Evaluating the performance of a production line by the Overall Equipment Effectiveness: An approach based on Best Manufacturing Practices

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Abstract

The work presented in this paper constitutes a contribution to improve and evaluate the performance of a production line, by using the Overall Equipment Effectiveness (OEE) indicator. In this paper, we propose and implement an OEE improvement approach based on Best Manufacturing Practices (BMPs) and applied to a case study of a production line at a food company. To do this, we conducted an internal benchmarking study to select BMPs and we applied them to improve the performance of this production line and then, the total performance of the OEE. By applying these Best Manufacturing Practices (BMPs) to this production line, we were able to improve its performance from 63 % to 84 %. In addition, the OEE was improved from 45% to 70%.

Keywords:
Overall Equipment Effectiveness; production line; performance; Best Manufacturing Practices.

1. Introduction

Today's market and competitive pressures require companies to develop and maintain a high level of coherence between their strategy, action programmers, practices and performance. A lot of effort has been put into identifying "best" practices to support companies achieve superior performance. However, most research has failed to investigate the effect of these practices on performance, whilst perhaps even less is known about the extent to which they are indeed generic. Therefore, this paper will take a different perspective.

In the industrial sector, the production companies tend to employ methods and tools to measure the production performance. The main reason is the need to quantify the achievement of the objectives set by the companies and, consequently, to identify areas of improvement (Huang et al., 2003; De Carlo et al., 2014).
The pursuit of operational excellence at workshops in production companies is a driving factor for continuous improvement, and therefore for the international competitiveness and business success (Roessler and Eberhard, 2015).

This necessity for efficient production systems results in the appearance of numerous papers in the literature that deal with the measurement of system performance (Muthiah and Huang, 2006; Neely et al., 2005; Gomes et al., 2004; Tangen, 2005).

The major goals of these tools of measuring production performance are to free up capacity and therefore to create more value from existing resources with fewer additional costs (Baggaley, 2006; Erlach, 2010; Roessler and Eberhard, 2015). Among the most used tools to achieve the goals, there is the overall equipment effectiveness (OEE) indicator which will be discussed in this article.

The Japan Institute of Maintenance (JIPM) developed the indicator Overall Equipment Effectiveness (OEE), which became widely used in many industries. In addition, it is the key methodology for improving the quality and Lean production. The strength of the OEE index is in making losses more transparent and in highlighting areas of improvement (Iannone and Nenni, 2013).

In this paper, we propose and implement an OEE improvement approach based on Best Manufacturing Practices (BMPs) and applied to a case study of a production line at a food company. For this, we conducted an internal benchmarking study to select BMPs to improve the performance of the production line that will be the subject of our case study. Then, we applied these Best Manufacturing Practices (BMPs) to our production line to improve his performance and then, the total performance of the OEE.

2. Research background

2.1. Overall Equipment Effectiveness

Overall Equipment Effectiveness (OEE) is a way to monitor and improve the efficiency of the manufacturing process. OEE is a hierarchy of metrics proposed by Seiichi Nakajima (1988) to measure the performance of the equipment in a factory. These metrics help gauge the plant's efficiency and effectiveness and categorize the key productivity losses that occur within the manufacturing process.

OEE is a powerful tool that can be used also to perform diagnostics as well as to compare production units in different industries. The OEE has born as the backbone of Total Productive Maintenance (TPM) and then of other techniques employed in asset management programs, Lean manufacturing (Womack et al., 1990), Six Sigma (Harry, 1998), and World Class Manufacturing (Womack et al., 1990).

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. By definition, OEE is the calculation of Availability, Performance, and Quality.

$$OEE = Availability\ x\ Performance\ x\ Quality \quad (1)$$

OEE is not only a metric, but it also provides a framework to improve the process. A model for OEE calculation aims to point out each aspect of the process that can be ranked for improvement. There are many events within a manufacturing process that can affect OEE. The major goal behind an OEE program is to minimize or reduce the causes of inefficiency in the manufacturing environment.

The Table 1 represents a list of the Major Loss Events that commonly occur to decrease the productivity and efficiency of a machine. We find also the Loss Category associated with the OEE Metric.

Table 1. 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 Ajustements/Setups	Availability	Down Time	Process Warm Up, Machine Changeovers, Material Shortage
MachineStops	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

On the base of six major Losses Events, it is possible to understand how the Planned Machine Run Time decreases until to the Final Machine Run Time and the effectiveness are compromised. Let us go through the next Figure 1.

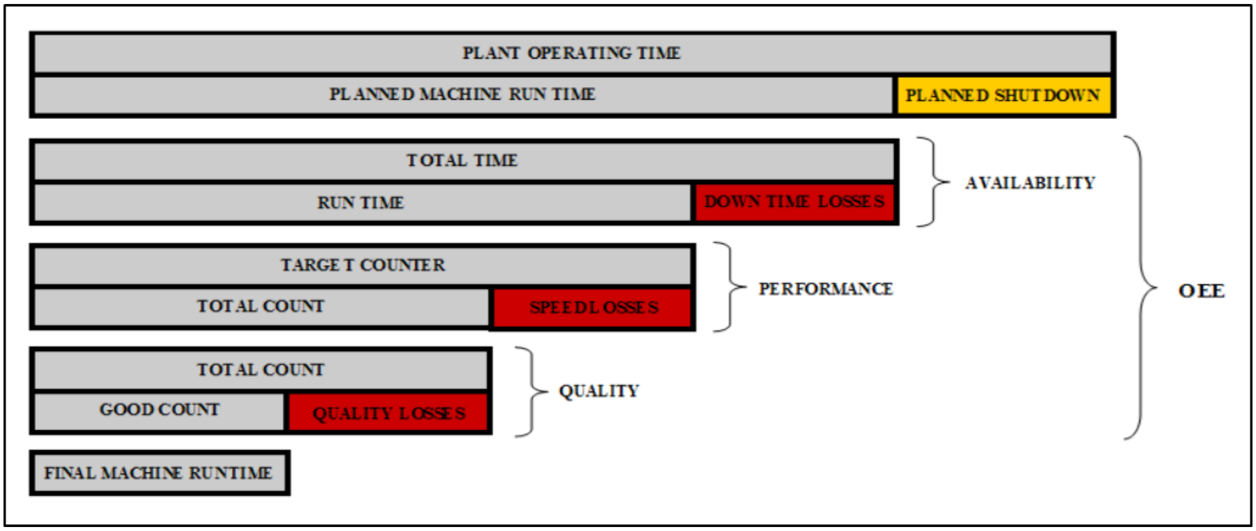


Figure 1. Breakdown of the calendar time

At this point, we can define:

$$Availability\,(A) = \frac{RunTime}{TotalTime} \tag{2}$$

$$Performance\,(P) = \frac{TotalCount}{TargetCounter} \tag{3}$$

$$Quality\,(Q) = \frac{GoodCount}{TotalCount} \tag{4}$$

In addition, OEE can be defined as:

$$OEE = \frac{FinalMachineRunTime}{PlannedMachineRunTime} \tag{5}$$

2.2. Best practice in manufacturing

Productivity, and practices to improve it, has been the subject of research over many years. Attempts to define and replicate practice to improve performance came to the fore in the 18th and 19th centuries.

Practices are the established processes which a company has put in place to support the way in which the business operates. Best practices are those that lead to world-class performances. World class manufacturing is defined as the point where companies equal or surpass their competitors in every area of their business (Voss et al., 1995b). Best practice can cover numerous areas including agile and lean manufacturing, six sigma, new product development, ISO 9000 and ISO 14000, process analysis and simulation, quality function deployment, theory of constraints, supply chain management, statistical process control, and statistical quality control (Revelle, 2001). There is a link between best performing companies and the adoption of best practice (Quesada-Pineda and Gazo, 2007). It does not matter whether the application or technology solution is a commercial off-the-shelf solution, a custom solution or a hybrid of custom and commercial (Meyers, 2010). However, Voss (2005) argues that there is no such thing as a 'best' practice. Practices evolve, need adapting to the context, and what may be best in one context on day, may not be best in another the next. The more prevalent best practices applied in manufacturing today are noted below.

- Lean (Hines et al., 2004; Bendell, 2005; Shah and Ward, 2003, 2007; Shah et al., 2008).
- Just in time (Seyed-Mahmoud, 2004).
- Continuous improvement (Munro, 2012).
- Total Quality Management and ISO 9000 (BSI, 2013; Boiral and Amara, 2009).
- ISO 14000 (ISO, 2012; Teng, 2011).
- Health and safety (Health and Safety Executive, 2012; Occupational Health and Safety, 2012).
- Six Sigma (Shafer and Moeller, 2012).

- 5S (Bayo-Moriones et al., 2010).
- Failure mode and effects analysis (Frank and Echeveste, 2012).

2.3. Developing best practice through benchmarking

Benchmarking has developed rapidly since its introduction by Xerox in the late 1970s (Andersen and Camp, 1995). Benchmarking is a process of identifying, sharing and using knowledge and best practices (Maire, 2002). A benchmarking study includes analysis of the organization's own process, and study of benchmarking partners' processes.

Benchmarking is defined as "the process of identifying and learning from best practices anywhere in the world" (Allan, 1997). By identifying the "best" practices, organizations know where they stand in relation to other companies. The other companies can be used as evidence of problem areas, and provide possible solutions for each area.

There are different types of benchmarking that the managers can use. Tuominen (1997), Bogan and English (1994) identified these three major types: Strategic benchmarking, Performance benchmarking, and Process benchmarking.
In addition to the types, there are four ways of benchmarking which consist of: internal benchmarking, competitive benchmarking, functional or industry benchmarking, and process or generic benchmarking (Elmuti and Kathawala [5]).It is important to choose the optimal way because it reduces the costs of the activity and improves the chances to find the 'best practices' we can rely on.

The first basic type of benchmarking is the internal benchmarking. This is benchmarking against operations. It is one of the simplest forms since most companies have similar functions inside their business units.

Determining the internal performance standards of an organization are internal benchmarking's main objective. This enables the sharing of a multitude of information. The benefit of immediate gain comes from identifying the best internal procedures and being able to transfer them to other portions of the organization. Unless it is later used as a baseline for external benchmarking, companies implementing this type can often retain an introverted view (Matters and Evans, 1997).

In this paper, we will focus on internal benchmarking to determine Best Manufacturing Practices (BMPs) to improve the performance of the production line that will be the subject of our case study.
For this, we follow the benchmarking wheel model (Shah and Kleiner, 2011); this model is a 5-stages process that was created by observing more than 20 other models.

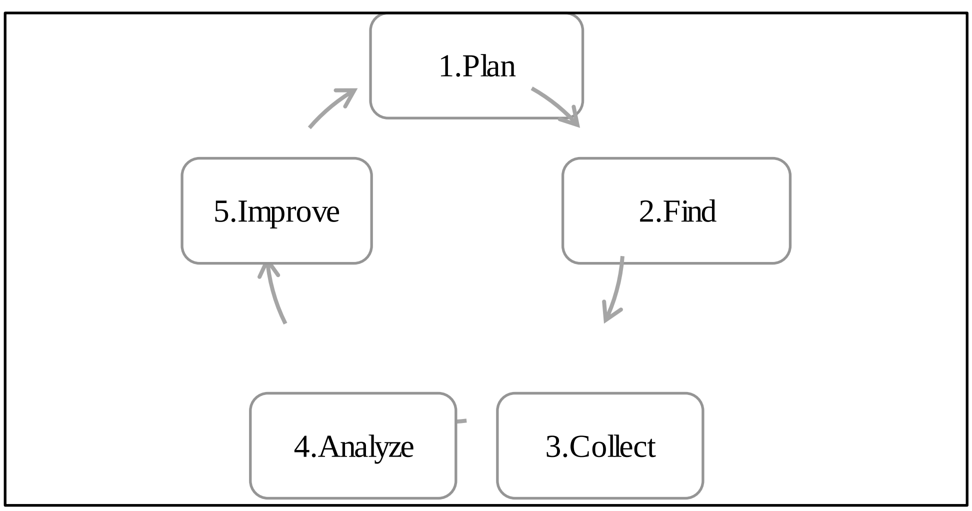


Figure 2. The benchmarking wheel model

It is simple and comprises the following stages:

1. Plan: Assemble a team. Clearly define what you want to compare and assign metrics to it.
2. Find: Identify benchmarking partners or sources of information, where you will be able to collect the information.
3. Collect: Choose the methods to collect the information and gather the data for the metrics you defined.
4. Analyze: Compare the metrics and identify the gap in performance between your company and the organization observed. Provide the results and recommendations on how to improve the performance.
5. Improve: Implement the changes to your products, services, processes or strategy.

After the introduction and implementation of benchmarking stages, we were able to identify five of the following Best Manufacturing Practices (BMPs):

- Apply the 5S method to work better.
- Implement the SMED method to reduce systematically series change time.
- Use the PDCA method to identify the steps simply to improve the quality in the production line.
- Use the empirical method of questioning 5 W's (Who, What, Where, When, Why?) to contribute to the resolution of an existing problem.
- Use the Pareto Principle to know where to concentrate efforts and resources for continuous improvement.

3. CASE STUDY AND RESULTS

In this section, we present a study of the performance evaluation of a production line at a food company by the OEE. After a study based on history, it seems clear that this production line is the most critical in the company, because its OEE is very low. An analysis is needed for this line to detect problems that penalize its OEE. For this, we presented the evolution of this indicator and its components (A, P, Q) (Availability, Performance, and Quality) to determine the causes of the radical regression of OEE.

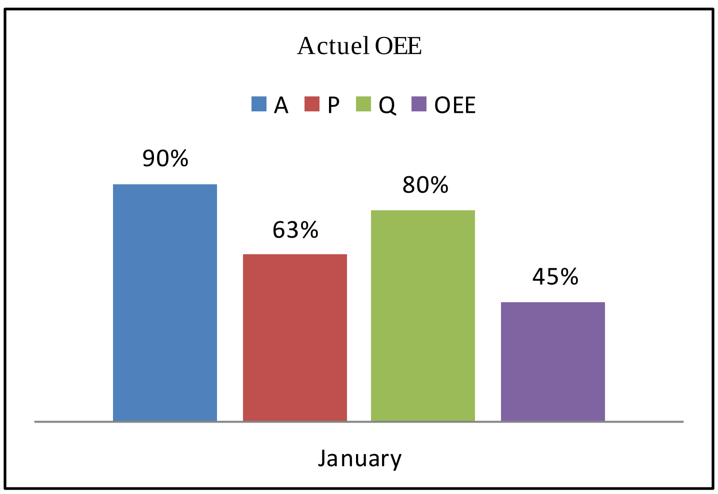
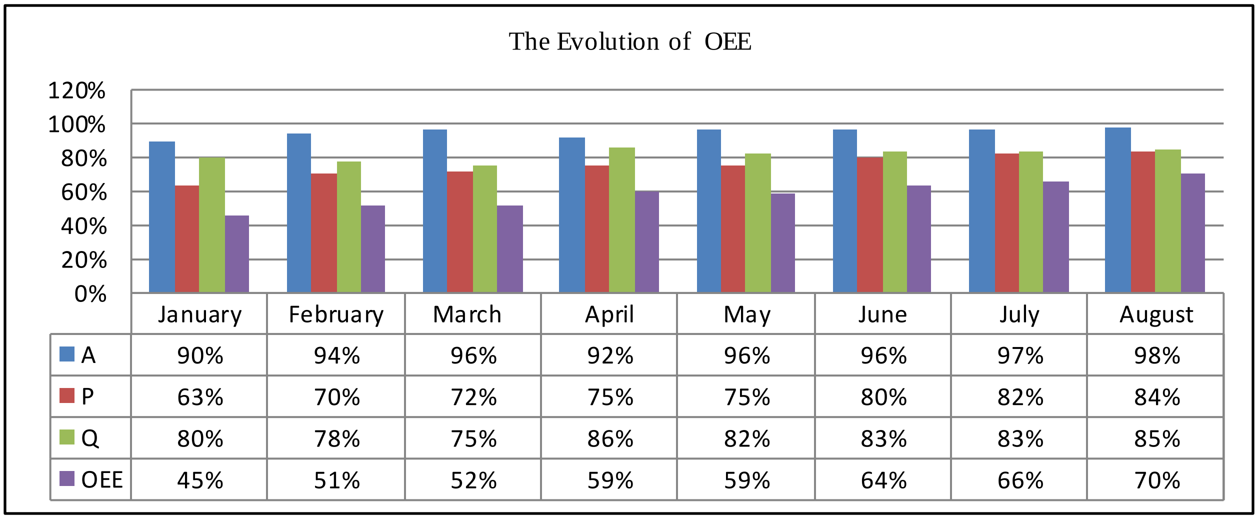


Figure 3. OEE and its components on January

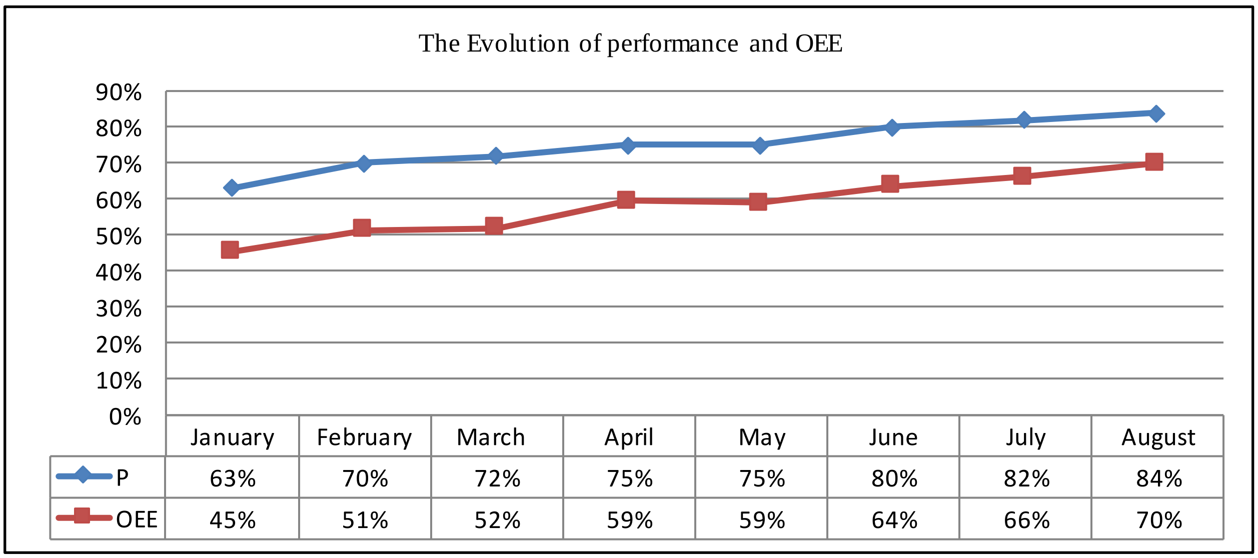
From Figure 3, we can see that this production line is available, because its availability rate exceeds 90% and the quality rate is 80%. However, its performance rate does not exceed 63%. Therefore, the Performance of this production line is one of the leading causes of non-OEE.

After the establishment of Best Manufacturing Practices (BMPs) to improve the OEE for this production line during eight months, we found the following results presented in Figures 4 and 5.



	January	February	March	April	May	June	July	August
A	90%	94%	96%	92%	96%	96%	97%	98%
P	63%	70%	72%	75%	75%	80%	82%	84%
Q	80%	78%	75%	86%	82%	83%	83%	85%
OEE	45%	51%	52%	59%	59%	64%	66%	70%

Figure 4. The evolution OEE, A, P and Q



	January	February	March	April	May	June	July	August
P	63%	70%	72%	75%	75%	80%	82%	84%
OEE	45%	51%	52%	59%	59%	64%	66%	70%

Figure 1. Evolution of availability and OEE

From these results, we note that the implementation of Best Manufacturing Practices (BMPs) has allowed us to improve the OEE from 45 % in January 2016 to 70 % in August 2016.

After we applied these Best Manufacturing Practices (BMPs) to our production line, we were able to improve its performance from 63 % in January 2016 to 84 % in August 2016.

4. CONCLUSION

In this paper, we achieved our objective of improving and evaluating the performance of a production line, by using the Overall Equipment Effectiveness (OEE) indicator.

The main idea of this work is to start with an internal benchmarking study to select the Best Manufacturing Practices (BMPs) in order to improve the Performance of the production line at a food company. We were also able to apply these Best Manufacturing Practices to this production line, which constituted the subject of our case study.

By applying these Best Manufacturing Practices (BMPs) to this production line, we were able to improve its Performance from 63 % in January 2016 to 84 % in August 2016. In addition, the OEE was improved from 45 % in January 2016 to 70 % in August 2016. We also found that the improvement of Performance had a positive impact on the other components of the OEE, with an availability rate of 7% and 3% for quality. These results show the interest to evaluate and improve the OEE with this approach based on Best Manufacturing Practices.

In this work, we focused on the Performance and Best Manufacturing Practices for improving and evaluating the performance of a production line. As a future work, we will study the other components of the OEE, and we will apply the Best Maintenance Practices and the Best Quality Practices in order to investigate the impact of these practices on the OEE.

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