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Improvement in Delivery Times Using Lean Manufacturing Tools in a SME the Beverage Sector in Peru

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Abstract. The non-alcoholic beverage industry, such as bottled water, is one of the largest industries in which the process is carried out at the lowest cost, but with the highest quality in the final product. This sector has a significant impact on the world economy, and consumption per person is constantly growing. This research focuses on the improvement of delivery times through Lean Manufacturing tools. The model makes use of tools such as 5S' to create and maintain a more efficient and productive space, improve overall equipment efficiency through Total Productive Maintenance, and optimize material and operator movements by eliminating unnecessary ones using Standard Work, from that were positive indicators for management. For the validation of our proposal, an integrating model of the pilot plans was carried out in order to corroborate the efficiency of the proposed tools using the Arena software. By validating the proposed model, it was possible to reduce the rate of products delivered out of time by 37.82%, increase the OEE of the machine by 16% and reduce cycle times.

Keywords. beverage sector, delivery time, 5S', total productive Maintenance, standard work|

1. Introduction

Worldwide manufacturing encompasses economic activities that are dedicated to the physical or chemical transformation to obtain new products. It is divided into Primary Manufacturing and Non-Primary Manufacturing. The importance of this sector in the country's economy is reflected in the Gross Domestic Product (GDP) it contributes to the country. In 2021, the manufacturing sector contributed 71,157 million soles, representing 13.1% of the national GDP [1]. Likewise, it is characterized by its great contribution in exportswith a value of 6,938.4 million PEN in 2021 and by the creation of jobs. This is evidence of the important role that thissector plays in Peru's economy.

For the development of this research, this article focuses on the non-primary manufacturing subsector of the non-alcoholic beverage industry, specifically the bottled water product. Compared to the production of table water, in 2021 it increased by 7.7%

with respect to 2020. However, it is still below the level it had before the pandemic with an increase of -18.7% with respect to 2019 [2]. It is worth noting that this subsector contributes 5% to the manufacturing GDP, which means an income of 5,367 million soles to the national economy [3].

The industry of non-alcoholic beverages such as bottled water and fruit juice (carbonated and non-carbonated), is one of the largest industries in the world, where it is processed at the lowest cost, but maintaining the quality of the final product [4]. This industry has a significant impact on the global economy with revenues of approximately 1'038'054 USD and a volume of 109.5 L/person on average during 2020, in addition, this sector is expected to grow by 6.8% annually until 2025 [5].

In this industry, several problems can be found, among them is the loading of trucks, in addition, problems with the routes and delivery times of the products can be evidenced. Another of the main problems encountered is the lack of service level compliance in the delivery of orders, which can significantly affect sales. Service level is critical, as it is strongly associated with safety stock, warranty policies, delivery facilities, rework facilities, and delivery policies [6]. Also, there are problems related to the weight load this due to the efforts made by the operators when moving heavy products, in addition to the maintenance practices to the machines and routine inspections, due to the high quality expected of the product [7]. Likewise, another problem that generates large economic losses is found in the filling process due to the high production times, which originates the reduction of the productive capacity, increasing unproductive times and without organizing the workstations [8]. That is why, this research has the purpose of improving delivery times through Lean Manufacturing tools, such as 5S, Total Productive Maintenance and Standard Work, in order to maintain a more efficient space and tools, in addition to optimizing movements. unnecessary. This research is structured by introduction, state of the art, proposed model, validation, discussion and conclusion, which will lead us to have a better understanding and relationship with the proposed topic.

2. State of Art

2.1. 5S'

Philosophy that creates and maintains a more efficient and productive space [9]. The so-called 5s is a tool belonging to the Lean Manufacturing section and is one of the first to be studied and applied within an SME such as in the manufacturing, textile or beverage industry to implement a total management system [10]. Previous studies mention that one of the problems they face is the high production times and for this, they propose several Lean Manufacturing tools and among them is the 5S to achieve process improvement in a bottling water company [11]. All stations should be evaluated, documenting through photos or videos each part of the process for better understanding and thus be able to identify anomalies or Lean waste within the production plant and have established an initial situation [12]. With this implementation, it is possible to improve the times both inside and outside the production area since they influence the distribution and delivery times of the product to the customer.

2.2. Total Productive Maintenance (TPM)

Strategy established to increase the efficiency of the equipment, seeking to minimize failures and improve both the human and material element [13]. Managers stipulate that machinery must be ready to work at any time, therefore, this tool takes a very important role within the manufacturing industry, since this will avoid delays in Set-up times and equipment maintenance, in addition, with its application occupational accidents can be reduced [14]. Previous studies applied TPM to avoid failures in their machines, training personnel in maintenance techniques and thus not making mistakes, which led to an increase in machine efficiency by 47.56% [11].

One of the pillars of the TPM is autonomous maintenance that is based on being able to train the operators, in such a way that they are independent monitoring the equipment and developing basic maintenance tasks. Likewise, train them to detect changes and solve problems more effectively without the help of a technician, making them also focus on their functions, avoiding distracting them. This implementation will help operators to become familiar with the plant equipment with which they work and fully understand it, thus also helping to prevent breakdowns.

2.3. Standard Work

For a standardized work, the concepts of takt time and sequence of activities are related, where an adequate waste management will be established in which it will be sought to optimize movements of operators and materials. Therefore, the necessary documentation will be prepared in which the different processes will be summarized and taken as a reference [15]. Previous studies applied in critical processes, a standardization of the work method to eliminate all types of waste, including unnecessary time and movements [16].

3. Methodology

After having carried out a deep analysis of the articles found, it was possible to make a comparison between the methodologies and tools used in order to choose the most appropriate to our problem. The proposed model will help us and facilitate the understanding and development of our case. Likewise, this model proposes the combination of lean manufacturing tools such as TPM, 5S, and Standard work, in order to achieve the reduction of excess waste and improve order management. Table 1 below shows the authors who have contributed the most to identify the tools required for the proposed model:

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Table 1. Comparative matrix of components of the proposal vs the state of art

Authors	Components		
	Reduce plant clutter	Implement autonomous maintenance	Standardize process activities
Borges, R., Freitas,F., Sousa, I.(2015)	5S		
Torres, R., Ramirez, J., Catillo, J., Nunura, C. (2021)	5S	TPM	
Riad, S., Mynuer, M., Harunur, B.(2017)	5S		Standard Work
Capcha, E., Vila, W.,Viacaba ,G.,Quiro z,J., Cardenas, J.(2021)	5S		Standard Work
Zennaro, I.,Battini, D.,Persona A.,Sgarbossa,F.(2019)		TPM	
Proposal	5S, TPM & Standard Work		

According to the bibliographical review, it was observed that the best tools to address the problems raised are the so- called Lean Manufacturing, which are the most favorable to implement within an SME, especially if it is in the manufacturing sector. The tools selected within the Lean category are 5S, TPM and Standard Work, since these 3 works simultaneously, in order to reduce plant disorder, increase equipment efficiency and eliminate all kinds of waste including time and movements unnecessary respectively. Figure 1 shows the series of steps that will be followed to carry out this research.

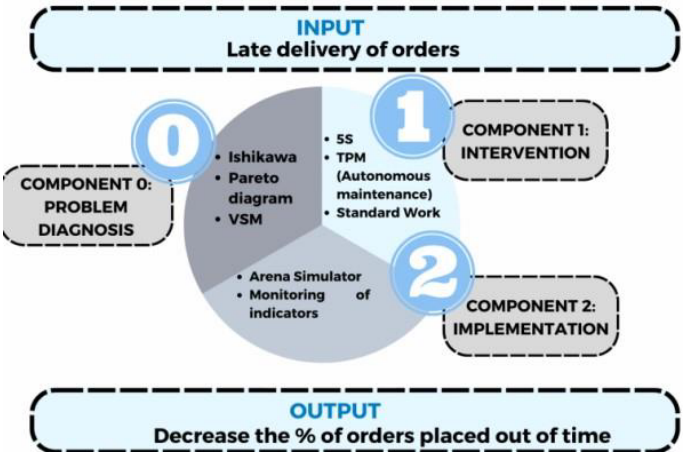

Figure 1. Proposed improvement model.

3.1. Model Components

- Component 0: Problem diagnosis: In this first stage, the initial situation of the organization was evaluated and the VSM tool was used for this purpose, with which the wastes were revealed, and it was possible to observe in detail how each stage of the production process is working, as well as the status of the machinery involved from water purification to its final disposal. Subsequently, the Pareto diagram was used to prioritize the problems found and assign their

percentage of participation within the macro, which led to the identification of points for improvement. Finally, the Ishikawa diagram was used to identify the root causes of the aforementioned problems.

- Component 1: Intervention: Lean Manufacturing tools will be applied in this component. Regarding the 5s, objects that are not part of the process but that take up space were eliminated, tools were placed within the operator's reach, a cleaning plan, document, and sign were implemented.

  Now we will proceed to use the TPM tool, in relation to autonomous maintenance. The machinery used in the table water manufacturing process is specialized and therefore, if there is any problem, an expert is required to solve it. What will be implemented with this tool is to adequately plan the maintenance always required. The goal is to reach zero failures. This will reduce unplanned maintenance costs and prevent unplanned downtime.

  Regarding standardization, a mapping of activities will be carried out, specifying what is done and how each of them is done. Subsequently, a new process will be designed, eliminating unnecessary steps to streamline and simplify the process. Likewise, we will train operators and implement monitoring of their activities.
- Component 2: Implementation: Regarding the implementation phase, it consists of 2 components. This refers to the implementation of KPI's to be able to identify the change with the implemented models, and at the same time the use of the Arena simulator, which will help us to get closer to reality. Then, with the results obtained from the simulation, we will proceed to compare the initial information with the results obtained and check the effectiveness of the proposed tools. Table II shows the real values obtained from observations, studies and information in the field, which are compared with the expected values in reference to the sector and previous studies.

Table 2. Comparative matrix of components of the proposal vs the state of art

	Indicators		As Is	To be	Improved
5s	Audit qualification		26	84	69.05%
TPM	OEE		46%	51%	9.8%
Standard Work	Washing and labeling	Cycle time (seg)	270.33	254.67	- 5.80%
	Production and filling	Cycle time (seg)	3732.33	3713.33	- 0.51%

4. Validation

4.1. Initial Diagnosis

In Peru, companies in the soft drink sector contribute directly and indirectly to the generation of employment with more than 180 thousand jobs, and to have an idea of their impact on the tax authorities, between 2000-2011 they paid approximately 5 million PEN in taxes [17]. In the beverage sector, it is important to take into account indicators such as the level of service, quality of deliveries, lead time for delivery, in order to satisfy the customer and be reflected in the company's sales. However, in the

company under study the problem of late delivery of orders is reflected, with an average percentage of 54.5% of orders delivered out of time. In addition, in the article entitled "Model to Increase the Productive Capacity of an SME in the Beverage Sector Applying 5s Tools, Autonomous Maintenance, Plant Distribution and Automation", conducted by [8] the rate of products delivered out of time should be less than 10%, as a result of its application they obtained a rate of 8.78%. Given this, compared to the sector the company studied has a variation of 36.82%.

Three main causes for the delay in the delivery of orders were found, these are the inefficient handling of orders, which represents 57.7%, the excess of wastage in the orders, 31.3%, and the failures in the operators, which represent 11%.

4.2. Validation of the Design and Comparison with the Initial Diagnosis

For the validation of the design, it was necessary to comply with the three components proposed. The first component is based on identifying the root causes of the delay in the delivery of orders through a problem tree in which it was found that the disorganization of the company, lack of stock, lack of maintenance, inventory in poor condition and poor standardization of processes. In the second component, the proposed tools were implemented, starting with the 5S', then the Total Productive Maintenance and finally the Standard Work. Finally, the third component focuses on analyzing the previously determined indicators to be measured.

4.3. Proposed Improvement - Simulation

As a validation tool, Arena software was used to evaluate the feasibility of the proposed scenario. For the first scenario, a simulation of the process to produce water drums was carried out. Figure 2 represents the company's production system, entities, attributes and activities performed in each of them. The time conditions to be considered are 8 hours of simulation time, 24 hours per day, seconds as the basic unit of time and 30 initial replications. It should be noted that the proposed scenario is based on the reduction of times in each thread after having applied the proposed Lean Manufacturing tools.

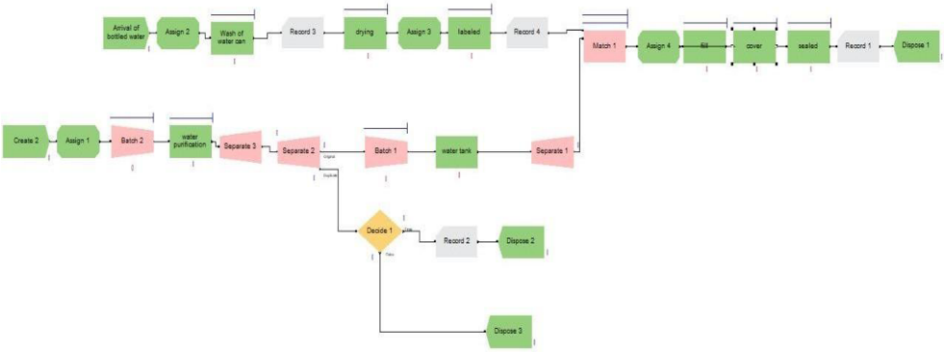

Figure 2. Improved situation model

Table 3. Comparison of indicators

Problem	Actual	Objective	Improved	Cause	Indicator	Actual	Objective	Improved
Delay in order delivery	46.32%	8.78%	8.5%	Company disorganization	5s' audit	26	84	73
				Absence of maintenance	OEE	46%	51%	62%
				Poor standardization of processes	Cycle time Washing and Labeling	270.33 seg	254.67 seg	124.18 seg
					Cycle time Production and Filling	3732.33 seg	3713.33 seg	3634.9 seg

The Arena software was used as a validation tool, to test the viability of the tools mentioned above in the proposed model.

In this part, the input variables, the entities, the scope of the system, as well as the sample size, among others, will be specified. For the first activity, a simulation was performed for the arrival of water bottles, which arrive at time intervals that conform to a constant distribution. They are then washed by an operator, in which the time intervals are adjusted to a uniform distribution, lasting between 160 and 180 seconds. They are then dried and labeled, both with uniform time intervals. At the same time, the water treatment process is carried out in the corresponding machine. Both processes are carried out in parallel, after which the water bottles are filled, capped and sealed independently of each other. With the proposed tools, a positive change can be observed with respect to the initial indicators. As can be seen in table III, the indicators obtained from the simulation in the software, after applying the improvements, demonstrate the feasibility of the investigation.

5. Discussion

The proposed model based on the improvement of delivery times in a company in the beverage sector using Lean Manufacturing tools can be implemented to other companies in the sector that present similar problems such as disorganization, lack of maintenance and lack of work standardization. Since such tools have a great impact on growing organizations such as SMEs, this is where the company in question of the present research is located. Because companies such as SMEs commonly arise from family ideas or entrepreneurship, but are growing without any control in their processes, therefore, when performing an audit or inspection can be found many opportunities for improvement and in these is where the tools of Lean Manufacturing are applied. There were limitations for the implementation of our tools such as the lack of specific knowledge of the operators in certain tasks as well as the lack of company policy.

When analyzing the results obtained, the main indicator to be measured, which is the delay in the delivery of orders, could be reduced from 46.32% to 8.5%, which means that the production plant can increase the number of orders to be distributed. This indicator was affected by the way the process was carried out by the operators, since both

the production area and the storage area were not in the right conditions and this meant a delay per bottle produced, since they did not have greater management knowledge within the organization. Therefore, one of the causes that contributed to this improvement is the application of the 5s tool, which helped us to increase the organization of order taking, managing to increase the score from 26 to 73 points, managing to improve the process of a water bottling company, in which necessary and unnecessary objects were classified [11].

In addition, the overall efficiency of the equipment was improved, increasing from 46% to 62%, seeking to minimize failures and improve both human and material elements [13], also seeking not to waste time, not to have accidents, not to have high Set-up times or defective products [18].

Finally, the cycle times of the operations decreased, it will be sought to optimize the movements of operators and materials. For this, the necessary documentation will be carried out summarizing the different processes and will be taken as a reference [15], which makes the production time per drum lower and the planning can be satisfied.

6. Conclusion

After conducting the research to the company studied, it can be concluded that the implementation of Lean Manufacturing tools can achieve an improvement in production times, which can be evidenced in the above.

With analysis tools such as VSM, problem tree, Pareto diagram, Ishikawa diagram, 5why's, it was proposal for improvement, from which positive results were obtained. In this sense, it was found that the main problem in the company was the delay in the delivery of orders, which was caused by the failures of the operators due to lack of training, excessive waste, high production times and others.

The Lean Manufacturing tools allowed the reduction of cycle times, as well as the improvement in the performance, availability and quality of the machines. Also, by implementing techniques such as the 5S's, it allowed to have a better order and distribution in the plant, which reduces unnecessary movements and times. The proposed methodology of Lean Manufacturing tools such as the 5S, Standard Work and TPM helped to reduce the delay in the delivery of orders. It has been demonstrated that these tools are of vital importance and should be implemented in all types of companies because they help to reduce costs, reduce downtime and improve product quality. We were able to reduce the delay in the delivery of orders to 8.5% and that is thanks to the implementation of lean manufacturing tools.

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