Improvement Model to Increase Productivity Using SLP, 5S and Standard Work at a Pisco Producer SME in Peru

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Abstract

Over the years, the Pisco industry has experienced significant growth, which is why the SMEs in the sector need to improve their production processes. Many of these companies have difficulties in their production processes related to low productivity, mainly due to inefficient plant distribution. Therefore, the main purpose of this scientific article is to support these companies in the Pisco industry by increasing their productivity. This will be achieved by implementing the following improvement proposal using the engineering tools of Systematic Layout Planning, 5S, and Standard Work. The proposal of this article is a new plant layout, in order to eliminate unnecessary transfers in the production process, alongside standardized processes and an innovative temperature control system. The proposed model was validated with the use of Arena Software by comparing the pre-implementation and post-implementation results of the model, in order to verify if the implementation of these tools had a positive impact on the Pisco producing company. As a result, the productivity increased by 11%, the transfer times between stages were reduced from 20,36 hours to 13,86 hours, meaning a 31,92% reduction per production process; and the waste generated during the process was reduced by 11%. Also, from a financial point of view, a payback period of 1,51 years and an NPV of USD 3 938,92 were obtained.

Keywords
Productivity, Systematic layout planning, 5S, Standard Word, Pisco.

1. Introduction
Pisco production belongs to the agro-industrial manufacturing economic sector in Peru with participation in two activities. The first activity is agriculture, due to the inputs required in the production process and the second activity is alcoholic beverages, due to the nature of the finished product. The Ministry of Production (2022) states that, at the end of 2021, total sales of Pisco amounted to more than 6 million liters, which represented a growth of 53,2% over the previous year. Likewise, ADEX (2022), claims that between 2017 and 2021, Peruvian exports of Pisco expanded by an annual average of 6,2% and during 2021, Pisco exports accumulated USD 7,2 million, which represented a growth of 81,6% over the previous year. In addition, during the first semester of 2022, Pisco exports accumulated USD 4,6 million. This is due to the worldwide recognition of the product's quality. For this reason, distillate consumers are in constant search for different flavors and smells, characteristics that can be offered by the different varieties of Pisco grapes. Despite this, production methods vary according to the empirical experience of the different producers throughout the country. This situation generates products of different qualities and low productivity, a consequence, in certain cases, of bad practices in the production process due to lack of knowledge, incorrect plant layout and use of inappropriate technology (Mendoza 2015).

Companies in the manufacturing sector, as is the case of the Pisco industry, have a problem with the management of their operations or activities, since only 5% add value to the process. Additionally, there are 35% of activities that do not add value and 60% of unnecessary activities (Vargas et al. 2022). Consequently, a model was developed to increase productivity and standardize the different stages of the Pisco production process using SLP, Standardization of Work and 5S. It should be emphasized that this model is applicable to any Pisco producer SME that seeks improvement in

their productivity indicators and the standards of its final product, in order to enhance the development of the industry. Finally, this scientific article is divided into 6 chapters
; Introduction, Literature Review, Methods, Results and Discussion, Economic Analysis and Conclusions.

1.1 Objectives
The overall objective of this article is to increase the company's profitability by reducing more than USD 10 000 in unnecessary costs. In this line, it is proposed to increase the productivity index by at least 8%, at first, thanks to the proposed new plant layout and the standardization of processes in the different stages. Thus, the key contribution of this article will be to be able to generate a greater quantity of liters of Pisco, in order to generate higher income and reduce costs.

2. Literature Review
After having compiled and analyzed a series of articles that help to support the problem identified, many authors point out the importance of using Lean Manufacturing tools in order to enhance the performance of any production flow. Lean Manufacturing is a philosophy that seeks to maximize efficiency, reduce costs, improve the quality of the products produced and observe how workers perform in factories. Lean Manufacturing philosophy is said to be "Lean" because it uses half the human effort and half the production space (Ali et al. 2016). Ali et al. (2016) also argue that plant layout is related to production control and product quality, since, by having a well-organized and studied layout, they make the machinery and transportation routes within the plant efficient. In addition, it was evidenced that thanks to the implementation of Lean tools, such as 5S and Standard Work, a significant reduction in manufacturing times was achieved, as well as a decrease of 5% of defective products (Barrientos et al. 2020). In this sense, all the literature reviewed was classified into three typologies: Productive improvements through the application of SLP, Application of 5S for the restructuring of processes and Structured processes under standardized guidelines.

2.1 Productive improvements through the application of SLP
With regard to this first group of articles, we sought to be able to find authors that support the different results that could be obtained through the use of this tool. According to Suhardi et al. (2019), facility layout design is an influential factor in the performance of a company to support the optimized production process. In addition, this method allows improving the flow of activities as a result of the redesign of the plant or space where the production process takes place, in order to reduce distances and unnecessary transfers to improve the workflow (Vargas et al. 2022). The planning of a correct plant layout consists of 4 stages, whose series of procedures allows identifying problems, evaluating, observing and proposing solutions by means of elements and symbols defined in the methodology in relation to the process in question (Paucar et al. 2023).

2.2 Application of 5S for the restructuring of processes
The main objective of the application of 5S is to organize the processes in an orderly and clear way. The 5S methodology is usually carried out with the support of colored cards to correctly classify and identify objects or materials in the production plant, with the purpose of having a better organization and therefore, a better workflow (Lira-Aquino et al. 2021). In addition, this tool seeks to reduce human and production errors that can be dangerous and even jeopardize the total production. As described by Dextre-del-Castillo et al. (2020), the name of this tool comes from a Japanese terminology, where each one of the phases embraces each one of the five "S": Seiri, classify and select; Seiton, organize; Seiso, clean; Seiketsu, standardize; and Shitsuke, discipline.

2.3 Structured processes under standardized guidelines
For this last typology, the standard work tool can be defined as one that, through specific instructions, helps the production process to achieve the most efficient results possible (Mor et al. 2019). Guzel and Asiabi (2020) argue that the tool, after a thorough analysis and review, produces a series of standard operating procedures (SOPs). In this way, it is possible to constantly monitor the stages of the process and the activities that make it up in a given period of time. Likewise, giving the opportunity and clarity in the areas that affect the flow of the process, leading to an elimination or restructuring of these. To relate the term standard work to the actual application of this research, the characteristics that make up the production of Pisco were consulted at a technical level. Alcoholic fermentation is defined as the chemical process by which yeasts transform the sugars in the must into ethanol and carbon dioxide, for this to occur it must be under conditions of oxygen limitation and controlled temperature for optimal development (Reaño, 2015). In this regard, it should be noted that large producers have been implementing this type of technology over the last few years, due to a clear improvement in process performance, which is directly transferred to the quality of the final

product obtained. However, small and medium-sized producers do not innovate with it, mainly due to lack of knowledge and fear of change. In addition, Mor et al. (2019) also argue that the application of this tool reduces unit costs and reduces flow and movement inefficiencies.

3. Methods

During the literature review, several articles were found where the same engineering tools proposed in this article are applied. The articles analyzed and considered relevant were classified into 3 different typologies, as previously described in the Literature Review chapter. Table 1 below shows which articles were chosen as the most appropriate to solve the problem identified in the company.

Table 1. Comparative matrix

Author	Inefficient plant layout	Waste	Non-standardized processes
Ali Naqvi, S.A; Fahad, M; Atir, M; Zubair, M; Musharaf, M; Xu, W. (2016)	SLP	SLP	
Espinoza-Berrocal, R; Vilchez-Peralta, B; Flores-Perez, A. (2023)	SLP, 5S	SLP, 5S	TQM, Standard Work
Lira-Aquino, A., Miranda-Poccori, E., Altamirano-Flores, E., & Cardenas-Rengifo, L. (2021)		5S	Standard Work, Kanban
Suhardi, B; Juwita, E; Asturi, R.D. (2019)	SLP, Ergo-Lean	SLP	
Vargas-Altamirano, A; Ulloa-Durand, J; Flores-Perez, A; Quiroz-Flores, J; Collao-Diaz, M. (2022)	SLP, 5S	SLP, 5S	TQM, Standard Work
Vargas-Pachas, S; Huamani-Huapaya, S; Flores-Perez, A (2023)	SLP, 5S		Standard Work
Proposal	SLP	5S	Standard Work

3.1 Proposed model

The proposed model was developed with the information gathered in the literature review and with the information obtained from the company. Likewise, this model behaves as a process, it has input variables and by using the proposed tools, the output variables are obtained as shown in Figure 1.
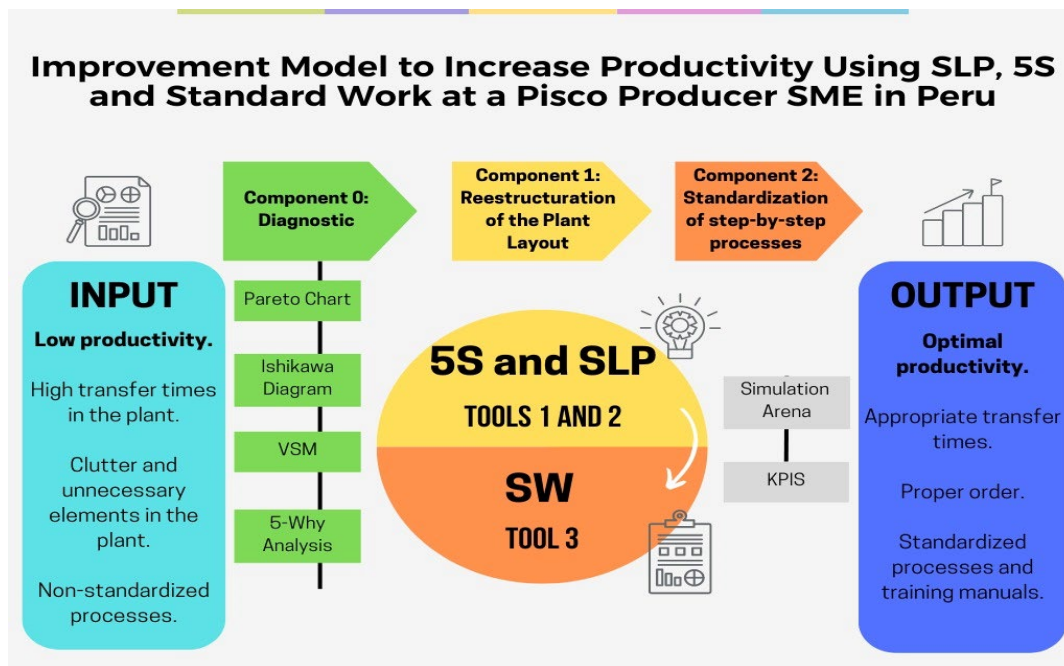
Figure 1. Proposed improvement model

The proposed model consists of a model with 2 main components, being the component 0 the diagnosis of the company to understand the initial situation through the use of diagnostic tools. The next component is the restructuration of the Plant Layout using the 5S and SLP tools, and the last component would be the Standardization of step-by-step processes. This model is validated and monitored through simulation software, in order to measure the KPIs of the company prior to the implementation of the model and post implementation of the improvement proposal.

3.1.1. Component 0 – Diagnosis: This component consists of a diagnosis of the company to determine the main problem, as well as the reasons and causes. The main problem identified was low productivity in the Pisco production process, with the main causes being a poor plant layout, non-standardized processes and waste generated. It should be noted that in this component the weight of each cause identified is determined and, in this way, it is possible to identify the articles in which the authors have faced similar problems in the sector and thus be able to analyze the use of tools to solve these problems. For the development of this diagnosis, a field visit was made to the production plant located in Lima, Peru, as well as the use of diagnostic tools such as the Ishikawa Diagram, a Value Stream Mapping (VSM), a Pareto Diagram and 5 Why Analysis.

3.1.2. Component 1 – Restructuration of the Plant Layout: For this component, the tools illustrated in Figure 1 were used, which are 5S and SLP. These two tools were chosen because, according to the articles reviewed in the literature review, they complement each other well to achieve an adequate plant redistribution. With the use of the 5S tool, we sought to organize the production plant and eliminate unnecessary elements prior to the new plant design. A system of color cards was proposed for each object identified in the production plant, where the color red was used for unnecessary items or items to be eliminated; the color yellow was used for items that are in poor condition and need repair; and finally, the color green was used for items that are in the wrong place. However, the use of this tool was not sufficient for the restructuring of the plant layout. For this reason, it was complemented with the SLP tool, since with this tool it was possible to analyze the flow and stages of production, in order to develop an initial path diagram and a relational diagram of activities. Likewise, the matrix table method was used to determine the effort made by the operators in the transfer of materials and the routes they take. Subsequently, a space analysis was performed and the Guerchet method was applied in order to identify and calculate the space required for each stage and the elements involved in them. Finally, having the information of the relationship between stages, required effort and necessary spaces, a new plant design proposal was elaborated, and a new plant route diagram was proposed.

3.1.3. Component 2 – Standardization of step-by-step processes: For this component, the tool illustrated in Figure 1, Standard Work, was used. In this component, it was proposed to establish procedures in the production process, in order to have a homogeneous production chain, and thus reduce downtime between stages. This final component will consist of two main phases: training plant personnel and preparing a checklist of the new process activities with the new plant layout. Regarding the personnel training phase, it was proposed to develop a General Training Plan for all the company's employees. This Training Plan has 4 modules, which are the following: The optimal Pisco production process, the correct use of materials and machinery, occupational health and safety, and plant cleanliness and order. With regard to the checklist phase of the Pisco production process activities, posters were printed so that plant personnel have a guide at all times and supervisors can control activities more efficiently. A temperature control system was also implemented in the fermentation stage. The purpose of this system is to maintain a constant temperature of 20°C, since at this temperature the yeast reaches its optimum environment and, consequently, the greatest possible amount of potential alcohol is generated from the must.

3.2 Indicators: The indicators are important to be able to demonstrate the performance of the proposed model and to analyze whether the previously described objectives were achieved. These indicators, together with their formulas, are detailed below:

Transfer times: With this indicator, it is possible to calculate the total time of transfers between stages that the operators need in the whole process.
Objective: To reduce transfer time by at least 15%.

$$Transfer\ times: \frac{\sum Transfer\ times\ between\ stages}{Number\ of\ stages\ in\ the\ production\ process}$$

Productivity: With this indicator, it is possible to calculate the productivity percentage of the Pisco production process.
Objective: To increase the productivity percentage by at least 8%.

$$Productivity: \frac{Liters\ of\ Pisco\ obtained}{Liters\ of\ must\ entering\ the\ distillate\ process}$$

Waste: With this indicator, it is possible to calculate the percentage of wastage in the Pisco production process.
Objective: Reduce the percentage of wastage by at least 10%.

$$Waste: \frac{Liters\ of\ non-distilled\ must}{Liters\ of\ must\ entering\ the\ distillate\ process}$$

4. Results and Discussion
4.1 Numerical Results
This section shows the results obtained throughout the research. Firstly, after collecting information from the company, a current productivity indicator of 13% was obtained, which is lower than the market average of 19%, giving a negative gap of 6%. In relation to this, a productivity indicator of 23,69% was obtained after implementing the improvement model. Translated into real values, the process generates 1 089 liters of Pisco for approximately 4 500 liters of must available for distillation (488 liters of additional Pisco) after the implementation of the model. If we compare this value with the company's initial situation, an increase in productivity of 11% was achieved. Likewise, a positive gap of more than 4,5% with respect to the industry average was achieved. For this reason, a reduction in costs of at least 60% of the total economic impact (more than USD 10 000) was generated. Likewise, the travel time between stages of the production process was calculated, which was a total of 20,36 hours. One of the objectives of this article was to reduce this time by at least 15%. The results showed a reduction of 31,92%, from more than 20 hours of transfers to 13,86 hours (6,5 hours less). For the last indicator, waste generated, a reduction of 11% was achieved, going from 87,88% in the initial situation of the company to 76.88% after the implementation of the improvement model, remembering that due to the nature of the process it is not possible to reduce this indicator by less than 70%. In addition, financial indicators were obtained that support the viability of the improvement proposal. Considering an investment of USD 8 021 for the implementation of the improvements, a payback period of 1,51 years was obtained;

that is, after a year and a half it will be possible to see effective not only the recovery of the investment, but also the savings of more than USD 10 000 in unnecessary costs. On the other hand, the NPV value at the end of the 2-year projection yields a value of USD 3 939 and an IRR of 53%, considering an opportunity cost of capital (COK) of 40%.

4.2 Graphical Results

Likewise, the graphs and tables obtained that were part of the solution and that support the results obtained will be shown below.

Figure 2 shows the productivity of the sector on average and the productivity of the analyzed company for the period from 2019 to 2023. With the results obtained, it can be seen that the productivity of the company after the implementation of the improvement model would be above the industry average.
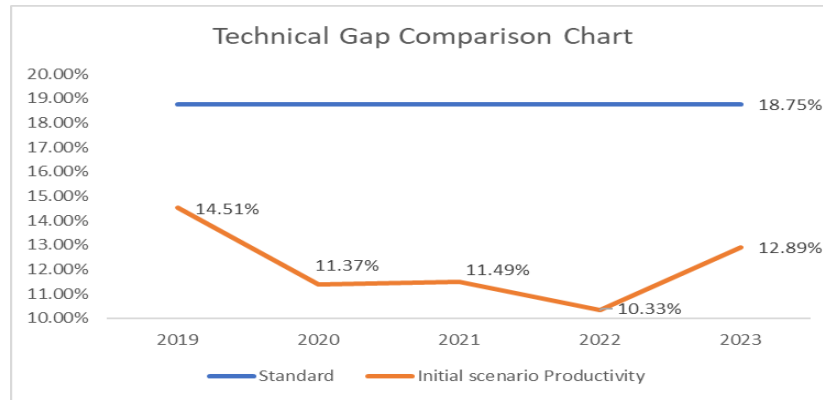

Figure 2. Comparative graph of the productivity between the sector and the company at initial state

Figure 3 shows the post-implementation value stream mapping, detailing the production processes for making Pisco, with their respective times by stages, transfer times between stages, total time that does not add value and total value-added time.
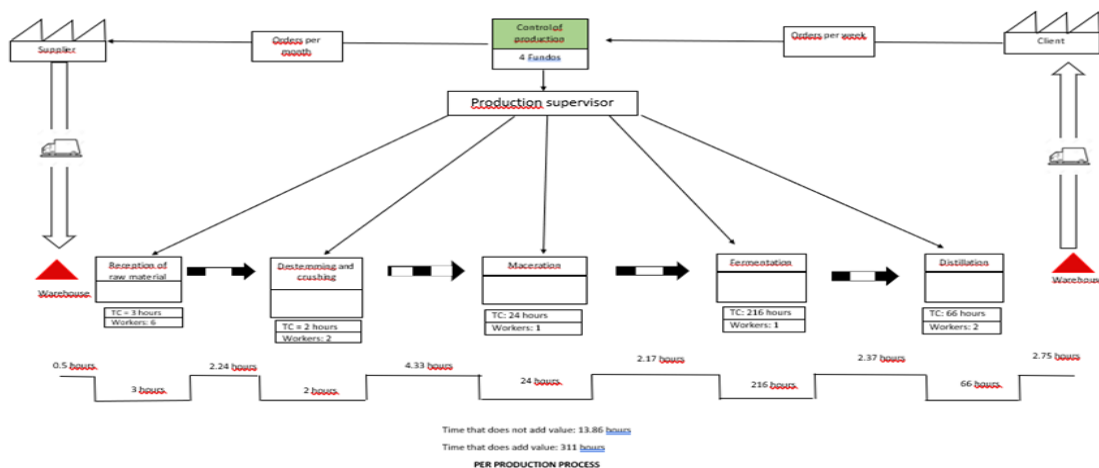

Figure 3. Value Stream Mapping after de implementation of the improvement model

In the same context, results were obtained after the implementation of the 5S tool. For this tool, an initial evaluation was elaborated taking into account the aspects detailed in Table 2 and an evaluation after the implementation of the improvement model.

Table 2. Comparative results of the implementation of 5S

Comparative between the initial and final audit			
Aspect	Initial score	Final score	Variation
Organization and cleanliness in work areas	1	5	4
Safety in each work sector	3	4	1
Minimal presence of unnecessary objects	1	5	4
Proximity of materials	3	4	1
Unobstructed transfer areas	2	5	3

Likewise, a new plant layout was prepared for the company, as shown in Figure 4. In this updated layout, it can be seen that the processes are more linear and the transfer of workers was reduced, as well as the transfer between stages.
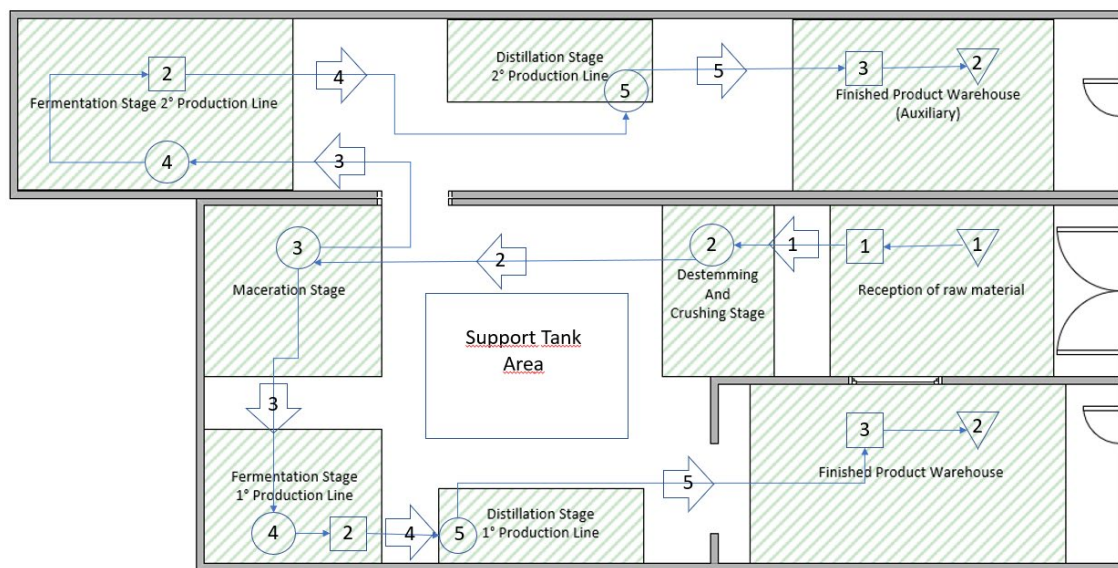

Figure 4. New plant layout

4.3 Proposed Improvements

With respect to the improvement model implemented, as previously described in this article, 3 engineering tools were used, divided into two implementation components. First, in component 1, the 5S and SLP tools were used. For the 5S tool, an initial evaluation of the production plant was carried out. Subsequently, a series of observations were elaborated with their respective scores in order to compare these results after the implementation of this tool. During this initial evaluation, several deficiencies were identified in the production plant, which would be causing the low productivity in the company. For the first phase of implementation of this tool, the first S, Seiri, was applied. In this phase, the objects were classified into three different categories: red for items to be eliminated; yellow for items to be repaired; and green for items to be relocated. The second phase, Seiton, consisted of organizing the production plant. To this end, a list was drawn up with yellow and green items to be relocated after SLP implementation. The third phase, Seiso, consisted of cleaning the production plant. To achieve this, a cleaning plan was drawn up so that the operators, after each production process, would keep their work area clean and tidy to be able to perform their functions optimally. The fourth phase, Seiketsu, consisted of developing a cleaning follow-up plan. The purpose of this plan

was to create habits in the operators and to facilitate the work of the production plant supervisors. The last phase, Shitsuke, consisted of creating discipline. For this last phase, a training manual was prepared for the company's personnel and its purpose was to create a safe, orderly and clean work environment, and thus be able to perform a better job. For the SLP tool, the current route diagram of the production plant was drawn up after analyzing the flow and stages of production. First, a relational analysis of activities was performed in order to determine the relationship between the stages of the process and thus be able to determine a correct distribution of the plant, as shown in Figure 5.

Figure 5. Relational Analysis of activities

The first opportunity for improvement identified when performing the relational analysis of activities was that the fermentation and distillation stages should be close due to the sequentiality of the process; however, it was observed that, in the current relational diagram, this is not fulfilled. Then, the matrix table method was applied to determine the total effort of the operators in the production process by the distance traveled. As a result, a total of 2 964 596 l-m/year and 160 000 kg-m/year were obtained with the current distribution. Subsequently, a space analysis was performed in order to identify the space required for each stage and element involved in the production process. The Guerchet method was used for this purpose. As a result, a total proposed required area of 385,21 m2 was obtained versus the 443,11 m2 of required area of the current situation. It should be noted that the capacity of the plant is 400 m2 and for this reason, the company incurs in an extra expense to rent an additional warehouse. With the results obtained from the implementation of the 5S and SLP tools, a new plant layout proposal was developed, taking into consideration the relationship between stages, required effort and the necessary spaces.

Finally, for component 2, the Standard Work tool was used. The implementation of this tool consisted of 2 main phases. In the first phase, a General Training Plan was developed for all the company's employees. This plan consists of 4 main modules, which are as follows: The first module is the optimal Pisco production process, where the aim is for the operators to learn the new process flow, transfer of materials and routes. The second module consists of the correct use of materials and machinery to avoid reprocessing or other errors in the production stages that could lead to a decrease in productivity or an increase in transfer times. The third module consists of occupational health and safety, and the fourth module consists of plant cleanliness and order. In the second phase, a checklist of activities in the Pisco production process was drawn up and posters were printed so that plant personnel have a guide at all times and supervisors can control activities more efficiently.

In addition, a training guide was prepared for all the company's employees, detailing the target audience, methodology, training objectives, training index, duration and frequency of training. In addition, a temperature control system was implemented in the fermentation stage. The purpose of this system is to maintain a constant temperature of 20°C during fermentation, since at this temperature the yeast reaches its optimum environment and, consequently, the

greatest possible amount of potential alcohol is generated from the must. The greater the amount of potential alcohol possible, the greater the number of liters of Pisco obtained in the distillation, since it consists of concentrating the alcoholic particles of the compound.

4.4 Validation

In order to obtain more reliable results, the Arena simulation software was used as a validation tool. The simulation was elaborated taking into account the whole process necessary for the production of Pisco, from the reception of the raw material to the obtaining of Pisco after the distillation stage. In addition, the Input Analyzer software was used to determine the optimal number of replicates required for the simulation of the model, which were 122. In addition, for the comparison of the proposed model and the initial situation of the process, a confidence level of 95% and an error percentage of 10% were applied. Figure 7 shows the proposed model that considers two production lines instead of one, as in the first scenario. After running both simulations in Arena, the indicators to be measured were exported and it can be concluded that the results obtained with the improvement model are far superior. In line with that, according to the proposal, the productivity indicator increases considerably; otherwise, the time between stages decreases to the same extent, one of the specific objectives of the article.
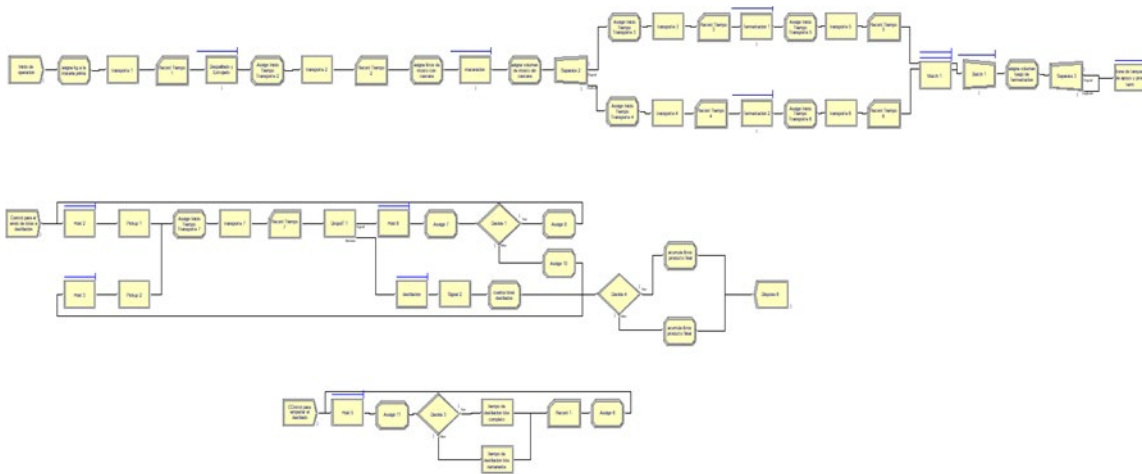

Figure 6. Simulación del Modelo To Be

As a result of the improvement model implemented in the company, it was possible to obtain better indicators in the company by using the engineering tools proposed in this article. These results obtained through simulation can be seen in Table 3 below.

Table 3. Indicators results

Measurement of improvement model							
Problem	Actual	Objective	Improved	Indicators	Actual	Objective	Improved
Low Productivity	12,12%	20,12%	23,69%	Transfer times between stages (hrs/process)	20,36	17,31	13,86

				% of Waste generated	87,88%	71,3%	76%

5. Economic Analysis

After the proposed model was implemented and the previously described results were calculated, then, proceeded to validate the feasibility of the research from an economic approach without considering financial expenses; that is, the company assumes the investment by its own capital. In this way, very interesting economic indicators were obtained. First, the total investment (USD 8 021) takes into consideration the costs of implementing the 5S tools (USD 911,92), SLP (USD 5 147,30) and Standard Work (USD 1 961,96). This investment can be recovered in a period no longer than 1,51 years, which is the value of the payback period. In addition, taking into account a 2-year projection, the NPV of the project results in USD 3 939. The cash flow presented in the given time horizon, together with the economic indicators can be seen in Table 4. Finally, a 40% opportunity cost of capital (COK) was considerate, based on the gross margin, investment expectations and valuing the economic effort of the company in making the investment for the proposed improvement. With this, the IRR was determined at 53%. It should be noted that a growth factor is assumed from the third year after the implementation of the proposed model.

Table 4. Projected Financial Cash Flow (in USD)

Year	0	1	2
Net Revenue		7 420,03	7 420,03
Financial Cash Flow	-8 021,18	7 420,03	7 420,03
Discounted Cash Flow	-8 021,18	5 300,02	3 785,73
Cumulative Cash Flow	-8 021,18	-2 721,16	1 064,57

6. Conclusion

Based on the validation carried out, it was possible to demonstrate that, through the correct implementation of engineering tools, it is possible to make improvements in the Peruvian Pisco industry. In the case of this article, it was possible to increase the company's productivity by 11%, which translates into a total of 1 452 Pisco bottles of 750ml each. Likewise, thanks to the new plant layout, the elimination and reorganization of elements and the new standardized processes, carried out with the SLP, 5S and Work Standardization tools, respectively, it was possible to reduce transfer times from 20,36 hours to 13,86 hours, which means a reduction of 6,5 hours or 31,92% per production process. Likewise, it was possible to reduce waste generated by 11.88% per production process. On the other hand, the improvement proposal of this article has the potential to generate a positive economic impact of more than USD 10 000 per year. Finally, if this proposal is analyzed and implemented by other small and medium-sized companies in the Peruvian pisco sector, it could generate growth in the industry, since one of the main problems in the industry is an inadequate distribution of the production plant, and with this model, they would be attacking the main problem.

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