Proceedings of the International Conference on Industrial & Mechanical Engineering and Operations Management
Dhaka, Bangladesh, December 26-27, 2020

Review of Total Productive Maintenance (TPM) & Overall Equipment Effectiveness (OEE) Practices in Manufacturing Sectors

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Abstract

The main objective of this research paper was to put the detailed and broader picture of TPM & OEE in terms of their implementation in manufacturing sector. This narrative research was based on the secondary data which was collected from the previously conducted empirical studies, case studies and literature reviews. Literature review was presented and discussed in detail. Since, the equipments' productivity has been the severe problem in the manufacturing sector because it is associated with the cost; thus it has been the focus of practitioners & researchers to study and implement such practice by which the problem of equipments' productivity can be overcome. TPM & OEE are used to improve equipments' productivity which is also associated with time, material, process and cost. Therefore, it is of the extreme need to conduct such study about the implementation of TPM & OEE. In the present paper, TPM & OEE are discussed but in the future, other maintenance practices can be discussed in depth in order to put clearer and broader picture of effectiveness and loopholes. In this regard, present review was conducted so as to put the open and broader picture of major maintenance management practices i.e. TPM & OEE comprehensively.

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Keywords
Total Productive Maintenance (TPM); overall equipment effectiveness (OEE); lean manufacturing; maintenance management; productivity.

1. Introduction

Due to Globalization Companies are trying to produce cost effective and better-Quality products in order to remain competitive in the business, therefore many companies are adopting different techniques in their production systems such as TPM, TQM, JIT & Lean Manufacturing, Manufacturing Systems in Particular often operate at less than full capacity, and with low productivity. Today there is a basic business demand for improving manufacturing Performance and quest to increase Productivity. Total Productive Maintenance (TPM) is a scientific technique that is utilized to Evaluate the equipment's Performance relative to Product Quality, in addition it helps in spotting the Pivotal instrumental elements (Nakajima, 1988). To improve the effectiveness the TPM uses a system of maintenance centered around entire lifecycle of the product. With the help of TPM several losses can be brought under control such as equipment breakdown, period etc. using independent staff operating teams, This Strategy carries a Significant effect on Production System, Operations and Product Layout on instrument maintenance.

Nakajima mentioned that a number of industries tries to implement Total Productive Maintenance, however only a handful of industries gets Output or utilization upto 60-90% of the troubles. It displays an improvement in Production. It includes three steps i.e. increasing equipment effectiveness, autonomous maintenance by operators and establishing quality groups for accomplishing goals.
Manufacturing sector has its own objectives which nowadays necessitates the implementation of TPM in industries. The main objectives of the manufacturing industries are focused on eliminating wastage in increasingly changing economic circumstances, increasing production without compromising on product quality, increasing overall value, manufacture a batch amount at the earliest of the time and end product delivered to customer should be defect free.

TPM was introduced during the most capital-intensive manufacturing times of all. (Robinson & Ginder) found that recently in Japan TPM Concepts are being used as a wide range of services and that the traditional thought of TPM being associated with manufacturing was getting obsolete. They conclude that TPM concept of reliability was being transformed from equipment reliability to a structure or system reliability.

1.1 History of TPM
Total Productive Maintenance at its core is a Japanese Concept. The Origins of inception of TPM goes as far back as 1951, in the days when Preventive Maintenance was introduced, But the idea of Preventive maintenance belongs to USA. Nippondenso is credited as the pioneering company for Plant Wide maintenance in 1960. By the way idea of Preventive Maintenance, workers manufactured goods through machines and the maintenance group was dedicated with the responsibility of maintaining such machines. However, with the increasing automation of Nippondenso Plant, Maintenance became more costly as more workers were required. Management made the decision for routine maintenance work to be carried out by the machine Operators. (This is Known as Autonomous Maintenance, one of Prominent ideas of TPM), on the other hand maintenance Personnel would only take up essential maintenance tasks.

Thus, Nippondenso which already Pioneered Preventive Maintenance, Pioneered autonomous maintenance as well. The Maintenance Staff went in For Equipment Modifications in order to enhance reliability. Such Modifications were either made in the existing equipment or were incorporated into new machines or equipment. This Strategy resulted in Maintenance Prevention.Thus, Preventive Maintenance along with Maintenance Prevention and Maintainability Enhancement Gave birth to Productive Maintenance (Venkatesh, J. 2007). The main objective of Productive maintenance was to maximize Plant & Equipment effectiveness in order to obtain Optimum Production Equipment Lifecycle cost.

Nippondenso further introduced the idea of Quality Circles, involving all employee's participation. resulting in all employees actively contributing in implementation of Productive Maintenance. Based on these Developments and Contribution Nippondenso was recognized with prestigious award by the Japanese Institute of Plant Engineers (JIPE). Thus, Nippondenso became the first organization associated with Toyota Group get TPM Certification.

1.2 Goals of Total Productive Maintenance
The major goals of (TPM) are the following:

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a) Accomplish zero defects, no breakdown and zero maintenance related accidents in all functional areas of organization through the implementation of a Life cycle approach for enhancing overall performance of equipment.
b) Increase Efficiency by extremely motivated employees by involving people at all level of the Company.
c) Establishing Small voluntary groups for identifying Causes of Breakdowns, Possible Plant and Equipment Improvements, in order to reduce defects and encourage Self Maintenance.

1.3 Benefits of Total Productive Maintenance

There are many benefits of Total Productive Maintenance (TPM) . The benefits can be classified into direct benefits and indirect benefits. The direct benefits and indirect benefits are mentioned in the given table.

Direct benefits of TPM	Indirect benefits of TPM
• Improved Productivity and OPE Index (Overall Plant Effectiveness) from 1.5 up to 2 times. • Amendment of Customer Complaints. • Production Costs could be reduced by up to 30% • Obtain Customer Satisfaction up to 100% • Decrease in Maintenance related accidents. • More Eco-FriendlyProduction due to Less Wastage.	• More Confident Employees. • A Clean and attractive Plant Environment. • Employees become more acceptable to Change Management. • Higher Teamwork among employees due to increased involvement at all levels of Organization as result of TPM. • Better Exchange and use of Knowledge and Experience. • Employees get a Sense of Ownership in the Organization.

2. Research gap

In Many Industries, measuring the effectiveness of the Production System is of utmost importance, Recent trends indicate that many manufacturing Processes are not performing as intended, They often operate at less than full capacity, with low Productivity and the costs of producing Products are high, , competition and the drive for profit is Forcing many Industries to introduce different approaches for improving operational performance, Total Productive Maintenance (TPM) & Overall Equipment Effectiveness (OEE) are the major maintenance management practices for improving equipments' productivity. This Study takes into account the core concepts of Total Productive Maintenance (TPM) & Overall Equipment Effectiveness (OEE) to explore the potential of Total Productive Maintenance (TPM) & Overall Equipment Effectiveness (OEE) in the Operational Efficiency of the manufacturing sector.

Since, lean is waste elimination technique and like others its maintenance management tools i.e. Total Productive Maintenance (TPM) & Overall Equipment Effectiveness (OEE) have captured the immense attention of businessmen and the academicians. It has been reported that studies lack which examine the Total Productive Maintenance (TPM) & Overall Equipment Effectiveness (OEE) implementation in various sectors. Such studies are significant and need of the hour for the development of maintenance management knowledge because individual sectors have fundamental variance in their production or service processes (Shou et al., 2017). In this regard, present review was conducted so as to put the open and broader picture of one of the major maintenance management practices Total Productive Maintenance (TPM) & Overall Equipment Effectiveness (OEE) comprehensively.

3. Aim and objectives

This research aimed to present the applications of the major lean tools of maintenance management i.e. Total Productive Maintenance (TPM) & Overall Equipment Effectiveness (OEE) in the various manufacturing sectors along with their effectiveness, impacts and their benefits after implementation. The major objectives of this research are the following:

- To discuss the applications of Total Productive Maintenance (TPM) & Overall Equipment Effectiveness (OEE) in various manufacturing sectors; and
- To highlight the effectiveness of Total Productive Maintenance (TPM) & Overall Equipment Effectiveness (OEE) in equipments' productivity.

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4. Research methodology

A narrative literature review was conducted to put the detailed and broader picture of the major lean tools of maintenance management i.e. Total Productive Maintenance (TPM) & Overall Equipment Effectiveness (OEE) in terms of their implementation in manufacturing sector. For the analysis of literature, narrative review is used and it enables an extensive understanding of problems and controversies associated with the use of technology and at the same time, it helps to take out the key success factors of adopting and using technologies (Frennert & Östlund, 2018) . By this method, researchers conduct analysis of debates and outcomes of already conducted research; moreover, it helps in figuring out the research gap and future implications (Ferrari, 2015). Present research paper, summarizes the data and evidences as collected from the previously conducted research on the implementation of the major lean tools of maintenance management i.e. Total Productive Maintenance (TPM) & Overall Equipment Effectiveness (OEE).

4.1 Data collection and analysis

This narrative research was based on the secondary data which was collected from the previously conducted empirical studies, case studies and literature reviews. Research papers on the implementation of mentioned lean tools of maintenance management i.e. Total Productive Maintenance (TPM) & Overall Equipment Effectiveness (OEE) were downloaded and most suitable research papers were considered for the literature review. The data was extracted from those papers and was summarized, tabulated and discussed.

5. Literature review & discussions

Tsarouhas (2013) conducted the Case study and investigated the relation between factory management operation of the production line of a beverages Industry. The Study was carried out on a Line of Products known as Limoncello.The analysis of Failure and repair data over a Period of 8 months of various machines on the line was undertaken for evaluation of Overall Equipment Effectiveness Metrices and for identification of most frequent breaking equipment as well as most frequent type of occurring failures. The Analysis were carried out using Descriptive Statistics and Pareto Analysis at both level and at machine level. The three Metrices of OEE were computed in order to get an idea on the overall Performance of line and the failure data analysis identify the key point in the production Process that Demand immediate attention and improvement. The results of this Study identify that the line was not working on standard required efficiency and that the component on Performance Efficiency (P.E) and Quality Rate were identified as the critical components that needed to be immediately improved. Three of the Six machines on the line contributed to most frequent breakdown amounting up to 80% of all breakdowns. It was identified that for every 237 minutes a failure occurred at line which lasted from 10 to 700 minutes. The Recommendations which were Put forwarded for improvement of the line was the implementation of a TPM Program, replacement of the machines Subject to most frequent breakdowns, and Training of the Maintenance Staff and Operators, Tsarouhas (2013).

Lakho et al. (2020) discussed the implementation of Total Productive Maintenance (TPM) and Overall Equipment Effectiveness (OEE) in Maintenance Management. The authors have discussed few related case studies about the implementation of Total Productive Maintenance (TPM) and Overall Equipment Effectiveness (OEE) in the maintenance management activities of various manufacturing industries. Lakho et. al. (2020) presented the detailed review of Total Productive Maintenance (TPM) and Overall Equipment Effectiveness (OEE) and discussed the implementations and benefits of Total Productive Maintenance (TPM) and Overall Equipment Effectiveness (OEE) in maintenance management activites of various industries.

Khan (2018) conducted the preliminary study on lean manufacturing practices about textile manufacturing industry. The author mentioned that he used the Gemba, Waste Relations Matrix, Cause & effect analysis, ranking and statistical techniques to identify and analyse the wastes of lean manufacturing. The seven deadly wastes of lean manufacturing are investigated and defect is identified as the most significant waste in the textile manufacturing industry. The author suggested most relevant lean practices to eliminate /reduce the most significant defect waste of lean manufacturing which include Total Productive Maintenance (TPM) as well.

Shahin & Isfahani (2015) presented the research and integrates the concepts of Continuous Production and Overall Equipment Effectiveness and Goes on Design a new equation for computation of Equipment Effectiveness in a Continuous manufacturing Environment using the production environment to Steel Industry that Operates its facility

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on four 300, 350 ,500 and 600 factories having different type of rolling mill sites that Produce a Specific Product. This Paper goes in to elaborate how the traditional methods of computation of OEE does not apply to Continuous Production Lines by proving how traditional OEE computation provides only a Single ratio and this singular ratio does not capture the real effectiveness of the equipment on line, and this results in wrong calculations and estimations, and may impose additional costs on the Plant. The authors propose a new methodology for Evaluation of Equipment Effectiveness, by combining concepts of continuous Production and traditional OEE computation method, according to the results of this Study the new proposed method is suggested to accurately reflect the equipment effectiveness in Continuous Production lines by making some slight but significant changes in the traditional approach of OEE. The authors conclude that new proposed methodology is equally applicable to other industries Operating on Continuous Production such as Food, Pharmaceutical or metal industries , Providing same advantages as discussed in this study though the Degree to which it becomes more reliable in comparison to traditional OEE in other Continuous Industries is yet to be Studied and left as Future research Directives (Shahin & Isfahani, 2015).

Lahri & Pathak (2015) evaluates Overall Equipment Effectiveness of a CNC Table Type Boring and milling machines at Heavy Machinery manufacturing Plant. The methodology which was adopted for this was that of a Case Study, both Primary and Secondary Data were collected for the analysis. After the analysis of the Study it was found that the associated CNC machines were working much below the proposed world class OEE Standard, Thus it was concluded that there was sufficient room for improvement.
The Recommendation which were Put Forward for the improvement of the OEE Score of the CNC machine were the following.

- It was decided that the House keeping of the machine would be carried out during lunch time , which would sufficiently reduce delay from 60 min to 50 min.
- Canteen staff should be increased, in order to reduce time taken for lunch distribution, which currently stand at 30 min, however the allotted time for breaks were only 15 min.
- During observation it was found that tool Selection and tool insert unavailability was taking a lot of time during which equipment remained idle for as long as 60 min, this problem can be copied by employing experienced man power and classification of tool inserts.
- An Operation process Sheet (OPS) and drawing of the component Should be Provided to the Operator before commencement of Operation, so that Operator can easily understand sequence of the operations to undertake for machining of that particular part.
- It was found that during the Process of Loading, the clams were not properly arranged, moreover the helpers of the operators were not sufficiently trained Which lead to an unnecessary increase in Setup times., Thus it was Suggested that there should be a prior arrangement of clams and other necessary accessories required for the operation.

After the implementation of above Suggestions, it was found that the OEE Score of the CNC table machine increased from a mere 62% to 75% , However it is Still far below world Standard OEE , Hence there is Room for further improvement (Lahri & Pathak , 2015).

Khan et. al. (2020a) conducted the exploratory study to explore the major lean manufacturing practices in the textile industry and highlighted the applications of popular lean practices for the textile industry. The authors mentioned the substantial benefits of the applications of highlighted lean practices including Total Productive Maintenance (TPM) in the specific segments of the textile industry.

Nisbantoro et al. (2018) explores the Evaluation of Overall Equipment effectiveness in a Injection Molding Manufacturing Industry. Injection Molding is one of the most widely utilized techniques for Polymeric fabrication Process. It involves manufacturing of an article by pouring molten Plastic Substance into under extreme Pressure into a mold, where it is cooled Solidified and then released by opening of the two halves of the mold. The Plant under Study Produces Plastic Casings for Various Home appliances and other Equipment Such as vehicle spare parts, hospital Instruments, office Equipment and casings for various heavy machines. The Organization has Four injection molding machines with up to Eighty tons of mold capacity, each machine Produces a Specific type of Part and requires Setup and adjustments before each batch. Each type of part that is being produced has a different cycle time and different material. The Research approach undertaken for this Study was direction observation of the Production Floor and in order to obtain the first-hand knowledge on how the Process works, The Process involves Data Collection in Downtimes, uptimes of machines repairs undertaken and the previous records of the failures Data

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was also collected from daily production reports The Results of the Study show that two of the Four Injection Molding Facilities underperformed in Equipment Effectiveness by up to 10% in comparison to world Class OEE, However the remaining two were working Optimally and exceeded the Suggested OEE Standard of 85%. In addition to Computation of OEE Score Pareto Analysis was carried out in order to find out the most frequent causes of lower OEE Score, as well as 5 Why Analysis to Pin down causes of Breakdown out of which Operator Breaks and Setup and adjustment times seems to be the most contributing Factor. This Study's Scope was not extended to the improvement of OEE Score hence was just limited to Current equipment's Score's Evaluation, the improvement was left as a future research Directive Nisbantoro et al. (2018).

Saleem & Nisar (2017) targeted the goal of their paper to devise a guideline to increase the production rate of the tyre curing press whilst reducing the downtime and maintenance cost of the tyre curing press with the aid of a maintenance management strategy centered on overall efficiency of equipment (OEE). Before and after rectifying the causes of failures, the methodology is focused on assessing the OEE of the tyre curing press. Using the risk priority number, the failure mode and effect analysis (FMEA) technique is used to determine the root causes of repeated failures in the tyre curing press. After rectifying the repeated failures calculated using the FMEA technique, a major improvement in the value of OEE is observed. It is therefore concluded that the OEE and FMEA help to boost the industrial efficiency and competitiveness of the production facilities under research. This research is restricted to the determination, not of the entire production method, of the OEE of individual machines only. Manufacturing facilities rely on the operational environment; it would therefore not be justified to compare two separate production facilities based on the OEE value. In order to take competitive advantages, such as minimizing equipment downtime, increasing efficiency and reducing cost of maintenance, this study can be applied in any tyre industry. For the studied organization, the perspective from which the paper examines the bottleneck issue in the tyre production line is original and shows good results. It enables the firm to apply the very same approach for enhancing manufacturing efficiency and productivity in its other production equipment, lines and factories (Saleem & Nisar 2017).

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Khan et. al. (2020b) conducted the detailed systematic review of lean manufacturing practices in the pharmaceutical industries and highlighted the feasible applications of Value Stream Mapping (VSM) to pharma industry. The authors mentioned the substantial benefits of applying the specific lean and Total Productive Maintenance (TPM) practices in the selected segments of the pharma industry.

Kaczmarek & Piechowski (2016) mentioned that the purpose of their paper is to examine the overall effectiveness of equipment in the automotive industry. The OEE assessment is the primary and essential step in taking steps that aim for organizational effectiveness. Companies use different techniques to calculate performance in order to retain a competitive edge in the market. The most widely referenced in the literature and applied in practice, calculation of the effectiveness of the use of manufacturing equipment is presented in the paper called Overall Equipment Effectiveness. The company that is the focus of this study is a pioneer in the manufacture of aluminum alloy die casting, aluminum precision machining and iron casting for the automobile sector. The organization focuses on producing turbocharger components and brake systems. The business has been Profiting from the ideas of Lean Manufacturing for many years, which includes all production departments as well as other departments within its scope. Inside the framework, tools such as 5S, SMED, Kaizen Events are applied, and the idea of Total Productive Maintenance has been implemented by the organization for almost a year. This paper addresses three critical factors concerning the OEE calculation. Firstly, the multiplicity of loss-determining methods and related OEE estimation models. Second, not just to monitor losses, OEE can be used. Its true benefit is the provision of knowledge on potential improvements. Thirdly question of availability and reliability of the data required to measure the OEE is discussed Kaczmarek & Piechowski (2016).

Rajput et. al. (2020) conducted the case study at the automobile assembling plant to improve the productivity. The authors applied the lean tools and techniques to identify the causes of low productivity and proposed the lean manufacturing practices for the expected productivity improvement at the automobile assembling plant. Rajput et. al. (2020) compared the pre and post lean productivity to highlight the benefits of the Total Productive Maintenance (TPM) and lean manufacturing practice i.e. (takt time) in an automobile assembling plant.

Sohal et al, (2010) explores a plan for operations that should be focused on a strong regulated and compatible working method paired with motivated shop floor teams that promote process improvements in that standardized

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work. As a crucial starting point for teams to recognize their equipment losses and to develop improvement plans to eradicate them, OEE data on machine efficiency is addressed. It takes on the Research approach of Studying a number of case Studies of different industries and from different Sectors where OEE was implemented as a Performance measurement tool and analysis the decisions behind Selecting it as Equipment, The authors tried to determine the major motivating factors which leads management to consider OEE implementation as Crucial and Beneficial.It concludes that the application of the OEE is usually based on the motivation for the study and comparison of the use of resources at the plant using a simple reference measure. It is also possible to turn the use of OEE into a framework for evaluating production data in order to find possible Opportunities for improvement and to promote lean initiatives. Thus, OEE usually progresses from a simple productivity measure as the original target, to being a method for enhancing the efficiency of data collection to support CI goals by removing waste Sohal et al, (2010)

Villamizar et al., (2018) introduces a new technique for assessing the efficacy of urban freight transport networks using the metric of OEE (Overall Equipment Effectiveness), a well-known factor employed in the paradigm of Lean Manufacturing. To explore the relationships and trade-offs between economic growth, performance, and availability, the approach uses a mathematical framework with multiple objective functions, two of which are multi-objective. The ultimate aim is to maximize the parameters of the OEE and the productivity of the transport system. Using actual data from the city of Begot, Colombia, this technique was tested. In verify the proposed method, tests were carried out with various firms, prices, demands and travel times. The findings show the advantages of using multi-objective functions to maximize both OEE (quality, efficiency and availability metrics) and income.The approach suggested offers an assessment of the tactical and operational choices made by businesses in Configuring a framework for urban freight transport Villamizar et al., (2018).

Khan et. al. (2020c) conducted the comprehensive review of lean manufacturing in Pakistan. The authors have identified the potential, benefits and applications of lean manufacturing in the various manufacturing sectors of Pakistan. The authors have mentioned the case studies to support the growing awareness and increasing scope of lean manufacturing Total Productive Maintenance (TPM) in the major industrial sectors of Pakistan.

Garza-reyes (2015) mentioned that the aim of his study is to propose an alternative OEE-derived metric, Overall Resource Effectiveness (ORE), which takes these variables into account. The article discusses the past of the OEE and examines its shortcomings. It then illustrates the ORE measures conceptual and quantitative development and the methods employed for its measurement. Empirical and simulation-based ORE analyses and implementations are performed for verification using two case studies. The outcomes obtained from both empirical and simulation-based analyses indicate that OEE may not be a suitable metric for some particular processes and that ORE may provide a more comprehensive view of key performance indicators and knowledge. ORE may provide more detailed information to decision makers about the efficiency of their processes.This will enable them to make informed strategic decisions and initiatives required to enhance their operations. This article introduces a modern and alternative method for calculating the productivity of production equipment and processes Garza-reyes (2015).

Sahito et. al. (2020) conducted the case study at the pharmaceutical plant to Identify, analyses and elimination the Lean Manufacturing Wastes through Lean Manufacturing Practices. The authors have identified the lean manufacturing wastes in pharmaceutical plant by lean standards and then analysis is performed by using the statistical tools and techniques. Sahito et. al. (2020) suggested the most suitable lean and Total Productive Maintenance (TPM) practices for eliminating/reducing the most significant wastes at the pharmaceutical plant and compared the pre and post study scenario.

Kumar et al., (2014) claimed that their research was undertaken in order to optimize the Production Planning and Process improvement in a impeller Producing Factory. The Research approach involves reviewing the current Planning and Scheduling techniques, identification of bottlenecks in the Process, change over Processes, and decreasing in Process inventory. The Software and tools employed for this Sturdy was SMED from the ideas of Lean manufacturing and Preactor APS Scheduling Software Built by Siemens. The Outcome of this Research was an improvement of 4.4% in Delivery Performance and a reduction of 47% in Setup times of particular impellers Kumar et al., (2014).

Hedman et al., (2016) mentioned that the goal of their research is to determine key factors and possible drawbacks in automatic OEE calculation. It is done by analyzing raw data obtained from a broad data collection utilized for

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OEE Evaluation; 23 separate firms and 884 devices. The mean OEE was estimated at 65%. Since the loss categories were either incomplete or had inadequate definitions, nearly half of the reported OEE losses could not be categorized. Moreover, 90% of the identified downtime may be specifically attributed to support tasks carried out by workers and not to the automated process itself. To fully explore the capacity of automated data acquisition systems and to extract reliable OEE measures which can be used to enhance production efficiency, the results and recommendations of this study can be implemented Hedman et al., (2016).

Kumar et. al. (2020a) conducted the case study for the Performance Evaluation of Motorcycle Assembly Line through the Lean Manufacturing Practices of Total Productive Maintenance (TPM) and Overall Equipment Effectiveness (OEE). The authors measured the performance of the assembly line through the lean tools and techniques and compared the OEE of the plant with the world class OEE. Kumar et. al. (2020a) identified the gap between the OEE of the plant and world class OEE and suggested the measures to reduce the gap.

Modgil & Sharma (2016) conducted the study with the aim to examine the effect on organizational efficiency and its interdependence of the approaches of total productive maintenance (TPM) and total quality management (TQM) activities. Three key concepts, namely TPM, TQM and pharmaceutical industry operational efficiency, are included in the current analysis. With the assistance of literature, within TPM, four factors were recognized, including disciplined maintenance, information monitoring, housekeeping and worker participation. Four frameworks have been taken into account in TQM, including quality data and monitoring, innovative products, research and development (R&D) management and technology leadership. in this research for review, 254 responses were used out of 410 Indian pharma companies approached for the research. To evaluate the suggested structure, factor analysis, path model, and structural equation modelling were used. The findings of alternative models have been analyzed, evaluated and published. Finally, to prove and disprove the theories, the overt and covert impact of TPM and TQM on operational efficiency has been verified and reviewed. The current research offers the executives with helpful perspectives. It has been stated in writings that TQM helps to enforce TPM. TPM plays a major role in practice in achieving consistency in operations and, thus, in goods. In exchange, quality goods help to improve operating efficiency at the site level with decreased in process inventory, fewer faulty products and decreased scrap. The organization's TPM activities would help accelerate the rate of product development and efficiency improvements, which are crucial for the pharmaceutical industry. Constant monitoring of TPM procedures can assist organizations to conduct regular operations and maintenance requirements over a given period of time for each machine. The current study identifies the cross-dimensional relation between TPM, TQM and operational efficiency. The pharmaceutical sector is a dynamic system of sophisticated processes and equipment. The quality of machines / equipment, after personnel, explains the power of an enterprise. The devices require periodic maintenance to achieve the optimal requirements for the goods. Medications have very strict requirements, which can only be obtained if machines / testing equipment are upgraded and regularly maintained. The TPM procedures would allow factories to improve operational efficiency by having process quality Modgil & sharma (2016).

Khan et al. (2020d) mentioned that there is tremendous potential of lean manufacturing tool of Value stream mapping in manufacturing industries. The authors have discussed few related case studies about the implementation of Value stream mapping in manufacturing industries. Khan et. al. (2020d) presented the detailed review of Value stream mapping and discussed the applications and benefits of Value stream mapping Total Productive Maintenance (TPM) in manufacturing industries.

Hooi & Leong (2016) mentioned in their article that the aim of their article is to analyze the multidimensional nature of total productive maintenance (TPM) in the Malaysian manufacturing sector and its association with the enhancement of production efficiency. Particularly, this research assesses the significance of the success factors of each TPM Program for improving production efficiency. To validate the suggested research model, input from 89 employees who responded to the survey was used. To determine the Malaysian context, a standardized questionnaire borrowed from Ahuja and Khamba (2006) has been used. The empirical results indicate that conventional maintenance and TPM deployment programme have a substantial impact on Operational performance, but not on upper management and maintenance organization leadership. In the early stages, top management responsibilities and dedication are crucial to defining the strategic plan and implementing the execution of the entire project. Conventional maintenance and TPM deployment programme, however, gradually allow commitment, proper planning, correct implementation and continuous improvement, eventually dramatically enhancing the measures of production efficiency. The results further show that, in the longer term, TPM is not viable in Malaysia's manufacturing industries. For senior managers of manufacturing organizations which have introduced TPM or are

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contemplating implementing TPM in their organizations, this review is important. In order to provide a perspective into whether TPM is economically sustainable, this research adds to the literature by investigating beyond the implementation and stabilization stage of TPM Hooi & Leong (2016).

6. Conclusion

Literature review was conducted on the major lean tools of maintenance management i.e. Total Productive Maintenance (TPM) & Overall Equipment Effectiveness (OEE) in the context of their application and implementation in various manufacturing sectors. Most of the modern manufacturing and automotive companies, some of SMEs, food and construction companies have implemented mentioned lean tools of maintenance management i.e. Total Productive Maintenance (TPM) & Overall Equipment Effectiveness (OEE). Due to the lack of awareness about the effectiveness and impact of these lean tools of maintenance management i.e. Total Productive Maintenance (TPM) & Overall Equipment Effectiveness (OEE), the few companies are still reluctant to adopt them. At the other hand, resistance from employees and top management are also the main hindrances in the way to this change. In this regard, one of the researcher have suggested that the employees must be taught for proper Total Productive Maintenance (TPM) & Overall Equipment Effectiveness (OEE) implementation from the bottom to the top in the execution of an autonomous flow of maintenance as machine operators are the main linkage to perform simple maintenance and fault finding tasks (Singh et al., 2020).

7. Acknowledgement

We are very thankful to our colleagues and well wishers at the department of Industrial engineering & management and Mehran UET, Jamshoro, Sindh, Pakistan to motivate and guide us. We also acknowledge our textile industry friends to guide us in the local & global scenario of lean manufacturing in textile industry. We are also very thankful to the administrative and technical support from the administration & management of Mehran UET, Jamshoro, Sindh, Pakistan for their cooperation and support. We are especially thankful to Mehran UET Library & Online Information Centre to provide the free access to the valuable databases and relevant books, magazines, journals etc.

8. Future implications

In the present paper, the major lean tools of maintenance management i.e. Total Productive Maintenance (TPM) & Overall Equipment Effectiveness (OEE) are discussed but in the future research, other maintenance tools and techniques can be discussed in depth in order to put more clear and broad picture of effectiveness and loopholes. More research papers can be considered in order to draw better and effective conclusion.

9. Conflict of interest

There were no conflict of interest among the authors of the present research paper.

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