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Potential of Implementing Total Productive Maintenance (TPM) on a Small-Scale Machine Shop

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Abstract

Introduction: Total Productive Maintenance (TPM), which originated in Japan's industrial sector, is a comprehensive approach aimed at optimizing production systems by actively involving all employees in the upkeep and maintenance of machinery and equipment. When TPM principles are effectively applied, they significantly reduce the risk of equipment failures and drive productivity to its maximum potential. This paper delves into the feasibility of implementing TPM in small-scale machine shops, with a specific focus on improving the quality and efficiency of wheel rim replacement processes.

Objectives: The primary objective is to assess the existing practices in a small-scale machine shop and pinpoint areas where TPM can be introduced to drive improvements. This study seeks to address key challenges, such as cutting irregularities and outdated equipment, that currently hinder productivity and quality. Through the application of root cause analysis, the paper aims to identify and implement solutions that will enhance operational efficiency and minimize waste in the wheel rim replacement process.

Methods: Implementing a Total Productive Maintenance (TPM) program fosters a shared responsibility for equipment maintenance, encouraging greater involvement from all levels of plant floor workers, which can significantly boost productivity. In a small-scale machine shop, TPM emphasizes that maintenance should be a collective effort, engaging not only the maintenance team but all employees, including top management, in the upkeep of equipment. By applying the 5S principles and Autonomous Maintenance (AM), the shop can create a more organized and efficient environment, making it easier to identify and address problems, thus restoring equipment to its optimal operating condition.

Results: The observation of a small-scale machine shop's operations revealed that neglecting the foundational 5S principles can lead to significant negative outcomes, including delays, defects, and declining employee morale. The shop's failure to consistently apply 5S practices, such as organizing tools and maintaining a clean workspace, contributed to inefficiencies and potential safety risks. Furthermore, the limited availability of functional lathe machines and inadequate maintenance practices resulted in increased downtime, affecting overall productivity and quality.

Conclusions: The implementation of TPM in a small-scale machine shop requires a proactive approach, ensuring that quality and productivity are prioritized even before the work process begins. Success hinges not only on the workers' efforts but also on the active involvement and support of management, including the acquisition of necessary facilities to enhance working conditions. Management must be prepared to address the challenges and risks associated with TPM implementation, potentially conducting a cost-benefit analysis to ensure the initiative's profitability and long-term growth.

Keywords: Total Productive Maintenance, Small-scale Machine Shop, Wheel rim, Welding, Machining.

1. Introduction

TPM originated in Japanese industrial sector that aims to help maintain and improve production system, involving all employees at all levels in the maintenance and servicing of their organization’s equipment and machinery. Applying the principles properly will help you minimize the likelihood of equipment failures and maximize productivity and continuity. It helps raise awareness among employees about technology, safety, and the environment because it instils a sense of ownership of the equipment and machinery they work with daily [2].

The core TPM initiatives classified into eight TPM pillars or activities for accomplishing the

manufacturing performance improvements include autonomous maintenance; focused maintenance; planned maintenance; quality maintenance; education and training; office TPM; development management; and safety, health, and environment [3].

TPM implementation is a positive step for everyone in the organization as it helps grow the organization, however most organizations face challenges while TPM implementations. Among the challenges are: 1. *Lack of Commitment*. Top management is the key for success or failure of any TPM implementation. They are influencers and authorities. 2. *Resistance to Change*. Any change (good or bad) requires some effort in changing the way we used to do things before. 3. *Management see it as a cost centered*. TPM requires investment in the form of time, people, material, and money. If you don't understand the main objective, then it might look like a cost centered instead of a profit centered to the management. 4. *Lack of Reward Program*. Any development could only take place when the way of implementation is different from the traditional one. TPM is such an unconventional methodology which is much progressive. 5. *Lack of TPM Knowledge*. TPM is very effective yet a complex mechanism. It is much more than fixing machines and equipment. In most cases, TPM fails due to its incorrect implementation and lack of support system [4].

In this paper, it is discussed that TPM are mostly applied to a company or bigger organization. However, the potential implementation of TPM in a small-scale machine shall be considered to improve quality and productivity.

Small-scale machine shops often offer fabrication and machining jobs. This includes repairs, fabrication of machine and automobile parts, machining, milling, threading, gear fabrication and grinding works limited to more conventional type of operations. Manpower is less expected in numbers. It also includes replacing and removing parts which then produced work that brings to its good operating condition. A good alternative way before any customer would decide to purchase a new unit is by having it done or undergoing repair works instead. Wheel rims are always subjected to excessive loads and often results in wear and tear resulting to cracks and holes irregularities on the wheel disc or rim plate. Machine shops offer fabrication jobs to replace the rim without buying new ones.

One of the small-scale shops in rural area situated in one of the provinces of the Philippines that caters job which replaces damaged wheel rim plates of trucks. With its location away from city limits, it caters for most of these jobs regularly. Hauling trucks come and go and other heavy loading vehicles used in hauling have always been the center of their operations. An ideal place to cater for these trucks having problems with their rim plates.

The damaged rim is brought in the shop for inspection if it could still be subjected for repair and identifies what action to be undertaken. Though they only cater for rim plate replacement or repair, the customer is also being informed if they need to buy a new one. For all repair jobs, the damaged rim plate is removed with oxy-acetylene cutter manually. The wheel rim undergoes machining to eliminate irregularities during cutting. Attachment of the prefabricated rim plate is aligned with the machined rim and subject for arc welding process. The newly attached rim plate requires centering works and alignment then subject to machining after arc welding process to ensure proper surface finish.

With the observation conducted and interviews from the owner and the operator, this paper noted the operation undertaken and the situation of the workplace and what processes are being made in terms of quality and productivity.

2. Objectives

This focuses on a particular job on wheel rim replacement prosses and has been identified to be a pilot area for possible TPM implementation where it identifies one problem on cutting irregularities that affects productivity and quality.

The process of discovering the root causes of problems to identify appropriate solutions is done with root cause analysis (RCA) and follows the following steps: 1. Define the Problem, 2. Gather Data, 3. Identify Causal Factors, 4. Determine the Root Cause(s) and 5. Recommend and Implement Solutions [5].

Cracked portion between holes

Removed damaged rim plate

Machining after removing damaged portion

Repalced rim plate welded and machined

Figure 1. Job Flow

Along with the processes as shown in figure 1, certain factors had been taken into considerations and some areas identified could still be potentially improved, such as:

- Inadequate number of experienced operators on manual oxy-acetylene cutting process which lead to time factor concern, and some resulted to over cutting that produced penetration through holes on rim.
- Cutting irregularities are more likely to be acquired.
- Only two conventional type lathe machines can cater the size of rim are working.
- Manual lifting and alignment of the rim plate during machining and attachment by the operator.
- Competent arc welder is also needed.

Shop floor conditions also concern the work process in general. The following are:

- 5s implementation is needed.
- Incoming and outgoing of workstation is inadequate.
- PPEs are inadequate.

One of the goals of TPM is to maximize quality production and minimize waste of time and material. Conducting a root cause analysis is an essential problem-solving method used to isolate and identify concerns [5].

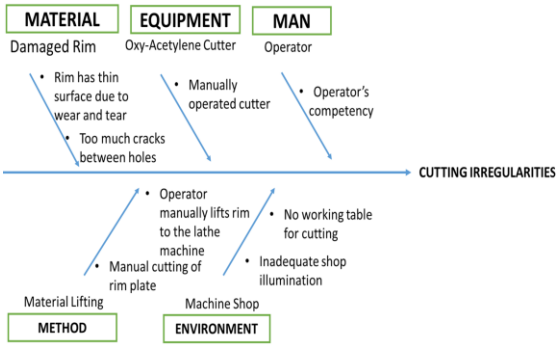


Figure 2: Fishbone Diagram

Cutting irregularities on wheel rim replacement were considered a need of prior attention and the possible causes of the problem, as shown in figure 2. Understanding how to solve it and learn the underlying issues within the root cause will take it to the idea that is to apply what we learn from this analysis to systematically prevent future issues or to repeat successes [6].

3. Methods

The implementation of a TPM program creates a shared responsibility for equipment that encourages greater involvement by plant floor workers. In the right environment this can be very effective in improving productivity [7]. The concept of potential implementation of Total Productive Maintenance (TPM) in a small-scale machine shop is a strategy that operates according to the idea that

everyone in a shop should participate in maintenance, rather than just the maintenance team. This approach uses the skills of all employees that includes the top management and seeks to incorporate maintenance into the everyday performance of a facility [8].

As observed during the interview with the shop owner and operators, one of the requirements of implementing TPM is to identify pilot area. The possibility on which is the easiest to improve, where the constraints took place, and which is more problematic is studied. In order to restore equipment to its prime operating condition, the concept of 5S and Autonomous Maintenance (AM) is applied [f]. The 5S principle is the foundation concept in TPM implementation together with its pillars in which proper implementation helps makes problems visible and identified. It is a systematic process of housekeeping to achieve a serene environment in the workplace involving the employees with a commitment to sincerely implement and practice housekeeping. Problems cannot be clearly seen when the workplace is unorganized. Cleaning and organizing the workplace helps the team to uncover problems. Making problems visible is the first step to improvement. [9].

The observed scenario on a small-scale machine working on wheel rim replacement in Table 1 shows that TPM starts from 5S and if it is not taken seriously, then it leads to 5D (delays, defects, dissatisfied customers, declining profits, and demoralized employees).[10]

Table 1: 5S Observation in the workplace.

5 S	**Observed working Images**
SEIRI (Organize/Sort)	
Incoming tires with rims stock in one corner waiting for inspection.	
SEITON (Tidiness/ Systematize)	
Lathe Operators' cabinet for tools and cutters not attended.	
SEISO (Cleaning/ Sweep)	
Removed damage rim plates place on the floor not in the scrap area.	
SEIKETSU (Standardize)	
PPE not mandatory worn by the operator during welding.	
SHITSUKE (Discipline/ Self-discipline)	
Unclean machine surface after used.	

The entire edifice of Total Productive Maintenance is built and stands on eight pillars [9]. However, this

paper studied these pillars to contextualize on a small-scale machine shop in rural areas.

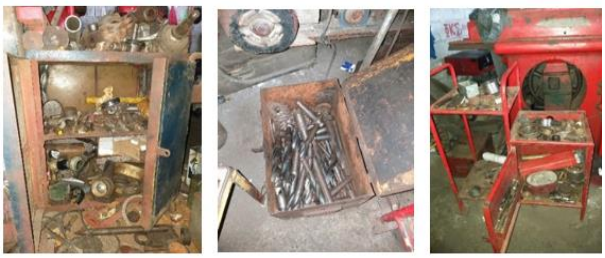
Autonomous Maintenance (AM)

Autonomous maintenance is defined as a maintenance strategy where machine operators continuously monitor their equipment, adjust, and perform minor maintenance tasks on their machines. [11]. The operator of the lathe machine shall be given enough reminders to do basic maintenance to ensure the two conventional lathe machines only allocated for the rim plate machining are always in good condition.

On the other hand, the available lathe machine working for the wheel rim is limited to only two functional lathes which could be subjected for Overall Equipment Efficiency (OEE) in the future. This is considered downtime in productivity. It may demand more cost in the part of management.

Kaizen

Kaizen is a Japanese term meaning change for the better or continuous improvement [12]. Kiazen is applied by combining different improvement tools and techniques [13]. The *Poka Yoke* device could be applicable to how the operators handle these tools and determine the problem that can be potentially improved. It was observed that tools and cutters were place all in one place and it is not in their proper place. It may seem very negligeable, but this may cause operation delays.



Lathe accessories, tools, and cutters are not kept properly.

Planned Maintenance

Planned maintenance is a proactive approach to maintenance that focuses on minimizing the downtime and costs associated with breakdowns [14]. Since these machines operate regularly, the company as well as the operator must perform regular periodic maintenance. Specifically, only two lathe machines work for the job despite the presence of other non-functional machines. If these machines were put back to their running condition, works would not be filing up waiting.

Quality Maintenance

Quality Maintenance activities are to set equipment conditions that preclude or prevent quality defects, based on the basic concept of maintaining perfect equipment to maintain perfect quality of products [10]. During the process, the condition was then checked to verify the output of the work if the alignment of the holes agree with the rim plate undergoing machining works. Every time aligned work was done, it must be checked and measured through testing rotation to avoid being off-centered. Good quality output always results in customer satisfaction.

Training

Education is given to operators to upgrade their skill. It is not sufficient to know only “Know-How” but they should also learn “Know-Why”. By experience they gain “Know-How” to overcome a problem on what to be done. This they do train them to know “Know-why”. The employees should be trained to achieve the four phases of skill. The goal is to create a factory full of experts [10]. In the case of the operator’s training, it is highly required to make sure that the processes undertaken always result in quality output thus minimizing the waste of both time and materials. This could also enhance their competencies and work attitudes.

Office TPM

Office TPM should be started after activating four other pillars of TPM (AM, Kaizen, PM, and QM). Office TPM must be followed to improve productivity and efficiency in the administrative functions and identify and eliminate losses. This includes analyzing processes and procedures towards increased office automation [10]. A report shall be initiated by the operator on the material waste made to lessen the cost involved in the process. Inventory and other mitigating ways to minimize them is necessary. On the management side, upon identifying the submitted report, the management will probably provide what needs to be addressed to improve the quality of work.

Installing CCTV in the workplace helps provide monitoring. Priority on procurement of new devices that aids to lessen defects like automated cutter attachment.

Safety, Health, and Environment

To maintain a safe and healthy working environment that eliminates potential health and safety risk, resulting in a safer workplace which specifically targets the goal of an accident-free workplace [7]. Proper implementation of PPEs and housekeeping concern will foster safe workplace and surrounding area most importantly to the workers. Equipment safety also has an equal impact on the quality of work for both the worker and its output.

4. Results

Implementing a Total Productive Maintenance (TPM) program that involves all employees in equipment maintenance can significantly boost productivity in a small-scale machine shop. For successful TPM implementation, identifying a pilot area for focused improvements and applying 5S principles and Autonomous Maintenance (AM) are crucial to restoring equipment to optimal conditions. Observations show that neglecting 5S can lead to operational issues like delays, defects, and declining profits, highlighting the importance of systematic workplace organization. Autonomous Maintenance helps keep equipment, such as lathe machines, in good condition through continuous operator oversight, which is vital for reducing downtime and maintaining productivity. Additionally, effective training programs and continuous improvement practices, including Kaizen, are essential for enhancing employees' skills and understanding, thus improving overall quality and reducing waste in the production process.

5. Discussion

The study recognizes only the potential implementation of TPM in a small-scale machine shop in rural areas. A summary of observations comes from the assumption that if TPM is to be implemented there would be possibilities for these concerns or challenges to be addressed to both top and bottom stakeholders to expect improved quality of work outputs and productivity. Here are some areas identified:

1. Total working time per unit will be lessens.
2. Minimized downtime.
3. Performance efficiency of equipment improves.
4. Quality rates also improve.

However, different challenges also hamper TPM implementation if the management sees less on its commitment and manifests resistance to change. Another way to look at it is if the financial aspect matters both in the possibility to acquire new equipment or facilities or to renovate its physical setups or possibly its production line cost much for a small-scale machine shop.

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