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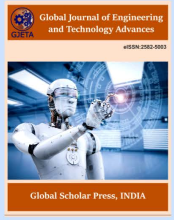

(RESEARCH ARTICLE)

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Maintenance management in an industrial process: Case study in a company of the Industrial Pole of Manaus

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Abstract

In an increasingly competitive market, and given the current economic problems, it is necessary that companies invest in improving their production processes. Based on the above, the objective of this work was to develop research aiming to apply quality management tools that are widely applied in maintenance management in a production process of a company from the Manaus Industrial Pole to eliminate the process downtime due to problems with sticks with thick layer of paint and varnish. During the process, important steps were fulfilled within the research and starting from the initial diagnosis developed as well as the application of the mentioned tools, results were obtained that allow us to affirm the importance of the application of the maintenance management tools in this area, by obtaining satisfactory results both in quality gains and work time, translating into efficiency.

Keywords: Quality tools; Painting; Management; Industrial process

1. Introduction

The technological advances of the last decades have accelerated the globalization process, allowing competition among companies to occur at an international level. This has caused quality, which often did not receive much attention from managers due to the difficulty in measuring its benefits, to become something essential for the success of companies, sometimes being the determining factor in successful business operations in companies.

In the case of the automotive industry, the external appearance of a given product has a high incidence on the subjective appreciation of customers.

The process of manufacturing and painting automobiles is complex and faces several factors that generate defects on the vehicle body, thus impairing the quality perceived by the customer and directly impacting the result of the assembler. In the case of the company where the study was carried out, the defects identified in the painting of the body of the audited vehicles in the last year represented 12% of the total defects found. Given the importance of the product's

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image, it is essential to direct improvement actions and quality control of the paint and panel finish of the manufactured automobiles.

Based on the above, the objective of this work was to develop research aiming to apply maintenance management tools in a productive process of a company from the Manaus Industrial Pole in order to eliminate the process stoppage for inoperative time due to problems of rods with a thick layer of paint and varnish.

The relevance of this work is based on the importance of understanding how maintenance management through the use of quality tools can direct the maintenance of competitiveness, productive efficiency, adequate allocation of resources and cost reduction.

The results obtained allow us to affirm the importance of the efficient application of maintenance management tools in this area, by obtaining satisfactory results both in quality gains and work time, translating into efficiency.

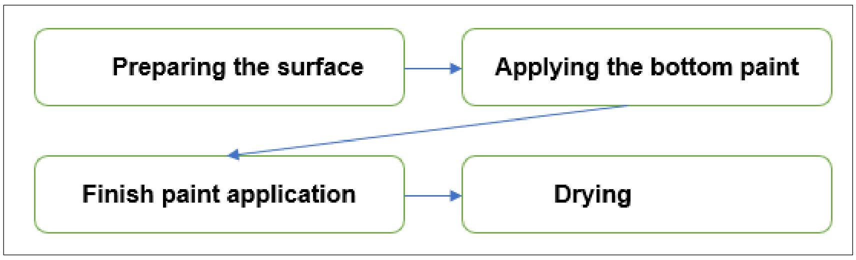
2. Theoretical background

The results of this search were oriented to the deepening of the main processes that take place in the sector that is the object of the research, as well as the maintenance management tools used, thus facilitating a better understanding of the work.

2.1. Painting System

There is a relationship between the substrate, the nature of the material to which the paint will be applied, the thickness, the color, the desired finish, the expected durability and the estimated cost. For painting effectiveness and longevity, these basic factors must be defined, and specific and very important stages must be followed. The set of each of these stages is what forms the painting system [1,8,17].

The basic stages that make up the painting system can be seen in the following flowchart.



2.2. Preparing the surface

Surface preparation is one of the most important factors for quality painting and is carried out for two basic reasons. The first is to remove materials from the structure that may impede the adhesion of the paint, such as oils, grease, fats and oxidation. Besides creating an appropriate roughness profile to improve adhesion [7,17].

In general, the surface preparation process can be done through pre-cleaning, which consists of methods for removing all oil, grease, and other contaminants acquired in handling or previous processes of cutting, stamping, welding, and others. The techniques usually used for this operation include the application of solvents, detergents, degreasers, and water vapor, in addition to cleaning by abrasive blasting, considered the most efficient method for removing oxides, weld spatter, and other impurities that occur during the part manufacturing processes. The abrasive blasting can be done by compressed air or centrifugal turbines and the most used abrasives are sand, steel shot and aluminum oxide [7, 17,18].

Also, in the stage of surface preparation, some companies adhere to the phosphatization operation, which aims to improve both the adhesion of the paint and the corrosion protection. In short, the phosphating operation consists of depositing a layer of crystals on the surface, forming a protective alloy. Often, the phosphatization process is allied to degreasing in the operation to remove grease, oil, lubricants, which may still be on the surface of the substrate [7]

The surface preparation operations may be inserted in a traction painting line, or be worked separately. Regardless of the origin of the part, surface preparation is a step preceding the other phases of painting and, for this reason, must be monitored and understood for the efficiency of the painting process as a whole.

2.3. Applying the bottom paint

The application of the bottom paint, also known as primer, is applied before the finishing paint, with possible exception in the case of powder paints. In most cases it only facilitates the adhesion of the paint to be applied in the sequence and creates the first protective anti-corrosion film [1,17].

2.4. Finish paint application

The finishing paint gives the product its characteristic colors and achieves its main purpose of anti-corrosion protection. However, some precautions are necessary such as the number of coats, the waiting time between them, the curing temperature, the minimum thickness and the conditions of the paint booth. Generally, the definitions of each of these parameters are established by the company, through internal process regulations and the criteria set forth in the ABNT standards, as well as considering the nature of the paint used and the aggressiveness of the corrosive environment to which the product will be subjected [17].

2.4.1. Drying

The drying operation usually occurs in two stages in the painting system, after the surface preparation operations and after the painting itself. In general, the procedure is carried out through stoves or hot air blowers, at temperatures between 100°C and 150 ºC [1,19].

As the surface preparation techniques usually have mechanisms for applying liquid-based substances and rinsing operations, it is necessary to eliminate moisture from the parts before applying the paint, in order to avoid the formation of bubbles, which could harm the paint [1,15]. While, after applying the paint, it is essential to wait for it to dry, this time is related to the thickness of the layer applied and can be accelerated by drying methods. A part is considered dry when the paint film does not absorb the powder particles, there is no detachment, displacement, wrinkling or other alteration of the surface. Thus, a dry part can be handled and transported without causing damage to the quality of the paint [8].

2.4.2. Painting Methods

Industrial painting can follow two concepts: mass production painting and field painting. In the first, the process occurs in fixed installations, such as booths and greenhouses. In the second, the application of paint takes place in mobile facilities, which can be represented by blasting machines, guns and other equipment [6,8].

There are various painting methods, both for powder and liquid paints. Highlighting liquid paints, there are techniques such as: brush, roller and gun painting, which is the most traditional application. All these are normally used to reinforce edges and corners, and have a wider application in final touch-up cells, that is, outside the painting system, characterizing the concept of field painting. With regard to more usual techniques for the concept of serial manufacturing, one can exemplify the immersion painting, where this procedure can be without or with electric current and the parts are immersed in tanks of paint. Or electrostatic painting, where in this case, the application occurs by paint spray polarized by electrostatic charges [1, 7,8].

2.4.3. Tools used in maintenance management

Quality tools are static and managerial techniques that assist in obtaining, organizing, and analyzing the information needed to solve problems [3].

The use of the tools, such as Pareto, Ishikawa, Brainstorming and PDCA, allows testing hypotheses raised, analyzing productivity losses and proposing improvement actions.

2.4.4. Pareto Diagram

The pareto diagram is a graphic resource that uses vertical bars, with the objective of establishing an order of the causes of losses that must be remedied. from these graphs one can determine which problems must be solved and what their priority is. It was first presented by the Italian economist Wilfredo Pareto, in 1897[4].

The diagram makes possible the visualization of the causes of a problem from the highest to the lowest frequency / severity clearly identifying the location of the vital causes that originated the problem [3].

2.4.5. Cause and effect diagram

It was developed by KAORU ISHIKAWA in 1953 at the University of TOKYO to represent the relationship between some effects that could be measured and the set of possible causes that produce the effect [10].

The CAUSE-AND-EFFECT diagram is a graphical representation that allows you to easily visualize the chain of causes and effects of the problem. the diagram shows the relationship between quality characteristics and factors and represents the relationship between the effect of all possible causes that contributed to that effect [9,10].

For each of the effects there are numerous causes within categories such as the 6 m's: method, labor, raw material, machines, measurement and environment.

Through a list of possibly causes the most probable ones are identified and selected for further analysis.

2.5. The PDCA cycle

The PDCA cycle is composed of four phases, divided into: plan (Plan), execute (Do), check (Check) and act (Act). The PDCA stands out in the organizational environment as a management method for process improvement and problem solving, being the basis of continuous improvement, and can be used in any type of organization, whether in a private company, a non-profit organization or in a public sector [11].

States that the PDCA cycle enables the guidelines outlined by the strategic planning to be made feasible in the company, being of utmost importance the alignment of all employees of the organization [6,12].

The PDCA cycle acts as an agent for planning and organizing activities, as well as maintaining the implemented improvements. Standardization comes at the end of a well-defined process. The cycle is used as the basis of the scientific approach to problem solving [13,14].

The PDCA cycle applies in many different areas, since it meets the needs for correction, following all phases of the production process, from planning to final verification [5].

Below is presented some work that used the PDCA cycle in search of identifying, understanding and improving some processes in terms of product quality to be delivered to the final consumer.

Employed the PDCA cycle in student capitation process in a college in the city of Manaus (AM), obtained in this study the main percentages of the causes that lead students not to renew their enrollment with the Colleges [12].

Application of the PDCA cycle in a shipping company applying quality tools and logistics, presenting the whole sequence of implementation and results obtained [2].

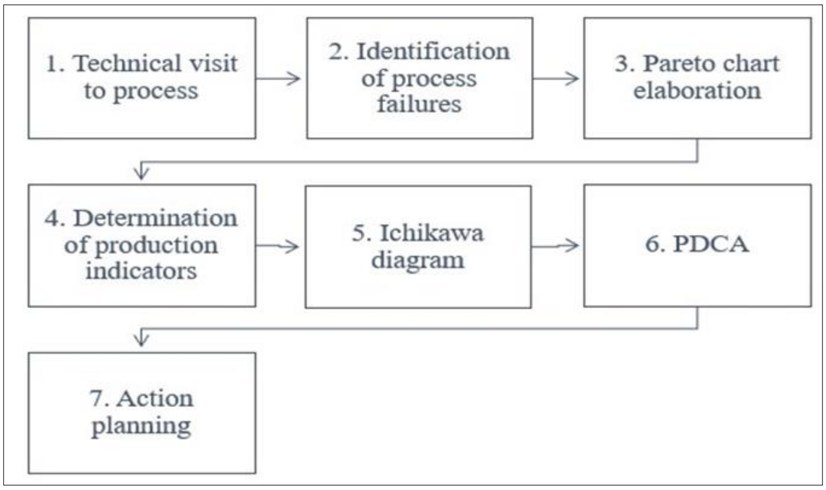
Optimization operational proposal organized public port of Manaus (OPPM): a case study, evidenced the inefficiency of the operational logistics of an attrition for workers and their port users [16].

The improvement of productive processes through the application of production management tools: a case study in a company in the shipping industry for the verification of critical points of their processes within the corporate environment and points of improvement using the PDCA tool [9].

Another of the quality tools commonly used in maintenance management and braisntroming; it is a group dynamic widely used by many companies, especially, as an alternative to solve specific problems, elaborate new ideas or projects and/or perform, planning, always seeking to combine information with the basic stimulus of creative thinking [3]

3. Material and methods

In this work we sought to reduce the downtime of equipment caused during the process of painting motorcycle tanks. The same is developed in a paint booth in a company in the industrial hub of Manaus.



Authors,2023

Figure 1 Diagram of the work development

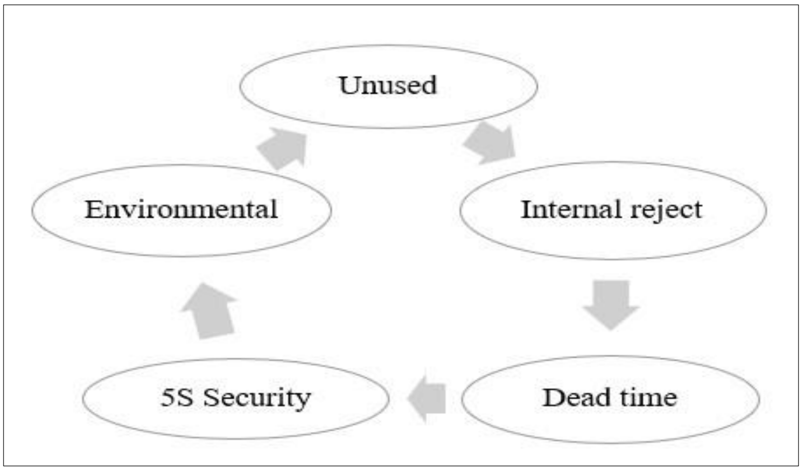
4. Results and discussion

The metallic parts are painted in a company in the industrial hub of Manaus following a continuous process through 1 painting booth as shown in figure 02.

Source: Metal part painting company, 2022

Figure 2 Flow of the metallic parts process

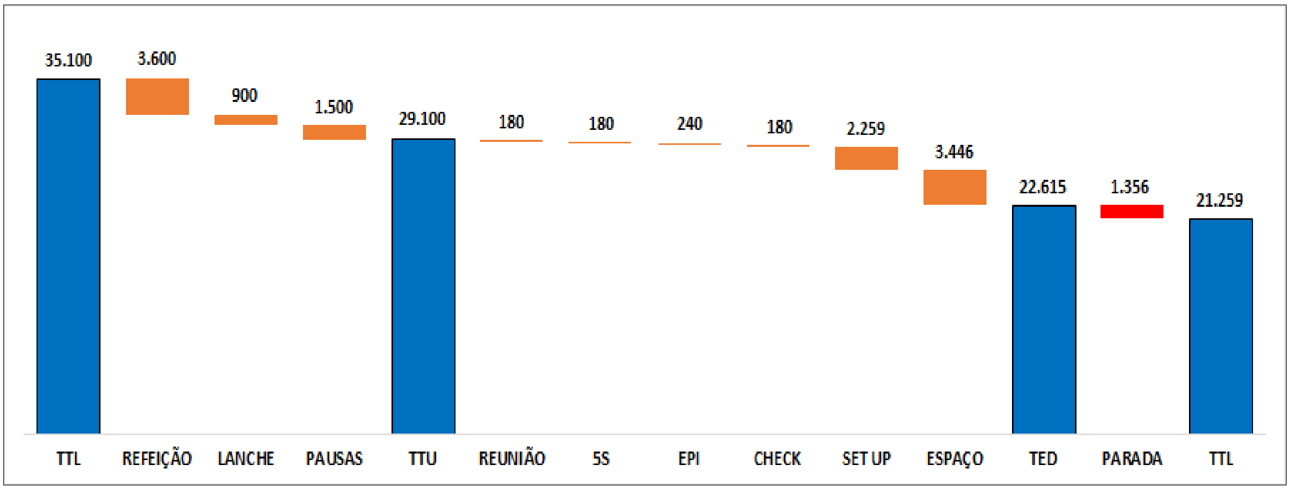
After getting to know the process of painting metal parts, the indicators of rejection of parts were evaluated, where the 6 major defects of the painting process were stratified according to figure 03.



Source: Metal part painting company, 2022

Figure 3 Performance indicators (performance)

Evaluating the work rate of the metal parts painting sector, it was possible to analyze that the process stoppage rate is abnormal as per figure 04.



Source: Authors, 2022

Figure 4 Work rate (Time in seconds)

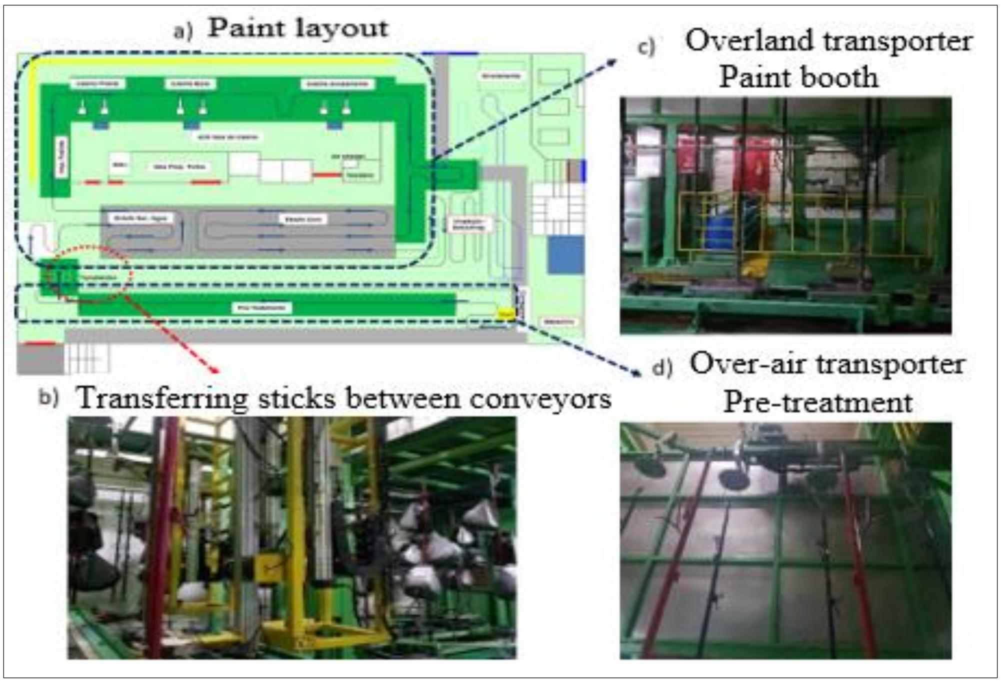
Analyzing the work rate the equipment stoppage has caused a daily loss of 1356 seconds (23 minutes approximately), converting this in HG (rod) in 48 HG (96 tanks) that could be sent to the final client.

Where the same is related to the transferor, equipment that performs the transfer of sticks from the land carrier to the air carrier, as shown in figure 05.

Source: Metal Part Coating Company, 2022

Figure 5 Transferring Tank Rods

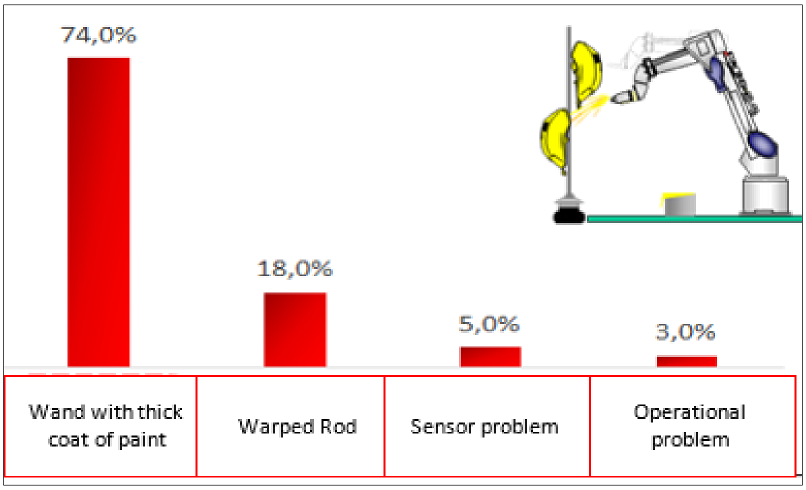
As shown in Figure 06, it can be observed in the layout the points where this transfer occurs.



Source: Metal part painting company, 2022

Figure 6 (a) Layout of the metallic paint sector, (b) stick transfer between conveyors, (c) land conveyor of the paint booth and (d) air conveyor of the pre-treatment

The factors that cause the protractor to stop are related to a stick with a thick layer of paint, a warped stick, a sensor problem, and an operational problem, as we can see in percentage in Figure 07.



Source: Authors, 2022

Figure 7 Chart of factors that generate downtime in the protractor

Where in figure 08, 74% of the factors that cause the equipment to stop is related to the thick layer of paint. After this result was performed the measurement with the caliper to assess the layer of ink on the stick as shown in Figure 08.

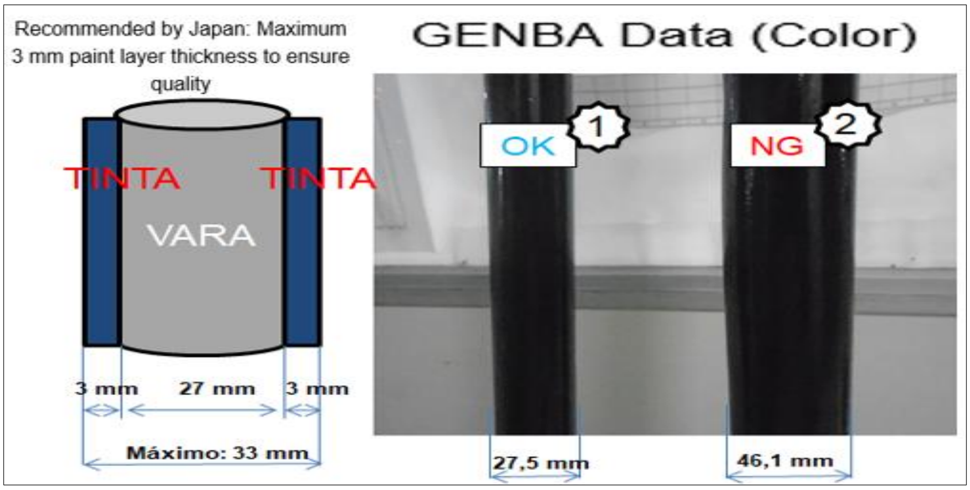
Source: Authors, 2022

Figure 8 Layer measurement

The average thickness of the paint layer found on the rods separated for firing was 43.1 mm.

Using the cause-and-effect diagram, where we can observe that in the method item, the item maintenance of sticks where the number of sticks is not enough to perform rod exchange rotation.

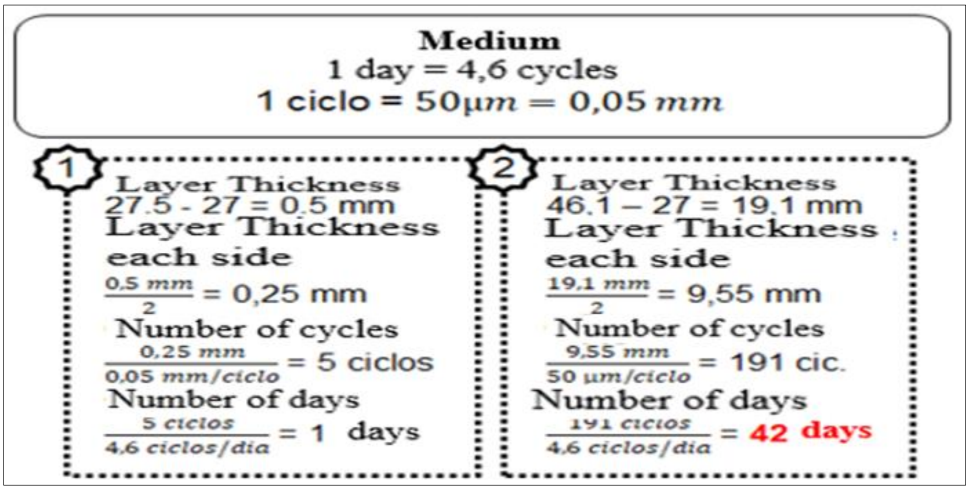
Using the 5 Whys to understand the problem in the high rate of unscheduled downtime due to protractor problems. The high rate of downtime occurs due to ineffective maintenance of the rods as a result of the quantity available for rotation. Performing a layer analysis of the part without paint residue and checking the Japan base coat pattern we found the following values below. The analysis of the paint layer on the rod was illustrated in the figure 09.



Source: Authors, 2022

Figure 9 Analysis of the paint layer on the rod

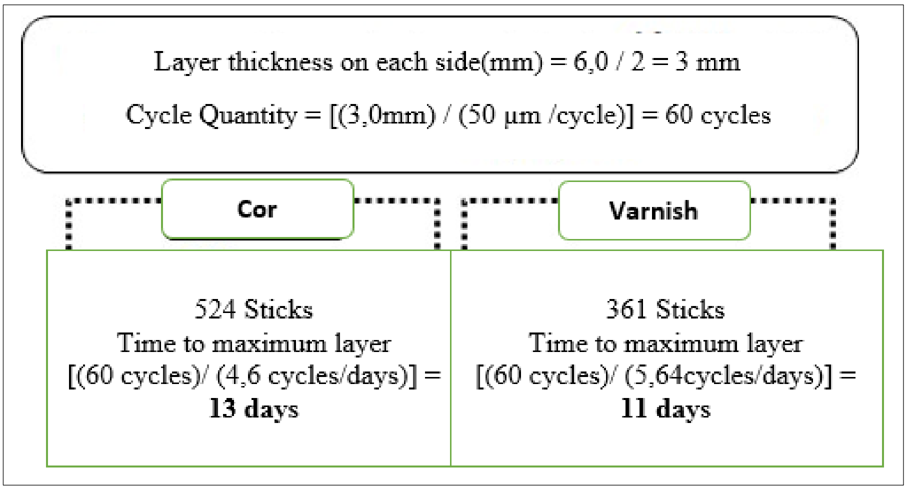
This process allowed us to establish that the flow of rod firing was happening every 42 days where it was deviating from the pattern predetermined by the original manufacturer and owner of the company, as shown in figure 10.



Source: Authors, 2022

Figure 10 Current condition analysis calculation

And the ideal firing condition should follow the basis of figure 11.



Source: Authors, 2022

Figure 11 Ideal condition

For the calculations, the following parameters made available by the sector were used, according to the reality of the process as shown in figure 12.

Proces	Air Transfers (stick)	Land Transfers (stick)	Total	Cycle Time (hours)	Time per day
Color	148	376	524		4,6
Varnish	83	278	361	3 h	5,4

Source: Authors, 2022

Figure 12 Number of sticks x cycle time

Based on the data collected, two proposals were suggested to solve the problem:

- Increase the protractor opening to fit the thicker rod.
- Acquire sticks to perform maintenance and burns

After evaluating the two proposals, it was decided that the most feasible proposal would be number 2 (Acquire sticks for maintenance and firing).

This step could be achieved more easily than the first option that would require several readjustments increasing the time

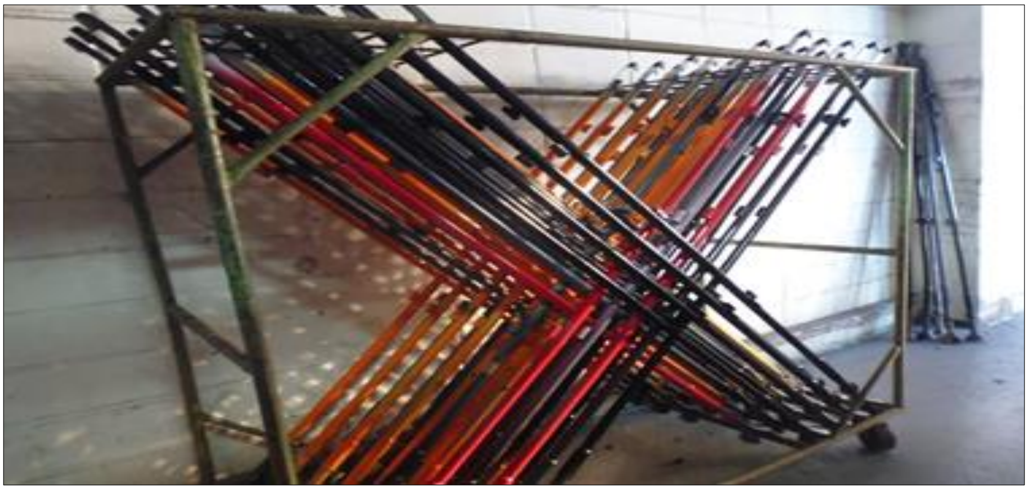
4.1. Acquisition of reserve game

To assess the feasibility of the activity it was necessary to verify if it would change any characteristics of the process, and so an activity schedule was drawn up as shown in figure 13.

No	Implementation Schedule	Year 2022			
		Jan	Fev	Mar	Apr
1	Study of the material and positioning of the sticks	Green			
2	Test development	Green			
3	Procurement of sticks		Green		
4	Placement of sticks and follow-up		Green		
5	Processing of results: production capacity and impacts on stock			Green	
6	Finalizing the tests and drawing conclusions			Green	
7	Deployment in production				Green

Legend: Green - fulfilled; white - not fulfilled. Source: Authors, 2022

Figure 13 Activity schedule

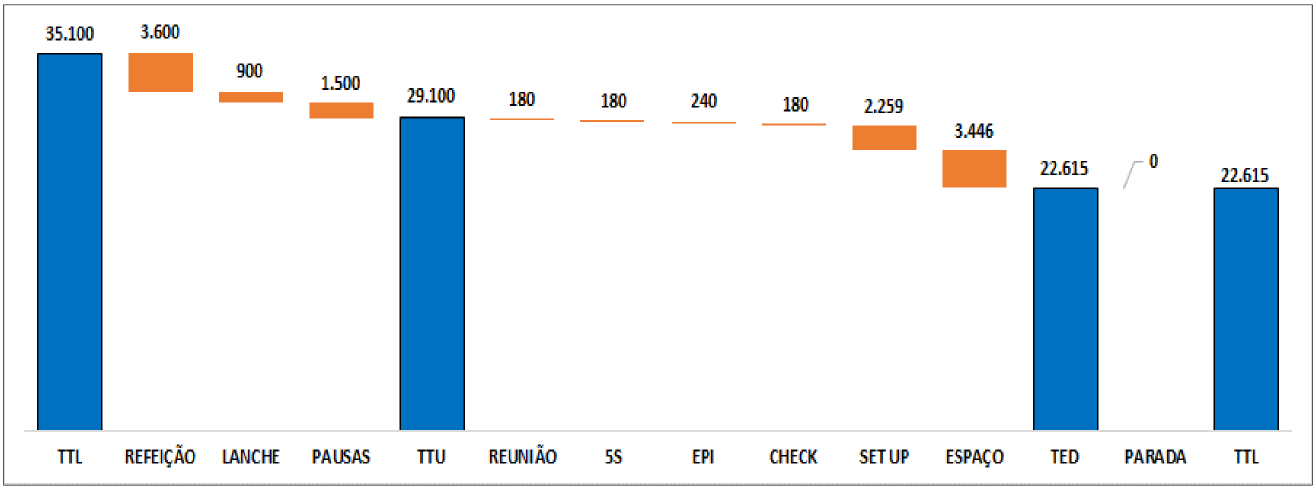


Source: Metal Part Painting Company,2022

Figure 14 Spare stick game

After acquiring the reserve set of 524 sticks, there were no equipment downtime problems due to thick ink layer.

In figure 15 you can see the work rate



Source: Authors, 2022

Figure 15 Work rate (seconds)

It reduced 1,356 seconds of equipment downtime, a 6% increase in production capacity in the metal parts painting sector.

The results allowed to start the implementation the following month after the test with satisfactory results.

5. Conclusion

The research developed allowed the existing problem to be solved, thus eliminating the process stoppage due to downtime caused by problems with sticks with a thick layer of paint and varnish.

In the maintenance management of the aforementioned company, tools were applied that made it possible to direct preventive actions to eliminate lost time and thus increase production.

The use of spare parts in this case contributed to the elimination of the problem of equipment downtime in the process.

Compliance with ethical standards

Acknowledgments

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Disclosure of conflict of interest

No conflict of interest exists between the authors of this article

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