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RESEARCH ARTICLE

ANALYSIS OF LEAN MANUFACTURING WASTE FACTORS IN THE BREWING INDUSTRY OF ENSENADA, BAJA CALIFORNIA, MEXICO

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Abstract

This research was developed to evaluate the eight wastes in a brewing industry located in the city of Ensenada, where they were presented each daily period, worrying supervisory, specialized and managerial personnel. This process was developed by applying continuous improvement to increase productivity and quality indexes, and thus obtain a reduction in costs. To carry out the application of continuous improvement, the supply chain and inventories had to be reduced, which was a problematic situation that was constantly presented, as well as an analysis to create robust systems and raw material delivery in the required times and in the right places. Another relevant factor evaluated was the improvement of the plant distribution, where processes were presented where long periods of time were generated between each industrial operation carried out. Once these new processes were developed, productivity and quality indices greater than 75% were obtained, and economic gains were generated, where previously they were a maximum of 50%, which generated economic losses. The investigation was made from 2019 to 2020.

Introduction:-

The beer industry is one of the most important in the global economy, (García J, 2018), where in the Mexican Republic some industries of this type of product are installed in different regions of the country, being the city of Ensenada, Baja California, Mexico (ACERMEX, 2019; INDEX-EN, 2018); where a brewing industry is installed, and in which there were certain deficiencies in the industrial processes, and caused economic losses and the productivity and quality levels were fro to 50% to 60%, which worried supervisory, specialized and managerial personnel. Based on what happened, the decision was made to evaluate the eight wastes using the tools of the lean

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manufacturing methodology. In figure is showed an evaluation of the factors involved in the improvement in the application of the lean manufacturing (Loza A et al, 2009; Martínez-Jurado P et al, 2014).

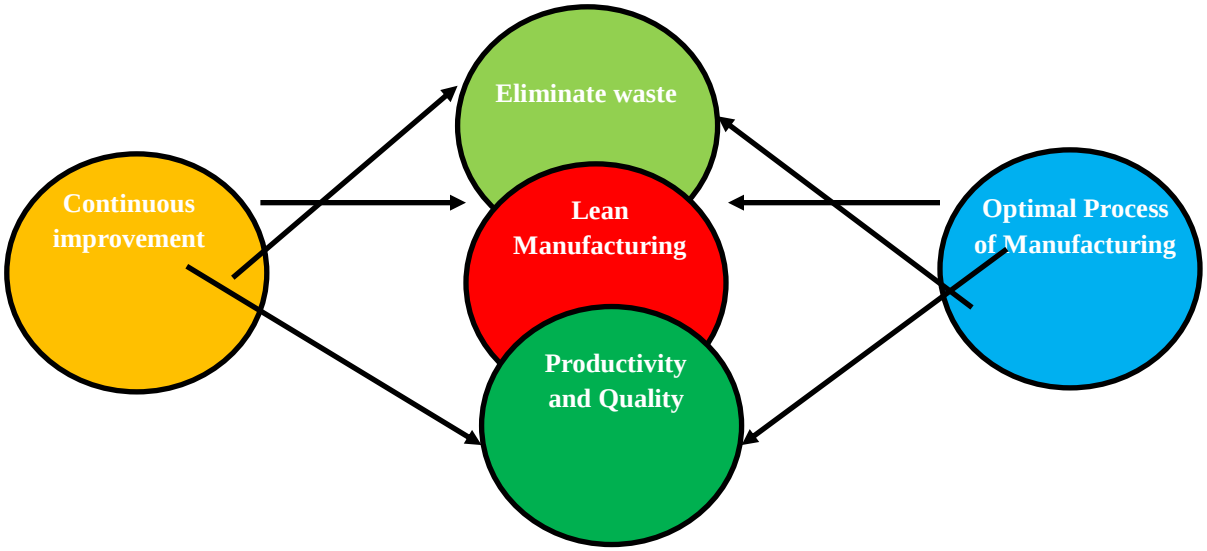

Figure 1:- Relevant factors of the Lean Manufacturing.
Source Analysis of the investigation

Waste factors analysis

Lean manufacturing is widely applied in industrial processes of any type of industry, and in this research carried out in a brewing industry, the eight types of waste, considered by this methodology, were evaluated, explaining below (Belekoukias I et al, 2014; Schlechtendahl J et al, 2015):

a) Defects. They are generated when industrial processes are elaborated with inadequate methods, in addition to the fact that it is sometimes contemplated that they are presented by inexperienced personnel. This must be considered because they can generate extra jobs, stop the production line and with it economic losses.

b) Overproduction. It occurs when products are manufactured in industrial processes, without considering a limit quantity, generating inventories in some areas of the manufacturing area and this causes unexpected expenses. In addition, sometimes only one type of products are manufactured, when industries tend to manufacture different types of products, and when these cases arise of manufacturing a single type of product to a large extent and not producing several, poor planning can be generated, and later, and with it, to be able to originate that at the time of requiring another product there will not be the necessary by-products (products made without finishing) and to be able to stop the production line, causing great concerns to the supervisory and managerial personnel.

c) Waiting times. This can occur when there is no optimal production planning or inadequate plant distribution, causing the raw material, by-products or finished products to be waiting for their next industrial processes, and causing waiting times that are sometimes excessive that causes delays in manufacturing processes.

d) Wasted talent. There are occasions in which, there are personnel with experience or knowledge of a specific area or subject, required in the optimal development of industrial processes, and it is not contemplated, being a type of wasted talent, and the optimal levels are not generated. productivity and quality and the required quantities of manufactured products, as well as being able to cause errors and thus defective products that cause economic losses.

e) Delay in transportation. When there is no adequate planning for production processes, delays can be generated in transport processes of any kind (manual (made by people), special trolleys (pulled by people), forklifts (with specialized motor)). This can cause delays in industrial processes and with it sometimes even stop the production line and cause both supervisory and managerial staff concerns, as well as delays in delivery to customers, which may cause customers to desist from buying the products manufactured and thus cause economic losses.

f) Inventory generation. The best option to have an efficient manufacturing process at each stage of industrial processes is not to have inventories at each stage of production. When a storage of raw materials, by-products or finished products occurs, it means that there is an inadequate planning of production or the generation of errors, causing great concerns to supervisory and managerial personnel and economic losses.

g) Inappropriate movements. These can occur when there are inadequate working methods, causing even discomfort in the operating personnel of manufacturing areas (which can be mild or serious, and can immobilize

joints or organs of the human body), or fractures or breakage of pieces of Industrial equipment and machinery (causing some equipment or machines to be disabled for long periods of time, while the damaged parts are obtained). This causes great concern to supervisory and managerial personnel and financial losses.

h) Elaboration of extra processes. They occur when errors are generated in industrial processes, either by operating personnel in manufacturing areas that develop their activities incorrectly or by equipment or machinery that is programmed or planned, and with this, unnecessary processes are generated.

Of the eight wastes mentioned above, we proceeded to analyze in this investigation those that occurred most frequently, being defects, time delays in the delivery of raw materials, by-products and finished products to customers and generation of unnecessary inventories (Kang H et al, 2016).

Continuous improvement factors

To optimize the manufacturing processes of the industrial company where the scientific study was carried out, factors such as those mentioned below were evaluated and with which the required improvements were generated in the manufacturing areas (Drath R et al, 2014):

a) Improved delivery of supplies. It was prepared based on the supplies required in each stage of the manufacturing processes, where it was observed that there was no adequate planning of the delivery of supplies and delays were generated in some stages, so there was no production flow optimal, causing late delivery to the customer of manufactured products and this caused some customers to refuse to purchase the products and caused economic losses.

b) Inventory reduction. The stages of the manufacturing areas were evaluated, where storage of raw materials, by-products and finished products were constantly generated, being considered as unnecessary inventories; that originated extra work and with it unnecessarily occupied areas of the manufacturing areas. This evaluation was developed to reduce these inventories and have more space in the manufacturing areas and thus obtain an optimal production flow for immediate delivery to the customer of the manufactured products.

c) Development of robust systems. Each stage of the manufacturing areas was analyzed in all the industrial processes required for the manufacture of the products in the industrial company where the scientific study was carried out, to determine where it was necessary to implement robust systems (systems with equipment and specialized machinery with devices of specialized control and with computer equipment suitable for the improvement of activities at each stage of manufacturing). This helps to increase productivity and quality levels.

d) Improve the layout of the plant. It was necessary to make an improvement in the plant distribution, because there was not an adequate production flow to avoid delays in the supply chain from raw materials, by-products and finished products, for immediate delivery at each stage of manufacturing and fulfills delivery to the customer in the agreed periods.

e) Optimal production flow. With the improvement of the distribution of the plant, an optimal production flow was obtained, with which an immediate delivery was generated in each manufacturing stage of all industrial processes, from raw materials, by-products and finished products to customers, generating economic gains.

These five factors were relevant in the increases in productivity and quality and in products manufactured in an adequate manner without generating unnecessary inventories, and are represented in figure 2.

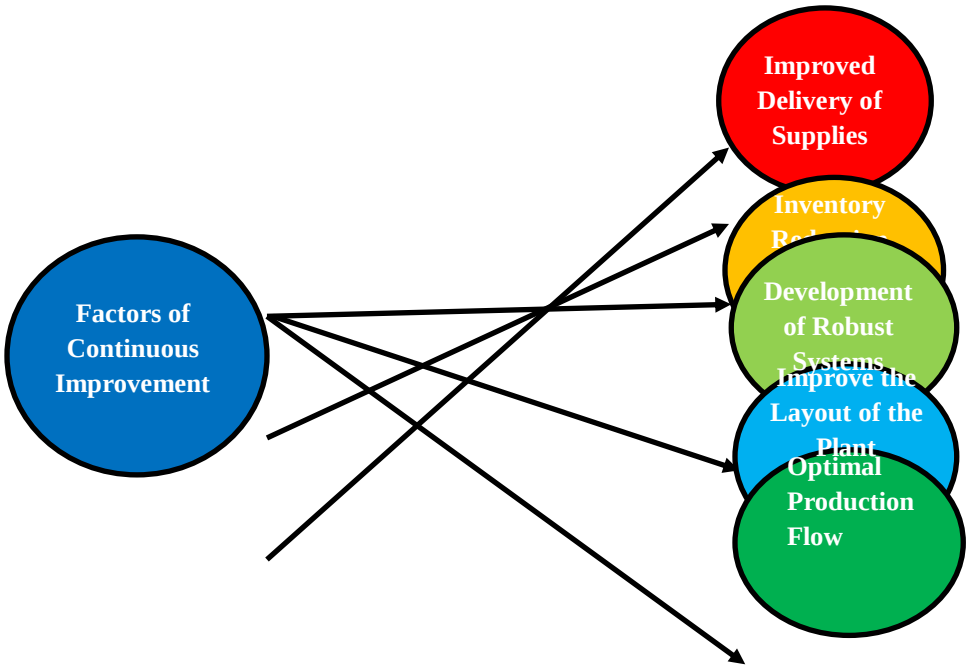

Figure 2:- Factors of Continuous Improvement.
Source Analysis of the investigation.

Brewing industry

This type of industry in very relevant in the countries where it is developed, being an important factor in the Gross Domestic Product (GDP), due to its large amount of demand for manufactured products and the enormous generation of sales, as it is a product consumed by various social classes. In the Mexican Republic there are two main global brand companies, being Grupo Modelo and Grupo Heineken Mexico (formerly called Cervecería Cuauhtémoc Moctezuma), and others of a smaller scale with respect to the amount of products manufactured and sales (ACERMEX, 2019). In addition, Craft beer production companies are included, such as the company, where this research was carried out, which is located in the city of Ensenada, Baja California, in the northwest of the Mexican Republic. Figure 3 shows an industrial process of brewing beer (Gutiérrez H et al, 2013; Boyd D et al, 2012).

Figura 3:- Industrial process of a brewing company similar to that of the industry where the investigation as made.
Source. https://www.puntoporpunto.com/secciones/punto-de-encuentro/cerveceras-en-mexico-continuan-en-la-incertidumbre/

Metodologhy:-

In this investigation, experimental processes were made to improve the conditions of the manufacturing areas and thus have optimal it was prepared levels of productivity and quality, describing the stages of the investigation immediately:

a) Evaluation of productivity and quality levels. An evaluation was made of defects, delay tie and generation of unnecessary inventories.

b) Analysis of delivery of supplies. An analysis was made to reduce the delay tie of delivery supplies.

c) Evaluation of a new robust system. An evaluation was made to improve the productivity and quality levels with an automatic electronic device of control.

d) Analysis of production flow. An analysis was made to improve the production flow and with this the increase of the productivity and quality levels.

Results:-

This scientific study generated relevant information from the analysis and evaluations made to determine the waste analyzed (defects, time delays in the delivery of raw materials) of the eight waste of the lean manufacturing of the brewing industry where the investigation was made, described in the next sections.

Evaluation of productivity and quality levels

An analysis of the productivity and quality indices was carried out, evaluating the presence of defects in various areas of the industrial processes of the brewing industry where the scientific study was carried out. To carry out the analysis, it was necessary to describe the seven stages of making beer, describing them as follows (Boyd D et al, 2012):

Step 1. Raw material is received from a supplier for the manufacture of beer.

Productivity analysis.

The personnel that receives the raw material was not trained before the investigation was carried out and errors were generated when loading the raw material, causing it to fall to the floor and be damaged, causing no production to be generated.

Quality analysis.

Certain part of the raw material was not in raw material, it was not in conditions to make the beer manufacturing process, because when the raw material fell to the ground, it became contaminated, so it was necessary to return to buy raw material, generating economic losses.

Step 2. The malting process is carried out.

Productivity analysis.

To make beer it is necessary to have four ingredients; water, malt, hops and yeast. The malting process is the first stage in this manufacture, where the barley malt cereal grains go through a controlled germination process. Only that the personnel was not trained to an adequate quantity for this industrial stage, and they were not trained, nor the manufacturing personnel did not read the work instructions, and sometimes the malting process was not generated properly and it was necessary to redo do it, causing loss of material and thus there was no production, without generating productivity.

Quality analysis.

By not knowing adequately the quantity of barley grain for the malting process, the quality at this stage of the industrial process was low, and it was necessary to dispose of to a specialized landfill for ecological confinement, and it was necessary to carry out the process again. of malting, generating economic losses.

Step 3. The mashing process is carried out.

Productivity analysis.

This next stage is made to mix the water with the barley malt grains, perfectly and is placed in a container to generate a temperature of 68 ° C for four hours, for a product called must. This was done to generate the action of enzymes cutting the long carbon chains that make up starch and converting it into fermentable sugars. Except that the personnel did not know the time required for this stage of the industrial process and they were not trained, nor did the manufacturing personnel read the work instructions, and the must was not generated properly, requiring it to be elaborated again.

Quality analysis.

By not generating the process of this manufacturing stage in an adequate way and having low quality, it was necessary to make the purchase of the raw material required for this process again, causing economic losses.

Step 4. The cooking process is carried out.

Productivity analysis.

The must obtained from the previous stage is passed to a specialized cooking pot for this industrial process, and the hops are added to generate the bitter taste and characteristic aroma of the beer, being carried out in a period of 60 minutes. Subsequently, the unwanted hop and barley residue are sent to the center of the mix, through a high-speed centrifugation activity, to prevent this residue from being sent to the heat exchanger and the fermenter and cause some unsuitable situation, and an unsuitable product is developed. Only at the time of carrying out this stage of the industrial process, the staff did not know the time required, as well as the lack of training was presented to the manufacturing staff, and they did not read the work instructions, causing the product to not be created correctly. adequate and it was necessary to re-elaborate this stage of the industrial process and thus have a low level of productivity.

Quality analysis.
By not having an adequate process in this industrial stage, part of the low-quality product was manufactured, so it was necessary to carry out this activity again, causing economic losses.
Step 5. The process of cooling of the manufactured product is carried out.

Productivity analysis.
Once the must was free of the unwanted residue of hops and barley, the cooling process of the product manufactured in the previous stage is carried out, until the must passes from high temperature (up to 68 ° C), to a temperature environment for a period of time no longer than 15 minutes, developing this activity to prevent the must from becoming contaminated and generating desired flavors in this part of the product. Only at the time of carrying out this stage of the industrial process, the staff did not know the time required to achieve the cooling of the must, in addition to the lack of training for the manufacturing staff, and they did not read the work instructions, causing the product to It was not created properly and it would be necessary to re-elaborate this stage of the industrial process and thus have a low level of productivity.

Quality analysis.
By not having an adequate process in this industrial stage, part of the low-quality product was manufactured, so it was necessary to carry out this activity again, causing economic losses.
Step 6. The fermentation process is carried out.

Productivity analysis.
This is one of the most important stages in the manufacture of beer, where the yeast transforms the fermentable sugars of the must into alcohol and carbon dioxide, and this stage of the process can last from six to twelve days, in any type of beer. Only at the time of carrying out this stage of the industrial process, the staff did not know the period required to achieve the fermentation process and sometimes the period of six to twelve days required was not met (sometimes it was a shorter period and sometimes longer than the required period), causing the product to not be created properly and it was necessary to re-elaborate this stage of the industrial process and thus have a low level of productivity.

Quality analysis.
By not having an adequate process in this industrial stage, part of the low-quality product was manufactured, so it was necessary to carry out this activity again, causing economic losses.
Step 7. The ripening process is carried out.

Productivity analysis.
This stage is carried out in specialized and conditioned tanks, where the product as a beverage generated in the previous stage is subjected to low temperatures (close to 5 ° C), to preserve the appropriate bitter taste and smell. The period of this stage lasts two weeks. Only at the time of carrying out this stage of the industrial process, the staff did not know the period required to achieve the maturation process and sometimes the period of weeks was not fulfilled (sometimes it was a shorter period and sometimes greater than the required period), causing the product to not be created properly and it was necessary to re-elaborate this stage of the industrial process and thus have a low level of productivity.

Quality analysis.
By not having an adequate process in this industrial stage, part of the low-quality product was manufactured, so it was necessary to carry out this activity again, causing economic losses.
Step 8. The beer bottling process is carried out in glass bottle containers and aluminum cans.

Productivity analysis.
After carrying out the maturation process in the previous stage, the brewed beer undergoes a final filtering process to remove impurities and is immediately packaged. Only at the time of carrying out this stage of the industrial process, the staff did not know about the final filtering process and sometimes impurities appeared once the beer was packaged, generating defective products, causing the product to not be created properly and it was necessary to redevelop this stage of the industrial process and thus have a low level of productivity.

Quality analysis.
By not having an adequate process in this industrial stage, part of the low-quality product was manufactured, so it was necessary to carry out this activity again, causing economic losses.

Table one shows the productivity and quality indices and the continuous improvement process to prevent the defects from being repeated.

Table 1:- Productivity and quality analysis in manufacturing areas of the beer industry (2019-2020).

Step	Activity	Productivity, %		Quality, %		Improvement
		BC	AC	BC	AC	
1	Reception of raw material	55	82	49	80	Courses of capacitation to people of manufacturing areas
2	Malting Process	54	84	51	83	Courses of capacitation to people of manufacturing areas
3	Mashing Process	58	88	53	86	Courses of capacitation to people of manufacturing areas
4	Cooking Process	55	84	52	82	Courses of capacitation to people of manufacturing areas
5	Cooling process	57	83	50	80	Courses of capacitation to people of manufacturing areas
6	Fermentation Process	55	81	48	81	Courses of capacitation to people of manufacturing areas
7	Ripening Process	59	86	52	80	Courses of capacitation to people of manufacturing areas
8	Bottling Process	57	87	50	82	Courses of capacitation to people of manufacturing areas

BC. Before Capacitation; AC. After Capacitation.

In the previous table, the percentage indexes of productivity and quality are observed, where the indexes are shown before the training process (between 50% and 60%), and the indexes after the training process (between 80% and 90%) , achieving improvement once the training courses have been developed.

Analysis of delivery of supplies
An analysis of delivery times was developed from the arrival of the supplier's raw material, and thus continuously between each stage and delivery to the customer, showing the information in table 2.

Table 2:- Analysis of delivery times in manufacturing areas of the beer industry (2019-2020).

Step	Activity	Time Delivery, min		Improvement
		BC	AC	
1	Reception of raw material	27	16	Courses of capacitation to people of manufacturing areas
2	Malting Process	24	13	Courses of capacitation to people of manufacturing areas
3	Mashing Process	24	11	Courses of capacitation to people of manufacturing areas
4	Cooking Process	22	10	Courses of capacitation to people of manufacturing areas
5	Cooling process	25	14	Courses of capacitation to people of manufacturing areas
6	Fermentation Process	27	15	Courses of capacitation to people of manufacturing areas
7	Ripening Process	24	13	Courses of capacitation to people of manufacturing areas
8	Bottling Process	22	11	Courses of capacitation to people of manufacturing areas

9	Customer Delivery	17	7	Courses of capacitation to people of manufacturing areas

BC. Before Capacitation; AC. After Capacitation.

As can be seen in table two before preparing the training courses, the delivery times between each stage from the initial process of receiving the raw material to the end of delivery to the customer (ranging between 15 and 30 minutes), and reduced once the training courses for manufacturing personnel were developed (ranging from 5 minutes to 20 minutes). The personnel that participated in the training courses were operational, specialized, supervisory and managers.

Evaluation of a new robust system

An analysis was carried out to organize the products made in the warehouse with a robust automated system, which generated an indicator signal when a product was not in its corresponding place to achieve optimal organization. The prototype proposed as an automated detection device is represented in the form of a block diagram in figure 4.

Figura 4:- Representación de las etapas del dispositivo automatizado.

The robust system contemplates the steps represented in figure 4, with each stage of the automated system being explained immediately:

1) Power supply. It generates the electrical energy necessary for the automated system to operate in optimal conditions.

2) Product detection module in correct location using barcode. It is a system that contains a bar detector module, a component made up of a black space and a blank one that together read the codes and the component that generates the bar code characters.

3) Indicating device. It is an element that originates an indicator signal, being in this automated system it is a low intensity light source.

4) Peer to Peer system. Components that generate data information by means of a signal captured from the bar code and be sent to a single computerized computer that stores the captured data

5) Information storage equipment. Computerized computer that stores the data captured with the barcode system.

Conclusions:-

With the development of this research, it was possible to improve industrial processes, being able to reduce three of the eight defects presented in the analysis of lean manufacturing, to obtain an increase in productivity indices, generating economic gains and reversing the uncomfortable situation that arose. presented before this scientific study was carried out. The research helped to generate the necessary improvements that would generate the control of the industrial operations of the manufacturing area. The detailed analysis with the manufacturing tools originated the information required to determine what was happening in the industrial process and thus make the pertinent improvements. The development of the automated system supported to a great extent to control the location of the products in the warehouse area and not to generate confusion at the time of sending to the clients and to avoid claims between each stage of the manufacturing areas, regarding the three wastes of lean manufacturing evaluated.

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