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Total Productive Maintenance (TPM)-: A state-of-the-art Review

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Abstract - Maintenance is the core function to keep a system running and avoid failure. Total Productive Maintenance (TPM) has broadly utilized maintenance strategy to improve the customer's satisfaction and hence obtain a competitive advancement. The goals of TPM are zero breakdown, no slow running, no defects, and making the production environment safe and in a perfect condition [2]. TPM offers a complete maintenance methodology the concept emphasizes sustaining the overall effectiveness and utilization of equipment through the active participation of equipment workers in the setting of teamwork or small group activities.[4]

***Key Words*:** *Total Productive Maintenance, Predictive Maintenance,Pillars,*

1.INTRODUCTION

Increased global competition has augmented the importance of total productive maintenance (TPM) in obtaining and maintaining a competitive advantage. More and more organizations are seeking proactive tools such as TPM to enhance their competitive position[5] The efficiency of maintenance is seen as vital to the competitiveness of manufacturing companies (Nakajima 1988, Nakajima 1989). To succeed in demanding market conditions, manufacturers must rely on a dependable manufacturing system in order to produce efficiently on a high quality level. Consequently, the concept of total productive maintenance (TPM) was introduced in the field of production and operations management aiming at improving maintenance. Today, cost, quality, and time should be seen as key drivers for competitiveness. Firstly, manufacturing companies should strive for a superior cost position. As a result, the importance of maintenance has increased due to its potential for guaranteeing high machine availability and failure-free machine operations, thus, contributing to high process efficiency.Secondly, manufacturers should also be able to offer high quality products. Accordingly, production on a high quality level is necessary to meet quality specifications. Consequently, maintenance performance must be enhanced to enable a high process capability since only machines with a high maintenance standard are able to produce with less or no failures.[1]

TPM adoption brings forth the growth of workers' involvement in terms of new skills learned and number of proposals for solutions because their participation in TPM allows active engagement in corporate life and ownership in the workplace. This further leads to increased work efficiency and quality, decreased work-related accidents and complaints, and reduced internal waste.[4] Total productive maintenance (TPM) represents a potential source of improvement for an organization and a possible next step for extending the benefits of the
total quality management (TQM) concept. It involves the whole organization and when implemented effectively benefits all sections of the business through improved efficiency and better overall performance. TPM is emerging as an essential strategic tool for companies and its importance is no longer restricted to just the manufacturing sector. The scope of TPM extends far beyond manufacturing to areas such as research and development, and logistics. While TPM was the focus of the automobile industry, it is now spreading to other industries such as paper, food and oil refinery industries as well as to the service industries.[5] Maintenance has been one of the most researched topics in manufacturing due to its significant role in overall costs, productivity and quality. By effectively integrating the maintenance function with engineering and other manufacturing functions, companies can improve reliability, availability and performance and can save significant amounts of time, money and other resources [6]

2. Maintenance Types:

Total productive maintenance TPM is increasingly being seen as a suitable initiative technique for effectively involving the workforce in manufacturing based organizations to produce increased productivity.TPM implicitly takes into account the customer dimension through waste reduction, productivity improvement, timeliness and planning of activities, gathering and analyses of data, and improvement of quality.[5]

Maintenance can be divided into Corrective Maintenance (CM) and Preventive Maintenance (PM).

Corrective Maintenance (CM) is carried out after a fault has been recognized; it is intended to put the failed item back into a state in which it can perform its required function. In reality, machine breakdown is common after long-time operation, hence, the machine will be unavailable while processing tasks due to its failures. Since machine breakdown will reduce production efficiency, maintenance as an important part in manufacturing systems is used to keep machines in good condition to decrease failures, which makes maintenance planning become more and more important in manufacturing processes [13]. corrective maintenance, or
breakdown maintenance, which strives to reduce the severity of equipment failures once they occur [15]

Preventive Maintenance (PM) is carried out at predetermined intervals or according to prescribed criteria and is intended to reduce the probability of failure or the degradation of items. The aim of PM is to provide maximum system reliability and safety with a minimum of maintenance resources. However, PM requires that the items in question have an expected life span or a measurable degradation rate. [3] Preventive maintenance is a schedule of planned maintenance actions aimed at the prevention of breakdowns and failures. The primary goal of preventive maintenance is to prevent the failure of equipment before it actually occurs. It is designed to preserve and enhance equipment reliability by replacing worn components before they actually fail [11]. One is preventive maintenance, which strives to reduce the frequency of equipment failures once they occur. The intention

is to build a system that will find potential failures, make changes or repairs, and prevent failure [15]

Total Productive Maintenance has become one of the most expedient approaches to guarantee high machine dependability. The following figure depicts the relevance of Total Productive Maintenance for the success factors cost, quality, and time.[8]

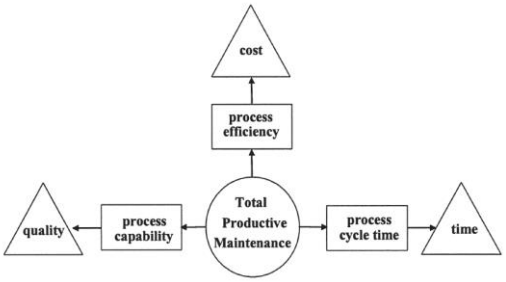

Fig. No. 1: The Relevance of Total Productive Maintenance for Competitiveness.

3. Pillars of TPM

The goal of the any TPM program is to improve productivity and quality along with increased employee morale and job satisfaction. Earlier preventive maintenance was considered as non value adding process, but now it is essential requirement for longer life cycle of machines in an industry. TPM is an innovative approach to maintenance that optimizes equipment effectiveness ,eliminates breakdowns, and promotes autonomous operator maintenance through day-to-day activities involving the total workforce.[9] Total productive maintenance [18, 88] is a stepwise strategy that combines best features of productive and preventive maintenance with total employee engagement to maximize overall equipment efficiency (OEE) [14].

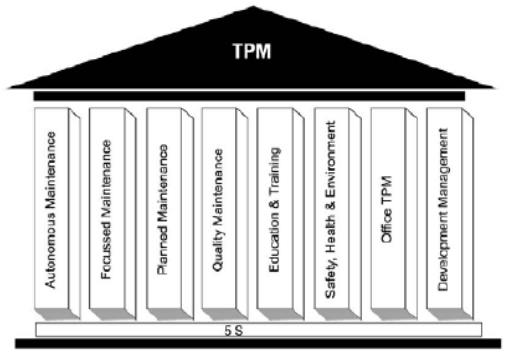

Fig. No 2: Pillars of Total Productive Maintenance

TPM entails eight main elements/pillars that can be considered as principles/tools of TPM in an organization..
Autonomous maintenance • Performance improvement • Early equipment management • Planned maintenance • Environment health and safety • Office TPM • Education and training • Quality maintenance
5 S
TPM starts with 5S. 5S can be called as foundation stone of TPM implementation. It is a Japanese way of housekeeping. Problems cannot be recognized is the work place is unorganized.[9] 5S comprise Seiri, Seiton, Seiso, Seiketsu and Shitsuke helps officer to manage surrounding work place to be clearly seen by people or equipment to be disciplined.[10]

JISHU HOZEN (Autonomous Maintenance)
The operators are responsible to upkeep their equipment on daily basis to prevent it from deteriorating. By use of this pillar, the aim is to maintain the machine in new condition.[9] Operator is able to take care of small reparation on failed equipment by without maintenance officer. Maintenance officer can spend time learning and practicing other advanced skills to maintain equipment.[10]

Focused maintenance
This pillar aims to improve overall equipment effectiveness (OEE) by minimizing waste in the system. Normally it is deployed by a small group of employees that regularly identify and resolve recurring problems in order to incrementally improve the operation of the equipment [2].

Planned Maintenance
The method and activity to prevent equipment breakdown aim for continuously producing quality goods [10].Planned Maintenance is a proactive approach which uses trained maintenance staff to help train the operators to better maintain their equipment. Objective of Planned Maintenance are to achieve and sustain availability of machines, optimum maintenance cost, improve reliability and maintainability of machines, zero equipment failure and break down and ensure availability of spares all the time.[9]

Quality Maintenance
It is aimed for maintaining equipment to be perfectly ready to operate and produce quality goods without breakdown by quality goods is anticipated to be main variable [10].It is geared towards achieving customer satisfaction through delivery of highest quality product. Through focused improvement defects are eliminated from the process after identifying the parameter of machine which affects the product quality.[9]

Education and Training
Training current and future TPM employees including operators, maintenance staff, and managers plays a key role in having a successful TPM implementation for smart manufacturing systems [2]. Continuous improvement is possible only through continuous improvement in knowledge and skill of the people as different levels [9].

Safety, Health and Environment
The purpose of this pillar is to create a safe workplace and a surrounding area that is not damaged by our process or procedures.[9] Safety, Health and Environment is focused on the promote and activity to predict and prevent any damage from work in surrounding area and work place to officers to recognize Zero accident, Zero health damage and Zero fires campaigns [10].

Office TPM
This includes analyzing processes and procedures which can be automated. Office TPM addresses nine major losses which are processing loss, cost loss including in areas such as procurement, accounts, marketing, sales leading to high

inventories, communication loss, idle loss, set-up loss, accuracy loss, office equipment breakdown, communication channel breakdown, telephone and fax lines and time spent on retrieval of information.[9] To improve productivity and efficiency in the administrative roles, it aims to establish work procedure for officers to follow to eliminate any breakdown causes[10].

Early/Equipment Management

Early equipment management or also called development management tends to minimize the problems and running time for installing new equipment. Also, it improves the development of the new equipment by directing practical knowledge and understanding gained from TPM[2]

In manufacturing, machines suffer increasing wear with usage and age as deterioration process, which causes low reliability and high operational cost . Machine failures usually make huge economic losses. Hence, maintenance management as an important part in manufacturing systems has been widely used to keep machines in good operation to decrease failures and reduce high operational cost and breakdown cost [12]

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