Optimization of the Production Process of Sealing Bricks in a Ceramic Factory in Urucurituba City in Amazonas – Brazil

Denilson Fernandes Vital
denilsonvital71998@gmail.com
Coordenação de Engenharia de Produção do Centro Universitário FAMETRO - Brasil

David Barbosa de Alencar (Corresponding author)
david002870@hotmail.com
Coordenação de Engenharia de Produção do Centro Universitário FAMETRO - Brasil

Mauro Cezar Aparício De Souza
mcas1691@gmail.com
Coordenação de Engenharia de Produção do Centro Universitário FAMETRO – Brasil

Alexandra Priscilla Tregue Costa
ptreguep@yahoo.com.br
Coordenação de Engenharia de Produção do Centro Universitário FAMETRO – Brasil

Francisco Carlos Tavares Amorim
amorim.mao17@gmail.com
Laureat International Universities – UNINORTE – Amazonas - Brasil

Ana Jaqueline Travessa Amorim
anajaque.arq@gmail.com
Laureat International Universities – UNINORTE – Amazonas - Brasil

Carlos Eduardo de Oliveira
ceoedu2450@gmail.com
Universidade Federal do Pará – UFPA - Brasil

Abstract

In recent years there has been a high growth in Brazil, in the construction industry this event reflects a great economic development in the regions of the country, in the Amazon, the ceramic brick industry has been gradually increasing to meet this demand, especially in the interior of the state. In them there are failures and waste during its manufacturing process that greatly affects the final product. This article aims to employ the quality tools in the production process of a ceramic pottery that is located in the city of Urucurituba - AM, through them to discover the flaws and propose improvements in the production process of sealing bricks so that there is no problems in the final product. Through site visits data were *collected through interviews with employees and the plant manager, the visit also allowed the mapping of the process of manufacturing eight-hole bricks, from this verification it was possible to apply the flowchart that allowed describing Throughout the process flow, the Ishikawa Diagram was also applied, which made it possible to detect faults (cracks and cracks) and their root causes. These occur during the brick production process and used the 5W2H, which helped to organize the ideas. and make a proposal to solve the problems, and bring quality to the final product*

Keywords: Brick; Quality tools and process; Ceramic;

1. INTRODUCTION

Ceramics companies, also known as potteries, being small, medium or large have great contributions to the national and regional economy. Some of these contributions are in increasing employability, providing salary and income, especially for people who have not had access to a professional qualification. These companies participate in about 1% of the Brazilian GDP (Gross Domestic Product), which corresponds to about 12 million reais [1].

In the presented pottery there are many failures during its production process that cause defects in the final product. Employing quality tools makes it possible to detect the problems that occur during the brick making process, to correct them and thus improve their quality.

According to [2] “Quality is the necessary condition to guarantee the success of a production operation”.

It is of the utmost importance to produce quality to remain competitive in the market and to ensure the success of the enterprise, correcting the errors that occur during the brick production process, will eliminate or reduce the rework, waste and productivity costs of the company. By taking these steps the organization will gain control over its process and offer a better quality product, so it will be prepared to compete with competitors and stay alive in the marketplace.

This article aims to employ the quality engineering tools as a strategy for improving the production process of a ceramic industry, located in the city of Urucurituba-AM. As for its specific purpose, analyze the process of producing the sealing bricks, identify and apply the appropriate quality tools to find out the problems or errors that occur during the company's product manufacturing procedure that lead to noticeable flaws in the final product. , and present an action plan to address these issues and increase the quality of the bricks.

2. THEORETICAL REFERENTIAL

2.1. Quality tools

Quality tools are methods used in industries that seek process improvement or solve problems that occur during them to make decisions, and obtain greater productivity, reduce losses, rework and consequent cost of production.

According [3] states that quality tools assist us in finding problems so that they can be solved in different situations and systems.

According to [4], the seven classic quality tools aim to assist and support management in decision making for problem solving or just to improve situations.

According to [5] identifies as a quality tool all processes employed to obtain improvements and positive results, thus allowing a better exploration of its products in the competitive market.

2.1.1. Flow chart

The flowchart is the representation of the processes of a company through graphic symbols in order to describe the step-by-step process flow.

The flowchart is an excellent tool for analyzing the process as it allows a quick understanding of the activities that are performed by all parties involved. It is a fundamental tool, both for process planning or elaboration, as well as for process improvement or analysis, criticism and changes [6].

According to [7] The flowchart is an essential tool in any product and service quality program. It is a very useful tool for recording a product's production flow or a service delivery flow by adopting a “common language or universal language” for learning, communication or dialogue purposes and for opportunities for improvement.

2.1.2. Ishikawa Diagram

Also known as Cause and Effect Diagram or Fishbone Diagram, it is a tool used in many areas such as quality control, people management and decision making.

Usually this diagram is used to jointly visualize the main and secondary causes of a problem, broaden the possible causes of the problem, enrich its analysis and identify solutions, as well as analyze the process for improvement [8].

For [9], the diagram can be adjusted to the needs of the organization, primarily in establishing responsibilities by designating the authority of each element or action. We also realize that the analysis is represented by the 6 Ms, which are:

1 M (materials): refers to the analysis of the characteristics of materials for uniformity, pattern, etc .;

2 M (machine): refers to the operation of the equipment and its proper operation;

3 M (method): consider how the actions will be developed:

4 M (environment): assesses which situation may be the cause of a particular effect (execution situations and / or fixed infrastructure);

5 M (labor): characterizes the pattern of labor used, if it is properly trained, if it has the necessary skills, finally, if it is qualified to perform the task;

6 M (measurement): translated by how values are represented (by distance, time, temperature etc.) and by the measuring instruments used.

2.1.3. 5W2H

According to [10, the 5W2H tool is understood as an action plan, that is, the result of planning as a way of guiding actions that should be executed and implemented, being a way of monitoring the development of what is established in the planning stage.

Tool 5W and 2H addresses the use of questions that begin with the letters W and H, which also contains the meaning of each one. The questions aim to generate answers that clarify the problem to be solved or that organize ideas in problem solving [9].

2.2. Ceramics Industry

In Brazil, before the colonization of the Portuguese, different peoples already lived on the banks of the Amazon River, more than 1,000 years AD, and these peoples used the clay for housewares, for house building, for religious purposes and even for decorative purposes. Archaeological studies show that the oldest and best known here in Brazil are the Marajoara ceramics of the people who inhabited the island of Marajós, a very advanced indigenous culture. There are also studies that indicate Brazilian ceramics over 5000 years ago [11].

According to [12], states that the Portuguese only concentrated and qualified the labor that existed here, setting up potteries to speed up and enrich the process.

The Amazon is a state in great economic development. Over the past 7 years, Suframa has invested in the Interiorization program, the equivalent of one hundred and twenty-nine million reais, in projects aimed at generating infrastructure in the 52 (fifty-two) state-owned municipalities. The red ceramics industry is an essential sector for the national economy, as it supplies the civil construction production chain throughout the national territory and is also fundamental for the habilitation sector [13].

The municipality of Urucurituba is located in the interior of the state of Amazonas, according to data from [14] estimated that its population is 22,537 (twenty two thousand, five hundred and thirty seven) inhabitants. The city contains only one pottery industry in its entire territory, it produces about 320 million bricks per month, which are distributed and marketed in the municipality and surrounding cities.

According to [15], materials can be classified into two groups: traditional ceramics and technical ceramics, whereas traditional ceramics use clay, silica and feldspar as raw materials and technical ceramics are composed of materials. pure or almost pure.

According to [16], ceramic materials have as main characteristics among the materials used for construction, durability and ease of manufacture, as well as abundance of raw material, low cost. One of these ceramics that has become a basic component of any masonry construction is brick and can be classified as: solid, drilled and perforated.

The activities of an industry operating in the traditional red ceramics sector begin in the mining of the raw material. Often two or three types of clay materials are plowed to achieve the desired characteristics in the final product. Most of the raw materials used are natural, being in deposits scattered in the earth's crust [17].

2.2.1. Production Process: Sealing brick.

According to [18], he mentions in his research the red ceramic production process is divided according to the steps:

Raw Material: Most of the red ceramic extrusion masses are mainly made up of two clays, one very plastic and one not very plastic, which are transported from the deposits to the storage sheds, where they are dosed according to the desired ceramic characteristics for the product.

Destroyer: It has the function of crushing the larger clumps of clay (clods), in order to facilitate the subsequent operations.

Mixer: Performs circular motions, allowing the homogenization of the dough and the addition of water, until the ceramic dough formed has adequate moisture and plasticity for extrusion.

Laminator: Performs circular movements, allowing the homogenization of the dough and the addition of water, until the ceramic dough formed has adequate moisture and plasticity for extrusion.

Extruder: Also known as maromba, the homogenized clay is driven, thrown into a vacuum chamber and pressed against a steel die (mouthpiece), where the dough is shaped to the desired shape.

Cutting: At the exit of the extruder, the continuous molded dough is cut manually or automatically, with the desired dimensions, having then the ceramic block.

Drying: Molded elements are arranged in covered sheds, placed on shelves (fixed or movable) or even stacked on the floor to reduce their moisture content.

Synthesizing or Burning: The firing temperature ranges from 750 to 900ºC for the blocks, and may reach 1200ºC in the case of ceramic tubes. The firing step is conducted in thermal equipment called furnaces, which can use various types of fuels as a source of energy.

Cooling: After burning, the product remains inside the oven so that it can cool, as it cannot suffer a sudden drop in temperature, otherwise deformation and cracking may occur.

Storage: Storage of the final products is done in a covered area, remaining there until commercialization.

Also according to [18], for a better visualization and understanding of the steps of the brick production process can be illustrated according to Figure 1:

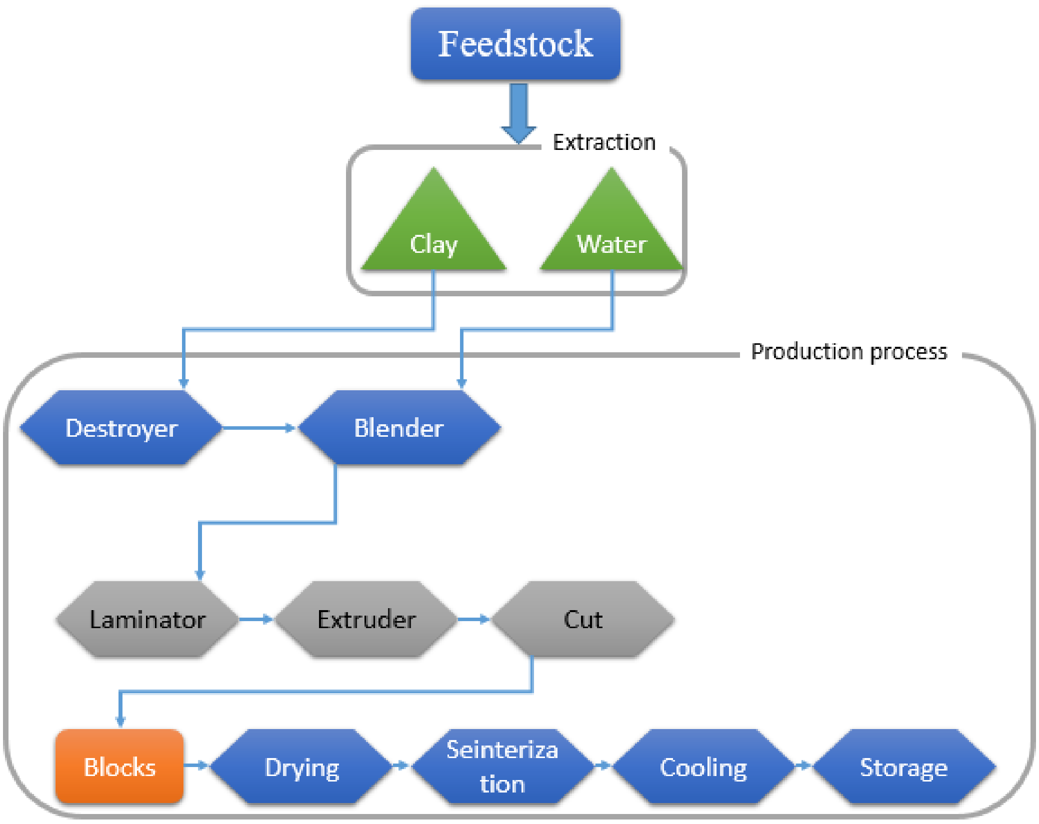

Figure 1 - Flowchart of the production process of ceramic blocks.

Source: Adapted from [18].

For each purpose there will be specific process needs to be performed by people or a group of people [19].

In this sense, according to [20] states that "the act of producing implies transforming" and can be considered the practical result, material or immaterial, intentionally generated through a set of organized factors.

Quality will be mainly ensured by minimizing the variety of important features [21].

3. TOOLS AND METHODS

This work is a case study conducted in a ceramic industry (pottery), located in the city of Urucurituba-AM, from May to August 2019.

Through on-site visits to the company, interviews and application of questionnaires to employees and their manager, it was possible to obtain updated information and data from the pottery production process. The data allowed the application of quality tools: Flowchart, Ishikawa Diagram and 5W2H, whose objective was to map the process, discover the problems and propose a solution to optimize the brick production process.

From the objectives were used the methods for the elaboration of the work. Flowchart allowed to map all the steps of the brick manufacturing process and to find out where the production errors occur in them. The Ishikawa Diagram made it possible to uncover the problems that occur in the company's production process and its root causes, and the 5W2H helped to provide a proposal for the continuous improvement of the brick manufacturing process, the ideas that will be presented allowed reducing waste and improving the company's production efficiencies.

Essentially for the theoretical basis of the research were extracted contents of books and academic articles in which it deals with the areas of quality and the ceramic industry.

4. CASE STUDY

4.1. Company characterization

The company in which the case study was prepared has been in operation for 6 years and is located in a rural area of Urucurituba-AM. It is a small pottery that has: 1 complete brick making machinery, 5 drying sheds, 2 synthesizing ovens, and an outdoor storage area, as shown in Figure 2.

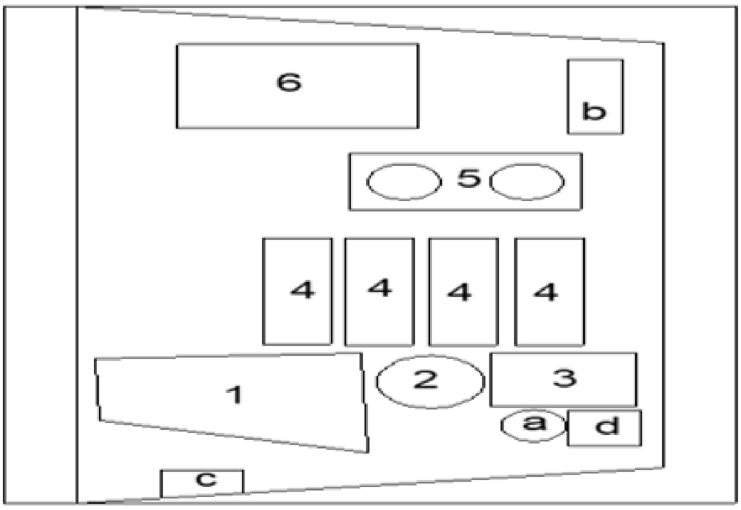

Figure 2: Sketch of brick factory.

Source: Own authorship.

Subtitle:

1- Raw Material Stock. 2- Coffin feeder. 3- Machinery.

4- Drying sheds. 5- Ovens. 6- Storage of the final product.

a- Artesian well and water boxes. b- dining hall.

c- office. d- deposit of materials.

The company has 21 employees which is divided as follows: 1 owner, 1 manager, 1 bucket driver and 1 backhoe driver, 1 coffin digger, 7 production / machinery staff, 3 drying loaders, 5 loaders oven and storage and 1 supply.

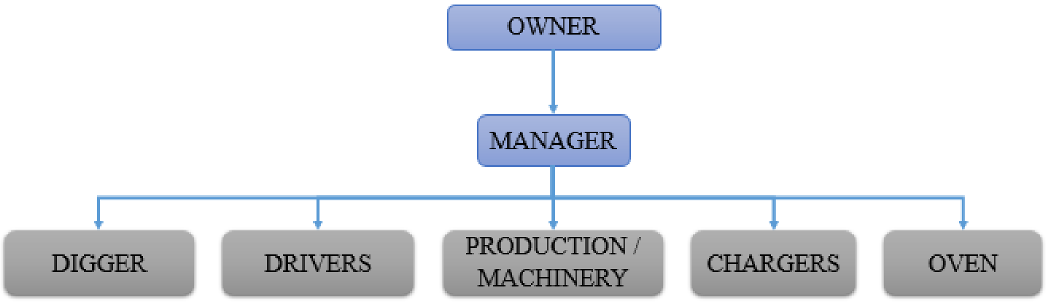

Figure 3: Organization chart of the company.

Source: Own author.

The company only produces eight-hole sealing bricks, in this study it was defined the flow chart tools, Ishikawa diagram and the 5W2H. The flowchart was employed to identify the process flow of brick production. The Ishikawa diagram was used to identify production problems and their root causes. 5W2H was applied in order to make the necessary decisions to control the potential causes and to solve the problems of the brick production process, thus improving the pottery product quality.

4.2. Process Flowchart

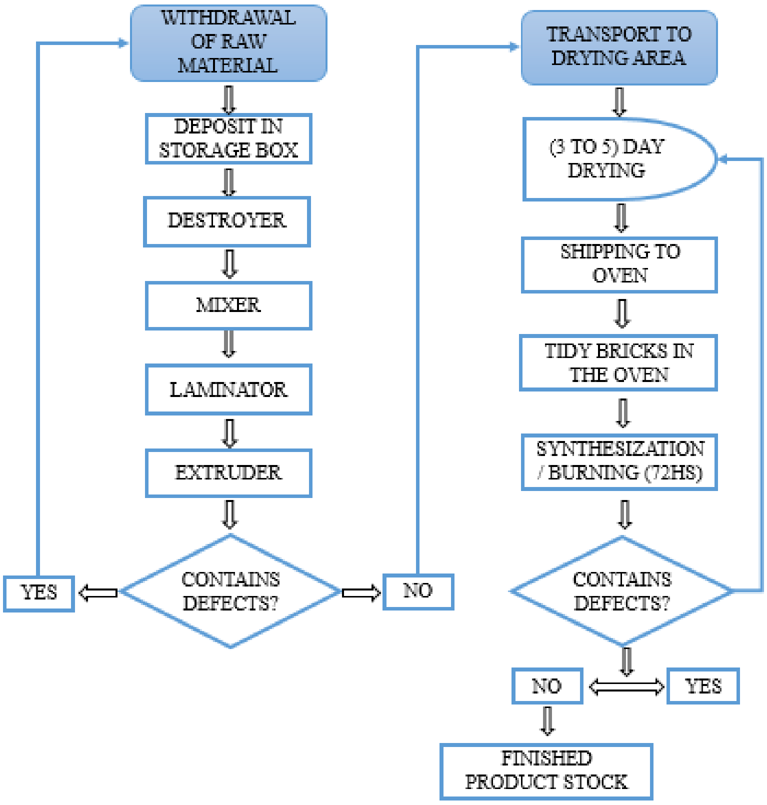

Figure 4: Flowchart of the production process of the pottery studied.
Source: Own author.

First step: The raw material, the clay, is removed by the pottery employees from land owned by the owner of the company, which is approximately 2km away from the factory. Clay is transported by company vehicles and placed in towers in the pottery clay storage area.

Second step: the raw material is deposited by a tractor inside the storage coffin (figure 5) where excavation by a worker occurs (figure 6), the clay is moved through conveyor belt and proceeds to the next process.

Figure 5: Tractor placing clay in the coffin   Figure 6: Worker digging the clay

Third step: the hard clay moves to the destroyer where the large pieces of clay are crushed into smaller pieces by the machines (figure 7), then moves to the mixer where it is mixed with water to soften the clay, it is sawdust. will help the dough to heat and burn better when baking (figure 8).

Figure 7: Destroyer. Figure 8: Mixing with water and sawdust.

Fourth step: the clay is still being conveyed by the conveyor belt to the rolling mill, where the raw material will be rolled and its disintegration process will be complete (figure 9).

Figure 9: Laminator.

Fifth step: the clay is moved to the extruder or maromba where it goes through the extrusion process in this step is added more water to the clay does not harden is to damage the machine, it is also used a vacuum pump that serves to generate air in the clay and compacting it, so the product takes on the desired shape (figure 10).

Figure 10: Extrusion Process.

Sixth step: The products are transported by rollers and go to a table where the bricks are cut by a line that is positioned horizontally that moves every 15 seconds to cut the bricks to optimal size. The leftovers and the defective bricks are placed in a separate area where they will be reused back to the coffin (Figures 11 and 12).

Figures 11 and 12: Cutting process.

Seventh step: Bricks are transported by wheelbarrow to the drying sector and stay there for 3 to 5 days, drying, depending on the weather (Figures 13 and 14).

Figure 13: Internal drying area Figure 14: External drying area

Eighth step: After the drying process the bricks are again transported by wheelbarrows to the ovens where they will be arranged to go through the synthesizing or burning process (Figure 15). In this process the oven doors are sealed with soft clay so that the outside air does not enter and the internal temperature of the oven does not come out (figure 16). In this process an exhaust fan is also used to trap the fire in the oven. burning for 72 hours.

Figure 15: Synthesizing process

Figure 16: Oven door seal

Eighth step: After this procedure the oven doors are broken and the bricks removed, fans are used so that employees are not exposed to high temperatures in the process of removing bricks from inside the oven. Then the product is transported by the employees to the finished product inventory area (figure 17), where they go through a survey and separate the products, the good ones are arranged on pallets organized by thousands of trucks and then delivered to their trucks. resellers or customers. The raw bricks are taken to the drying area and will go through the burning process again. Cracked bricks are discarded. And the burned bricks will be separated and reused in works in the pottery or sold at a lower price in the market because it is used to make houses and pots.

Figure 17: Finished product stock area.

4.3. Definition and analysis of problems.

The company produces about 320,000 bricks per month, it has 2 ovens each supports burning 27,000 bricks, but only 23,500 bricks are good for trading, ie the company operates with only 87% of its production. , another 13% are losses that occur in it.

The quality problems in brick production are shown in figure 18. Presented in the following chart:

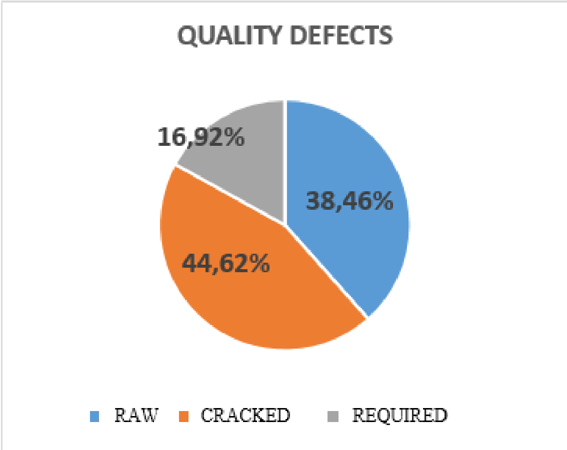

Figure 18: Graph with percentages of problem bricks.

As observed in the graph in Figure 18, of the problems found, 16.92% refers to burnt bricks, 38.46% of raw bricks and 44.62% of cracked bricks.

This paper seeks to solve the two major problems that occur in the company that are cracked and raw bricks. Using the Ishikawa diagram it was possible to find the root causes of these problems.

Root causes of cracked bricks.

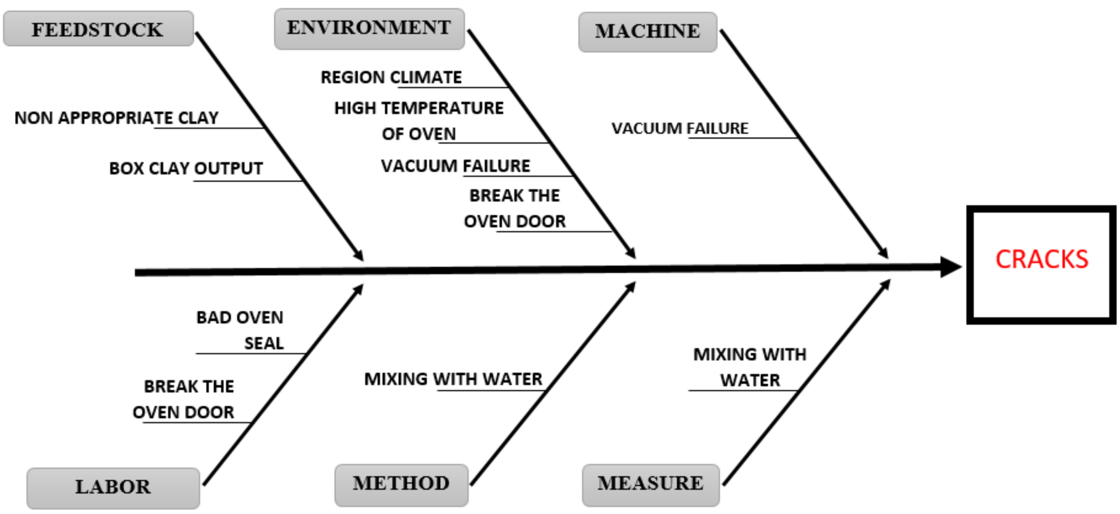

Figure 19: Ishikawa Diagram – Cracks

UNPROPRIATE CLAY: The clay that is placed in the coffin is not 100% suitable for brick making as it has a portion of the upper soil layer, the perfect brick making clay is about 80 cm deep underground. . The top layer of soil is very hard and contains tree roots, stones and other solid aggregates, which obstructs the passage of good clay on the mat and cause cracks in the bricks in the burning process. (FEEDSTOCK).

CLAY CLAY OUTPUT: The raw material when it arrives in the pottery is placed in high towers on site the material hardens, when it is placed in the coffin the clay is already in the shape of stones they fall on the mat and obstructs the passage of the ideal clay for The mixing thus causes cracks in the final process of the bricks. (FEEDSTOCK).

REGION CLIMATE: Because the photo of the Amazon has a tropic climate (hot and humid) and the pottery is located in the rural area of the city in an area surrounded by woods, the bricks that are in the drying area are exposed to winds and serene, Because the sheds are covered but do not have a side shield, this suit does not allow the bricks to dry well, and when being transported to the ovens cracks occur. (ENVIRONMENT).

HIGH OVEN TEMPERATURE: Because the furnace does not know the exact temperature inside the oven when placing too much firewood causes the oven to come out of its ideal temperature when the bricks are exposed to high temperatures comes from cracking the bricks. (ENVIRONMENT).

VACUUM FAILURE: The vacuum pump is placed in the extrusion process to generate air in the clay so that it does not come out softly through the mouth of the machine. When the amount of clay in the maromba is lower than the vacuum pump does not work perfectly that causes cracks in the bricks (MACHINE).

MIXING WITH WATER: When little water is mixed in the clay, the clay does not reach its ideal point and cracks in the products. (METHODS AND MEASUREMENT).

POOR OVEN SEALING: When the oven door seals are poorly sealed, the cold winds from the outside environment enter the oven and there is a sudden variation in temperature and the result is cracking of the bricks inside the oven. (LABOR AND ENVIRONMENT).

INADEQUATE BREAKING OF OVEN DOORS: When the bricks are already baked you must break the oven doors to remove them, if by breaking the door quickly hot air will come out quickly and the temperature will drop is where the bricks crack. (LABOR AND ENVIRONMENT).

Root causes of raw bricks.

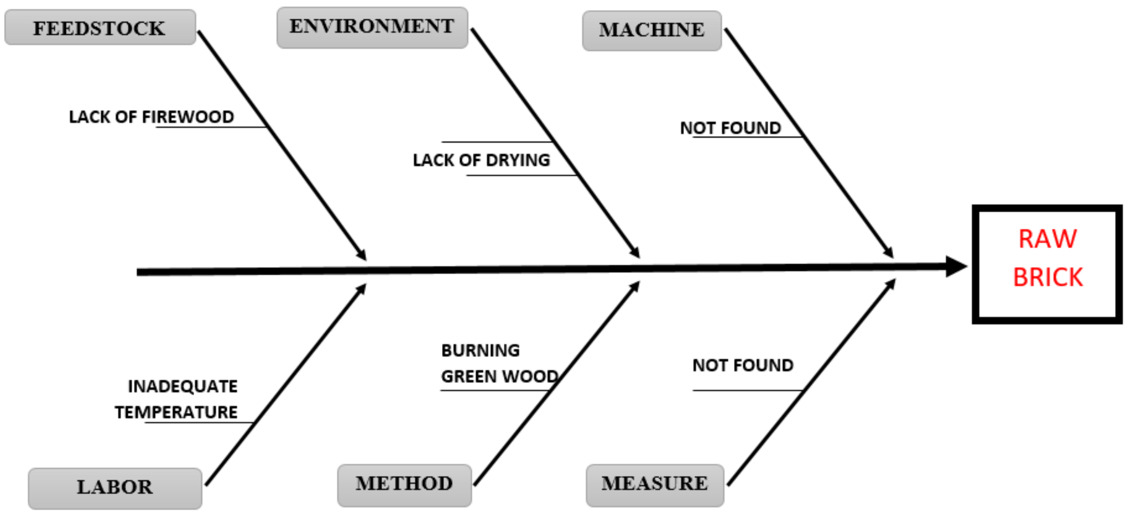

Figure 20: Ishikawa - Raw diagram

BAD DRYING: Due to the fact that the drying sheds do not have a lateral seal, the bricks are exposed to wind and serene and in the rainy season the bricks do not dry well and are placed moist in the oven and do not burn well. (ENVIRONMENT).

GREEN WOOD BURNING: Green firewood is often burned in the oven because dry firewood is not available in stock, this affects the burning of bricks as green firewood takes longer hours to heat the oven and burn them, this delay makes that the bricks don't bake perfectly. (MEASURE).

BAD TEMPERATURE CONTROL: The furnace does not know the temperature of the furnace, and varying it allows many bricks not to reach the exact point and become raw. (LABOR)

LACK OF WOOD: At many times in the synthesis there is a lack of firewood in the final period of the process, this fact makes the oven does not reach its ideal temperature causing many bricks to be undercooked.

4.4. Proposal for improvement.

Defined the major causes of problems affecting brick quality, and applied the 5W2H tool to manage ideas that solve those problems.

5W2H action plan to solve crack and raw brick problems.

What?	Who?	Where?	Whwn?	Why?	How?	How much?
What should be done?	Who is responsible?	Where should it be done?	When should it be done?	Why does it need to be done?	How will it be done?	How much will it cost?
Withdrawal and storage of raw material	Backhoe driver and the digger	Extraction Area	Every Friday from 7:00 to 9:00 hours	Get quality raw material and avoid cracking the bricks	Using the backhoe to remove the clay	$ 0.00. (For only the work will be perfected.)
Control the amount of materials in the production process	Production staff / machinery	Productive sector	Every full weekday	Avoid cracking the bricks	Monitoring the amount of material in the process	$ 0.00. (For only the work will be perfected.)
Purchase clear plastic tarps for drying area	Owner	Trade	September 5, 2019	Avoid exposure to winds and serene, and do not get raw and cracked	Company resource	$ 1.200,00
Buy thermometers for the ovens	Owner	Trade	August 30, 2019	Monitor oven temperature	Company resource.	$ 800,00
Train the synthesizing / burning process staff	Manager	Productive sector	August 25, 2019.	Empower workers and reduce quality problems	Through hands-on training	$ 0.00. (For only the work will be perfected.)
Control over the stock of firewood	Manager	Productive sector	Every full weekday	Do not miss proper wood for burning	Spreadsheets or inventory control software	$ 0.00. (For only the work will be perfected.)

Figure 21: 5W2H Action Plan Table.
Source: Own Authorship

5. RESULT AND DISCUSSIONS

This work was elaborated with data collection, through interviews with the employees and the company manager. It was possible to map the whole process of brick production with their help, with mapping the flow chart was applied to have a better view of the flow. In the production process of the pottery, at this stage the points were identified where the most frequent problems in brick production (raw material collection, drying and synthesis) occur during the production process and are only noticed in the final product.

After mapping, the Ishikawa diagram was also used, which identified the most frequent problems in bricks (raw and cracked) and pointed out its root causes which are: Clay not suitable for production, the output of the coffin clay, the climate of the region. high oven temperature, vacuum failure, mixing with water, poor oven sealing and improper oven door breakage. Defects occur during the synthesizing / burning process and are visible only in the final product.

The proposal to solve these problems that occur during the brick production process of the company was elaborated with the aid of the 5W2H tool, which proposes: To remove the appropriate raw material to put in the storage coffin, to control the correct amount of the materials during the process. production process, buy clear plastic tarpaulins to fence the sides of the drying sector, buy a digital oven thermometer, train employees on the synthesizing process and have control over the stock of firewood.

This measure will allow the correction of failures and bring continuous improvement in the brick making process. This proposal will eliminate 10.8% of the waste that the company has with defective bricks, and will make it work with 97.8% of productive efficiency.

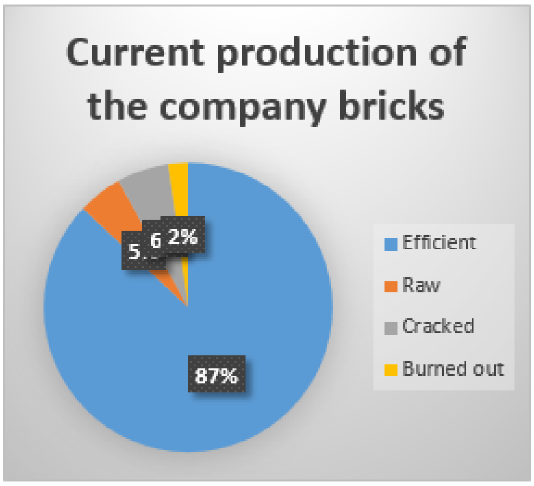

Figure 22: Graph of the current production of the company.

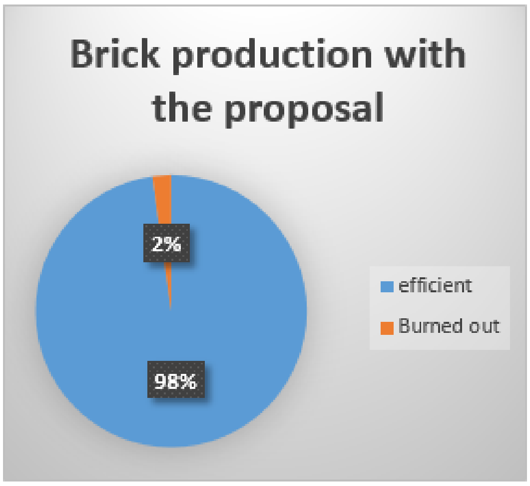

Figure 23: Graph of the company's production with the proposal.

6. FINAL CONSIDERATIONS

Quality tools provide ways of defining, measuring, analyzing and proposing solutions to problems that interfere with company performance, quality, and bottom line, as well as establishing better data-based resolution methods, which increases the prospects for success. company.

The purpose of this work is to employ solutions to correct the errors that occur during the production process of bricks that cause damage to that company and improve the quality of its products. The study made it possible to employ solutions to correct these problems, all process steps were examined in detail, in which occurrences of failures in the pottery production procedure were identified. The proposed improvement suggested to the owner and manager of the company was elaborated through a thorough investigation with the help of bibliographic studies and dialogues with experienced and knowledgeable people, the factors are in agreement with the data collected with the employees and the manager. of the company, the solutions presented was taking into account the economic situation of the company.

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