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# *Application of the OEE tool in an auto parts industry's production line*

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## *ABSTRACT*

*The aim of this paper is to work on lean manufacturing's theory of tools in practice in a multinational auto parts industry responsible for the exhaust industry, located in state of São Paulo, Brazil. When use tools like OEE, TPM and Kaizen, it is possible to analyze the conditions of the equipment in the current scenario in production, proposing improvements such as professional maintenance planning, generating Kaizens, facilitating periodic activities (inspection, cleaning, lubrication and others) and training the employees to perform the autonomous maintenance, reducing the paras and faults of the equipment. was possible to optimize the OEE indicators: availability, performance and quality, resulting in a significantly better overall efficiency index.*

***Keywords****: OEE; TPM; Kaizen; Availability; Performance; Quality; Lean Manufacturing.*

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## 1. INTRODUCTION

The current market has increasingly demanded that companies make their products available with quality, flexibility, reliability and low cost. The ability to use more efficient methods, increasing production capacity and availability, allows for greater volume flexibility, thus meeting customer demand, since the greater the availability, the greater the productivity.

According to Mariano, Ricci and Braga (2016), given the current scenario experienced by organizations, there is a constant search for methods focused on improving productivity with high quality and low cost. Following this concept, tools that contribute in this sense are observed, such as the OEE (Overall Equipment Effectiveness) methodology, as well as the Jidoka (Automation with a human touch), derived from the Toyota Production System in the 90s and TPM (Total Productive Maintenance), which groups tools with a focus on equipment efficiency.

Within this reality, the present work aims to analyze how the performance indicator known as OEE and other parameters present in the Lean Manufacturing can be applied as global performance indicators, assisting managers in decision making, seeking to improve the process, in order to reduce costs and maximize product availability, ensuring its competitiveness.

Still, the research aims to address what can be improved for the efficiency of the equipment and operation, generating more satisfactory results, such as product quality and higher productivity rates. The implementation of OEE comes as an aid for the practical implementation of improvement in a production line, which represents a great positive point within the company.

## 2. LITERATURE REVIEW

Here are present the main theoretical topics that will serve to support the research, such as OEE, TPM, Kaizen and other tools that help in the context of operational efficiency in industries.

### *2.1 Overall Equipment Effectiveness - OEE*

The OEE started in the TPM systematic, developed by Toyota, with a focus on the application in equipment and machines with reference index for efficiency analysis, to carry out maintenance and return to base conditions (CARDOSO, 2013).

In order to understand the biggest cost drivers for organizations, tools such as OEE are used to stratify information such as productivity, performance and quality of equipment present in the production process and to deal with the shortest possible time, achieving better efficiency.

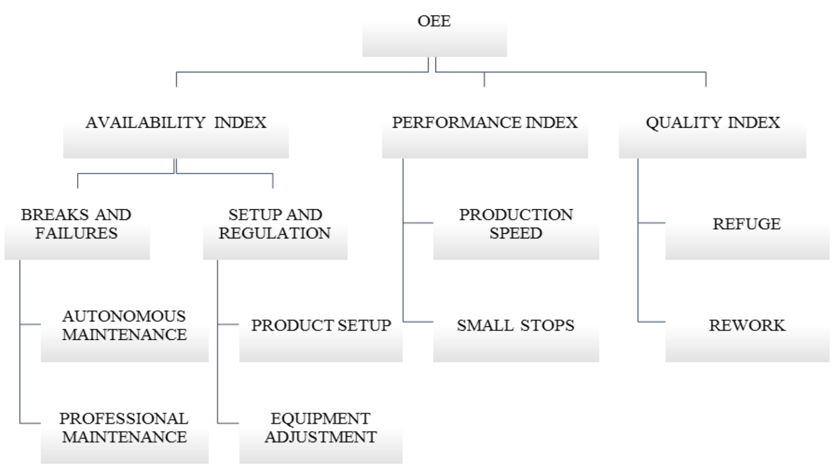
Thus, it can be said that a production manager focuses on meeting the day-to-day situational needs, knowing that data must be portrayed in real time, analyzed in a real way at the exact moment, managing visually, aiming, based on concrete information, making decisions as soon as possible (CARDOSO, 2013).

The OEE indicator, based on methodology in an organization, is considered acceptable when it assumes a minimum result of 85%. Therefore, the product is calculated among the key indicators such as availability, performance and quality (SOUZA; CARTAXO, 2016).

$$OEE = (AVAILABILITY * PERFORMANCE * QUALITY) * 100 \geq 85\%$$

The literature reveals that the JIPM (Japan Institute of Plant Maintenance) defined that minimum acceptable values in an organization following Word Class standards would be to meet at least 95% of Performance, 90% of Availability and a Quality index of 99 % (CARDOSO, 2013). Figure 1 presents the OEE system.

**Figure 1** – OEE System




Source: Adapted from Chiraradia (2004).

*2.2 Availability*

According to Harilaus (2014), organizations have increasingly used monitoring methods, as a way to measure the efficiency of equipment maintenance, in order to optimize their availability, pointing out unplanned stops such as breaks, failures and periods of interruptions during production.

Availability is one of the essential indicators to determine the available time of the equipment to be used, being necessary its monitoring for decision making, foreseeing poor maintenance planning, which can result in unscheduled stops and increasing equipment unavailability (HARILAUS 2014).

$$AVAILABILITY = (REAL\ TIME\ /\ AVAILABLE\ TIME) * 100 \geq 90\%$$

*2.3 Performance*

Indicators such as KPI (Key Performance Indicator), used as a means of communication, allow managers in an organization to communicate with leaders about how efficient a process is in a given period. Based on KPI's, action plans and decision making become fast, reducing fluctuations in goals and preventing these improvements from being performed based on inconsistent data. The definition of the KPI range is as important as the results presented, assuming that a greater number of indicators can make decision-making difficult, due to the various variables involved (CARDOSO, 2013).

$$PERFORMANCE = (REAL\ PRODUCTION / THEORETICAL\ PRODUCTION) * 100 \geq 95\%$$

*2.4 Quality*

Quality is synonymous with perfection, following a series of pieces with conformities in documentation, drawings and processes. Its main objective is always to be in the standard. Quality is having its potential and capacity that the product or service has to come out according to the transcribed project, be it via system or physical, continuing to make correct parts according to the requests and requirements (PALADINI, 2012).

Quality within the OEE tool is essential in terms of parts without errors. There is no point in having good availability if quality is desired. In this case, the three keys of the OEE for the best results are in line: the best result comes from the total number of parts produced with excellent quality (CARDOSO, 2013).

$$QUALITY = [(TOTAL\ PRODUCED - WASTE - REWORK) \div TOTAL\ PRODUCED] * 100 \geq 99\%$$

*2.5 Total Productive Maintenance – TPM*

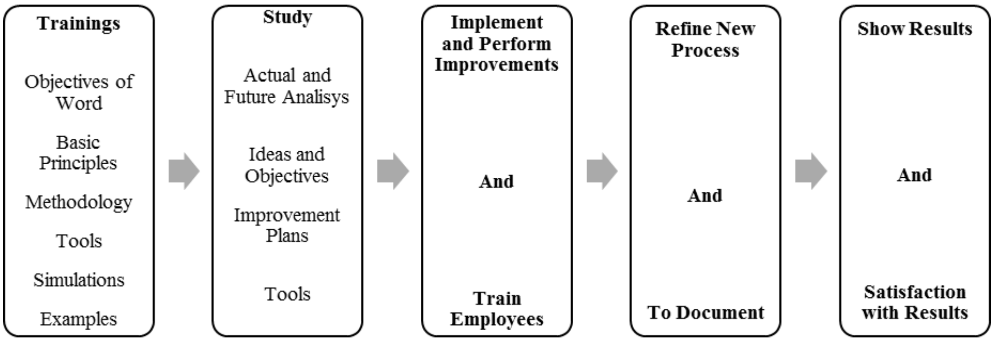
Started in the United States of America and dominated as preventive maintenance, the TPM methodology was introduced in Japan in the 1950s by “Toa Nenryo Kogyo”, a pioneer in the application of preventive maintenance (PEREIRA, 2011).

At the end of the 1960s, there was an evolution from the concept to the TPM methodology, implemented by “Nippon Denso Co”, a Toyota group company. The objective of the methodology is management with a focus on continuous improvement of equipment efficiency, in view of the established functional maintenance system, aiming to reduce or even eliminate losses, based on the eight maintenance pillars: autonomous maintenance, planned maintenance, initial control, specific improvement , education and training, safety and environment, administrative area and quality (PEREIRA, 2011).

*2.6 Kaizen*

The word KAIZEN, originally from the master IMAI, has the following definition: KAI means change and ZEN means better, that is, change for the better or continuous improvement. The objective of the tool is to improve something that can add efficiency, profit, time and a better flow to the industry, bringing to work a leaner view and strategies to change some specific process, or even try to improve what is already good (BALLESTERO-ALVAREZ, 2016). Figure 2 shows the flow of execution of the Kaizen tool.

**Figure 2** – Kaizen System




Source: Adapted from Ballestero-Alvarez (2016).

*2.7 State of Art*

This section presents current works, present in the literature, that used OEE, in line with other methodologies, to improve industrial processes.

In a case study applying OEE in a grain processing line, it was observed that with the use of an approach based on Lean Manufacturing tools, in conjunction with the Production Planning and Control, it was possible to plan the production and obtain a better understanding of the process and flow of activities. Still, with training and the use of the TPM tool, it was possible to involve the operator more with the process, enabling the identification and collection of downtime and failures during production (SILVA; FREITAS; MANVAILER, 2016).

Also, according to the authors, the TPM tool was essential to check the availability of the equipment and provide better quality in the products, making it possible to understand the voices of the stops by breaks or failures to be analyzed. Based on the development and data obtained, it was possible to carry out the OEE study presented and implement the tool as a form of management, providing improvements for the use of the equipment, focusing on cost reduction directly affecting the company's indicators (SILVA; FREITAS; MANVAILER, 2016).

According to Santos (2018), in a study applying the OEE system for measuring the efficiency of mobile equipment in a logistics system in the loading and unloading of products for storage, it was possible to analyze key indices such as availability, performance and quality of equipment with the objective of optimizing resources in the organization, through the modeling of the process flow, which was performed with the extraction of daily data, which were adapted to the proposed situation.

In a small factory that produces rubber used to make garments, a study was carried out using OEE along with the TPM methodology. In the study it was possible to identify the failure modes and breaks and failures of the equipment. Thus, by conducting systematic training, it was observed that operational involvement is essential for data collection through chrono analysis during stops and intervals in the use of equipment. The information was translated using spreadsheets and graphs with the aid of Microsoft Excel. As a result, a reduction in costs was achieved and it was possible to propose suggestions for improvements in the process and manufacturing efficiency (CARDOSO; GIL; GOMES, 2018).

Based on a study of the chassis revision process, which takes the verification of 100% of the products that arrive from the assembly lines, with the help of tools to improve performance and productivity, such as 5S and Kaizen, Cardoso, Gasperi and Vidor (2018) concluded that, with the implementation of tools and devices optimizing the flow and performance of the process, standardization of the processes with a standard manufacturing script, it was possible to reduce the high production costs and increase productivity, carrying out continuous improvement projects. In this context, the OEE tool that demonstrates the overall efficiency of the equipment was used.

The three key factors (availability, performance and quality) of the OEE tool were applied in a sugarcane harvesting process, which required certain improvements in the efficiency of its equipment, where the process of cutting, transshipping and transporting sugar cane between other processes had higher percentages of problems. Based on data collection performed in the field, the systematic of continuous improvement was addressed, focusing on the root cause of equipment problems (ANNA; DA SILVA; MENEGON, 2018).

In the application of the OEE system in an umbilical cable supply industry, the method of research and results developments was approached, collecting data through production reports daily pointed out by the plant operators, being transcribed and plotted in spreadsheets, linking a flow for better work development. The use of the Ishikawa Diagram tool was fundamental to exemplify and assist in identifying the root causes of problems in the production process (DE SOUSA; CARTAXO, 2016).

According to a case study applying OEE in a feed producer, it was observed that the tool is increasingly used by companies in conjunction with the philosophy of Lean Manufacturing, where the main objective is the efficiency of the production process. The result obtained is fundamental so that through the OEE it is possible to analyze the possible increase in productivity and the consequent reduction in production costs (CARDOSO, 2013).

A study carried out for the implementation of the OEE tool in a painting line in a metallurgical company, was carried out through bibliographic researches, the Pareto Diagram tool, equipment analysis, loss calculations, availability and efficiency and, finally, the implementation of systematic. After training on the TPM tool, it was possible to generate products with quality and competitive cost (DESIOMBRA, 2014).

## 3. METHODOLOGICAL PROCEDURES

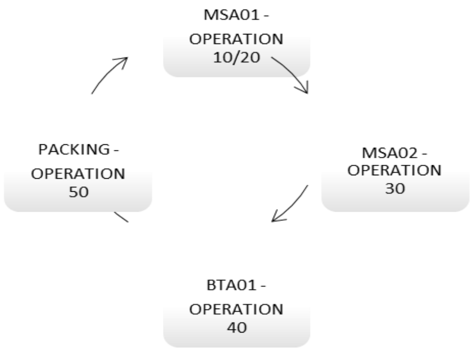
The present study is carried out in a multinational company in the auto parts industry, located in the state of São Paulo, Brazil, where this unit is responsible for the exhaust sector.

The proposed study has as main objective to work the OEE methodology applied in practice, through a case study, comprising the key indicators and the daily data collection during the period of two weeks in two productive shifts. The development will basically be modeling the flow of the production process and identifying the equipment to be analyzed, extracting data collected during the production appointment daily, transcribing them and building a database, performing the calculations of the indicators that will result in the global index.

According to Gil (2008), a case study is a research method that has been shown to be increasingly used, as it deals with works with intense and deep content, aiming to propose a vast knowledge about the study, exploring and investigating the situation of the problem, even when the data do not have a robust definition, transcribing and explaining the influencing factors.

Also, according to the author, conducting a case study requires a long time, but the baggage of studies carried out in recent years makes it possible to use the method for reduced times based on work already done (GIL, 2008). Figure 3 shows the process flow to be analyzed.

**Figure 3 - Process flow**




Source: The authors.

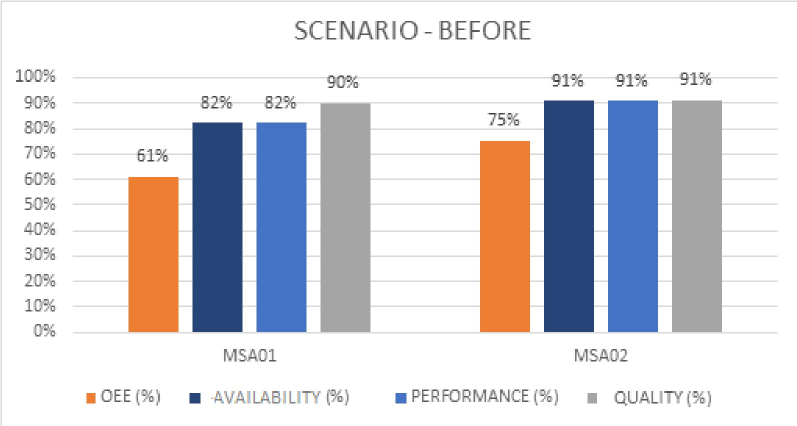
After, the process is carried out again, during the same period analyzed, after the TPM and Kaizen methodology was generated and implemented, focusing on improvements in equipment efficiency.

By transcribing the data collected during the first two weeks, the flow of the production process on the line was concluded and it was determined that BTA01 (automatic test bench), because it is a test equipment where it does not transform the product, is not carried out global efficiency analysis, therefore the equipment to be analyzed are the MSA01 and MSA02 (automatic welding machines), as they are equipment where the process and welding of the exhaust sets are carried out.

## 4. RESULTS AND DISCUSSION

Figure 4 shows the initial production scenario for the production cell.

**Figure 4** - Breakdown of the previous OEE index.




Source: The authors.

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In the scenario previously analyzed, it is possible to observe about the deployment of the OEE index and the respective key indicators that the equipment has values below the minimum acceptable as well as the methodology that, according to Cardoso (2013), the minimum acceptable values have been defined must meet 90% Availability, 95% Performance and 99% Quality. Table 1 shows the data collected from the equipment in the initial scenario.

**Table 1** - Data collected from the equipment in the previous scenario

| | *MSA01* | | | *MSA02* | | |
|---|---|---|---|---|---|---|
| | *WEEK 1* | *WEEK 2* | *AVERAGE* | *WEEK 1* | *WEEK 2* | *AVERAGE* |
| *OEE (%)* | *63%* | *59%* | *61%* | *74%* | *76%* | 75% |
| *AVAILABILITY (%)* | *84%* | *81%* | *82%* | *91%* | *90%* | 91% |
| *PERFORMANCE (%)* | *84%* | *81%* | *82%* | *91%* | *90%* | 91% |
| *QUALITY (%)* | *89%* | *90%* | *90%* | *89%* | *93%* | 91% |
| AVAILABLE TIME (H) | 68,0 H | 68,0 H | 68,0 H | 68,0 H | 68,0 H | 68,0 H |
| REAL PRODUCTION TIME (H) | 57,0 H | 55,0 H | 56,0 H | 62,0 H | 61,5 H | 61,8 H |
| MAINTENANCE TIME (H) | 8,0 H | 11,0 H | 9,5 H | 4,0 H | 3,5 H | 3,8 H |
| FAILURE TIME (H) | 3,0 H | 2,0 H | 2,5 H | 2,0 H | 3,0 H | 2,5 H |
| THEORETICAL DAILY AVERAGE PRODUCTION (un) | 272 un | 272 un | 272 un | 272 un | 272 un | 272 un |
| REAL DAILY AVERAGE PRODUCTION (un) | 228 un | 220 un | 224 un | 248 un | 246 un | 247 un |
| AVERAGE DAILY REFUND (un) | 7 un | 9 un | 8 un | 12 un | 8 un | 10 un |
| AVERAGE DAILY REWORK (un) | 17 un | 12 un | 15 un | 15 un | 9 un | 12 un |

Source: The authors.

Analyzing the equipment, it is possible to observe that the Performance indicator of MSA01 and MSA02 present values below the minimum acceptable, due to the high hourly rate of corrective maintenance and adjustments during the production process, directly influencing the Performance and Quality indicators, where both present values below acceptable.

By implementing the TPM system, it was possible to deal with corrective maintenance stops and adjustments or failures during the production process. Performing the restoration of the basic conditions of the equipment together with the Kaizen methodology, functionalizing projects to improve the setup and fixation of the devices in the equipment, a plan for preventive maintenance and autonomous maintenance was defined. In this plan, qualified operators were allowed to perform small maintenance during daily routines, such as inspection, cleaning, retightening and lubrication.

Thus, it was possible to monitor the useful life of each component of the equipment, carrying out planned maintenance and reducing corrective measures by an average of 81%. Adjustments or failures have been reduced by an average of 69%. Regarding performance and quality, these represented average values of 12% in gain in daily productivity and 98% in reduction of scrap and 74% in rework. Table 2 shows the data collected from the equipment in the scenario after the improvements implemented.

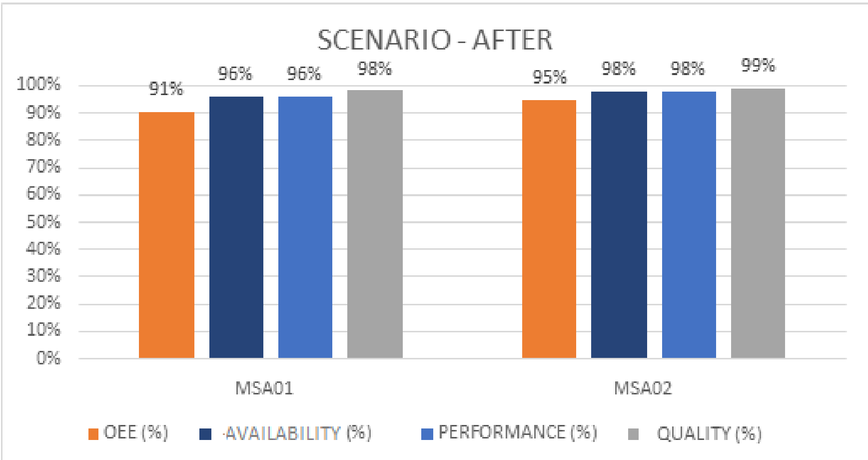
**Table 2** - Data collected from the equipment in the scenario after the improvements

| | *MSA01* | | | *MSA02* | | |
|---|---|---|---|---|---|---|
| | *WEEK 1* | *WEEK 2* | *AVERAGE* | *WEEK 1* | *WEEK 2* | *AVERAGE* |
| *OEE (%)* | *90%* | *92%* | 91% | *95%* | *95%* | 95% |
| *AVAILABILITY (%)* | *96%* | *97%* | 96% | *98%* | *98%* | 98% |
| *PERFORMANCE (%)* | *96%* | *97%* | 96% | *98%* | *98%* | 98% |
| *QUALITY (%)* | *98%* | *98%* | 98% | *99%* | *99%* | 99% |
| AVAILABLE TIME (H) | 68,0 H | 68,0 H | 68,0 H | 68,0 H | 68,0 H | 68,0 H |
| REAL PRODUCTION TIME (H) | 65,0 H | 65,7 H | 65,4 H | 66,4 H | 66,8 H | 66,6 H |
| MAINTENANCE TIME (H) | 2,0 H | 1,5 H | 1,8 H | 1,0 H | 0,5 H | 0,8 H |
| FAILURE TIME (H) | 1,0 H | 0,8 H | 0,9 H | 0,6 H | 0,8 H | 0,7 H |
| THEORETICAL DAILY AVERAGE PRODUCTION (un) | 272,0 un | 272,0 un | 272,0 un | 272,0 un | 272,0 un | 272,0 un |
| REAL DAILY AVERAGE PRODUCTION (un) | 260,0 un | 262,8 un | 261,4 un | 265,6 un | 267,0 un | 266,3 un |
| AVERAGE DAILY REFUND (un) | 0,1 un | 0,5 un | 0,3 un | 0,1 un | 0,0 un | 0,1 un |
| AVERAGE DAILY REWORK (un) | 5,0 un | 4,0 un | 4,5 un | 2,0 un | 3,0 un | 2,5 un |

Source: The authors.

Figure 5 shows the production scenario of the production cell after the improvements.

**Figure 5** - Breakdown of the OEE index afterwards




Source: The authors.

Table 3 shows the average results comparing the previous scenario and the post-improvement scenario.

**Table 3** - Comparison of average values collected before and after

| | ***BEFORE*** | | ***AFTER*** | | ***RESULTS*** | |
|---|---|---|---|---|---|---|
| | ***MSA01*** | ***MSA02*** | ***MSA01*** | ***MSA02*** | ***MSA01*** | ***MSA02*** |
| | ***AVERAGE*** | ***AVERAGE*** | ***AVERAGE*** | ***AVERAGE*** | ***AVERAGE*** | ***AVERAGE*** |
| ***OEE (%)*** | *61%* | *75%* | *91%* | *95%* | 30% | 20% |
| ***AVAILABILITY (%)*** | *82%* | *91%* | *96%* | *98%* | 14% | 7% |
| ***PERFORMANCE (%)*** | *82%* | *91%* | *96%* | *98%* | 14% | 7% |
| ***QUALITY (%)*** | *90%* | *91%* | *98%* | *99%* | 8% | 8% |
| **AVAILABLE TIME (H)** | 68,0 H | 68,0 H | 68,0 H | 68,0 H | | |
| **REAL PRODUCTION TIME (H)** | 56,0 H | 61,8 H | 65,4 H | 66,6 H | 17% | 8% |
| **MAINTENANCE TIME (H)** | 9,5 H | 3,8 H | 1,8 H | 0,8 H | -82% | -80% |
| **FAILURE TIME (H)** | 2,5 H | 2,5 H | 0,9 H | 0,7 H | -64% | -73% |
| **THEORETICAL DAILY AVERAGE PRODUCTION (un)** | 272,00 | 272,00 | 272,00 | 272,00 | | |
| **REAL DAILY AVERAGE PRODUCTION (un)** | 224,00 | 247,00 | 261,40 | 266,30 | 17% | 8% |
| **AVERAGE DAILY REFUND (un)** | 8,00 | 10,00 | 0,30 | 0,05 | -96% | -100% |
| **AVERAGE DAILY REWORK (un)** | 14,50 | 12,00 | 4,50 | 2,50 | -69% | -79% |

Source: The authors.

Analyzing the results, it can be seen that, on average, the equipment showed very significant results. The Indicators of Availability and Performance in both equipments presented average values of 14% for MAS01 and 7% for MSA02. Regarding the Qualities indicators, it presented an average value of 8% in both equipments.

The OEE indicator, based on the methodology, must assume a minimum value of 85%, the scenario presented after the improvements resulted in satisfactory values where the equipment presented a gain of 30% for MAS01 and 20% for MSA02.

Maintenance times have been reduced considerably, which is also considered to be a great result of the case study, coupled with reduced failure times. The result of these results is also due to the high reductions in refund and rework.

## 5. CONCLUSIONS

This work presented the application of the OEE methodology, in a factory in the auto parts business. The results of the work showed the importance of evaluating the key indices (Availability, Performance and Quality) of the equipment, focusing on continuous improvement. With the application of the TPM system, it was possible to identify and quantify the stops due to breaks and failures during the production process, improvements in the management of professional and autonomous maintenance. Together with the Kaizen methodology, focusing on improvements, it was possible to highlight the work done and measure the cost reductions for the company during the work.

Despite the short time of development of the case study, analysis and implementation of improvements, very satisfactory results were evidenced, but with several possibilities for improvements in the production process that would require a longer and more intense work that may be carried out in future works, used on the basis of new improvement projects in other production lines.

## References

ANNA, A. M. G. S.; DA SILVA, J. E. A. R.; MENEGON, N. L. M. Fatores Condicionantes do indicador OEE – Overall Equipment Effectiveness – em colhedoras de cana-de-açúcar. In: SIMPÓSIO DE ENGENHARIA DE PRODUÇÃO, n. 25, 2018, Bauru, SP. **Anais**...SIMPEP, Bauru, São Paulo, 2018.

BALLESTERO-ALVAREZ, M. E. **Gestão da qualidade, produção e operações**. 2. ed. São Paulo: Atlas, 2016.

CARDOSO, C. **OEE na Prática**: Gestão da Produção com índice OEE. 1° Edição. KITE Mês, 2013. Disponível em: http://www.kitemes.com.br/e-books/e-book-oee-na-pratica/. Acesso em 18 mai 2019.

CARDOSO, J. J.; DE GASPERI, D. F.; VIDOR, L. P. Aplicação de Metodologia Kaizen na padronização do processo de revisão final de produtos em uma indústria montadora de veículos automotores. In: SIMPÓSIO DE ENGENHARIA DE PRODUÇÃO, n.25, 2018, Bauru, SP. **Anais**... SIMPEP, Bauru, São Paulo, 2018.

CARDOSO, L. H.; GIL, C. S. E.; GOMES, R. R. M. Aplicação da Eficiência Global de Máquinas (OEE) em uma indústria de Elástico. In: SIMPÓSIO DE ENGENHARIA DE PRODUÇÃO, n.25, 2018, Bauru, SP. **Anais**... SIMPEP, Bauru, São Paulo, 2018.

CHIRARADIA, A. **Utilização do indicador de eficiência global de equipamentos na gestão e melhoria contínua dos equipamentos**: um estudo de caso na indústria automobilística. Dissertação. 130f. (Mestrado em Engenharia) – Universidade Federal do Rio Grande do Sul – Escola de Engenharia. Porto Alegre, RS. 2004.

SOUZA, M. C. M.; CARTAXO, G. A. A. Aplicação do indicador OEE (Overall Equipment Effectiveness) em uma indústria fornecedora de cabos umbilicais. In: ENCONTRO NACIONAL DE ENGENHARIA DE PRODUÇÃO, n.36, 2016, João Pessoa, PB. **Anais**...ENEGEP, 2016.

DESIOMBRA, J. **Implantação da ferramenta OEE (eficiência global do equipamento)**: estudo de caso em uma empresa metalúrgica de grande porte. Monografia (Engenharia de Produção) - Universidade Tecnológica Federal do Paraná. Ponta Grossa, 2014.

SANTOS, A. S. Aplicação do OEE para a medição de eficiência de equipamentos móveis. In: ENCONTRO NACIONAL DE ENGENHARIA DE PRODUÇÃO, n.38, 2018 Maceió, AL. **Anais**...ENEGEP, 2018.

GIL, A. C. **Métodos e técnicas de pesquisa social**. 6. ed. São Paulo: Atlas, 2008.

HARILAUS G. X. **Gerenciando a Manutenção Produtiva**. 2 ed. Belo Horizonte: EDG Editora, 2014.

MARIANO, F. D.; RICCI, G. L.; BRAGA, W. L. M. **Eficiência global de equipamento - OEE**: O impacto do Jidoka, São Paulo, v. 4, n.1, p. 1-10, 2016.

PALADINI, E. P. **Gestão da qualidade**: teoria e prática. 3 ed. São Paulo: Atlas, 2012.

PEREIRA, M. J. **Engenharia de Manutenção** - Teoria e Prática. 2 ed. Rio de Janeiro: Editora Ciência Moderna Ltda., 2011.

SILVA, G. R.; FREITAS, L. D.; MANVAILER, R. H. M. Aplicação do OEE em uma Linha Beneficiadora de Grãos: Um estudo de caso. In: SIMPÓSIO DE ENGENHARIA DE PRODUÇÃO, n. 23, 2016, Bauru, SP. **Anais**... SIMPEP, 2016.