# Evaluation of Overall Equipment Effectiveness in a Heavy Engineering Industry: A Case Study

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## Abstract

This case study research is conducted to measure the Overall Equipment Effectiveness (OEE) of the heavy engineering industry and compare it with world class standards. The primary and secondary data were needed for the study. Primary data was collected from the production line of case industry and secondary data was obtained from maintenance department of the company (previous six months` data) and the internet resources. The data included planned and unplanned downtime, number of shifts, shift lengths, plant operating times, actual operating time, rework and repairs which were necessary for computation of OEE metrics. Moreover, the data on time between failures and time of repairs was also collected from maintenance department of the company. The data was analyzed in MS excel and Minitab. Availability, performance, quality and overall OEE were calculated as 77.50%, 58.94, 97.42% and 44.5% respectively. Whereas, world class standards are availability (90%), performance (95%), quality (99.90%) and overall OEE (85%). To perform like world class manufacturing systems is far bigger challenge than just running it. This paper provides the guidance for calculating OEE and its comparison with world class standards. Further research can be conducted with OEE and other lean tools in the case industry and other industries.

## Keywords
Overall Equipment Effectiveness (OEE), Lean, TPM, Maintenance, Manufacturing.

## 1. Introduction

Production field is an important ingredient to speed up financial growth of the state. Current developments in globalization as well as innovation impact manufacturing systems. Manufacturing companies currently require to regularly improve their performance in addition to efficiency in order to remain to be competitive along with take on market pressures (Haddad et al., 2021). For a number of years, a great deal of firms have actually been making use of lean manufacturing systems following the Toyota version in order to lower in-process profligacy as well as enhance their added value (Lugert et al., 2018). Because of heightened globally competitors in the manufacturing field, typical effectiveness methods disappear valuable in assessing the effectiveness of machines. A lot of the techniques developed have really concentrated on establishing the production performance of a machine for a details period nevertheless stop working to think about the machinery performance background (Muthumanickam et al., 2020). One element maintaining the success of a manufacturing market is figured out by the smooth manufacturing procedure (Nurmutia et al., 2020). Lean manufacturing is the appropriate option for the waste free production (Nurmutia et al., 2020).

The lean manufacturing has shown the great potential in various manufacturing sectors throughout the world (Khan et al., 2020a). There is great potential of lean manufacturing in Pakistan as well ( (Khan et al., 2020b). The manufacturing in Pakistan can get the tremendous benefits by Total Productive Maintenance (TPM), *Value stream mapping* (VSM) and Overall equipment Effectiveness (OEE) to improve its performance (Zaidi et al., 2021).

Lean Production has actually confirmed to be a resilient selection that, when completely taken on by the different celebrities through the supply chain, supplies appropriate cause regards to revenues (Romero and Arce 2017). Since its growth by Toyota in the 1940-50s, lean has ended up being among one of one of the most prominent supervisory paradigms in business ambiences as extensive academic along with empirical evidence has really demonstrated its operation to boost the competition of organizations (Garza-Reyes et al., 2018). Lean manufacturing, a quality administration method initially produced to remove waste in the vehicle industry, is specified as a system that makes use of less inputs and also establishes the very same results while including much more value to clients (De Steur et al., 2016).

The OEE is a requirement for evaluating the operation of the below systems of the equipment; it is made use of for boosting performance of a tool (Muthukumar and Thiruchitrambalam 2020). The OEE sign (Total Equipment Efficiency), devices application indicator, is a worldwide demand for figuring out the operation of machines (Brzeziński and Klimecka-Tatar 2016). (Khan, 2018) & (Khan et al., 2020c) explored the lean manufacturing practices including TPM & OEE and highlighted their applications & substantial benefits related to textile industry. Complete devices effectiveness (OEE) is a crucial operation indication took advantage of to gauge devices performance (Corrales et al., 2020). In recent times, the need for regular production procedures has in fact raised considerably. As a result, a great deal of the strategies that have actually been developed to determine the operation in addition to performance of production treatments are being taken a look at (Muthumanickam et al., 2020). This is utilized not equally as an indication and lorry driver for monitoring and also controlling manufacturing equipment efficiency yet furthermore for the improvement of processes as well as efficiency (Clarence and Daud 2020).

Existing study to enhance the OEE evaluation by conquering its constraints has actually been done. By providing even more specific information, this can inhibit a wrong choice. OEE is the outcome of computation of factors that add to from a product such as, timetable, effectiveness as well as likewise top-notch (Gozali et al., 2020). Khan et al., (2020d) conducted the detailed systematic review of lean manufacturing practices including TPM & OEE and highlighted their applications & benefits in the selected segments of pharmaceutical industry. Access describes the tool or cell being readily offered for production when set up. At one of the most typical levels, when a treatment is running it is creating value for completion user. When a procedure is stopped, it's developing an expense without any connected value. Whether it results from mechanical failing, resources or motorist problems, the cell or machine is either creating or not producing. By contrasting set up run time to real run time, the availability aspect of OEE allows a decision of shed manufacturing as a result of down time (Gozali et al., 2020). Sahito et al., (2020) conducted the case study at the pharmaceutical plant and suggested TPM & OEE for reducing lean wastes. As a result, all processing times as well as operations call for to be cared for as well as analyzed in an excellent way with certain evaluation techniques to attain a stable along with dependable job- circulation to improve as well as sustain the general efficiency (Haddad et al., 2021).This research paper was comprehended with the evaluation of operational efficiency of the ABC manufacturing company by calculating the overall equipment effectiveness.

## 2. Literature Review

Manufacturing is specified as a procedure of changing materials into products. For this reason, companies will make sure that customers are supplied items with the most affordable feasible expense in order to have a lot more reliable and effective production job (Esmaeel et al., 2018, Esmaeel et al. 2018a). Typically, alternate techniques are purposeful to reduce the troubles that happen continuously in the system (Tayal et al., 2021). Tayal et al. (2021) mentioned that existing jobs of literature are largely obsessed on using different techniques in various markets. The OEE is a standard for examining the performance of the sub systems of the machine; it is utilized for boosting efficiency of a machinery. The efficiency of the machinery can be improved, so actions are taken to enhance the performance (Muthukumar and Thiruchitrambalam, 2020). Implementing OEE in developing countries, especially in small and medium-sized organizations is thought of a crucial success to boost these business (Jaqin et al., 2020). OEE is an efficiency proportion between real manufacturing and also what could be preferably produced (Muthumanickam, Thugudam, Ibne Hossain, et al., 2020), (Corrales et al., 2020). Business cannot be separated from issues attached to the performance/effectiveness of the equipment and also devices. It can be seen from the engine that runs daily without a break brought about not all of the high quality of products according to the top-notch requirements set by the business (Siregar et al., 2018). Nallusamy et al., 2018 showed that, downtime losses are not the only influencing standard, yet still time of an equipment is another variable that consists of in the variant in total equipment performance (OEE). It is an idea where the traffic procedures of a particular procedure are lowered to particular extent (Singh and Narwal, 2017). General Equipment Effectiveness (OEE) is amongst the strategies used to determine the efficiency of a tools with 3 measurement variables, particularly; schedule rate, efficiency rate, and premium rate (Tobe et al., 2017). It is evident that the section OEE can be boosted considerably by applying total reliable maintenance lean gadgets such as JishuHozen, Kaizen and so on in a production business (Nallusamy et al., 2018). In today's exceptionally vibrant and quickly changing environment, the globally competitors amongst organizations has actually led the maintenance jobs to précised demands in the manufacturing firm (Singh et al., 2020). OEE can be boosted by lowering the malfunctions as well as changeovers losses which are related to accessibility and by minimizing the flaws as well as setup scraps losses which are connected with excellent quality (Singh and Narwal, 2017). Organization performance, OEE, as well as current enhancements in globalization and also advancement impact making systems. international rivals has required the remedy of both trusted and reputable standards in response to the worldwide economic climates for the purpose of enhancing the total effectiveness (Esmaeel et al., 2018). OEE has actually wound up being gradually prominent as one of the managerial techniques throughout the globe.

Kumar et al. (2020) compared the compared the OEE performance of automobile assembling plant with world class OEE and suggested lean practices for improvement in OEE performance. Rajput et al. (2020) conducted the case study at the automobile assembling plant to improve the productivity and discussed the implementation benefits of TPM, TAKT time and OEE. Lakho et al. (2020) and Virk et al. (2020) presented the detailed review of TPM and OEE in maintenance management activities of various manufacturing sectors and highlighted their implementations and benefits. General devices performance (OEE) is a metrics to assess how properly a production procedure is managed (Esa & Yusof, 2016). Several of the relevant research studies have actually been carried out when it comes to OEE which exists as under.

Nurprihatin et al. (2019) conducted the study on the greatest downtime that took place in a particular line of item and essential machine. This research study contributes to dominating and making the machine's performance and capability better. We make use the Total Effective Upkeep (TPM), which started by determining General Devices Effectiveness (OEE) and also Six Substantial Losses. This research study offered the source of the lowered worth of OEE, provided the performance maintenance strategy according to MTBF as well as MTTR, as well as recommended the TPM implementation. OEE value for WP-ATB 08 machine on line 7 in the packaging location was 71.27%, with availability, efficiency, and top-notch value are 82.56%, 90.83%, 95.04% especially. This OEE worth does not yet get to the world-class conventional worth (85%) and also one of the most budget-friendly worth is the accessibility consider terms of section difference from its private world-class standard (7.44%). Because of this we go deeper right into the particular six massive losses on the equipment, such as failure losses (11.67%), configuration and modification losses (5.76%), and also speed losses on still as well as little interruption (4.11%), reduced speed losses (7.62%), remodel losses (0.67%), and scrap losses (2.87%). We find the highest possible contribution to the reduced OEE worth is malfunction losses. In looking after failing losses, we give the relevant information concerning the MTBF and also MTTR amount to 2313 minutes and 289 mins, particularly. Additionally, we also recommend the strong use the 8 columns of TPM and FIVE to improve the performance (Nurprihatin et al., 2019).

Siregar et al. (2018) performed their at a plant food company in Sumatra, where firms that produce fertilizers in substantial total up to fulfill the needs of customers. Subsequently, to determine as well as enhance the

performance of the tool in the device Plant Urea-1 simultaneously after that utilized technique of Total Tools Effectiveness (OEE), which is one vital element in the General Effective Upkeep (TPM) to gauge the efficiency of the machinery to make sure that it can take actions to preserve that degree. In July, August and September OEE worth over the common set at 85%. At the same time, in October, November and December have really not got to the traditional OEE. The decreased value of OEE as a result of absence of time routine of machines for the production closed down because of the occurrence of the engine enough time to ensure that the ease of access of decreased production time. 1. The worth of OEE obtained throughout July, August as well as September 2016 has actually reached the expected criterion, indicating that the machine is being utilized appropriately. 2. Recommended in boosting the performance of the machine on the Urea-1 Plant System can be boosted with the increase of preventive maintenance that is to inspect the machine periodically as well as execute prompt upkeep (Siregar et al., 2018).

Nallusamy et al. (2018) accomplished research; an effort was made to apply total effective upkeep to accomplish basic tools effectiveness (OEE) near to world class standards. While computing OEE, the components impacting it are recognized and also efficiency renovation actions are tackled. From the observed outcomes, it was discovered that, the portion OEE can be boosted from 55.45% to 68.04% by implementing this approach in device array markets. From the previous files, before the implementation of TPM and OEE is 55.45% just. After efficient application of TPM it was disclosed that OEE is improved to 68.04%. Therefore, the OEE has really been enhanced concerning 13% by reducing the being rejected price as well as general cycle time to satisfy the demand at correct time (Nallusamy et al., 2018).

Singh and Narwal (2017) under taken their study in the thing production market and OEE principles are had a look at in the numerous lines (establishing, property, pinion and so on). The three criteria such as schedule, efficiency as well as top quality of the process are occupied for this function. From this result of factors impacting OEE are examined. Even performance is maximum and also top quality is great but as a result of much less availability OEE get affected as well as its worth finished basically to the value of schedule. It is observed from the result that performance is frequently above or equal to that of schedule because schedule thinks about downtime loss. Entire plant OEE is 88.72% which serves according to top quality OEE it should be more than 85%. It is observed from the calculated information that if we want to improve OEE from established worth we require to enhance availability and quality (Singh and Narwal, 2017). Singh and Narwal (2020) achieved their study to establish the help of OEE propositions for accomplishing core expertise in process sectors. The purpose of the research was to identify the influence of vital OEE suggestions and also dimensions on managerial performance. The paper emphasizes the demand to bring disciplined company modifications in releasing maintenance renovation activities for authorizing the enhancements in the performance of the industry. The above-stated details illustrates that the application of OEE has actually considerably increased the efficiency of equipment of the four workstations as observed by the writers from 2 to 8 percent. The successful OEE execution in addition aids to lower the downtime of linked workstations from 7 to 22 minutes. The being rejected rate of all workstations a little minimizes to 22 to 33 tons every day and also the arrangement time of these workstations additionally came down to 2 to 6 minutes daily. From the above conversations, it is visible that reliable OEE implementation in the sugar mills can bring favorable alterations in the handling market. The advancement of sectors is just practical when the administration will certainly room and also honestly implement performance-enhancing techniques such as OEE (Singh and Narwal, 2020).

Prabowo et al. (2018) intended to assess the application of 8 TPM Columns as well as assess the impacts on producing performance in the form of General Equipment Efficiency (OEE) and Waste. This research study uses questionnaire-based study method. The variety of examples spread is 40 systems. This includes questionnaires returned as well as filled out 33 studies and also which deserves to be refined as numerous as 30 examples. Afterwards examined the trustworthiness and dependability of relevant information using SPSS program. Validity important worth R = 0.361 for n = 30 and also error rate 5%. For stability examination, R value = 0.60 was picked. From the legitimacy exam, there are 7 points of inquiries that are not valid so it is not consisted of in the following process. For the integrity examination of the collection of concerns is rather trusted with the value of Cronbach's alpha of 0.811. From the CFA analysis, only 6 of 8 TPM pillars are significant while for manufacturing performance simply OEE variable is significant. Link in between 8 Pillars of TPM and production performance is Solid sufficient with a value of R = 0.862, which likewise suggests 74.3% (R2) variable manufacturing efficiency can be explained/influenced by variable 8 Column TPM and also 26.7% the remainder by various other variables (Prabowo et al., 2018).

## 3. Problem Statement

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 because they are often operated at

less than full capacity which results in greater cost and less productivity. Competition and the drive for profit is Forcing many Industries to introduce different approaches for improving operational performance. Among them OEE is a major quantitative matrix used for gauging the efficiency of manufacturing lines. This research paper was comprehended with the evaluation of operational efficiency of the ABC manufacturing company.

## 4. Research Objectives

The aim of this research was to compute OEE score of the case company's production line for the product x.

(1) To compute OEE score of the line and compare it to the world standard OEE score
(2) To compare OEE score to the world class standard OEE score

## 5. Research Methodology

### 5.1 Data Collection

For the present research paper, both primary and secondary data were required. Primary data on the subject was collected by deep observation on the line and secondary data was obtained from maintenance department of the company (previous six months` data). The data included planned and unplanned downtime, number of shifts, shift lengths, plant operating times, actual operating time, rework and repairs which were necessary for computation of OEE metrics. Moreover, the data on time between failures and time of repairs was also collected from maintenance department of the company.

### 5.2 Data Analysis

Data obtained from maintenance records were put into MS excel. Analysis included the frequency distribution, graphical representation of the data and Pareto analysis. Graphical representation included bar charts and histograms. Formulae presented in 6.3 were used for the calculation of OEE. In last, calculated value of OEE was compared with world class standard (85%). Moreover, descriptive statistics (mean, STD, co-efficient of variance, maximum, minimum and skewness) was used for the analysis of time between failures and time of repairs. It was conducted in MS excel and Minitab.

## 6. Results

Results are presented into two parts i.e. calculation of OEE and its comparison with world class standards.

| S.No | Shift | Job setting | Date & Shift duration | Operation details | Down time | Down time reason | Budget Hrs | Actual Hrs | Remark |
|---|---|---|---|---|---|---|---|---|---|
| 1- | A & B | First | 5/10/15 ( 6am-10pm)<br>16 hrs shift | Job load at 8:00 am<br>Job setting time-8:00am to 9:20 am<br>Program making and tool preparation 20 min<br>Bore of 140 dia 4-NOS Rough cut, Bore of 160 dia Rough | 120 min<br>15 min<br><br>45 min | 120 min No load<br>15 min more due to crowd in canteen<br>Tool insert unavailable | 30 | 39 | Issue of tool insert from store is a time consuming process which increase down time |
| | C | First | 5/10/15 (10pm-6am)<br>8 hrs | Bore of 160 mm dia complete<br>Bore of 140 mm dia finish cut complete 4-NOS<br>Bore facing 6-NOS complete | 30 min | Insert not available | | | Store Department takes much time to issue new inserts. |
| 2- | A | First | 6/10/15 (6am-2pm)<br>8 hrs | Groove 146*15 width 3 NOS both side<br>Groove 164*10 width 2 Nos both side<br>Drill 17.5*16 , Tap M20*30 deep completed | 60 min | Operator not available | | | working on other machine |
| | B | Second | 6/10/15 (2pm-6pm)<br>8 hrs | Job unload than rotate setting adjustment<br>Drill 26 mm dia complete<br>Bore 45^+.02 finish complete<br>Job completed and rework is carried out. | 15 min | More time in tea break | | | Here 1 Hrs more for Rework due to some unfinished drill and bore end surfaces. |

Figure 1. Description of collected data from the case company

### 6.1 Calculation of OEE

OEE is the product of three contributing factors i.e. availability, performance and quality (Tayal et al., 2021, Nurprihatin et al. 2019). Availability is concerned with the overall stoppage time resulting from, unplanned downtime, process setup and changeovers and other unplanned stoppages, thus the availability is taken into consideration as the theoretical production time which is highlighted against unscheduled downtime. Performance is computed by minor stoppages and speed of the production line. In last, quality which is defined as the ratio of good production to total production.

### 6.1.1 Obtained Data from the Case Company

Primary Data was collected manually by continuous observation from 20-10-2020 morning 8 am to 25-10-2020 Evening (40 hours, 5 Shifts). While secondary data about equipment failure, failure modes and, repair times over a period of 6 months was obtained from maintenance records so that the most occurring failures could be identified. Maintenance staff was responsible for keeping computer-based records of the failures of the line. Those records covered a time period of 180 days. During that period the line operated for 8 hours a day. The collected data covered the Failure mode or modes that had occurred during each shift, the relevant action taken to repair the failure, the downtime and the exact time of failure as can be seen in the figure 1. Based on the records a total of 315 failures were identified for the whole line.

### 6.1.2 Calculation of OEE

Data was gathered in MS excel worksheet and was analyzed to compute the OEE, As per OEE tool method, a calculation excel worksheet was initiated containing required formulae as presented under heading 6.3. Calculation sheet is presented below in figure 2.

| OEE KEY FIELDS DATA | | | | | | |
|---|---|---|---|---|---|---|
| No. of Shifts : | 5 | | | | | |
| Shift Duration : | 8 Hour Shift ( 9:00 AM - 5:00 PM) | | | | | |
| Shift Length (min) : | 480 | | | | | |
| Short Breaks : | 4 | Breaks | 15 | MIN EACH | 60 | Minute |
| Meal Breaks : | 0 | Breaks | 60 | MIN EACH | 0 | Minute |
| Unplanned Downtime : | 285 | Minute | | Scheduled Maintenance | 0 | Minute |
| Change Overtime : | 120 | Minute | | House Keeping of M/C | 60 | Minute |
| Rework Time Duration: | 60 | Minute | | Total Planned Downtime Per Shift | 120 | Minute |
| Planned Production Time: | 1800 | Minute | | | | |
| Total Operating Time : | 2400 | Minute | | | | |
| Actual Completion Time: | 2265 | Minute | | | | |
| Remaining Budgeted Time For | 1335 | Minute | | | | |
| Actual Operating Time : | 1395 | Minute | | | | |

| OEE MATRICES CALCULATIONS | | | |
|---|---|---|---|
| OEE MATRIX | CALCULATION | OEE | OEE% |
| Availibility (A) | *Actual Operating time / Planned Production Time* | 0.7750 | 77.500 |
| Performance Efficiency (PE) | *Remaining Budget Time/Actual Completion time* | 0.5894 | 58.94 |
| Quality Rate (QR) | *Actual Completion Time / ( Rework + Actual Completion Time)* | 0.9742 | 97.42 |
| Overall OEE | *Availibility x Performance Efficiency x Quality rate* | 0.4450 | 44.5 |

Figure 2. Spreadsheet made for the calculation of OEE

A look at the line graph presented in figure 3 indicates that availability, performance and quality were calculated to be 77.50%, 58.94 and 97.42% respectively. Moreover, overall OEE score was calculated to be 44.5%.

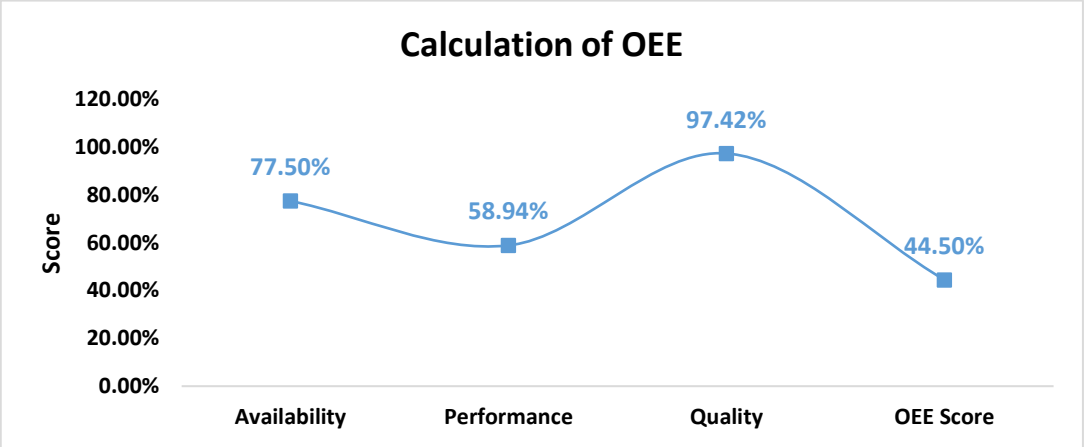


Figure 3. Calculated OEE

### 6.2 Comparison of Calculated OEE with World Class Standard

After the calculation of OEE of production line, when it was compared to the world class standard, it was revealed that it was less than the world class standard i.e. 85% as can be seen in the graph presented in figure 4. Three of the parameters were less than the world class standard and the difference was of greater magnitude.

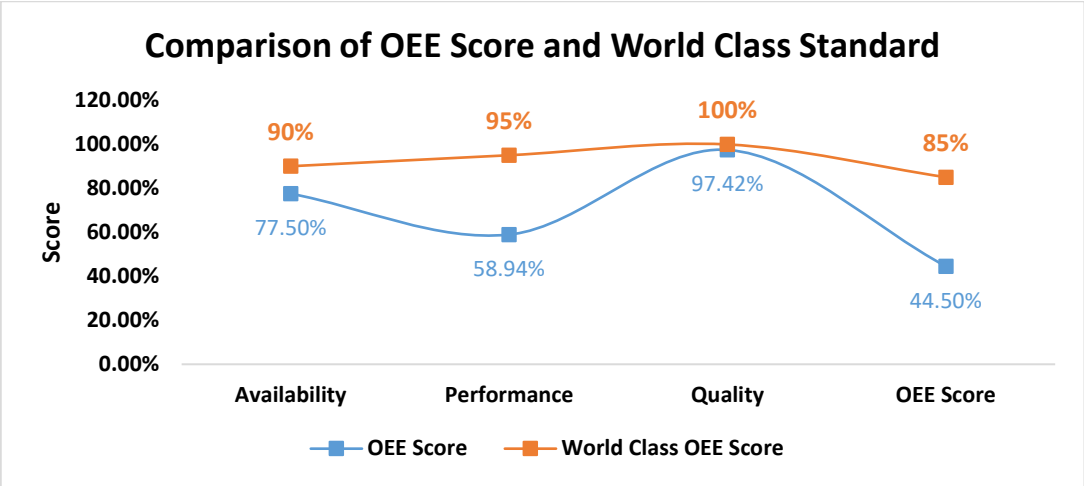


Figure 4. Comparison of calculated OEE with world class standard

## 7. Discussion

A procedure on the production floor can be broken off due to an issue in the manufacturing machinery/ machinery, for example the engine stops suddenly and the length of setup time as well as the decrease in the engine manufacturing rate, the engine generates faulty products and damages to the engine. This causes losses to the firm due to the fact that along with decreasing the efficiency as well as effectiveness of machinery/equipment and also productivity companies additionally resulted in the cost to be induced due to such damage (Siregar et al., 2018).

Many challenges are connected to the capacity of the companies to catch-up with the recent trends of production in order to stay in service (Esmaeel et al., 2018). Increasing performance and efficiency in the industrial area is a required and must be carried out in order to improve the competitiveness of the business (Tobe et al., 2017). Lean Manufacturing is just a team of strategies for the identification and also elimination of the waste inside the worth stream (Tobe et al., 2017). In order to reduce waste in the production system, there are numerous techniques and also OEE is one of them. In the worldwide market today, many manufacturing organizations realized that their survival in the business globe depend highly on obtaining competitive OEE (Esa & Yusof, 2016).

Number of scientists have actually worked on OEE in the context of enhancement in production section. Some their works are talked about. Nurprihatin et al. (2019) computed the value of OEE for WP-ATB 08 machinery on line 7 in the product packaging location was 71.27%, with accessibility, efficiency, and also top-notch value are 82.56%, 90.83%, 95.04% specifically (Nurprihatin et al. (2019). In the present research, the overall OEE performance of the line was calculated to be low i.e. 44.5%. The major causes are speed losses, excessive breakdowns, and high levels of defective products. The most frequent number of failures Occurred on M1 were up to 35% of all failures. Furthermore, machine 3 was accounted for 23% of all failures. Considering the Scores of all three OEE Matrices i.e. performance efficiency need immediate attention for improvement and are probably affecting the final score of OEE to greater extent in comparison to other two matrices. It can also be concluded that minor stoppages and speed losses in production line are most contributing reason for lower efficiency and OEE Score of the line. Singh and Narwal (2017) observed from the calculated information that if we want to boost OEE from determined value we need to enhance access and top quality (Singh and Narwal, 2017). Nallusamy et al. (2018) carried out the effective application of total effective maintenance (TPM) and also it was disclosed that the worth of OEE was boosted to 68.04%. Therefore, the OEE has really been boosted worrying 13% by reducing the being rejected rate and also basic cycle time to satisfy the demand at correct time (Nallusamy et al., 2018). Siregar et al. (2018) performed their research study in fertilizer business and recommended in improving the effectiveness of the machine on the Urea-1 Plant System be boosted with the rise of precautionary upkeep that is to examine the machinery periodically and execute timely upkeep (Siregar et al., 2018). Singh et al. (2020) said that effective OEE implementation in the sugar mills can bring positive

alterations in the handling market. The growth of markets is simply practical when the administration will certainly space and honestly carry out performance-enhancing methods such as OEE (Singh et al., 2020). In the present research, availability of the line is 82.4% which is coincided with the target's availability (90%) of the production line. The Current performance efficiency of the line is 97.5%, which diverts a little from the target (99.9%). These losses are usually connected to the minor stoppages due to not having the access of needed tools or their distant access as the problems occurred on machine 5 and 6.

## 8. Conclusion and Suggestions

The operation of the production line is not so efficient; therefore the availability, performance and quality should be improved. In addition, unfavorable impact of the failures on the production process should be avoided. It was suggested to upgrade the operation management, through total productive maintenance (TPM) programs.5 why and cause and effect diagrams were also the suggested tool for the improvement of OEE score for the improvement of OEE score. It was observed that housekeeping of machine was used to be carried out during machining hours, which accounts for up to 120-minute delay. So, if housekeeping of machine was to be carried out during lunch time or during break time; in this way, delay can be reduced to 40 minutes from 120 minutes. Tool unavailability was a big problem it usually took huge time to find the tools from other machines; so during that period machine was used to be ideal. In this regard, if the authority ensures the availability of tools on the line, much of the productive time can be saved.

## 9. Future Implications

Further research can be conducted on how the OEE score can be improved further in the case company. There are many other lean tools to organize the maintenance tools and devise the maintenance policy in order to achieve the handsome rates of productivity and efficiency. The other lean tools can be explored in future.

## 10. Limitations

Due to time constraint and data access limitations, researchers could not managed to spend time on the other areas of the industry and other lean practices. The TPM & OEE are remained the focused lean practices to the targeted area of the industry.

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## Conflict Of Interest

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

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