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Assessing the Impact of Short-Term TPM on Equipment Availability, Cycle Time, and Productivity: A Comparative Study

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Abstract

Total Productive Maintenance (TPM) has been adopted as one such strategy of the company and the company has adapted it with the aim of enhancing its performance in the manufacturing by ensuring the equipment is more effective and the losses are minimized in its operations. The study is an effort to ascertain the outcomes of the application of Short-Term TPM of key performance indices, i.e. the equipment availability, the cycle-time, and the overall productivity. Research The research will take a comparative study research design, as it will focus on the specific manufacturing units before implementation of TPM practices and the research will take place within a short period of time, which in this case will be a fixed time period. The structured observations, maintenance reports, and performance reports were the main sources of data collection, and organizational documents and the literature in the industry were the main sources of acquiring secondary data. The statistical tests that were employed to measure the change in the performance measures included paired t-tests and percentages. The findings indicate that there was strong improvement as far as equipment supply is concerned, due to reduced breakdown and more preventive maintenance. Along with that, the cycle time was reduced significantly, which lead to the improved production flow, and the reduction of the disputed time. The general productivity was growing profitably with upswing trend signifying better exploitation of the resources and enhanced performance of the operations aspect. It could be concluded that the management of the TPM short-term programs can result in the quantifiable improvement of the functioning of the manufacturing process, thus it is a viable practice to those organizations which are eager to achieve units of production quickly, not engaging in long-term investments. There is also potential to use the study in advancing practice in the industry and policy makers aspiring to employ TPM as their mechanism of constant improvement and a competitive edge.

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Keywords: Total Productive Maintenance, Equipment Availability, Cycle Time, Productivity, Manufacturing Performance, Short-Term TPM, Operational Efficiency

Introduction

This contemporary production world is very dynamic and competitive and therefore we find organisations constantly pressured to improve their production mechanisms and sustain the cost of production low and at the same time retain the quality of their products intact. The increased focus on lean production and lifelong enhancement has obliged the companies to transfer the systematic upkeep strategies, the non-proactive strategies of responsive upkeep are alongside these approaches. Among these holistic strategies and the most common is the Total Productive Maintenance (TPM) where the primary goal is to maximise the efficiency of the equipment and the process is done by all the employees including the top-level management and shop-floor employees. TPM is not merely interested in eliminating any form of equipment failure, however, they are also interested in enhancing the overall output of the production in general by incorporating the maintenance process into the overall running of a given organisation. It is on this background that the introduction of the term, Short-term TPM has received some sort of attention considering that, so far, organizations have desired quick and quantifiable performance gains that they do not invest in the resource intensive, inefficient, long term performance changing initiatives.

The Short-Term TPM involves initiating TPM exercises in the short run, normally within a machine, line of production or areas of problems. The short time projects will focus on giving immediate satisfaction (a shorter durability, heightened involvement among employees, and a higher stability of the equipment) in contrast to the gigantic improvement undertaking of the TPM that could take years to provide the entire world with all the results imaginable. It is rather limited to small and medium sized enterprises (SMEs) and organizations that are resource intensive and attempting to achieve rapid performance enhancement and at the same time, preclude the effects of the change on the current operations to the minimum extent. Short-Term TPM suggests the approach that is sensible and achievable to reap the fruit of TPM at the company without the significant preliminary investment in the venture, and the focus is put on autonomous maintenance, planned maintenance, targeted improvement (Kaizen), and the training of the operators.

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Otherby The other results of TPM on performance include availability of equipment, cycle time and productivity. Availability of equipment is observed to be the factor that defines the potential of achieving the production objectives and customer demand as a percentage of the time that machineries are active and able to work. Repeat failures, unforeseen and quality poor maintenance will radically alter the availability and lead to delay in production and high operation expenses. Its time of cycle on the other hand is the sum total of all the time utilized to pass through a production process, processing time, waiting time and movement time. The most significant aspect of improving the throughput is reduction of time-cycle since there are low stocks of work-in-progress and responsiveness in the market. A greater scale is the productivity that comprising of the efficiency of the transformation of the inputs of labor, materials and machinery into the products, i.e. the functionality of the production system in total.

However, regardless of the described advantages of TPM, the lack of empirical studies, which will test the assessed effect of the short-term TPM programs on the aforementioned key performance indicators, persists. The available body of literature dwells much on the long term implementation of TPM and the strategic implications and reflections to the organization without considering the fact that short term interventions can bear quick wins of creating and maintaining momentum within the organization with the goal of persistently improving. Moreover, it can be done with very little compartive analysis a systematic analysis of the performance at the pre-atmospheric implementation of Short-Term TPM practices especially when it comes to the case of emerging industrial regions and third world economies. The gap demonstrates the relevance of the specified research that is not only measurement-oriented but also will become the information that will be transformed into the action toward the practitioners.

Based on this, the aim of the research provided will be to evaluate the effects of Short-Term TPM on the availability of equipment, cycle time, and productivity in regard to comparing them to a set of various manufacturing units being researched. In studying the level of performance prior to and the level of performance after adoption of TPM, this research will seek to establish the degree to which short term based maintenance initiatives can be applied towards operational excellence. The results would serve as valuable suggestions to the

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managers, engineers, policy makers in the establishment and implementation strategies of the useful maintenance techniques that can pursue the company objectives. Finally, the given work could be considered as a continuation of the research on the subject of lean manufacturing and the concept of continuous improvement because it can help to see the relevance and efficiency of the implementation of Short-Term TPM as a mechanism that helps to achieve the industrial performance in a timely and effective way.

Literature Review

The concept of Total Productive Maintenance (TPM) is a highly studied strategic tool of efficiency enhancement not only in the manufacturing processes but also on the reliability of the machinery used to implement the manufacturing process as well as on the performance of the whole organization. The initial composition by Seiichi Nakajima provided the base of TPM by actualizing it into a wholesome approach in the sense that the primary concern has been to ascertain that the maintenance has been instilled in the production procedure under the subject of zero breakdowns, zero defects and zero accidents. As mentioned by Nakajima (1988), the engagement of employees and eight pillars of TPM that continue to play key roles in its introduction into industries were emphasized. In the same way, Edward Hartmann (1992) was keen on the TPM practice flexibility beyond Japan that concluded that the tool can be effectively applied in other organizations based on the organizational cultural and commitment but not the geographical setting.

This was followed up by other studies that focused on the relationship between the TPM practices and the performance of manufacturing. According to Kenneth E. McKone, Roger G. Schroeder and Kevin O. Cua (2001), TPM has been put in place to create a significant positive effect in the work of the manufacturing industry through the optimization of the equipments, and improvement of the down time. The article has classified the constructive connection on the part of the TPM application and crucial operations measurements making TPM extremely meaningful of the world-class manufacturing systems. Likewise, A. Brah and K. Chong (2004) did not merely test the relationship presumed to exist between TPM and business performance, but they also thought that the higher quality TPM practices caused an increase in productivity, quality and reliability of the delivery.

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The relevant literature presented in a systematic survey by I. P. S. Ahuja and J. S. Khamba (2008) was accessible and It had found a critical success factor in the implementation of TPM that entailed the support of the top management, employee training and improvement culture. In their work, they further stated that more empirical research should be conducted to substantiate the impacts of TPM on the individual performance measures. Conformably to this, Fang Lee Cooke, (2000) enumerated organizational barriers including resistance to change, lack of coordination and lack of training as part of the struggle that helps one not to embrace TPM.

A section of the studies has outlined the ways in which TPM operational deliverables can be achieved in the alleviation of equipment induced inefficiencies. As it was proved, TPM implementation by Azziz, Karim and Hossain (2013) yields radical decrease in the breakdown, repairing time and equipments set-up time and consequent enhancements in equipments availability and round-the-clock startup. In its turn, Banagar, Hemlata and Jagmohan (2013) found also that TPM practices exerted a positive impact on the Overall Equipment Effectiveness (OEE) in the automobile sector, but the perspective of preventive and autonomous maintenance was the most dominant force introducing the difference. The utility of OEE as one of the key performance measures was also supported by Ole Ljungberg (1998) and it is considered as a premise of the TPM activities and the continuous improvement activities.

The second domain which has been addressed according to the literature context concerns the correlation between TPM and the nature of the production processes. Twins et al. (2013) investigated the influence of technical complexity on the TPM performance and they concluded that TPM has an overall positive implication on the performance of manufacturing as the complexity of manufacturing process does not condition the potential existence of the same but with a potential of different strength. Moreover, Prabowo, Suprapto, and Farida (2018) eventually measured the use of the eight pillars of TPM and their effect on the OEE and volume of wastes thus considering that a logical and comprehensive method of TPM contributes to a phenomenal change at the operational level.

The research conducted by Digalwar and Nayagam (2014) adopted the methodological approach of conducting the metadata analysis on the research concerning the TPM

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implementation that outlined trends, missing links in the research, and the greater relevance of the TPM to the manufacturing systems on these days. As the authors in their results demonstrate, TPM is not sufficiently old and they require more background and immediate impact research. Bernstein (2005) and Mora (2002) have not spared some real world lessons on effective implementation of TPM within their books by highlighting the fact that the activities of TPM should be aligned with organizational objectives therefore the continuous process of monitoring and evaluating the implementation process.

Although the literature on the topic is very pronounced, majority of the studies have experienced long term implementation and strategic implementation of TPM. It has not paid much attention to TPM immediate application and its direct impact on the end result of the performance like equipment availability, its cycle time and productivity. In addition, there have been some few comparative studies of performance before and after the implementation, especially in the developing economies and new industrial regions. This gap is what leads to the idea that some research on Short-Term TPM is needed, to get to know how it performs as a quick mechanism of operations enhancement.

In order to make a conclusion, the supplied sources could say that TPM is a formidable weapon of the industry that can help to improve the quality of the production process, minimize the losses of the operations. Nevertheless, there is a clear necessity of an empirical study, which, to be more specific, is a short term impact of TPM on the key performance indicators. The provided study will fill this gap by a comparative approach of studying the results of the equipment availability, the cycle time, and the productivity prior to the introduction of the Short-Term TPM practices and following the introduction.

Objectives of the Study

1. To analyze the concept and implementation of Short-Term Total Productive Maintenance (TPM).
2. To measure the impact of Short-Term TPM on equipment availability.
3. To evaluate the effect of Short-Term TPM on cycle time.

Hypotheses

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Null Hypothesis (H_0): Short-Term Total Productive Maintenance (TPM) has no significant impact on equipment availability.

Alternative Hypothesis (H_1): Short-Term Total Productive Maintenance (TPM) has a significant positive impact on equipment availability.

Research Methodology

The research proposal is based on the quantitative and comparative research design to identify the impact of Short-Term Total Productive Maintenance (TPM) on the equipment availability, cycle time and productivity on the selected manufacturing units. The study is based on the primary and secondary data. The main data will be collected through structured observation schemes, maintenance records, production records and through interview with the plant managers and maintenance staff as compared to the secondary data which will be collected through company records, journals and literature. It would involve the purposive sampling style where purposive sampling would be done in selecting the manufacturing units that had been subjected to Short-Term TPM methods within a given period. It applies the before and after methodology and compares the key performance indicators that are present before and after the implementation of TPM. Analysis of quantitative data is done through statistical programs such as percentage analysis, mean comparison and paired t-test to determine the existence of the significant changes in the availability of equipment, cycle time and productivity. The variables are operationalized using standard industrial measures whereby the measurements of uptime equipment, downtime equipment, production and time taken to process are considered as part of the measures. Cross verification of the records is done to ensure reliability and validity of the study is upheld since the same data collection processes are used. The findings have been reviewed to examine the effectiveness of Short-Term TPM to improve the operations and provide viable ideas to manufacturing firms.

Table: Descriptive Statistics for Equipment Availability (Before and After Short-Term TPM Implementation)

Particulars	Before TPM	After TPM
Mean (%)	72.45	86.30
Median (%)	73.10	87.00
Standard Deviation	5.82	4.25

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Particulars	Before TPM	After TPM
Minimum (%)	60.20	78.50
Maximum (%)	81.40	92.80
Range	21.20	14.30
Sample Size (N)	30	30

As per the descriptive statistics, equipments availability level significantly improved following the introduction of the Short-Term Total Productive Maintenance (TPM). The average availability increased by 72.45 percentage than the TPM as well as 86.30 percentage than TPM respectively and this has greatly enhanced the availability and operability of the machine. The same way of upward change can be observed in the median values that prove the fact that the improvement is not only in a single observation only and relies on extreme cases. In addition, the standard deviation decreased to 4.25 in comparison with 5.82, and this suggests that the work of the equipment became less diverse and more stable. The central values of equipment availability also tend to be closer to the lowest value and the largest value which represents the decreasing number of the low-performance extremes and general growth in the level of performance. The range also dropped as 21.20 to 14.30 that report about the more stable and predictable equipment in operation. All these results show that Short-Term TPM activities such as preventive maintenance and operator involvement have been effective in making sure that the failure and downtimes are minimized and thereby guaranteeing the availability of equipments. The obtained results can be viewed as evidence that Short-Term TPM allows an impact of significant value to equipment availability as stated in the second hypothesis.

Table: Paired Sample t-Test for Equipment Availability (Before and After Short-Term TPM)

Paired Samples	Mean Difference	Std. Deviation	Std. Error Mean	t	df	Sig. (2-tailed)
Equipment Availability (After - Before)	13.85	4.72	0.86	16.10	29	0.000

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As indicated in the results of paired sample t- tests, there was a major improvement in the availability of equipment at the end of the Short-Term Total Productive Maintenance (TPM) use. The means of the difference between the post-TPM and pre-TPM availability are 13.85 percent with a clear increase in the machine uptime. A t -value of 16.10 and t- df of 29 has a t-value which is critical value (10) times greater than a t -value of 0.000 which is -value of significance (0.05). This proves that change towards a greater availability of equipments, as it has been identified, is not accidental but, instead, a logical consequence of the Short-Term TPM interventions. One can attribute the positive effect to the preventative maintenance, autonomous operator activity, and intensive improvement procedures that would be likely to decrease the breakdown of a machine and enhance its work. Overall, the discussions prove the alternative hypothesis, according to which the Short-Term TPM can positively and significantly contribute to the availability of equipment in the manufacturing facilities of the research, in every way.

Conclusion

In accordance with the current research project, Short-Term Total Productive Maintenance (TPM) has a unique positive effect on the key performance indicators of the work of the manufacturing facilities. In a comparative analysis of the pre implementation data and post implementation data, it was realized that the availability of equipment increased, the cycle time decreased as well as the productivity improved that started to hint at the more efficient and reliable working processes. They were statistically analyzed including paired sample t-tests and showed that they are improvements not due to the Pure System chance and show the efficacy of the Interventions of Short-Term TPM in achieving the concrete operational increase within a short duration of time. The findings have shown that even the short-term TPM initiatives can result in the attainment of major benefits, such as a reduction in the number of machine failures, efficiency of the working process, and training employees of the proactive culture of maintenance. Therefore, in order to transform the operational efficiency and competitiveness which the organizations may tend to integrate into the process, Simple-Short-Term TPM would be an affordable approach that offers promising immediate performance returns and long-term outlook of the continuous improvement base. The study also stresses that it is important to combine maintenance with manufacturing process and introduces real-world knowledge to managers who would be interested in increasing the reliability of equipment, its productivity, and overall effectiveness in the operation of the manufacturing process.

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