A Review on Effective Utilization of Resources Using Overall Equipment Effectiveness by Reducing Six Big Losses

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ABSTRACT

In present world scenario, when manufacturing companies encounter capacity problems, they immediately look for increasing overtime, number of shifts and purchase new machine and equipments. Instead, focus must be on the better utilization of resources and increasing performance of the existing machines, so that there is better equipment performance, reduction in bottlenecks, decrease overall downtime, improve operator performance and minimization of setup time and other major forms of losses thus enabling in decision on the investment of buying new machines. Overall Equipment Effectiveness measures the gap between the actual performance and the potential performance of a manufacturing unit. OEE is broken down into three measuring metrics such as Availability, Performance, and Quality; these help gauge the plant's efficiency by categorizing the key losses that affects the manufacturing process. In this review, it is seen that total productive maintenance methodology is implemented to achieve OEE nearing to world class standards. It is seen that downtime losses are not the only influencing parameter but ideal run rate of a machine is another factor that adds to the variation in OEE. It is evident from one of the examples that OEE percentage can be improved substantially by implementing Total Productive Maintenance tools such as 5S, Jishu Hozen, Kaizen etc in a manufacturing firm. While calculating OEE, the factors influencing it are identified and performance improvement measures are undertaken and through this, OEE percentage can be improved. This concept can be applied to manufacturing industries, plastic industry, petrochemical processes and pharmaceutical industry.

Keywords: Overall Equipment Effectiveness, Major Losses, Total Productivity Maintenance, Availability, Performance, Quality, World Class Score.

I. INTRODUCTION

Every manufacturing firm in today's business scenario with increasing competition, attempts to be an effective, low-cost producer of their product with high productivity. Many a times, attaining higher productivity and bringing their product to the market with minimum cost is not possible due to various factors related to capacity problems and problems related to performance of machines such as machine breakdown, minor stoppages, unplanned maintenance, reduced speeds, quality rejects and rework etc. In such a situation an investment is made on buying new equipments, increased shifts and increased working hours etc thus, is causing business executives to be sensitive about all aspects of manufacturing operational costs. Hence lean

tools must be used. It is called lean as it uses less, or the minimum, of everything required to produce a product or perform a service [3]. It is therefore the elimination of seven important wastes is important in Lean environment to ameliorate the effects of variability in supply, processing time or demand [8]. However, it is very difficult to find a concise definition which everyone agrees. Different authors define it distinctively [11]. Overall Equipment

Effectiveness (OEE) is one of the effective tools that meet the above objectives by analyzing and improving the production process. OEE shows how well a company is utilizing its resources, which include equipment, labor and the ability to satisfy the customer in terms of delivering quality products. It is a way to monitor and

improve the efficiency of a manufacturing process [9]. The OEE tool gives you the ability to determine the machines for productivity improvements. The OEE of a machine or set of equipment is a Key Performance Indicator (KPI) that indicates the equipment's overall operational performance i.e., combination of measurement of plant availability, performance efficiency and quality of a specific plant, equipment or process. The need for OEE as indicated by the Industry Week 2001 census of Key Performance Metrics for manufacturing here the survey shows that the top 4% of world-class manufacturers benefit from a low 2% (median value) of unscheduled machine downtime. This means that the remaining 96% percent have an opportunity to improve performance by reducing unscheduled downtime. Downtime reductions can be readily achieved by using OEE to gain visibility into machine status and to perform root-cause analysis of problems [13]

LITERATURE REVIEW

Overall Equipment Effectiveness measures the gap between the actual performance and the potential performance of a manufacturing unit. OEE is effective tool to benchmark, analyze, quantifying, monitoring and improve the effectiveness of any manufacturing processes. It helps drive improvement through a better understanding of losses and also provides an objective way to set improvement targets and track progress towards reaching those targets. OEE is broken down into three measuring metrics of **Availability, Performance** and **Quality** i.e., performance metric compiled from data on Machine Availability, Performance Efficiency and Rate of Quality that is collected either manually or automatically.

OEE = Availability*Performance*Quality

- Availability is the percentage of the actual amount of Production time the machine is running to the production time the machine is available. [14]
  Availability = (Operating time – Downtime) /Total Operating Time
- Performance is the percentage of total parts produced on the machine to the production rate of machine.
  Performance = Total output/potential output [14]

- Quality is the percentage of good parts out of the total parts produced on the machine. Quality = Good output/total output

The OEE metric starts with the idea of Theoretical Operating Time which is the maximum amount of time that a facility could be open and available for the manufacturing process to produce. From Theoretical Operating Time, you subtract a category of time called Scheduled Shutdown, which includes all the events that should be excluded from efficiency analysis because there is no intention of running production. The leftover available time is the Loading Time [15] as shown in figure 1 and the OEE calculation begins with it.

A. Major losses

Availability takes into consideration any Down Time Losses. Performance takes into consideration any Speed Losses. Quality takes into consideration any Quality Losses. [16]

The 6 big losses are described as follows:

1**. Break down losses**: These are losses of quantity via defective products and losses of time due to decreased productivity from equipment breakdowns.

2. **Setup and adjustment losses**: These losses stem from defective units and downtime that may be incurred when equipment is adjusted to shift from producing one kind of product to another.

3. **Idling and minor stoppage losses**: Typically, these kinds of small losses are relatively frequent. They result from brief periods of idleness when between units in a job or when easy to clear jams occur.

4. **Reduced speed losses**: These losses occur when equipment is run at less than its design speed.

5. **Quality defects and rework**: These are product related defects and corrections by malfunctioning equipment.

6. **Startup losses**: These are yield losses incurred during early production, from machine startup to steady state. [1]
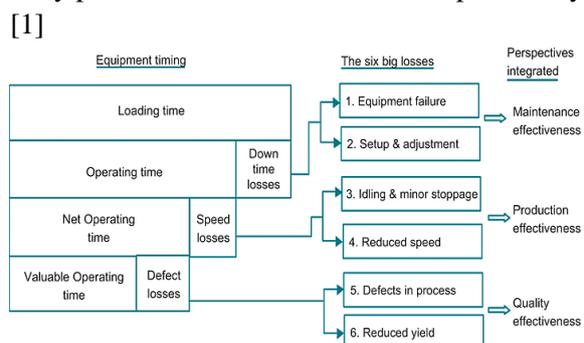

Figure 1: Six Big Losses in OEE

An OEE score of 100% is perfect production: manufacturing only good parts, as fast as possible, with no down time. An OEE score of 85% is considered world class. An OEE score of 60% is fairly typical for discrete manufacturers, but indicates there is substantial room for improvement. An OEE score of 40% is not at all uncommon for manufacturing companies that are just starting to track and improve their manufacturing performance. It is a low score and in most cases can be easily improved through straightforward measures (e.g. by tracking down time reasons and addressing the largest sources of down time – one at a time). [16]

B. The terminologies used in OEE are:

1) RUN TIME (Availability Metric) - The total production time that the machine has been running and producing parts.
2) SETUP TIME (Availability Metric) - The period of time on the machine required for an operator to perform all the necessary tasks to produce the first good part.
3) DOWN TIME (Availability Metric) - The period of time the machine is not available for production due to maintenance or breakdown.
4) TOTAL TIME (Availability Metric) - The total accumulated machine time of Run Time + Down Time +Setup Time.
5) TARGET COUNTER (Performance Metric) - the number of parts or cycles that should be completed at a particular point within the shift, day, or production run.
6) TOTAL COUNT (Performance & Quality Metric) - The total number of parts, good and bad, that are produced on a machine.
7) GOOD COUNT (Quality Metric) - The input count for any part produced to manufacturing specifications on the machine. [12]

II. METHODOLOGY

Generally, OEE captures reasons for downtime such as machine conditions, material status, production personnel or quality issues and can encompass the individual machine level, a line or cell level, or the entire plant. At the plant level, OEE metrics can be correlated with other plant metrics to provide Key Performance Indicators. With enterprise level technologies, such as Executive Dashboard, managers can monitor and maintain OEE plant metrics and drill down to find root causes of problems, getting minute-by-minute updates to enable real-time process improvement. [17]

Nilesh Ayane et al. [2015] [1] reports the importance and benefits of calculating the overall equipment effectiveness for achieving total productive maintenance for a construction equipment. According to the paper, success of any construction company depends on the output from the operations with effective utilization of men, material and machineries. Thus, effective utilization of these construction equipments form the major factor in differentiating the construction companies as heavy or low construction companies. For maintaining the effectiveness of these construction equipments OEE of those equipments has to be calculated. The 6 major losses are identified based on its availability, performance and quality and hence minimizing the breakdown losses, increasing the performance and quality rate. It leads to reducing the overall operation cost and improving the productivity. The cost component usually depends upon the nature of the project and the extent to which equipment is employed. In a building project, the equipment costs may vary from 5% to 10% of the direct costs. While in highway construction projects, the plant and equipment costs may touch as much as 40% of the project direct costs [1]. The main objective is to improve the effective use of equipments by OEE in construction industry. As per this work, Success of OEE depends on various pillars like 5-S, Jishu Hozen, Planned Maintenance, Quality maintenance, Kaizen, Office TPM and Safety, Health & Environment. The key factors for this implementation are workers involvement and top management support [1].

Suresh kumar et al. [2012] [4] proved that overall equipment effectiveness is important for increasing the productivity by reducing the cost. The effectiveness and the energy consumption of the equipments i.e., roaster, destoner, pulverizer and packaging machine used in a food processing industry for a breakfast cereal are calculated. In this work, the utilization of OEE is measured thus, to improve the production performance. Here the efficiency and the energy consumption by each machine are being calculated. The data for calculation of OEE is collected for each machine for different

production planned time like schedule time, downtime etc. The percentage of availability, performance and quality is calculated. The OEE value for destoner at 300 min production planned time is 67.79% and 74.99%. Thus this difference noted is due to ideal run rate and downtime losses. The efficiency and the energy consumed are also calculated with load and without load on the machines. It was found that there was high amount of wastage of energy in the pulverizer when the machines were running without load, due to improper supply of material. The energy loss was due to the high HP of the machine, thus resulting in higher consumption of energy. Hence after analyzing the information collected, it is seen that packaging being the final step of the process had least OEE which had to be improved to compensate the previous processes. It is found that when the OEE score of a machine increases, the total energy consumed is reduced. For reducing the breakdown of machines standard equipment conditions and operating conditions, improvement in operating skill were followed.

According to Dashrath kumar et al. [2014] [5] a company must focus on the improvement of its performance by reducing waste, reducing cost, improving the productivity, quality and satisfying the customer demands. OEE being derived from total productive maintenance (TPM) is used to achieve the above goals in this paper. The equipment effectiveness in a plastic pipe production industry was calculated. The data related to the production of various diameter pipes manufactured for different months were collected. The data related to the planned scheduled time of machines, stoppages, production time, total production for certain shift or period, number of pipes rejected were noted and the three basic metrics: percentage of availability, performance rate, quality rate were calculated. The OEE value 79.38% was obtained before implementing TPM. The 6 major losses were encountered and by implementing the program of continuous and organized improvements of the production processes were carried out. The OEE value after the implementation was 85.44%. Thus due to implementation of TPM the overall effectiveness of the equipment was improved by reaching the world class score. OEE in this paper helped to analyze, monitor and measure the percentage of utilization and identify causes related to the effectiveness of the equipment.

According to Binoy Boban et al. (2013) [2] the OEE can be improved by implementing a maintenance plan in a manufacturing firm. Here, OEE of existing process/ plant is analyzed and compared with the world class OEE score as shown in table 1. The data related to number of shifts and time of each shift is obtained from the manufacturing firm. The total downtime, capacity, batch size and number of rejects are noted. The calculation of OEE for the existing condition of selected machines is calculated as shown below [2].

Availability (A): Operating time /planned production time where,

- Planned production time = Shift length − Break time
- 24 hrs - 0 = 24 hrs (for 1 day)
- 24 * 30days = 720hrs = 43200min
- Operating time = planned production time − down time
- 43200 -10320 = 32880min
- Availability = 32880 / 43200 = 0.7611
- Quality (Q): (Processed amount − Defected amount)
- Processed amount = (761.7 -44) / 761.7 = 0.9422
- Performance (P): (Processed amount / Operating time)
- Capacity = [(761.7 / 32800) / 0.042] = 0.552
- OEE =0.7611 * 0.9422 * 0.552 = 0.3958 = 39.55% ≈ 40%

OEE factor	World class	Obtained
Availability	90.0%	76.11%
Performance	95.0%	55.2%
Quality	99.9%	94.2%
Overall OEE	85.0%	40%

Table 1: comparison of OEE of existing machine and world class score

The OEE of existing machine is 40% is found to be less than the world class score 85%. The score of OEE indicates that performance of machine must be improved immediately. The company here decides to prepare a maintenance plan by implementing TPM tools such as

5S; Jishu Hozen, Kaizen and Planned Maintenance. This will lead to improvement in the effective utilization of machines, thus reducing the downtime, increasing the batch size and reducing the rejects. The OEE score after the implementation of TPM is 44.2%. Here, it is found that the score is increased by 4% due to a maintenance plan implemented by the company, which helped them to improve their performance and quality. It helped to mark a considerable growth in the market by reducing scrap/waste and can be improved by implementing TPM to all machines.

Vijaykumar et al. [2014] [10] reports that improvement in production effectiveness is important factor in a process industry. He explores the problems associated in an injection molding process in a automobile parts manufacturing company. The problems such as breakdown of machine, production adjustments, poor working of defective equipments were noted which lead to major losses in the company's growth. To overcome these problems TPM tools were implemented such as 5S, Jishu Hozen, Kaizen, and Classification of Abnormalities were implemented. The 11 machines that were causing bottlenecks in the injunction process were identified and the data related to each machines such as its capacity, planned time, downtime, setup time, total number of parts produced, number of good and rejected parts are collected. The production detail about the number of shifts, total working days, breaks, meeting times known as planned downtime are noted. Here, OEE of one machine IMM 06- hydraulic machine is calculated before TPM was implanted. OEE=77.09x 89.45x 88.95 = 61.34% [10]. By implementing the TPM tools of standardizing, systemizing and maintaining the process with continuous improvements the bottlenecks were reduced and losses due to these factors were reduced. The planned production downtimes were also reduced. Due to these changed factors, the time taken for setup and change of moulds were reduced which lead to decrease in mechanical, electrical, safety design breakdown factors. Change in production downtime and planned production time, the number of parts planned to be produced were increased which in turn lead to decreased rejection and increased good parts with constant ideal run rate. These change in factors helped improve the effective use of machines. Thus the OEE score after implementation was 81.21%. It was found here that there was a considerable growth in the use of machines. There was a improvement by 19% of all

machines with low machine breakdown, less idling and minor stops time, less quality defects, reduced accident in plants, increased the productivity rate, optimized process parameters, worker involvement, improved profits through cost saving method, increased customer satisfaction and increasing sales.[10]

Vivek prabhu et al. [2014] [6] provides a strategy that the resources can be utilized to its best by optimizing OEE using genetic algorithm. According to the paper, the machines must be reliable to improve the productivity which includes availability of machines with least breakdown. Here the focus is made on reducing the mean time between failures (MTBF) thus reducing the mean time to repair (MTTR) in a tyre manufacturing process. This was achieved by collecting and analyzing data of the number times of failures and root causes for those failures. The statistical data is collected.

MTBF = Total breakdown time / Number of occurrence
MTTR = Total repair time / Number of occurrences
Availability = MTBF / (MTBF + MTTR)
Quality Rate = (Output - Rejected) / Output

OEE is calculated for 5 processing machines i.e. extruding, calendaring, bead making, tyre building, vulcanizing by calculating the availability rate, performance rate and constant quality rate. Here, OEE score is compared by keeping the scale up to 95%. Score above 95% is considered as better performance of machines. The OEE score of all processes except extruding had very less score. Genetic algorithm is used to optimize the performance rate by using solve XL an excel Add-Ins. A genetic algorithm is a iterative process with a set of instructions that is repeated until a best solution is obtained. While optimizing OEE, calculated values are considered as a minimum value and expected values are considered as a maximum value of OEE which is obtained by solving in solve XL. In this paper it is proved that optimization of OEE can be done by using Excel sheet which monitors and measure the data collected. It is seen here that to achieve optimum OEE value of 84.645% optimized values are Availability 90%, Performance Rate 95% and Quality Rate 99%.

According to Muhammad Abdus Samad et al. [2012] [7] downtime, speed losses and quality losses are the factors that affect the improvement in the productivity of a

manufacturing company. In this paper, overall equipment effectiveness in used to calculate, measure, evaluate and monitor these losses by increasing the efficiency of a CNC cutting machine in a shipyard company. The main 3 losses are identified and the key causes that lead to these major problems are identified. OEE was calculated for cutting of 47 steel plates. It was found that out of 100% of production time; only 42% of the time was utilized for cutting whereas other 52% of the time was spent in non-value added operations such as downtime, changeover and breaks as shown in the figure.
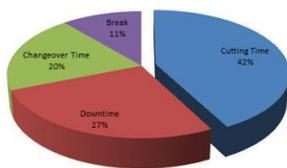
Figure 2: Sub-divisions in plant operating time

The data for 5 days related to the planned production time such as number of shifts, total working hours, number of days were obtained. Here it is noticed that out of 620 parts produced there were 24 parts rejected, thus it was seen that the quality of products produced were reduced. The measure of fully operating time, total operating time and actual operating time was calculated. The OEE score of existing machines were 35.01% which is found to be less than the world class score. It was found that there need to be lot of improvements in availability factor, which was due to high losses in changeover times and breakdown of machines. And also some performance improvement measures were implemented by the company such as 5S was suggested to reduce changeover times, sufficient trucks were allotted for fast delivery, standardization and organization of process, maintenance of the equipments. These helped improve the productivity and growth of the company in the market.

III. CONCLUSION

From the above papers it is evident that, OEE is the one of the simplest way to calculate the effective use of the equipments in a company. OEE is the representation of percentage of time the machine is actually producing quality components in comparison to the time to which it should have been producing quality components. Overall performance of a single piece of equipment, or even an entire firm governed by the cumulative impact of 3 factors: availability, performance, quality. Implementation of OEE in manufacturing concern cannot be a short term goal but, it is a co0ntineous improvement program where higher level of OEE near world class score can be achieved by reducing 6 big losses and implementing of TPM tools. Operational efficiency can be achieved such as improving productivity, reducing breakdown of machines, reducing rejects, improved number of quality products. Implementing OEE program can be considered as cost effective method by calculating the machines effectiveness than that of purchasing new machines. It helps to increase overall output through continuous improvement by identifying the largest priority source of losses. Thus, helps in producing additional number of products in the same time with same equipment. The 6 big losses can be reduced by

- Identifying and monitoring the losses using root cause analysis method
- Implementing single minute exchange of die program which helps reduce set up time
- By providing appropriate training to the machine operators to handle machine stoppages
- Monitoring the data such as wear and tear of machines can help maintain the equipment efficiency.

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