# PDCA Cycle Application in the Beer Filtration Process

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## Abstract

*The brewing process requires that the manufacturing of your product be done and controlled in such a way that the entire characteristic of the product is preserved from receipt of raw material to finished product. Thus, this work aims to propose actions that allow identifying possible critical steps of oxygen increases during the beer filtration process. Using the PDCA cycle methodology to analyze possible failures, be it people, management or equipment, and seek improvements through the analysis and monitoring of objective actions capable of identifying and addressing all problems at the process stage, thus ensuring, improving the sensory quality of beer and producing with, lower dissolved oxygen content. The PDCA cycle will be used because it is a sequence of activities that are cyclically performed to improve activities and continuous application and allows a real use of the processes generated in the company, aiming at reducing costs and increasing productivity. Therefore, the scientific problem of this work refers to the evaluation of points of the manufacturing process that causes premature aging and oxidation in the produced beers.*

**Keywords:** PDCA, Process Flow and Process Mapping;

## 1. Introduction

The structure of a company in the brewing process is divided into three major stages: Manufacturing, in order to obtain results that help achieve the main objective of this work, the following actions were defined: Map all the most critical points that are within reach. to do without the investment requirement and identify and budget the others that need to invest to improve the process: Identify the possible failures in the brewing process by applying auxiliary tools and quality tools with (PDCA): Follow up how often problems occur in the process: Standardize and revise operating procedures and train the entire operation so that everyone can perform the activities in the same way and identify, evaluate and bring effective solutions to each problem if it occurs:

Standardize actions through preventive maintenance procedures and operational standards. The PDCA cycle is defined as a sequence of activities that are cyclically traversed to improve activities and continuous application and that allows a real use of the processes generated in the company, aiming at cost reduction and productivity increase. (planning), Do (check), Check (check) and Act (act) and is related to the philosophy of continuous improvement.

Thus, the general objective of this work is to propose actions that allow to increase the sensory quality of the beer ensuring the production of beers with low dissolved oxygen in the finished product, analyze the possible failures of people, management or equipment and seek the Improvements through analysis and monitoring of objective actions capable of identifying and addressing all problems in the brewing process, thus ensuring the improvement of the sensory quality of the beer and producing with lower dissolved oxygen content.

## 2. Theoretical Reference

### *2.1 PDCA*

#### *2.1.2 PLAN*

The cycle begins with defining a plan based on company guidelines or policies. At this stage you choose a process or problem to solve, which can be an activity, assembly line, method, etc. This phase, according to Campos (2004), is subdivided into five stages:

Problem identification: This is performed every time the company encounters an undesired outcome (effect) from a process (set of causes). B. Set Goal: The problem will always be the missed goal, the difference between the current result and a desired value called the goal. Every goal to be defined should always consist of three parts - management objective, time frame and value. ç. Phenomenon analysis: detailed analysis of the detected problem and its characteristics, through facts and data collected. d. Process Analysis (Causes): Search for the most important causes that cause the problem by analyzing the important characteristics. and. Action Plan: This is the product of the entire process for the PLAN stage, which contains, in detail, all actions that must be taken to achieve the initially proposed goal.

#### *2.1.3 DO*

Execution of the plan consisting of training those involved in the method to be employed, the execution itself and data collection for further analysis. This stage, according to Campos (2004), is subdivided into two: a. Training: when the plan is disclosed to all involved prior to execution; B. Action Execution: when the plan is executed. During this execution periodic checks should be made to maintain control and eliminate any doubts that may occur throughout the execution. All actions and good or bad results must be recorded to fuel the next step of the PDCA cycle.

### 2.1.4 CHECK

It is the analysis or verification of the results achieved and data collected. It may occur concurrently with the realization of the plan when it is verified whether the work is being done properly, or after execution when statistical analysis of the data and verification of control items are performed. In this phase errors or faults may be detected.

### 2.1.5 ACT

Characterized by the corrective actions, that is, the correction of the failures found in the previous step and the process of standardization of the actions performed, whose effectiveness was previously verified. It is at this stage that the Cycle begins again leading to the process of continuous improvement.

Therefore, the scientific problem of this work refers to the evaluation of points of the manufacturing process that cause early oxidation in the produced beers.

The Planning step (P) is intended to list the objectives to be achieved in the process, to decide on the methods to be employed to achieve the established goals. ALVES, EAC. PDCA as a routine management tool. In: XI National Congress of Management Excellence. 2015. p. 1-12.

### 2.1.6 The Diagram of Causes and Effects

It is the representation of the possible causes that lead to a certain effect. For the authors Paladini (2012) and Carvalho (2012) the diagram which is known as herringbone chart or Ishikawa diagram, reference to the Japanese engineer Kaoru Ishikawa (1915 - 1989) who created this diagram in 1943. The purpose of this tool It is analysis of the operations of the productive processes.

Cause groupings are established by similar categories or observed during the classification process. The cause and effect diagram can be used to verify and identify the factors that will influence a job to be done, as a proactive way to anticipate problems and challenges. It can also be used to identify where project control efforts will provide the most value: what should be measured, when, how, etc. (MULCAHY, 2013). In reactive work, you can help solve the problem quickly and effectively instead of using a contour solution whenever the problem occurs.

BUCHELE, Gustavo Tomaz et al. Analysis of empirical qualitative articles on methods, techniques and tools for innovation. RAM. Mackenzie Administration Journal, v. 16, no. 3, p. 136-170, 2015.

### 2.1.7 The Flowchart

It is a graphical representation that allows the easy visualization of the steps of a process. According to Juran (2009) most flowcharts are built from a few symbols. The flowchart begins with an issue / problem / mission / project that needs treatment or care within a team or organization (SHETACH, 2011). Graphically, flowcharts are the heart of business process mapping Barbrow and Hartline (2015). A flowchart where roles are assigned indicates a process map consisting of shapes representing different elements of a workflow.

### 2.1.8 The Pareto Chart

It is a bar chart made from a data collection process and can be used when prioritizing a problem or situations related to a particular subject. The methodological perspective of this research turns, according to Padua (2004), to the solution of problems such as search, inquiry, investigation, reality inquiry.

### *2.1.9 Process Mappings*

A widely used tool for standardizing work steps, identifying opportunities for process improvements, but taking into account the complexity of each structure to be analyzed. Thus its objective is to bring improvements to identify bottlenecks, delimit functions and roles and measure process performance. In a broader approach, Oliveira (2007) defines process as a set of sequential activities that are logically related to each other, with the purpose of meeting and, preferably, supplanting the needs and expectations of the company's external and internal customers. In this sense, Barbrow and Hartline (2015) point out that processes map delays and execution problems, and display information about workflows in a format that allows managers to make evidence-based decisions. To map a process is to make an initial design, observing how a succession of activities are performed and interrelated.

## 3. Tools and Methods

Using the Process Mapping tool, it was possible to survey the data and identify the most critical stages of the brewing process. Through the flowchart, the evaluation of the criticality of all stages, especially those with the most problems, was broader.

The Pareto Graph showed that the collected data were essential for prioritizing the problem encountered. In this item will be presented the application methods of the PDCA tool as a beer filtration process management system in a brewery, and it is located in the city of Manaus Amazonas. The PDCA cycle lasted five months. The methodology was applied from June to November 2019 and the initial analysis was made taking into account the data from January to May of the same year. To start the application of the PDCA tool it is necessary to have a knowledge about the industrial production process of the brewery in which the methodology was applied. The brewery under study has an engineering area that is responsible for the planning and control management of preventive and corrective maintenance of the other areas, including the brewing process area. The equipment has specific periodic maintenance plans that can be preventive inspection, cleaning, lubrication and retightening of technical level to operational parts. In the brewery studied, the main indicator linked to product analysis is the tasting called sensory analysis. There is also the use of the quality tool Ishikawa Diagram, also known as Cause and Effect Diagram, in order to organize the reasoning in discussion of the problem addressed in production, to survey and visualize the root causes of the problem and to identify possible corrective and preventive solutions. . The flowchart tool aimed to show the stages of the manufacturing process defining each activity and its importance in the increment. The planning stage was divided into problem identification, observation and analysis.

## 4. Study Application

### *4.1 Check*

Through the survey in all procedures of beer filtration, especially in the stages of dosing of inputs or some inputs during the process. At first it was identified that we had failures in the functional part of the equipment called Deaerator, where these failures were responsible for the high oxygen content to the storage tank from which it was dosed during beer production and filtration and in the period. From January and February the results were well above target, and ideal for production use.

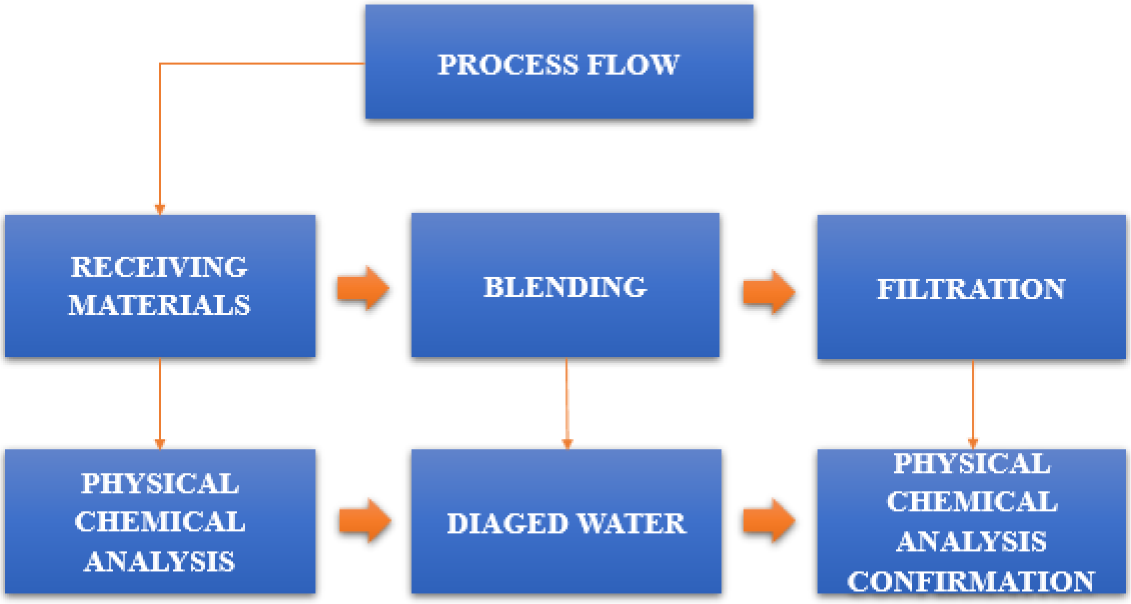
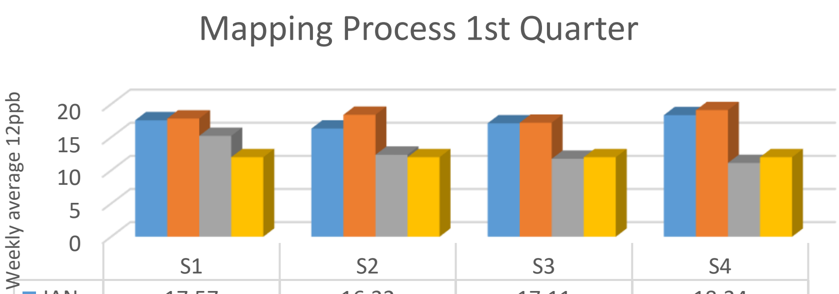



Figure 01- Old beer filtration flow.
Source: Adapted from AMBEV (2019).

The problem was identified through a tasting sensory analysis where it was found the presence of high oxidation in the product, the high oxygen content in the product is one of the main causes for the early aging of beers, thus not reaching its stability in the market. These same defects were also identified by the brewer's internal tasters not only oxidation but at least two more, but the focus for elimination was all on incorporating oxygen content into the process from maturing beer transfer, receiving, filtration, blending and storage. shipping to production lines. As first steps of the improvement work, several analyzes were carried out in the field with the aid of equipment available from engineering, analyzes carried out since receipt, filtration inlet and especially after blending with deaerated water, the main focal point of oxygen incorporation. During this stage it was also identified that there were many leaks in the equipment heat exchanger plates due to failure of preventive maintenance, problems that would be crucial for contamination during water production and its use during the beer blending process. The following table shows the accumulated average of the week, where the ideal would be a maximum of 12.00.




| | S1 | S2 | S3 | S4 |
|---|---|---|---|---|
| JAN | 17.57 | 16.32 | 17.11 | 18.34 |
| FEB | 17.83 | 18.4 | 17.2 | 19.1 |
| MAR | 15.22 | 12.37 | 11.76 | 11.13 |
| GOAL | 12 | 12 | 12 | 12 |

Figure 02: Identification of old process results
Source: Adapted from AMBEV (2019).

### *4.2 Improvement Proposals*

#### *4.2.1 Act*

At this stage of analysis, the keyword will be Why. The challenge was to find out why the problems are happening in those foci identified in the observation phase that are the root causes. And for that it was necessary to know the process flowchart to understand the impact caused on the final product produced. This phase of the PDCA is characterized by the corrective actions, ie, the correction of the failures found in the previous step and the process of standardization of the actions performed, whose effectiveness was previously verified. It is at this stage that the Cycle begins again leading to the process of continuous improvement. ALVES, E. (2015). PDCA as a routine management tool. In XI National Congress of Management Excellence (pp. 1-12).

The planning proposal for the solution of the problem was to survey all the material needed to perform a general maintenance of the equipment. For this, the technical part of the engineering involved the identification and urgent purchase of the parts that had not been available in the warehouse.

Schedule a break of at least 48 hours for maintenance of the equipment.

#### *4.2.2 Plan*

The planning step was based on the hidden risks of the equipment, evaluation of the possible problems to be encountered during long equipment shutdown, this involves the risks of not coming back in good efficiency, not delivering volume to the lines, breaking any parts. at the time of disassembly of equipment to remedy the leaks.Assessment of the best form of execution of the actions and their distributions during the maintenance and the actions directed to each owner with deadline for execution.

#### *4.2.3 DO*

Polacinski, et al (2012) describe that the tool consists of an action plan for pre-established activities that need to be developed as clearly as possible and maps them out through the central objective of the 5W2H tool, which is to respond to seven basic questions and organize them.

Nakagawa (2014) states that the tool is useful in its use both to implement simple, everyday company decisions and to be useful when coupled with other analytical tools or plans that require action, as well as in situations involving the implementation of several decisions.

For Candeloro (2008), the 5W2H tool is a kind of checklist used to ensure that the operation is conducted without doubt by managers and employees. The 5W corresponds to the following English words: What (what); Who (who); Where; When and why. The 2H are: How (how) and How Much (how much). When defining an action that should be taken, a simple table is developed applying 5W2H, according to table 4, where questions are arranged and what is expected of each one. DE AVILA NETO, Clovis Antunes et al. Application of 5W2H for the creation of the internal work safety manual. SPACIOS Magazine | Vol. 37 (No. 20) Year 2016, 2016.

For the organization of the actions generated from the 5 Whys done in the previous step, a technique called 5W2H was used. In addition to organizing the actions, it also defined the owners or those responsible for them, the end time, who was trained, the place of training and the financial cost. Basically it was to implement all actions generated from the action plan in a short term of 4 months and as effectively as possible. So it was important to prioritize the treatment of risks, ie prioritize actions.

Table 1: Generated Planning Action Plan

| **Action Plan Generated in Planning** | | | | |
|---|---|---|---|---|
| **Action** | Who | When | Where | **Cost** |
| **Include components in the equipment maintenance plan checklist.** | Intern | July | Filtration Process | - |
| **Use the technical drawing for the correct assembly of the plates and grease fittings.** | Intern | May | Filtration Process | - |
| **Buy Grease Plates & Plates** | Engineering Technician | February | Filtration Process | R$ 12.000,00 |
| **Set periodicity for cleaning and retightening of equipment.** | Filtration Supervisor | March | Filtration Process | - |
| **Include Oxygen incorporation site mapping in the heat exchanger in the Operational Standard.** | Operation | May | Deaerator Equipment | - |
| **Revision of Deaerator heat exchanger maintenance plan.** | Operation | June | Deaerator Equipment | - |
| **Replace gaskets and place them as stock item in the warehouse.** | Engineering Technician | March | Heat exchanger | R$ 9.530,00 |
| **Replace oxygen sensor In line.** | Engineering Technician | June | Deaerator Equipment | R$ 4.122,34 |
| **Include in the standard the deaeration system CIP step, which during CIP the inline must be in module off.** | Filtration Supervisor | June | Operational Standard | - |
| **Create monthly cleaning procedures for the equipment.** | Intern | July | Deaerator Equipment | - |
| **Define and train one equipment owner in each shift.** | Intern | July | Deaerator Equipment | - |

Source: Adapted from AMBEV (2018).

The execution of one of the main actions that directly influenced the results was the cleaning and inspection of the centrifuge and water deaerator heat exchangers that were carried out at the end of March. The activity involved disassembly, opening and internal and external cleaning. centrifuge changer that took place late May in addition to the exchange of critical components: gaskets and plates. The equipment was mapped in the Ishikawa diagram because of the leakage by the plate that accumulated dirt shown in the following figure, but despite the maintenance performed the problem persisted, being solved with the analysis of 5 Whys pointing to the fundamental cause that was the plates. small holes identified in a second attempt to close the heat exchanger. After the cleaning activity was completed, all components were mapped and a component checklist for biweekly and monthly frequency cleaning was created, as well as the annual cleaning procedure describing each activity step as stipulated by the brewery. The lessons learned during the implementation of the Action Plan were standardized through the various tools provided by the company such as standards, checklist, cleaning maintenance procedure and inspection, among others.

The main objective of this step is to make the actions that improve the results can be performed again, perpetuating the good practices regardless of the brewery management or the people who hold positions and perform functions.

Standardization was developed by creating a document that describes in detail the cleanliness maintenance action of heat exchangers describing who, when and how it should be done. This document is company standard and classified as controlled documents, and all involved, supervisors or operators, should be trained in this new cleaning and inspection procedure. Also, in the operating standard “Enable Aldox or Unpowered Water System” where there was an opportunity to include the step in which during the CIP the inline must be in module off. The procedures and patterns generated at this stage come naturally if the cycle has been assertive in addressing the problem.

## 5. Results

The results achieved showed that the improvement tools especially the PDCA Cycle are of great importance for handling process bottlenecks. However, as found by Correa (2017) and Neto and Paes (2010), care in the planning stage, especially in the correct identification of the problem, in the analysis of the problem and in-depth knowledge about the process to be analyzed are fundamental in the elaboration of the Plan. Action and, consequently, the reflection of the process performance is shown: the new Process Mapping and the graph with the comparative results to the months after the maintenance and application of the new plan in the equipment where it was identified as the main cause of beer oxidation.

### *5.1 New PLAN*

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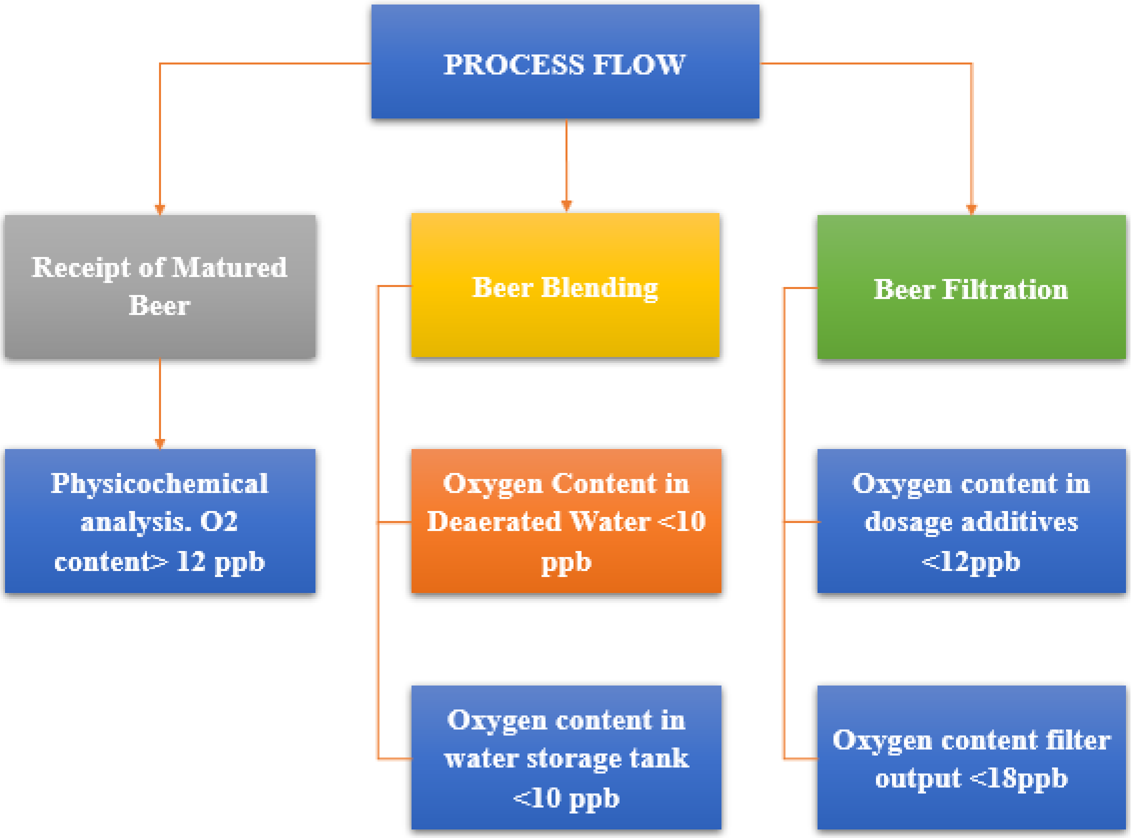


Figure 3: New Process Flow for Beer Filtration
Source: Adapted from AMBEV (2018).

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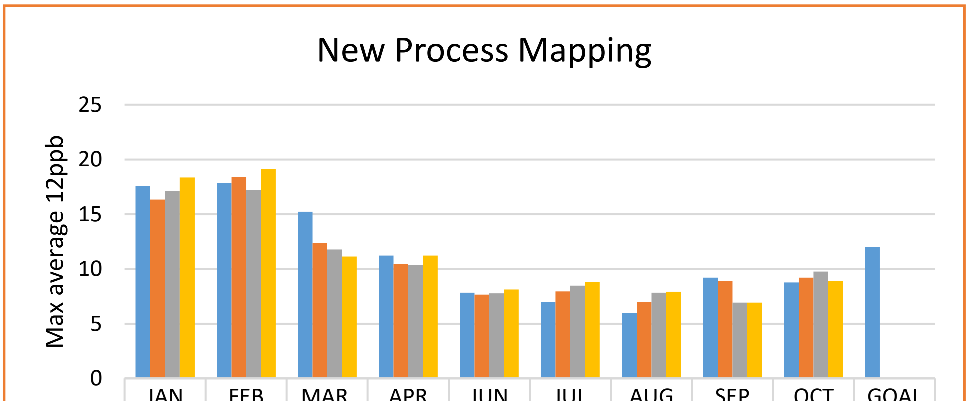


| | JAN | FEB | MAR | APR | JUN | JUL | AUG | SEP | OCT | GOAL |
|---|---|---|---|---|---|---|---|---|---|---|
| S1 | 17.57 | 17.83 | 15.22 | 11.22 | 7.84 | 6.98 | 5.96 | 9.21 | 8.77 | 12.00 |
| S2 | 16.32 | 18.4 | 12.37 | 10.42 | 7.66 | 7.94 | 6.99 | 8.91 | 9.21 | |
| S3 | 17.11 | 17.2 | 11.76 | 10.37 | 7.77 | 8.48 | 7.82 | 6.93 | 9.76 | |
| S4 | 18.34 | 19.1 | 11.13 | 11.23 | 8.11 | 8.78 | 7.92 | 6.93 | 8.92 | |

Figure 4: Comparison after equipment maintenance
Source: Adapted from AMBEV (2018).

It was possible to confirm that one of the advantages of the application of the method was the high level of organization promoted by the cycle allowing the search for continuous improvement (a fact evidenced at the operational level, where the practice reduced the incorporation of oxygen in the process), the maturation of people. involved in troubleshooting and troubleshooting; and the feedback promoted by the cycle, since actions whose proven efficiencies can be used to solve other problems of the same nature as found in the studies by Andrade (2013).

## 6. Conclusion

The present work shows after a deep analysis through the PDCA continuous improvement methodology that the improper incorporation of oxygen in the beer during the manufacturing process is extremely harmful to the sensory quality of the product, thus compromising the reach of the sensory indicator target. . According to the specific conclusions the results were satisfactory for the performance of the results and less overload for the operational team besides: The methodology made it possible to find the main points of incorporation of oxygen in the process that were leaks in the heat exchanger in the filtration area. ; Mainly using the Ishikawa Diagram with the participation of employees from different areas of the brewery studied through the application of Brainstorming and the 5 Whys auxiliary tools were analyzed and found the causes: high oxygen high water at the exit of the heat exchanger. deaerator, failure to perform maintenance quality and incorporation of oxygen into the filtration inlet; The realization of a PDCA cycle allowed the Company to propose actions at no financial or reasonable cost to the brewery which, by complying with 90% of this action plan, resulted in the evolution of the result performance in the finished product; In the course of the work it was evident that most of the actions were aimed at the maintenance, modification or alteration of procedures and not the structural physical projects or parameterization of variables, but the application of the PDCA methodology allowed the standardization of actions during the period. work may even be criticized later because the methodology has a philosophy of continuous process improvement.

It was concluded that this work fulfilled all its general and specific objectives, assisting in the process management system, identifying and standardizing improvements and improving the tools, as well as developing the analytical sense in a complex process.

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