Waste Reduction through Overall Equipment Effectiveness a Lean Manufacturing Principle in Small Scale Industry: A Review

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Abstract— Small scale sector play a vital role in Indian economy, and contributes more than 50% of industrial production in value addition term. Small scale sectors generates one third of export revenue and employs largest manpower next to agriculture. In India, the survival and growth of small-scale industries are quite competitive and largely depends upon its ability to innovate, improve operational efficiency and enhance productivity. Indian industries have been trying to adopt new business initiative in order to stay competitive in the fierce market place. Lean manufacturing is one of these initiative that focus on the cost reduction by eliminating non-value added activities (Muda or waste). Overall Equipment Effectiveness (OEE) is one of the Lean manufacturing principle that helps an organization to identify the non-value adding elements in the targeted process and brings a product or group of produces that uses the same resource through the main flow, from raw material to the arms of customers. OEE is already selected as best lean manufacturing principle for case company using Analytic Hierarchy Process (AHP). This paper discussed the method of OEE and its benefits to different industries. This paper also presents a Literature review to summarize the various applications of this principle and improvement achieved by various industries. The paper concludes with highlighting OEE's important contribution to revealing and curtailing extravagances in the target process.

Key words: Lean Manufacturing, Muda, Overall Equipment Effectiveness (OEE) and Analytic Hierarchy Process (AHP)

I. INTRODUCTION

To remain in business arena it is up most important to win hearth of customers through quality and cost. It is also crucial to have sustainable production with continuous improvement. This forces all organizations to evaluate customer's needs and problems and take best possible course of action to satisfy them. The present need of an organization is to deliver high quality of products through continuous improvement [1]. Manufacturing organization throughout the world is under great pressure to reduce the cost and meet the global quality standards [2]. Lean manufacturing is the hymn of survival and success for any organization through minimizing the wastage of resources and moving towards implementation of lean manufacturing have become key strategies to achieve cost cutting. The goal of lean manufacturing is to minimize all types of waste(non-value added activity) through incorporating less human effort, less inventory, less time to develop product and less space to become highly responsive to customer demand, while at the same time producing top quality products in the most efficient and economical manner.

The aim of this paper is to review the implementation of Overall Equipment Effectiveness (OEE) in Ghanshyam Steel a small scale flange coupling manufacturing company near Bhavnagar, Gujarat, India. OEE is already selected through Analytic Hierarchy Process (AHP), a Multi Criteria Decision Making (MCDM) technique considering different criteria of case company. The concept of Overall Equipment Effectiveness was originated in Japan at beginning of eighteenth century. The Japan institute of plant maintenance promoted the total productive maintenance (TMP) which includes overall equipment effectiveness. The calculation of OEE is general and it can be applied to any manufacturing company [3]. The goal of TPM is to reduce the six major equipment losses to zero and it has been recognized necessary for survival of organization. The TPM is Japanese system of management developed from preventive maintenance concept. The TPM emphasizes the role of team work, group activities and participation of all employees to accomplish equipment improvements objectives [4]. The Just in Time (JIT) and Total Quality Management (TQM) are closely tied to each other and it is an extension of Preventive Maintenance (PM), where the machines work with high productivity and efficiency. The maintenance is all employees' responsibility and focus to prevent the problem before it may occur [5].

II. PROBLEM STATEMENT

Research at Lean Enterprise Research centre (LERC) U.K. indicated that for a typical manufacturing company the ratio of activity could be broken down as in table1.

Types of Activities	%Share
Value-added activity	5
Non Value-added activity(wastes)	60
Necessary non value-added activity	35
Total activities in % share	100

Table 1:

This implies that up to 60% of the activity at a typical manufacturing company could potentially be eliminated. All Lean manufacturing principles are not possible to implement in small scale industry because of limited resources i.e. finance, infrastructure, work force available etc. The best Lean manufacturing principle is to be select using MCDM technique considering different effective criteria of small scale industry. OEE, potential Lean manufacturing principle is selected using AHP considering different criteria is to be applying for performance improvement of case company.

III. OVERALL EQUIPMENT EFFECTIVENESS (OEE)

OEE is a procedure used for determination of effectiveness of equipment. Though the definition implies that OEE is a measure of particular equipment, but it can be also used to determine efficiency of product lines, sections of plant or

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even the entire plant. It continuously focuses the plant on the concept of zero waste [21].

The losses are divided into six pivotal categories which influence the overall performance of the equipment. These are:

1) Equipment failures/breakdown losses mean the time and quantity loss due to defective products.
2) Set up and adjustment losses mean time loss due to defective products and downtime loss that occur when production of one item ends and the equipment is adjusted to fulfill the desired requirements.
3) Idling and minor stop losses when the production is interrupted by a temporary bottleneck or when a machine is not running.
4) Reduced speed losses refer to the difference between speed of equipment design and speed of actual operation.
5) Reduced yield losses occur during the early stages of production from start of machine to stabilization.
6) Quality defect and rework are losses in quality caused by malfunctioning of production parts.

Fig. 1 shows the block diagram of various types of OEE losses in a production line.

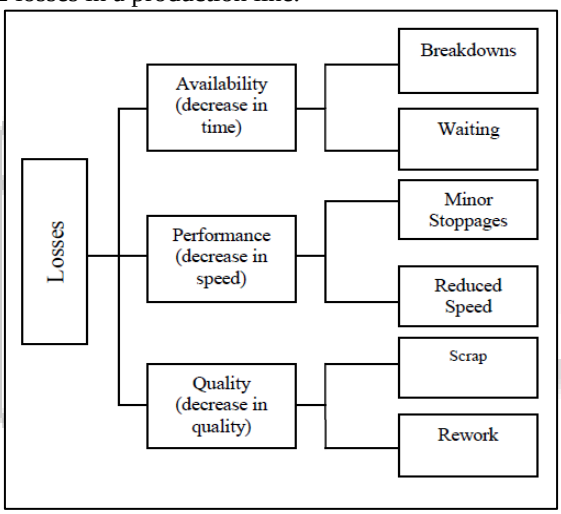

Fig 1: OEE losses

Among all the losses the first and the second are termed as downtime loss and are used to calculate Availability of machinery. However the next two are speed losses which determine the performance efficiency and the final two losses are taken to be losses due to defect found in the product.OEE is calculated in terms of these six losses, which are function of performance rate, availability and quality rate of the machine, production line or factory. These losses can be negated by a tool known as Total Productive Maintenance [21].

Overall Equipment Effectiveness (OEE) is a way to monitor and improve the efficiency of manufacturing process, Developed in the mid 1990's. OEE has become an accepted management tool to measure and evaluate plant floor productivity. OEE is broken down into three measuring metrics of Availability, Performance, and Quality. These metrics help gauge your plant's efficiency and effectiveness and categorize these key productivity losses that occur within the manufacturing process. OEE empowers manufacturing industries to improve their processes and in turn ensure quality, consistency, and productivity measured at the bottom line [22].

1) Availability (A):

It takes into account Down Time loss, which includes all events that cease planned production for a perceptible length of time(typically several minutes or longer).It is calculated as the ratio of Operating Time to Planned Production Time, wherein Operating Time is simply Planned Production Time minus Down Time. Down Time includes job setting time, defect and rework time, meal break, idle time, job replacement time, material unavailability time [21].

A = Operating Time/Planned Production Time

2) Performance (P):

It takes into account speed loss, which includes all factors that generate the production process to operate at less than the maximum possible speed when running. It is the ratio of Net Operating Time to the Operating Time. The Net Operating Time is the product of processed number of parts and the theoretical cycle time of each part [21].

P = (Theoretical Cycle Time*Processed number of Parts)/Operating Time

3) Quality (Q):

It takes into account quality loss, which factors out manufactured parts that do not meet quality standards or dross parts, including parts that require rework. It is calculated as the ratio of Fully Productive Time (fastest possible time for good parts) to Net Operating Time (fastest possible time for total parts) [21].

Q = (Total parts-Defect parts)/Total parts

OEE is the product of three measures: Availability, Performance, and Quality.

OEE = Availability × Performance Efficiency × Quality

IV. TOTAL PRODUCTIVE MAINTENANCE

TPM evolved way back in 1951 when preventive maintenance was introduced in Japan. Nippondenso of Toyota Group became the first company to attain TPM certifications. It is a maintenance program with a newly delineated concept for the main parts and equipments. The objective of TPM is to commercially increase production and simultaneously increasing confidence of the employees and contentment at work. Total Productive Maintenance is nothing but an extension of Total Quality Management. In a nut shell, TPM can be summarized as the backbone of any sound production process occurring in a machine assembly [21].

The paramount targets of TPM are: no product defects, no equipment unplanned failures and no fatal injuries. It is accomplished by studying the past data of the aforesaid factors by using Ishikawa fishbone diagram analysis or why- why analysis and find out the hidden fuguai in the initial step of TPM autonomous maintenance. The basic six losses mentioned above can be removed by TPM with the help of continuous improvements. Japanese technologies are suffused to achieve the target of zero. TPM has 8 pillars of activity which are set to eliminate wastes [21].

Figure 2 shows the block diagram of the eight pillars of TPM.

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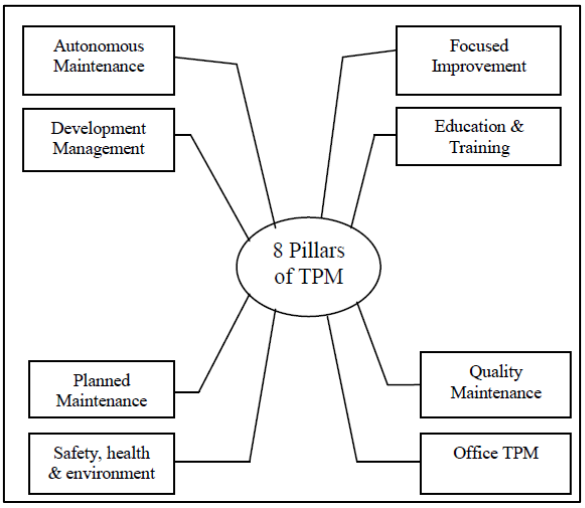

Fig. 2: 8 Pillers of TPM

1) Autonomous Maintenance: It is a process to keeping a place clean to make maintenance easier to perform. The features of this pillar are incubating skills and ownership and undergoing cleaning, lubrication, inspection on the production equipment.
2) Development management: Machine development to achieve high equipment effectiveness and rapid methodology to develop new product.
3) Planned Maintenance: The function of this pillar is to minimize unplanned failures in production process. The features are a) effective and efficient planned maintenance, time based maintenance system over machine life cycle and b) Improving Mean Time Before Failure(MTBF) and Mean Time To Repair(MTTR).
4) Safety, Health and Environment: Its motive is making a working place more comfortable. Its objectives are a) Provide appropriate work environment. b) Eliminate incidents of injuries and accidents.
5) Focused improvement: It focuses on the features a) working out loss structure and loss mitigation. b) Achieve improved system efficiency. c) Improve OEE of production system.
6) Education and Training: It helps in involving and enhancing human resource in industry. It included multi skilling of employee, aligning employees to organizational goal and periodic skill evaluation and updating.
7) Quality maintenance: It tends to no scrap and it includes achieving zero defects and breakdown, tracking and addressing equipment problems and root causes and setting 3M (man, machine, material) condition.
8) Office TPM: Its motive is to extend TPM to office and it includes remove procedural skirmish, focus on addressing cost related issue and apply 5S in office and working area.

V. LITERATURE REVIEW

Mehmat et. al., (2008) gave the brief history of Lean manufacturing and discussed the different facets that are components of a lean culture and programs. Author examined the specific impact of each of the lean manufacturing principle on the bottom line and performance of a company. In this paper different principle of lean manufacturing has been discussed in order to improve quality and efficiency of the manufacturing organization [6].

Ihezie and Hargrove (2019) evaluated and performed an assessment of the current status of manufacturing organization. An assessment tool is used to evaluate current Lean manufacturing state in terms of actual manufacturing practice related to inventory cycles, production processes, maintenance procedure and operation, facility layout, quality control and other key metrics used to improve manufacturing facilities. In this paper, Lean assessment procedure and selection lean manufacturing tool considering different criteria has been discussed [7].

Miller et. al. (2010) A small furniture production company has integrated lean tools and sustainability concepts with discrete event simulation modeling and analysis as well as mathematical optimization to make a positive impact on the environment, society and its own financial success. The background of lean and green manufacturing has been discussed. Eight typed of wastes identified by Toyota have been discussed in this paper. Nine forms of wastes identified by green manufacturing have also been discussed in this paper. A case study of chair manufacturing company has been taken in this paper. [8].

Wong Cheng and Wong Yew (2011) attempted to understand and actual implementation of lean manufacturing in electrical and electrode manufacturing industry. A case study was conducted by asking relevant question through a structured interview approach with the key personal that are responsible for lean manufacturing implementation. Lean manufacturing has been implemented between 4 to 6 years in case companies. Lean Manufacturing tool grouped in focused areas improve performance of the case company. Total four companies have been taken for case study [9].

Amin and Karim (2012) developed a methodology to quantitatively measure the performance of manufacturing system in detecting causes of inefficiency and to select appropriate lean strategies to address problem identify. A systematic methodology has been developed to support lean manufacturers to effectively select lean strategy for their organization and evaluate process improvement [10].

Huang S.H. (2004) proved that competition and the drive for profits are forcing industry to implement various productivity improvement tools. In this paper, an approach based on OEE is developed to model the productivity of a manufacturing system in terms of overall throughput effectiveness (OTE) [11].

Nakajima (1989) state that OEE is viewed as key performance measure in mass production environments applied to any kind of production. Being aggregated metric instead of many detailed metrics, OEE is experienced as user friendly and clear overall metric [12].

Jayaswal pratesh and Rajput S. Hemant (2012) implementated kaizen and Jishu Hozen to improve OEE in Leaf spring manufacturing industry. OEE has been increased from 43% to 68% and labor cost decreased by 43%. The increase in OEE resulted not only in better productivity but also excellent resources exploitation, high quality product and enriched employee moral and motivation [13].

Paropate V. Ravikant and Sambhe U. Rajeshkumar (2013) worked on TPM implementation in midsized Indian enterprise. In this paper they carried out case study on cotton

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spinning plant to identify extensive deficiency associated with equipment effectiveness. They intended to analyze the practical problems accomplishing TMP and improved the effectiveness of critical machine by significant value[14].

Hedge G. Harsha, Mahesh N.S., and Doss Kishan (2009) performed a case study on OEE improvement in CNC machine shop. They studied the history of machine to find bottleneck machine, whose OEE was 43%. They emphasized on the OEE parameters like availability, performance and quality and formed a TPM team to address a systematic approach towards systematic approach. TPM techniques line cleaning with meaning, Preventive maintenance, Kaizen and Pokayoke were successfully implemented by TPM team, consequently they were able to raise OEE from 43% to 72%[15].

Shahu Shekhar, Patidar Lakhan, Soni K. Pradeep (2015) worked on 5S transfusion to OEE for upgrading production level. The objective of integrated concept was to create a clean, healthy workplace, improve quality and employee's satisfaction. In this paper the model has been developed to identify a relationship among 5S, OEE and manufacturing productivity. They also carried out an analysis to justify that the use of 5S, calculation of OEE, analysis of current OEE status on manufacturing units helps access the current performance of assembly line and points out the vital factors for productivity improvement[16].

Vigneshwaran S., Maran M., Manikandan G.(2015) Proposed a review of literature on the impact of implementation of TPM. They tried to point out the tangible and intangible benefits obtained as a result of implementation of TPM. They highlighted the involvement of TPM in improving OEE and employee moral[17].

Lalkiya Meet and Kushwaha K. Deepak (2015) Proposed a research work on optimizing and analyzing OEE through TPM in cement industry. They made an attempt to measure and analyze OEE of machinery producing Portland cement. They measured the performance of existing system and reference value were obtained for design of experiment. They used Minitab16 software to perform an experiment on three factors and two levels of OEE. The most influential factor among them and the relationship between availability and performance rate and quality rate were obtained by them through main effect plots and regression analysis. They finally used the counter plots and response surface method to find the optimized value of the three factors of OEE. They concluded that the simulated value of the output will be useful information to the industry [18].

Gupta K. Amit and Garg R.K. (2012) worked on OEE improvement through TMP keeping in mind the global competition in manufacturing and production sector and customer satisfaction. Customers delight lies in product quality, delivery time and cost of product. TPM is a policy aimed at increasing the availability of existing machine thereby minimizing the absence of extra capital investment. The aim of this research paper is to study the effectiveness and implementation of TPM in Automobile Manufacturing industry, the increase in efficiency and productivity of equipment in terms of OEE. On the basis of result they developed a data base which can be further used [19].

Fore S. and Zuze L. (2010) proposed a plan for OEE implementation through TPM. They approached a case study where focus was made on improving the maintenance in a manufacturing setup. They used different data collection method like interviews, reviewing, documenting and historical records in addition to direct and participatory observation. The production was based on total kilowatt of motors produced per day. The target was 75 kilowatts per day which accounted for 91% availability. The factors affecting the manufacturing process were reduced demand and lack of raw materials. Due to lower availability of machines, the company had to reset the usual figure of 250 kilowatts per day to 75 kilowatts per day. General machine breakdowns too contributed to the problem [20].

VI. CONCLUSION

OEE is an important performance measure for effectiveness of any machine. A careful analysis is required to know the effect of various components. From the above literature review, it is found that all the manufacturers' fundamental priority is to improvement Overall Equipment Effectiveness by the systematic and methodical implementation of TPM. The pillars of TPM formed the core of the study, the tools for improvement incorporated through TPM varied from researchers to researchers. The three parameters of OEE viz. availability, performance rate and quality rate are taken special care and their improvement directly contributed to improve OEE of the concerned machine. Moreover the literature emphasized on developing workplace condition, developing machine condition, zero defect, zero accident, all employee participation, creating amicable work environment, engaging amiable behavior among fellow employee, boosting employee morale and confidence to go with customers' satisfaction to the fullest as far as possible.

Each of review paper provides platforms for implementation of OEE in case organization. Reading the review paper helped to clarity my understanding of OEE and TPM. This paper reports some significant results of the application of OEE in manufacturing industries. It can be concluded that OEE is an effective tool for identifying the processing waste and improving overall effectiveness and efficiency and is equal applicable to different type of manufacturing industries. As OEE is already selected a best lean manufacturing principle through MCDM technique, this review gives motivation to my research work at Ghanshyam Steel, a small scale industry.

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