A COMPARATIVE REVIEW OF RELATIONSHIP BETWEEN SIX SIGMA, TPM AND RCM ON PERFORMANCE IN THE ORGANIZATIONS

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ABSTRACT

Over the past few decades, quality management has been recognized as giving the edge for competitiveness and long term profitability. The maintenance management is important because the benefits of quality management cannot be realized without the sustained performance of equipment affecting the product quality .This has lead to the development of maintenance strategies such as Total Productive Maintenance (TPM) and Reliability Centered Maintenance (RCM). This paper reviews in brief the theoretical aspects of TPM, RCM and Six Sigma which highlights the similarities, differences and potentialities of these approaches in manufacturing performances.

INTRODUCTION

Maintenance costs are a major part of the total operating costs of all manufacturing plants. Depending on specific industry, maintenance costs can represent between 20 and 55 percent of the cost of goods produced. For example, in food industries, average maintenance costs represent about 20 percent of the cost of goods produced, whereas maintenance costs for iron and steel, pulp and paper, and other heavy industries represent up to 60 percent of the total production cost. One of the most substantial is that maintenance expenses are planned and controlled. This is particularly significant. Maintenance costs account for between 15 to 40 per cent of the total cost of production in typical manufacturing. Pre-tax profit is typically 5 per cent. That means that any maintenance cost ignorance goes directly to pretax profit. Over the past decade it has been recognized that maintenance is not an expense rather its an investment.

In today's industrial huge losses and wastage occur in the manufacturing shop floor. This waste is due to operators, maintenance personal, process and non-availability of components in time etc. Other forms of waste includes idle machines, idle manpower, break down machine, rejected parts etc. are all examples of waste. The quality related waste are of significant importance as they matter the company in terms of time, material and the hard earned reputation of the company. There are also some other invisible wastes like operating the machines below the rated speed, break down of the machines and bottle necks in process.

Zero oriented concepts such as zero tolerance for waste, defects, break down and zero accidents are becoming a pre-requisite in the manufacturing and assembly industry. In this situation, a revolutionary concept of TPM, RCM and Six Sigma has been adopted in many industries across the world to address the above said problems.

Six Sigma, Reliability Cenered Maintenance (RCM) and Total Productive Maintenance (TPM) have gained considerable acceptance in manufacturing industries. These improvement drives are adapted for raising performance standards of Industries in various sectors. Many aspects in Six Sigma, RCM and TPM are considered complementary to each other and thereby being implemented simultaneously by many companies to achieve synergy. This

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paper aims to provide the comparative contributions of three drives to improve business performance.

MAINTENANCE METHODS

The following types of maintenance management method are generally employed by various Industries:

1. *Run-to-Failure Maintenance Management or Breakdown maintenance:*

A plant using run-to-failure management does not spend any money on maintenance until a machine or system fails to operate. In run-to-failure maintenance management when a machine breaks down, fix it and "If it ain't broke, don't fix it" .Run-to-failure is a reactive management technique that waits for machine or equipment failure before any maintenance action is taken; however, it is actually a "no maintenance" approach of management. It is also the most expensive method of maintenance management. In this type of management, however, machines and other plant equipment are not rebuilt, nor are any major repairs made until the equipment fails to operate. The major expenses associated with this type of maintenance management are high spare parts inventory cost, high overtime labour cost, high machine downtime and low production availability. The result of this reactive type of maintenance management is higher maintenance cost and lower availability of process machinery.

2. Preventive maintenance (1951):

It is a daily maintenance (cleaning, inspection, oiling and re-tightening), design to retain the healthy condition of equipment and prevent failure through the prevention of deterioration, periodic inspection or equipment condition diagnosis, to measure deterioration. It is further divided into periodic maintenance and predictive maintenance. Just like human life is extended by preventive medicine, the equipment service life can be prolonged by doing preventive maintenance.

2a. Periodic maintenance (Time based maintenance - TBM):

Time based maintenance consists of periodically inspecting, servicing and cleaning equipment and replacing parts to prevent sudden failure and process problems.

2b. Predictive maintenance:

This is a method in which the service life of important part is predicted based on inspection or diagnosis, in order to use the parts to the limit of their service life. Compared to periodic maintenance, predictive maintenance is condition-based maintenance. It manages trend values, by measuring and analyzing data about deterioration and employs a surveillance system, designed to monitor conditions through an on-line system.

3. Corrective maintenance (1957):

It improves equipment and its components so that preventive maintenance can be carried out reliably. Equipment with design weakness must be redesigned to improve reliability or improving maintainability. This happens at the equipment user level. E.g. Installing a guard, to prevent the burrs falling in the coolant tank.

4. Maintenance prevention (1960):

This program indicates the design of new equipment. Weakness of current machines is sufficiently studied (on site information leading to failure prevention, easier maintenance and prevents of defects, safety and ease of manufacturing). The observations and the study made are shared with the equipment manufacturer and necessary changes are made in the design of new machine.

What is Total Productive Maintenance (TPM)?

Total Productive Maintenance (TPM) is a maintenance program, which involves a newly defined concept for maintaining plants and equipment. The goal of the TPM program is to

markedly increase production while, at the same time, increasing employee morale and job satisfaction.

Total Productive Maintenance (TPM) describes a synergistic relationship among all organizational functions, but particularly between production and maintenance, for continuous improvement of product quality, operational efficiency, capacity assurance and safety. The essence of TPM is that production equipment operators share the preventive maintenance efforts, assist mechanics with repairs when equipment is down, and, together, they work on equipment and process improvements in team activities.

Total Productive Maintenance (TPM) brings maintenance into focus as a necessary and vitally important part of the business. It is no longer regarded as a non-profit activity. Down time for maintenance is scheduled as a part of the manufacturing day and, in some cases, as an integral part of the manufacturing process. The goal is to hold emergency and unscheduled maintenance to a minimum.

The basic measure associated with Total Productive Maintenance (TPM) is the OEE. This OEE highlights the actual "Hidden capacity" in an organization. OEE is not an exclusive measure of how well the maintenance department works. The design and installation of equipment as well as how it is operated and maintained affect the OEE. It measures both efficiency (doing things right) and effectiveness (doing the right things) with the equipment. It incorporates three basic indicators of equipment performance and reliability (J Vanketesh). Thus OEE is a function of the three factors mentioned below.

1. Availability or uptime (downtime: planned and unplanned, tool change, tool service, job change etc.)

2. Performance efficiency (actual vs. design capacity)

3. Rate of quality output (Defects and rework)

Why TPM?

TPM was introduced to achieve the following objectives. The important ones are listed below.

• Avoid wastage in a quickly changing economic environment.
• Producing goods without reducing product quality.
• Reduce cost.
• Produce a low batch quantity at the earliest possible time.
• Goods send to the customers must be non-defective.

Difficulties faced in TPM implementation

One of the difficulties in implementing TPM as a methodology is that it takes a considerable number of years. The time taken depends on the size of the organization. There is no quick way for implementing TPM. This is contradictory to the traditional management improvement strategies. Following are the other difficulties faced in TPM implementation. (J Vanketesh)

• Typically people show strong resistance to change.
• Many people treat it just another “Program of the month” without paying any focus and also doubt about the effectiveness.
• Not sufficient resources (people, money, time, etc.) and assistance provided
• Insufficient understanding of the methodology and philosophy by middle management
• TPM is not a “quick fix” approach, it involve cultural change to the ways we do things
• Departmental barrier existing within Business Unit
• Many people considered TPM activities as additional work/threat.

What is RCM?

RCM was developed in the commercial aircraft industry for improved safety and reliability. RCM is a technique for developing a PM (preventive maintenance) program. It is based on the assumption that the inherent reliability of the equipment is a function of the design and the build quality. An effective PM program will ensure that the inherent reliability is realized. It cannot, however, improve the reliability of the system. This is only possible through redesign or modification. The application of PM is often misunderstood. It is easy to erroneously believe that the more an item is routinely maintained, the more reliable it will be. Often the opposite is the case, due to maintenance-induced failures.

RCM was designed to balance the costs and benefits, to obtain the most cost-effective PM program. To achieve this, the desired system performance standards have to be specified. PM will not prevent all failures, and therefore the potential consequences of each failure must be identified and the likelihood of failure must be known. PM tasks are chosen to address each failure by using a set of applicability and effectiveness criteria. When developing the PM program, it should, however, be realized that RCM will never be a substitute for poor design, inadequate build quality or bad maintenance practices.

It was first published by the US Department of Defense in 1978 (SAE International, 1999).The process of RCM is summarized as follows:

All intended functions of equipment is listed down, then the possible failure modes of each function. The causes of each failure mode are listed next, and last maintenance tasks are selected to prevent the cause from taking place (Moubray, 1997).

The original RCM model is called classical RCM. Classical RCM attempts to list down all functions, all failure modes, and all causes which can be a very lengthy process. Many RCM applications, however, utilize a streamlined version of RCM (SAE International, 1999). Streamlined models focus only on critical functions, critical modes of failure, and dominant causes. After determining all dominant failure causes, maintenance task selection logic is applied. For each cause, condition monitoring is applied if applicable. If not applicable then interval-based maintenance is applied which if not applicable either, then a redesign or run-to-failure strategy is selected depending on the tolerability of the failure (Wilmeth and Usrey, 2000).

An RCM analysis basically provides answers to the following seven questions.

1. What are the functions and associated performance standards of the equipment in its present operating context?
2. In what ways does it fail to fulfill its functions?
3. What is the cause of each functional failure?
4. What happens when each failure occurs?
5. In what way does each failure matter?
6. What can be done to prevent each failure?
7. What should be done if a suitable preventive task cannot be found?

MAIN STEPS OF AN RCM ANALYSIS

The RCM analysis may be carried out as a sequence of following activities or steps.

1. Study preparation
2. System selection and definition
3. Functional failure analysis (PPA)
4. Critical item selection
5. Data collection and analysis
6. FMECA
7. Selection of maintenance actions

8. Determination of maintenance intervals
9. Preventive maintenance comparison analysis
10. Treatment of non-critical items
11. Implementation
12. In-service data collection and updating

The main objective of RCM is to reduce the maintenance cost, by focusing on the most important functions of the system, and avoiding or removing maintenance actions that are not strictly necessary. If a maintenance program already exists, the result of an RCM analysis will often be to eliminate inefficient PM tasks.

What is Six Sigma?

Six sigma has become a popular approach in many organizations today to drive out variability and reduce waste in processes using powerful statistical tools and techniques. In statistical terms, six sigma means 3.4 defects per million opportunities (DPMO), where sigma is a term used to represent the variation about the average of a process.

Six Sigma is the rating that signifies "best in class", with only 3.4 defects per million units or operations. The primary use of Six Sigma in measuring zero defects has been in the manufacturing industry. Most Indian manufacturing firms operate on an average rate below four sigma level. Whatever the industry, most companies averaged a level of four sigma at the beginning of 1990.

Zero defects are an approach which stresses the fact that all errors are preventable. The concept identified mainly with Philip Crosby, is more than three decades old. The concept of possible near-perfection returned in the mid-1980s in the form of a technical document at Motorola called "Six sigma mechanical design tolerance". Six Sigma is a way to measure the probability that companies can manufacture or produce any given unit of a product (or service) with zero defects.

The Five Steps to Six Sigma

The Six Sigma methodology has a core process: Define-Measure-Analyze-Improve-Control (DMAIC) methodology. The five steps to Six Sigma along with the tools are shown in Fig. below:

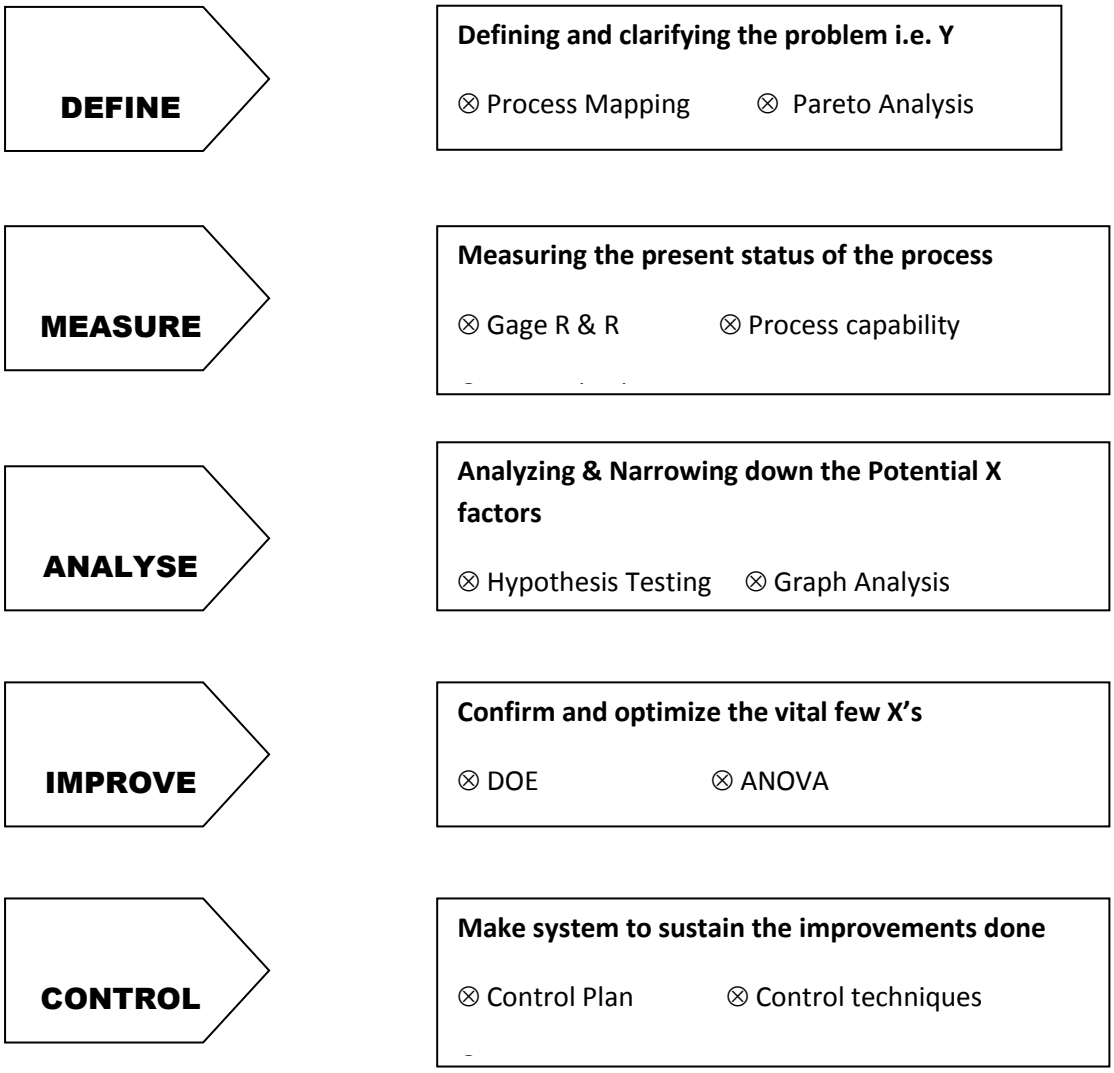

Fig. - Five Steps to Six Sigma

Similarities and differences between TPM, RCM and Six Sigma

The TPM, RCM and Six Sigma closely resemble each other. Many of the tools such as Pareto analysis, Fishbone diagram, Statistical process control etc. used in Six Sigma can be used in TPM.

Six Sigma was the strategy adopted primarily due to the prescriptive and methodological approach towards identifying proactively the elimination of the seven wastes by focusing on the process characteristics that are critical to both the internal and external customer. Deploying the fusion of these methodologies (Six Sigma & TPM) is a powerful antidote to achieve high OEE whilst contributing positively to reducing the causes of equipment/process variation and quality problem. However, this marriage is not without problems. Due to its prescriptive stance, Six Sigma is perceived by the workforce in general to be a project-oriented and technical discipline, the latter a major problem with the relatively lower educational background of the majority of the workforce. TPM on the other hand, focuses more on continual improvement in the overall business-manufacturing process. However, despite being at odds in some instances, the synergies gained outweigh the pains. The

DEMAIC approach used to implement Six Sigma can be applied to achieve the above said objectives of TPM. Table 1 highlights that Six Sigma and TPM are not mutually exclusive, but are mutually supportive in that they complement each other's shortcomings: Six Sigma's apparent lack of people orientation and TPM's over-indulgence to people oriented team-based continual improvement efforts.

TABLE I: SIX SIGMA AND TPM: MUTUALLY SUPPORTIVE

SIX SIGMA	Design	Measure	Analyze	Improve	Control
TPM	Identify equipment performance	Measure it	Analyze the losses	Improve it	Develop maintenance schedule to control

Following are the similarities the differences between Six Sigma, TPM and RCM are summarized below.

Category	Six Sigma	TPM	RCM
Object	Quality (Output and effects)	Equipment (Input and cause)	Equipment (Input and cause)
Means of attaining goal	Various Statistical tools	Employees participation and it is hardware oriented	Failure modes effects and criticality analysis
Target	Quality for products and zero defects PPM	Elimination of losses and wastes.	Elimination of losses and wastes.
Origin	USA	Japan	USA
Period	1980	1988	1978
Implementation time	Short	High(3-5years)	Medium(2 years)
Scope of application	Enterprise Wide	Manufacturing Wide	Manufacturing Wide
Participation	Normally Everyone participate	Everyone participate	Normally Everyone participate

TPM was developed for the manufacturing sector, while RCM was originally developed in the aircraft industry; both are now widely used in various industrial sectors. TPM focuses on integrating operators within maintenance work and on continuous and systematic improvement in order to maximize overall equipment effectiveness. RCM can be described as a systematic approach for identifying effective and efficient preventive maintenance tasks, by means of function and risk analysis.

Benefits of TPM

TPM has numerous benefits. One of the most substantial is that maintenance expenses are planned and controlled. This is particularly significant. Maintenance costs account for

between 15 to 40 per cent of the total cost of production in typical manufacturing. Pre-tax profit is typically 5 per cent. This means that any maintenance cost avoidance goes directly to pre-tax profit.

Another very concrete benefit is the reduction of the maintenance force. By turning all of the preventative maintenance activities over to the production force, the maintenance personnel who were previously doing the preventative work are not needed. After implementing TPM, General Motors Canada was able to reduce its maintenance force from 75 to 52, a 31 per cent drop.

There are a variety of other benefits to TPM, although they are less measurable.

- As employee involvement increases, employee relations improve. Operators are now recognized as thinking contributors to the company.
- As the quality of the product improves, so will customer satisfaction. Customers expect a consistent reliable product and TPM can help to achieve that.
- As operators become more familiar with the tools and techniques used in the problem solving process, the rate at which problems are resolved will increase.
- As equipment becomes more reliable, and the process more repeatable, scheduling the flow of work through the process becomes easier. The need for safety stock and time buffers decreases. Product flows through the system faster; resulting in fewer dollars tied up in inventory, as well as improved lead times that can result in increased market share.

Conclusion

Productivity plays a crucial role in boosting the growth of the organization and helps them to survive in a competitive world. Nowadays, besides measuring the productivity that enables the managers to know the current situation of their company, there are some tools and techniques that help managers to improve the productivity value. Among them, this study reviews the TQM and TPM and emphasizes that how these mentioned productivity tools can influence the productivity based on managerial viewpoint. This paper highlight as to how Six Sigma, RCM and TPM impact on the productivity Six Sigma, TQM influences the effectiveness through the improving the outcome by increased customer satisfaction and also increasing the efficiency by increasing the quality of output. On the other hand, TPM, RCM by improving the performance of equipment and also increasing the involvement of the employees and improves the job satisfaction. But if implemented together they have much similarity and can contribute much more towards the improvement of the performance of the organizations. The implementation of these will imply a significant cost and it may take several years before the benefits from these strategies out weights the cost.

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