World Journal of Engineering Research and Technology
WJERT
www.wjert.org
SJIF Impact Factor: 5.218

TOTAL PRODUCTIVE MAINTENANCE-AN IMPORTANT STRATEGY OF MAINTENANCE MANAGEMENT

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Article Received on 27/04/2018 **Article Revised on 18/05/2018** **Article Accepted on 08/06/2018**

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ABSTRACT

The aim of this article is to present the systematic literature review on TPM methodology. The various concepts related to this approach, case studies performed in different organizations and surveys performed by different researchers have been discussed. Moreover, overall equipment efficiency has been related to TPM concept as it is useful for improving the equipment performance. Findings suggest that TPM has proven to a effective maintenance strategy for carrying out continuous improvement in manufacturing system processes. This will be useful for researchers and academicians to know the significance of maintenance activities towards performance improvement.

KEYWORDS: Total Productive Maintenance, overall equipment efficiency, and performance improvement.

1. INTRODUCTION

In today's industrial scenario huge losses/wastage occur in the manufacturing shop floor. This waste is due to operators, maintenance personal, process, tooling problems 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 other invisible wastes like operating the machines below the rated speed, start up loss, 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 Total Productive Maintenance (TPM) has been adopted in many industries across the world to address the above said problem (Singh et al., 2013). Low productivity, downtime, and poor machine performance is often linked to inadequate plant maintenance, which in turn can lead to reduced production levels, increasing costs, lost market opportunities, and lower profits (Jonsson 2000). Maintenance has now become a strategic tool to increase competitiveness rather than simply an overhead expense that must be controlled (Waeyenbergh and Pintelon, 2007). Investment in maintenance, one of the basic functions of a firm, returns improved quality, safety, dependability, flexibility and lead times (Teresko, 1992).

The rapidly changing global marketplace calls for affecting improvements in a company's performance by focusing on cost cutting, increasing productivity levels, quality and guaranteeing deliveries in order to satisfy customers (Raouf, 1994). Companies are facing continuous pressures from consumers demanding better value for the same price, suppliers wanting better prices for their services, governments enforcing stricter regulations, and shareholders/parent companies requiring higher returns on investments (McCarthy and Rich, 2004). These challenges are forcing the manufacturing organizations globally to foster high reliability, availability and maintainability in the manufacturing systems by implementation of various strategic and proactive market driven strategies to remain competitive in a highly dynamic environment(Ahuja et al., 2006).. This article attempts to find useful contributions in the field of Total Productive Maintenance and presents the literature systematically.

2. LITERATURE REVIEW

This section describes literature on conceptual framework, case studies and surveys performed by different researchers in different industries to ascertain the contribution of different TPM practices towards performance improvement.

2.1 Literature related to conceptual framework

Maggard et al. (1989) defines TPM as an innovative, nontraditional approach to plant maintenance that is complementary to total quality management (TQM), just-in-time manufacturing (JIT), total employee involvement, continuous performance improvement, and other world-class manufacturing strategies. Nakajima (1988) explained that TPM is productive maintenance carried out by all employees through small group activities. TPM in this definition covers three areas: equipment, people, and the workplace. One of the main

aims of TPM is to increase productivity of plant and equipment in such a way as to achieve maximum productivity with only a modest investment in maintenance. Willmott (1994) portraits TPM as a relatively new and practical application of Total Quality Management (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 realise skilled trades to concentrate on problem diagnostic and equipment improvement projects. TPM has been depicted as a manufacturing strategy that is comprised of five steps (Shirose, 1992; Suzuki, 1992):

- Step 1: maximising equipment effectiveness through the optimisation of equipment availability, performance, efficiency and product quality
- Step 2: establishing a maintenance strategy (classical preventive maintenance) for the entire life cycle of the equipment
- Step 3: covering departments such as the planning, user and maintenance departments
- Step 4: involving all staff members from top management to shop floor workers
- Step 5: promoting improved maintenance through small-group autonomous activities.

TPM provides a comprehensive, life-cycle approach to equipment management that minimises equipment failures, production defects, and accidents. It involves everyone in the organisation, from top-level management to production mechanics, and production support groups to outside suppliers (Ahuja and Khamba, 2008a). TPM is not a maintenance specific policy; it is a culture, a philosophy and a new attitude towards maintenance. TPM is a system (culture) that takes advantage of the abilities and skills of all individuals in an organisation. TPM initiatives are targeted to enhance the competitiveness of organisations and encompass a powerful structured approach to change the mind-set of employees thereby making a visible change in the work culture of an organization (Heston, 2006). TPM implementation in an organisation can ensure higher productivity, better quality, fewer breakdowns, lower costs and reliable deliveries, motivating working environments, enhanced safety and improved morale of the employees (Tripathy, 2005).

2.2 Literature related to case studies

Bamber et al. (1999) outlines research carried out by the Aeronautical, Mechanical and Manufacturing Engineering Department at Salford University aimed at discovering the factors affecting the successful implementation of TPM. This research has led to the development of a generic model indicating factors affecting the successful implementation of

TPM. The validity of the generic model has been tested in a UK manufacturing small- to medium-size enterprise (SME) and the case study research findings further triangulated through a review of documented case study evidence. This research has also led to the development of recommendations to improve the TPM development and implementation program of the case study organisation.

Cooke (2000) reported the finding of a study of the production and maintenance function of four processing/manufacturing companies. It intends to highlight the difficulties that these companies have been faced with in their attempt to implement TPM initiatives between the production and maintenance departments in order to improve organisational efficiency. The paper concluded that implementing TPM is by no means an easy task, which is heavily burdened by political, financial, departmental and inter-occupational barriers.

Tsarouhas (2007) aimed to develop a methodology for increasing production rate, improving the quality of the products and providing a healthier and safer work environment in the food industry. The methodology is based on analysing the reliability data of an automatic production line. It is divided into four steps, whose aims are to bring forth improved maintenance policies of the mechanical equipment. Also, the continuous and thorough inspection of the production process is achieved through measurements of the overall equipment effectiveness The goal of development methodology is to bring competitive advantages, such as: increasing the productivity; improving the quality of the products; and reducing the cost production of the line.

Ahuja and Kumar (2009) carried out their study at a precision tube mill that has successfully implemented TPM and has reaped significant benefits as a result of TPM implementation, to study the TPM implementation issues and achievements realised as a result of strategic TPM implementation. The study revealed that strategic TPM initiatives can significantly contribute towards the improvement of manufacturing performance in the organisation, leading to the realisation of core competencies for meeting global challenges.

Wakjira and Singh (2012) evaluated the contributions of total productive maintenance (TPM) initiatives towards improving manufacturing performance in Ethiopian malt manufacturing industry. The TPM implementation dimensions and manufacturing performance improvements have been evaluated and validated by employing overall equipment

effectiveness (OEE) in boiler plant. Results of investigation demonstrated the significant 5% improvement in OEE.

Amin et al. (2013) developed the technology by incorporating concepts of lean manufacturing, total productive maintenance (TPM) and low cost automation techniques to increase their competitiveness. Proper understanding of process requirements and tool designing in accordance with process requirement are the two major factors which help to down size the machine and to identify unnecessary parts. By applying these techniques on BC-21 machine, Munjal Showa is able to reduce the space used by 68 percent, break downs by 93 percent, cycle time by 48 percent and an increase in productivity by 52 percent.

Bartz et al. (2014) showed the implementation of a maintenance management model based on total productive maintenance (TPM) in a production line of a metallurgical company, with high-precision equipment requiring effective maintenance to maintain the quality of the production process. It has been observed that after the implementation of TPM, and the results of these performance indicators were collected again after the application of the model. Thus, it is concluded that the TPM assists in improving industrial performance and competitiveness of the production line studied.

2.3 Literature related to Surveys

Davis (1997) outlined various reasons for TPM failure within UK manufacturing organizations including lack of commitment of top management, deployment of inexperienced consultants, lack of structure, failure to implement change on the shop floor, lack of education and training for employees, lack of employee involvement, and poor structure to support the TPM initiatives.

Jonsson (1997) emphasized on improvement of the maintenance management components in the Swedish manufacturing organizations. He has described five linked components of maintenance management as: strategy, human aspects, support mechanisms, tools and techniques, and organization and advocates for formulating clear maintenance strategies that are linked to manufacturing and corporate strategies.

McKone et al. (2001) investigated the relationship between TPM and manufacturing performance through structural equation modelling. TPM has a positive and significant relationship with low cost (as measured by higher inventory turns), high levels of quality (as

measured by higher levels of conformance to specifications), and strong delivery performance (as measured by higher percentage of on-time deliveries and by faster speeds of delivery). The study derives a positive relationship between TPM and MP. The results show that there is a significant and positive indirect relationship between TPM and MP through JIT practices.

Cholasuke et al. (2004) examined the current status of maintenance programs in the UK manufacturing organizations through a pilot survey of 18 UK manufacturing respondents. A radar diagram was generated showing the current status of maintenance management in the UK. The chart shows that only one-third of the organisations seriously consider good maintenance management practices and realise the full benefits. Any preparation of adequate reports on performance and cost is visibly lagging behind. The paper also explored the opportunities for improving maintenance management in UK manufacturing organisations. The crucial involvement of the management is fundamental to give the guidance and direction to the maintenance function.

Ahuja and Khamba (2008b) depicted the results of the detailed survey related to maintenance practices adopted in 85 Indian manufacturing industries. The objective of the survey is to assess the status of prevailing maintenance-related capabilities of Indian manufacturing organisations and ascertain the exploits of manufacturing entrepreneurs across the country with various maintenance practices. The survey explores the present status of the capabilities of the manufacturing industry with regard to the following attributes: adequacies of maintenance organisations and structures in the organisation, and the effectiveness and extent of various maintenance practices such as PM, PdM, CMMS and TPM. The study revealed that Indian entrepreneurs have been reasonably successful in improving the maintenance performance in the organisations, and the maintenance improvement initiatives have significantly contributed towards enhancing the overall manufacturing performance.

Ahuja and Khamba (2009) suggested an indigenous TPM methodology (ITPMM) to guide TPM implementation programme in typical Indian manufacturing environment. ITPMM is aimed at facilitating the successful TPM implementation by providing activities and supporting documentation needed for TPM implementing process. ITPMM can help users to avoid common problems and pitfalls during TPM implementation. ITPMM proposed has been categorised into three phases namely: introduction phase, TPM initiatives implementation phase and standardisation phase. ITPMM provides more capability of

customisation. It can be modified to meet needs of the enterprises attempting to implement TPM. ITPMM supports the user to implement TPM in any time frame considered beneficial to the enterprise.

Ahuja and Singh (2013) performed a survey in 36 manufacturing industries of Northern India to assess the importance of TPM initiatives including Maintenance Organisation Issues, Traditional Maintenance Issues, Startup TPM implementation Issues, and Core TPM Pillar Issues towards manufacturing performance improvement. The study revealed that TPM implementation is not an overnight programme and it requires a reasonable period of holistic interventions, varying between three and five years, to realise the true potential of TPM.

3. Literature suggesting OEE as a measure of TPM

Starting in the 1980s, and after the introduction of total productive maintenance (TPM), the maintenance function gained recognition as a main contributor to companies' overall equipment effectiveness (OEE). As one of the main measure of overall utilization of facilities (Hansen, 2001), OEE is widely used in TPM and lean manufacturing. OEE is a quantification of how efficiently and effectively a company performs compared to its designed capacity, during its scheduled run time Total Productive Maintenance (TPM) is based on three interrelated concepts:

- Maximizing equipment effectiveness;
- Autonomous maintenance by operators; and
- Small group activities.

Within this context, OEE (overall equipment effectiveness) can be considered to combine the operation, maintenance and management of manufacturing equipment and resources (Dal et al., 2000). Accordingly, OEE attempts to identify production losses and other indirect and "hidden" costs, which contributes with a large proportion of the total cost of production. These losses are formulated as a function of a number of mutually exclusive components, namely: availability (A), performance (P) and quality (Q). In essence, OEE is the result achieved by multiplying these three factors together as shown below:

$$OEE=A \times P \times Q \text{ (Garza-Reyes et al., 2010)}$$

- A= Availability
- P=Performance Efficiency
- Q=Quality Rate

$$\text{Availability} = \frac{\text{Loading time} - \text{Down time}}{\text{Loading time}}$$

Performance efficiency (PE) = Operating speed rate * Net operating rate

$$\text{Operating speed rate} = \frac{\text{Theoretical cycle time}}{\text{Actual cycle time}}$$

$$\text{Net operating rate} = \frac{(\text{Processed amount})^* (\text{Actual cycle time})}{\text{Operating time}}$$

$$\text{Quality rate (Q)} = \frac{\text{Processed amount} - \text{Defect amount}}{\text{Processed Amount}}$$

OEE focuses on six major losses, namely, breakdown, setup adjustments, reduced speed, minor stoppages, rework and yield losses. All these losses lie under the umbrella of availability, performance and quality (Nayak et al., 2013). Saleem et al. (2017) formulated a benchmark to increase the tyre curing press production rate while minimizing tyre curing press downtime and maintenance cost with the help of a maintenance management technique based on overall equipment effectiveness (OEE).

CONCLUSION

From the literature survey, it is concluded that there is vast literature available on TPM approach which will give the broad view of different maintenance practices over a period of time. TPM has proven to be a advanced maintenance strategy for reducing the maintenance of manufacturing equipments though systematic procedure. Success stories suggest that it requires time to fully implement the maintenance system in the organization. The overall equipment effectiveness can be significantly improved by implementing TPM in manufacturing organization. Many benefits can be occurred after successful implementation of TPM approach including increased productivity, improved quality, cost reduction and improved safety aspects of the organizations. Process industry is also benefited by this approach as this approach is capable of flow of product making the continuous flow of the product.

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