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# A Literature Review on Overall Equipment Effectiveness

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## Abstract

Overall equipment effectiveness (OEE) is a concept where the bottleneck operations of a particular process are reduced to certain extent. A pilot scale study is under taken in the product manufacturing industry and OEE concepts are implemented in the job floor. The three parameters such as availability, performance and quality of the process are taken up for this purpose. The OEE concepts were implemented in a periodic manner and continuous improvement in the job floor was monitored which proved some positive output

***Keywords****:* Overall equipment effectiveness (OEE; Availability; Performance; Quality.

## 1. Introduction

It's not uncommon today to find owners and operators of production facilities looking for ways to improve the performance of their assets and the quality of their products. So what's new about that?
The financial pressure from company stakeholders is greater than ever before. To maintain a competitive business means getting more from the assets you already have. Your customers, your supply chain, the cost of capital, cost of labor and the shareholders are all driving businesses to increase production and reduce costs without resorting to major capital investment and without compromising product quality.
As any plant manager would attest this is easier said than done, and the clear majority of production facilities still have enormous potential for improvement when it comes to plant performance. So why is it so difficult?
The inability to access reliable and timely plant information and ad hoc approaches and knowledge that only exist in people's heads all contribute to making this difficult. This white paper explores the key steps needed to realize genuine performance improvement using well known methodologies combined with next generation MES applications.
In recent times we have experienced a consolidation in the approach taken to performance improvement that is surprisingly common across a diverse range of industries. The most common approach to performance measurement is the use of the KPI known as Overall Equipment Effectiveness (or OEE). While not a new concept, it is only now being recognized in industries far removed from automotive or pure manufacturing where its roots have been. This means we now have a well-defined method of measuring plant performance that has universal meaning and acceptance.

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### *1.1 Efficiency, effectiveness and productivity*

There are certain terms that are often used in different ways. Three of them are efficiency, effectiveness and productivity. Therefore it is necessary to start with giving their definition. An installation produces outputs by transforming inputs. An installation is a certain well chosen level of corporate assets where a transformation process takes place. For instance, in the welding line of a car factory, steel (input) is transformed into car doors (output). However steel is not the only input. Labor and energy are other examples of an input.[1]

Productivity is defined as the actual output over the actual input (e.g. number of cars per employee).
The effectiveness of the installation is the actual output over the reference output. Productivity can be influenced not only by changing the effectiveness but also by altering the efficiency; this is the actual input over the reference input.

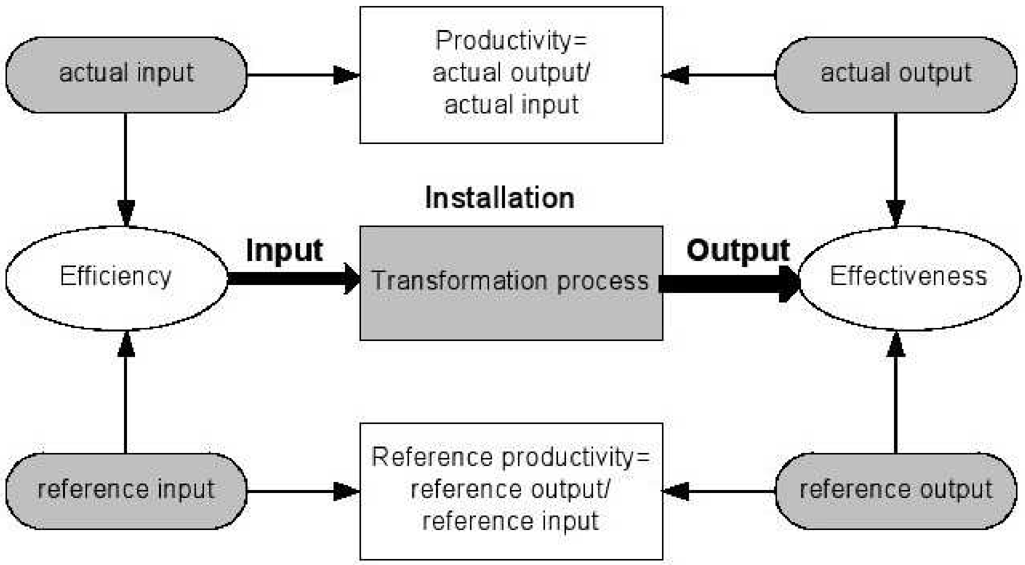


**Figure 1:** Efficiency, effectiveness and productivity

It is obvious that installation effectiveness is one of the important factors that influence the production cost-prize. Other contributing factors are raw materials, utilities, people and work methods. Raw materials as input can be actual raw materials as well as semi manufactures (altering the raw material to create a portion of, but not the final product), from a previous installation but they have to be exterior to the own installation. It should be clear that the maximization of installation effectiveness can't be the one and only goal. The costs of maximizing effectiveness should not outweigh the benefits.

OEE stands for Overall Equipment Effectiveness. It is a measure of how effective your installations are. There are different ways of defining OEE. In this chapter one definition will be given. In the appendix another definition will be given that is widely spread in literature but is not always applicable in practice. The latter definition is only added for reasons of completeness. [1]

## 2. Literature Review

OEE is defined as a key metric in Total Productive Maintenance (TPM) and Lean Manufacturing programs that gives a consistent way to measure the effectiveness of TPM and other initiatives by providing an overall framework for measuring production efficiency. Company-wide, TPM is concerned with eliminating all forms of waste. OEE shows how well a company is utilizing its resources, which include equipment, labour and the ability to satisfy the customer in terms of delivering quality products.

Overall Equipment Effectiveness (OEE) is a way to monitor and improve the efficiency of your 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 companies to improve their processes and in turn ensure quality, consistency, and productivity measured at the bottom line.

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

OEE = Availability × Performance Efficiency × Quality

**Metric 1: Availability**

Availability = Run Time / Total Time

**By Definition**: Percentage of the actual amount of production time the machine is running to the production time the machine is available.

Simple OEE: The total run time of the machine subtracting all unplanned downtime.

**Metric 2: Performance**

Performance = Total Count / Target Counter

**By Definition:** Percentage of total parts produced on the machine to the production rate of machine.

Simple OEE: How well a machine is running when it is running?

**Metric 3: Quality**

Quality = Good Count / Total Count

**By Definition:** Percentage of good parts out of the total parts produced on the machine.

Simple OEE: How many good parts versus bad parts a machine has produced.

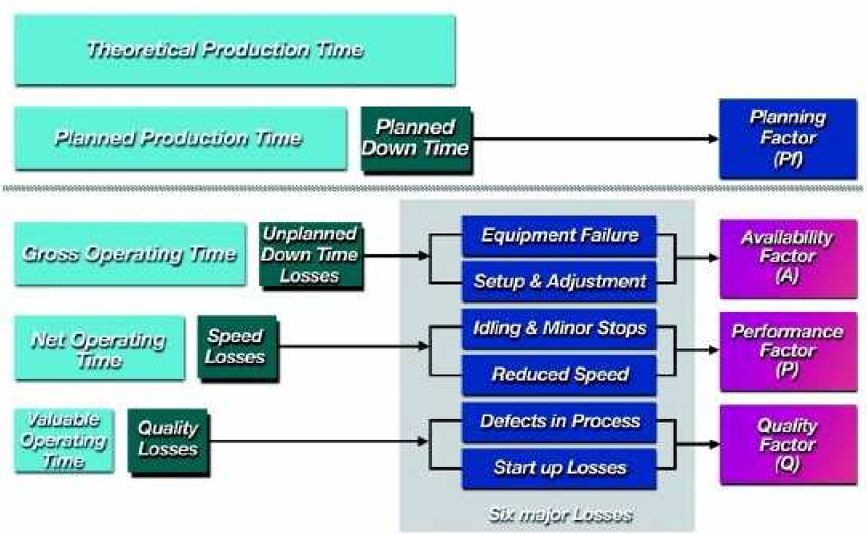


**Figure 2:** Overall Equipment effectiveness

Consistent improvement or a high OEE shows that a company is successful in driving out waste and improving customer service. Three key parameters are measured, which are combined together to produce a measure of equipment effectiveness known as Overall Equipment Effectiveness (OEE).
These three measures are:

- **Availability**: - This monitors how long a machine is actually available to operate (i.e. available time minus planned and unplanned downtime) measured against the total net available time, (i.e. available time minus any planned downtime)
- **Performance Efficiency**: - This records the production rate or speed of the production process versus the design or ideal rate.
- **Quality**: - A measure of the percentage of defects produced by the process.

Overall Equipment Effectiveness (OEE) is a key measurement of efficiency in manufacturing processes (at machine, manufacturing cell or assembly line levels).

The concept had its roots in the Total Productive Maintenance (TPM) concept first conceived and used in the Japanese automotive industry in the 1960s and 70s. Thanks to the work of Seiichi **Nakajima [2]** of Nippon Denso, a major supplier to Toyota, the western world heard of and started to adopt this tool in the late 1980s. OEE at its simplest form is the cumulative impact of three factors – availability, performance and quality.

**Huang S H et al. [2004] [3]** proved that Competition and the drive for profits are forcing companies to implement various productivity improvement efforts. Implementation of total productive maintenance (TPM) techniques has led to significant productivity improvements for individual equipment, particularly in the semiconductor industry. The productivity improvements achieved at the equipment level are significant but insufficient because what a company really needs is a highly efficient system/factory. This is especially true in the discrete manufacturing industry. In this paper, an approach, based on overall equipment effectiveness (OEE), is developed to model the productivity of a manufacturing system in terms of overall throughput effectiveness (OTE). Sensitivity analysis and theory of constraints are used to help identify productivity improvement opportunities.

Remarkable improvements have occurred recently in the maintenance management of physical assets and productive systems, so that less wastage of energy and resources occur. The requirement for optimal preventive maintenance, using, for instance, just-in-time (JIT) and total quality-management (TQM) techniques, has given rise to what has been called the total productive maintenance (TPM) approach. The study of **Probert [4]** explores the ways in which Nigerian manufacturing industries can implement TPM as a strategy and culture for improving its performance and suggests self-auditing and bench-marking as desirable prerequisites before TPM implementation.

**Mark et al. [2005] [5]** put a strategy stating that developing society needs to adapt to change and foster creativity. In the pursuit of continual improvement (e.g., reducing fossil fuel consumption and waste, better service performance, greater availability and improved reliability), implementing wise maintenance-schedules is essential for contemporary organizations. Several studies of a wide range of Nigerian industries indicate that indigenous low availability and low productivity are endemic. The resulting closure of some of these industries has triggered off a realization of the strategic challenges in maintenance management. In addition, the increasingly-competitive business environment in Nigeria has raised the strategic importance of maintenance functions, especially in organizations with significant investments in physical assets. Five strategic aspects of maintenance management have been identified, namely: maintenance methodology; support processes; organization and work structuring; comparable culture; and general management policy **[6-9].** Three factors that permeate these dimensions are wise leadership, excellent communications and an understanding of the human factors involved.

According to **Nakajima et al. [1988] [10]** Overall Equipment Effectiveness (OEE) is viewed as key performance measure in mass-production environments applied to any kind of product. It was introduced by Nakajima [1988] in the context of Total Productivity Maintenance (TPM) and is focused at equipment /

machines. Being aggregated metric instead of many detailed metrics, OEE is experienced as user friendly and clear overall metric and appreciated professionals.

According to **Huang et al. [2003] [11]** report that the concept of OEE is becoming increasingly popular and that it has been widely used as a quantitative tool essential for the measurement of productivity in semiconductor manufacturing operations, because of extreme capacity constrained facility investment. They state that traditional metrics for measuring productivity, throughput and utilization, are insufficient for identifying the problems and underlying improvements needed to increase productivity.

OEE is defined as a measure of total equipment performance, that is, the degree to which the equipment is doing what it is supposed to do. Many aspects of OEE have been considered as, states that the definition of OEE does not take into account all factors that reduce the capacity utilization, e.g.planned downtime, lack of material input, lack of labour. Moreover, the available time for operation would be a more appropriate basis for time measurement than the loading time as it was originally used. Similarly, a fixed planned production time and calculates the difference between the actual and planned production time

OEE is a "best practices" way to monitor and improve the effectiveness of your manufacturing processes (i.e. machines, manufacturing cells, assembly lines).

OEE is frequently used as a key metric in **TPM** (Total Productive Maintenance) and **Lean Manufacturing** programs and gives you a consistent way to measure the effectiveness of TPM and other initiatives by providing an overall framework for measuring production efficiency.

## 3. OEE Terminology:

This section describes the various plant manufacturing terms that make up Simple OEE and the three metric values (Availability, Performance, Quality) used in the calculation of Simple OEE.**[12]**

**(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.

**(8) AVAILABILITY** = Run Time / Total Time

**(9) PERFORMANCE** = Total Count / Target Counter

**(10) QUALITY =** Good Count / Total Count

**Simple OEE** begins with Planned Machine Run Time and with reductions from the three metrics, **Availability** (Downtime Losses), **Performance** (Speed Losses), and **Quality** (Quality Losses) determines the Final Machine Run Time.

**Availability** takes into consideration any Down Time Losses

**Performance** takes into consideration any Speed Losses

**Quality** takes into consideration any Quality Losses

## 4. Loss Categories of Simple OEE

On the previous section, we explained that the three Loss Categories reduce the Planned Run Time of the machine. Listed below in Table 1 are the three Loss Categories (Down Time, Speed, and Quality) of Simple OEE and examples of events that can occur in a production process of a machine to reduce productivity. These Loss Categories contribute to lowering the overall Simple OEE value of the machine. [12]

**Table 1**: (Loss Categories)

| Simple OEE Loss Category | Simple OEE Metric | Loss Category Examples |
|---|---|---|
| Down Time Losses | Availability | 1. Equipment Failures<br>2. Tooling Damage<br>3. Unplanned Maintenance<br>4. Process Warm Up<br>5. Machine Changeovers<br>6. Material Shortage |
| Speed Losses | Performance | 1. Product Misfeeds<br>2. Component Jams<br>3. Product Flow Stoppage<br>4. Level of Machine Operator Training<br>5. Equipment Age<br>6. Tooling Wear |
| Quality Losses | Quality | 1. Tolerance Adjustments<br>2. Warm Up Process<br>3. Damage<br>4. Assembled Incorrectly<br>5. Rejects<br>6. Rework |

**100% Availability = No Down Time Losses**
- Machine has been running without any recordable stops

**100% Performance = No Speed Losses**
- Machine has been running at the maximum speed (target counter)

**100% Quality = No Quality Losses**
- Machine has not produced any bad parts (bad/reject/rework)

## 5. Major Loss Events Affecting Simple OEE:

There are many events within a manufacturing process that can affect Simple OEE. The major goal behind a Simple OEE program is to minimize or reduce the causes of inefficiency in the manufacturing environment. Below in Table 2 is a list of the Major Loss Events that commonly occur to decrease the productivity and efficiency of a machine and the Loss Category associated with the Simple OEE Metric. [12]

**Table 2** (Major Loss Events)

| Major Loss Event | OEE Metric | Loss Category | Example of Loss Category |
|---|---|---|---|
| Machine Breakdowns | Availability | Down Time | Equipment Failures, Tooling Damage, Unplanned Maintenance |
| Machine Adjustments /Setups | Availability | Down Time | Process Warm Up, Machine Changeovers, Material Shortage |
| Machine Stops | Performance | Speed | Product Misfeeds, Component Jams, Product Flow Stoppage |
| Machine Reduced Speeds | Performance | Speed | Level of Machine Operator Training, Equipment Age, Tooling Wear |
| Machine Startup Bad Parts | Quality | Quality | Tolerance Adjustments, Warm Up Process, Damage |
| Machine Production Bad Parts | Quality | Quality | Assembled Incorrectly, Rejects, Rework |

## 4. Conclusion

OEE is not the solution to all the problems, in fact simply measuring OEE is of no use. OEE works best when it is used as a strategy i.e. as a part of overall organization improvement plan. Any policy deployment should cascade relevant elements of OEE data down to individual department managers and staff. This is necessary to ensure that it is not the sole responsibility of production or maintenance department to improve OEE; other departments are also equally involved. OEE is a measure of overall efficiency of an organization and it has a direct impact on company’s bottom line. A greater return on investment is expected by improving OEE. It is also an effective tool of comparison within plant, at different sites and also against competitors.

## 5. Results and Discussion

Skills matrix was developed aligned to the One Best Way, which highlighted key skills gaps across the organization. This was used to priorities training and coaching plans, at both an Individual and team level. The skills matrix also enabled experts to be identified who subsequently played a key role in developing other staff through training and coaching. Buddies were also identified to cover unplanned absence. Annual business objectives were revised for Project Managers, increasing the focus of the PMs and their line management on financial control during reviews.

## 6. Scope of Future Work

The data's obtained from the industry can be entered in the software and the simulated outputs can be interoperated. The software includes TIMERPRO and VIP-PLANOPT. The various parameters involved in causing the downtime should be periodically monitored and other quality tools should be implemented in the factory floor in order to improve the machine performance.

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### A Brief Author Biography

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