

Practical application of total productive maintenance in Japanese industrial manufacturing plants

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Abstract. Total productive maintenance (TPM) has been widely applied in many industrial fields, especially in Japanese industrial companies. From a management point of view, this is an activity that involves all members of the company, from company president down to the most junior company employee. From a point of view of economical effectiveness, a company can benefit from implementing company-wide TPM activities, such as, increasing the availability of existing equipment hence reducing manufacturing costs and reducing equipment investment cost. TPM is not just another “program for maintaining machines”. It is a program that can help a company to remain viable and to develop. This paper has reviewed the research relating to TPM world-wide and has found that the practical application of TPM in Japanese industrial plants has not been concretely discussed. The main purpose of this research is to carry out an empirical study on items in the actual manufacturing activities and to point out the practical application of TPM in Japanese industrial plants.

Keywords: Total productive maintenance, kaizen, productive manufacturing, safety, environment.

1. Introduction

Total productive maintenance (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 were producing goods using machines and a maintenance group was

dedicated to working at 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. The maintenance group took up only essential maintenance works. Thus, Nippondenso, who already followed preventive maintenance, also added Autonomous maintenance - done by production operators. The maintenance crew also work on equipment modification to improve reliability. These modifications were made to existing equipment or incorporated in new equipment. This led to maintenance prevention. Thus, preventive

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maintenance along with maintenance prevention and maintainability improvement gave birth to productive maintenance.

By then Nippon Denso had made quality circles, involving employee's participation. Thus, all employees took part in

"The aim of productive maintenance was to maximize plant and equipment effectiveness to achieve the optimum life cycle cost of production equipment."

implementing productive maintenance. Based on these developments Nippondenso was awarded by the Japanese Institute of Plant Engineers (JIPE) a distinguished plant prize for developing and implementing TPM. Thus, Nippondenso of the Toyota group became the first company to obtain TPM certification. Nakajima Seiichi [1] introduced TPM to achieve the following main objectives: i) Avoid wastage in a quickly changing economic environment, ii) Production of goods without reducing product quality, iii) Reduction of cost, iv) Production of a low (should this be "high") batch quantity in the shortest possible time, v) Goods sent to customers must be without defect. Nakajima also used a concept he calls "overall equipment effectiveness" (OEE) to measure the realistic level of equipment use in operations. Nakajima claimed that in most companies an OEE of 50 per cent or less is common when allowing for downtime, scrap/rework loss and inefficient use of equipment. Furthermore, he cited 85 per cent OEE as ideal, essentially allowing only for set-ups and planned maintenance. Based on input from a panel of managers, several of whom had studied Japanese plants, it was found that Japanese managers allowed anywhere from 12 per cent to 18 per cent capacity slack in their production systems. Based on the findings and recommendations of authors in the JIT field the JIT lines in this study will utilize a pull-oriented production line with 20 per cent capacity slack. According to Chan et al. [2], the differences

between traditional Productive Maintenance (PM) in the US style and TPM developed in Japan can be clarified by citing the characteristics of TPM as follows: i) TPM is aimed at overall pursuit of production efficiency improvement to its maximum extent. Many production systems are human-machine systems. Needless to say, dependence of production systems on equipment increases as automation progresses. Similarly, production efficiency is governed by degree of proficiency in methods of manufacturing, usage, and maintenance of equipment. TPM is designed to prevent the occurrences of stoppage losses due to failures and adjustment; speed losses resulting from minor stoppages and speed reduction; and defect losses caused by process defects, start-up and yield declines, by improving the methods of manufacturing, usage, and maintenance of equipment.

ii) In contrast, the approach of traditional US style PM is centered on

"The purpose of TPM is to maximize the efficiency of production systems in an overall manner."

equipment specialists. Although improving the methods of equipment manufacturing and maintenance PM does not call for pursuing overall production efficiency to its limit by improving methods of equipment use.

One of the characteristics of TPM is autonomous maintenance (AM), which means operators must look after their own equipment. Operators must protect the equipment used by them. Failures and defects are the "illnesses" of equipment. To prevent such "illnesses", routine maintenance (cleaning, oiling, tightening, and inspection) must be implemented without failure. Furthermore, maintenance staff, who are the "medical practitioners specializing in equipment", conduct periodic inspections (diagnosis) and carry out early repair (treatment). In the US, work specialization has progressed so that operator is occupied with production (operation), while maintenance is under the charge of maintenance staff. Routine

maintenance is the task of maintenance staff, and is not considered as the task of operators. TPM also consists of small-group activities in which all members participate. Small-group activities in TPM are conducted by employees who, based on self-discipline, conduct work jointly with the formal operation. Operators themselves enforce AM by performing cleaning, oiling, tightening, inspection, and other routine maintenance tasks. Such AM is part of the operator's normal work, and therefore completely different from the voluntary type. TPM small-group activities are called "overlapping small-group activities", because they are conducted jointly with formal organization. At the individual level, small groups set their own themes and targets by which they conduct their activities. These small groups include a managerial staff group, composed of a section manager and led by the plant manager, a group led by a section manager, with unit chiefs or team heads as its members, and a frontline group headed by a managerial staff member, such as a unit chief or team head, and made up members of a unit or team. Such overlapping small-groups led by formal organization constitute a major characteristic of TPM. Many devotees of the Japanese style TPM, such as Tajiri and Gotoh [3] and Shirose [4] regarded Nakajima as the father of TPM and they recognize that a full definition contains the following five points: i) TPM aims at attaining the most efficient use of equipment (i.e. overall efficiency). It establishes a total (company-wide) TPM system encompassing maintenance prevention, preventive maintenance, and improvement related maintenance. ii) It requires the participation of equipment designers, equipment operators, and maintenance department workers. iii) It involves every employee from top management down. iv) It promotes and implements PM based on autonomous, small group activities. Notwithstanding that a complete definition of TPM must include the five point definition, Nakajima attempts to summarise an entire

philosophy in succinctly defining TPM as: "Productive maintenance involving total participation in addition to maximizing equipment effectiveness and establishing a thorough system of PM", where PM is a comprehensive planned maintenance system.

The Western approach to defining TPM is as follows: In the UK, TPM has been pioneered by Willmott [5] who managed large scale studies of maintenance practice in the UK and written extensively on TPM for the Department of Trade and Industry. Willmott acknowledged the five point definition that is at the heart of the Japanese approach to

"Another US advocate of TPM, suggests that TPM is maintenance that involves all employees in the organization and accordingly includes everyone from top management to the line employee: this encompasses all departments including maintenance, operations, facilities, design engineering, project engineering, instruction engineering, inventory and stores, purchasing, accounting finances, and plant/site management."

TPM and consequently accepts this as being an accurate and true reflection of the main principles. However, he provides a definition that is more suited to Western manufacturing and suggests: "TPM seeks to engender a company-wide approach towards achieving a standard of performance in manufacturing, in terms of the overall effectiveness of equipment, machines and processes, which is truly world class". Similarly, Edward Hartmann, former president of the International TPM Institute Inc., who was recognized by Nakajima as the father of TPM in the USA, also provides a definition that is suggested as being more readily adopted by Western companies. Hartmann [6] states: "Total productive maintenance permanently improves the overall effectiveness of equipment with the active involvement of operators".

The American Society of Manufacturing Engineers (ASME) provides a short definition from the Tool and Manufacturing Engineers Handbook devoted to continuous improvement techniques from Bakerjan [7] simply stating: "TPM is a management technique that involves everyone in a plant or facility in equipment or asset utilization". A more detailed definition includes a focus on improvement in a wider context and Rhyne [8] considers TPM as: "a partnership between the maintenance and production organizations to improve product quality, reduce waste, reduce manufacturing cost, increase equipment availability, and improve the company's overall state of maintenance".

To apply TPM concepts successfully to plant-maintenance activities, the entire workforce must first be convinced that the top-level management is committed to the program (Pintelon and Gelders [9], Rodrigues and Hatakeyama [10], Swanson [11]). The senior management team sets company-wide PM policies, that is, placing goal-setting central to the TPM programmed promotional structure and committees. The middle management oversees the departmental polices, goal-setting and departmental PM promotional committees. The shop-floor management sets the PM goals according to team groups' activities. In all, this will involve design, operation, maintenance, engineering and sales activities, and may require hiring or appointing a TPM coordinator, whose responsibility is to advocate through an educational program the TPM concepts to the workforce and check that they are being implemented. As soon as the coordinator is convinced that everybody involved has bought into the idea of the TPM program, a study and action team is formed and consists of representatives from those who directly have an impact on the problem being addressed. Operation and maintenance staff, shift supervisors, schedulers and top management might all be in the 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. Usually, the TPM coordinator heads the team until others become familiar with the process and a team leader should then emerge naturally (Robert. J, [12]). Sometimes, it may even be

"The action teams are charged with the responsibility for pinpointing the problems, indicating the remedial processes and in particular, detailing a course of corrective actions."

worthwhile for team members to pay visits to nominally-similar plants that have attained world-class standards in order to observe TPM methods, techniques and observe work in progress there. The teams are encouraged to start on small problem-solving projects and keep meticulous records of their progress: once the teams are familiar with the TPM methodology and achieve success in overcoming small problems, other more complex enigmas can be tackled. What then are best practices? How TPM links with JIT and TQM (Cua, Mackone, Schroeder [13]). How does one enterprise begin to benchmark other companies to help them achieve best practice within the organization? How does an industry come to know it has achieved world-class status? A definition of best practice, adapted to the maintenance process, is

Specifically, benchmarking is the practice of measuring performance against a preset standard. Benchmarking is used by industries to learn about practices that have been proven to lead to superior performances and then to adopt them into their own

"The integrated maintenance practices that enable a company to achieve a competitive advantage over its competitors in the maintenance process."

organizational process. McQueen [14] suggested three types: i) Internal benchmarking, whereby multiple-plant organizations set company-wide standards for each of the sites to

follow, and then charts each site’s performance relative to those standards. ii) Industry benchmarking, where a company’s performance is measured against those of other organizations in the same industrial sector. iii) Best-practice benchmarking, through which performance is measured against those of other companies considered to be the leaders of that industry, regardless of the end product or provided service of the particular business.

Research of TPM has been studied in many aspects, especially the difference between TPM and PM, how to implement TPM, and the lessons from the failure of TPM. However, whilst there were a few research studies about the implementation of TPM in Japanese industrial plants, specifically research into the practical application of the TPM spirit on manufacturing activities was not found. This is a lack in the research in this field. Therefore,

this research will concentrate on the empirical study of the actual application of TPM in industrial plants.

2. Practical application of total productive maintenance in the industrial plants

The implementation of TPM in Japanese Industrial Plants was studied by carrying out interviews with a company wide range of managers including directors, production engineers, production managers and maintenance managers and maintenance team members. The purpose of the study is to introduce the current model of TPM and point out the actual application of TPM in the plants. The TPM implementation process is illustrated in Figure 1, TPM is conducted on a Plant-wide basis with the involvement of all employees (Figure 1).

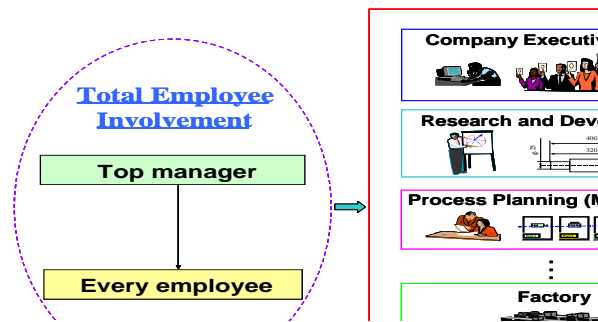


Figure 1. Total productive maintenance as total employee involvement activity.

Source: Made by the author based on the direct interview with Japanese industrial companies.

This program is led by Senior Management and deployed to every employee of the company. A TPM committee is formed representing the company executive board and those members are selected from many related divisions within the company. The

following are the 8 main criteria for implementing TPM: 5S; Autonomous maintenance; Planned maintenance; Quality maintenance; Maintenance training, Kaizen, Office maintenance, and Safety, Health, Environment (Figure 2).

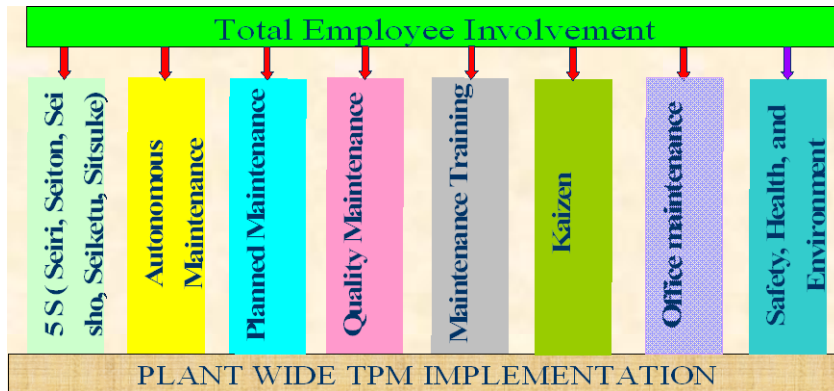


Figure 2. TPM implementation model.

Source: Made by the author based on the direct interview with Japanese industrial companies.

2.1. 5S

The concept of 5S (Seiri means sorting, Seiton means set in order, Seiso means sweeping, Seiketsu means standardizing and Sitsuke means self discipline) is necessary for TPM. As shown in Figure 3, every factor of 5S is linked together with the central role of ‘Sitsuke’. Problems cannot be clearly seen when the work place is disorganized. Cleaning and organizing the workplace helps the team to uncover problems. Making problems visible is the first step of improvement.

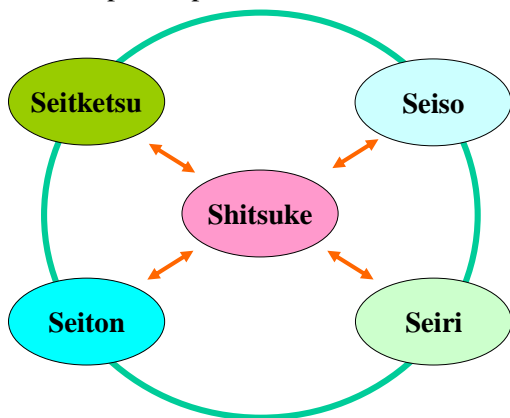


Figure 3. 5S of TPM.

Source: Made by the author based on the direct interview with Japanese industrial companies.

Seiri means sorting and organizing the items as critical, important, frequently used items, useless, or items that are not needed as of

now. Unwanted items can be salvaged. Critical items should be kept for use nearby and items that are not to be used in near future, should be stored. For this step, the worth of the item should be decided based on utility and not cost. As a result of this step, the search time is reduced. An example of how to Seiri is applied to the tools of maintenance is as follows: Tools whose frequency of use is very low (less than once per year) should be stored away from the workshop. The tools that are used everyday should be kept at the workplace.

The concept of Seiton here is that “each item has a place, and only one place”. The items should be returned after usage to the same place each time. To identify items easily, name plates and colored tags are used. Vertical racks can be used for this purpose, and heavy items occupy the bottom position in the racks. For example, tools and equipment should be kept where they will be used, and the process should be set in an order that maximizes efficiency.

Seiso involves cleaning the work place free of burrs, grease, oil, waste, scrap etc. there should be no loose hanging wires or oil leakage from machines. At the end of each shift, the work area is cleaned up and everything is restored to its place, making it easy to know what goes where and to know where everything is. The key point is that maintaining cleanliness should be part of the daily work - not an occasional activity initiated when things get too messy.

Seiketsu means that there should be standardized work practices or operating in a consistent and standardized fashion. Everyone knows exactly what his or her responsibilities are as regards Seiri, Seiton and Seiso. Employees have to discuss together and decide on standards for keeping the work place, Machines and work area neat and clean. These standards are implemented for the whole organization and are tested and inspected randomly.

This includes: following work procedures, punctuality, dedication to the organization etc. Sitsuke includes maintaining and reviewing standards. Once the 4S have been established, they become the new way to operate. Sittsuke helps to maintain the focus on this new way of operating, and do not allow a gradual decline back to the old ways of operating. However, a new point is understood that when an issue arises such as a suggested improvement or a new way of working, or a new tool, or a new output requirement, then a review of the first 4S is appropriate.

2.2. Autonomous maintenance

Autonomous maintenance requires the active involvement of equipment operators to eliminate equipment deterioration through cleaning, monitoring, fastener tightening, data collection, and reporting equipment conditions and problems to the maintenance staff. Information collected by the equipment operators contributes to overall equipment effectiveness measures and to reliability and maintainability improvements for both new and existing machines. Further, the operators must work to develop a deeper understanding of their equipment, which should improve their operating skills. Daily cleaning reduces wear on the machines and provides an opportunity to inspect for excessive wear and

minor equipment malfunctions. The appropriate person can be notified or corrective action taken, prior to excessive damage taking place. Minor adjustments made by operators, where appropriate, help keep overhead costs low by avoiding a special trip to the machine by a maintenance mechanic. This immediate operator response assures adjustments are made before they can contribute to equipment breakdown or variations in production items. Autonomous maintenance, practiced by an operator, or manufacturing work cell team member, will help to maintain high machine reliability, low operating costs, and high quality of production items.

Implementation steps of autonomous maintenance:

- Training of employees: Educate employees about TPM and its advantages. Educate employees about abnormalities they may encounter in equipment. The machine operator needs to undergo the training before operating the machine. By acquiring this new technical knowledge, operators are made well aware of machine parts.

- General inspection: Employees are trained in disciplines such as pneumatics, electronics, hydraulics, lubricants and coolants, drives, bolts, nuts and safety. This is necessary to improve the technical skills of employees and to ensure the correct use of inspection manuals. After acquiring this new knowledge, the employees should share this with their workmates. This process is called *yokoten* in Japanese industrial manufacturing plants.

“Autonomous maintenance has several targets, which include: uninterrupted operation of equipment, flexible operators to operate and maintain other equipment, eliminating any defects at the source through active employee participation, and reduction of oil consumption and process time.”

- Autonomous inspection: New methods of cleaning and lubricating are used. For example, the use *maintenance free bearings* for parts that needs oiling every day. Each team member prepares his own autonomous chart and schedule in consultation with his/her supervisor. The *ho-ren-sho* (report, contact and discussion) of every team member should be done every day. Based on experience, parts, which have never given any problem, or parts, which don't need any inspection, are removed from the list permanently.

- Standardization: Make a standardized maintenance process for every machine. Up to the previous step only the machinery/equipment was concentrated upon. However, in this step the surroundings of the machinery are organized. Necessary items should be organized, so that there is no searching and if searching for an item is necessary then searching time is reduced. The work environment is modified so that there is no difficulty in getting any item. Everybody should follow the work instructions strictly. Necessary spares for equipment is planned and procured.

Autonomous Management: TPM targets must be achieved by continuous improve through Kaizen. The PDCA (Plan, Do, Check and Action) cycle must be implemented for maintenance activities.

2.3. Planned maintenance

Planned maintenance has several targets. These targets include:, ensuring good availability of machines, reduction of maintenance cost and spares inventory, improvement of the reliability and maintainability of machines, achievement of zero equipment failure and break down, reduction of maintenance, and ensuring the availability of spares at all times. Team members can set up the program to solve maintenance problem from a reactive to a proactive approach. Planned maintenance consists of four items:

- Preventive Maintenance
- Breakdown Maintenance

- Corrective Maintenance

- Maintenance Prevention

Implementation steps of planned maintenance:

- Equipment evaluation and recording of the present status: Each machine or piece of equipment has a status check sheet and all maintenance information is included on the sheet. For example the evaluation of a machine might include which parts should be oiled or repaired. Each TPM team member follows the instruction information recorded on the status sheet in order to look after the machine.

- Restore deterioration and improve weakness: Deterioration and weakness of equipment are recognized in the periodic check process. Maintenance team members carry out daily checks every lunch time for each manufacturing shift. The machine is examined to find the problem. If the problem is severe, it should be fixed immediately even if this means stopping the line. If the problem is not severe but needs to be fixed to ensure the good condition of the machine, it should be fixed at weekend or on long holidays.

- Building up of the information management system: For tracking the problem easily, maintenance information for all equipment is not only recorded on check sheets, but the TPM information system should be implemented. Maintenance history and countermeasure information is kept in the TPM database. This information will be used for troubleshooting and optimization of maintenance.

- Equipment diagnostic technique is developed for analyzing future break-down problems to prevent unplanned occurrence defects. The concept of the preventive maintenance diagnostic process is illustrated in Figure 4.

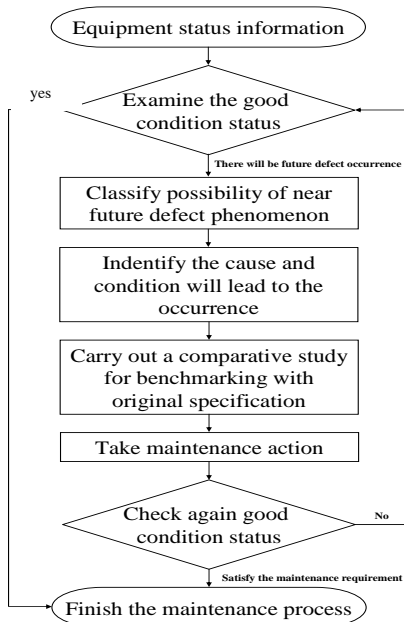


Figure 4. Preventive maintenance process.

Source: Nakajima [1]

2.4. Quality Maintenance

Quality maintenance (QM) activities create equipment conditions that eliminate quality defects, based on the concept of maintaining perfect equipment to maintain perfect quality of products. The target of QM can be listed as: achieve zero customer complaints, reduce in-process defects, reduce the cost of quality, defect free conditions and control of equipment. QM activities support quality assurance, focus on the 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.

Production conditions are checked and measured periodically to confirm that measured values are within standard values in order to prevent defects. The transition of measured values is watched to predict the possibility of defects occurring and to take counter-measures before problems arise. Quality Maintenance is aimed at customer satisfaction through the production of highest quality goods in a defect free manufacturing process. The focus is on eliminating non-conformance in a systematic

manner, much like focused improvement. Team members 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.

Implementation of quality maintenance

The main implementation focus is defect data collection. Quality defects are classified as customer-side defects and in-house defects. For customer-side defects, data can be archived from customer-side rejection. In-house, data include data related to products and data related to process:

- Product defect
- Severity of the defect and its contribution - major/minor
- Location of the defect with reference to the layout
- Magnitude and frequency of its occurrence at each stage of measurement
- Occurrence trend at the beginning and the end of each reduction/process/changes. (Like pattern change, ladle/furnace lining etc.)
- Occurrence trend with respect to restoration of breakdown / modification / periodical replacement of quality components
- The operating condition for individual sub-process related to worker, method, material and machine
- The standard settings/conditions of the sub-process
- The actual record of the settings/conditions during the defect occurrence

2.5. Total productive maintenance training

It is aimed to have multi-skilled revitalized employees whose morale is high and who are 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 for them to have only "Know-How" but they should also learn "Know-why". From experience they gain "Know-How" - to overcome a problem they know what needs to be done. They do this without knowing the root cause of the problem or knowing why they are doing so. Hence, it

becomes necessary to train them on knowing “Know-why”. The employees should be trained to achieve four phases of skill. The goal is to create a factory full of experts. The different phases of skills are:

Phase 1: Do not know

Phase 2: Know the theory but cannot do

Phase 3: Can do but cannot teach

Phase 4: Can do and also teach

Target of TPM Training:

- Achieve and sustain zero losses due to lack of knowledge / skills / techniques

- Aim for 100% participation in suggestion scheme

- Focus on improvement of knowledge, skills and techniques

- Creating a training environment for self-learning based on perceived needs

- Training curriculum / tools / assessment etc. conducive to employee revitalization. Training to reduce employee fatigue and make work enjoyable.

2.6. Kaizen

The objective of TPM is maximization of equipment effectiveness. TPM aims at maximization of machine utilization and not merely machine availability maximization. As the main factor of TPM activities, Kaizen pursues efficient equipment, operator, material and energy utilization. These are the fundamentals of productivity and Kaizen aims

at achieving substantial effects. Kaizen is a daily activity, the purpose of which goes beyond simple productivity improvement. Kaizen is a very familiar word in Japanese; “Kai” means change, and “Zen” means good (for the better). Basically kaizen is aimed at small improvements, but carried out on a continual basis and involving all people in the organization to achieve the best profit for the company. Kaizen is the opposite to innovation. Kaizen requires little or no investment. The principle behind it is that a very large number of small improvements are more effective in an organizational environment than a few improvements of large value. Kaizen is aimed at reducing losses in the workplace that affect the business’ efficiency. By using a detailed and thorough procedure, we eliminate losses in a systematic way using various Kaizen tools. These activities are not limited to production areas and can be implemented in administrative areas as well.

Kaizen implementation

The Kaizen implementation cycle is described in Figure 7.5. There are four main processes for implementing the Kaizen cycle as below:

- Identify the problem (What, When, Where, Who, Why, How)
- Investigate the main factors
- Kaizen implementation
- Set up the standardized work for maintenance activities

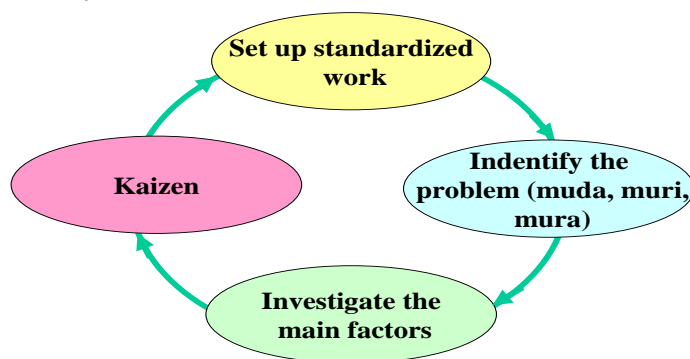


Figure 5. Kaizen implementation cycle.

Source: Made by the author based on the direct interview with Japanese industrial companies.

2.7. Office total productive maintenance

Office TPM is also an important criterion for company-wide TPM application. Not only Plant TPM gives benefit, but the company also achieves many benefits from Office TPM. These are: involvement of all people in support functions for focusing on better plant performance; Better utilized work area; Reduction of repetitive work; Reduction of inventory levels in all parts of the supply chain; Reduction of administrative costs; Reduction of inventory carrying cost; Reduction in the number of files kept; Reduction in expenses due to emergency dispatches/purchases; Reduction of manpower; The establishment and maintenance of a clean and pleasant work environment.

Note that office TPM is an activity implemented after activating four other criteria of TPM (autonomous maintenance, Planned maintenance, quality maintenance and Kaizen). Office TPM must follow to improve productivity and efficiency in the administrative functions and identify and eliminate losses. This includes analyzing processes and procedures towards increased office automation. Office TPM includes twelve major losses given as: Processing loss; Cost loss including in areas such as procurement, accounts, marketing, sales leading to high inventories; Communication loss; Idleness 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; Expenses on emergency dispatches/purchases.

Office TPM implementation

Managers from one of the support functions e.g. Production Preparation Engineer, Human Resource, Head of Finance, Purchasing, etc. should head the implementation committee. Members representing all support functions and people from Production & Quality should be

included in the committee. TPM co-ordinates plans and guides the committee:

- Providing awareness about office TPM to all support departments
- Helping them to identify losses in each function in relation to plant performance
- Identifying the scope for improvement in each function
- Collecting relevant data
- Helping them to solve problems in their circles
- Fanning out to cover all employees and circles in all functions.
- Making up an activity board where progress is monitored on both sides - results and actions along with Kaizens items such as: Inventory reduction, Lead time reduction of critical processes, Motion & space losses, Retrieval time reduction, Equalizing the work load, Improving the office efficiency by eliminating the time loss on retrieval of information, by achieving zero breakdown of office equipment such as telephone and fax lines.

Office TPM supports the plant, initially through autonomous maintenance of the machines after receiving training. Such support means Office TPM can eliminate the logistics problems for situations where there is a lack of materials, parts and other necessary tools. After TPM is successful internally, the experience of TPM should be extended to suppliers.

2.8. Safety, health, and environment

Safety, Health and Environment are very important issue for implementing TPM. This criterion is also considered in the beginning steps of the design process. Attention to Safety, Health and Environment will influence the image and reputation of the company. Implementation targets for this activity consist of three items:

1. Zero accidents
2. Zero health damage
3. Zero fires

Implementation of Safety, health, and environment

Zero accidents is considered a high priority in manufacturing activities. In order to do this the following main points are implemented:

- Design equipment of high safety standard. Equipment should be fitted with automatic stop in the event of emergencies.

- Implement education about safety for every worker and operator. Without a safety certificate, members cannot enter the workplace or operate equipment. Note that the human factor is the most important; even though you may make a high level of safety equipment, if the worker violates safety rules, serious accidents will happen.

Zero health side effects is also an important factor of TPM. The following points are also considered to reduce health side effects:

- Create a good working environment such as: set up a smoke extraction system, install a ventilation system in the work area

- Ask workers to wear safety helmets, shoes, gloves and glasses

- Organize periodic health checks for every worker

Achieving zero fires is an activity that should involve all members. Specifically managers are responsible for zero fires. Some main actions to be implanted are mentioned below:

- Educate members with fire-prevention knowledge

- Set up a fire-emergency center inside the factory

Safety is given priority in the plant, managers look after functions related to safety. To create awareness among employees, various competitions, such as thinking up safety slogans, Quizzes, Drama, Posters, etc. related to safety can be organized frequently. Those activities are also finding points of this research.

3. Conclusions

This research has pointed out the concept of practical TPM implementation in Japanese

industrial manufacturing plants, specifically the application of TPM for the actual manufacturing activities. From a management point of view, TPM involves all members of the company, TPM may be the thing that stands between success and total failure for some companies. Employees must be educated and convinced that TPM is not just another "program of maintaining machines" it is a program to help the company survive and develop. TPM works with JIT (just in time), TQM (total quality management), CIQ (continuous quality improvement) and TEI (total employee involvement) and together with these will form a high efficiency manufacturing model. The concept of TPM can be adapted to work not only in industrial manufacturing plants, but also in construction, maintenance, transportation, and in a variety of other areas. The concept of TPM can also be applied creatively to a wide range of Vietnamese industrial companies. Future research topics on TPM will be undertaken by investigating the current application of TPM in Vietnamese companies, and an application model for Vietnamese companies will be made.

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Ứng dụng thực tiễn của “Bảo trì sản xuất tổng thể TPM” tại các nhà máy sản xuất công nghiệp ở Nhật Bản

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Tóm tắt. Bảo trì sản xuất tổng thể (Total Productive Maintenance - TPM) được ứng dụng rộng rãi tại nhiều ngành công nghiệp, đặc biệt tại các công ty sản xuất công nghiệp của Nhật Bản. Ở góc độ quản lý, đây là một hoạt động liên quan tới mọi thành viên trong công ty - từ chủ tịch hội đồng quản trị đến các nhân viên. Ở góc độ hiệu quả kinh tế, một công ty có thể thu được nhiều lợi nhuận từ việc triển khai các hoạt động bảo trì sản xuất trên quy mô toàn công ty, như nâng cao hiệu quả của các thiết bị hiện có từ đó giảm chi phí sản xuất và chi phí đầu tư thiết bị. TPM không chỉ là một “Chương trình bảo dưỡng máy móc”, nó còn là phương thức quản trị giúp công ty duy trì và phát triển bền vững. Bài viết đã khảo sát nhiều nghiên cứu trên thế giới về TPM và nhận thấy việc ứng dụng thực tiễn TPM tại các nhà máy sản xuất công nghiệp ở Nhật Bản chưa được các tài liệu phân tích đầy đủ, chính xác. Mục tiêu của bài viết này là thực hiện nghiên cứu thực chứng, từ đó nêu ra được những ứng dụng thiết thực của TPM trong các nhà máy công nghiệp tại Nhật Bản trong những năm gần đây.