- Inspect the indications related to problems. Gather in detail data on indications like observations, substantial proof and proof from photography. By an ishikawa diagram to trail indications and record data while one is at the machine or equipment is strongly recommended.
- Talk about and find with the team, latent reasons of the problems, ensure the probable causes by the proof collected, and converse most effectual ways to determine matter.
- To enforce the decided fixes schedule downtime.
- After fixing is done, start again production and further watch effectiveness of the fix. If it solves the problem, a note s to be made to apply the alteration and go to the further cause of time of stoppage. If required, then collect further information and have next session of brainstorming.

13.5. Step 5: Planned Maintenance, Putting into practice

Adding active maintenance techniques into the plan is the last step of the TPM execution process. It encompasses working off planned maintenance, the third pillar. Components which have to acquire proactive maintenance by viewing three factors: wear parts, parts that fail and stress regions. Infrared thermography and vibration analysis is used for it .

Next, employ proactive maintenance periods. Such periods can be rationalized as required. Set up the existing level of wear and further a baseline replacement timeline for wear and predicted failure-based parts. when these have been determined, proactive schedule of replacement whole wear and failure-prone parts can be created. When performing it, use "run time" in place of "calendar time." Now, build up an unvarying process for generating work orders dependent on the schedule of planned maintenance.

By designing a feedback system maintenance intervals can be optimized. Logs for every wear and breakdown-likely parts where workers are able to record data of replacement and state of component at the instance of change will be major part. Follow the planned monthly maintenance audits to confirm the schedule of maintenance and the part logs are being kept the latest can be conducted. Reconsider the logs' data to check for prospective adjustments.

14. Introduction of TPM steps in a firm

14.1. Step A - Introductory stage

(1) Management declaration about Total Productive Maintenance initiative to everybody in the organization

Correct perceptive, dedication and dynamic top management involvement is essential. Top management ought to have knowledge programs, thereafter announcement is done. It ought to be published in the house magazine and the notice board.

(2) Initial learning and propaganda for TPM

Based on the requirement training is to be done. Awareness and intensive training ought to be done. Take those people who are concerned to places where TPM successfully implemented prior.

(3) Setting up TPM and departmental committees

Comprises by TPM as part of it are autonomous maintenance, improvement, quality maintenance etc. Committees must be set up to take care of all those requirements.

(4) Establishing the TPM working system and target

Benchmarking of each area is done and target for achievement is fixed.

(5) A master plan for institutionalizing

Further, TPM has to be implemented as organizational culture. PM award achievement is the proof of obtaining a satisfactory level.

14.2. Step B - Introduction stage

All should be invited to this ceremony. Suppliers must understand that we require quality material. Related and affiliated companies who can be our customers, sisters concern etc. Some may learn from us and some can support us and clients will get the communication that we are keen for quality output of products.

14.3. Step C - Implementation

In this stage eight pillars in the development of TPM activity are carried out. Out of these four activities are for launching the system for efficiency of production, one for new products initial control system and equipment, next one for enhancing the administration efficiency and are for control of safety, sanitation as working environment.

14.4. Step D- Institutionalising stage

Maturity stage is achieved by all three activities. Now for PM award can be applied. Also plan for next level to which this movement can be advanced.

Sustaining the upgrading attained with TPM

Putting into practice a TPM program put forward short-term achievement. The strategy is nourishing that achievement over the long period. It commences along with the workforce. If workforce accept the program of Total Quality Management, imagine the superior future of the firm and can observe how this superior prospective benefits the workforce, it can generate a great feeling of bonding. To make strong the well-known bonding among employees gratifying achievements is a brilliant way.

Another method to attain continuing upgrading with Total Productive Management program is by dynamic leadership. By this the importance of the program by actions is illustrated. Leadership engagement stops people from going back into prior work habits and addition of new vigour into the process repeatedly. Incessant improvement assists your Total Productive Management program get used to altering environments and stops the delaying of program and workforce from being monotonous.

15. TPM benefits

Great advantages of putting into practice a TPM program is transforming from reactive maintenance to predictive maintenance. Reactive maintenance is expensive, for machinery repairs bill as well as for increased random downtime. (Table 1)

TPM Benefits

Table 1: Direct and Indirect Benefits of TPM.

Direct Benefits	Indirect Benefits
Reduction in unplanned down-time so that there is an growth in OEE	Confidence levels of Employee are elevated.
Customer complaints are reduced.	An orderly, clean workplace is produced.
Accidents in workplace are Reduced.	Positive attitudes of employ-ees increases by a feeling of ownership
Cost of manufacturing reduces.	Following pollution control measures.
Quality of product increases.	Knowledge sharing between departments.

16. TQM and TPM; Similarities and differences

A great resemblance is there between the TPM program and the TQM program. Tools like benchmarking, documentation, employee empowerment, etc. applied in Total Quality Management are also applied to put into practice and augment Total Productive Management. The resemblance between them are.

1. In both programs total dedication to the work by higher management is necessary.
2. Empowerment of workers must be done to corrective action initiation, and
3. A long term vision must be there as Total Productive Maintenance may take more than a year to

implement and is an intermittent process. There should be alterations in employee's frame of mind to their work responsibilities.

17. Conclusion

In recent times, industry rivalry is elevated, TPM is the only tool which might stands amid failure and success firms. Its worth is proven. It can be accepted to put in manufacturing industries, building construction, civil maintenance, shipping, and in a lot many areas. Workforce have to be convinced and persuaded that Total Productive Maintenance is not merely "*program of the month*" and the top management is fully dedicated to the Total Productive Maintenance program and the adequate time essential for complete execution. If TPM program is implemented properly, it can provide high returns.

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