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TPM – TOTAL PRODUCTIVE MAINTENANCE

Abstract: *This paper describes foundations of TPM (Total Productive Maintenance) in around the world. TPM is Japanese technique whose main goal is to increase productivity of existing equipment by prolonging investment in capacities, achieving machine reliability and profitable investment. It describes, basic elements of TPM and eight pillars representing backbone of this technique. Implementation plan and twelve steps which are important for good implementation of TPM in industry. TPM is a combination of American preventive maintenance and the Japanese concept of total quality management and overall employee participation. This technique is methodology developed by Japan to support the underwater system. TPM is proven production strategy that is globally used to achieve organizational goals of competence in a competitive environment. The introduction of the TPM methodology provides guidance to organizations to transform their business community by integrating culture, processes and technology. TPM is widely recognized as a strategic weapon to improve production performance to increase the efficiency of production facilities. Originally presented as a set of practices and methodologies aimed at producing enhanced performance equipment, TPM has matured in comprehensive equipment that optimizes productivity of production.*

Keywords: *TPM, technique, production, methodology*

1. Introduction

According to Nakajima, Vice President of the Japanese Institute for Plant Maintenance, TPM is a combination of American preventive maintenance and the Japanese concept of full quality management and overall employee collaboration. TPM is a methodology developed by Japan to support the application of the system. TPM is a proven product strategy that has been successfully used to achieve competency in competitive environments. A completed TPM methodology provides the organization

of mortals to transform their managerial integrity of integrated cultures, processes and technologies. TPM is considered as a Japanese response to the American style of productive maintenance. This is a Japanese concept developed in 1970. By extending preventive maintenance to become more productive maintenance. TPM is an innovative maintenance approach that is complementary to TQM, JIT, continuous performance enhancement (CPI), and other global strategies. TPM is widely recognized as a strategic weapon to improve production performance to increase the efficiency of

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production facilities. Originally presented as a set of practices and methodologies aimed at producing enhanced performance equipment, TPM has matured in comprehensive equipment that optimizes productivity of production. TPM delivers maintenance as a necessary and essential part of the job. TPM describes the synergistic relationship between all organizational functions, but especially between production and maintenance, to continuously improve product quality, operational efficiency, productivity and security. TPM is an irreplaceable strategic initiative that meets the requirements of users concerned with the price, quality and delivery time. Almost all industrial production processes are carried out with the aid of machines, as a result of which each production-oriented organization is largely dependent on its machinery (Wal and Lynn, 2002). When a breakdown or a long-term disruption occurs of machines, equipment or important tools, this will automatically have far-reaching consequences for the total production (Ahuja, 2006).

2. Literature review

The literature has revealed that the manufacturing organizations worldwide are facing many challenges to achieve successful operation in today's competitive environment. Modern manufacturing requires that to be successful, organizations must be supported by both effective and efficient maintenance practices and procedures. Over the past two decades, manufacturing organizations have used different approaches to improve maintenance effectiveness (Roup, 1999). One approach to improving the performance of maintenance activities is to implement and develop a TPM strategy. The TPM implementation methodology provides organizations with a guide to fundamentally transform their shopfloor by integrating culture, process, and technology (Moore, 1997). TPM is

considered to be Japan's answer to US style productive maintenance (Wal and Lynn, 2002). TPM has been widely recognized as a strategic weapon for improving manufacturing performance by enhancing the effectiveness of production facilities (Dwyer, 1999; Dossenbach, 2006).

TPM has been accepted as the most promising strategy for improving maintenance performance in order to succeed in a highly demanding market arena (Nakajima, 1988). TPM is the proven manufacturing strategy that has been successfully employed globally for the last three decades, for achieving the organizational objectives of achieving core competence in the competitive environment (Ahuja et al., 2006). TPM is a highly influential technique that is in the core of "operations management" and deserves immediate attention by organizations across the globe (Voss, 1995). TPM is a methodology originating from Japan to support its lean manufacturing system, since dependable and effective equipment are essential pre-requisite for implementing Lean manufacturing initiatives in the organizations (Sekine and Arai, 1998). While Just-In-Time (JIT) and Total Quality Management (TQM) programs have been around for a while, the manufacturing organizations off late, have been putting in enough confidence upon the latest strategic quality maintenance tool as TPM. Figure 1 shows the relationships between TPM and Lean Manufacturing building blocks. It is clearly revealed, that TPM is the corner stone activity for most of the lean manufacturing philosophies and can effectively contribute towards success of lean manufacturing. TPM is a production-driven improvement methodology that is designed to optimize equipment reliability and ensure efficient management of plant assets (Robinson and Ginder, 1995). TPM is a change philosophy, which has contributed significantly towards realization of significant improvements in the

manufacturing organizations in the West and Japan (Maggard and Rhyne, 1992). TPM has been depicted as a manufacturing strategy comprising of following steps (Nakajima, 1989; Bamber et al., 1999; Suzuki, 1992):

- Maximizing equipment effectiveness through optimization of equipment availability, performance, efficiency and product quality;
- Establishing a preventive maintenance strategy for the entire life cycle of equipment;
- Covering all departments such as planning, user and maintenance departments;
- Involving all staff members from top management to shop-floor workers; and
- Promoting improved maintenance through small-group autonomus activities.

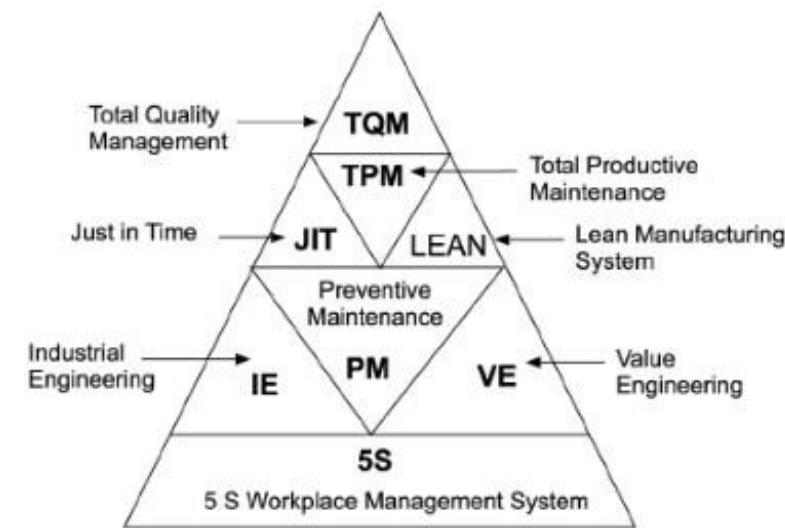


Figure 1. Relationship between TPM an lean manufacturing philosophies

Nakajima (1989), a major contributor of TPM, has defined TPM as an innovative approach to maintenance that optimizes equipment effectiveness, eliminates breakdowns, and promotes autonomous maintenance by operators through day-to-day activities involving the total workforce (Bhadury, 2000). The emergence of TPM is intended to bring both production and maintenance functions

together by a combination of good working practices, team-working and continuous improvement (Cooke, 2000). Willmott (1994) portraits TPM as a relatively new and practical application of TQM and suggests that TPM aims to

promote a culture in which operators develop “ownership” of their machines, learn much more about them, and in the process realize skilled trades to concentrate on problem diagnostic and equipment improvement projects. TPM is not a maintenance specific policy, it is a culture, a philosophy and a new attitude towards maintenance (Chowdhury, 1995). TPM is a system (culture) that takes advantage of the abilities and skills of all individuals in an

organization (Patterson et al. 1995). An effective TPM implementation program provides for a philosophy based upon the empowerment. (Davis and Willmott, 1999).

3. Basic elements of TPM

TPM is an important world-class production program introduced during the quality revolution. TPM aims to increase the effectiveness of equipment through its lifetime. He strives to maintain the equipment in optimum condition to prevent unexpected failures, speed losses and quality deficiencies that arise from process activities. There are three final goals of the TPM: zero defects, zero accidents and zero malfunctions. Nakajima suggests that equipment should use 100% of its capacity through 100% time. The benefits of TPM can be classified into six categories, including productivity, Q-quality, C-cost, D-delivery, safety (S-safety) and moral (M-morals). TPM is conceived as a comprehensive production strategy to improve productivity of equipment. According to OEE reference values, P, Q, C, D, S and M can enable the organization to achieve zero defects, defects, stopping machines, accidents and pollution, which serve as the ultimate goals of TPM. The strategic elements of the TPM include cross-functional teams to remove obstacles to the continuous operation of machines, rigorous preventive maintenance programs, improve maintenance management practices, maintenance at low-level equipment, and support information systems for the development of imported equipment with lower costs, and greater reliability. Similar to TQM, TPM is focused on improving all major performance indicators. TPM implementation requires long-term commitments to achieve improved OEE through exercise, management support, and teamwork (Ben-Daya, Duffua, Raouf, Knežević and Kadi, 2009). Figure 2 shows the TPM implementation frameworks and

describes the tools used in the execution of the TPM program with the potential calculation of the benefits and the desired goals. The TPM initiatives proposed by the Japan Institute of Plant Maintenance (JIPM) include an eight-pillar implementation plan that results in a significant increase in productivity through controlled maintenance, reduced maintenance costs, and reduced set-up and downtime (Chowdhury, 1995). The basic principles of TPM are often called columns or TPM elements. Even the TPM building has been built and stands on eight pillars. TPM shrinks the way for excellent planning, organizing, monitoring and controlling practices through its unique eight pillars of methodology that include: autonomous maintenance, focus on improvements, planned maintenance, quality maintenance, education and training, safety, health and the environment. The eight pillars of the Nakajima TPM implementation model are shown in Figure 5, and Figure 4 shows the maintenance and organizational progress of the initiatives associated with the respective TPM pillars. TPM initiatives aim to achieve improved security, asset utilization, production capacity without additional investment in new equipment, human resources, and continuing to reduce equipment maintenance costs and improve the continuous operation of the machine. It provides an effective way of implementing activities through its TPM promotions organizations that include 100% of employees on a permanent basis (Voss, 1995). The total involvement of employees, independent maintenance by operators, small group activities to improve equipment reliability, productivity and continuous improvement (Kaizen) are principles that respects TPM..

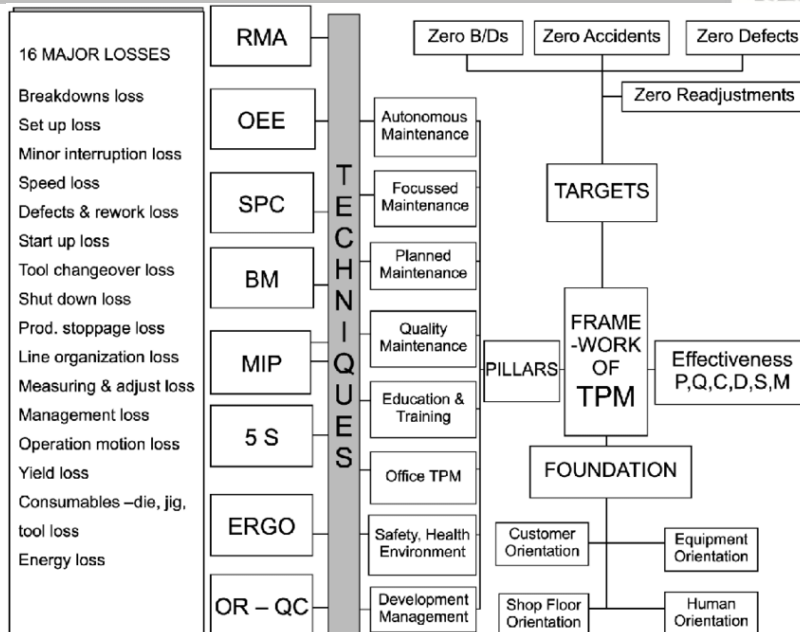


Figure 2. TPM backbone (Nakajima, 1988)

There are a number of tools that are traditionally used to improve quality. TPM uses the following to analyze and solve equipment and process related problems: pareto analysis, statistical control of the process (SPC), problem solving techniques (brainstorming, causal diagrams and 5-M approach), poka-yoke systems (error research), autonomous maintenance, continuous improvement, 5S, reduction of setup time (SMED), waste minimization, benchmarking, bottleneck analysis, reliability, maintenance and availability (RMA) analysis, recognition and award program, and system simulation. TPM provides a comprehensive approach throughout the life cycle, managing equipment that reduces equipment defects, manufacturing errors, and accidents. The goal is to improve the continuous production availability of the system and prevent deterioration of equipment for maximum efficiency. These goals require strong governance support, as well as the continued use of work teams and groups with small activities to achieve

incremental improvement (Ben-Daya, Duffua, Raouf, Knežević and Kadi, 2009; Nakajima, 1988).

Pillar 1 - Autonomous Maintenance (JISHU HOZEN): this step involves improving the operator on the machine (device, equipment) to be able to take care of minor maintenance actions, thus releasing more capable, more qualified, maintenance workers for more serious maintenance tasks. It should be ensured that the equipment works without interruption, that is, to remove faults at the very beginning. Objectives JISHU HOZEN:

- reducing oil consumption by 50%,
- reduction in the duration of the production process and
- increasing the use of autonomous maintenance itself

Pillar 2 - Focus on improvements (Kaizen): "KAI" means change, while "ZEN" means improvement. So, basically this means small improvements that are

constantly being implemented and involves all people and organization. This is something that is contrary to the great innovations - the prince of this pillar is that it is better to apply a large number of small and small innovations. Kaizen does not cause any additional costs and investments. They are implemented both in production and in the administrative sphere.

Kaizen goals:

- achieve and maintain zero loss and
- achieving 30% savings in production

So, all that is achieved through the mentioned Kaizen policy, through analyzes, costing, Kaizen registers and ending tables. Kaizen aims to increase the efficiency of equipment, the operator on the machine, and the way of using materials and energy. It extends the theme of 6 major losses and treats the wider area through 16 major losses.

Pillar 3 - Planned maintenance

Parts maintenance in 4 groups:

- preventive maintenance,
- Corrective maintenance,
- maintenance according to the state
- prevention

This raises our efforts in response to proactive maintenance and trained maintenance workers train the machine workers (operators) to be able to better maintain their equipment.

Pillar 4 – Quality Maintenance

What is it?

Design error detection and prevention into production processes. Apply Root Cause Analysis to eliminate recurring sources of quality defects.

How does it help?

- Specifically targets quality issues with improvement projects

focused on removing root sources of defects.

- Reduces number of defects.
- Reduces cost by catching defects early (it is expensive and unreliable to find defects through inspection).

Pillar 5 - Education and training: The goal is to have skilled workers whose morale is high and who want to come to work and perform tasks efficiently and independently. This is why trainers are trained to improve their capabilities. Employees should be trained until all four stages of skills or abilities are passed:

- Phase 1 - I do not know what this is about,
- Phase 2 - I know theoretically, but I do not know how to apply it,
- Phase 3 - I know, but I do not know how to transfer knowledge and
- Phase 4 - I know how to make it, and I would also know how to learn a colleague

Pillar 6 - Safety, Health and Environment:

The objectives are clear, namely achieving zero incidents, zero injuries and zero fires. Therefore, it is necessary to focus on achieving a safe work environment that will not be compromised by work processes or procedures. This TPM column will actually be embedded in all the other pillars of the TPM program.

Pillar 7 - TPM office: the TPM office should be formed after activating the previous pillars. Office or, in other words, the office should be formed to monitor the improvement of productivity, efficiency in administrative work in order to eliminate losses, which involves analyzing processes and procedures.

Pillar 8 - Development Management: The goal is to reduce the time required to start new equipment.

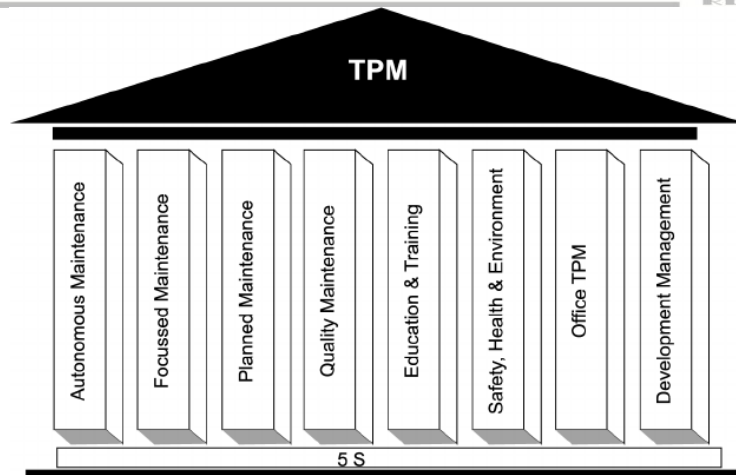


Figure 3. Access from the eight pillars of TPM (suggested by JIPM)

4. Results of TPM Implementation

The research methodology is based on quantitative and qualitative analysis of TPM effect at MMA and Antioquia's eastern region. For doing this, it was done

a previous analysis for the local environment, with different companies that implement TPM in the studied region. A characterization of the reported income statements was made and finally a survey was done to the TPM leaders of the analyzed companies. Table 1 shows a list of such companies.

Table 1. Companies analyzed

Company	Company
Microplast	Cerveceria Union S.A.
Colderplast	Procter & Gamble Volombia Ltda.
New Stetic	Colceramica S.A. Planta Le Estrella
Industrias Vera	Vajillas Corona (Loceria Colombiana)
Industrias Ceno	Sumicol
Carton de Colombia	Colorquimica
Incolmos Yamaha	O-I Peldar
Industrias Almenticias Noel S.A.	Litografia Cadena
Industria de Almentos Zenu S.A.	RECO S.A.
Compania Nacional de Chocolates	UMO S.A.
Dulces de Colombia	Bonem S.A.
Colcafe	Alico S.A.
Sofasa S.A.	

From a survey made to a focus group, which were answered effectively by 16 of 28 requested companies, basic indicator information was obtained. From 16

companies that answered, 16 reported OEE data, 13 reported failure decrease and only 5 reported the throughput increase rate.

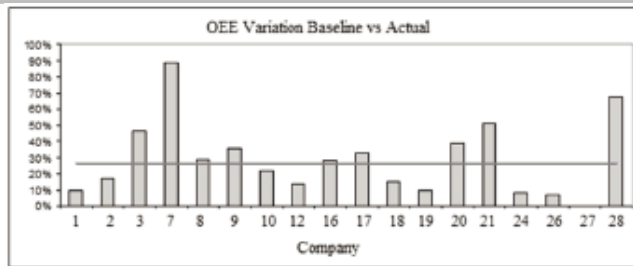


Figure 4. OEE variation Baseline vs. Actual

For OEE values in the studied companies, a difference is established between the baseline and actual value for this indicator. This difference can be notice in 4.

Table 2 shows a basic descriptive statistical analysis of the improvement in the OEE for the studied companies.

Failure decrease, typically improved by TPM implementation (it is part of 3Z's model, since zero failures is a fundamental TPM objective) is shown in fihure 5. 2 shows the descriptive statistical analysis for this figure.

Table 2. Descriptive statistics analysis of OEE Variation

Data/Variable	Value
N	18
Average	29%
Standard Deviation	23%
Maximum	89%
Minimum	0%

Table 3. Descriptive statistics analysis of Failure Variation

Data/Variabel	Value
N	15
Average	27%
Standard Deviation	27%
Maximum	92%
Minimum	5%

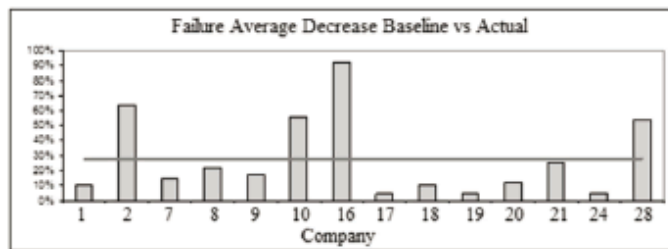


Figure 5. Failure average decrease, Baseline vs. Actual

Conclusion

As defined in this paper, Total Productive Manufacturing (TPM) is a structured equipment-centric continuous improvement process that strives to optimize production effectiveness by identifying and eliminating equipment and production efficiency losses throughout the production system life cycle through active team based participation of employees across all levels of the operational

hierarchy. Although TPM is historically equipment-focused, effective implementation offers a continuous improvement methodology to increase overall manufacturing productivity. TPM methodology provides enterprises with the tools required to explore, increase, document, and proliferate organizational learning.

TPM is itself an adaptive process, changing to support increasingly complex

environments. TPM is an enabling methodology when integrated with other continuous improvement programs such as Lean Manufacturing, Total Quality Management, or 6-Sigma. Although further research and experience is warranted, TPM provides opportunity as an effective tool to improve the performance of factory automation. TPM Maintenance Prevention activity pushes reliability and performance improvement opportunity from the factory floor to equipment and process design and construction. Successful implementation of TPM is not a simple task for organizations and many fail

to achieve their TPM goals or abandon TPM implementation altogether. This paper identifies many roadblocks to effective implementation as well as success criteria to overcome those roadblocks. TPM success requires strong and active support from management, clear organizational goals and objectives for TPM implementation, disciplined execution of the TPM methodology, an unwavering focus on elimination of equipment/process breakdown and quality loss, organization willingness and ability to learn and change, and committed focus on long-term objectives.

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