How to reduce craters in the painting process of a PIM company?

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Abstract

Two Wheels sector is one of the most important in the Industrial Pole of Manaus and has recently faced a growing competition scenario, combined with the reduction in sales. Manufacture products with quality it is necessary for companies to remain competitive in the market. With this in mind, the present study was performed in the Painting process of a company located in two wheels sector, which was facing increasing crater defect in February 2012. The objective is to propose improvements in the painting process to reduce the crater defect using a descriptive method divided into seven stages (literature review, problem identification, observation, analysis, action plan, verification and standardization). The research found the main cause and proposed an action plan to solve the problem and may result in experiences to others who wish to realize further research on the subject.

Keywords: Crater; Quality Management; Paint Shop

1. Introduction

The Two-Wheeler sector has been integrated with the Manaus Industrial Pole (PIM) since the 1970s and is currently one of the most important, accounting for 14.76% of total PIM revenues in the first half of 2019, behind only the computer goods industry, with 22%, according to data from the Manaus Free Zone Superintendence (SUFRAMA, 2019).

Also, PIM's two-wheeler sector is the largest in Latin America, both in terms of the number of companies and products. Currently, the sector has the highest rate of production chain density in the Manaus Free Zone, with historical indices of regionalization and nationalization of inputs around 75% of production. The hub consists of about 70 companies, including manufacturers of finished goods and components, parts and pieces (SUFRAMA, 2019).

This scenario is of increasing competition, which makes the survival of Two-Wheeler Polo companies increasingly challenging. To remain competitive in the marketplace, companies increasingly need to maximize their resources and lower manufacturing costs to produce quality products at lower prices.

Feigenbaum (1994) affirms that quality and safety costs represent a significant proportion of GDP and that the responsibility for cost falls heavily on the producer in the form of quality costs, which may range from 7% to 10% (or more) of the sales revenue.

This research was developed in Company X, from the PIM Two-Wheeler sector, more specifically in the Fuel Tank Painting sector, from the identification of the increase of the crater defect in February 2012.

Craters are small semi-spherical deformations that form on the last layer of the painting or even more severe depressions that reach the substrate of the painted part. The defect is only possible to be observed after the tank is painted and because it is a defect difficult to correct, it generates a greater need for polishing processing, reducing the efficiency of the area, generating higher costs with sandpaper, polishing bar and overtime. Besides, when the amount of crater in the tank is very large, it is necessary to sand the entire affected area and repaint the part, increasing the sector rework cost.

Given the above, the objective is to propose improvements in the painting process to reduce the Crater Defect. The specific objectives are a) to map the processes of the Varnish Painting Line; b) investigate the causes of the defect; c) implement improvements that reduce the crater defect.

The work is important for the company because it aims to reduce the internal defect of the Painting sector, which consequently will reduce costs and increase product quality, besides motivating employees.

For the academy, it is important because it will generate knowledge that can be used by other academics, besides providing the development of future research.

For society, it is relevant due to the purchase of better quality products, as well as the reduction of pollutants emitted in the environment due to the reduction of rework.

2. Theoretical Referential

2.1 Quality

Not only is there a definition of Quality, but several well-known authors also have a view on the subject. Feigenbaum (cited Oakland, 1994, p.15) classifies Quality as “the total characteristics of a product and service relating to marketing, engineering, manufacturing and maintenance, by which the product or service when in use, will meet expectations of the customer".

Concisely, Dr. Deming believed in quality through process control and improvement, using statistical techniques. Dr. Juran argued that quality is fit for use. Crosby defined quality as a defect-free product, so it created a zero-defect. Dr. Ishikawa believed in quality as the ability to meet customer needs. Dr. Taguchi considered quality to be the minimum loss of products (adapted from AVELINO, 2005).

With intensifying competition between companies and expanding customer demands, surviving in the market becomes increasingly difficult. According to Campos (2004) what ensures the survival of companies is the guarantee of their competitiveness, to be competitive you must be productive, and productivity depends on the quality of the manufactured product.

Also according to Campos (2004) the main objective of companies is to contribute to satisfying people's needs, this includes both the consumer, the employee, the shareholders, as well as the company's neighbors. Therefore, producing with quality is important for all people who somehow interact with the company.

2.2 Quality Tools

“Quality tools are techniques used to define, analyze, measure and propose solutions to events that interfere with good business performance, that is, they are often used to support the development or decision in analyzing a given problem. Thus, its application acts as an extremely important mechanism for taking managerial attitudes” (MIGUEL, 2006 apud LEAL, 2011).

The main tools used in problem analysis and troubleshooting are:

a. Process Mapping (Flowchart): This involves describing processes in terms of how activities relate to each other. It can be used to gain a detailed understanding before breeding (SLACK; CHAMBER; JOHNSTON, 2009).

b. Pareto Chart: identifies the situations that occur, placing them on a decreasing frequency scale (MARTINS; LAUGENI, 2004).

c. Ishikawa Diagram: Also known as the cause and effect diagram, identifies in which and how the factors material, labor, machine, and working method influence the occurrence of a problem in the production process (MARTINS; LAUGENI, 2004).

d. Verification Sheet: Rodrigues (2006 apud SAMED, 2011) affirms that this is a tool used to tabulate data from a particular observation, identifying and analyzing the occurrence of selected facts within a time interval

e. Matrix 5W2H: The terminology comes from the English words What, Who, Why, When, Where, How, How much/How many, this tool can be applied to various areas of knowledge, serving as the planning basis for the given actions (CAMPOS, 2006 apud SAMED, 2011).

There are other little-known tools also used more participative that can be used to diagnose and solve problems, such as Figure Rica, SCORE Matrix, Objectives Tree, Challenges Tree, which are described by da Silva (2018).

2.3 Painting Process

According to Polito (2006) painting means protecting and beautifying. Care must be taken to ensure that the qualities of the paint remain firm and adhering to the substrate while maintaining the essential properties for a while. This same concern should be directed to the preparation of surfaces to be painted, professionals with quality, experience, and modern equipment.

The preparation of the part to be painted is done through a pretreatment whose purpose is to convert the metal surfaces by chemical deposition of a phosphate layer that will serve as a base for painting, a non-metallic layer; this will guarantee the final quality of the surface product against corrosion and excessive wear (HENKEL, 2012).

Once prepared, the piece can be layered with paint. Ink means a mixture of dispersed pigments, solid or liquid resins, solvents, and additives which, when applied onto a substrate, can form an opaque (glossy or matte) film which adheres thereto, giving it the color, beauty, and protection (DUPONT, 2012).

Pigments are products made of solid, insoluble particles in the vehicle (resins) which, when dispersed, give color and opacity (covering power) to the paint, in some cases, it has an anti-corrosive function. Solvents are responsible for the flow ability and applicability of the paint and this flow ability is measured by the viscosity of the paint, which is the property of fluids to move by molecular diffusion (DUPONT, 2012).

Varnishes are mixtures of resins (solid or liquid), solvents and additives that, when applied on a substrate, can form a transparent (not necessarily colorless) film that adheres to it, giving it beauty and protection (DUPONT, 2012).

The most common way to apply paint or varnish to the substrate is by spray guns. With the aid of pumps, ink is transferred to the gun, which also receives pressurized air. This combination of air and paint form the spray that is applied to the part to be painted.

3. Methodology

For the sake of preserving the name of the company, in the present work, it was called Company X. The company is privately held, is located in the Manaus Industrial Pole and is headquartered in Japan.
At the time the survey was conducted, the year 2012, the main products manufactured in the Manaus plant were motorcycles with 150 to 1000 cc, as well as the assembly of 15 to 90 Hp outboard motors.
The annual motorcycle production capacity was 350,000 units and 17,000 outboard engines. The factory had 2,000 employees and the production flow chart is shown in Figure 1.

Figure 1: Company X Organization Flowchart
Source: Author

The factory has 5 independent painting sectors (Tank, Metal, Outboard, ABS1, and ABS2), and the research was applied in the Tank Painting sector.
Around 54 employees act in the sector where the motorcycle fuel tanks are painted. The sector flowchart is represented in Figure 2.

Figure 2: Production in Tank Painting Flowchart
Source: Author

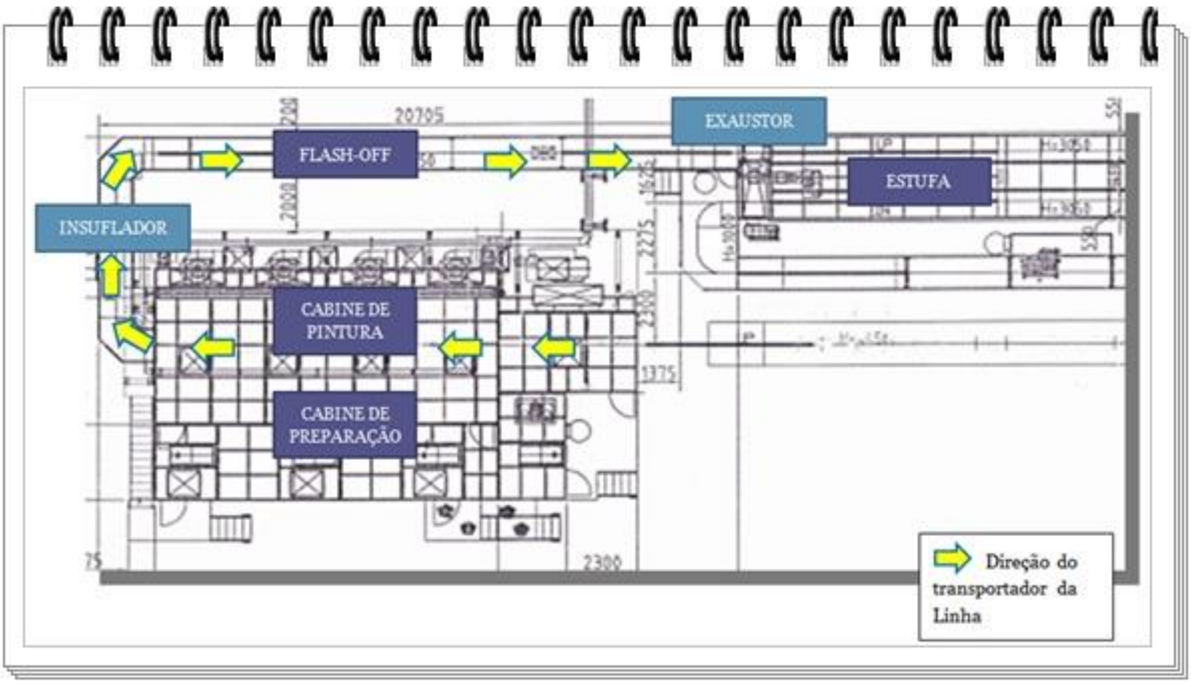


Figure 3: Varnish Paint Line
Source: Author

The study was done at the Varnish Paint Line, where the crater defect was identified. The Line is composed of the following elements (Figure 3):

• Preparation booth: the area where the varnish is mixed with the diluent and catalyst so that it is at the correct application viscosity on the part;

• Paint Booth: a place where painters with the aid of guns apply the varnish on the piece.

• Greenhouse: the system responsible for heating the painted part to speed up the process of curing the varnish;

• Flash-off: the space between the spray booth and the greenhouse, necessary for some of the solvent present in the varnish to evaporate before entering the greenhouse;

• Insufflator: the system responsible for cooling the Paint Booth and Flash-off, keeping the temperature around 25 ° C. It can be regulated through valves to inflate more or less air into the Paint Line;

• Exhaust: the system responsible for removing vicious air from within the Paint Line. Like the Insufflator, the Exhaust can also be set to exhaust more or less air. The interaction between the insufflator and the exhaust fan forms the air balance within the line.

3.1 Data Collection

The research was carried out in the Tank Painting Varnish Application Line.

The study has an applied nature, with a descriptive approach, through literature review, documentary research, case study and use of quality tools with seven steps organized according to the schedule described in Chart 1.

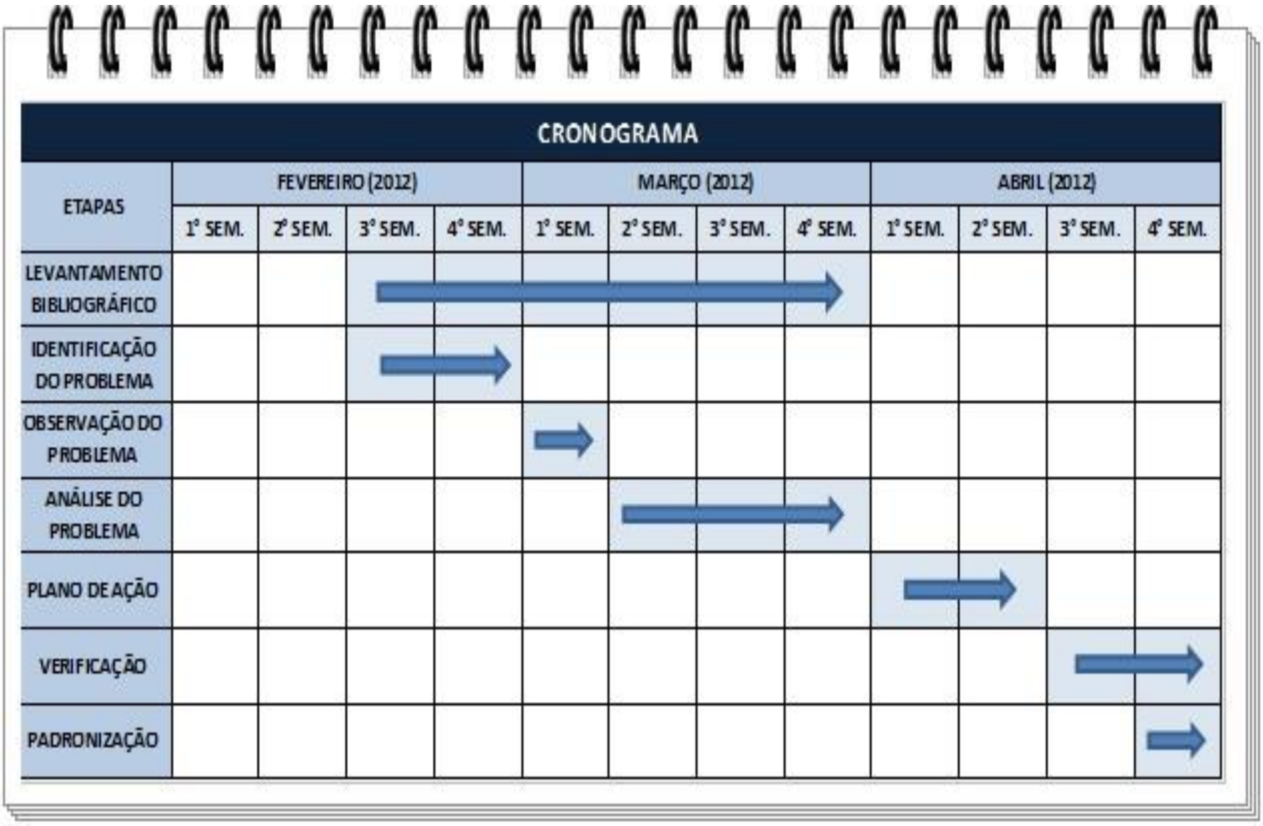


Chart 1: 2012 Research Schedule

Source: Author

The team was composed of two people, who after seeking information about the process, operationalized the activities planned in the schedule, with the help of the person in charge of the sector.

The information was collected through the monitoring done in the production process, as well as data provided by the company.

3.1.1 Bibliographic Survey

At this stage, a literature review was conducted to identify articles, books and manuals that addressed the painting process, as well as references on the Quality Tools, important for the research to be performed. As short formation about the crater defect was identified, the experience of the painting process operators was of great importance for the research.

3.1.2 Problem Identification

The choice of the crater defect as the main defect to be studied was made from the analyzes in the sector that showed that this defect corresponded to the highest index among all problems, as shown in Figure 4, with the Pareto graph of Tank Painting defects of February 2012.

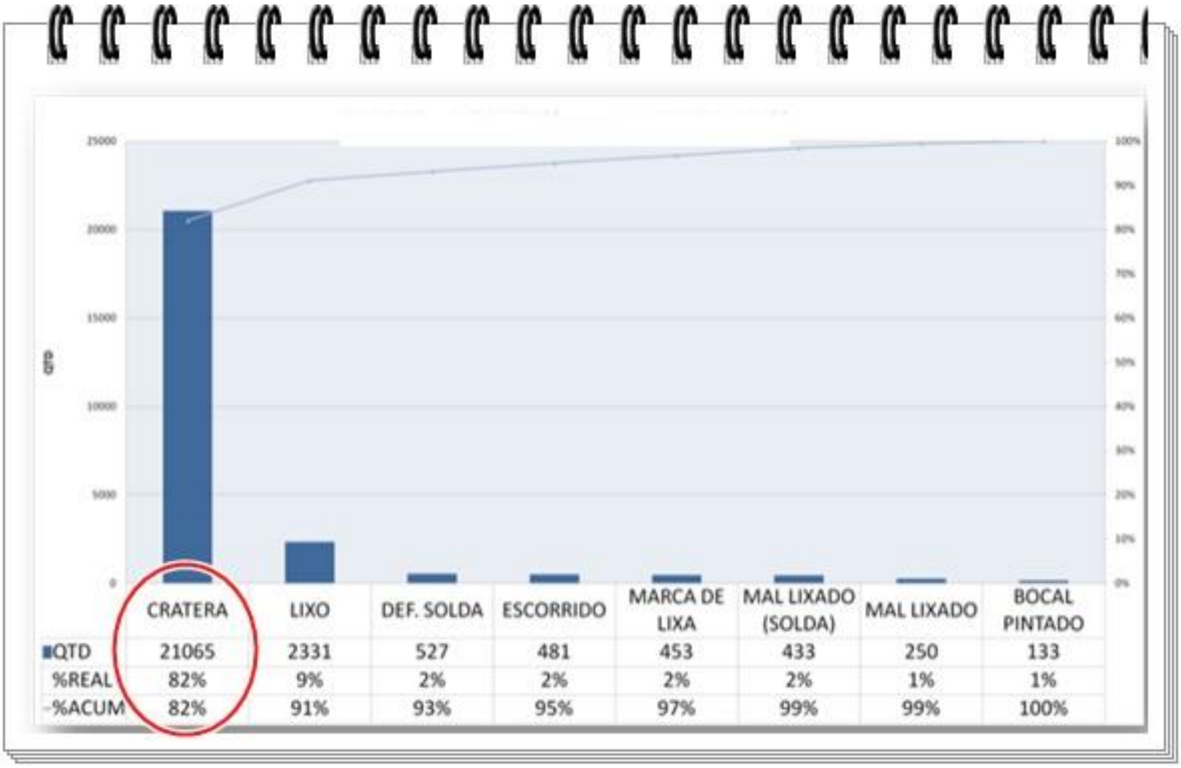


Figure 4: Q Number of Tank Painting defects in February 2012.
Source: Author

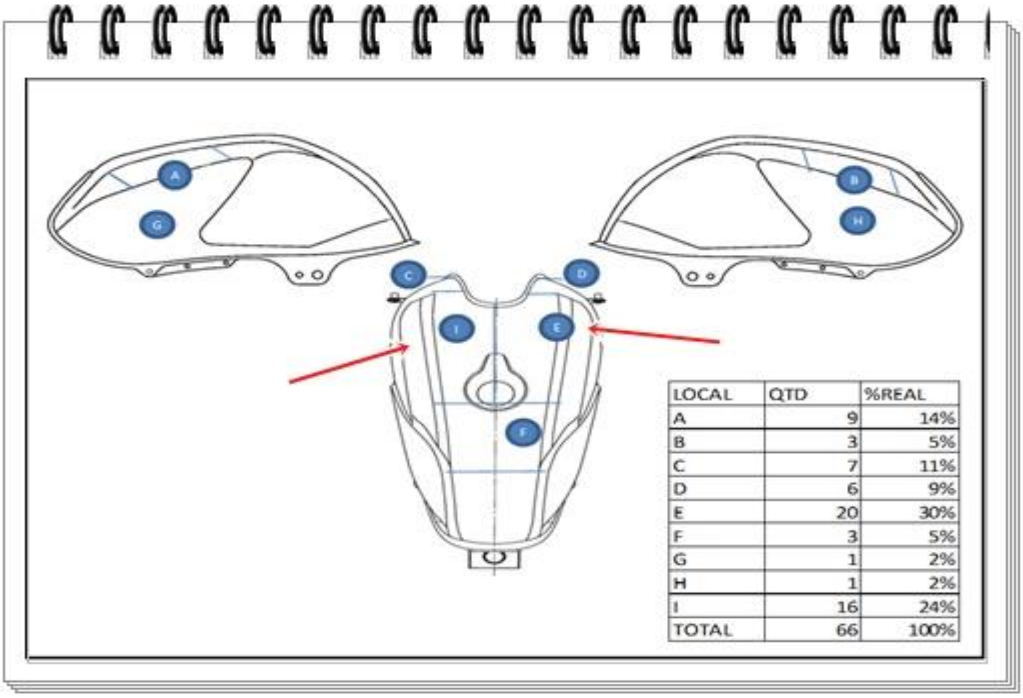
3.1.3 Problem Observation

Observation of the problem began in the first week of March 2012. It was found that the defect occurred in the Varnish Application Line throughout the production day.

The defect occurred in all fuel tank models and all colorings, and in black coloration models, the defect was clearer. One of the characteristics observed was that the crater always occurred at the top of the tank, as can be seen in Figure 5.

Figure 5: Crater defect feature
Source: Author

A pictographic analysis of the fuel tank was made, where 10 varnished pieces of random models and colorings were analyzed. The amount of defect per piece was found to be an average of 66 craters, concentrated in regions I and E, as shown in Figure 6.



LOCAL	QTD	%REAL
A	9	14%
B	3	5%
C	7	11%
D	6	9%
E	20	30%
F	3	5%
G	1	2%
H	1	2%
I	16	24%
TOTAL	66	100%

Figure 6: Fuel Tank Pictographic Analysis
Source: Author

3.1.4 Problem Analysis

The analysis of the problem took place between the second and fourth weeks of March 2012.

According to observations made and the staff's experience of the painting process, eleven possible causes were raised for the problem as illustrated in Figure 7.

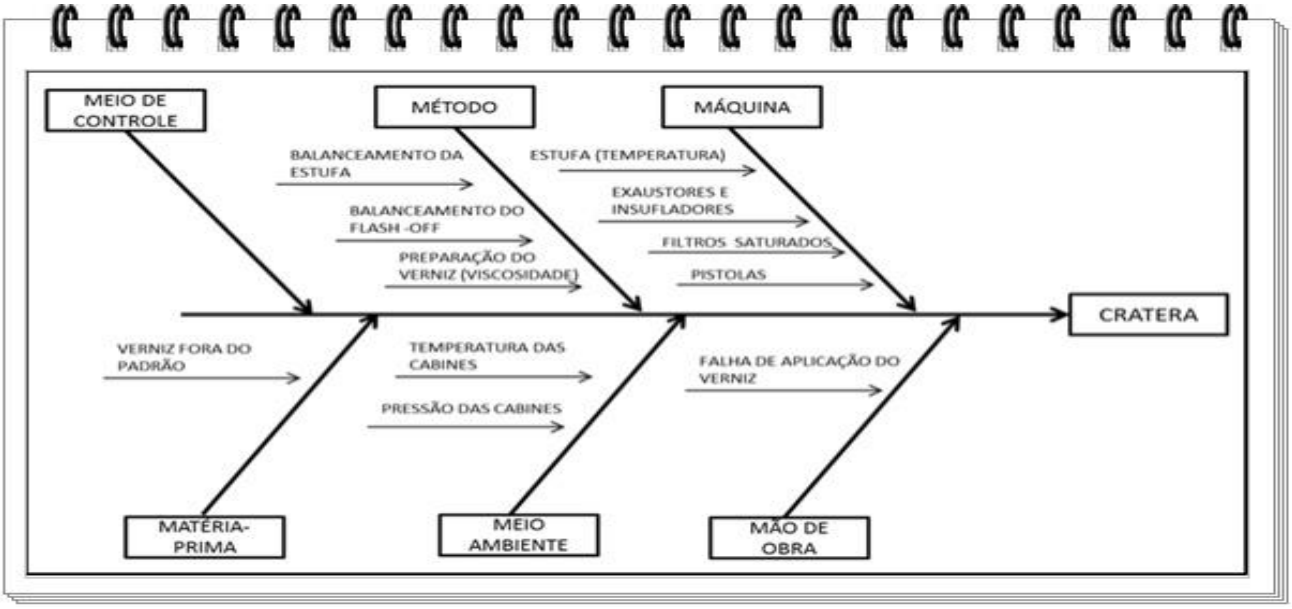


Figure 7: Potential Causes of Crater Defect

Source: Author

MONITORAMENTO DO PROCESSO - PINTURA VERNIZ

DIA	HORA	TEMPERATURA (°C)		PINTORES			UMIDADE DO AR (%)		VELOCIDADE DO AR (m/s)	VISCOSIDADE DO VERNIZ (seg.)
		CAB. PINTURA	CAB. DE PREPARAÇÃO				MAX	MIN		
19	13:55	28,2	29,1	M	C	J	79,41	50,78	0,48	15,56
20	08:10	28,5	29,3	C	V	M	78,02	51,81	0,35	15,91
21	15:30	28,7	29,5	M	V	A	70,80	69,10	0,34	15,64
22	10:15	28,5	29,4	C	J	L	69,59	68,36	0,32	16,20
23	14:00	28,6	29,3	C	V	M	72,40	69,20	0,36	15,70

DIA	HORA	BALANCEAMENTO DA CABINE	TEMPERATURA DA ESTUFA (°C)	MODELO	COR	LOTE	OBSERVAÇÕES
19	13:55	OK	80	18D	PRETA	649	NENHUMA OBSERVAÇÃO A SER FEITA
20	08:10	OK	82	18D	ROXO	429	
21	15:30	OK	82	1S4	VERM.	114	
22	10:15	OK	81	18D	ROXO	430/431	
23	14:00	OK	83	21D	AZUL	368	

Chart 2: Variable Monitoring

Source: Author

From the possible causes raised, the first step was to set up a check sheet and monitor the variables regarding the Paint and Varnish Preparation Booths, besides the Greenhouse, that could be causing the defect, as shown in Chart 2.

The variables were analyzed on five days during five different times during the production day.

The second step was to analyze the air balance within the flash-off generated by the Insufflator and Exhaust. For this, a tool was used that generates smoke less dense than air, allowing to verify its direction (Figure

8).

Figure 8: Air Balancing Analysis
Source: Author

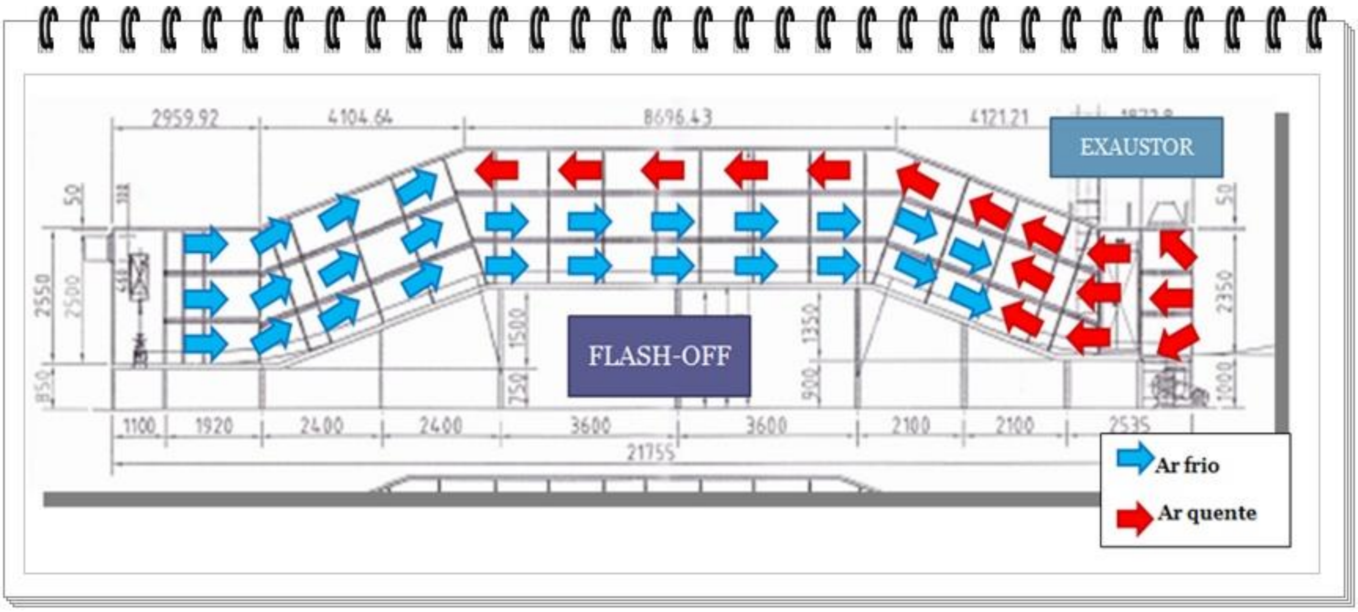


Figure 9: Air balance inside Flash-off analyses.
Source: Author

4. Results

After monitoring the variables related to the Painting and Preparation Booths of Varnish, Greenhouse, Insufflator and Exhaust Fan, the data collected was analyzed. Inside the Prep Booth, the temperature was within standard and it was found that the viscosity of the varnish was within that specified by the supplier. In the Paint Booth, the room temperature was also within the standard, the painters were applying the varnish as specified and the gun setting was correct. The humidity and air velocity did not show any abnormality inside the booth and the temperature inside the greenhouse was as determined.

Regarding the balance within the flash-off, it was verified that the hot air generated by the greenhouse was entering the flash-off, as shown in Figure 9.

From this analysis, a hypothesis was raised for the appearance of the crater defect. The warm air from the greenhouse being less dense than the cold air would flash in from the top and this would cause the tank varnish to heal faster in the upper region.

Thus, when passing through the greenhouse, the upper region of the tank would have greater difficulty in releasing the solvents contained in the varnish, thus generating the craters.

4.1 Action plan

Upon the hypothesis raised, actions were defined to contain the crater defect. The first action was to regulate the inflator shut-off valve so that more cold air was thrown into the flash-off. The second action was to regulate the exhaust shut-off valve so that hot greenhouse air would no longer enter the flash-off and no cold flash-off air would enter the greenhouse, which would decrease efficiency equipment and may cause other problems in painting. The plan has two actions and is described in Chart 3.

WHAT?	WHEN?	WHERE?	WHO?	HOW?
Increase Flash-off Insuplation	14/04/12	Varnish paint shop	Anonymous	Adjusting inflavator valve
Increase oven exhaust	14/04/12	Varnish paint shop	Anonymous	Adjusting inflavator valve

Chart 3: Action Plan

With the planned actions, the flash-off and greenhouse air balancing were as described in Figure 10.

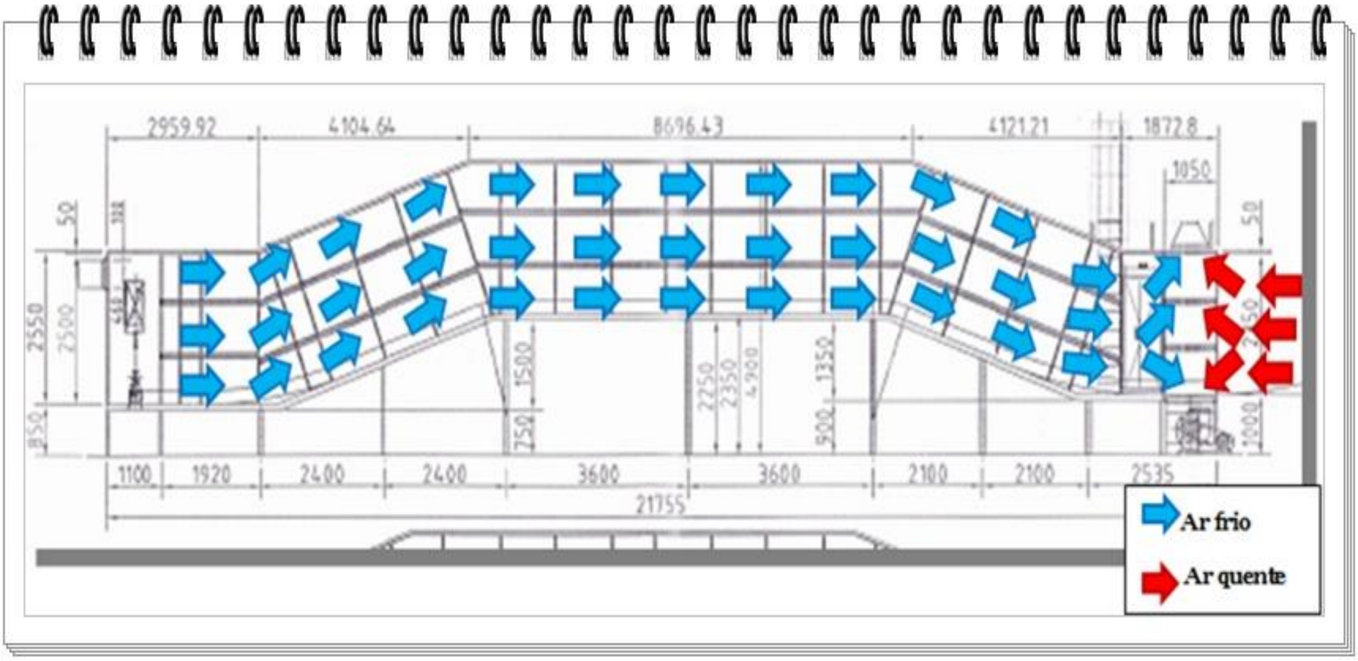


Figure 10: Check for new air balance in Flash-off.

Source: Author

With the new balancing, it was found that warm greenhouse air no longer entered the flash-off and neither cold flash-off air entered the greenhouse, as shown in Figure 11.

Analyzing the production data of the Varnish Line on the days following the actions performed, it was observed that the crater defect no longer appeared among the largest defects of the Line (Figure 12).

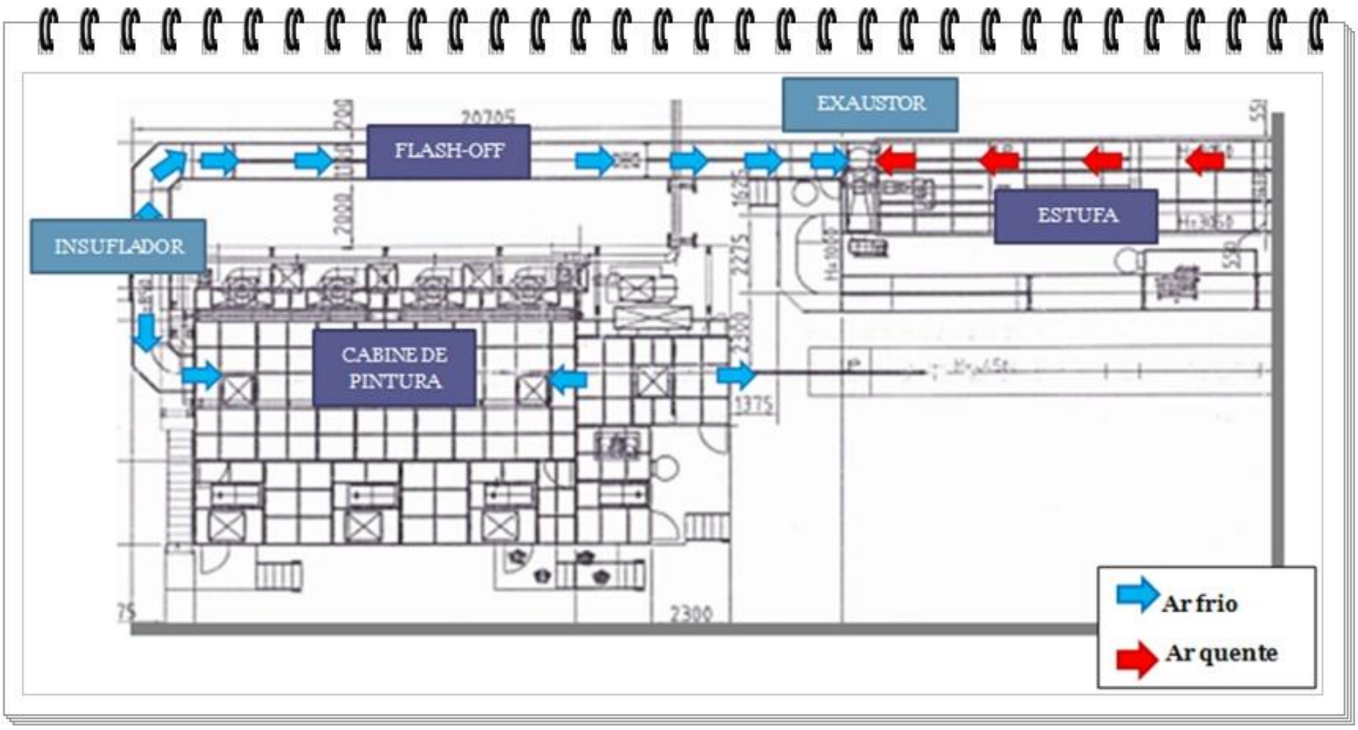


Figure 11: Verification of the new air balance in the Varnish Painting Process.

Source: Author

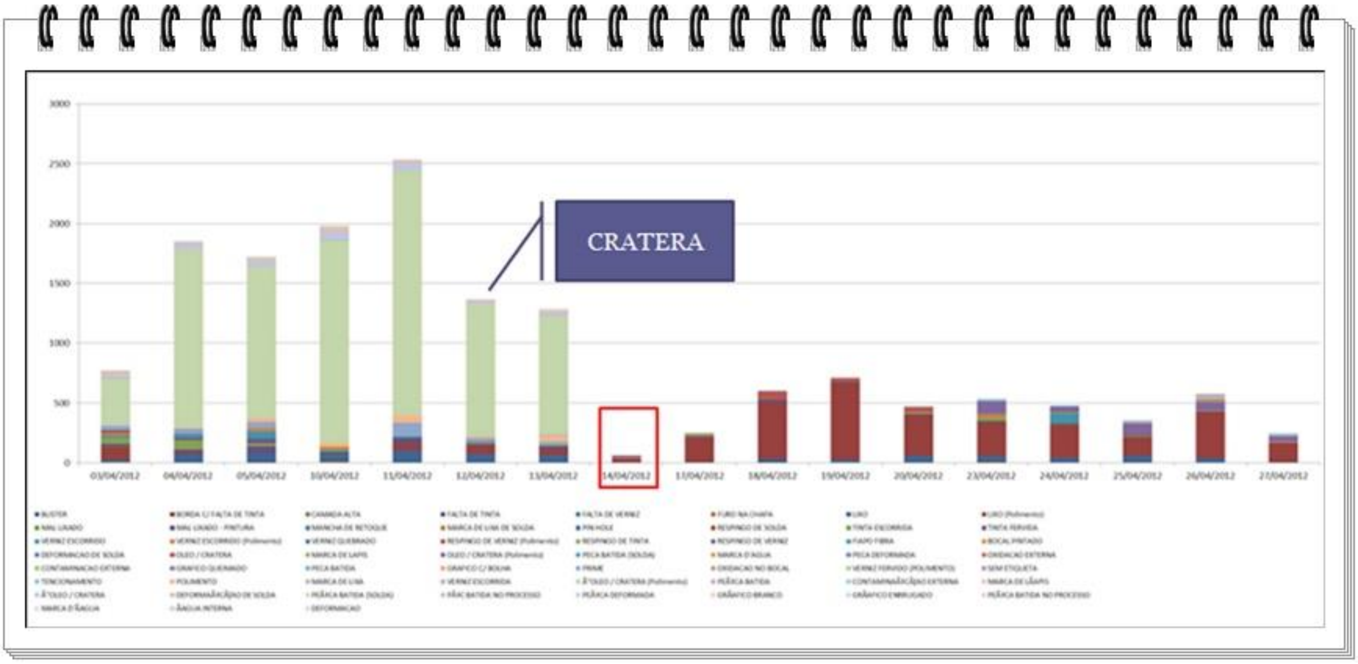


Figure 12: Tank Paint defect index in April 2012.

Source: Author

The new adjustment made to the Flash-off blower valves and the exhauster of the greenhouse was standardized, and a tape was placed marking the ideal opening position of the valves, as shown in Figure 13.

Figura 13: Marking of Flash-off and Exhaust Vent Valves.

Source: Author

This new adjustment has been included in internal industry documentation. Leaders and incumbents were briefed on how to solve the cratering problem and were trained on how to properly balance Flash-off and Greenhouse.

5. Conclusions

The research aims to propose improvements in the painting process to reduce the Crater defect. To this end, a 7-step schedule was executed between February and April 2012. After analyzing the data, the following conclusions were reached:

1°) The process mapping of the Varnish Paint Line was of fundamental importance for the research progress, as it allowed to raise the possible process variables that could be causing the Crater Defect. The greatest difficulty encountered in carrying out the work were the few existing references about the problem;

2 °) The main cause for the defect to occur was the air balance inside the flash-off due to the warm air entering the greenhouse which was causing the fuel tank to prematurely cure. The new adjustment made in the system caused the Crater Defect index to decrease from 82% in February 2012 to 6% at the end of April 2012;

3 °) As an improvement, the valves regulating the air inlet of the Insufflator and the exhaustion of the Greenhouse were marked with ribbons and their adjustment was included in the Machine Check-Sheet, so that they are checked daily, to that the defect does not recur;

4 °) As a suggestion for the company, it would be important to invest in the qualification of the Quality Tools Painting Line Managers, to be able to make better use of their practical knowledge, to analyze and reach the causes of the problems;

5 °) It was presented in the Pareto Chart of the Painting Tank of February 2012, that the second biggest defect of the sector was the Garbage, which are several particles that incorporate the piece before it is cured. As a proposal for future research, a study of the causes of the Trash Defect can be made and propose improvements to reduce it.

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Acknowldgments

We would like the Company X managers for their support and also Doctor Elaine Ferreira and MSc Leandro Leite for their contributions during the Industrial Engineering Course Examining Board when the article was defended in 2012.