Non-Conformity Reduction in Painting Sector in Plastic Parts in a Company of the Industrial Pole of Manaus - IPM

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Abstract

Among the focuses of industries is the reduction of waste costs, this makes the product competitive, reduces the number of failures and, consequently, the price to the end consumer. Industrial Pole of Manaus (I.P.M.) promotes the economic development of the region and brings together large and medium-sized companies that use plastic painting as one of the stages of their production process and care about quality and invest in management methodologies, resources and technologies to optimize your processes. With this in mind, improvements were proposed in a company to reduce defects in paint in plastic parts in the motorcycle sector, and the use of appropriate quality tools and management techniques, which enabled a more assertive decision-making, measured its effects and solved the causes of the problem. The type of non-conformity of the highest level of occurrence was approached, which are defects classified as impurities, from it were identified root causes found, all variations in processes that benefit the emergence of this defect and opportunities for improvements in the process. This it can be done only with behavioral changes and with minimal economic investment.

Keywords: Quality tools; Rework; Quality management; Defects;

1. Introduction

With increased competitiveness, that becomes long-term increasingly fierce and accentuated, companies have the ever increasing need to continually improve, to avoid non-conformity in their products or processes, which may cause discomfort in the customer. According to [1] Total quality control is associated with the principle that quality is a work of all. Nowadays, it is important a high quality standard that favors market reliability, but does not affect the competitiveness of costs.

Most quality-related problems can be solved by using quality methods and tools, which can identify and resolve the root cause of the problem. They can even give, if well employed, the quality assurance, is generally the prevention of quality problems by means of planned and systematic activities, and should include the establishment of a good quality management system [2], the assessment of its suitability, the audit of the operation of the system and its revision.

With this, management seeks reliable techniques and tools that facilitate and assist decision-making regarding problems with non-compliance and over-rework. This coupled with cost reduction and as a consequence a more affordable price, favors the approximation, loyalty and customer satisfaction.

The study proposal will be to describe and analyze the methods of applying the appropriate quality tools and techniques to the company, for the reduction of defects that usually concern this type of process or production flow. In other words, the analysis will be carried out around the proposed project and employ for the reduction of rework by non-conformities in the painting process in plastic parts of motorcycles.

Accordingly, this scope, the objective of the article is to identify the actual results, and how its implantation was made, because, many improvement projects do not achieve good results due to several factors: inappropriate management, incorrect definition of the goal, lack of commitment of the team, among others [3].

Therefore, the entire flow of painting processes of the parts will be described by mapping the process flow, and will be presented the non-conformity and rework indexes of the line to demonstrate the effects of employing these techniques for resolving these types of problems.

2. Theoretical Foundation

2.1. Lean Production

Lean production is a reference to the Toyota production system of 1948 developed by Taiichi Ohno. According to [4] the “lean” production is actually a research program linked to MIT to define a much more efficient, flexible, agile and innovative production system than mass production.

Lean production is based on the premise of producing more with fewer resources, through improvement processes aimed at eliminating waste with the involvement of the company's organizational culture [5].

Regardless of the type of company or size, the concepts of Lean Production when implemented, can bring significant results in the short and medium term, therefore, its focus is to use tools to identify and eliminate wastes that only add cost to the company, but that does not add value to the product.

2.2. Quality Management

Quality Management (Q.M.) is part of every company that aims to meet customer expectations for product quality and to promote quality as an organizational culture of its production processes.

According to [6] quality management also aims to reduce waste and non-quality costs in production operations, improving business efficiency and enabling more competitive pricing, supporting QM is product and production process related, the smaller the waste as defects in the product or rework in the productive lines, smaller cost by causing results such as increased competitiveness, with the possibility of reducing the price of the product, market gain and customer loyalty.

2.3. Process Mapping

Process mapping is important in identifying the logical sequence of operations that occur during the manufacture of a product or service provision. Additionally, it is also an important activity within the process management, it maps and describes with depth each operation developed in the processes and allows them to know in detail.

In a company, it is common for their processes to pass through so-called “addictions”, which is a kind of process variation that modifies the original and that over time can become common. This is just an example of variation, but they can occur in any operation and processing step, due to raw material, work, or maintenance of the machine, cause adjustments in the process, that, over time, they are creating new procedures, new paths, which, in turn, modify the original process [7].

2.4. 5s Methodology

Started in Japan after the Second World War and that is linked to the philosophy of Lean production. 5S was created with the aim of promoting a suitable working environment to increase productivity [8].

According to [8] 5S is an educational process that aims to promote the behavioral change of people through participatory practices and knowledge of information, this change in behavior favors insertion and better understanding of the concepts of the philosophy of continuous improvement.

5S are concepts based on Japanese ideograms, where each S refers to five words that compose a consensus forming an important organizational program.

Seiri – means sense of utilization.

Seiton – means sense of organization.

Seiso – sense of cleanliness.

Seiketsu – sense of standardization.

Shitsuke – which translates as a sense of self-discipline.

For [9] the adoption and implementation of the criteria set out in the 5S program enable the achievement of relevant results.

2.5. Kaizen

Japanese origin, Kaizen is a word consisting of two ideograms: Kai, which represents change, and Zen, virtue or kindness. Bringing closer to its real representation in companies, Kaizen means change to the best and is a tool used for continuous improvement.

The Kaizen method of continuous improvement is generally described as a project focused on quality has the goal reduction of cost, waste and increased productivity.

Its execution takes into account some basic rules, such as:

- It aims to reduce cost;
- It is important that it be measured;

- It is usually applied in the form of small, medium or large project.

Kaizen is very simple, logical and obvious, but must respect some steps in its development and adoption process [8], that is, it must comply with a technical sequencing with the help of quality management tools.

2.6. PDCA Management System

The implementation of the quality management tools usually uses a general method, which may be called "Operation Logic" [7]. The most commonly used method for project management is PDCA, this method involves logical and technical sequencing activities, establishing structuring scripts that help the development by dividing the type of activity.

PDCA cycle aims at continuous improvement, and each letter determines a step of the process cycle:

Plan (P): It is the planning of actions that you want to implement. Here the action must be defined in a clear and objective way, thus, in this stage are defined the goals and objectives.

Do (D): Step in which is performed of what was planned in the previous step; activities such as training are performed at this stage. Here are also collected the data that will be analyzed in the previous step.

Check (C): This phase is present in all other stages, because it refers to the evaluation of what is being developed, it controls and analyzes the results of the previous action and coordinates the actions that will be taken in the next phase.

Act (A): At this stage, the action process is defined as agreements with the results obtained, whether the goals and objectives have been achieved or not.

Eventually, the cycle completes itself when this last step (action) finish and it is returned to planning. This logic completes the effort by continuous improvement [7].

2.7. Quality Tools

The process of continuous improvement involves important Kaoru Ishikawa seven quality tools proposed steps, such as data collection and process observation, search for root causes of problems, implementations of improvements without affecting the quality and verification of the results obtained, for this.

The quality tools assist in all these steps and in a technical and organized way facilitate the work. There are more than seven quality tools, since there are variations of the same tool [10], and there are management methods, however, only those that conform to the type of organizational culture should be employed, should be linked to the company's values and objectives. The use of only a few tools does not interfere with the quality of improvement projects; it should be available methods and techniques that facilitate the implementation of actions, using quality tools, adequate [7].

Action Plan 5W2H: This tool assists in the search for root cause of problems and helps in decision-making of actions that will be taken. It constitutes a spreadsheet with columns and lines, and divide by English words that mean why (?), what (?), when (?), where (?), how (?) and how much (?).

Flowchart: A tool shows visual and illustrative operations of a process. It is a very useful tool to record the flow of production by adopting a common language/universal language for learning purposes [10].

Cause-and-effect diagram: Developed by Kaoru Ishikawa, this tool aims to identify the root cause of problems; it has a fishbone shape and helps in quality management and control. According to [6], the diagram is structured to illustrate the various causes that lead to a problem.

Pareto chart: is a graphical resource used to establish an ordering on the causes of problems to be solved. It is a bar graph that sorts the frequencies of occurrences, from the highest to the smallest, allowing the prioritization of the problems.

Check sheet: The check sheet is a tool used to quantify the frequency with which certain events occur, in a certain period [11].

3. Tools and Methods

Through a case study, the research was conducted in a plastic injection industry of the Industrial Pole of Manaus.

For the development of the work, bibliographical bases were needed for the study to obtain a better understanding of the problems faced in the painting process with the objective of finding and eliminating root causes. Concepts focused on quality management and articles focused on strategies for eliminating problems in painting processes were researches considered relevant for the advancement of the work.

The article will divide into 4 phases for better actions management (PDCA), based on the operation logic of the Kaizen method because the focus of the work is the improvement of quality. They are: Diagnosis and planning of actions, execution, evaluation, and discussion of learning.

In the first phase (P), diagnosis and planning of actions, the current situation of the painting process has been described and was defined the quality tools and techniques that best suit the process, the company and the type of problem, to identify the main types of non-conformity in the product as well as its cause-effect.

Second phase (D), it was performed the planned and schematized actions, by choosing the pilot line to implement the actions to reduce defects.

In the third phase (C), the results obtained after the application of the improvements were check, which will show the real efficacy of this type of study in reducing defects. Here, the observed improvements and their effects on the resolution of the problem were discussed, comparing the data collected before and after the employment of the improvements.

The last phase (A); the main points of challenges and possible failures in the previous phases that may have affected the project in some way it were discussed, highlighting the action whose results were more relevant.

4. Implementation

4.1. Company Characterization

Through a case study, the research was conducted in a plastic injection industry of the Industrial Pole of Manaus, which has the processes of plastic injection, finishing and molding of EPS wedges.

The company faces various types of problems related to non-compliance and over-rework, consequently, to an increase in raw material waste and labor cost. This type of problem is one of the seven main deadly wastes. A focus was given to the type of defect that occurs in the finishing sector of technical parts injected and painted in thermoplastic resins with the use of paints and diluents, for the two-wheeled pole segment, this due to the high recurrence rates of this defect and the number of rework.

Due to the large amount of rework, the category of defect that it has been studied is characterized as impurities; ordinarily, this type of non-conformity is very common to occur in painting processes, but that with some changes it was possible to decrease the number of parts with this type of defect in the company.

4.2. Characterization of the Painting and Finishing Sector

For a better visualization of the production process, the mapping of the painting and finishing process was carried out, every procedure was accompanied by the production leader of the line. Figure 1 shows the flowchart of the process performed.

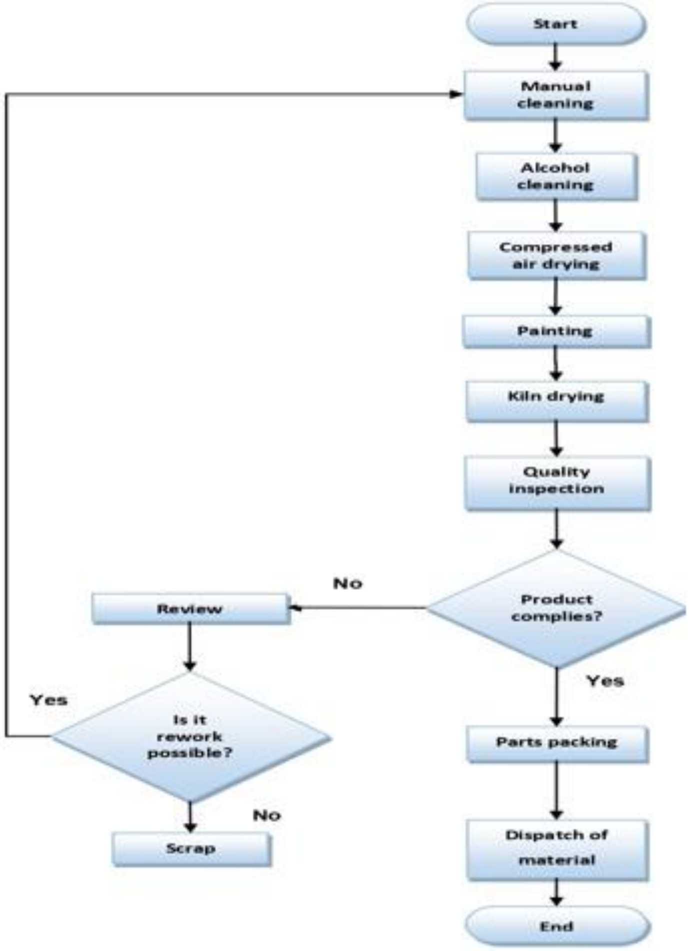

Figure 1: Flowchart of the parts painting process
Source: Author

Figure 1 illustrates the mapping of the painting process of the plastic parts. The description of each step can be seen below, following the flowchart:

1) Start: Phase of receipt of production order and arrival of material in production.

2) First cleaning: In this step with a cotton cloth, the workpiece is cleaned by the employee and placed on the treadmill.

3) Second cleaning: Still with the help of a cotton cloth, the collaborator cleans part, but this time with alcohol to take away possible remnants of oils and other debris that might be in the workpiece.

4) Drying with compressed air: A piece of liquid is removed from the workpiece; the workpiece must be 100% dry to avoid problems in the painting.

5) Painting: This step is subdivided into three other. In the first, the painting is done with the primer, this

special paint serves as preparation for painting the workpiece surface, it will allow a better adhesion of finishing paints. In the second, the painting of the first layer of the finishing paint is carried out. Third, the painting of the second layer of the finishing paint is carried out.

6) Drying in kiln: After the painting process, the parts follow to kiln for ink drying.

7) Quality check: It is checked if the workpiece conforms to the specifications and acceptable quality level. In case the part is not in conformity, the revision is made, in case workpiece can be reworked, it returns to step two, if it cannot, is considered scrap and discarded. However, if the piece is conforms to the specifications it follows to the next step.

8) Packing: Here the piece is packed and placed in cars in the form of bookcase, which when it reaches a certain quantity of parts is sent to storage.

9) Dispatch of material: In this step is made the separation and storage of pallets by part type and customer for subsequent shipment.

10) End: The product is sent to the customer and finalized the process.

The distribution of the stages of the flow of production processes of the painting of the parts can also be observed in Figure 2. The activities are distributed according to the layout of line 1, the production line in which the study was applied.

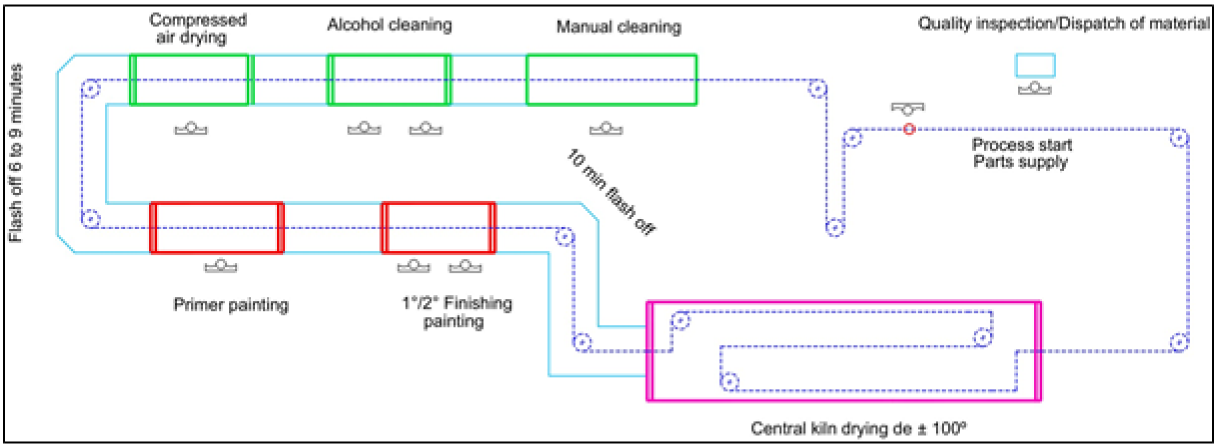

Figure 2: Mapping of line 1, process flow of parts paintings
Source: Author

4.3 Main Types of Defects Produced in the Painting Process

In the painting sector some characteristic defects occur in the part in this type of process, defects that because numerous parts be reworked by non-conformity, furthermore, depending on the degree of defect this can make the piece useless for sale and, therefore, it makes it scrap, increasing the costs. All types of defects found are cataloged by the quality sector, below are some defects identified:

Crater: Small holes, created due to the porosity of the workpiece. Figure 3.
Thin paint layer: Non-uniform painting. Figure 4.
Water mark: Paint failures due to lack of correct drying. Figure 5.

Figure 3: Crater
Source: Author

Figure 4: Thin paint layer
Source: Author

Figure 5: Watermark
Source: Author

Over paint: Caused by the malfunction of the paint gun, leaving the ink layer above the specified.
Impurities: Small particles that when the workpiece is painted are noticeable. They are classified as "fur" or "point" detritus according to figures 6 and 7.

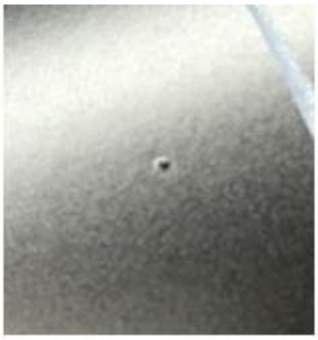

Figure 6: Point detritus
Source: Author

Figure 7: Fur detritus
Source: Author

4.4. Defect Checklist

After the identification of the most frequent failures, the verification sheet tool was used to survey the necessary data. The data are for the month of march/2019, only the parts reworked.

Table 1: Checklist

Defect	**Description**	**N° of occurrences**
Crater	Small holes due to porosity	56
Thin paint layer	Parts of the piece without ink	15
Over paint	High layer of paint	27
Water mark	Lack of drying	36
Impurities	Small debris / dirt present on the part.	227

Source: Author

4.5. Defect Index

To prioritize the resolution of a failure/defect was elaborated the Pareto chart with the data collected and shown on the check sheet.

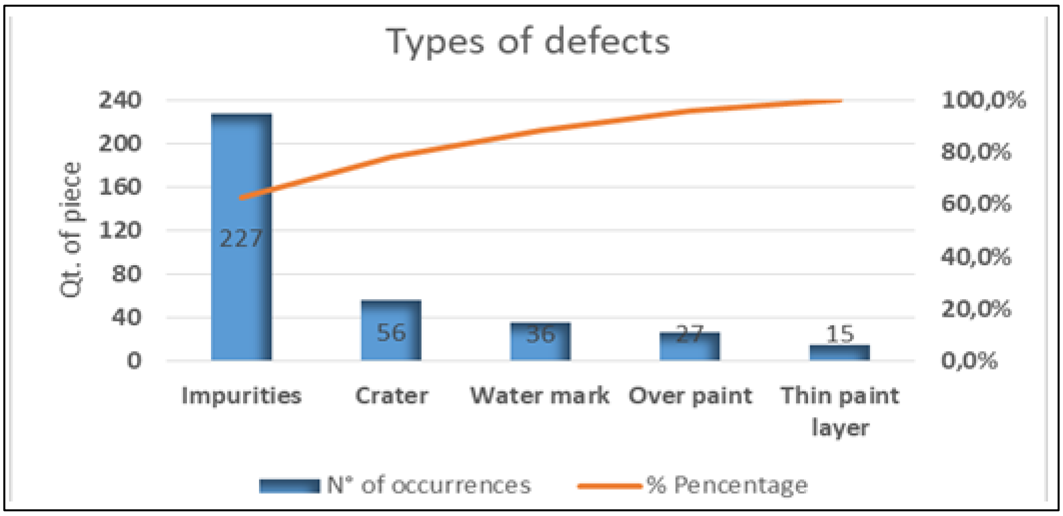

Figure 8: Pareto chart
Source: Author

The defect of the impurities type represents an average of 62.9% of the parts that are reworked in the sector.

4.6. Identification of Faults Causing the Defect with Impurities

The observation of deviations in the process that may cause defects with impurities were documented to identify their causes, possible factors influencing the rate of occurrence of impurities were distributed among 6 categories through the Lean tool cause-effect-diagram. Figure 9.

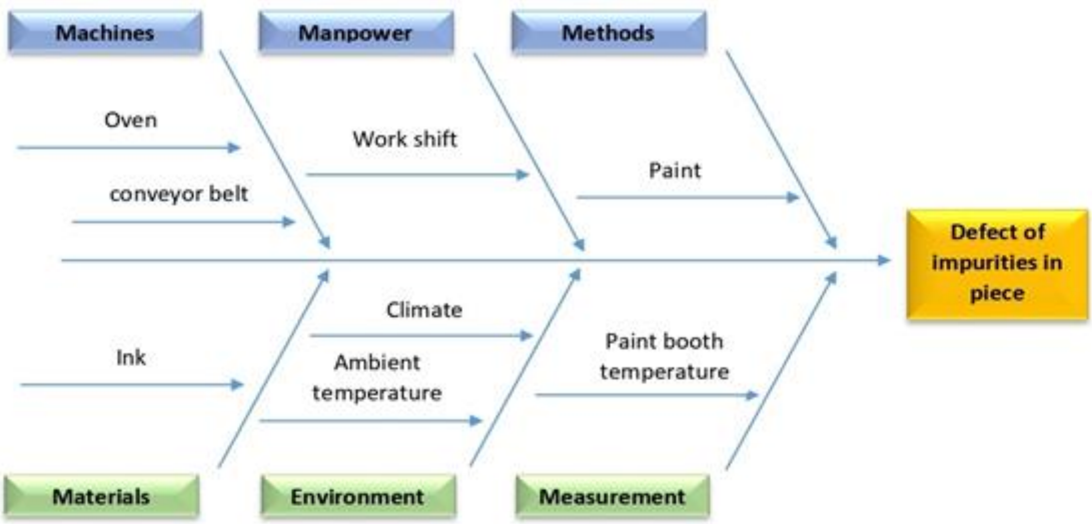

Figure 9: Cause-effect-diagram
Source: Author

The diagram in Figure 9 establishes factors that may influence the index of parts with impurities; these factors were identified through data and interview with line leaders.

5. Results and Discussions

5.1. Action Plan and Improvements Applied to the Process

After identification and monitoring of failures, action plans were carried out to improve and correct process deviations.

5.1.1. Change of cleaning routine

One of the improvements implemented was the change of the cleaning routine; this procedure improved the process to prevent dust from influencing the painting.

In the previous form, the cleaning was performed 1 hours before each work shift start. Cleaning is now performed at the end of each turn. This prevents dust from spreading in the air by the cleaning process and reaching the workpiece at the time of painting. This routine change was made in the cleaning of the whole sector (kiln, treadmill, box and paint booth).

In addition to the physical structure of the sector, cleaning should also occur in materials and tools, such as paint pistols and crawler hanger. The entire cleaning process has been patronized with working instructions, informing the correct way of cleaning.

5.1.2. Maintenance

Another measure adopted was the improvement in Preventive Maintenance Planning (P.M.P.). It was observed that the rates of impurities in the parts were higher in rainy days, and with the monitoring was detected the existence of leaks in the process, these leaks were the cause of the increase of impurities in rainy weather days. Now, the essential preventive maintenance is made on the premises of the sector.

In addition to the facilities, the work materials were also included in the Preventive Maintenance Planning, a different material (guns, hoses, etc.) should be used each work shift, and materials from the previous shift should undergo analysis and inspection to avoid failures. It is now no longer allowed the continuous use of a tool for more than one work turn without checking its performance.

5.1.3. Protective Nets

In the previous process the improvement, the parts were fixed in mat hooks and were followed suspended in the process, the pieces advanced the whole process without any type of protection facilitated contact with impurities, as shown in Figure 10.

Figure 10: Track Parts

Source: Author

The measure adopted to solve the problem was to protect the parts with protective nets. While the workpiece follows on the treadmill to the paint booth, the chosen protective net would cover the workpiece not limiting the temperature penetration, which would not affect the drying process.

Another problem that protective networks help to solve is relative to industry fans, while ventilating the environment, also spread dusts. To solve the problem, a protective screen was employed by the company; however, it was found that this screen consisted of a material that also scattered fur detritus, according to figures 10 and 11.

Figure 11: Filter Fan
Source: Author

Figure 12: Fur detritus
Source: Author

5.1.4. Ink Recirculation

The ink recirculation process was used to avoid loss of ink quality because this action prevented the ink from remaining unused for a long time. This process was done in such a way that two lines could use the same ink, through flexible hoses, which started in the dispensing pump to the pistol of each collaborator responsible for the painting.

After follow-up, it was observed that this process influenced the rate of impurities, because the distribution pump was shared with more than one line caused the ink to not have enough pressure to cross the lines.

So with this detection, it was extinguished the process of recycling ink to avoid problems with quality and the recirculation of paralyzed ink to avoid the defects of impurities in the parts, which made the company open a new parallel project to improve the recirculation process.

5.1.5. Temperature Control

Among the possible failures, the temperature was the least showed some direct relationship with the presence of impurities present in the defective parts. However, the temperature can affect the viscosity and quality of the ink, which could generate defect.

Therefore, the sector HVAC (Heating, Ventilating and Air Conditioning) system would pass through predictive, monthly maintenance. In addition to temperature control, to avoid large variations.

5.2. Results Obtained

After the implementation of the improvements, two-month data were collected for comparison and verification of the results. In the first month, it was possible to observe a reduction in the rate of defective parts, 62.9% of parts that were reworked due to impurities, to a frequency of 19.9%. In the second month there was another reduction and passed to a frequency of 11.5% of parts with defects of impurities. Therefore, it can be inferred that with the help of classical tools and techniques of quality, when worked correctly can positively affect in the company.

6. Final Considerations

As presented in the study, the tools used, proved their efficiency and efficacy in resolving and identifying the root cause of problems related to process deviations.

It was observed that in addition to the tools used, knowledge was needed in project management methodology. To better organize the defined actions, control and choice of data collected.

The non-conformity indexes caused by the impurities had an expressive reduction according to the graphs presented, and demonstrate the efficiency of the choice of tools that suit the culture and type of process of the company.

Within what was proposed, the work achieved its objectives, that is, demonstrated the best way to collect data by mapping the process, established tools in conjunction with project management methodologies and defined the type of non-conformity to be eliminated through the collected data, and with the identification of the cause-effect, applied the proposed improvements.

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