

Evaluation of total productive maintenance implementation in manufacture

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Abstract. This paper describes an evaluation of the Total Productive Maintenance (TPM) implementation. The evaluation is done by comparing the results of the application using the 5S foundation and the eight pillars of TPM with the company's achievement goal of 80%. 5S foundation includes Sort, Set in Order, Shine, Standardize, and Sustain. TPM method consist of eight pillars are include Autonomous Maintenance, Focussed Maintenance, Planned Maintenance, Quality Management, Education and Training, Safety, TPM offices, and Development Management. The evaluation of the TPM implementation is carried out using the nominal group technique method. The group consists of 10 managers, and supervisors are directly involved in implementing 5S on the production floor. The assessment results obtained on the 5S foundation application of 82%, Autonomous Maintenance of 83%, Focussed Maintenance of 75%, Planned Maintenance of 80%, Quality Management of 84%, Education and Training of 88%, Safety, Health & Environment of 78%, TPM office of 73%, and Development Management of 75%.

1. Introduction

Maintenance is the conception of all activities needed to maintain or maintain the quality of work facilities, machinery, and equipment to functions correctly and originally. The primary purpose of Maintenance is to keep the production process to run in operation conditions optimum. Maintenance is carried out to maintain equipment performance, maximize equipment life, and minimize production costs due to possible damage.

Total Productive Maintenance (TPM) was first introduced by Nippon Denso Co. Ltd. on Japan on 1971. TPM is the concept development of preventive care developed in the United States. Total Productive Maintenance is used as an innovative approach of Maintenance care by optimizing the equipment effectiveness, the elimination reduction of sudden damage (breakdown), and autonomous maintenance by the operator through daily activities involving the entire workers [1]. TPM is the method to improve production designed to optimize equipment reliability and ensure efficient factory asset management [2].

Total Productive Maintenance is a strategy widely used in productive areas to increase the availability of machinery, production equipment, and provide economic benefits to the company [3]. The purpose of entire productive care is to maintain the machine/equipment condition supports the implementation of the production process to achieve profitable care [4]. Total care systems including preventive maintenance, improved maintenance, and preventative maintenance. Full participation of all employees, including autonomous maintenance by operators through small group activities.

The implementation of the TPM model implies the keys to successful implementation, based on the action plan, training at all levels, monitoring indicators, organizational characteristics consideration and the ability to handle and react to productive process activities [5]. TPM is excellent planning, organizing, monitoring, and controlling the process through the eight pillars methodology which is includes: (1) autonomous maintenance; (2) focussed maintenance; (3) planned maintenance; (4) quality maintenance; (5) education and training; (6) safety, health and environment; (7) TPM office; and (8) development management [6,7].



The application of TPM is proven to provide good changes to the company in the form of increased productivity, improved quality, cost control, the accuracy of product delivery to consumers, maintaining safety, and increasing enthusiasm in creating workplaces are conducive to plant operations [3,8]. Because TPM can minimize waste on the production floor due to damage machines and equipment to use. Waste is an activity that does not add value but absorbs resources causing a burden on production costs [9].

TPM is a continuous improvement process focused on equipment structure to optimize production effectiveness through identification and losses reduction from equipment inefficiencies and the production system life cycle through active participation of team-based workers at all levels of the operational hierarchy [10]. Research on the TPM application in the manufacturing industry is much done. The application of TPM is carried out at one of the automotive companies in Germany. The result is an increase in productivity of 20% from before. This goal was obtained from the three pillars of the TPM application, namely continuous improvement, autonomous maintenance, and training and education [11].

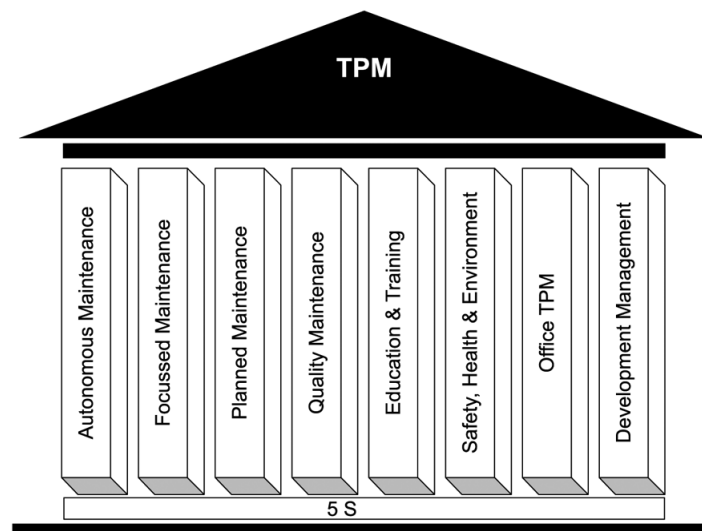
The other research conducted on 30 electronics companies shows that the application of TPM contributes to factory performance includes cost reduction, quality loss, smooth product delivery, and productivity improvement. The result indicates that planned maintenance pillars have most significant impact on factory performance improvement [12]. One crucial element of productivity improvement is the existence of good machine maintenance management. The absence of maintenance engineers and maintenance planners in the organization cause lead to scheduled machine maintenance programs [13].

Research on the TPM application also carried out in the milk sector [14], sewing process in the footwear industry [15], automobile industry [16], casting industry [17], aircraft industry [18], etc. The implementing of autonomous maintenance and planned maintenance pillars improve machine and equipment performance, production results, and reduce reject and rework [19]. Most of the papers describe how the application of TPM in the manufacturing and service industries. However, this paper describes the evaluation of the TPM pillars in the manufacturing industry, especially in the beverage industry packaging.

2. Methodology

This study is field research by collecting quantitative and qualitative data at six months of period. All data and information obtained from one of the beverage industry, which is very famous in Indonesia. The marketing area of beverage product packaging is spread from the west to the east in Indonesia. This study focuses on the evaluation of the TPM application in the beverage industry packaging. An assessment of the TPM pillar implementation is carried out to obtain information about the pillars application that the goal has not been reached.

Weak pillars are then analyzed so that the improvements can be made. Assessment of the TPM application and analysis of problems using the Nominal Group Technique (NGT). NGT, is a qualitative method to obtain evaluations from stakeholders, NGT is flexible enough to combine with various techniques [20]. NGT is chosen to prevent one person from dominates the discussion. NGT was attended by ten people consisting of one production manager, three production supervisors, two technical supervisors, two maintenance supervisors, and two 5S program supervisors. NGT facilitated by the researchers to obtain an assessment of the TPM application and analyze the weaknesses of the programs run.



Note: Approach suggested by the Japan Institute of Plant Maintenance

Figure 1. Pillars of TPM

Ishikawa diagram is used to analyze the TPM pillar application, which is weak. Ishikawa diagram chosen because it has several advantages, namely helping determine the root cause, encouraging group participation, using an organized format, easy to read, showing possible causes of variation, increasing process knowledge, and identifying areas to collect data.

3. Result and discussion

3.1. 5S Foundation

The 5S program (workplace management), which is the philosophy of Sort (Seiri), Set in Order (Seiton), Shine (Seiso), Standardise (Seiketsu) and Sustain (Shitsuke) are run in the bottle beverage industry since 2012. The 5S program is currently running by standards-setting for each area and conducting audits every month to assess constancy with their performance. The assessment results of the 5S implementation on the beverage industry can be seen in Table 1.

Table 1. Result of 5S implementation assessment

No	Statement	Score
1.	All items are put in the right place	4
2.	There is a label in every shelf and work equipment	5
3.	There is a temporary place to put equipment that can't be used	3
4.	Clean work floor, no garbage and water	3
5.	Work tables, machines and equipment neat and clean arranged	4
6.	There is an SOP cleaning in each machine and work area	5
7.	All workers work based on SOP applied	4
8.	Audit implementation is do routinely	4
9.	There is follow up of audit implementation	4
10.	There is a slogan to increase the spirit of 5s implementation	5
Total		41

The value obtained from the results of brainstorming using the Nominal Group Technique is 41 with a maximum score of 50. The percentage of 5S implementation achievement by 82% exceeds the company achievement of 80%. However, improvements can be made, mainly the temporary areas, to

put equipment that is not used (Sort) and clean the work area, especially the floor (shine). 5S implementation can handle the problem of unwanted materials, improper use of workspace, more time to search for documents and equipment, and the unpreparedness of the machine to be used [21].

3.2. Pillar of total productive maintenance

The first pillar, namely Autonomous Maintenance, is a maintenance activity carried out by the operator that gives a very significant contribution to improving the equipment utilization. By the application of the Autonomous Maintenance pillar, it provides routine maintenance responsibilities for the operators such as machine cleaning, lubrication, and machine inspection. So that the operator has a high sense of ownership for the equipment used. With the Autonomous Maintenance Pillar, the machine or production equipment ensured to be clean and well lubricated and identify the performance deterioration of the machine/equipment before severe damage occurs.

The second pillar of Focused Maintenance is carried out by forming a working group that proactively identifies the problem on the machine/equipment. The aims to get improvements to the maintenance problems faced. The third pillar of Planned Maintenance is carried out with scheduled maintenance based on the damage ratio has occurred and/or predicted. Planned Maintenance can reduce damage occurs suddenly and better control the level of component damage. The fourth pillar of Quality Maintenance is done by ensuring that the equipment or machine able to detects and prevents errors throughout the production process. Based on the ability, the production process becomes quite reliable in producing quality products according to the specifications. Control the level of product failure and minimize production costs.

The fifth pillar of Education and Training is needed to fill the knowledge gap of TPM implementation. Lack of knowledge of the tools or machines used cause damage in the equipment and caused low work productivity which is disturbs the company. With adequate training, the ability of operators can be improved so that they perform necessary maintenance activities when technicians are trained in enhancing their ability of carrying preventive maintenance and the ability to analyze damage to machinery or work equipment. Training at the managerial level also enhance the ability of managers to guide and educate their workers (mentoring and coaching skills) of TPM implementation.

The sixth pillar of Safety, Health, and Environment describes the workers able to work and carry out their functions in a safe and healthy environment. The company must provide a safe and healthy environment and free from hazardous conditions. The purpose of this pillar is to achieve the goal of a workplace that is free of accidents. The seventh pillar of the Office of TPM is to spread the ideas of TPM into the administration function. The purpose of this TPM pillar is that all participants in the organization (company) have the same concepts and perceptions, including administrative staff (purchasing, planning and accounting).

The eighth pillar of Development Management aim to improve the existing system through supporting factors improvement such as training workers, designing new equipment, and starting new maintenance improvement initiatives to fit the improved system. The assessment of the TPM pillar is carried out by the NGT method, together with the managers and supervisors in the company are directly related to the eight pillars application.

The maximum score of each variable is 5 (very good) and the minimum score is 1 (low). The results of the assessment can be seen in Table 2.

Table 2. Results of TPM implementation assessment

No	Statement	Score	Average Score	% Achievement
1. AUTONOMOUS MAINTENANCE PILLAR				
1	All workers clean the machine and work table every day	5	4.17	83%
2	The operator do checking and inspect machine and equipment independently	5		
3	There is One Point Lessons in equipment and machine	5		
4	Control of contamination source	3		
5	There is a standard checking process	5		
6	There are manual instructions of tools abnormality, processes and products	2		
Total		25		
2. FOCUSED MAINTENANCE				
1	There is a working group to identify the machine/equipment proactively	5	3.75	75%
2	There is a systematic action to eliminate losses	4		
3	Structural loss mitigation	2		
4	There is an action to improve OEE	4		
Total		15		
3. PLANNED MAINTENANCE				
1	There is a daily maintenance activity routinely	5	4.00	80%
2	There is a maintenance activity periodically (weekly and monthly)	5		
3	There is a report of the maintenance implementation	5		
4	There is a machine inventory based on theoretical age	1		
5	There is a record of each repair and replacement part	4		
Total		20		
4. PILLAR OF QUALITY MAINTENANCE				
1	All workers can understand the quality goals of the company	3	4.20	84%
2	There are routine maintenance activities of each operator so that the production process is based on standards	5		
3	Control devises usage such as controls visual, control machines (poka-yoke), inline detection and segregation of defect	4		
4	There are groups of quality control	5		
5	There is a suggestion system for quality improvement	4		
Total		21		
5. PILLAR OF EDUCATION AND TRAINING				
1	There is a general training for all workers including discipline, ethic, work culture, 5S, GKM and, etc	5	4.40	88%
2	There is a training in machine operation and maintenance	5		
3	There is up-to-date workers training needs based on competence	4		
4	Expert workers can operate the machine or be rotated in another workplace	4		
5	Training of general autonomous maintenance (Check, Inspection, Lubrication)	4		
Total		22		

No	Statement	Score	Average Score	% Achievement
6. PILLAR OF SAFETY, HEALTH AND ENVIRONMENT				
1	There is a work safety procedure	5		
2	Workers using Personal Protective Equipment (PPE)	3		
3	Green environment	4		
4	Treatment of solid and liquid waste	5		
5	Utilization of waste products for internal and external needs of the company	5		
6	Sport facilities	3	3,90	78%
7	Air circulation (ventilation) permanent at least 10% of the floor area	3		
8	Noise, Threshold <85 dB	3		
9	Lighting	3		
10	Water quality meets the requirements of clean water and drinking water-based on applicable regulations	5		
Total		39		
7. PILLAR OF OFFICE TPM				
1	There are regular meetings between departments	3		
2	There are regular meetings of each department	3	3.67	73%
3	There are regular meetings of each section	5		
Total		11		
8. PILLAR OF DEVELOPMENT MANAGEMENT				
1	There is a standard improvement as a result of the Continuous Improvement process	4		
2	The realization of workers suggestion for continuous improvement	4		
3	Workers participation in providing suggestions for continuous improvement	3	3.75	75%
4	There is a management support for workers suggestion such as providing rewards for realization of all suggestions	4		
Total		15		

The implementation of TPM conducted by one of bottle beverage industry is already quite good but still must be improved. The application of TPM pillars as the consideration are Focused Maintenance, Safety, Health and Environment, Office TPM, and Development Management. The application of the four pillars are less than 80% of the maximum goal. Therefore, further studies done to find out the causes of the weak implementation of the four pillars.

The implementation of Autonomous Maintenance, Focused Maintenance, and Planned Maintenance pillars is carried out by Check, Inspection, Lubrication, Adjustment, and Repair application. The Check and Inspection process is carried out concerning to the Autonomous Maintenance concept. All workers are responsible for cleaning and inspecting their work equipment that they use every day. The Lubrication and Adjustment process is also carried out by the operator concerned and supervised by a supervisor. The Repair process for general parts is also done by the operator-assisted by his supervisor. Extensive damage repairs are usually handled by competent outsiders.

Planned Maintenance is carried out in this company consists of daily, weekly, monthly, and overhauls maintenance. Daily Maintenance is carried out for 1 hour at the end of the third shift. The aim is to check critical components and machine lubrication. Weekly Maintenance is carried out at the beginning of the week to check the condition of the machine and equipment. Monthly Maintenance is done at once a month. Overhaul maintenance is a comprehensive check for all performance based on management.

4. Conclusion

Implementation of 5S, Autonomous Maintenance, Focussed Maintenance, and Planned Maintenance, Quality Maintenance, and Education and Training had been reached the company goal of 80%. While the implementation of Focused Maintenance, Safety, Health and Environment, Office TPM, and Development Management are less than 80% Of Each Pillar. The next effort is made to investigate the causes of the TPM implementation goals are not achieved.

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