# A REVIEW OF OVERALL EQUIPMENT EFFECTIVENESS

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**Abstract:** *The Overall Equipment Effectiveness (OEE) calculation is a metric that gives us daily information about how effectively the machine is running and which of the six big losses we need to improve. Overall equipment effectiveness is not the only indicator to assess a production system, but it is certainly very important if our goal is improvement. OEE is sometimes referred to as Utilization and is the percentage of your total productive capacity that you are actually using. The aim of this paper is to make a review on the method of calculus of the equipment performance indicator, Overall Equipment Effectiveness*

**Keywords:** *Overall Equipment Effectiveness, capacity, system.*

## 1. Introduction

OEE is a "best practices" way to monitor and improve the effectiveness of your manufacturing processes. OEE is simple and practical. It takes the most common and important sources of manufacturing productivity loss, places them into three primary categories and distills them into metrics that provide an excellent gauge for measuring where you are - and how you can improve! [Vorne, 2008].

The first application of OEE can be traced to the late 1960's when it was used by Seiichi Nakajima at Nippon Denso as a key metric in TPM. According to Nakajima, "TPM is a plant improvement methodology, which enables continuous and rapid improvement of the manufacturing process through the use of employee involvement, employee improvement and closed-loop measurement of results." [Brag, 2003]

Honda (2000) stated that OEE is a measure of how well equipment or lines are utilized in relation to their full potential. OEE is based on the product of three individual factors, Availability (Operating Rate), Performance efficiency and Quality rate. The main objective to measure OEE is to make constraint or "bottleneck" equipment run more effectively. OEE and its individual factors will give the plant numbers to see where the equipment is loosing time, i.e. if it has much downtime or has speed losses or if the quality is poor [Högfeld, 2005].

The goal of measuring OEE is to improve the effectiveness of your equipment. Since equipment effectiveness affects shop floor employees more than any other group, it is appropriate for them to be involved in tracking OEE and in planning and implementing equipment improvements to reduce lost effectiveness. Let's look at some of the benefits of OEE measurement for operators and shift leaders or line managers.

It's recommend that the operator collect the daily data about the equipment for use in the OEE calculation. Collecting this data will:

- teach the operator about the equipment;
- focus the operator's attention on the losses;
- grow a feeling of ownership of the equipment.

The shift leader or line manager is often the one who will receive the daily operating data from the operator and process it to develop

information about the OEE. Working hands on with the data will;

- give the leader/manager basic facts and figures on the equipment;
- help the leader/manager give appropriate feedback to the operators and others involved in equipment improvement;
- allow the leader to keep management informed about equipment status and improvement results.

One of the major goals of OEE is to reduce and/or eliminate what are called the Six Big Losses – the most common causes of efficiency loss in manufacturing, figure 1.

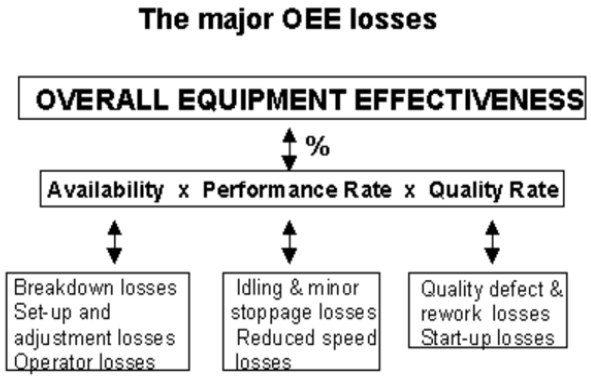


**Figure 1**. *The OEE losses*

The following table lists the Six Big Losses, and shows how they relate to the OEE Loss categories [Vorne, 2008].

**Table. 1** *OEE Loss Category*

| Six Big Loss Category | OEE Loss Category | Event Examples | Comment |
|---|---|---|---|
| ***Breakdowns*** | Down Time Loss | Tooling Failures/Unplanned Maintenance/ General Breakdowns/Equipment Failure | There is flexibility on where to set the threshold between a Breakdown (Down Time Loss) and a Small Stop |
| ***Setup and Adjustments*** | Down Time Loss | Setup/Changeover /Material Shortages/Operator Shortages/ Major Adjustments/Warm-Up Time | This loss is often addressed through setup time reduction programs. |
| ***Small Stops*** | Speed Loss | Obstructed Product Flow/Component Jams Misdeeds/Sensor Blocked/Delivery Blocked/ Cleaning/Checking | Typically only includes stops that are under five minutes and that do not require maintenance personnel. |
| ***Reduced Speed*** | Speed Loss | Rough Running/Under Nameplate Capacity/Under Design Capacity/ Equipment Wear/Operator Inefficiency | Anything that keeps the process from running at its theoretical maximum speed |
| ***Startup Rejects*** | Quality Loss | Scrap/Rework/In-Process Damage/ In-Process Expiration/ Incorrect Assembly | Rejects during warm-up, startup or other early production. May be due to improper setup, warm-up period, etc. |
| ***Production Rejects*** | Quality Loss | Scrap/Rework/In-Process Damage In-Process Expiration/Incorrect Assembly | Rejects during steady-state production. |

## 2. The OEE metric

Overall Equipment Effectiveness (OEE) is a powerful metric that reflects the true performance of your manufacturing cell. OEE is sometimes referred to as Utilization and is the percentage of your total productive capacity that you are actually using. For example, if your OEE is 50% (which is surprisingly common) your cell is theoretically capable of producing twice as many acceptable parts as it currently making. The remaining 50% is often referred to as your "hidden factory" – capacity that you really need, but can't seem to find. A low OEE is often responsible for overtime, additional shifts and the possible acquisition of unnecessary capital equipment. World-Class OEE is considered to be greater than 85-90%.

OEE breaks the performance of a manufacturing unit into three separate but measurable components: *Availability - Av*, *Performance – Perf,* and *Quality - Q*.

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OEE breaks the performance of a manufacturing unit into three separate but measurable components: *Availability - Av*, *Performance – Perf,* and *Quality – Q,* figure 2.

$$OEE = Av \times Perf \times Q$$

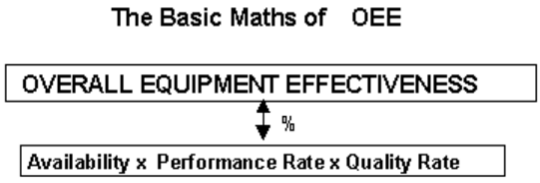


**Figure 2**. *The Basic Maths of OEE*

The Availability - *Av* is a percentage number showing how the machine was available when it was needed for production. It looks at the first two of the 6 Big Losses, Breakdowns and Setup/Adjustments. That is the downtime that is measured at the equipment. Usually if the measurements at the equipment/machine are collected manually it is times longer than 5-10 minutes.

Availability is calculated by dividing the Actual Operating Time by the Loading Time. The actual operating time is the loading time minus the sum of all downtime losses while operating, i.e. breakdowns and changeovers.

$$Av = Actual\ Operating\ Time / Loading\ time$$

$$Actual\ Operating\ Time = Loading\ time - Unplanned\ Downtime$$

$$Loading\ time = Total\ Available\ Time - Planned\ Downtime$$

The Performance Efficiency - *Perf* takes into account the unrecorded downtime. That is the third and fourth of the 6 Big Losses, all unrecorded downtime, i.e. short stoppages, usually less than 5-10 minutes and losses due to the difference between ideal cycle time and actual cycle time.

To be able to calculate the performance efficiency an ideal cycle time for the job running at the machine is needed. If the ideal cycle time is multiplied with the total parts produced the outcome will be the time it should have taken to produce the parts. To calculate the performance efficiency the time it should have taken is divided by the actual operating time.

$$Perf = (Total\ Parts\ Run \times Ideal\ Cycle\ Time) / Actual\ Operating\ Time$$

The quality rate captures the last two of the 6 Big Losses; time loss due to the rejected parts during production and the losses from initial startup to process stabilization. The quality rate is calculated by dividing the good parts produced by the total number of parts produced.

$$Q = (Total\ Parts\ Run - Total\ Defects) / Total\ Parts\ Run$$

## 3. Calculate the OEE metrics for a production cell

The production cell, analyzed in this study, is designed to produce alternatively two different types of products. Therefore, the monthly quantities required by the customer for the products are 320 products A and 640 products B.

The production cell works with reduced working week (5 days/week), in three shifts of 8 hours, with 30 minutes break per shift for the operator to eat and rest.

The application of the OEE for this cell is presented in figure 3.

| | Equipment ID: Production cell | | DATE | 2.04.2017 |
|---|---|---|---|---|
| | | | Shift no/day | 3 |
| EQUIPMENT AVAILABILITY | | | | |
| A. | Total Availability time | | 1440 | mn |
| B. | Planned Downtime | | 90 | mn |
| C. | Net Availability Time | | 1350 | mn |
| D. | Unplanned Downtime | | | |
| | | # breakdowns | 42 | mn |
| | | # setup | 10 | mn |
| | | # mirror breakdowns | 0 | |
| | | Total | 52 | mn |
| E. | Operating Tme | | 1298 | mn |
| F. | AVAILABILITY - Av | | 96.15 | % |
| EQUIPMENT PERFORAMNCES EFFICIENCY | | | | |
| G. | Total parts run (goods and bad) | | 2400 | sets |
| H. | Ideal cycle time | | 0.5 | mn/set |
| I. | PERFORMANCES - Perf | | 92.45 | % |
| QUALITY RATE | | | | |
| J. | Total Defects | | 200 | sets |
| K. | QUALITY | | 91.67 | % |
| | OVERALL EQUIPMENT EFFECTIVENESS | | 81.48148148 | % |

**Figure 3.** *Calculate the OEE for the production cell*

OEE it is a great tool for showing where biggest time losses are during production. In the following I will present the OEE diagrams where:

- the net operating time is the operation duration from which it was subtracted the MIA time;
- the valuable operating time is the net operation time from which was subtracted the time in of defect making.

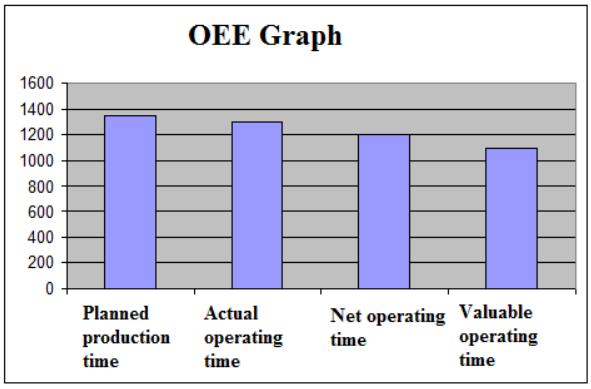


**Figure 4.** *OEE graph showing the time losses in minute*

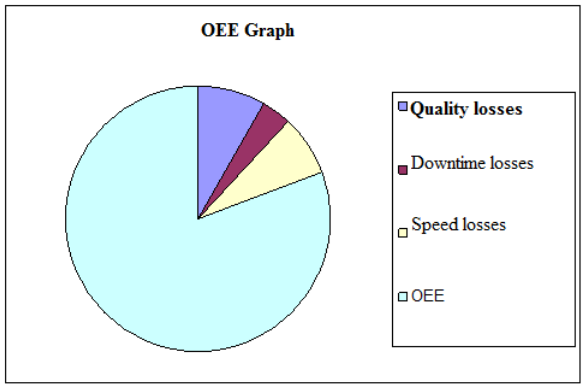


**Figure 5.** *OEE graph showing the time losses in percent*

## 4. Conclusions

Based on the wide spread and diverse understanding and use of OEE, there are several cautions regarding its use:

- The calculated OEE (OEE percentage) is not intended for use as a corporate or plant level measure. OEE percentage is a rough measure of selected equipment effectiveness only;
- Calculated OEE is not valid for comparing or benchmarking different assets, equipment, or processes. OEE is a

relative indicator of specific single asset effectiveness compared to it self over a period of time. However, OEE can be used to compare like equipment in like situations producing like products or output;

- OEE does not measure maintenance effectiveness because most of the loss factors are outside the direct control of the maintainers;
- There appears to be no valid specification of "world-class OEE." However, 85 percent OEE has been cited frequently. Also, "maximizing OEE" may not be justifiable. Optimum levels of OEE largely depend on the capability or capacity of the asset, the business demands, and whether it is a constraint in the process flow;
- OEE percentage calculations are not statistically valid. A calculated OEE percentage assumes that all equipment-related losses are equally important and that any improvement in OEE is a positive improvement for the business. This is generally not the case. OEE percentages can actually improve while actual quality losses increase significantly. OEE percentages can actually decline while output improves – efficiency and quality losses are reduced and the same planned output is generated in less time thereby lowering the "availability" percentage.

## 4 References

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